WAVES AND WAVE MOTION

There are only two ways by which energy can be transmitted from one point to another.

(1) By movement of particles of matter eg

- ❖ Movement of electrons through a wire will transfer energy from one point to another
- ❖ When a hammer strikes a nail, it transfers its kinetic energy to the nail therefore the nail is able to penetrate the piece

(2) By wave motion eg

- ❖ Sound waves transfer energy by vibration of particles
- ❖ Light energy is transferred from the sun to the earth

Definition

A wave is a periodic disturbance which travels with finite velocity through a medium and transfers energy one point to another without any particles of the medium travelling.

Waves are divided into two types namely;

(i) Electromagnetic waves

(ii) Mechanical waves

Mechanical waves

These are waves which require a material medium for their transmission.

Examples of mechanical waves

- Sound waves
- Water waves
- Waves in compressed springs
- Waves due to stretched string

Electromagnetic waves

These are waves produced by varying electric and magnetic fields and they do not require a material medium for their transmission.

Examples of electromagnetic waves

- Light waves
- $\gamma - rays$
- Radio waves
- All other electromagnetic band waves

Note:

All electromagnetic waves travel at a speed of light $ie\ 3x10^8 m/s$

Wave motion

These is a means of transferring energy

Types of wave motion

There are two types of wave motion namely

- Transverse waves
- Longitudinal waves

Transverse waves

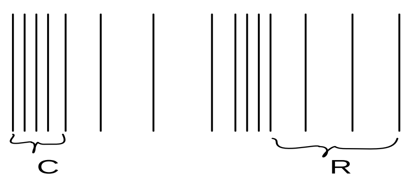
These are waves in which particles vibrate perpendicular to the direction of wave travel.

Examples

- Water waves
- Waves due plucked strings
- Light waves
- All electromagnetic waves ($eg\ \gamma - rays, X - rays$)

Longitudinal waves

These are waves in which particles vibrate parallel to the direction of travel of the wave.



C- Compression region

R- Rare faction region

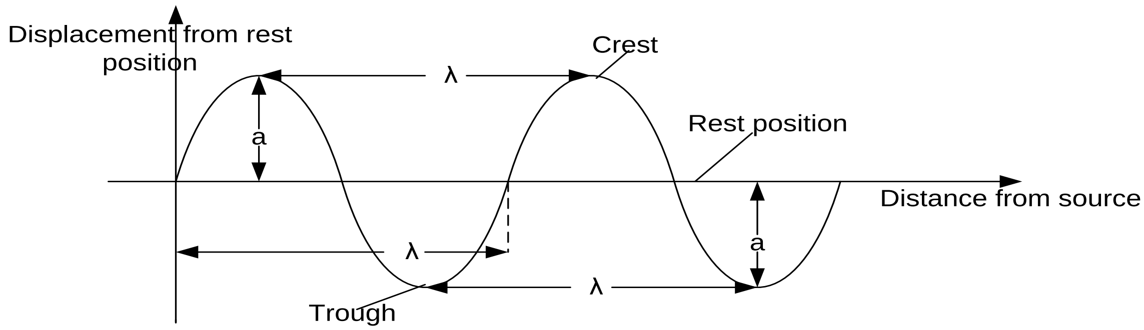
Examples

- Sound waves
- Waves due to stretched or compressed springs

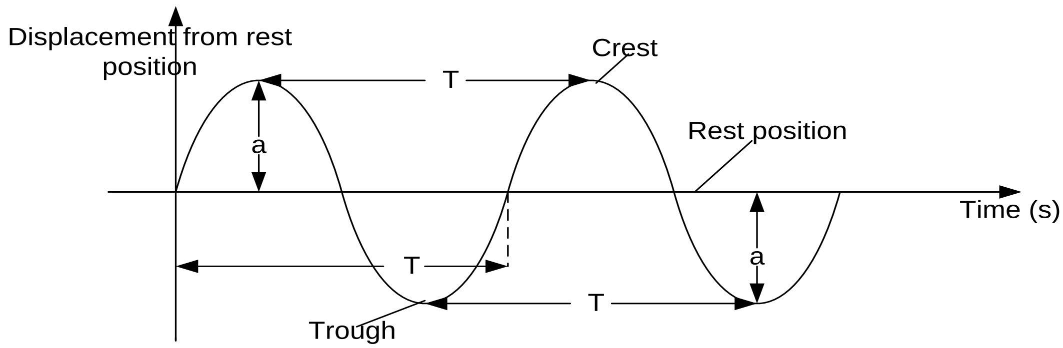
Differences between transverse and longitudinal waves

Transverse waves	Longitudinal waves
Particles vibrate at right angles to the direction of travel of the wave	Particles vibrate along the direction of travel of the wave
Transverse waves are represented by crests and troughs	longitudinal waves are represented by compression and rare faction regions

Representation of a wave



A displacement time graph can also be drawn



Terms used

(1) Amplitude (a)

This is the maximum displacement of a particle of a wave from its rest position.

(2) Wave length (λ)

This is the distance between two successive particles in phase.

Wave length of **a transverse** wave is the distance between two successive crests or successive troughs.

(3) Oscillation or cycle

This is a complete to and fro movement of a wave

(4) Period (T)

This is the time taken for one complete oscillation

$$\boxed{T = \frac{1}{f}}$$

Period T is measured in seconds

(5) Frequency (f)

The number of complete oscillations in one second

$$\boxed{f = \frac{1}{T}}$$

The S.I unit of frequency is Hertz (Hz)

(6) Speed (V) of the wave

This is the linear distance travelled by a wave per unit time

$$V = \frac{linear\ distance}{time\ taken}$$

Since one complete wave is produced in time **T** and the length of one complete wave is $\boldsymbol{\lambda}$

$$V = \frac{\boldsymbol{\lambda}}{T}$$

$$V = \frac{\mathbf{1}}{T} x\, \boldsymbol{\lambda}$$

But $f = \frac{1}{T}$

$$\boxed{V = f\, \boldsymbol{\lambda}}$$

(7) Crest and Trough

- ❖ Crest is the part of the wave above the line of zero disturbance
- ❖ Trough is the part of the wave below the line of zero disturbance

(8) Compression and Rare faction

- ❖ Compression is a region where the wave particles are crowded together
- ❖ Rare faction is a region where the wave particles further apart

(9) Phase

Particles are in phase when they are exactly at the same point in their paths and are moving in the same direction

(10) Wave front

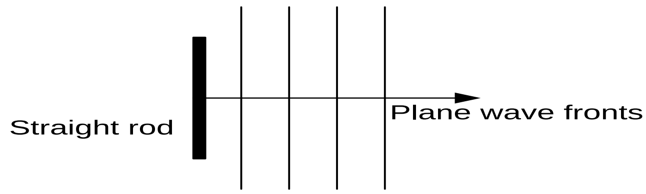
Is any line or section taken through an advancing wave in which all the particles are in the same phase.

Types of wave front

- ❖ Plane wave fronts
- ❖ Circular wave fronts

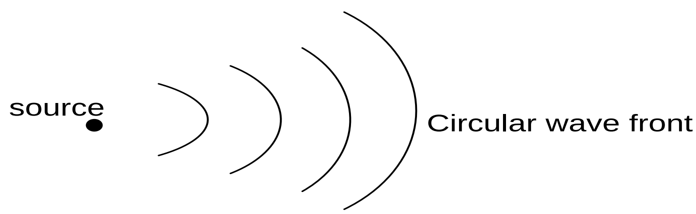
Plane wave fronts

Are produced when a straight rod is hit on the water surface



Circular wave fronts

Are produced when a metal sphere/ a stone is hit on a water surface

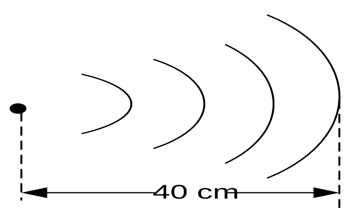


Note:

The distance between two successive wave fronts is the wave length (λ)

Examples

1.



The figure shows a wave of frequency 50Hz,

(i) the wavelength

(ii) the speed of the wave

Solution

$4\lambda = 40$

$\lambda = \frac{40}{4}$

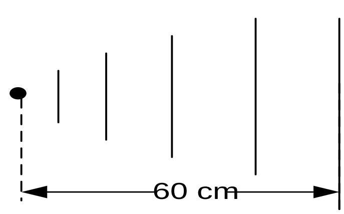
$\lambda = 10\ cm$

$v = f\ \boldsymbol{\lambda}$

$v = 50x\frac{10}{100}$

$v = 5m/s$

2.



The figure shows a wave of frequency 100Hz. Find the speed of the wave

Solution

$5\lambda = 60$

$\lambda = \frac{60}{5}$

$\lambda = 12\ cm$

$v = f\ \lambda$

$v = 100x\frac{12}{100}$

$v = 12m/s$

3. Capital Fm broadcasts at a frequency of 91.3MHz. If the wavelength of the waves produced is 3.2m, find the velocity of the radio waves

Solution

$f = 91.3MHz = 91.3x10^6 Hz,$

$\lambda = 3.2m$

$v = f\,\boldsymbol{\lambda}$

$v = 91.3x10^6 x3.2$

$v = 2.9x10^8 m/s$

4. Sanyu Fm broadcasts at a frequency of 88.2MHz. Calculate the wavelength of the radio waves.

Solution

Note: All electromagnetic waves $\boldsymbol{eg}$ radio waves travel at a speed of light $\boldsymbol{3x10^8 m/s}$

$f = 88.2MHz = 88.2x10^6 Hz,$

$v = 3x10^8 m/s$

$v = f\,\lambda$

$3x10^8 = 88.2x10^6\,\lambda$

$$\boldsymbol{\lambda} = \frac{3x10^8}{88.2x10^6}$$

$\lambda = 3.4m$

5. A vibrator produces waves which travel a distance of 12m in 4s. If the frequency of the vibrator is 2Hz, what is the wavelength of the wave?

Solution

$f = 2Hz, t = 4s, distance = 12m$

$$v = \frac{distance}{time}$$

$$v = \frac{12}{4}$$

$v = 3m/s$

$v = f\,\lambda$

$3 = 2\,\lambda$

$$\boldsymbol{\lambda} = \frac{3}{2}$$

$\lambda = 1.5m$

6. A vibrator has a period of 0.02s and produces circular waves of water in a tank. If the distance between any two consecutive crests is 3cm, what is the speed of the wave?

Solution

$T = 0.02\,s,$

But $f = \frac{1}{T}$

$$f = \frac{1}{0.02}$$

$f = 50Hz$

$\lambda = 3cm,\ \lambda = 0.03m$

$v = f\,\lambda$

$v = 50x\,0.03$

$v = 1.5m/s$

7. Water waves are produced at a frequency of 50Hz and the distance between 10 successive troughs is 18cm. Calculate the velocity of the waves.

Solution

$f = 50Hz$

$9\,\lambda = 18\,cm, \lambda = \frac{18}{9} cm$

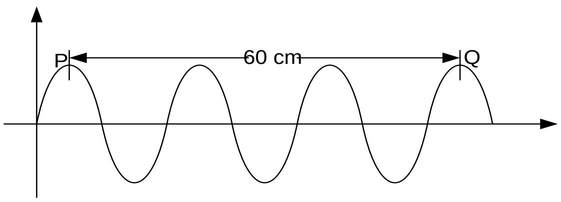
$\lambda = 2cm, \lambda = 0.02\,m$

$v = f\,\lambda$

$v = 50x\,0.02$

$v = 1m/s$

8.



The frequency of the distribution above is 250Hz and the distance PQ is 60cm. Find

(i) Period of the wave

(ii) The wavelength

(iii) Velocity of the wave

Solution

i) $T = \frac{1}{f}$

$T = \frac{1}{250}$

$T = 0.004\ s$

ii) $3\lambda = 60\ cm,$

$\lambda = \frac{60}{3} cm$

$\lambda = 20cm,$

$\lambda = 0.2\ m$

iii) $v = f\lambda$

$v = 250x0.2$

$v = 50ms^{-1}$

RIPPLE TANK

A ripple tank is used to study the properties of water waves. It consists of a shallow glass trough which is transparent.

In order to observe the wave patterns formed on water surface, the tank is placed between the light source and screen.

The image of the waves are projected onto the screen which is placed below it. The waves are produced by means of the dipper when it hits the water surface.

- Circular wave fronts are produced when the dipper is a sphere.
- Plane wave fronts are produced when the dipper is a straight rod.
- A stroboscope is used to make the wave appear stationery (and thus a clear view) hence the wave can be studied in details. It's rotated and its speed of rotation is adjusted until the wave is clearly viewed

Properties of waves

All waves can be;

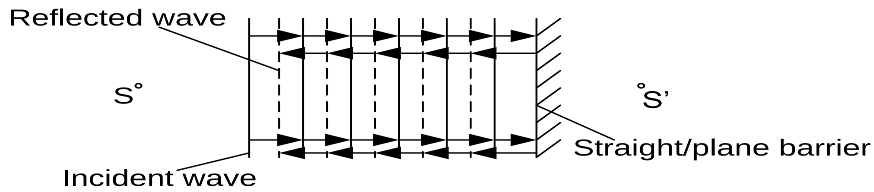
1. Reflected
2. Refracted
3. Diffracted
4. Interfered

1. REFLECTION OF WAVES

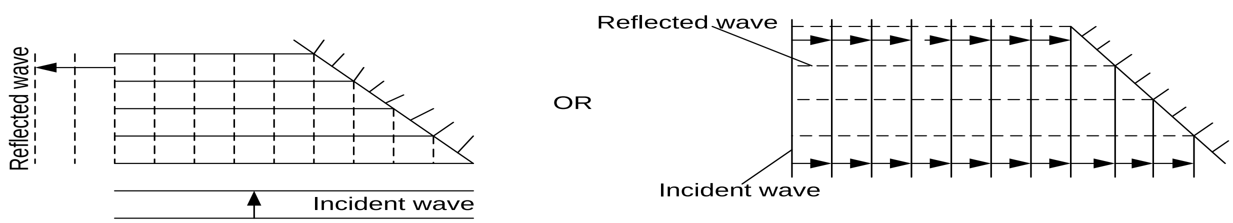
This is the bouncing back of waves when they meet a barrier

a) Plane reflector

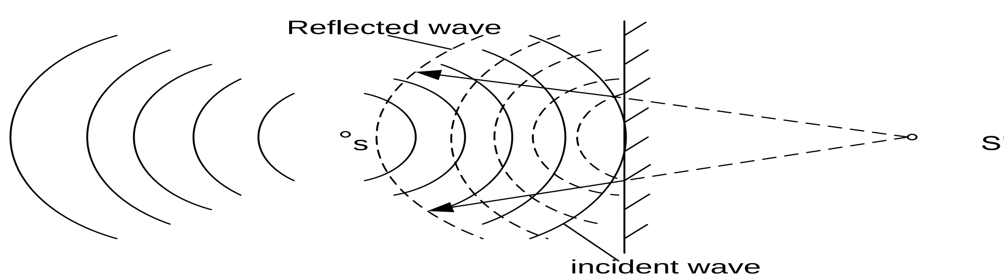
(i) Straight waves incident on a plane reflector



(ii) Straight waves incident on an inclined Plane surface

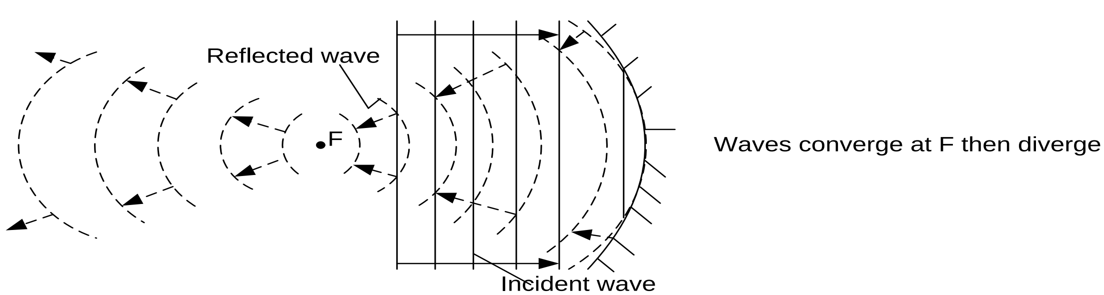


(iii) Circular waves incident on a plane reflector

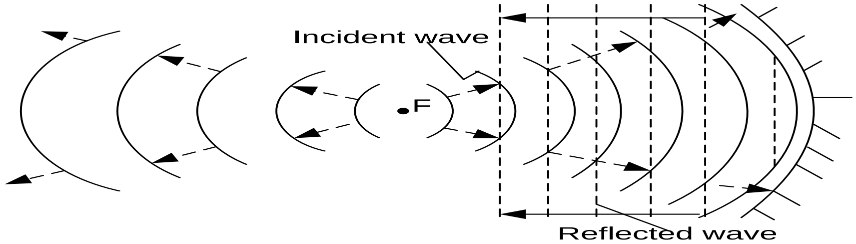


b) Concave reflector

(i) Straight waves incident on a concave reflector

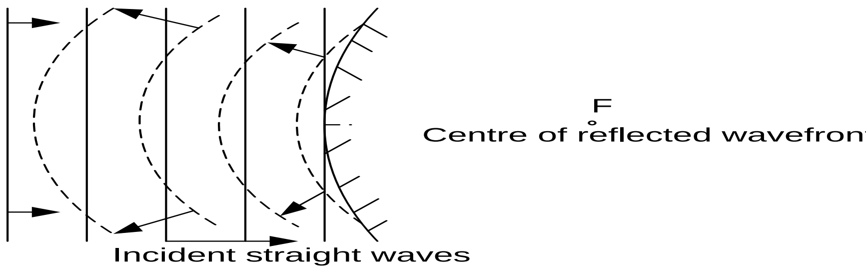


(ii) Circular waves on a concave reflector

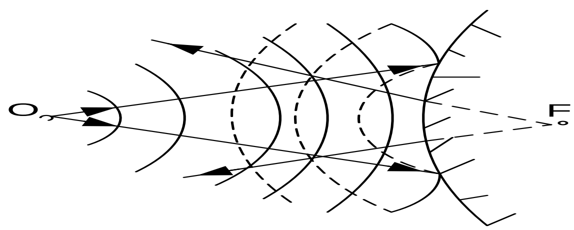


c) Convex reflector

(i) Plane waves incident on a convex reflector



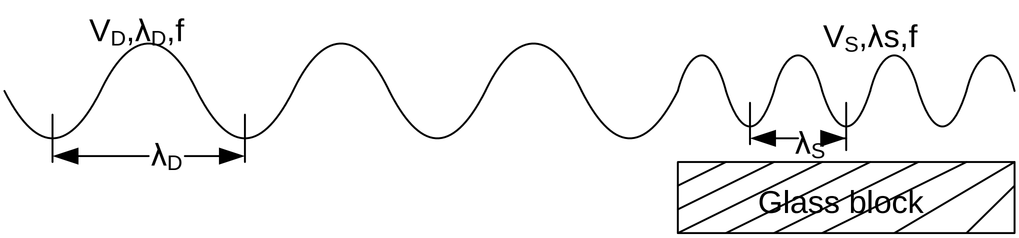
(ii) Circular waves incident on a convex reflector



2. REFRACTION OF WAVES

Water waves can be refracted by placing a sheet of glass in water to make it shallow.

The wave fronts are closer to one another in shallow water than in deep water. This implies that the wavelength is less in shallow water than deep water.



Refraction is as a result of a wave slowing down as it enters a denser medium (shallower water) and the wave fronts are closer together in shallow water than in deep water.

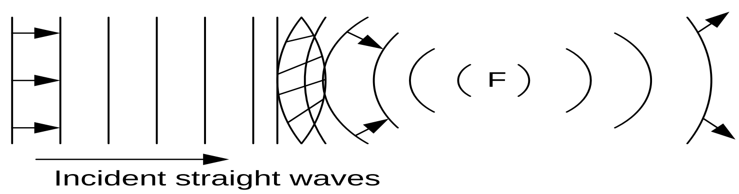
Note;

When water waves move from deep to shallow water it's amplitude and wavelength change but the **frequency** does not change.ie

- Amplitude reduce
- Wavelength reduce
- Velocity reduce
- Frequency remain constant

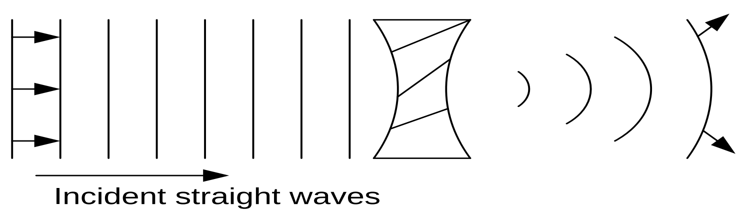
Refraction by lenses

a) Convex refraction



Straight waves converge to F then diverge.

b) Concave refraction

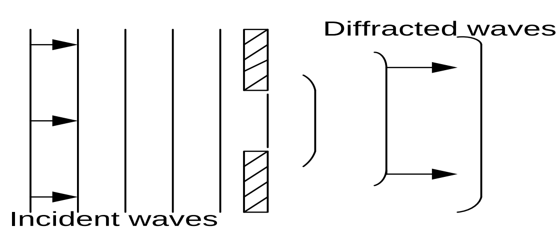


Waves diverge from F

3. DIFFRACTION OF WAVES

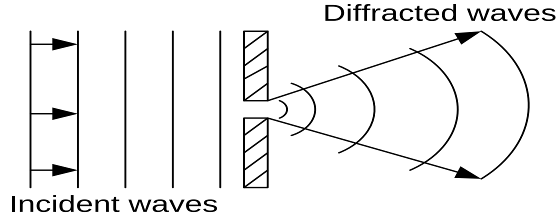
It is the spreading of waves around an obstacle when they pass through an aperture or gap.

(i) Wide gap



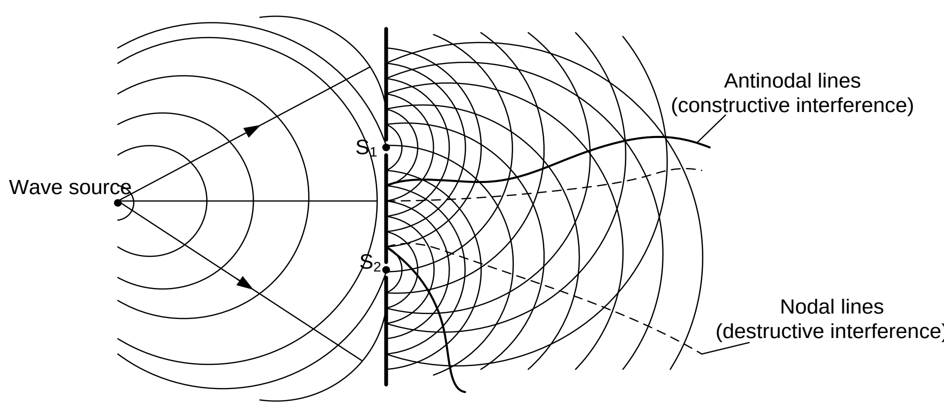
Nearly straight line waves are diffracted

(ii) Narrow gap



4. INTERFERENCE OF WAVES

Interference is the superposition of two identical waves travelling in the same direction having the same amplitude and frequency.



(i) Constructive interference

These are antinodal lines where crest meets a crest or trough meets a trough giving maximum interference.

(ii) Destructive interference

These are nodal lines where crest meets a trough giving minimum interference.

ELECTROMAGNETIC WAVES

This is a family of waves which are made of electric and magnetic vibrations of very high frequency.

Properties of electromagnetic waves

(i) Electromagnetic waves travel in a vacuum and therefore do not require a material medium for their transmission.

(ii) Electromagnetic waves travel at a speed of light $ie\ 3x10^3 ms^{-1}$

(iii) They are made of varying electric and magnetic vibration.

(iv) They vibrate with a high frequency.

(v) They have no charge.

Increasing wavelength (decreasing frequency) →

Ɣ-rays	X - rays	Ultra violet (U.V)	Visible spectrum	Infra -red	Radio waves Microwaves, T.V waves

V I B G Y O R

Wave band	Origin	Sources
Gamma radiations	Energy changes in nuclei of atoms	Radiactive substance
X- radiations	(1) High energy changes in electron structure of atoms (2) Decelerated electrons	X-ray tubes
Ultraviolet radiation	Fairly high energy changes in electron	(1) Very hot bodies eg electric arc (2) Electric discharge through gases
Visible radiation	Energy changes in electron structure of atoms	Various lamps, flames and any thing at or above the temperature at which it begins to emit red
Infra red radiation	Low energy changes in electron structure of atomws	All matter over a wide range of temperature from absolute zero upwards
Radio waves	(1) High frequency oscillatory electric currents (2) Very low energy changes in electron structure of atoms	Radio transmitting circuits and associated aeral equipments

Note

(i) Infrared radiations cause a sensation of heats (causes temperature to rise).

They are used in remotes of TV's

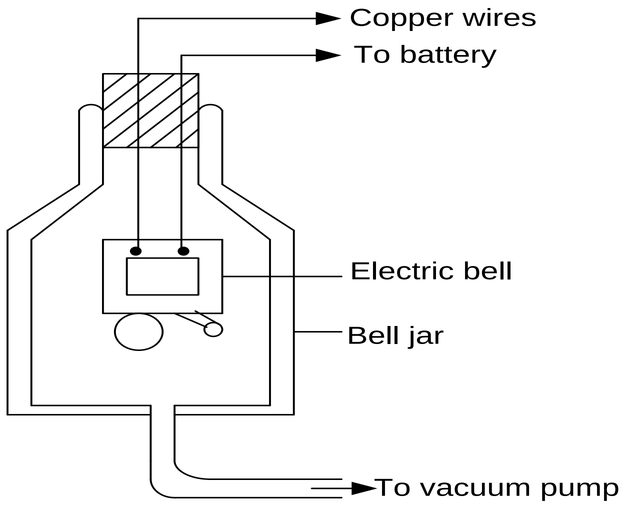
(ii) Radio waves can easily be detected by antenas

SOUND WAVES

Sound waves are produced when particles in the medium are set into vibrations.

A sound wave is an example of longitudinal waves therefore sound waves require material medium for their transmission.

Experiment: To show that sound waves require a material medium for their transmission



- ❖ When an electric bell is switched on, a loud sound is heard.
- ❖ But when the air inside the jar is gradually removed by means of a vacuum pump, the loudness of the sound heard gradually dies a way.
- ❖ When all the air has been completely removed from the jar no sound is heard even when the bell is still switched on.
- ❖ This shows that sound waves need a material medium such as air for their transmission.

Factor that affect the speed of sound

(a) Temperature

An increase temperature increases the speed of sound in air.

(b) Density of the medium

In a dense medium, the speed of sound is higher than in a less dense medium.

This explains why solids are better transmits of sound then air.

(c) Wind

The speed of wind within the material determines the speed of sound air because wind moves air which is the medium of transmission of sound.

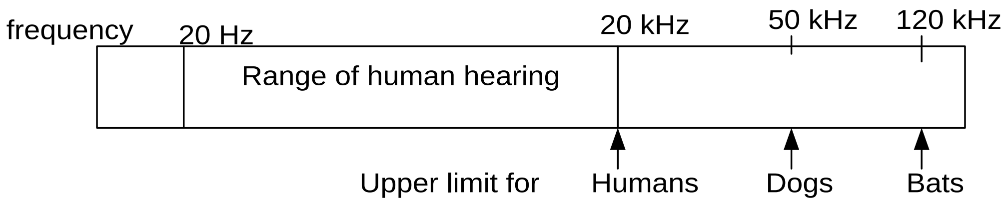
Note:

Pressure, pitch and loudness have **no** effect on the speed of sound in air.

Ultra sonic sounds

Ultra sounds are sounds above the range of human hearing.

The range of frequency which can be heard by a human ear lies between 20 and 20,000 Hz. Sounds of frequencies over 20,000Hz are **inaudible** to the human ear. Dogs can hear sounds which human beings cannot hear.



Uses of ultra sounds

i) Used for **cleaning** delicate machinery without dismantling

ii) Concentrated beams of ultra sounds are to **break** up kidney stones and gall stones without the patient needing surgery

iii) Echo sounders are used to measure the **depth** of the sea.

iv) The principle of echo sounding is used for **metal testing** to detect flaws.

v) Used for **scanning** the womb.

ECHOES

An echo is a reflected sound.

The time that elapses between hearing the original sound and hearing the echo depends on;

a) The distance away from the reflecting surface.

b) The speed of sound in the medium.

REVERBERATION

It is defined as the tendency of the original sound being prolonged due to multiple reflections.

- If the time taken to hear the echo is less than0.1 s, the human ear cannot distinguish between the original sound and the echo. If the time is just 0.1 s, the original sound appears to be prolonged. This effect is called reverberation.
- Too much reverberation makes the sound confused and indistinct. However, reasonable reverberation produce strong sound and this is applied in halls during speeches.

- Sound waves are absorbed by soft materials, such as human skin, clothes. Thus the reverberation time of a hall is less when filled with people than when empty. It's for this reason that echoes are not produced when the hall is filled with people.

Characteristic of sound

a) Pitch

This is the highness or lowness of sound.

Pitch depends on the frequency of the sound waves ie it increases as the frequency of sound increases.

b) Sound intensity

This is the flow of sound energy per unit area perpendicular to the direction of the sound.

Factors that affect sound intensity

- Density of the medium through which the wave travels.
- Square of the amplitude.
- Square of the frequency.

c) Loudness

This is sensation of a sound note in the ear of an individual.

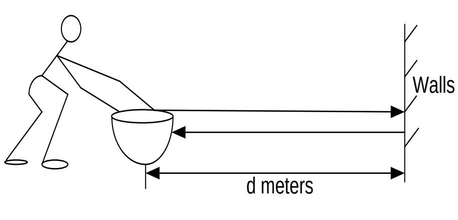
Loudness depends on;

- Sound intensity
- Sensitivity of the ear
- Pressure exerted on the ear drum by the waves

Examples

1. A man standing some distance from the vertical wall beats the drum and hears an echo after 2 s. Calculate the distance between the man and the wall assuming that the speed of sound in air is 330m/s.

Solution



$t = 2s,\ distance = 2\ d,$

$speed = 330m/s$

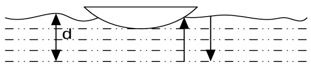
$$speed = \frac{distance}{time}$$

$$330 = \frac{2\ d}{2}$$

$d = 330\ m$

2. An echo sounder on a boat sends down a pulse through the water and receives its echo 0.9 s later. If the velocity of sound in the water is 1450 m/s, calculate the water depth.

Solution



$t = 0.9s, \; distance = 2\,d$

$speed = 1450m/s$

$$speed = \frac{distance}{time}$$

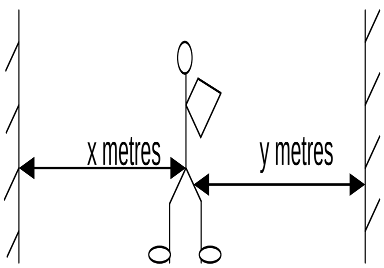
$$1450 = \frac{2\,d}{0.9}$$

$$d = \frac{1450x0.9}{2}$$

$$d = 625.5m$$

3. A man stands between two cliffs and makes a very loud sound, he hears the first echo after 1 s and the second $\frac{1}{2}$ s. Find the distance between the cliffs if the speed of sound in air is 330 ms^{-1}.

Solution



For first cliff

$t = 1s, \; distance = 2\,x$

$speed = 330m/s$

$$speed = \frac{distance}{time}$$

$$330 = \frac{2\,x}{1}$$

$$x = \frac{330x1}{2}$$

$$x = 165m$$

For second cliff

$t = 1\frac{1}{2}s, \; distance = 2\,y$

$speed = 330m/s$

$$speed = \frac{distance}{time}$$

$$330 = \frac{2\,y}{\left(\frac{3}{2}\right)}$$

$$y = \frac{330}{2} x \frac{3}{2}$$

$$y = 247.5m$$

Distance between the cliffs

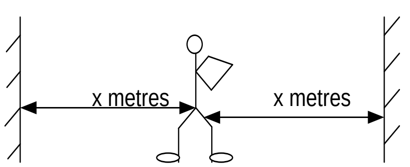
$= \; x + y$

$= \; 165 + 247.5$

$= 412.5m$

4. A man standing mid way between two cliffs claps and hears an echo after 3 s. calculate the distance between the two cliffs.

Solution



$t = 3s, \; distance = 2\,x$

$speed = 330m/s$

$$speed = \frac{distance}{time}$$

$$330 = \frac{2\,x}{3}$$

$$x = \frac{330x3}{2}$$

$$x = 495m$$

Distance between the cliffs

$= \; x + x$

$= \; 495 + 495$

$= 990m$

5. A tall wall is about 17m away, if sound travels to and fro in 0.1s. Find its velocity.

Solution

$$speed = \frac{distance}{time}$$

$$speed = \frac{2\,x}{t}$$

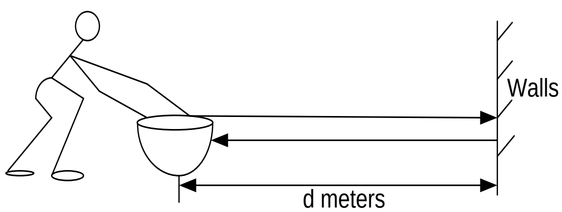
$$speed = \frac{2\,x\,17}{0.1}$$

$$speed = 340\ m/s$$

Exercise 1

1. A person standing $\mathbf{99}\boldsymbol{m}$ from a tall cliff claps his hands and hears an echo $\mathbf{0.6}\boldsymbol{s}$ later. Calculate the velocity of sound in air. **An[330m/s]**
2. A gun was fired and an echo from the cliff was heard $\mathbf{8}\boldsymbol{s}$ later. If the velocity of sound is $\mathbf{330}\boldsymbol{m/s}$, how far was the gun from the cliff? **An [1320m]**
3. A girl standing between two cliffs hears the first echo after $\mathbf{2}\boldsymbol{s}$ and hears another after a further $\mathbf{3}\boldsymbol{s}$. If the velocity of sound is $\mathbf{330}\boldsymbol{m/s}$, calculate the distance between the two cliffs. **An[1155m]**
4. A child stands between 2 cliffs and makes a loud sound, if the child hears the first echo after $\mathbf{1.5}\boldsymbol{s}$ and the second after $\mathbf{2}\boldsymbol{s}$. Find the distance between the two cliffs if the speed of sound in air is $\mathbf{330}\boldsymbol{m/s}$. **An[560m]**
5. A boy standing between two cliffs $\boldsymbol{A}$ and $\boldsymbol{B}$ claps his hands and hears the first echo from $\boldsymbol{A}$ after $\mathbf{4}\boldsymbol{s}$ and the second echo from $\boldsymbol{B}$ after $\mathbf{5}\boldsymbol{s}$. If the velocity of sound in air is $\mathbf{330}\boldsymbol{m/s}$, find the distance between $\boldsymbol{A}$ and $\boldsymbol{B}$.

EXPERIMENT: TO DETERMINE THE SPEED OF SOUND IN AIR USING ECHO METHOD



- Stand a measured distance, $\boldsymbol{d}$ from a reflector such as a wall.
- Make a sound by hitting a drum and instantly start a stop clock and stop it when the echo is heard
- Note the time, $\boldsymbol{t}$ indicated by the clock
- Speed sound in air is obtained from

$$speed = \frac{distance}{time}, speed = \left(\frac{2\ d}{t}\right)\ m\ s^{-1}$$

Example

A student made 50 claps in 2 minutes and hears echoes, if the velocity of sound in air is 330m/s. Find the distance between the student and the wall.

Solution

$$50\ claps = 2\ minute$$

$$1\ clap = \frac{2}{50}$$

$$1\ clap = 0.04\ minutes$$
$$= 0.04x\ 60s$$

t= 2.4 s

$$v = \frac{2\ d}{t}$$

$$330 = \frac{2\ d}{2.4}$$

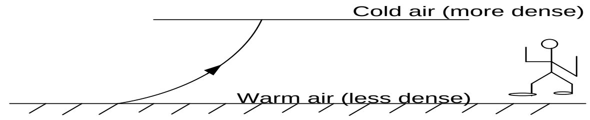
$$d = \frac{330x2.4}{2}$$

$$d = 396\ m$$

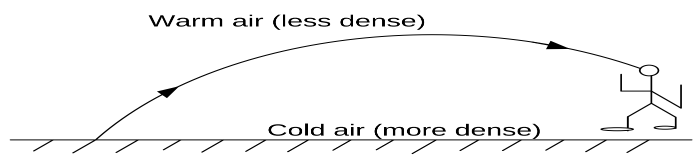
Refraction of sound

This is the change in the speed of sound waves as they move from one medium to another of different optical densities.

- During the day, air near the land is warm therefore less dense than that above it. Hence , sound produced during the day travels from a less dense medium to a more dense medium and is therefore refracted upwards and this explains why sound is not heard clearly during day time.



- At night, air near the land is colder than that above the land and therefore the cold air is denser. Hence sound traveling from a denser medium to a less dense medium undergoes total internal reflection at a certain angle and this makes a person at a distance to hear the sound, this explains why sound is heard clearly at night.



Differences between sound and light waves

Sound waves	Light waves
- They cant travel through a vacuum	- They can travel through a vacuum
- They travel at a low speed i.e 330m/s	- They travel at a high speed i.e $3x10^8$m/s
- Require a material medium for their transmission	-Do not require a material medium for their transmission
- They cant eject electrons from a metal surface	- They can eject electrons from a metal surface by photo electric emission
- They are longitudinal waves	- They are transverse waves

PROGRESSIVE AND STATIONARY WAVES

Progressive waves

This is a wave that moves from its source through a medium and spreads out continuously. Transverse and longitudinal waves are examples of progressive waves.

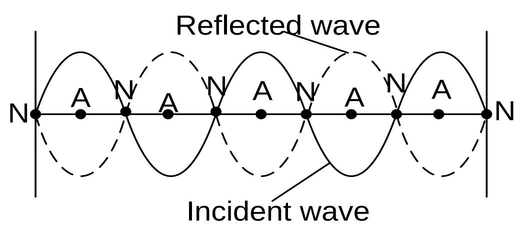
Stationary/ standing wave

Is one whose wave profile does not move along the medium and its formed as a result of superposing (overlapping) two waves of equal frequency and amplitude travelling in opposite direction.

Condition for stationary waves to be formed

- Waves must be moving in opposite direction.
- Waves must have the same speed, same frequency and equal amplitude.

When a wave travels along a given path and it strikes an obstacle such that it is reflected back perpendicularly, it will return along the same path. The incident and reflected waves combine to form a stationary wave.



A is antinodes;

These are points on a stationary wave where particles have maximum displacement.

N is nodes;

This is a point on a stationary wave in which particles are always at rest (zero displacement)

Note:

- The distance between two successive nodes or antinodes is $\frac{\lambda}{2}$ where λ is wavelength.
- When a stationary wave is produced, the distance between the source and reflector is a multiple of $\frac{1}{2}\lambda$.

$$\boxed{distance = n\frac{\lambda}{2}}$$

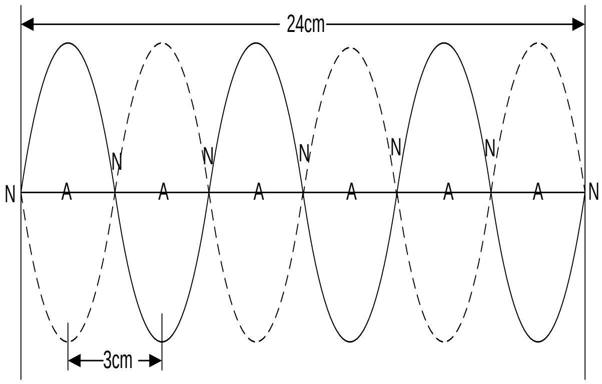
Where n is the number of loops ie n is 1,2,3 … … … …

Example

The distance between two successive antinodes on a standing wave is 3.0cm. if the distance between the source of the wave and the reflector is 24.0cm, find the;

(i) Number of loops (ii) Wavelength of the wave

Solution



i) $24 = n\frac{\lambda}{2}$

$24 = nx3$

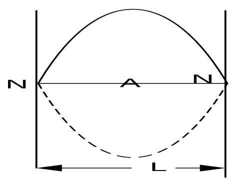
$n = 8\ loops$

ii) $\frac{\lambda}{2} = 3$

$\lambda = 6cm$

$\lambda = 0.06\ m$

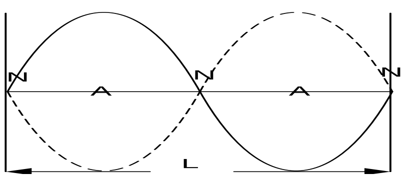
When a string is plucked in the middle, the wave below is produced



$l = \frac{\lambda}{2}$

$\lambda = 2l$

If the string is plucked $\frac{1}{4}$ way, the wave below is produced



$l = \lambda$

Factors on which frequency of a stretched string depends

1) Length

The frequency is inversely proportional to length ($f \propto \frac{1}{l}$)

2) Tension

Frequency varies with square root of the tension $f \propto \sqrt{T}$

RESONANCE

This occurs when an object is forced to vibrate at its own natural frequency by an external body vibrating at the same frequency.

Other terms

Fundamental note

This is the first loudest note produced by the lowest possible frequency.

Fundamental frequency

This is the lowest possible frequency that produced the first loudest note.

Overtones

These are note whose frequencies are multiple of the fundamental frequency

Resonance of air in pipes

These are two type of pipe for air vibrations.

(i) Open pipes

This is one that has both ends open *eg* trumpet, a flute

(ii) Closed pipes

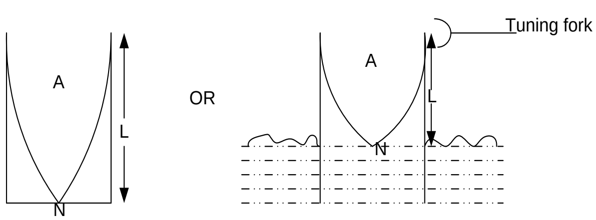
It is one in which one end is open, while the other is closed *eg* a long drum.

a) Resonance in closed pipes

When a vibrating tuning fork is held over a mouth of a tube, air inside the tube is set into vibration, the wave sent downwards is reflected from the water surface and a stationary wave is setup.

The column is increased gradually until a loud sound is heard. This is the first resonance or first harmonic.

First harmonic / fundamental note / first resonance



The length of the air column is L

$$L = \frac{1}{4}\lambda$$

$$\lambda = 4\,L$$

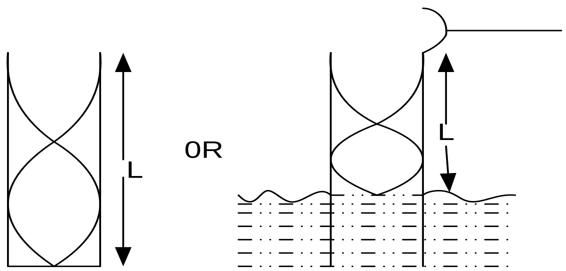
$$v = f_0\lambda$$

$$f_0 = \frac{v}{\lambda}$$

$$f_0 = \frac{v}{4\,\lambda}$$

f_0 is the fundamental frequency

Second harmonic / Second resonance / First overtones



The length of the air column is L

$$L = \frac{3}{4}\lambda$$

$$\lambda = \frac{4}{3}L$$

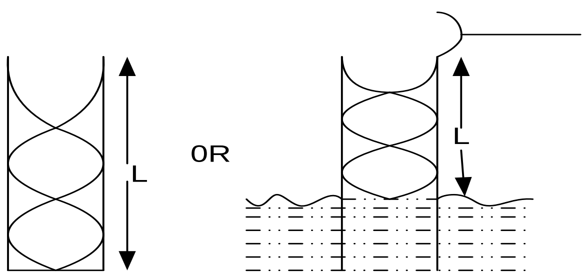
$$v = f_1\lambda$$

$$v = f_1\frac{4}{3}L$$

$$f_1 = \frac{3\,v}{4\,L}$$

$$f_1 = 3\,f_0$$

Third harmonic / Third resonance /Second overtones



The length of the air column is L

$$L = \frac{5}{4}\lambda$$

$$\lambda = \frac{4}{5}\,L$$

$$v = f_2\lambda$$

$$v = f_2 x\frac{4\,l}{5}$$

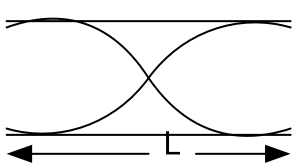
$$f_2 = \frac{5\,v}{4\,l}$$

$$f_2 = 5\,f_0$$

Note: In closed pipes only odd harmonics are produced

b) Resonance in open pipes

First harmonic / first resonance /fundamental note



$$l = \frac{1}{2}\lambda$$

$$\lambda = 2\,l$$

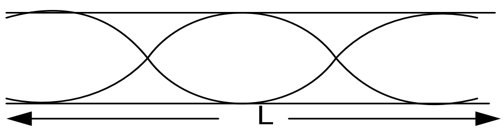
$$v = f_0\lambda$$

$$f_0 = \frac{v}{\lambda}$$

$$f_0 = \frac{v}{2\,l}$$

f_0 is the fundamental frequency

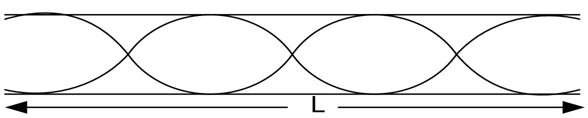
Second harmonic / Second resonance / first overtone



$$l = \lambda$$
$$v = f_1 \lambda$$

$$f_1 = \frac{v}{\lambda}$$
$$f_1 = \frac{2\,v}{2\,l}$$
$$f_1 = 2\,f_0$$

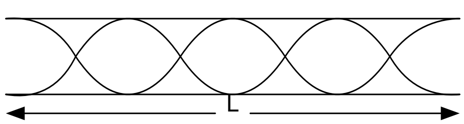
Third harmonic / Third resonance / Second overtone



$$l = \frac{3}{2}\lambda$$
$$\lambda = \frac{2}{3}\,l$$

$$v = f_2\,\lambda$$
$$v = f_2\,x\,\frac{2\,l}{3}$$
$$f_2 = \frac{3\,v}{2\,l}$$
$$f_2 = 3\,f_0$$

Fourth harmonic / Fourth resonance / Third overtone



$$l = 2\,\lambda$$
$$\lambda = \frac{l}{2}$$

$$v = f_3\,\lambda$$
$$v = f_3\,x\,\frac{l}{2}$$
$$f_3 = \frac{4\,v}{2\,l}$$
$$f_3 = 4\,f_0$$

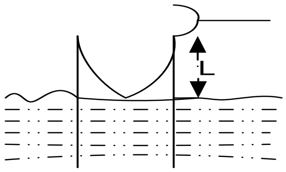
Note:

Open pipes produce both odd and even harmonics and this is why open pipes are preferred as musical instruments.

Examples

1. A long tube is partially immersed in water and a tuning fork of 425Hz is sounded and held above it. If the tube is gradually raised, find the length of the air column when resonance first occurs. [speed of sound in air is 340m/s]

Solution



$f = 425Hz, v = 340ms^{-1}$

$v = f\lambda$

$340 = 425x\boldsymbol{\lambda}$

$\lambda = 0.8\ m$

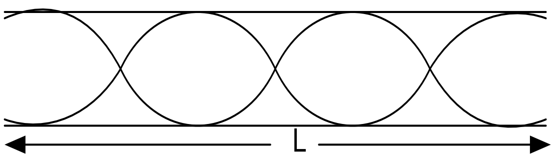
$L = \frac{1}{4}\boldsymbol{\lambda}$

$L = \frac{1}{4}x0.8$

$L = 0.2\ m$

2. The frequency of third harmonic in an open pipe is 660Hz, if the speed of sound in air is 330m/s. Find;
   (i) the length of the air column
   (ii) the fundamental frequency

Solution



i) $f = 660Hz, v = 330ms^{-1}$

$v = f\lambda$

$330 = 660x\boldsymbol{\lambda}$

$\lambda = 0.5\ m$

$L = \frac{3}{2}\boldsymbol{\lambda}$

$L = \frac{3}{2}x0.5$

$L = 0.75\ m$

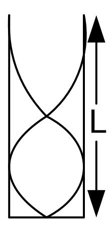
$ii)\quad f_2 = 3\ f_0$

$f_0 = \frac{660}{3}$

$f_0 = 220Hz$

3. A second harmonic of a closed pipe occurs when the length of the air column is 30cm, if the speed of sound in air is 330m/s. Find the;
   (i) frequency of the sound waves **(ii)** fundamental frequency

Solution



i) $L = \frac{3}{4}\boldsymbol{\lambda}$

$30 = \frac{3}{4}x\lambda$

$\lambda = 40\ cm$

$\lambda = 0.4\ m$

$v = f\lambda$

$f = \frac{330}{0.4}$

$f = 825\ Hz$

ii) $f_1 = 3\ f_0$

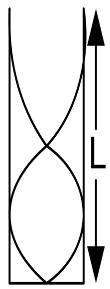
$f_0 = \frac{825}{3}$

$f_0 = 275\ Hz$

4. If the velocity of sound in air is 330m/s and the fundamental frequency is 110Hz in a closed tube. For the first overtone
   (i) What is the approximate length of the tube
   (ii) What would be the fundamental frequency if the tube was open at both ends

Solution

i) $f_0 = 110Hz,\ v = 330m/s$



$f_1 = 3\,f_0$

$f_1 = 3\,x110$

$f_1 = 330Hz$

$v = \ \ f_1\lambda$

$\lambda = \frac{330}{330}$

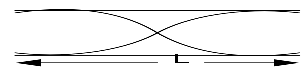
$\lambda = 1\ m$

$L = \frac{3}{4}\boldsymbol{\lambda}$

$L = \frac{3}{4}x1$

$L = 0.75\ m$

ii)



$L = 0.75\ m$

$L = \frac{1}{2}\boldsymbol{\lambda}$

$\boldsymbol{\lambda} = 2L$

$\boldsymbol{\lambda} = 2x0.75$

$\boldsymbol{\lambda} = \ 1.5m$

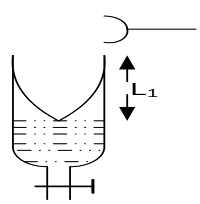
$v = \ \ f_o\lambda$

$f_0 = \frac{330}{1.5}$

$f_0 = 220Hz$

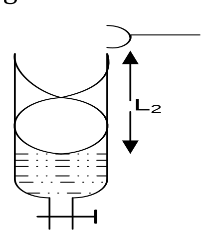
Experiment: To measure velocity of sound in air by Resonance tube

- A tuning fork of known frequency $\boldsymbol{f}$ is held over a mouth of tube containing water with a tap at the opposite end.
- The tuning fork is sounded and the level of water gradually lowered using a tap until when the loudest sound is heard. This is the point for the first resonance and the length of the air column $\boldsymbol{l_1}$ is measured.



$l_1 = \frac{1}{4}\lambda$**...............................(1)**

- The level of water is further run down until the second loudest sound is heard. This is the point of second resonance and the length of the air column $\boldsymbol{l_2}$ is measured.



$l_2 = \frac{3}{4}\lambda$**...............................(2)**

Equation (2) — Equation (1)

$$l_2 - l_1 = \frac{3}{4}\lambda - \frac{1}{4}\lambda$$

$$l_2 - l_1 = \frac{1}{2}\lambda$$

$$\lambda = 2\,(l_2 - l_1)$$

But $v = f\,\lambda$

$$\boxed{v = 2\,f\,(l_2 - l_1)}$$

Example

A tuning fork of frequency 256Hz produces resonance in a tube of length 32.5cm and also in one of length 95cm. Calculates the speed of sound in air column of the tube.

Solution

$v = 2\,f\,(l_2 - l_1)$

$v = 2\;x\;256x\left(\frac{95 - 32.5}{100}\right)$

$v = 320ms^{-1}$

SECTION A:

1. Which one of the following electromagnetic waves causes genetic disorders when absorbed in excess?
   A. Radio waves
   B. Infrared waves
   C. Ultra-violet waves
   D. X-rays
2. Superposition of two waves will produce a stationary wave if the waves have the same
   (i) velocity
   (ii) amplitude and frequency
   (iii) velocity in opposite directions
   A. (i) and (ii) only
   B. (i), and (iii) only
   C. (ii) and (iii) only
   D. (iii) only
3. A person blows air across the mouth of an open pipe of length 0.3m. Find the fundamental frequency (speed of sound=340m/s)
   A. $\frac{340}{0.3}$ B. $\frac{340}{4x0.3}$ C. $\frac{4x0.3}{340}$ D. $\frac{340}{2x0.3}$
4. Which one of the following radiations is emitted from white hot bodies?
   A x-rays B Ultraviolet C Infrared D gamma
5. Which of the following is a property of sound waves?
   (i) They require a material medium for transmission
   (ii) Their velocity increases with temperature

(iii) Their velocity increase with pressure

A. (i) only
B. (ii), and (iii) only
C. (i) and (iii) only
D. (i) and (ii) only

6. Which of the following is true about longitudinal waves?

(i) The distance between two consecutive rare-factions is the wavelength

(ii) The particles move away from the centre of a rare-fraction to a compression

(iii) The crests and troughs are the points of maximum displacement from the initial position

A. (i) only
B. (ii) only
C. (i) and (ii) only
D. (ii) and (iii) only

7. Which one of the following observations is correct about an electric bell enclosed in a gas jar connected to a vacuum pump?

A. Before air is removed, a loud sound is heard when the hammer hits the gong
B. Loudness of sound heard increases as the air is gradually removed from the jar
C. No sound is heard before air is removed from the jar
D. The electric bell stops working when air is completely removed from the jar

8. Sound waves travel a distance of 48 cm in 8 s. If the separation between successive compressions is 3.0cm, find the frequency of the wave

A. 0.5 Hz B. 2.0 Hz C. 18.0 Hz D. 128.0 Hz

9. A vibrator of frequency 20 Hz produces waves of velocity $2m\ s^{-1}$. Find the period of the waves

A. $1.0x10^{-1}$ s B. $5.0x10^{-2}$ s C. $5.0x10^{-1}$ s D. $1.0x10^{1}$ s

10. Which of the following is true about a standing wave?

(i) The wave profile does not move

(ii) It is formed when the waves of equal amplitude and speed moving in opposite directions overlap

(iii) It is formed when identical waves travelling in the same direction with equal speed overlap

A. (i) and (iii) only
B. (i) and (ii) only
C. (ii) and (iii) only
D. (i) only

11. The wavelength of a progressive transverse wave is defined as the

A. height of a crest
B. distance between a trough and a crest
C. distance between successive crests
D. distance between any two troughs

12. A stationary wave is formed when two waves of

A. equal amplitude and frequency travel along the same path in the same direction

B. equal amplitude and frequency travel perpendicularly to one another

C. equal amplitude and frequency travel along same path but in opposite directions

D. different frequencies travel along the same path but in opposite direction

13. The frequency of a vibrating string depends on

A. pitch B. length C. medium D. amplitude

14. Which one of the following electromagnetic waves lies between ultraviolet radiation and infrared radiations?

A gamma rays B visible radiation C x-rays D microwave radiation

15. A Sound wave produced by vibrating tuning folk is longitudinal because the air vibrates in.

A Same direction as that in which the prongs vibrate

B A direction opposite to that in which the wave is traveling.

C The same direction as that in which the wave is traveling.

D The opposite direction to that in which the prongs vibrate.

16. Water waves of frequency 6Hz travel 24m in 10 seconds. The wavelength of the waves is.

A. 0.4m B. 2.5m C. 14.4m D. 40.0m

17. The basic difference between transverse and longitudinal waves is in.

A. amplitude.

B. Wave length.

C. direction of vibration

D. Medium through waves travel.

18. In ripple tank, constructive interference occurs when.

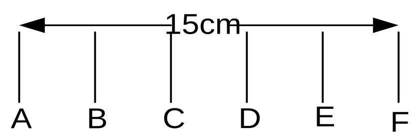
A. The wave is stationary.

B. A crest over laps with trough.

C. Crest overlaps with crest

D. The wave strikes a barrier.

19. The figure below represents straight waves A, B, C, D, E and F.



The diagram represents straight waves A, B, C, D, E and F. If after 5s, A occupies the position now occupied by F, Find the frequency of the wave.

A. 1Hz. B. 3Hz C. 9Hz. D. 15Hz.

20. Which one of the following bands has a wavelength greater than that of visible spectrum?

A. Gamma. B. X-rays. C. Ultra-violet. D. Infrared.

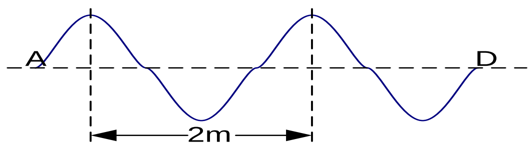
21. How long does it take an alternating $P.d$ of peak value 10V and frequency 50Hz to make one cycle?

A. 0.02s. B. 0.20s. C. 5.00s. D. 500.00s

22. A vibrator produces a sound wave that travels 900m in 3 s. If the wavelength of the wave is 10m, find the frequency of the vibrator.

A. 30Hz. B. 270Hz. C. 300Hz. D. 3000Hz.

23.



The figure above shows a ware produced in a string. If frequency is 2Hz, at what speed do the waves travel along the string?

A. 0.5m/s B. 1.0m/s C. 2.0m/s D. 4.0m/s

24. The electromagnetic radiation which causes the body temperature to rise is called?

A. X-rays B. gamma rays C. infra red D. ultra violet

25. A longitudinal wave is one in which the.

A. direction of propagation is parallel to that of the vibration producing it.

B. particle of medium through which it travels move opposite to the direction of propagation.

C. direction of propagation is perpendicular to the of the vibration producing it.

D. particles of the medium through which it travels move together with it.

26. Which of the following can be detected by an ordinary antenna?

A microwaves B infrared rays C ultra violet D gamma rays

27. A man standing in front of a tall wall makes a loud sound and hears the echo after 1.5 seconds. How far is he from the wall if the velocity of the sound in air is 330m/s

A. 110m B. 247.5m C. 330m D. 990m.

28. The number of vibrations a wave makes in one second is the.

A frequency B wavelength C period D amplitude

29. Which of the following are longitudinal waves?

A water waves B light waves C sound waves D Radio waves

30. Sound is produced by a source vibrating at a frequency of 50Hz. Given that its speed is 330m/s in air, its wavelength is.

A. 0.15m B. 6.6m C. 380m D. 16500m.

31. In forced vibrations, resonance occurs when the forcing

A. frequency is equal to the natural wavelength.

B. velocity is equal to the natural velocity.

C. frequency is equal to the natural frequency.

D. frequency exceeds the natural frequency.

32. The number of complete oscillations made per second is referred to as

A. periodic time B. Amplitude C. wavelength D. frequency

33. Points on a stationary wave which are permanently at rest are called.

A. crest B. troughs C. nodes D. anti-nodes

34. Which one the following radiations under goes the largest diffraction when passed through a narrow aperture?

A. radio waves B. Gamma rays C. yellow light D. infra-red rays

35. A source produces waves which travel a distance of 140cm in 0.08s. If the distance between successive crests is 20cm, find the frequency of the source.

A. 0.875Hz B. 8.750Hz C. 87.00Hz D. 87.50Hz

36. Which one of the following shows the order in increasing wavelength, of the members of the electromagnetic spectrum

A. ultra-violet, radio waves, infra-red

B. Radio waves, infra-red, x-rays, ultra-violet

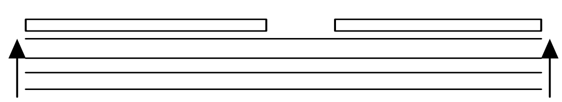
C. X-rays, ultra-violet, infra-red, radio waves

D. Gamma rays, ultra-violet, radio waves, infra-red

37. A man sees the flash from a gun fired 1020m away and then later hears a bang. How long does the bang take to reach him? (Speed of sound is 340m/s)

A. $\frac{1020}{340x\ 10}\ s$ B. $\frac{340}{1020}\ s$ C. $\frac{1020}{340}\ s$ D. $(340x1020)\ s$

38.



The diagram above shows parallel wave fronts approaching a narrow gap. Waves passing through the gap are likely to undergo.

A reflection B refraction C diffraction D interference.

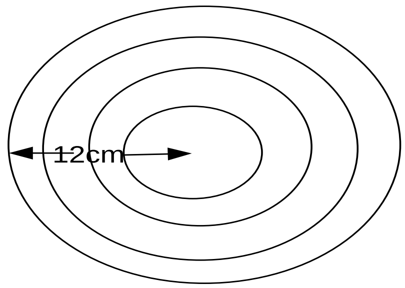
39. Which of the following radiations is emitted from the nucleus of an atom

A. Cathode rays B. Gamma rays C. Infra-red rays D. Ultra-violet ray

40. The effect produced when many echoes merge into one prolonged sound is known as.

A. Noise B. harmonic C. reverberation D. pitch.

41. The figure shows waves spreading out from a point. The wavelength of the waves is.



A. 3cm B. 6cm

C. 9cm D. 12cm

42. Ticker time is connected to the mains supply of frequency 40Hz. Find the time it takes to print three consecutive dots.

A 0.08s B 0.25s C 0.05s D 0.75s

43. What occurs when a body is made to vibrate with its natural frequency due to external vibration?

A. Echo B. resonance C. refraction D. reverberation

44.

Viabrator	Wavelength	Frequency
Wave P	1500m	0.2MHz
Wave Q	500m	……..

The table above shows readings obtained by using a vibrator which produces waves of constant velocity. Find the frequency of the wave Q:

A. 0.07MHz B. 0.3MHz C. 0.6MHz D. 1. 6MHz.

45. Which of the following are transverse waves only?

A. Radio, sound, ultraviolet
B. Ultraviolet, x-rays, water waves.
C. infrared, gamma rays, sound wave.
D. sound waves, ultraviolet.

46. A boy standing 150m from vertical cliff claps his hands and hears on echo 0.85s later. Find the speed of sound in air.

A. 128m/s B. 176m/s C. 255m/s D. 353m/s

47. In a sound wave particle of the medium.

A. are stationary
B. move along main the wave
C. vibrates in the some direction as the wave.
D. vibrates at right angles to the direction of the wave.

48. Which of the following statements is true about the wave traveling from one medium to another?

(i) its frequency and velocity change
(ii) its frequency and wave length change
(iii) its velocity and wavelength change

(iv) Only its frequency remains unchanged.

A (i) only B (ii) and C (i) (ii) and (iii) D (iii)and iv

49. Water waves travel a distance of 36cm in 6s and the separation of successive troughs is 3.0cm. Calculate the frequency of the wave

A. 2Hz B. 12Hz C. 18Hz D. 72Hz

50. Which of the following is true about sound waves.

(i) They are longitudinal

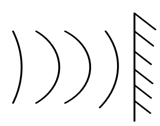
(ii) They are transverse

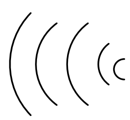
(iii) They are produced by vibrations

(iv) They are travel through an empty space

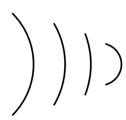
A (ii) and (iv) only B (i) and (iii) only C (i) , (ii) and (iii) only D (ii) , (iii) and (iv) only.

51. The figure below shows circular waves incident on a place reflector. Which of the following patterns represents the reflected waves?

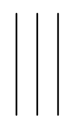




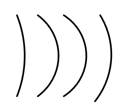
A



B



C



D

52. Which of the following are not electromagnetic waves?

A x-rays B Radio waves C microwaves D sound waves

53. A vibrator produces waves which travel a distance of 12m in 4s. If the frequency of the vibrator is 2Hz what is the wavelength of the waves?

A. 1.5m B. 3m C. 6m D. 24m

54. A girl stands in between two cliffs and claps her hands. She hears the first echo after 1s and a second echo after 2 second. If the speed of the sound is 300m/s, the distance between cliffs is.

A. 300m B. 450m C. 900m D. 1200m

55. Which of the following statement is true?

A. light waves, radio waves and sound waves will all travel through a vacuum.

B. light waves and radio wave will travel through a vacuum sound waves will not,

C. light waves and sound waves will travel trough a vacuum radio waves will not.

D. sound waves and radio waves will travel through a vacuum, light waves will not.

56. Sound waves.

A do not pass through a vacuum. B travel through solid at lower speed

C do not travel through liquid D travel at the highest speed in air

57. Which one of the following does not change when water waves travel from deep to shallow water?

A frequency B Amplitude C velocity D wave length

58. Sound travel much greater through.

A steel B wood C water D wavelength

59. Which of the following statements are true above refraction of waves?

(i) the speed of wave change

(ii) the wavelength changes

(iii) the direction of travel changes

(iv) the frequency changes

A (i) only B (i) and (ii) only C (i) , (ii) and (iv) only D (i), (ii) and (iii) only .

60. An echo is produced as a result of sound wave being.

A. absorbed by objects

B. transmitted by objects

C. deflected back by objects

D. bent around Connors by objects

61. The particles of a medium through which long traditional wave travels.

A. vibrate parallel to the direction of the propagation of the waves

B. vibrate perpendicular to the direction of the propagation of the wave

C. more a long with wave

D. more in the opposite direction to the wave

62. A girl standing 300m away from a high vertical wall makes a loud sound of frequency 60Hz. Calculate the wavelength of the sound. If the girl hears the echo after 2 seconds

A. 0.2m B. 2.5m C. 5m D. 10m

63. When sound wave pass through a metal bar, the atoms of the metal.

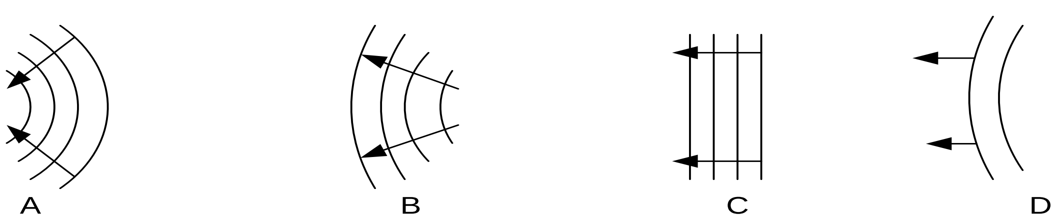
A rotate in circles

B more along the bar

C expands and contract

D vibrate about fixed point

64. Which one of the following best describes the patterns of circular waves refracted from concave refractor



65. The frequency of a radio wave is $6.6x10^5$Hz find the wavelength, if the velocity of light is $3.0x\ 10^8 m/s$

A. $2.2x10^3$m B. $4.45x10^2$m C. $3.60x10^3$ D. $1.98x10^{14}$

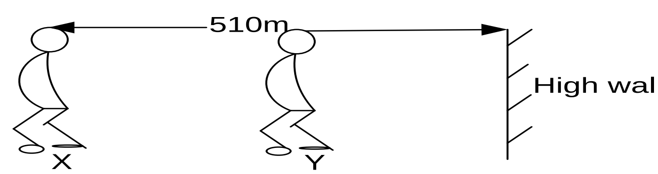
66. A vibrator produces waves which travel a distance of 35cm in 2 seconds if the distance between successive waves, crests is 5cm what is the frequency of the vibrator.

A. 3.5Hz B. 7.0Hz C. 14Hz D. 87.5Hz

67. Which of the following changes occur when a ripple from a region of deep water reaches a region of shallow water

A. velocity remains constant and wavelength increases
B. velocity decreases and wavelength decrease
C. frequency increases and the velocity increases
D. the frequency decreases and the wavelength increases

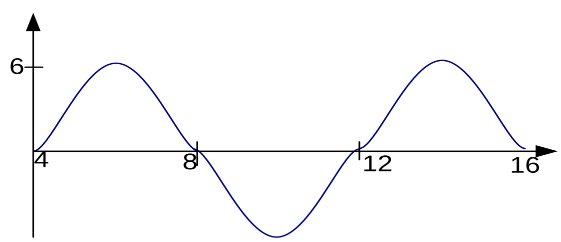
68.



In the diagram above, boy x clapped his hands once and boy y heard two claps, the interval between their arrival being 1s. Calculate the distance between x and y (speed sound =330m/s).

A. 255m B. 330m C. 345m D. 510m.

69.



The amplitude of the wave in the figure above is

A. 6cm B. 8cm

C. 12 cm D. 16cm

70. Sound travels faster on a hot day than on a could day because

A. the speed of air molecules is higher on hot day then on a cold day.
B. there are more conventional currents on a hot day then on a cold day.
C. there is less air molecules on a cold day than on a hot day.
D. there is more air molecules on a cold day than on a hot day.

71. The pitch of a note from a guitar string can be made higher by.

A. lengthening the string B. Tightening the string

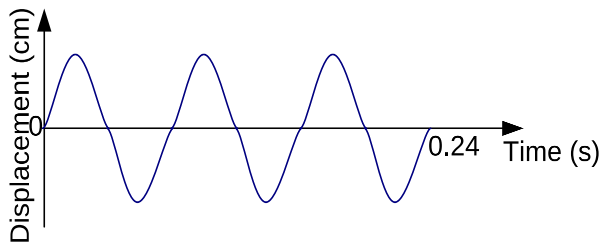
C. heating the string D. Increasing the thickness of string

72. Sound waves.
    A. do not pass through a vacuum
    B. travel through solids at a lower speed man in air
    C. do not travel through liquids
    D. do not travel at the highest speed in air
73. The particles of the medium, through which a transverse wave travels.
    1 remain stationary
    2 move along with the wave
    3 move counter to be wave
    4 vibrate perpendicular to the direction of the waves

    A. 1,2,3 only correct B. 1,3 only correct
    C. 2,4 only correct D. 4 only correct
74. A person at distance 100m from a cliff produces a sound and hear the echo sound 1.5s later. Calculate the speed of sound in air.
    A 120m/s B 240m/s C 270 m/s D 340m/s
75. The loudness of sound depends on.
    A. amplitude B. frequency C. velocity D. wavelength
76. A point of maximum energy on a stationary wave is
    A. Node B. crest C. antinodes D. amplitude
77. Which of the following electromagnetic waves has the longest wavelength?
    A. micro waves B. Radio waves C. antinodes D. amplitude
78. A man standing some distance from vertical wall beats a drum. He hears the echo after 2s. Calculate the distance between the man and the wall . (speed of sound = 330m/s)
    A 82.5m B. 165.0m C. 330m D. 660m
79. A sound wave of frequency 250Hz is produced 300m away from a high wall. If an echo is received after 2s. The wavelength of the sound is
    A. 2.4m B. 1.2m C. 0.83m D. 0.6m

SECTION B

1. The diagram below represents a wave



(a) Mark on the diagram the amplitude and label it, A
(b) How many cycles are shown on the diagram
(c) calculate the period for the wave

2. Forty waves are generated in 2 s. If the waves occupy a distance of 1.6 m, calculate
   a) Frequency of the waves
   b) speed of the waves
3. (a) What is meant by diffraction of waves
   (b) Draw a diagram to show the path of plane water waves through a narrow gap
   (c) State two factors that's that determine the intensity of sound
4. (a) What is a longitudinal wave?
   (b)

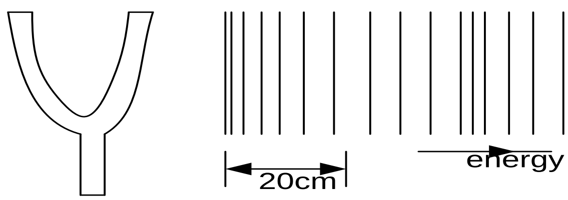


Figure above shows a sound wave produced from a tuning fork vibrating at 800 Hz. Calculate the velocity of the wave in the medium

   (c) State two factors which determine the velocity of sound in air
5. (a) State the laws of reflection
   (b)

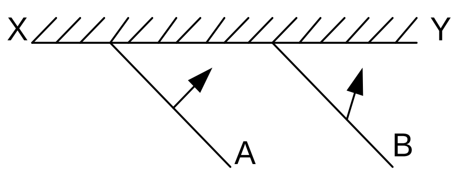
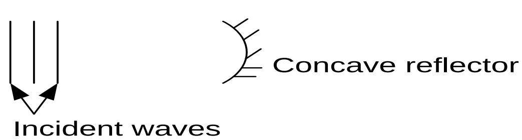


Figure above shows two successive parallel wave fronts A and B incident on straight barrier XY. Complete the diagram to show the reflected wave fronts

6. (a) What is a progressive wave?
   (b) What is meant by antinodes as applied to a stationary wave?
   (c) The distance between two successive antinodes on a stationary wave is 4cm. find the wavelength
7. (a)



The figure above shows straight water waves approaching a concave surface. Complete the diagram to show how it will be reflected.

(b) State what would happen to the waves if the concave surface was removed and depth of water reduced.

8. (a) What is an echo?

(b) When a hunter fires a gun, an echo from a cliff is heard 8s later. How far is the hunter from the cliff. (Speed of sound = 340m/s)

(c) State one practical application of echoes

9. (a) What is an echo?

(b) An echo sounder on a boat sends down a pulse through the water and receives its echo 0.9s later. If the velocity of sound in the water is 1450m/s. calculate water depth.

(c) State any two factors which determine the frequency of a note produced when a guitar string vibrates.

10. (a) What is meant by the term reverberation?

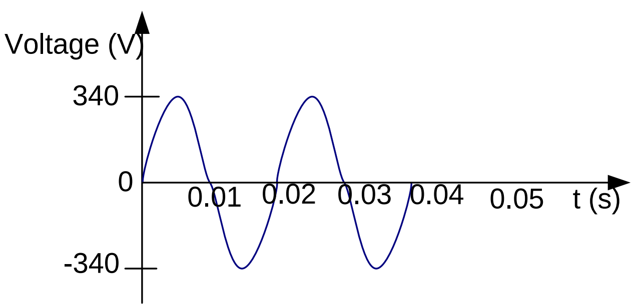
(b) State two factors which affect the frequency of a vibrating string

(c) A sound wave of frequency 440Hz has a velocity of 330m/s. Calculate its wavelength.

11. (a) Describes how a straight water is produced in a ripple tank.

(b) State the conditions for the occurrence of destructive interference of waves.

12.



The graph above shows the variation of an $a.c$ with time

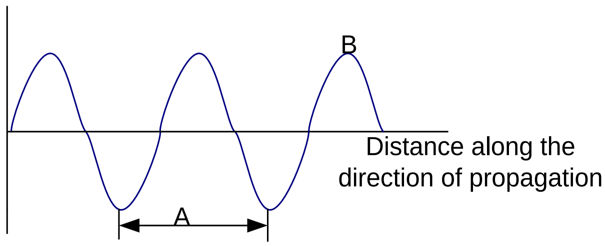
Find;

(i) the peak voltage

(ii) the frequency

13. (a) What is a transverse wave?

(i) The diagram below represents a wave traveling in water.

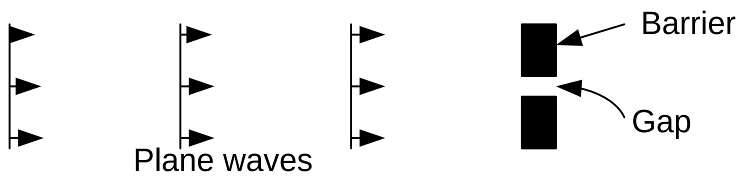


(i) Name the part labeled B

(ii) If the distance represented by A is 20cm and the speed of the wave is 8.0m/s, what is is the frequency of the wave?

14. (a) What is a standing wave?

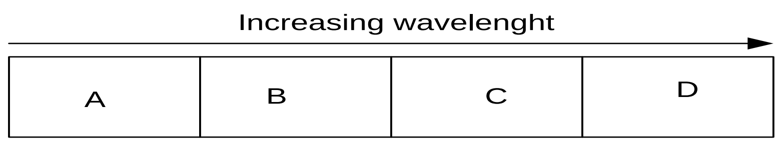
(b) The figure below shows plane waves approaching a gap in a barrier.



(i) Show on the diagram, the appearance of the waves after the barrier.

(ii) What is the effect of reducing the size of the gap?

15. (a) The figure below shows part of the electromagnetic spectrum consisting of gamma rays, radio waves, infrared and visible light.

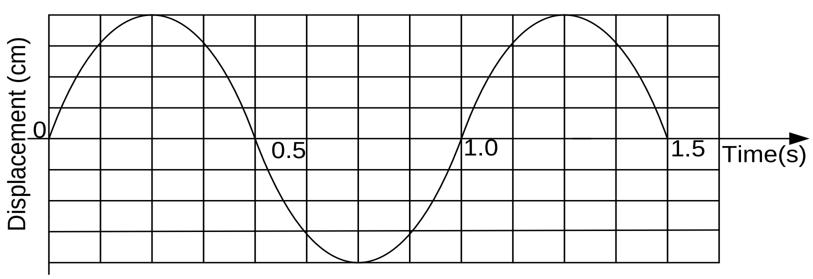


Identify the bands to which these radiations belong to A, B, C and D

(b) State one application of the radiation in.

(i) Band A (ii) Band B

16.

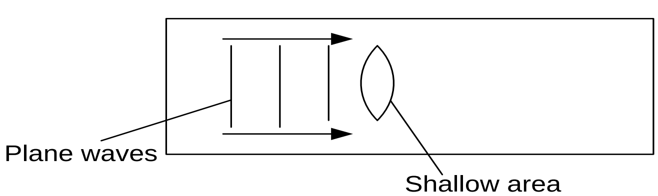


The diagram above shows a section of transverse wavelength 4.0cm paid its

(i) frequency (ii) amplitude (iii) velocity

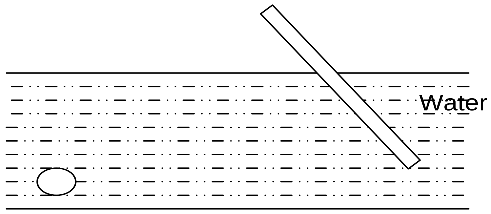
17. (a) What is meat by refraction?

(b)



Plane waves are generated at one end of a ripple tank. The waves travel towards the other end through a shallow region having the shape shown above. Complete the diagram to show the wave fronts

(c)



A stick is dipped in water as shown below. Draw away diagram to show how the stick will appear to an observer at 0.

18. (a) A gir l stands at a distance of 300m from a high cliff and blows a whistle. She hears the sound of the whistle again after 2s. Calculate the speed of sound

    (b) State two properties of electromagnetic radiations

19. (a) A girl at a distance of 165m from a high wall clapped her hands once but heard two claps.

    (i) Explain why the girl heard two claps

    (ii) Find how long it took her to hear the second clap. (Speed of sound in air is 330m/s)

    (b) Give one practical application in which the principle in (a) is used.

20. (a) (i) What is meant by reverberation?

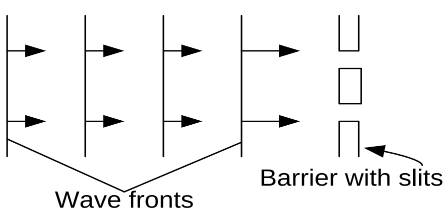
    (ii) How does complete absence reverberation affect speech in concert hall?

    (b) A girl produces sound waves near series of regularly spaced reflecting surfaces if the reflectors are 15cm apart and the velocity of sound in air is 330m/s calculate the frequency of the echo.

PAPER TWO TYPE

1. (a) What is meant by diffraction of waves

(ii) Figure below shows plane wave fronts incident on a barrier with two slits



(i) Copy and sketch the wave pattern beyond the barrier

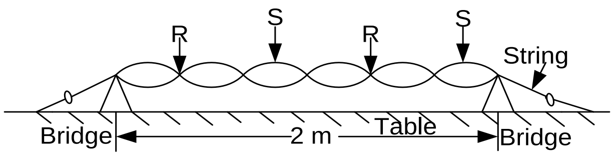
(ii) Describe what happens if slits are narrowed

(iii) Explain why the speed of sound at the top of a high mountain is different from that at sea-level

(iv) An experimenter standing between two high walls produces sound by hitting two pieces of wood. If the first echo is heard after 3.5 s and the second echo 2 s later, find the distance between the walls (speed of sound in air = 330m/s)

(v) What is meant by a standing wave

(vi) Figure below shows a string stretched between two bridges. When it is plucked at some point it vibrates as shown



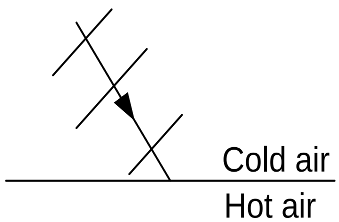
Name the points marked R and S

(i) Calculate the wave length of the wave in the string

2. (a) What is meant by the following as applied to sound waves

(i) Pitch (ii) Audio - range

(b) Figure below shows parallel sound waves travelling from a region of cold air to a region of hot air



(i) Copy and draw the waves pattern in the hot air, showing the direction of travel

(ii) Name the wave phenomenon show by the wave

(iii) Explain why the wave behaves the way you have draw in the hot air

(c) A student observed the time interval between the lightning flash from a distant storm and the accompanying thunder as 4 beats of his pulse. If the pulse rate is 72 beats per minute. Determine the:

(i) time in seconds taken for him to hear the thunder from the instant he sees the flash

(ii) distance of the storm from the observer (Take the speed of sound in air =330m/s)

(d) Give any two applications of ultrasonic sounds

3. (a) Define the following as applied to the wave motions

(i) Frequency (ii) Wave length

(b) What are transverse waves?

(c) A radio station transmits signals at a frequency of 103.7MHz. Find, the wavelength of the signals and state any assumption made

(d) Draw a diagram to show the pattern for a straight water wave passing through a narrow slit

(e) Describe an experiment to demonstrate that sound waves require a material medium for their propagation

(f) Explain how sound waves travel through air

4. (a) Define the following as applied to the wave motions

(i) Frequency (ii) Wave length

(b) Draw diagrams to show circular water ripples are reflected from

(i) concave reflector (ii) convex reflector

(c) (i) Distinguish between longitudinal waves and transverse waves

(ii) Give one example of each of the waves in (c) (i)

(d) State four properties of electromagnetic waves

(e) The distance between two successive antinodes on a standing wave is 3.0 cm. If the distance between the source of wave and reflector is 24.0cm, find the

(i) number of loops (ii) wavelength of the wave

5. (a) State the changes detected when listening to a sound note if the

(i) amplitude is raised (ii) frequency is raised

(b) Give three differences between light waves and sound waves

(c)

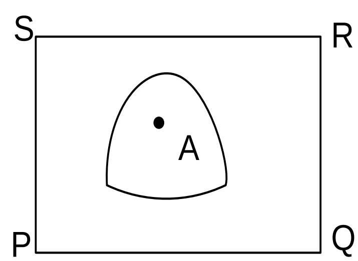
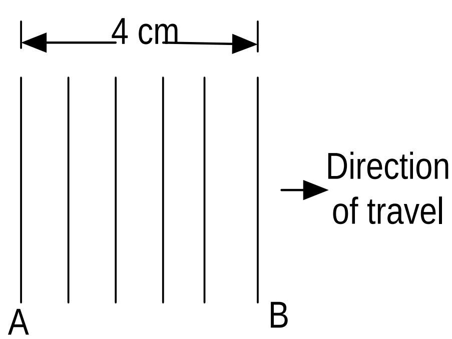


Figure above shows a ripple tank PQRS whose one side is raised. A ripple started by touching the water at A, and after one second it had the shape shown

(i) State which side of the ripple tank is raised

(ii) Explain the shape of the ripple

(d)



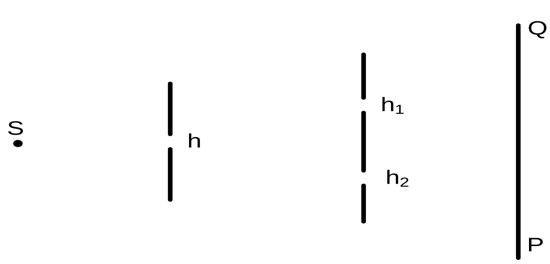
The lines in figure above shows crests of straight ripples formed in a ripple tank

(i) If after 10 seconds A is in position B, calculate the velocity of the ripples

(ii) Draw a diagram showing how the ripples would pass through wide gap of an obstacle the would meet

6. (a) Define the term constructive interferences as applied to sound waves.

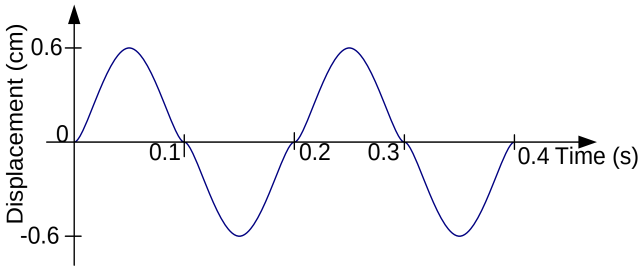
(b) The figure below shows a sources behind barrier with a single hole h, placed behind another barrier with two identical holes h_1 and h_2. A sound detector is moved along a line PQ.



(i) With the aid of the diagram explain what is detected

(ii) What is the significant of h_1 and h_2?

(c)



The figure above – shows the displacement time graph of a wave traveling through water with a velocity of 2.5mm/s. find the.

(i) the amplitude

(ii) the period

(iii) wavelength of the wave

(d) What are the conditions for formation of a standing wave with the wave in (c) above?

7. (a) Defines the following terms as applied to waves.

(i) amplitude (ii) frequency

(b) (i) What is meant by interference of waves

(ii) Using a labeled diagram, show how circular water waves are reflected from a straight barrier

(c) (i) Use a labeled diagram to show the bands of an electromagnetic spectrum

(ii) Calculate the frequency of a radio wave of wavelength 2m.

(d) With the aid of a diagram, show dispersion of light by a prism

8. [a] (i) State any three effects of electromagnetic radiation on matter .

(ii) State two properties that electromagnetic waves have in common.

(b) A radio wave of wavelength 330m is transmitted at frequency of 908kHz.find its velocity.

9. [a] (i) Define an echo

[ii] State the condition required far a stationary wave to be formed.

(b) [ii] list factors on which the frequency of a wave in a vibrating sting depends.

[c] Describe an experiment to demonstrate resonance in a closed pipe.

(d) A child stands between two cliffs and makes a loud sound. If it hears the first echo after 1.5s and the 2nd echo after 2.0s, find the distance between the two cliffs (speed of sound = 320m/s)

10. (a) State the difference between sound and light waves

(b) (i) Describe a simple experiment to determine the velocity of sound in air

(ii) Explain why the speed of sound is higher in solids than air

(d) Two people X and Y stand in a line at a distance of 330m and 660m respectively from a high wall. Find the time interval taken for X to hear the first and second sounds when Y makes a loud sound (speed of sound in air = 330m/s)

(e) (i) What is meant by a stationary wave

(ii) Give any two conditions

(iii) Name one musical instrument which produces stationary waves

11. (a) What is meant by sound?

(b) Describe the experiment to show that sound waves require a material medium for transmission.

(c) Explains briefly the following

(i) A dog is more able than a human being to detect the presence of a thief tiptoeing at night.

(ii) An approaching train can easily be detected by a human car placed close to the rays rails.

(d) A sound of frequency 250Hz is produced 120m away from a high wall calculate the

(i) Wavelength

(ii) Time it takes the sound wave to travel to and from the wall (speed of sound in air = 330m/s)

12. (a) (i) Describe how the speed of waves in a ripple tank can be decreased.

(ii) Explain the effect of decreases the speed of the wave in (a) on frequency

(b) With the aid of sketch diagrams, explain the effect of size of a gap on diffraction of waves

(c) (i) Give two reasons why sound is louder at night than during the day.

(ii) An echo- sounding equipment on a ship receives sound pulses reflected from the sea bed 0.02s after they were sent out from it. If the speed of sound in water is 1500m/s, calculate the depth of water under the ship.

(d) Identify two differences between water and sound waves.

13. (a) With aid of a diagram, explains the terms amplitude and wavelength as applied to wave motion.

(b) (i) Derive an equation relating velocity, v, frequency ,f, and wavelength , λ , of a wave.

(ii) A radio wave is transmitted at a frequency of 150MHz. Calculate its wavelength.

(c) (i) List four properties of electromagnetic waves.

(iii) A long open tube is partially immersed in water and the turning fork of frequency 425Hz is sounded and held above it. The tube is gradually raised, find the length of the air column when resonance first occurs. (neglect the end collection) (speed of sound in air = 340m/s)

14. (a) State three differences between sound and light waves?

(b) (i) Explain how stationary waves are formed?

(ii) State three main characteristics of stationary waves?

(c) (i) Define the term frequency and wave length as applied to sound.

(ii)Describe an experiment to demonstrate resonance in sound?

(f) The velocity and frequency of sound in air at a certain time were 320m/s and 200Hz respectively. At a later time, the air temperature changed and the velocity of sound in air was found to be 340m/s. Determine the change in wavelength of the sound.

15. (a) What an echo?

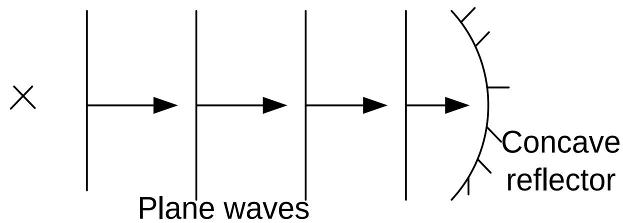
(b) (i) Describe an experiment to measure the speed of sound in air?

(ii) State any two likely sources of error in the experiment?

(c) Describe an experiment to determine how the frequency of the vibrating string depends on the wave length of the string.

16. (a) List three differences between sound waves and radio waves.

(b) The figure below shows waves propagating towards a concave reflector.



(i) Draw the diagram to show how the waves will be reflected.

(ii) If the velocity of the waves is 320m/s and the distance between the two successive crests is 10cm, find the period of the waves.

(c) Describe a simple echo method of determining the speed of sound in air.

17. (a) Define each of the following terms as applied to wave motion.

(i) Wave front. (ii) Wavelength.

(b) The wavelength of the radio wave is 10m. Calculate.

(i) The frequency. (ii) The period of the wave.

(c) Why does sound travel faster in solids than in gases.

(d) (i) Explain why an open pipe when used in producing different notes.

(ii) The frequency of the 3^{rd} harmonic in a closed pipe is 280Hz. Find the length of the air column in the pipe.

18. (a) (i) Describe a simple experiment to determine the velocity of sound in air.

(ii) What factors would affect the value of the velocity of sound obtained from the experiment in (i) above.

(b) Explain why a musical note play on a piano sounds different from that played on a guitar.

(c) (i)Calculate the wavelength of the sound waves of frequency 3.3KHz and speed 330m/s.

(iii) State four differences between sound and radio waves.

19. (a) Distinguish between longitudinal and transverse waves. Give an example of each.

(b) Describe an experiment to show interference of water waves.

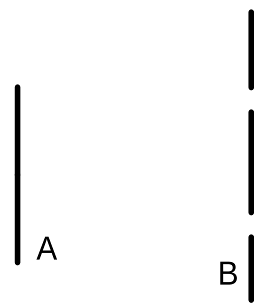
(c) (i) what are the conditions for the formation of standing waves.

(ii) Name two instruments where standing waves are applied.

(d) Describe the resonance method for determining the speed of sound in air.

(e) A fork has a frequency of 256Hz. Assuming the speed of sound in air is 320m/s, calculate the wavelength of the sound note given by the folk.

20. The figure above shows the diagram of a cross-section of a ripple tank in which A is a straight dipper and B is a barrier with two gaps.



(a) Sketch a diagram showing waves produced when A vibrates perpendicular to the water surface.

(b) What will happen when.

(i) The gaps are made narrower.

(ii) The separation of the gaps is decreased?

(iii) The frequency of vibration of A is increased?

(c) If a vibrates with a frequency of 20Hz and is 25cm from B, find

(i) The speed of the wave if a wave front takes 5 seconds from A to B.

(ii) The wavelength of the waves.

(d) State two differences between water waves and light waves.

21. (a) Give the two differences between transverse and longitudinal waves.

(b) Two identical sources are made to produce circular waves in a ripple tank.

(i) Explain with the aid of diagram how interference fringes may be obtained.

(ii) What happens when the distance between the sources reduced?

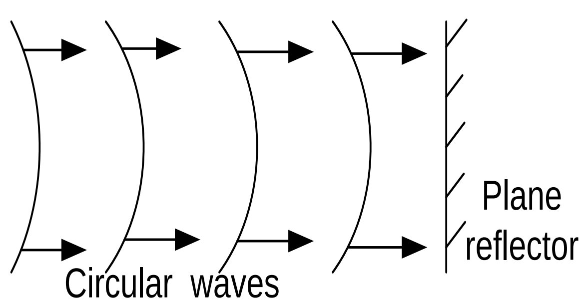
(c) A vibrator of frequency 50Hz produces circular waves in a ripple tank. If the distance between any two consecutive crests is 3cm, what is the speed of the waves?

(d) (i) Explain why echoes are not heard in small rooms.

(ii) Describe a simple echo method of determining the speed of sound in air.

22. (a) List three differences and three similarities between sound waves and light waves.

(b)



The above diagram show circular waves propagating towards plane reflector.

(i) Draw a diagram to show how the waves will be reflected.

(ii) Calculate the frequency of the waves. If their velocity and wavelength are 0.5m/s and 0.5m respectively.

(c) A man standing mid way between two cliffs makes a loud sound. He hears the first echo after 3 seconds calculate the distance between the two cliffs if the velocity of sound = 330m/s.

Modern physics

Production of electrons

Electrons can be produced by;

- Thermionic emission
- Photo electric emission

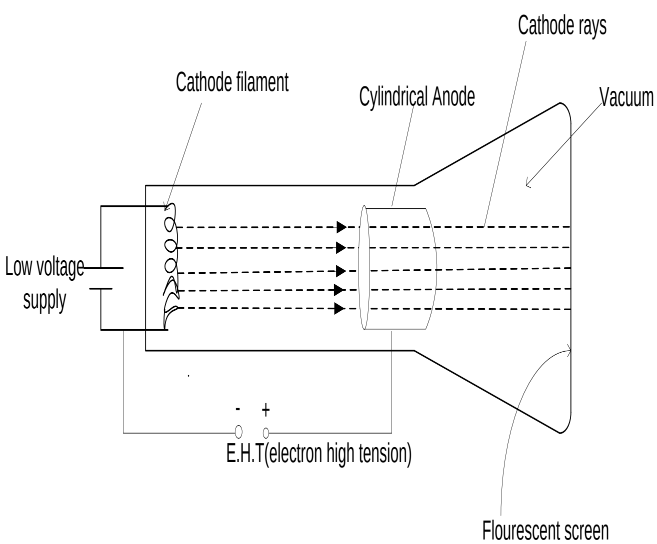
Thermionic Emission

This is a process by which electrons are emitted from a hot metal surface.

Cathode rays

Cathode rays are streams of fast moving electrons that travel from cathode to anode.

Production of cathode rays



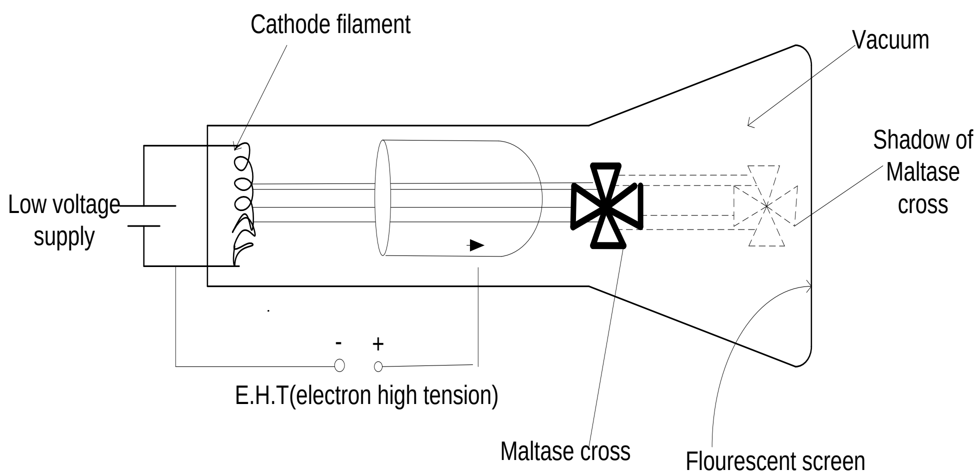
- When the cathode filament inside an evacuated glass tube is heated by a low voltage, the electrons are produced by thermionic emission and accelerated by E.H.T towards the anode.
- Electrons travel un deflected across the vacuum past the anode and produce aglow when they collide with fluorescent screen and give up their energy. It is the beam of fast moving electrons from the cathode which constitute the cathode rays.

PROPERTIES OF CATHODE RAYS

- They travel from cathode to anode in a straight line
- They are electrons and carry a negative charge
- They can be deflected in an electric field towards the positive plate
- They can be deflected in a magnetic field towards the North Pole according to Flemings left hand rule.
- They cause certain substances to fluorescence when they collide with them
- They posses kinetic energy which is changed to heat when they are brought to rest
- They can produce x—rays if they are of sufficiently high energy

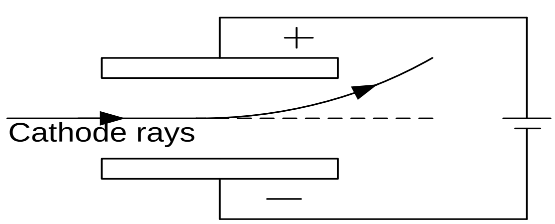
TO STUDY PROPERTIES OF CATHODE RAYS

1: Straight line movement



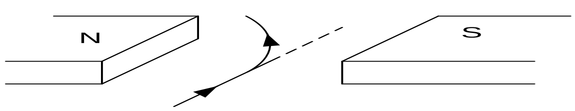
- ❖ A cathode ray tube is modified to include a maltase cross in front of the anode towards the screen.
- ❖ When the cathode is heat by low voltage, electrons are produced Thermionic ally and are accelerated by the anode. When they strike the maltase cross a sharp shadow is produced on the screen and this shows that cathode rays travel in a straight line

2: Carry a negative charge



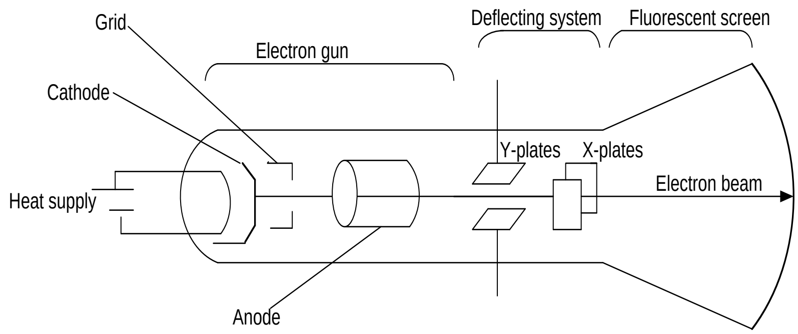
Cathode rays are deflected towards the positive plate

3: Deflection in a magnetic field



Cathode rays are deflected towards the North Pole according to Flemings left hand rule

THE CATHODE RAY OSCILLOSCOPE (CRO)



The CRO mainly consists of four main parts namely:- The electron gun, deflecting system, fluorescent screen and the time base.

The electron gun

This consists of the filament, cathode, grid control, and the anode

- Filament heats the cathode
- Cathode emits electrons thermionic ally.
- The grid, controls the brightness of the spot by controlling the number of electrons passing through it.
- The anode accelerate the electrons along the tube and focuses the beam of electrons into a small spot on the screen.

Deflecting system

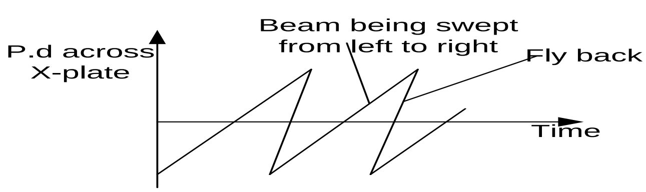
- This consists the x-plate and y-plate. The y-plates are horizontal in position and deflect the electron beam vertically when a $p.d$ is applied between them.
- X-plates are vertical in position and deflect the, electron beam horizontally when a $p.d$ is applied between them.

Screen

- It is the wide end of the tube and its inside is coated with zinc sulphide which glows or fluorescence when struck by energetic electrons.

Time base (sweep generator)

- The time base is connected to the x-plates and provides a saw tooth $p.d$ that sweeps the electron beam from left to right of the screen at a constant speed.



- The saw tooth then returns the beam to the initial position at the extreme left of screen almost instantaneously. The time taken for this right to left sweep is called **fly-back time.**

Note:

The glass tube is evacuated to prevent scattering of the electron beam due collision with air molecules.

USES OF THE CRO

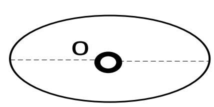
- It is used to display wave forms, the signal to be investigate is connected to the y-plate and the time base to the x-plate
- It measures voltage (AC or DC)
- Measures frequencies
- Used to measure phase differences
- Measures small time intervals

Advantages of CRO over a voltmeter

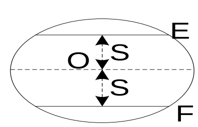
- It measures both AC and D.C voltage unlike a voltmeter measures only D.C voltage unless a rectifier is used
- It has an instantaneous response since the electron beam behaves as a pointer of negligible inertia.
- It has nearly infinite resistance to DC and a very high impedance to AC and therefore draws very little current.
- It has no coil to burn out.

APPEARANCE OF ELECTRON SPOT ON THE SCREEN

- When a signal is **not** connected to the y-plate and time base switched **off**, a bright spot is formed on the screen.



- When *the* $\boldsymbol{d.c}$ **voltage** is connected to the y-plate such that the top plate is positive the line is displaced to E. If the lower plate is positive the line is displaced to F. the displacement in either case is proportional to *the* $d.c$ voltage applied.

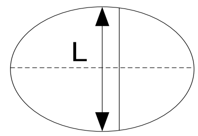


If in the CRO the gain control of the y-deflection amplifier is V_g Vcm^{-1} then

$V \propto S$

$$\boxed{\boldsymbol{V = VgS}}$$

❖ When **A.C** is connected to y-plate and time base switched off. The spot is a vertical line



The length L represents peak to peak voltage

$$2\,V_O \propto L$$

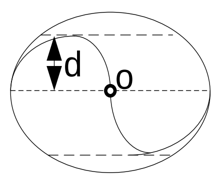
$$2V_O = VgL$$

where V_0 is peak voltage

$$\boxed{V_O = \frac{VgL}{2}}$$

Also $\boxed{Vr.m.s = \frac{V_0}{\sqrt{2}}}$

❖ When the A.C is connected to Y-plate and time base also switched on the a stationery wave is obtained

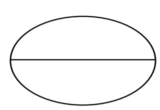


$V_0 \propto d$

$V_0 = V_g d$

Vr.m.s $= \frac{V_0}{\sqrt{2}}$

❖ Y-plate off and time base on

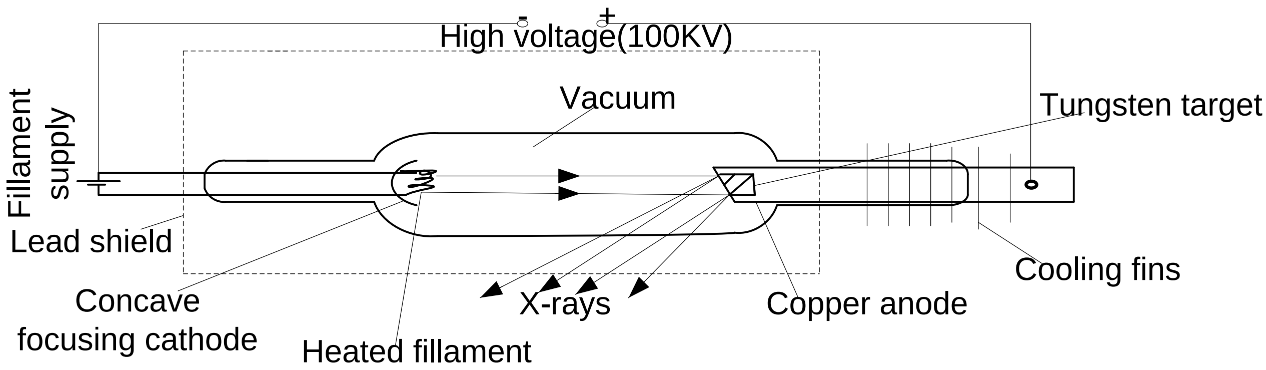


Horizontal line formed at the centre of the screen

X-RAYS

These are electromagnetic radiations of short wavelength ($\sim 10^{-10} m$) which travel at a speed of light and produced when fast moving electrons (cathode rays) strike a metal target.

X-RAY TUBE [PRODUCITON OF X-RAYS]



Operation

- The cathode is heated with low voltage and electrons are emitted thermionic ally. Electrons are then accelerated towards the tungsten target or any metal of high melting point by a high $p.d$ between the cathode and anode. Electrons gain kinetic energy and when they strike the target they surrender their kinetic energy to the target hence producing x-rays.
- Less than 1% of the kinetic energy of the electrons produces x-rays and the rest of the kinetic energy is converted to heat at the target which has to be kept cool by a liquid flowing continuously through the cooling fins.

Note:

(1) The energy changes in an x-rays tube are; electrical energy from low voltage source to heat energy used for heating the filament to kinetic energy of electrons and then to heat and x-rays.

(2) The intensity of x-ray beam increases with the number of electrons hitting the target, therefore intensity is controlled by filament current /heating current or supply voltage.

(3) The penetrating power (quality) of an x-ray beam is controlled by the accelerating $p.d$ between the cathode and the anode

(4) X-rays with high penetrating power are called hard x-rays while those with low penetrating power are called soft x-rays.

(5) The x-ray tube is totally evacuated to prevent collision of electrons with gas molecules.

PROPERTIES OF X-RAYS

(1) They travel in straight lines at the velocity of light.

(2) They cannot be deflected by electric or magnetic field(This is an evidence that they are not charged particles)

(3) They readily penetrate matter, penetration is least with materials of high density

(4) They can be reflected but not at very large angles of incidence

(5) Refractive indices of all materials are very close to unity (one) for x-rays so that very little bending occurs when they pass from one material to another

(6) They can be diffracted

The following properties 7 to 10 are used to detect x-rays

(7) They ionize gases through which they pass

(8) They affect photographic film

(9) They can produce fluorescence

(10) They can produce photoelectric emission

USES OF X-RAYS

Medical uses

- Used to detect fractures in bones
- Used to destroy cancer cell
- Used in detection of lung T.B
- Used for sterilization of medical equipment's

Industrial use

- They are used to locate internal imperfection in welded joints and casting
- They are used to detect cracks in metal parts which are invisible
- They are used to study structures of crystals

Agricultural uses

- Tracing phosphate fertilizers using phosphorus
- Sterilization of insecticides for pest control
- X-ray crystallography
- Used to study crystal structures and determine structure of complex organic molecules

Health hazard of x-rays

- They cause cancer
- They cause genetic damage and mutation
- They can burn the skin and other body tissues

Precaution

- ❖ Lead aprons should be worn while dealing with x-rays
- ❖ The brain and other delicate parts of the body should not be exposed to x-rays
- ❖ Unnecessary long time exposure to x-rays should be avoided.

How x-rays are used to locate broken bones

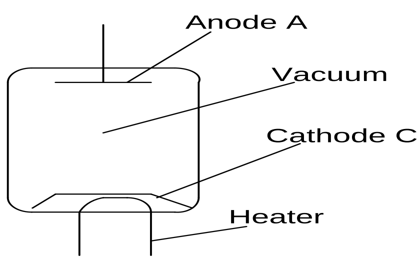
Bones are composed of much denser materials than flesh hence x-rays pass through the body and are absorbed by the bones onto a photographic plate which produce a shadow of the photograph of bones onto the flesh.

Question: Explain why soft x-rays rather than hard x-rays are used to detect fractures in bones

THERMIONIC DIODE

A thermionic diode is a device which is used to change alternating voltage to direct voltage. This process is called **rectification .**

Circuit symbol



A diode consists of cathode (c) and a metal Anode (A). these two elements constitute the electrodes of the valve which are placed inside an evacuated glass envelope.

RECTIFICATION

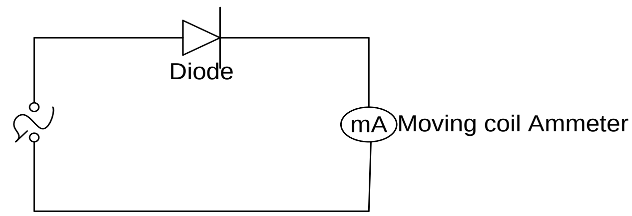
Rectification is a process of converting Alternating current to Direct current.

This can be done by use of

- ❖ Thermionic diodes.
- ❖ Semiconductor diode

When a rectifier is connected to a supply its supposed to conduct and when it does so its said to be **forward biased.** And when connected in a reverse way it fails to conduct therefore its said to be **reverse-biased.**

a) Half wave Rectification

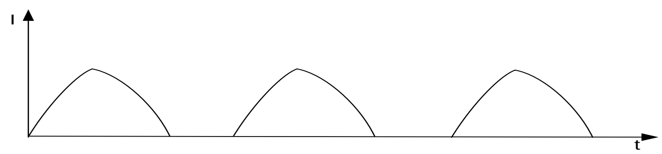


$A.c$ to be measured is first passed through the rectifier which converts it to $d.c$. The $d.c$ obtained is then measured using a moving coil ammeter.

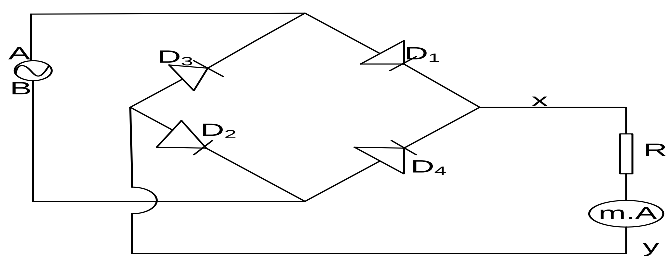
N.B:

The Arrow head in the rectifier symbol shows the direction of flow of current through the circuit.

A graph of I against t is drawn



b) Full wave rectification



- In the first half cycle when A is positive and B - negative diodes D_1 and D_2 conduct I (current) and it flows through the resistor R in the direction x - y. The diodes D_3 and D_4 do not conduct current I in this half cycle.
- During the next half cycle when B is positive and A is negative diodes D_3 and D_4 conduct while D_1 and D_2 do not conduct in this cycle. The current (I) flows through R in the direction x - y. The current through R is in the same direction throughout and it can be measured by moving coil ammeter.

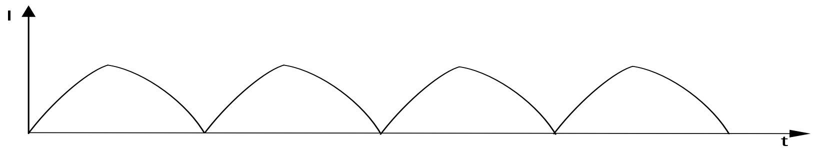
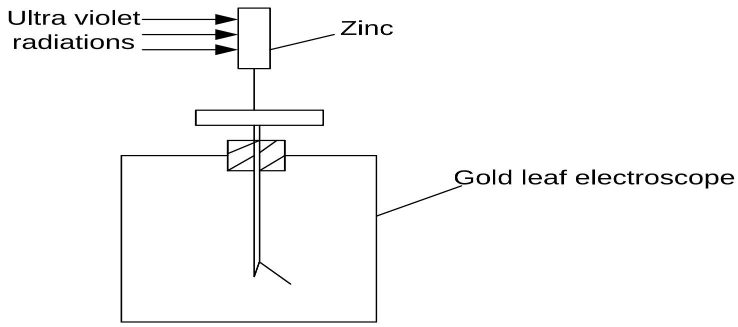


Photo electric emission

This is a process by which electrons are ejected from a clean metal surface when electromagnetic radiations of **a suitable frequency** fall on a metal surface.

EXPERIMENT TO DEMONSTRATE PHOTO ELECTRIC EFFECT



- ❖ When ultraviolet radiations fall on a cleaned zinc plate placed on a cap of a positively charged gold leaf electroscope, there is no change in the divergence of the leaf.
  This is because the electrons that are emitted photo electrically are attracted back by the positively charged zinc plate. Hence there is no charge in the magnitude or sign of charge on the electroscope.
- ❖ When ultraviolet radiations fall on a cleaned zinc plate placed on a cap of a negatively charged gold leaf electroscope, the leaf is seen to collapse gradually.
  This is because the electrons emitted from the zinc plate by the radiations are repelled from it electrostatic ally. This makes the electrons to move from the leaf and the gold plate to the zinc to replace the lost electrons. So the magnitude of the negative charge at the leaf and gold plate decreases thereby decreasing the divergence of the leaf gradually.

Note:

(1) If the intensity of UV radiation is increased for the positively charged electroscope there is no change on the divergence of the leaf. But for a negatively charged electroscope, the leaf collapses fast since the number of electrons emitted per unit time (photo current) from the zinc plate increases with intensity.

(2) If infrared radiations are used instead of UV **no effect** is observed on the leaf divergence because the frequency of the infrared is below threshold frequency for zinc. Hence it cannot eject electrons from the zinc plate no matter how intense it's radiation is.

NUCLEAR STRUCTURE

An atom consists of a small positively charged nucleus with negatively charged electrons revolving around.

The nucleus is the central positively charged part of an atom.

Nucleus contains protons and neutrons which are collectively referred to as **nucleons** or (nuclear number).

ATOMIC NUMBER, Z, MASS NUMBER, A, AND ISOTOPES

Atomic number Z of an element is the number of protons in the nucleus of an atom of the element.

Mass number A of an atom is the number of nucleons in its nucleus.

I**sotopes** are atoms of the same element which have the same number of protons but different number of neutrons and therefore different mass numbers.

Isotopes of an element whose chemical symbol is represented by $\boldsymbol{X}$ can be distinguished by using the symbol $\,{}^{A}_{Z}\boldsymbol{X}$

Where **A** is mass number and **Z** is atomic number

The number of neutrons $n = A - Z$

The number of electrons$= Z$

Example of isotopes

Isotopes of Lithium ${}^{7}_{3}\boldsymbol{Li}$ and ${}^{6}_{3}\boldsymbol{Li}$

Isotopes of uranium ${}^{235}_{92}\boldsymbol{U}$ and ${}^{238}_{92}\boldsymbol{U}$

Examples

1. Carbon 12 contains 6 protons and mass number 12, its written as ${}^{12}_{6}C$

   $A = 12,\ Z = 6,\ n = 6,\ e = 6$

2. Carbon 14 contains 6 protons and mass number 14. Its written as ${}^{14}_{6}C$

   $A = 14,\ Z = 6,\ n = 8,\ e = 6$

RADIO-ACTIVITY

This is the spontaneous breaking up of heavy unstable nucleus to daughter nuclei with emission of $\propto$ particles, β-particle and/or γ-rays.

Heavy nuclides are generally unstable hence this decay is in attempt to reach a stable state.

Radio-activity is said to be a random process because no particular pattern is followed.

TYPES OF IONISING RADIATIONS

a) **Alpha particles ($\propto$)**

They are Helium nuclei [$^4_2$He]

They have a mass of 4times that of hydrogen atom and a charge of +2e where e is the numerical charge on an electron.

Properties

- They have the least penetrating power among the ionizing radiations.
- They are positively charged hence can be deflected by electric and magnetic field
- They are the best ionizers of gases
- They have the shortest range in air among the ionizing radiations
- When emitted, they are emitted with the same speed
- They are easily absorbed by matter ie stopped by a few centimeters of air/paper.

Note

When a nucleus undergoes $\propto -$ decay it loses four nucleons, two of which are protons, therefore mass number A decreases by four while atomic number Z decreases by two.

Thus if a nucleus X becomes a nucleus Y as a result of $\propto -$decay then.

$^A_ZX \quad \rightarrow \quad ^{A-4}_{Z-2}Y \quad + \quad ^4_2He$

(Parent) (Daughter) ($\propto$ Particle)

Example

1. Uranium – 238 decays by $\propto -$emmission to thorium 234 according to

   $^{238}_{92}U \rightarrow ^{234}_{90}Th \quad +^4_2\propto$
2. $^{210}_{84}Po \rightarrow ^{206}_{82}Pb \quad +^4_2He$
3. Uranium $^{238}_{92}U$ decays by emitting 4 alpha particles to nucleus Z. What is the composition of Z.

   Solution

$^{238}_{92}U \quad \rightarrow \ ^{219}_{84}Z + \ 4\ ^{4}_{2}He$

Z has 84 protons and 135 neutrons

b) Beta particle (β)

It is a negatively charged electron which is moving at a high speed. It is represented as

$[\ ^{0}_{-1}e]$

Properties

- It has a higher penetrating power than $\propto$particle
- It is negatively charged hence deflected by electric and magnetic field.
- It is a moderate ionizer of gases
- It has a moderate range in air
- β particles are emitted by nuclei with various speeds
- It is lighter than $\propto -$particle
- Are not easily absorbed by matter ie can penetrate a few millimeters of aluminium.

Note

β-particles are emitted by nuclei which have too many neutrons to be stable. To gain a stable state one of its neutrons should change into a proton and an electron, when this happens the electron is immediately emitted as a β-particle.

Thus when a nucleus undergoes β-decay, it's mass number A does not change and it's atomic number Z increases by one

$$^{A}_{Z}X \quad \rightarrow \quad {}_{Z+1}^{\ \ A}Y \quad + \ ^{0}_{-1}e$$

(Parent) (Daughter) (β - Particle)

Example

1. Carbon-14 decays by β-emission to nitrogen- 14 according to

$$^{14}_{6}C \rightarrow \ ^{14}_{7}N \quad + ^{0}_{-1}e$$

2. $^{235}_{92}U$ decays by emitting 3 beta particles to form a daughter nuclei P. Find the nucleon number of P and its atomic number, hence find the number of neutrons and number of electrons.

Solution

$$^{235}_{92}U \rightarrow \ ^{235}_{95}P \quad + 3\,^{0}_{-1}e$$

Nucleon number= 235, atomic number= 95,

Number of neutrons= 140, number of electrons= 95

c) Gamma rays (γ)

They are electromagnetic waves of very short wave length and they travel with a velocity of tight.

Properties

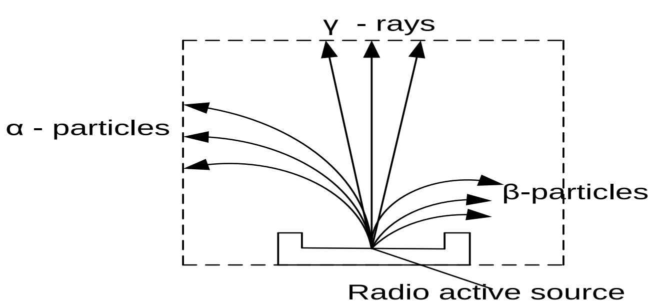
- They have the highest penetrating power and can only be stopped by thick lead sheet.
- They are electrically neutral hence they can't be deflected by electric or magnetic field
- They are the poorest ionizers of gases
- They can be diffracted and refracted

Note

Gamma ray decay involves the release of only energy without the change in atomic mass and atomic number $e.g$

$${}^{A}_{Z}X \rightarrow {}^{A}_{Z}Y \quad + \ \gamma$$

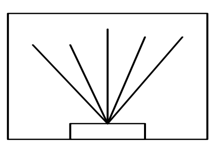
Passage of radiation in electric and magnetic field



Passage of radiation in a cloud chamber

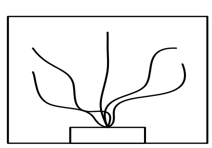
a) $\boldsymbol{\alpha - particles}$

$\alpha - particles$ Leave heavy straight continuous tracks all with the same range.



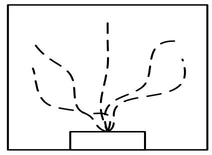
b) $\boldsymbol{\beta - particles}$

$\beta - particles$ Leave thin tracks which indicate that the particles curve in an irregular way.



c) $\gamma - rays$

$\gamma - rays$ Leave hairy tracks.



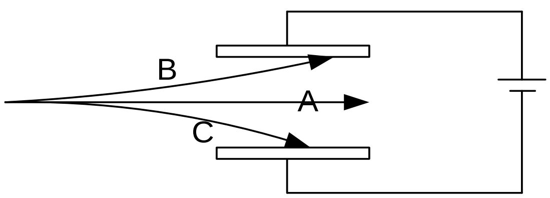
Example

1. a) ${}^{12}_{6}C$ emits two $\alpha - particles$, a $\beta - particle$ and $\gamma - rays$. Write a well balanced equation to find the atomic number and mass number of the daughter nucleus Y.

Solution

$$ {}^{12}_{6}C \rightarrow 2\,{}^{4}_{2}He \quad + {}^{0}_{-1}e \quad + {}^{4}_{3}Y \; + \gamma $$

b) α, β and $\gamma - radiations$ are passed through an electric field below, identify A, B and C



A- $\gamma\ ray$

B- $\beta\ particle$

C- $\alpha\ particle$

RADIOACTIVE –DECAY

Radioactive decay is the spontaneous disintegration of heavy un stable nuclides by emitting alpha particles, beta particles and /or gamma rays.

THE RADIOACTIVE –DECAY LAW $[\boldsymbol{N = N_0 e^{-\lambda t}}]$

The rate of disintegration of a given sample at any time is directly proportional to the number of atoms, N present at that time ,t.

The number of atoms decaying per second $\frac{dN}{dt} \propto$N

Where N is the number of un decayed atoms.

$\frac{dN}{dt} = -\lambda N$

Where λ is decay constant

$$\boxed{\boldsymbol{A = -\lambda N}}$$

Where A is activity or count rate per second and the S.I unit for activity (A) is Becquel (Bq)

Definition

Decay constant is the fraction of radioactive atoms which decay per second.

Activity is the number of decays per second.

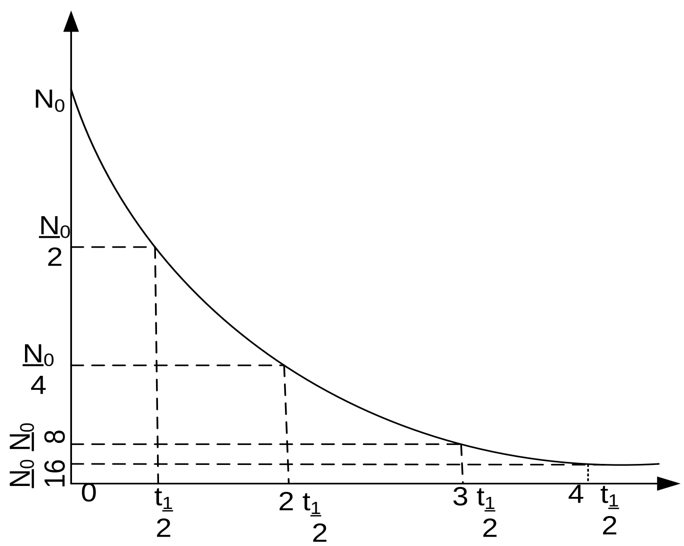
OR it is the number of radiations emitted per second.

- Activity depends on the number of un decayed particles present. The activity gets less as the number of un decayed particles get less.
- Activity (rate of decay) cannot be affected by physical conditions like temperature.

HALF LIFE [$t_{\frac{1}{2}}$]

Half life of a radioactive element is the time taken for half of the atoms to decay.

Consider the graph below



Examples

1. A radioactive sample has a mass of 16g and half life of 10 days. Find the mass after;

(i) 60 days **(ii)** 45 days

Solution

Mass remaining (g)	Time (days)
16	0
8	10
4	20
2	30
1	40
0.5	50
0.25	60

i) $= 0.25g$

ii) $= 0.75g$

2. The mass of a radioactive sample decays to $\frac{1}{16}$ of its original value after 16 days. Find;
   - i) Its half life.
   - ii) Fraction of the ground mass that will be remaining after 20 days.
   - iii) Fractions of the original mass that will have decayed after 20 days.

Solution

i)

Mass remaining (g)	Time (days)
M_0	0
$\frac{M_0}{2}$	$t_{\frac{1}{2}}$
$\frac{M_0}{4}$	$2\,t_{\frac{1}{2}}$
$\frac{M_0}{8}$	$3\,t_{\frac{1}{2}}$
$\frac{M_0}{16}$	$4\,t_{\frac{1}{2}}$

$4\ t_{\frac{1}{2}} = 16$

$t_{\frac{1}{2}} = 4$ days

Half life is 4 days

ii)

Mass remaining (g)	Time (days)
M_0	0
$\frac{M_0}{2}$	4
$\frac{M_0}{4}$	8
$\frac{M_0}{8}$	12
$\frac{M_0}{16}$	16
$\frac{M_0}{32}$	20

Mass remaining $= \frac{M_0}{32}$

Fraction $= \frac{M_0}{32} \div M_0$

$= \frac{1}{32}$

iii) Fraction decayed

$=1-\frac{1}{32}$

$= \frac{31}{32}$

3. A radioactive sample has a half life of $3x10^3$ *years*.
   - i) What does the statement half life of $3x10^3$ *years* mean

ii) How long does it take $\frac{3}{4}$ of the sample to decay

Solution

i) It means that the radioactive sample takes $3x10^3$ *years* for half its atoms to decay.

ii) If $\frac{3}{4}$ decay the $\frac{1}{4}$ of the particles remain.

Mass remaining (g)	Time (days)
M_0	0
$\frac{M_0}{2}$	$3x10^3$
$\frac{M_0}{4}$	$6x10^6$

Time is $6\ x\ 10^3 years$

4. In 168 seconds, the activity of the substance is $\frac{1}{8}$ of its original value, what is the half life of the substance.

Solution

Mass remaining (g)	Time (s)
M_0	0
$\frac{M_0}{2}$	$t_{\frac{1}{2}}$
$\frac{M_0}{4}$	$2\ t_{\frac{1}{2}}$
$\frac{M_0}{8}$	$3\ t_{\frac{1}{2}}$

$3\ t_{\frac{1}{2}} = 168$

$t_{\frac{1}{2}} = 56$ s

Half life is 56 s

5. X_g of the radioactive material of half life 3 weeks decays and 5.12g remain after 15 weeks. Determine X.

Solution

Mass remaining (g)	Time (Weeks)
X	0
$\frac{X}{2}$	3
$\frac{X}{4}$	6
$\frac{X}{8}$	9
$\frac{X}{16}$	12
$\frac{X}{32}$	15

$\frac{X}{32} = 5.12$

$X = 5.12x32$

$X = 163.84g$

6. The table below shows the count rate /activity of a certain radioactive material

Count rate	6400	5380	3810	2700	1910
Time	0	1	3	4	7

Plot a suitable graph and use it to determine the half life of the material.

Uses of radioactive decay/ radioactivity

USES RADIOACTIVITY

- Treatment of deep-lying tumors
- Measurement of thickness of metal sheet during manufacture
- Used to determine the exact position of underground pipes and allows leaks to be detected
- Radioactive phosphorous is used to assess the different abilities of plants to take up - phosphorous from different types of phosphate fertilizer
- Used in radioactive dating

Health hazard

- Causes Mutation (genetic changes)
- Causes Cancer cells

Precautions

- Lead aprons should be worn when dealing with radiations
- Avoid unnecessary exposure to the radiations
- Delicate parts like eyes, brain should not be exposed to the radiations.
- Radio isotopes should be held using tongs.

Nuclear reactions

When a tiny particle such as a neutron penetrates into the nucleus of another particle, a proton may be ejected.

The total mass number and atomic number on either side of the equation must be the same.

Eg

$$^{14}_{7}N \ + \ ^{4}_{2}He \ \rightarrow \ ^{1}_{1}H \ + \ ^{17}_{8}O$$

Examples

1. $^{160}_{70}Co$ is a radioactive isotope of cobalt which emits a beta particle and a very high energy gamma rays to form a nucleus X. write a balanced equation for the reaction.

Solution

$$^{160}_{70}Co \rightarrow {}^{0}_{-1}e + \gamma + {}^{160}_{71}X$$

2. When lithium is bombarded by a neutron, a nuclear reaction occurs which is represented by the equation below.

$$^{6}_{3}Li + {}^{1}_{0}n \rightarrow {}^{3}_{1}H + P$$

Complete the equation and name P

Solution

$$^{6}_{3}Li + {}^{1}_{0}n \rightarrow {}^{3}_{1}H + {}^{4}_{2}P$$

P is a helium nuclei (an alpha particle)

3. When Uranium $^{235}_{92}U$ is bombarded with a neutron, it splits according to the equation

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{m}_{n}P + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$$

Find the value of m and n

$$m = (235 + 1) - \left(92 + (3x1)\right)$$

$$m = 141$$

$$n = (93 + 0) - \left(36 + (3x0)\right)$$

$$n = 56$$

4. Two alpha particles are produced when an un known particle X is used to bombard lithium $^{7}_{3}Li$ as shown below.

$$^{7}_{3}Li + {}^{1}_{1}X \rightarrow {}^{4}_{2}He + {}^{4}_{2}He$$

Identify and name particle X

Solution: it's a proton

Nuclear Fission and Nuclear Fusion

Nuclear Fission

This is the splitting of a heavy nucleus into two light nuclei by bombardment with an energetic particle.

During this process a lot of energy is released *eg*.

$$^{235}_{92}U \quad + \quad ^{1}_{0}n \quad \rightarrow \ ^{141}_{56}Ba \quad + \ ^{92}_{36}Kr \ + 3\ ^{1}_{0}n + energy$$

Condition for fission to occur

- The nucleus should be bombarded by a highly energetic particle like a neutron
- There should be a heavy nucleus with isotopes which decay to produce high velocity neutrons.

Applications of fission

- Its used in production of atomic bombs
- Its also used in production of neutrons

Nuclear Fusion

This is the union of two light nuclei at extremely high temperatures to produce a heavy nucleus. *eg*

$$^{2}_{1}H \quad + \quad ^{3}_{1}H \quad \rightarrow \ ^{4}_{2}He \quad + \ ^{1}_{0}n + energy$$

Condition for fusion to occur

- High temperature is required to provide the nuclei which are to fuse with the energy to overcome electrostatic repulsion.
- Particles should approach each other at very high velocities to overcome the strong nuclear repulsion.

Note:

Solar energy is produced by the process of fusion

SECTIONA

1. The particles emitted by a hot piece of metal are

A. ions
B. protons
C. neutrons
D. electrons

2. Isotopes of an element.

(i) have same physical properties

(ii) have equal number of protons

(iii) have different number of neutrons

A. (i) only **C.** (ii) and (iii) only

B. (i) and (ii) only **D.** (i) and (iii) only

3. Which of the following statements is / are true about X-plates in a cathode ray oscilloscope.

(i) they control brightness of the screen

(ii) they deflect the electron beam horizontally

(iii) they are connected to the time base circuit

A. (i) and (ii) only C. (ii) and (iii) only

B. (i) and (iii) only D. (i) , (ii)and (iii) only

4. A radioactive material has a half-life of 3minutes. Find how long it takes a sample of mass $900g$ to decays to $56.25g$.

A. 4min B. 12min C. 16min D. 48min

5. A heated cathode of a vacuum tube emits

A. Protons B. neutrons C. electrons D. neucleons

6. Which of the following statements is correct about electrons in an atom?

(i) they are negatively charged

(ii) they revolve around the nucleus

(iii) they are found in the nucleus of the atom

A. (i) only C. (i) and (iii) only

B. (ii) and (iii) only D. (i) and (ii) only

7. Which of the following are advantages of a cathode ray oscilloscope when used as a voltmeter.

(i) the electron beam acts as a pointer of negligible inertia

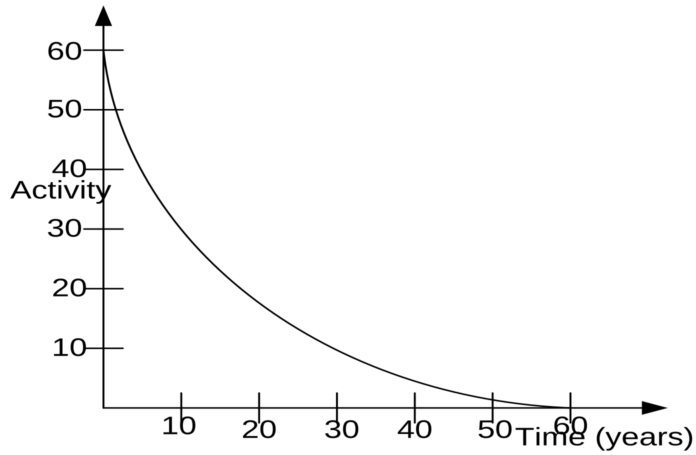
(ii) it draws more current from the circuit

(iii) it measure $a.c$ and $d.c$ voltages

A. (iii) only C. (i) and (iii) only

B. (ii) only D. (i) , (ii) and (iii)

8. Figure below shows a graph of variation of activity with time for a radioactive material



Find the half-life of the material

A. 10y B. 15y C. 20y D. 30y

9. Which of the nuclei ${}^{235}_{92}W$, ${}^{238}_{92}X$, ${}^{218}_{84}Y$ and ${}^{218}_{83}Z$ are isotopes?

A. W and Y B. X and Z C. Y and Z D. W and X

10. Which one of the following is not a radioactive emission?

A. $X - rays$ B. $\gamma - rays$ C. α – particles D. $\beta - particles$

11. In a cathode ray oscilloscope, the

A. horizontal plat deflect the electron beam in the Y-direction

B. electrons are accelerated towards the screen by the grid

C. vacuum hinders the motion of the electrons

D. electrons are emitted from heated anode

12. The radium ${}^{226}_{88}Ra$ nuclide has

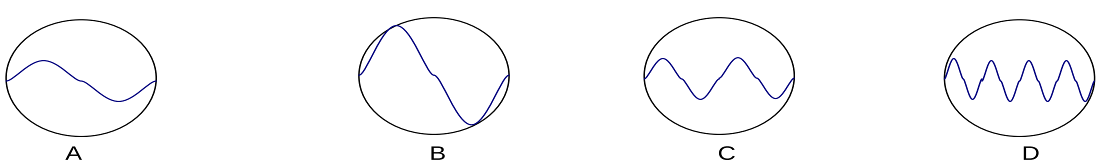
A. 138 protons and 88 neutrons

B. 138 neutrons and 88 protons

C. 138 electrons and 88 neutrons

D. 138 protons and 88 electrons

13. Which one of the following wave patterns on a C.R.O. represents sound of the highest pitch.



14. An element X has atomic mass of 228 and atomic number 90. It emits an β-particle forming an element Y. The symbol for Y is

A. ${}^{224}_{88}Y$ B. ${}^{228}_{90}Y$ C. ${}^{228}_{89}Y$ D. ${}^{228}_{91}Y$

15. An isotope of a nuclide ${}^{35}_{17}X$ has

A. 18 protons and 17 neutrons
B. 17 electrons and 18 neutrons
C. 17 protons and 20 neutrons
D. 18 protons and 18 neutrons

16. Which of the following equations represents a nuclear process in which an α- particle is emitted ?

A. ${}^{234}_{90}Th \rightarrow {}^{234}_{91}Pa$
B. ${}^{234}_{92}U \rightarrow {}^{230}_{90}Th$
C. ${}^{234}_{91}Pa \rightarrow {}^{234}_{92}U$
D. ${}^{222}_{86}Rn \rightarrow {}^{236}_{88}U$

17. The X and Y-plates in a cathode ray oscilloscope make up the

A. electron gun
B. deflecting system
C. focusing system
D. accelerating system

18. Cathode rays are

A. electromagnetic waves
B. streams of X-rays
C. protons emitted by a hot cathode
D. streams of electrons moving at high speed

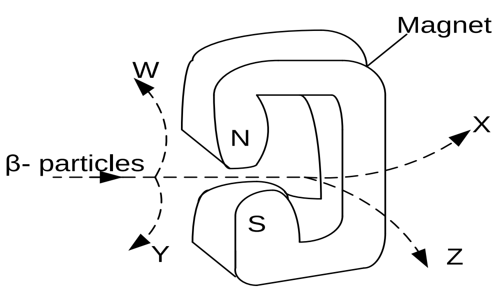
19. Which of the following gives the difference between α-particles and β-particles

A. The charge of an α-particles is +2 while that of and β-particles is -1
B. An α-particle is an electron while the β-particle is a helium atom
C. β-particles are more ionizing than α-particles
D. β-particles are heavier than α-particles

20. The particle that are emitted from a hot metal surface are called

A. electron B. neutrons C. proton D. alpha

21.



When a beam of $\beta - particles$ is directed between poles of a magnet as shown above, it will be deflected in the direction.

A. W
B. X
C . Y
D. Z

22. ${}^{236}_{92}X$ and ${}^{232}_{Z}X$ are isotopes of an element. Find the number of neutrons in the nucleus of ${}^{232}_{Z}X$

A. 144 B. 140 C. 92 D. 4

23. A nickel nuclide, ${}^{60}_{28}Ni$ contains

A. 28 protons and 28 neutrons
B. 32 electrons and 28 neutrons
C. 28 protons and 32 neutrons
D. 28 electrons and 32 protons

24. 2

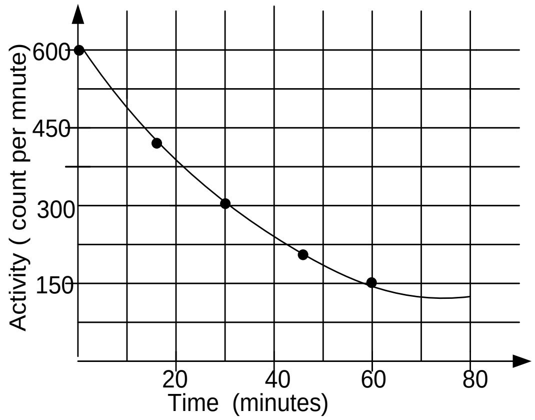


Figure above show a decay curve for a radioactive element. What is the half life of this element?

A. 15 minutes
B. 30 minutes
C. 45 minutes
D. 60 minutes

25. The activity of a radioactive element with a half life of 30 days is 2400 counts per second. Find the activity of the element after 120 days

A. 75 counts per second
C. 300 counts per second
B. 150 counts per second
D. 600 counts per second

26. $^{24}_{11}Na \rightarrow \; ^{A}_{Z}Y \; + ^{0}_{-1}\beta$

A radioisotope of sodium atom decays by emission of a beta particle as shown in the equation above. Find the values of A and Z

	A	Z
A.	24	10
B.	24	11
C.	24	12
D.	24	13

27.

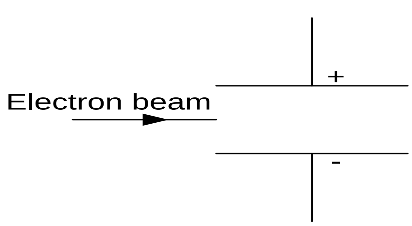


Figure above shows a beam of electrons incident mid way between two charged metal plates. Which of the following is correct?. The beam

A. is deflection towards the positive
B. is deflected towards the negative
C. moves perpendicular to plates
D. passes through the plates un deflected

28. A radioactive sample of 16g has a half –life of 6 days. How much of it will be left after 24 days

A. 1 g B. 4 g C. 32 g D. 48 g

29. An atom contains 3 electrons, 3 protons and 4 neutrons. Its nucleon number is

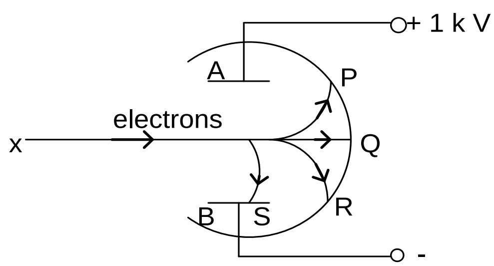
A. 3 B. 4 C. 6 D. 7

30. The process by which electrons are emitted from the surface of a metal by application of heat is known as

A. photoelectric emission C. thermionic emission

B. electromagnetic emission D. heat emission

31. In the diagram below, an electron beam XY enters an electric field between plates A and B as shown below.



which one is the possible route of movement of the electrons

A. YS

B. YR

C. YQ

D. YP

32. Radium nucleus $^{226}_{88}Ra$ decays to Randon (Rn) by α- particle emission. What is the nuclear equation for this reaction?

A. $^{226}_{88}Ra \rightarrow {}^{3}_{2}He + {}^{223}_{86}Rn$ C. $^{4}_{2}He + {}^{222}_{86}Rn \rightarrow {}^{226}_{88}Ra$

B. $^{226}_{88}Ra \rightarrow {}^{4}_{2}He + {}^{222}_{86}Rn$ D. $^{226}_{88}Ra \rightarrow {}^{1}_{0}n + {}^{225}_{86}Rn$

33. Which of the following parts of the cathode ray tube form the electron gun?

A. Cathode, metal anode, heater, grid

B. Grid, metal anode, cathode, Y-plates

C. Cathode, grid, heater, X-plates

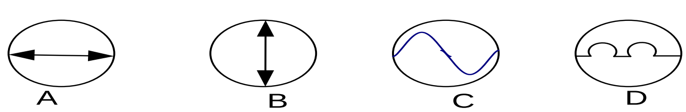
D. Cathode, metal anode, grid, heater, X-plates, Y-plates

34. State the radiations that may be emitted by a radioactive substance

A. Alpha, gamma and X-rays C. Gamma, alpha and beta

B. Cathode rays, X-rays and beta D. Cathode rays, X-rays and alpha

35. Which one of the sketches below represents the wave form observed in a C.R.O connected across an a.c supply when the time-base of the C.R.O is on?



36. The phenomenon by which electrons are released from a metal surface when radiation falls on it is known as

A. radioactivity

B. photoelectric effect

C. thermionic emission

D. reflection

37. The brightness of the spot on a C.R.O screen is controlled by

A. X-plate B. Anode C. grid D. cathode

38. The half-life of a radioactive 10s. How long will it take for mass of 16 g of that substance to reduce to 2 g.

A. 40s B. 30s C. 20s D. 10s

39. When uranium 235 is bombarded with a neutron, it splits according to the equation

$$ {}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{M}_{N}P + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n $$

M and N on P represent

	M	N
A .	56	141
B.	141	56
C.	199	36
D.	107	128

40. The brightness on the screen of a T.V set is determined by

A. darkness in the room

B. the size of the screen

C. the number of electrons reaching the screen

D. the direction of the aerial

41. Which of the following radiations is emitted from the nucleus of an atom

A. Cathode rays

B. gamma rays

C. infra red rays

D. ultra violet rays

42. The count rate from a radioactive source is 138 counts per minute when the background rate is 10 counts per minute. If the half- life of the source is 6 days. Find the count rate after 18 days.

A. 16.0 B. 17.25 C. 26 D. 42

43. In an atomic bomb, energy is produced by

A. fusion

B. fission

C. radioactivity

D. thermionic emission

44. Which of the following are attracted towards the negative plate in an electric field

A. Beta particles B. Alpha particles C. Gamma rays D. Neutrons

45. A rectifier is used to

A. step up an $a.c$ voltage

B. amplify an $a.c$ current

C. change an $a.c$ voltage to $d.c$ voltage D. change a $d.c$ voltage to an $a.c$ voltage

46. The cathode ray oscilloscope may be used to

(i) measure energy
(ii) measure potential difference
(iii) display wave forms

A. (i) only
B. (i) and (ii) only
C. (ii) and (iii) only
D. (i), (ii) and (iii)

47. Which of the following are properties of cathode rays?

(i) They travel in straight lines
(ii) They can penetrate thick sheet of paper
(iii) They darken a photographic plate
(iv) They are deflected by a magnetic field

A. (i), (iii) and (iv) only
B. (i), (ii) and (iv) only
C. (i), (ii) and (iii) only
D. (iv) only

48. Which of the following represents the appearance on the screen of a cathode ray oscilloscope when a $d.c$ voltage is connected across the Y-plate with the time- base switched on

A B C D

49. Thorium has a half-life of 24 days. How many days would it take 8 g of thorium to disintegrate to 1 g

A. 3 B. 24 C. 72 D. 96

50. Which one of the following is a property of X-rays?

A. They are deflected by magnetic field
B. They can ionize matter
C. They can cause photo-electric emission
D. They are electrically charged particles

51.

a b

Figures (a) shows a spot on the screen of a cathode ray oscilloscope. The spot can be turned into a horizontal straight line as shown in figure b) by

A. switching off the time-base
B. switching on the time-base
C. making one of the plates positive
D. connecting an $a.c$ voltage to the Y-plate

52. A possible isotope of ${}^{7}_{3}Li$

A. 2 protons and 3 neutrons
B. 2 protons and 4 neutrons
C. 3 protons and 4 neutrons
D. 4 protons and 2 protons

53. ${}^{228}_{90}Th \rightarrow {}^{A}_{Z}X + alpha\ particles$

The above equation represents an activity in which thorium decays and emits an alpha particle. Find the value of Z

A. 88 B. 89 C. 91 D. 92

54. Which of the following are not electromagnetic waves

A. X-rays
B. Radar waves
C. Microwaves
D. Sound waves

55. What is the process by which electrons are emitted from a hot filament

A. Radioactivity
B. Nuclear reaction
C. Thermionic emission
D. Thermoelectric effect

56. Elements X emits radiation r and forms element Y as given in the equation

$$\boldsymbol{{}^{A}_{Z}X \rightarrow {}_{Z-1}^{\ \ A}Y + r}$$

While A and Z are mass and atomic numbers respectively, radiation r is

A. alpha particles
B. beta particles
C. gamma rays
D. X-rays

57. The atomic number of an electron is the number of

A. protons in its atom
B. neutrons in its atom
C. electrons and protons in its atom
D. neutrons and protons in its atom

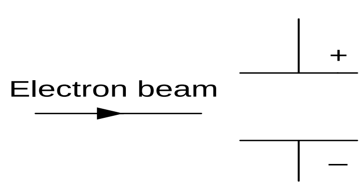
58. Nuclear fission occurs when

A. uranium is heated to a very high temperature
B. two deuterium (heavy hydrogen) atoms come tighter
C. a hydrogen molecule splits into two atoms
D. nuclei of uranium atoms split into lighter nuclides

59. The half-life of a radioactive elements is 10 days. Find the mass left after 40 days if the initial mass is 16 g

A. 1 g B. 2 g C. 4 g D. 8 g

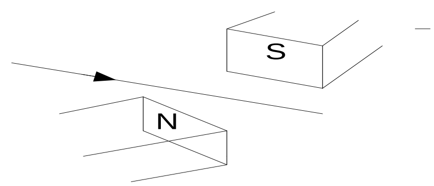
60.



A beam of electrons is incident mid way between two charged plates as shown above. The beam will

A. deflected upwards
B. deflected downwards
C. move perpendicular to the plates
D. pass through the plates un deflected

61.



The diagram above shows a beam of electrons directed to pass between the poles of a magnet. The electron beam would be.

A. deflected towards the south pole
B. deflected downwards
C. slowed down
D. reflected backwards

62. X-rays are

A. electrons of high velocity
B. particles of negative charge
C. neutrons of high velocity
D. electromagnetic waves

63. An alternating current can be changed to direct current by a

A. transformer
B. moving coil galvanometer
C. dynamo
D. diode

Section B

1. (a) Describe the composition of $^{238}_{92}U$

(b) A radioactive nuclide $^{235}_{92}X$ emits an alpha particle and a new nuclide Y is formed. Write a balanced equation to represent this nuclear change

(C) Give two applications of nuclear energy

2. (a) Give two differences between cathode rays and X-rays

(b) Why is there

(i) a cooling system in an X-ray tube ?

(ii) a vacuum in an X-ray tube?

3. **(a)** State any two properties of alpha particles

(b) Radon $^{222}_{86}Rn$ decays to radium isotope Ra, by emission of two beta particles according to the following equation.

$$^{222}_{86}Rn \rightarrow {}^{A}_{88}Ra + 2{}^{0}_{-1}e$$

(i) What is the value of A?

(ii) How many neutrons does the nucleus of radium isotope have?

4. **(a)** What is the purpose of a vacuum in the X-ray tube

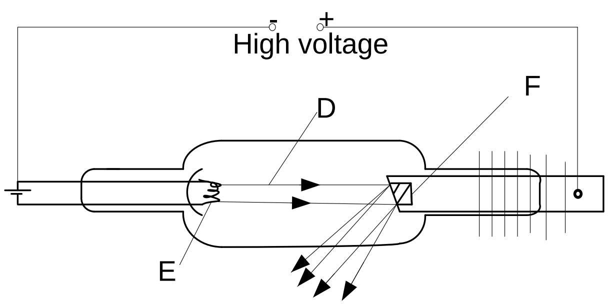
(b) State three reasons why it is possible to detect fractures in bones using X-rays

5. **(a)** What is meant by the term **radioactivity**

(b) ${}^{234}_{90}A \xrightarrow{(i)} {}^{234}_{90}B \xrightarrow{(ii)} {}^{234}_{92}C \xrightarrow{(iii)} {}^{230}_{90}D$

(i) The above equation shows three stage (i), (ii) and (iii) of the series

(ii) Which of the nuclei A, B,C and D are isotopes



The figure above shows the diagram of an X-ray tube

(a) Name the part labelled E

(b) What is the function of the part labelled F

(c) Why is the X-ray tube evacuated

(d) State two precautions to be taken when using X-rays

7. (a) What is meant by radioactivity?

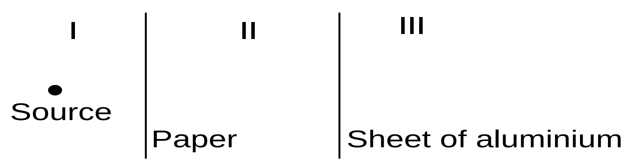
(b) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{236}_{92}U \rightarrow {}^{144}_{x}Ba + {}^{y}_{36}Kr + 2\,{}^{1}_{0}n + energy$

The equation above show a reaction which takes place in a nuclear reactor

(i) Name the reaction shown by the equation

(ii) Find x and y

8. (a)



A piece of paper and a thin sheet of aluminum are placed near a radioactive source as shown. If three different types of radiations are emitted, identify the radiations in

(i) region I (ii) region II (iii) region III

(b) What would be effect of an electric field on radiations in regions III

9.

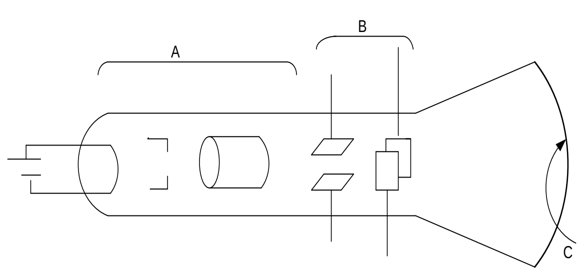


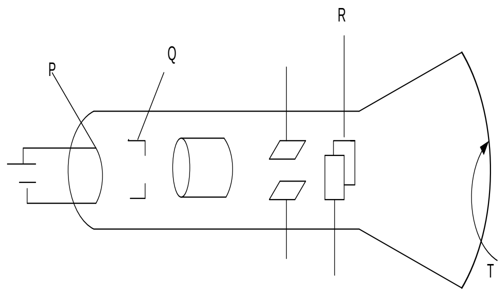
Figure above shows the main features of a cathode ray oscilloscope (C.R.O)

(a) (i) Name the parts labeled A, B and C

(ii) State the function of the parts labelled B

(b) State three applications of a C.R.O

10.



a) Figure above shows the main parts of a cathode ray oscilloscope. Name the parts labelled P, Q, R and T

b) State the functions of the parts labelled Q and T

11. (a) What is meant by

(i) mass number (ii) atomic number

(b) Name any two radiations emitted by a radioactive substance

12. (a) What is meant by radioactivity

(b) A radioactive material takes 50 hours for 93.75% of its mass to decay. Find its half-life

13. (a) (i) What is meant by nuclear fission

(ii) Give one method of starting the process in (a) (i)

(b) (i) Account for the energy released in nuclear fission

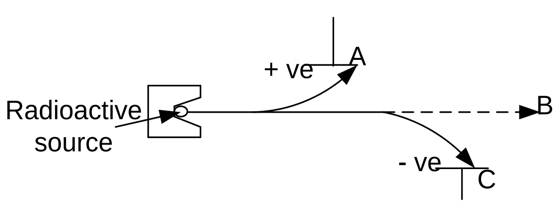
(ii) State one use of nuclear energy

14. (a) What is thermionic emission

(b) (i) State the function of a fluorescent screen on a C.R.O

(ii) Give two applications of a C.R.O

15.



A radioactive source emits radiations which are directed between two positive charged metal plates as shown above

(a) Name the radiation labelled A, B and C

(b) what can you deduce about the charges of the radiation

(c) what happens when the radio active source is completely covered with an ordinary sheet of paper

16. (a) What is meant by thermionic emission

(b) State two difference between cathode rays and X-rays

(c) In the production of X-rays in an X-ray tube, why the target must be cooled

17. The symbol $^{235}_{92}U$ denotes a uranium nucleus

(a) what is the meaning of

(i) 235? (ii) 92?

(b) Write down a balanced nuclear equation showing the decay of $^{235}_{92}U$ to a nuclide X by emission of an alpha particle

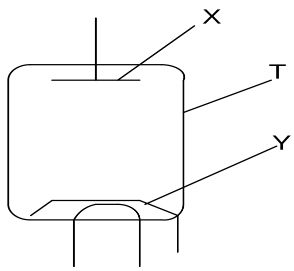
18. **(a)** What is a radioactive nuclide

(b) A radioactive element, X decays by emitting an alpha particle and gamma rays. Write a balanced equation for the decay.

(c) State what happens to a beta particle as it passes in between two oppositely charged plates

19. **(a)** What is thermionic emission

(b)



(i) The diagram above shows a thermionic diode. Name the parts labelled X and Y

(ii) Describe briefly how electrons are made to move across the tube T

Paper 2

1. **(a)** **(i)** Define the term **half- life** as applied to radioactivity

(iii) A radioactive material has a half life of 5 minutes. If the initial mass of the material is 120g, calculate the mass that decays after 20minutes.

(iii) Sketch a graph of the number of atoms of a radioactive material present against time to show how the half –life is determined from it.

(b) Explain the nature of the tracks of alpha particles and beta particles in air

(e) How does the passage of a beta particle through an electric field differ from that of an X-ray?

2. (a) List any two differences between X-rays and gamma rays

(b) With the aid of a labelled diagram describe how X-rays are produced

(c) What are the differences between hard and soft X-rays ?

(d) Define the following

(i) radioactive nuclide

(ii) isotopes

(g) Outline **three** uses of radioactivity

3. (a) What is meant by **thermionic emission**

(b) **(i)** Name the three main components of a cathode ray oscilloscope (C R O)

(ii) Describe the functions of each components you have named in (b) (i)

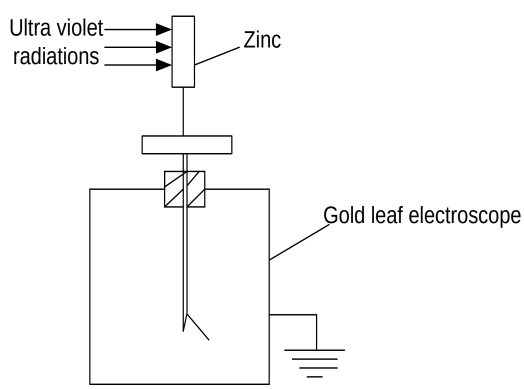
(iii) Give two uses of a C.R.O

(C) State the condition under which electrons can be used to generate X-rays

(d) Give one use of X-rays

4. **(a)** Distinguish between thermionic emission and photoelectric emission

(b)



Ultra violet radiations is incident on a clean zinc plate resting on the cap of a charged gold leaf electroscope as shown above. Explain what is observed if;

(i) the gold leaf electroscope is positively charged

(ii) radio waves is used instead of ultraviolet radiations

(vii) (i) With the aid of a labelled diagram, describe how X-rays are produced in an X-ray tube

(ii) Explain why soft X-rays are used instead of hard X-rays to take photographs of internal parts of a patient in hospital

20. (a) What is meant by

(i) radioactivity

(ii) half life

(b) What happens to activity of a radioactive material when its

(i) mass is increased

(ii) temperature is increased

(c) A material is wrapped in a photographic film and kept in a dark room. When the photographic film is removed, it is found to be darkened.

(i) Identify the material

(ii) Explain the observation

(viii) A radioactive substance of mass 60 g takes 400 years for its mass to be reduced to 15 g. Find its half- life

(ix) State

(i) two industrial and two medical uses of radioactivity

(ii) two health hazards of radioactivity

21. (a) (i) What are cathode rays?

(ii) State two differences between gamma rays and cathode rays

(b) Describe a simple experiment to distinguish the three radiations that are emitted by radioactive materials

(c) A radioactive element has a half life of 4 minutes. Given that the original count rate is 256 counts per minute,

i. find the time taken to reach a count rate of 16 counts per minute

ii. what fraction of the original number of atoms will be left by the time the count rate is 16 counts per minute

(d) **(i)** Which of the following nuclei belong to the same element

$$^{24}_{11}X\ ,\ \ ^{24}_{12}Y\ ,\ \ ^{25}_{11}Z$$

(ii) what is nuclear fusion?

22. **(a)** What are X-rays

(b) With the aid of a labelled diagram, describe the structure and operation of an X-ray tube

(c) Explain briefly how each of the following can be increased in an X-ray tube:

(i) intensity of X-rays

(ii) penetrating power of X-rays

(d) State **four** ways in which X-rays are similar to gamma rays

(e) Give **two** biological uses of X-rays

12. (a) (i) Distinguish between nuclear fusion and nuclear fission

(ii) State one example where nuclear fusion occurs naturally

(b) State one use of nuclear fission

(c) The following nuclear reaction takes place when a neutron bombards a sulphur atom.

$$^{34}_{16}S + ^{1}_{0}n \rightarrow \ ^{a}_{b}Y$$

(i) Describe the composition of the nuclide, Y formed

(ii) The nuclide, Y decays by emission of an α- particles and a γ-ray. Find the changes in mass number and atomic number of the nuclide

(iii) state two properties of α-particles

(d) The half-life of the isotope cobalt-60 is five years. What fraction of the isotope remain after 15 years

(e) State;

(i) one medical use of radioactive

(ii) two ways of minimizing the hazardous effects of radiation from radioactive materials

23. (a) Draw a labelled diagram to show the main bands of the electromagnetic spectrum

(b) (i) With the aid of a labelled diagram, describe how X-rays are produced in an x-ray tube.

(ii) State two applications of X-rays.

(c) The half-life of a radioactive substance is 3hours. Find how long it takes for the mass of the substance to reduce to one-quarter of its original mass.

24. (a) (i) What is meant by cathode rays

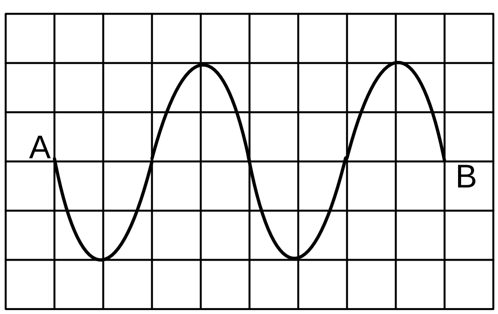
(ii) With the aid of a labelled diagram, describe how cathode rays are produced by thermionic emission

(b) With reference to the cathode ray oscilloscope, describe

(i) the function of the time-base

(ii) how the brightness is regulated

(c) A cathode ray oscilloscope (C.R.O) with time base switched on is connected across a power supply. The wave form shown below is obtained



Distance between each line is 1cm

(i) identify the type of voltage generated by the power supply

(ii) find the amplitude of the voltage generated if the voltage gain is 5 $V\ cm^{-1}$

(iii) Calculate the frequency of the power source if the time base base setting on the C.R.O is $5.0x\ 10^{-3}\ s\ cm^{-1}$

25. (a) What is meant by the following

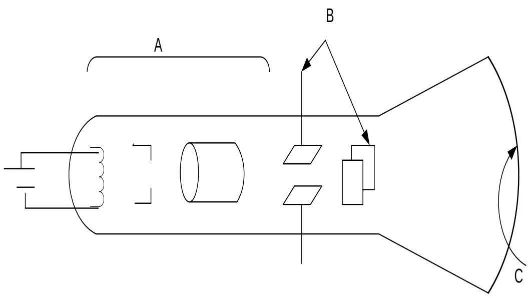
(i) thermionic emission (ii) photo-electric effect

(b) (i) State the condition necessary for photo electric effect to take place

(ii) With aid of a labelled diagram, describe how an alternating current can be fully rectified

(c) Explain how leakage of charge occurs at the ends of sharp conductors

26. (a)



The diagram above shows the main parts of a cathode ray oscilloscope (C.R.O)

(i) Name the parts labelled A, B, and C

(ii) Why is the C.R.O evacuated

(b) **(i)** Describe briefly the principle of operation of C.R.O

(ii) How is the bright spot formed on the screen

(c) Use diagrams to show what is observed on the screen of a C.R.O when

(i) the C.R.O is switched on and no signal is applied to the Y-plate

(ii) the time – base is switched on and no signal is applied to the Y-plate

(iii) an alternating signal is applied to the Y-plate while the time- base is switched off

(d) Give two uses of the C.R.O

27. (a) Describe a simple model of the atom

(b) Define the following terms

(i) Atomic number (ii) Isotopes of an element

(c) State two differences between an α-particle and a β-particle

(d) (i) What is meant by nuclear fission and nuclear fusion

(ii) Give one example of where each one occurs

28. (a) Name the electromagnetic radiation which

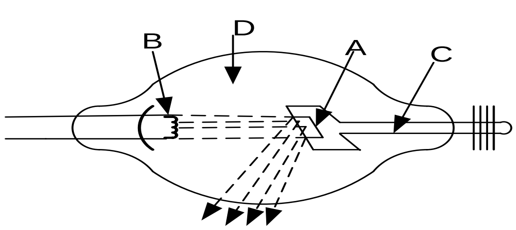
(i) causes sensation of heat

(ii) passes through a thin sheet of lead

(iii) is used in a satellite communications

(iv) is used for remote control of a television receiver

The diagram below shows main parts of an X-ray tube



(b) Name the parts labelled A, B, C and D

(C) List in order the energy changes which occur in the x-ray tube

(d) Describe one industrial use of x-rays

(e) (i) What is meant by the half-life of a radioactive material

(ii) The activity of a radioactive source decrease from 4000 counts per minute to 250 counts per minute in 40 minutes. What is the half-life of the source.

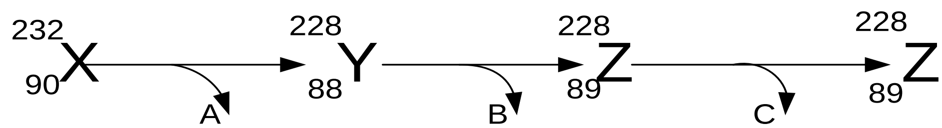
29. (a) Define half-life of a radioactive substance

(b) The mass of a radioactive substance decays to a $\frac{1^{th}}{16}$ of its original mass after16 days what

(i) is its half-life?

(ii) fraction of original mass will have decayed after 20 days

(d)



(i) Identify the particles or radiations A, B and C emitted in the decay process shown above

(ii) state two differences between radiations A and B

(iii) Name two health hazards of radioactivity

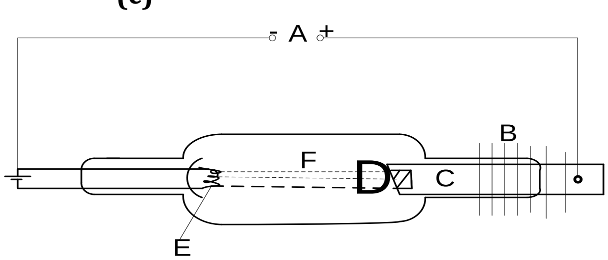
(iv) What is the difference between nuclear fusion and nuclear fission?

30. (a) (i) What is meant by a radioisotopes?

(ii) State one biological and one industrial application of radioisotopes

(b) Describe what happens when a beam of radiations consisting of α, β and γ-rays is incident on a thin sheet of lead

(c)



The diagram in the figure shows the essential parts of an X-ray tube

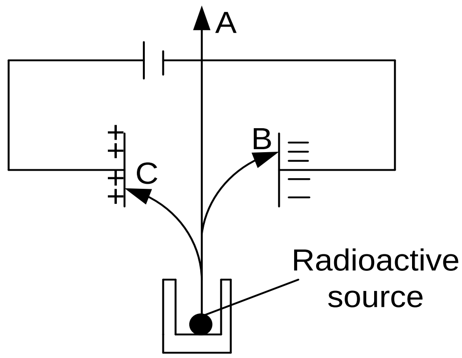
(i) Name the part labelled A, B, C, D, E and F

(ii) State the function of each part

(iii) Describe how x-rays are produced

(d) What safety precautions must be taken in an X-ray Laboratory?

31. (a) What is an alpha particle?



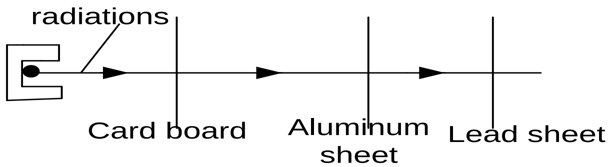
(b) A radioactive source decays by emission of all the three radiations. The radiation enter normally into an electric field as shown above. Which radiation are most likely to be detected at

(i) position A

(ii) position B

(iii) position C

(c)



A radioactive source which emits all the three radiations is placed in front of cardboard, aluminum and lead sheets as shown above. Name the radiation likely to be between the;

(i) Cardboard and the aluminum sheet

(ii) aluminum and lead sheets

(d) Name any three precautions which must be undertaken by one working with ionizing radiation

(e) Name one industrial and one biological use of radioactivity

32. (a) What is meant by the term

(i) isotopes **(ii)** Atomic number?

(b) (i) Name and state the nature of the emission from radioactive nuclides

(ii) What effects does each of the emissions have on the parent nuclide

(C) A radioactive sample has a half-life of $3x10^3$years

(i) What does the statement half-life of $3x10^3$years mean

(ii) How long does it take for three-quarters of the sample to decay

(d) Give two uses of radioactivity

MAGNETISM AND ELECTROMAGNETISM

MAGNETISM

A magnet is a substance which is able to attract a magnetic substance and it always points south-north direction when freely suspended.

Ferro magnetic / magnetic substances

These are substances which can be attracted by magnets.

$e.g$ Iron, steel, cobalt, tin, nickel $e.t.c$

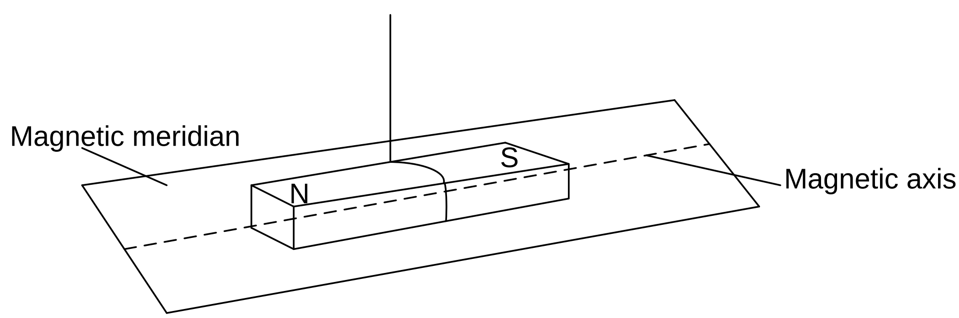
Non-magnetic substances

These are substances which cannot be attracted by a magnet.

$e.g$ Rubber, glass, copper tin, bronze, plastic $e.t.c$

Properties of a magnet

- Like poles repel and unlike poles attract
- When freely suspended it rest in the north- south direction with the north facing geographic north.
- Magnetic field lines run from north to south
- Magnetic force of attraction and repulsion is greatest at the poles.



When a freely suspended magnet rest in an approximate North- South direction.

The pole which points the north is called the North Pole (N) and the other is called South Pole (S).

(i) Magnetic axis

It is the central line joining the two poles

Or it is a line through the magnet about which the magnets magnetism is symmetrical.

(ii) Magnetic meridian

It is a vertical plane in which a freely suspended magnet rests.

(iii) Pole

This is a point on a magnet where the resultant attractive force appears to be concentrated.

Laws of magnetism

It states that like poles repel each other and unlike poles attract each other.

Determination of the polarity of a magnet

- The polarity of a magnet can be determined by bringing both poles in turn near to the known pole of a suspended magnet.
- Repulsion indicates similar polarity.

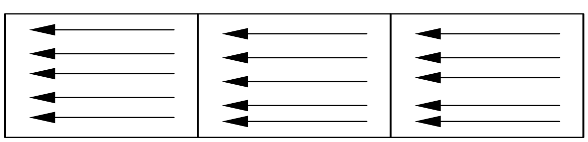
Note: Repulsion is the only sure test for the polarity of a magnet since attraction indicates two unlike poles or a pole and a magnet

THEORY OF MAGNETISM (DOMAIN THEEORY)

A magnet is made up of very many tiny magnets with their north poles pointing the same direction.

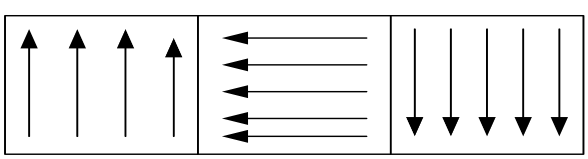
These tiny magnet are called dipoles.

- In a magnetized state all the dipoles face the same direction



Magnetized state

- In un magnetized state the domains are randomly arranged, the pole of one being neutral by the south pole of another.

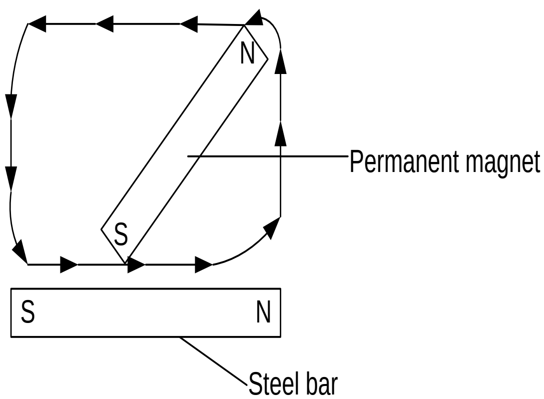


Un Magnetized state

Magnetization / Preparation of a magnet

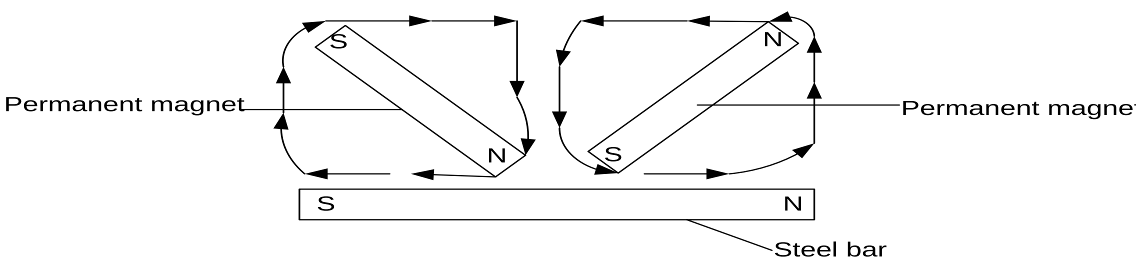
a) Stroking method

(i) Single touch method



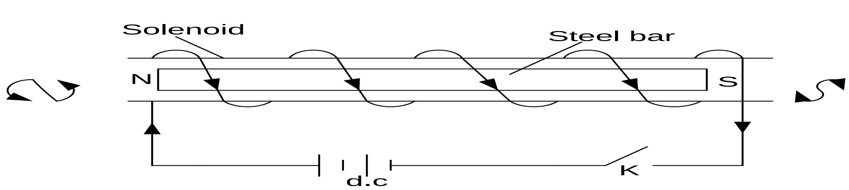
- In single touch method, a steel bar is stroked from one end to another several times in the same direction using the same pole of a permanent bar magnet.
- At the end of each stroke, the magnet is lifted up high above the steel bar.
- The pole produced at the end of the steel bar where the stroke ends is opposite to that of the stroking pole.

(ii) Divided / double touch method



- The steel bar is stroked from the center out wards with unlike poles simultaneously several times.
- At the end of each stroke both magnets are lifted up high above the steel bar.
- The poles produced at the ends of each stroke of the steel bar are opposite to the stroking poles respectively.

b) Electrical method



- A steel bar is placed inside a cylindrical solenoid having many turns of a copper wire and connected to a direct current supply.
- If the current is switched on for a short time and turned off, the steel bar will be magnetized

- The polarity of the magnet can be determined by looking at the end of the bar, if the current is flowing in a clockwise direction, that end will be South Pole and if it's flowing in anticlockwise direction that end will be North Pole.

Demagnetization

It is a process by which magnetization is weakened and finally destroyed.

It is achieved;

(a) Using alternating current ($a.c$)

The magnet is demagnetized by placing it in a solenoid through which an $a.c$ is flowing with the current still flowing, the magnet is slowing removed to a distance away from the solenoid while in the East – West direction.

(b) Strong heating and allowing it to cool while in an East – West direction.

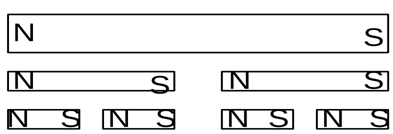
(c) Hammering while lying in East – West direction.

(d) Keeping like poles of a magnet near each other.

BREAKING A MAGNET

If a magnet is broken into two or more pieces each piece will be a perfect magnet with poles at either ends because each particle or molecule of a magnet is itself a complete magnet.

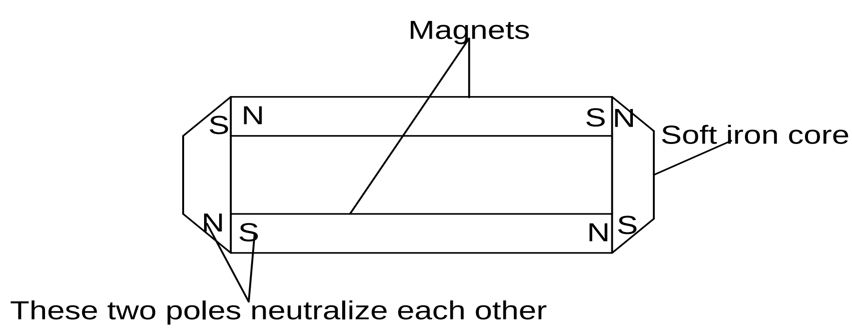
It is impossible to obtain a separate north or South Pole.



MAGNETIC KEEPERS

A bar magnet tends to become weaker with age, owing to self-demagnetization. This is caused by reversal of the direction atomic dipoles at the end of the poles of a magnet.

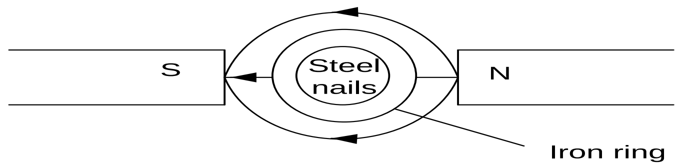
In order to prevent this bar magnets are stored in pairs with their opposite poles adjacent to each other using small pieces of soft iron called keepers placed across their ends.



MAGNETIC SCREENING / SHIELDING

The concentration of lines of force in soft iron can be used to shield objects from unwanted magnetism.

Delicate measuring instruments which are liable to be affected by external magnetic fields can be protected by enclosing them in thick walled soft iron ring.



Soft magnetic materials

These are materials which can easily be magnetized and also lose their magnetism easily.

Example is iron

Application

They are used in construction of electric bells, relays, electromagnets, transformers

Hard magnetic materials

These are materials which are not easily magnetized but take too long to lose their magnetism.

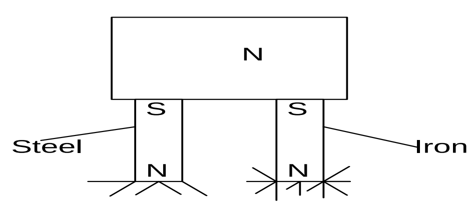
Example is steel

Application

They are used in construction of electric mortars, dynamos, loud speakers, telephone receivers.

Experiment to distinguish between soft and hard magnetic materials

- A strip of iron and steel of the same dimension both initially un magnetized are suspended side by side in contact with a pole of a permanent magnet. Both strips become magnetized by induction.
- Dip both steel and iron in iron fillings



- More iron fillings cling to iron indicating iron is easily magnetized than steel.
- Remove the strips from the magnet, more iron fillings remain on steel indicating that steel is not easily demagnetized and iron is easily demagnetized.

Magnetic field

This is the space around a magnet where magnetic force is exerted.

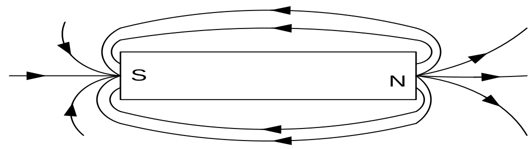
The field is strong close to the poles of a magnet and gets weaker further away.

The magnetic field is represented by lines of magnetic force called **magnetic flux** and they can be traced by use of a plotting compass or iron fillings.

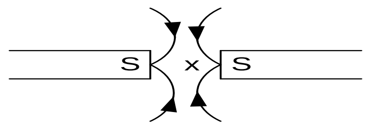
Magnetic field lines start from North Pole and end on the South Pole and never touch nor cross each other.

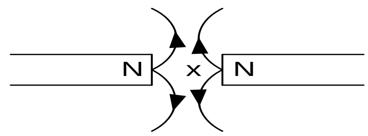
Magnetic field line patterns

(a) a bar magnet



(b) two like poles close to each other

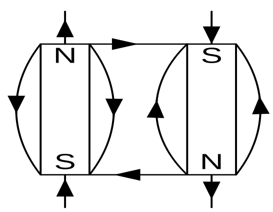




X- Is the **neutral point**

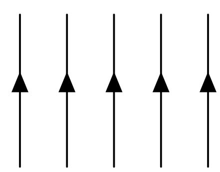
Neutral point is defined as a point at which the resultant magnetic flux density is zero**.**

(c) two un like poles close to each other



Earth's magnetic field

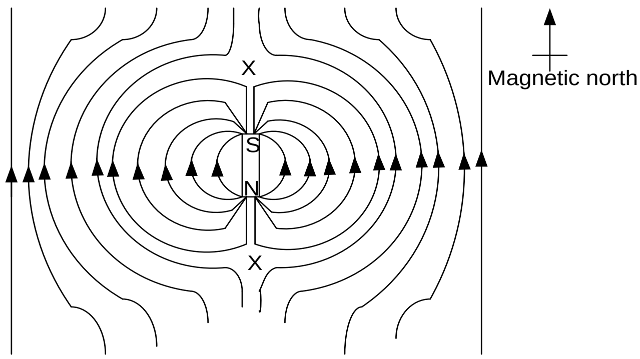
They run from geographic south to geographic north



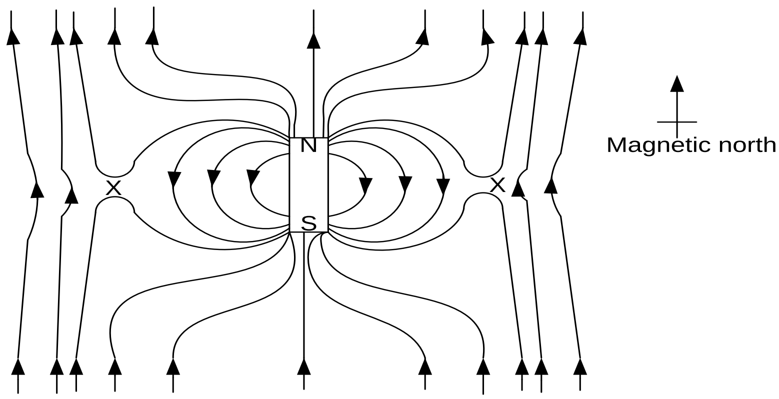
This shows that the earth behaves like a magnet with the North Pole in the southern hemisphere and South Pole in the north hemisphere.

A bar magnet in earth's magnetic field (Combined magnetic field)

a) **A bar magnet with its north pole on the earth geographic south**



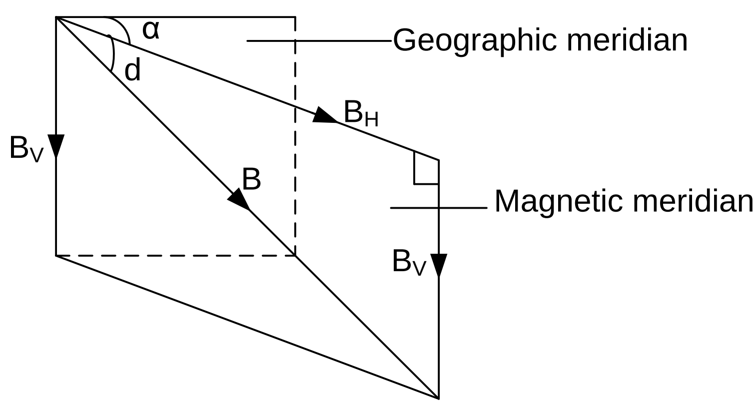
b) **A bar with its north pole in the earth geographic south**



***X*- Is the neutral point:**

Neutral point is defined as a point at which the resultant magnetic flux density is zero

Specification of the earth's magnetic field



Geographic meridian of a place:

This is a vertical plane containing the place and the earth axis of rotation.

Magnetic meridian of a place:

This is a vertical plane containing the magnetic axis of a freely suspended magnet under the influence of the earth magnetic field.

Angle of declination(α):

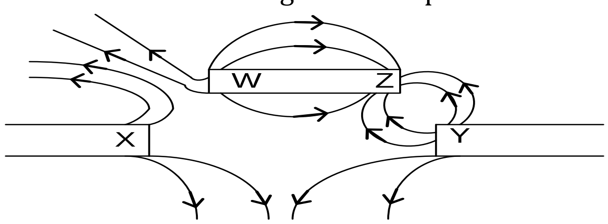
This is the angle between the magnetic meridian and geographic meridian

Angle of Dip (Angle of inclination):

This is the angle between the earth's magnetic field and the horizontal.

SECTION A

1. The figure below shows a magnetic field pattern around magnetic poles W, X, Y and Z



Which one of the following is correct about the poles W, X, Y and Z?

A. X and Z repel each other and they are North poles

B. Z and Y attract each other and will have a neutral point between them

C. X and Z repel each other and will have a neutral point between them

D. Y and W repel each other and they are both North poles

2. Which one of the following is correct about the molecular theory of magnets?

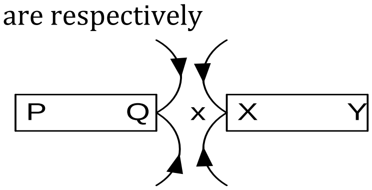
A. Dipoles of a magnetized material face the same direction

B. Un magnetized magnetic materials have no molecular magnets

C. Magnetic keepers reduce the magnetic force of the dipoles

D. Un magnetized magnetic materials have molecular magnets arranged in an orderly manner

3. The figure below shows magnetic field lines between two magnetic poles. The poles marked P, Q, X and Y are respectively



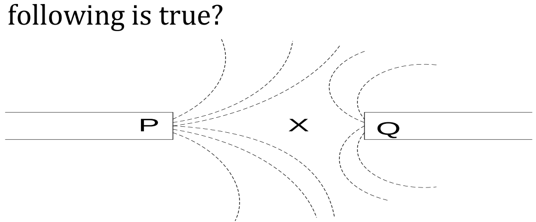
A. north, south, south and north

B. south, north, north and south

C. north, north, south and north

D. south, south, north and south

4. The figure above shows a pattern of iron fillings between two magnetic poles P and Q . Which one of the following is true?



(i) P and Q are liked poles

(ii) Pole P is strong than Pole Q

(iii)X is a neutral point

A. (i) only B. (i) and (ii) only

C. (ii) and (iii) D. (i),(ii) and (iii)

5. A magnet can be made to lose its strength by

(i) Heating

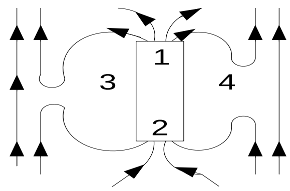
(ii) Throwing it violently

(iii) Putting it in a solenoid carrying direct current

A. (i) and (iii) only B. (ii) and (iii) only

C. (i) and (ii) only D. (i) , (ii) and (iii)

6.



The figure above shows the superposition of the earth's magnetic field and the field due to a magnet. Identify point marked 1, 2, 3 and 4

	1	2	3	4
A	South pole	North pole	Neutral point	Neutral point
B	North pole	South pole	Neutral point	Neutral point
C	Neutral point	Neutral point	North pole	South pole
D	Neutral point	Neutral point	South pole	North pole

7. A magnetic material can be magnetized by

(i) Stroking with a permanent magnet

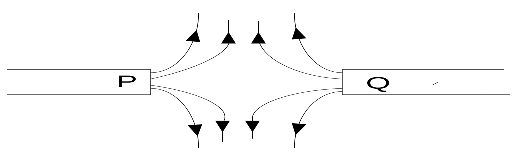
(ii) Using a direct current

(iii) By induction

A. (i) only B. (i) and (ii) only

C. (ii) and (iii) only D. (i), (ii) and (iii)

8.



	P	Q
A	N pole	S pole
B	N pole	N pole
C	S pole	S pole
D	S pole	Un magnetised iron bar

In the figure above name the polarities P and Q

9. Which of the following statements is not true about magnets?

A. Magnetic poles cannot be separated

B. Paramagnetic material is a material from which strong magnet can be made

C. The neutral point in a magnetic field is a point where there is no force experienced

D. Heating a magnet can reduce its magnetism.

10. Which of the following statements are correct?

(i) The particles of magnetic materials are tiny magnets

(ii) The particle is un magnetized iron arrange themselves in close chairs

(iii) The particles in a magnet are arranged in open chains with N pole of one particle against the S pole of its neighboring particle.

(iv) groups of atoms form a magnetic domain

A. (i), (ii) and (iii) only B. (i) , (iii) and (iv) only

C. (ii) and (iv) only D. (iv) only

11. Which one of the following diagrams shows the correct arrangement of the magnetic domains in a magnetized material?

A B C D

12. Which of the following statement(s) is/are true about molecular theory of magnetism?

A. breaking a magnet into two results to the formation of two magnet

B. heating and rough treatment destroys magnetism

C. the poles of a magnet are of equal strength

D. The lines of force travel from a north pole towards a south pole.

13. Four bars of metal P, Q, R, S are tested for magnetism. Q attracts both P and R but not S. S does not attract P ,Q or R. P and R sometimes attracts one another and sometimes repel each other . Which of the following statements is correct about P,Q,R and S?

A. P,Q and R are magnets, S is a magnetic

B. P and Q are magnets, R and S magnetic

C. P and R are magnets , Q is magnetic, S is non magnetic

D. P and R are magnets, Q and S are non magnetic.

SECTIONB

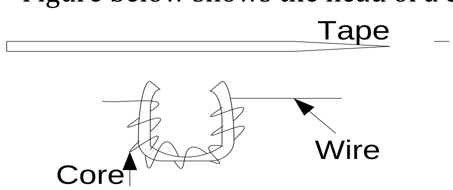
1. (a) What is meant by neutral point as applied to a magnetic field?

(b) (i) Draw a diagram to show the magnetic field pattern due to an iron ring placed in the earth's magnetic field

(ii) State one application of the effect illustrated in b (ii)

2. (a) What is magnetic field?

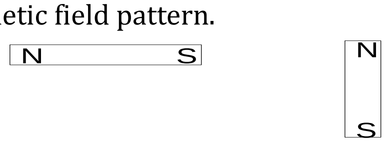
(b) Figure below shows the head of a cassette tape recorder



(i) Explain why a current through the wire causes the tape to become magnetized

(ii) The tape is usually made of plastic and coated with a thin layer of iron oxide. Why is iron oxide used?

3. (a) The diagram below shows tow identical bar magnets placed close to each other. On the diagram, draw the resultant magnetic field pattern.



(b) (i) Explain each of the following observations.

(i) A magnet hot stored in soft iron keepers becomes weaker.

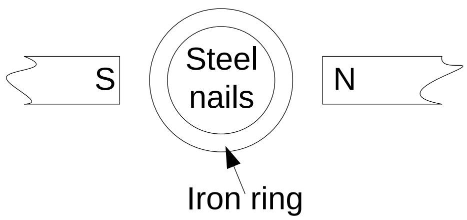
4. (a) What is a neutral point in a magnetic field?

(b)

The diagram above shows a straight conductor carrying current vertically upwards placed near a bar magnet. Sketch the magnetic field pattern around the wire and magnet.

5. (a) List two ways by which a magnet may lose its magnetic properties.

(b)



The figure above shows an iron ring between two opposite magnetic poles.

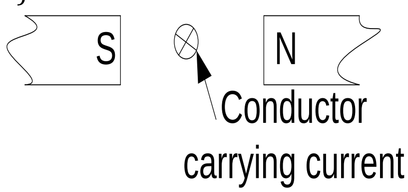
(i) Sketch the magnetic lines of force on the diagram

(ii) Explain what happens to the steel nails

6. (a) What is a soft magnetic material?

(b) State two ways in which a bar magnet can be demagnetized.

(C)



The figure above shows a straight conductor carrying current between the poles of a permanent magnet. Sketch on the diagram above the resulted magnetic field pattern.

ELECTROSTATICS (STATIC ELECTRICITY)

This means electricity at rest. It's observed;

When a plastic pen is rubbed with a cloth, it will pick up some pieces of paper.

A nylon cloth often crackles when it is taken off and if the room is dark, sparks can be seen too.

ELECTROSTATICS: Theory of static electricity

To understand static electricity, we look at the structure of an atom.

- An atom is made up of the central part called the nucleus which contains protons and neutrons, protons are positively charged and neutrons carry no charge.
- Revolving around the nucleus are electrons that are negatively charged
- The protons have an equal number to the electrons hence an atom is electrically neutral as a whole

Electrification by friction / charging by rubbing or friction

- When two bodies are rubbed together, body with loose electrons will lose its electrons to a body with firm electrons.
- The body which acquires electrons will have an excess of electrons hence becomes negatively charged while the body that loses electrons will have a deficiency of electrons hence it becomes positively charged.
- The number of electrons lost is equal to the number of electrons acquire therefore two insulating bodies rubbed together acquire equal and opposite charges.

Examples of charging by friction

- When a polythene rod (ebonite rod) is rubbed with fur (woolen duster), the ebonite rod becomes negatively charged while the duster becomes positively charged.
- If a glass rod (cellulose acetate) is rubbed with silk, a glass rod becomes positively charged while the silk becomes negatively charged.

Insulators and conductors

Conductor

This is a material with free electrons and it can allow electricity and heat to pass through it.

Examples: Copper, bronze

Insulator

This is a material without free electrons and it cannot allow electricity and heat to pass through it.

Examples: Dry wood, plastic

Semiconductors

These are materials which allow electric charges to pass through them with difficulty.

Examples: Moist air, paper

Law of electrostatics

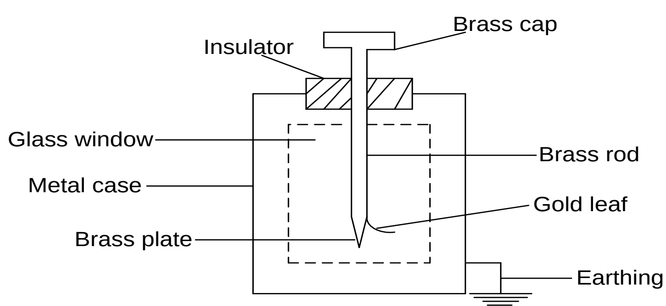
Like charges repel each other and unlike charges attract each other.

Precautions taken when carrying experiments in electrostatics

(i) Apparatus must be insulated

(ii) The surrounding must be free from dust and moisture

GOLD LEAF ELETROSCOPE (GLE)



Uses of GLE

(i) Test for the presence of charge

(ii) Test the sign of the charge

(iii) To test the magnitude of charge

(iv) Measure $p.d$

Electrostatic induction

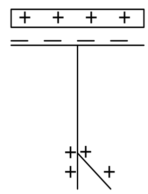
It's a phenomenon that describes the formation of charges on a conductor when a charged body is brought near it.

The charge acquired is opposite to that of inducing body.

Charging a gold leaf electroscope by induction

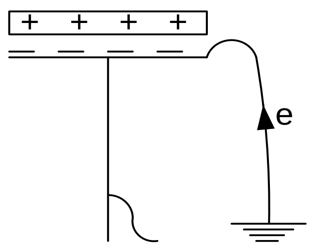
(a) Charging G.L.E negatively

i)



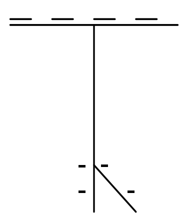
A positively charged glass rod is brought near the cap of the G.L.E, negative charges are induced on the brass cap and positive charges on G.L.E and brass plate.
The gold leaf diverges.

ii)



With glass rod still in position, the G.L.E is earthed momentarily by touching.
Electrons flow from the earth and neutralize the positive charge on the brass plate and gold leaf thus collapses.

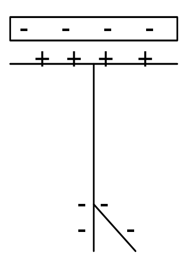
iii)



The earthing is broken and the glass rod removed, the negative charges then redistribute themselves to the brass cap, plate and gold leaf thus causing he leaf to diverge.
The electroscope is now negatively charged.

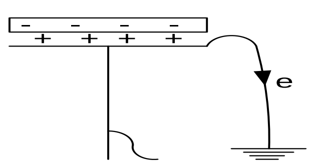
(b) Charging G.L.E negatively

(i)



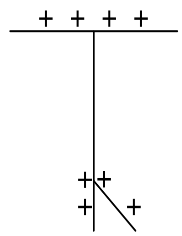
A negatively charged polythene rod is brought near the cap of the G.L.E, positive charge is induced on the brass cap and negative charge on the gold leaf and brass plate, the leaf diverges.

(ii)



With the polythene rod still in position, the G.L.E is earthed momentarily by touching.
Electrons flow from the brass plate and gold leaf and the leaf thus collapses.

(iii)



The earthing is broken and the polythene rod removed, the positive charges then redistribute themselves to the brass cap, plate and gold leaf thus causing he leaf to diverge.
The electroscope is now positively charged.

Testing for the sign of charge on a body

- Charge an electroscope negatively as explained above
- Bring the body whose charge is not known near the cap of *GLE*. If the leaf increases in divergence then that body is negatively charged, but if the leaf collapses, then that body has either **positive** charge or it is **neutral**
- To differentiate between the two alternatives, discharge the *GLE* and now charge it positively
- Bring the same body under test near the cap of appositively charged *GLE*. If the leaf divergence increases again, then that body has positive charges but if the leaf divergence decreases then that body is neutral.

  Note: Repulsion is the only confirmatory test for the sign of the charge

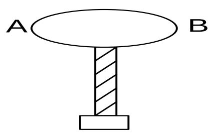
Summary

Charge on GLE	Charge brought near cap	Effect on leaf divergence
+	+	Increase(repulsion)
-	-	Increase(repulsion)
+	-	Decrease (attraction)
-	+	Decrease (attraction)
+ or -	Uncharged body	Decrease (attraction)

Charging a conductor by induction

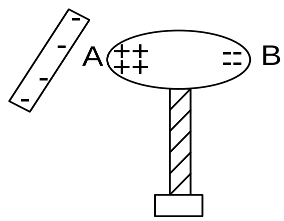
a) **Positively**

i)



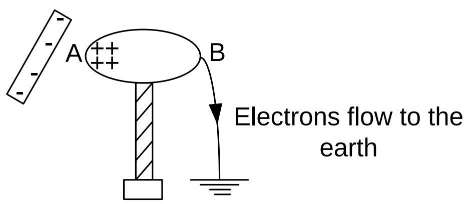
The conductor to be charged is sat on an insulating stand

ii)



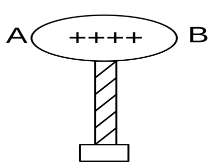
A negatively charged polythene rod (ebonite rod) is brought near end A of the conductor. Some of the free electrons are repelled towards end B leaving positive charges at end A

iii)



With the polythene rod still in position end B is earthed by momentarily touching it and electrons flow to the ground

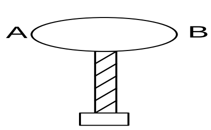
iv)



The finger is then removed and the rod also removed, the positive charges redistribute within the conductor.

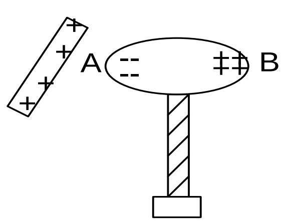
b) **Negatively**

i)



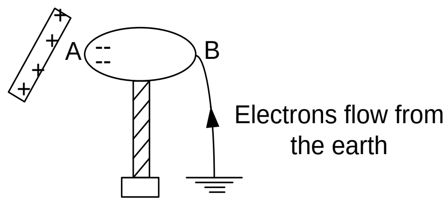
The conductor to be charged is sat on an insulating stand

ii)



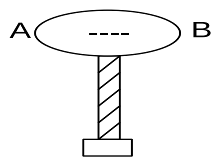
A positively charged glass rod is brought near end A of the conductor.
Negative charges are induced at the near end and positive charges at the far end.

iii)



With the glass rod still in position end B is earthed by momentarily touching it and electrons flow from the ground to neutralize the positive charges.

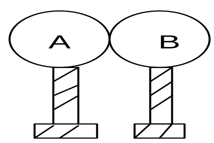
iv)



The finger is then removed and the rod also removed, the negative charges redistribute within the conductor.

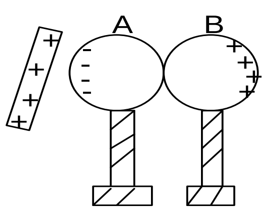
Separation of conductors

i)



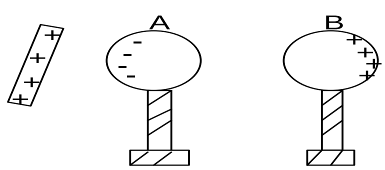
Two identical brass spheres A and B are placed together so that they touch one another.

ii)



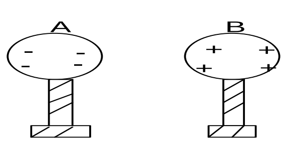
A positively charged rod is now brought near end A and as a result negative charge is induced at A and positive charges repelled to B.

iii)



Keeping the positive rod in position, sphere B is moved a short distance away from B

iv)



The charged rod is now removed and charges redistribute

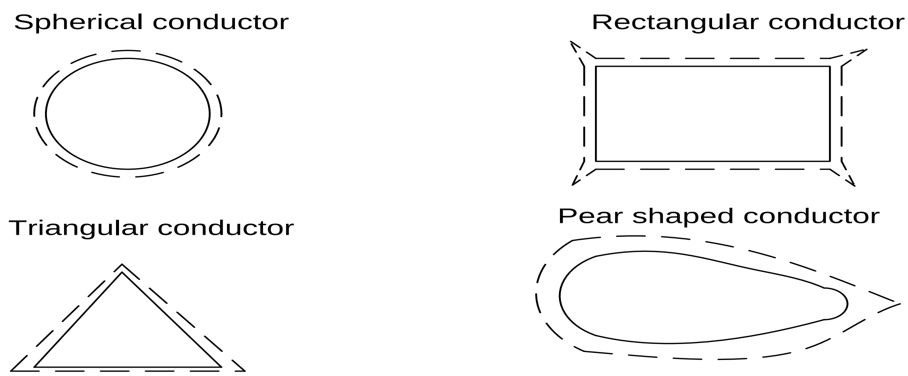
Explain how two spherical conductors made of brass can be changed oppositely and simultaneously by induction.

Distribution of charge over the surface of a conductor.

Surface charge density:

This is the quantity of charge per unit area over the surface of the conductor.

Charge is mostly concentrated at sharp points.



Note:

Charge only resides on the outside of a hollow conductor

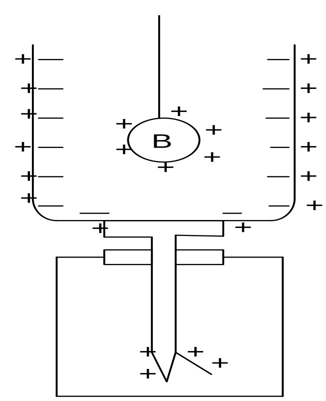
Experiment to show distribution of charge in a hollow conductor.

(Faraday's ice pail experiment)

Faraday investigated the effect of lowering a charged ball inside a hollow metal can.

Method:

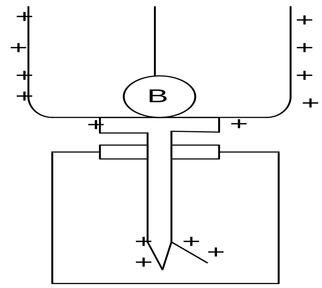
- Place metal can on a G.L.E and a metal sphere suspended on a thread is given a positive charge and then lowered in the metal can. The leaf of G.L.E diverges due to positive charge on the can.
- Move the ball around and inside the can without it touching the can.



Observation:

The divergence of the gold leaf is the same for all positions of a charged ball, B inside the can.

- ❖ Allow the sphere to touch the can inside of the can and note the divergence of G.L.E



Observation:

There is no change in leaf divergence. This is so because no charge is given or taken from the can.

- ❖ Remove the ball and note the gold leaf divergence

Observation:

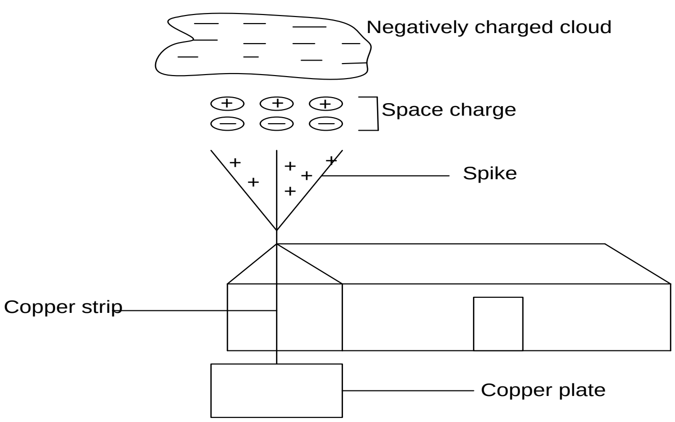
When a charged ball is removed after contact, it is totally discharged, the effect of touching the inside of the hollow can, the charge is transferred from the ball to the outside of the can

Action at sharp points [Corona discharge]

At sharp points, there is high charge density, which leads to a high electric field. This electric field ionizes the air molecules around the sharp points. The ions opposite to that on the sharp points are attracted to the sharp point and neutralize the charge there. **This apparent loss of charge by a conductor is called CORONA DISCHARGE.**

Lightening Conductor

A lightning conductor consists of a thick copper strip fixed on a wall reaching the highest point of the building and ending in several sharp spikes.



- When negatively charged clouds pass over the spikes, it induces positive charges on the spikes and repels negative charges to the earth. The positive charge on the spikes together with the negatively charged clouds gives an intense electric field that ionizes the air molecules between them.
- The positive ions are repelled by the positively charged spikes towards the clouds as space charge. The positive ions may neutralize the negative charge on the cloud hence reducing its dangerous effect. if it does not happen, the negative charge is passed to the earth through the copper strip thus preventing a large buildup of charge at the highest point of the building.

ELECTRIC FIELD

An electric field is a region within which an electric force is experienced.

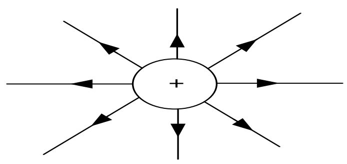
Electric fields can be represented by electrostatic lines of force.

Properties of electric field lines

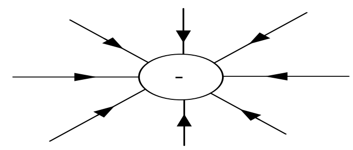
- They originate from positive and end on negative.
- they are in a state of tension which causes them to shorten
- they repel one another side ways

Field patterns

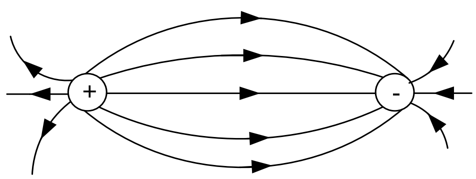
i) Isolated positive charge



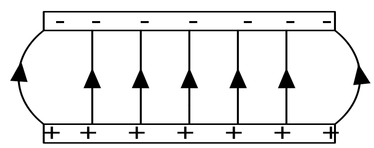
ii) Isolated negative charge



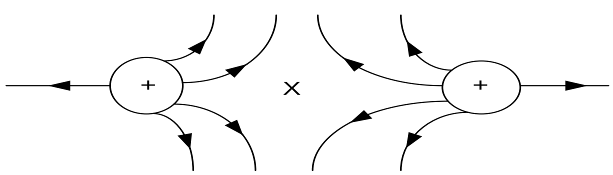
iii) Two equal opposite charges



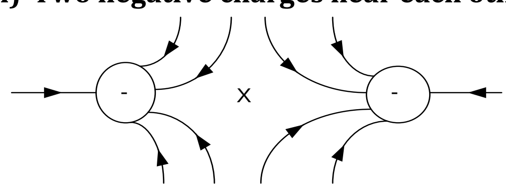
iv) Two parallel plates



v) Two positive charges near each other



vi) Two negative charges near each other

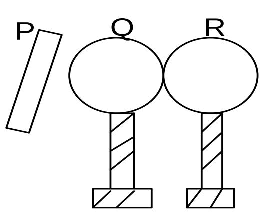


X is Neutral point;

Neutral point is the point in the electric field where the resultant electric force is zero.

Section A

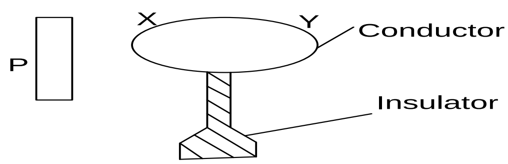
1. The figure below shows a charged rod P brought near conductors Q and R in contact



If P is removed after Q and R, and Q is negatively charged, then the charge on P and R are

	P	R
A .	+	-
A.	-	+
B.	-	-
C.	+	+

2. Which one of the following is observed when a positively charged body is brought near the cap of a positively charged electroscope?
    - A. The leaf diverges further
    - B. There is no change in the leaf divergence
    - C. There is a decrease in the leaf divergence
    - D. The leaf falls and then diverges again
3. A charged electroscope loses its charge when a flame is brought near its cap because
    - A. point action takes place at the cap
    - B. the flame blows the charges off the cap
    - C. charges of opposite sign from the flame are attracted on to the cap
    - D. the flames ionizes nearby air molecules and those of opposite sign are attracted on the cap
4. In the figure below, P is a charged body



The possible signs of charges at X, Y and P is

	X	Y	P
A.	Negative	Positive	Positive
B.	Negative	Positive	Negative
C.	Positive	Positive	Positive
D.	Negative	Negative	Negative

5. The law of electrostatic states that
    - A. charges occur in parts
    - B. charges repel each other
    - C. like charges repel each other
    - D. like charges attract each other
6. Which one of the following objects can be charged by friction?
    - A. Safety pin B. Copper plate C. Razor blade D. Plastic ruler
7. Charge distribution on a conductor depends on,
    - A. the material out of which the conductor is made
    - B. shape of conductor

C. quantity of charge

D. nature of the charge

8. Which of the following non – metallic electrical conductor?

A. brass B. copper C. graphite D. platinum

9. When a negatively charged body is brought near the cap of a positively charged electroscope, the gold leaf.

A. Remains unchanged B. Decreases in divergence

C. Increases in divergence D. Gains a positive charge.

10. Which one of the following materials can be electrified

A. Plastic pen B. Silver rod C. Copper rod D. Wet wood

11. When a charged body is brought near a cap of a negatively charged gold leaf electroscope, the

A. Divergence of the leaf does not change.

B. Leaf falls if the body is negatively charged

C. Leaf diverges if the body is negatively charged

D. Leaf diverges if the body is negatively charged

12. A conductor usually losses charge gradually by a process called.

A. Induction B. Insulation C. Conduction D. Leakage.

13. A brass rod is rubbed with silk and then brought near a positively charged gold leaf electroscope. The divergence of the leaf will

A. Increase B. Decrease

C. Not change D. Increase slightly and fall back.

14. The result of rubbing a glass rod with silk and separating then is

A. A negative charge on the rod and an equal positive charge

B. Equal amounts of negative charge on both

C. A positive charge on the rod and an equal negative charge on the silk

D. No charge on both rod and the silk

15. A metal rod gains a positive charge when rubbed with fabric. The fabric acquires.

A. no charge

B. A negative charge equal to that on the rod.

C. A positive charge equal to that on the rod

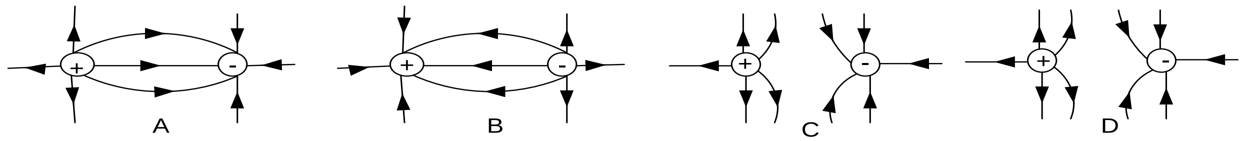
D. A positive charge greater than that on the rod

16. When a rod is brought close to the cap of a negatively charged gold leaf electroscope its leaf diverges, it shows that the rod is

A. Negatively charged B. Positively charged

C. Neutral D. Partially charged.

17. Which one of the following diagrams represents the correct electric field pattern for two oppositely charged points?



18. The laws of electrostatics induction state that
    A. Like poles repel and unlike poles attract
    B. Like poles attract and unlike poles repel
    C. Like charges repel and unlike charges attract
    D. Like charges attract and unlike charges repel

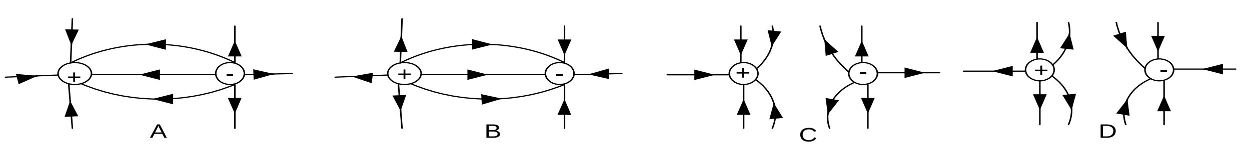
19. Which of the following actions will cause the leaf of a negatively charged electroscope to fall?
    (i) Bringing a positively charged rod near the cap
    (ii) Bringing a negatively charged rod near the cap
    (iii) Connecting the can to the earth.

    A. (i) and (ii) only B. (i) and (iii) only
    C. (ii) only (iii) only D. (i),(ii) and (iii)

20. When polythene and wool are rubbed against each other and then separated, they acquire
    A. No charge B. Equal amount of same type of charge
    C. Equal and opposite charge D. Both acquire positive and negative charges

21. A body can only be confirmed to be electrically charged when
    A. Another charged body attracts it.
    B. It does not affect the leaf of a charged electroscope
    C. It is repelled by another charged body
    D. It is found to have less protons than electrons

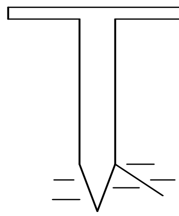
22. Which of the following shows a correct electric field pattern due to two charges?



23. It is easier to charge insulators than conductors because
    A. The insulators don't allow the charge to flow away but the conductors allow it to flow away
    B. The conductors retain the charge by conduction but the insulators release it to the atmosphere
    C. It is impossible to charge conductors under any condition

D. Insulators just receive the charge from the atmosphere without being rubbed

24. The diagram below shows part of the gold leaf electroscope. What will happen to the leaf if a positively charged rod is brought near the cap of the electroscope? It will



A. increase in deflection

B. remain in the same position

C. reduce in deflection

D. break off from the plate

25. Which of the following statement is true about a good electric insulator?

A. it acquires an electric charge when rubbed with suitable materials.

B. all its electrons are loosely bound to its atoms

C. electric charge easily flows on its surface

D. some of its electrons are free to move about

26. An electroscope becomes negatively charge when it

A. lose electrons B. gains protons C. gains electrons D. loses protons

27. An insulting rod that can be charged positively by rubbing with a piece of fabric is rubbed with fabric and left in contact for a long time then separated. What would you expect each one of them to have?

A. no charge

B. equal number of opposite charges

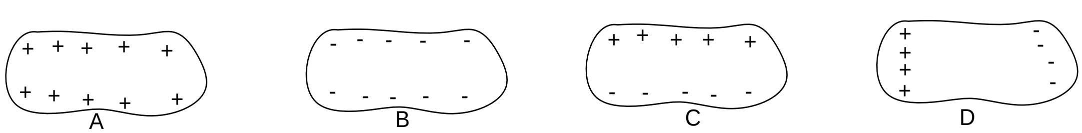
C. more positive charge on the rod than on the fabric

D. more negative charge on the fabric than on the rod

28. When a plastic rod is brought near a charged electroscope, the gold leaf is seen to diverge more. The possible charges on the rod and the electroscope are

	Electroscope	**Plastic rod**
A.	positive	negative
B.	negative	positive
C.	negative	negative
D.	positive	uncharged

29. Which one of the following shows the correct distribution of electric charges generated in clouds due to violent movements with in the thunder clouds?



30. The leaf of a charged electroscope gradually collapses with time due to

A. leakage to the surroundings | B. Surrounding magnetic field
C. pressure variation in the surroundings | D. Similar charges from the surroundings

31. An electroscope is negatively charged by induction. This means that it has
    A. gained electrons B. gained protons
    C. lost electrons D. lost protons

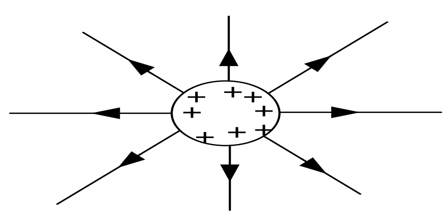
32. When a plastic rod is rubbed with a dry piece of cloth, the rod and the piece of cloth will
    A. both acquire negative charges B. both acquire positive charges
    C. acquire opposite charge D. have no charge

33. If a negatively charged ebonite rod is brought near the cap of a negatively charged electroscope, the leaves.
    A. decreases in divergence B. increases in divergence
    C. remain unchanged D. gain positive charges

34. When a body is brought near a negatively charged electroscope a decrease in divergence is observed. This may mean that the body is
    (i) positively charged
    (ii) negatively charged
    (iii) not charged at all
    A. (i),(ii) and(iii) C. (i) and (ii)only
    B. (i) and (ii)only D. (i) only

SECTION B

1. **(a)** When a balloon is rubbed with hair, it becomes negatively charged
    (i) Explain how the balloon becomes negatively charged
    (ii) Compare the magnitude of the charge acquired by the balloon with that on the hair
   (b) The diagram in the figure below shows electric field lines around a metal sphere in air



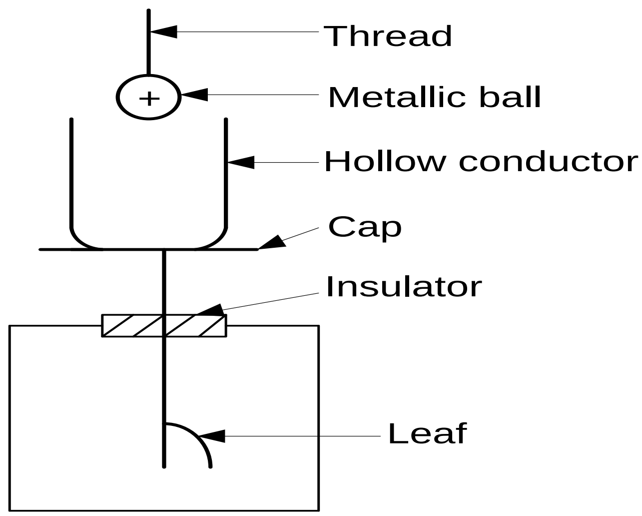
What will happen to the charges on the sphere if a sharp spike is placed on top of the sphere?

2. (a) State the laws of electrostatics .
   (b) Two insulating materials are rubbed together, describe what is observed if
      (i) the two are brought near the cap of a gold leaf electroscope
      (ii) only one of them is brought near the cap.

(c) Why is it difficult to perform experiments in electrostatics under damp conditions?

3. (a) Explain why a pen rubbed with a piece of cloth attracts pieces of paper.

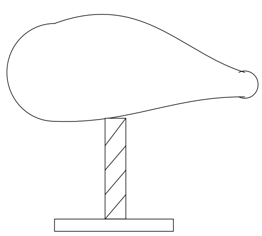
(b) A positively charged metallic ball is held above a hollow conductor resting on the cap of a gold leaf electroscope as shown below.



Explain what happens to the leaf of the electroscope as the ball is lowered into the conductor.

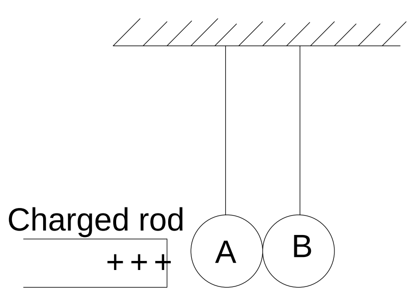
4. (a) What happens to an insulator when it is rubbed with another of different material?

(b) The figure below shows a conductor supported on an electrical insulator .The conductor is given some positive charge. Show how the charge is distributed on the conductor.



(d) Sketch the electric field pattern due to two unlike charges P and Q below.

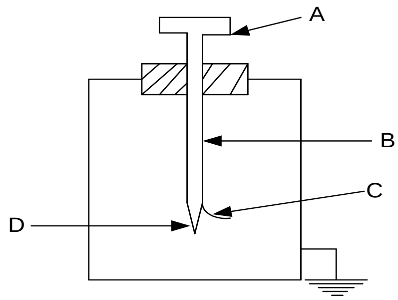
5. A positively charged rod is brought near two conducting spheres A and B in contact as shown below.



(a) Show that charges on the spheres

(b) Describe how the spheres may be given a permanent charge

6. (a)



The figure above shows the main parts of an electroscope. Name them.

(b) State two uses of an electroscope.

PAPER TWO TYPE

1. (a) Describe how you would use a gold leaf electroscope to determine the sign of the charge on a given charged body.

(b) Explain how an insulator gets charged by rubbing

(c) Sketch the electric field pattern between a charged point and a metal plate

(d) Describe how a lightning conductor safe guards a tall building from being struck by lightning

2. **(a)** What is meant by a conductor and an insulator?. Give an example of each

(b) (i) Explain briefly how you can charge a conductor negatively by induction

(ii) Describe how it can be confirmed that the conductor in (b) (i) is negatively charged

(c) Explain the action of a lightning conductor

3. **(a)** What happens when a glass rod is rubbed with

(i) Silk?

(ii) an identical glass rod?

(b) Describe how a gold leaf electroscope may be used to test the nature of the charge on an object

(c) Draw the electric field patterns for

(i) an isolated negative charge

(ii) two oppositely charged parallel plates at a small distance apart

(d) Explain why it is not advisable to touch the copper strip of a lightning conductor when it is raining

ELECTRIC CELLS

These produce electricity from their chemical reactions. A cell consists of two plates called electrodes of different elements in a liquid called an electrolyte.

There are two types of cells namely;

(i) Primary cells (ii) Secondary cells

Primary cells and secondary cells

Primary cells are cells that cannot be re charged. This is because the chemical reaction which produces an electric current is irreversible.

Examples

- ❖ Dry cells
- ❖ Simple cells

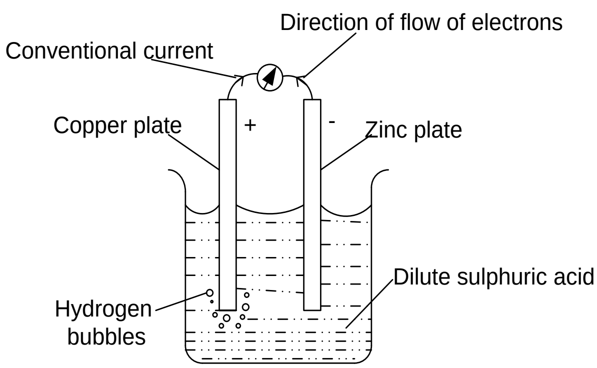
Secondary cells are cells that can be recharged. This is because the chemical reaction which produces an electric current can be reversed.

Examples

- ❖ Lead acid cells
- ❖ Nickel- iron cell

Primary cells

a) Simple cell



- ➢ When the copper and zinc plates are connected by a wire, the zinc slowly begins to dissolve in the acid and bubbles of hydrogen gas are formed on the copper plate.
- ➢ At the same time, a current of electrons drift through the wire to the copper plate. The zinc dissolves making the zinc plate electron rich (negatively charged) and hydrogen is given off at the copper plate making it electron deficient (positively charged).
- ➢ The formation of hydrogen bubbles on the copper plate stops the flow of current and it is called **polarisation**

Defects of a simple cell

(i) Polarization

This is the formation of hydrogen bubbles on the copper plate. This hydrogen layer insulates the plate and stops the flow of current.

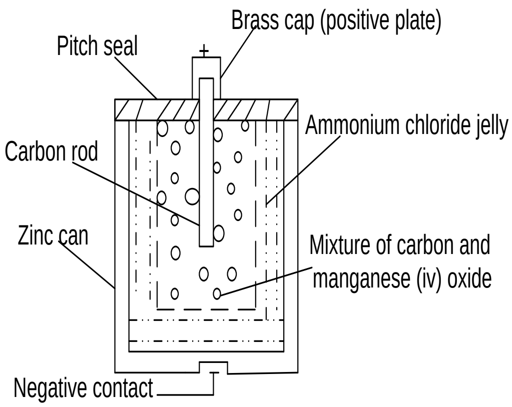
Polarization can be minimized by using a depolarizing agent/ oxidizing agent like manganese (iv) oxide or potassium dichromate which oxidises hydrogen to water.

(ii) Local action

If impure zinc is used, bubbles of hydrogen will be seen coming from the zinc plate. This is called local action.

Local action can be minimized by cleaning the zinc plate with sulphuric acid and mercury using cotton wool.

b) Dry cell



- The positive element of a dry cell consists of a carbon rod surrounded by a mixture of powdered carbon and manganese (iv) oxide.

This positive element is placed inside the zinc can and surrounded by aluminum chloride jelly. The jelly is prevented from drying by sealing it with a metal disc at the top of the cell.

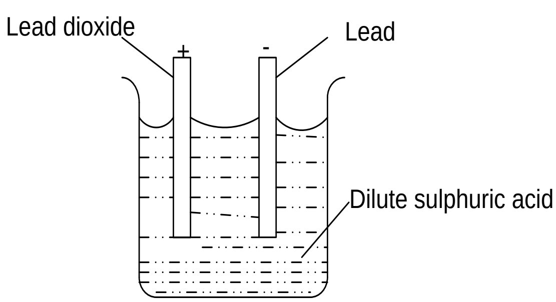
- The source of energy is the chemical action between zinc and ammonium chloride as a result hydrogen is produced which collects on the carbon rod and polarizes the cell.
- The mixture of carbon and manganese (iv) oxide surrounds the carbon rod which acts as an oxidizing agent and zinc can acts s a negative terminal.

Note :

Dry cells give a large current and are used for a variety of purposes.

Secondary cells

a) Lead acid cell (accumulator)



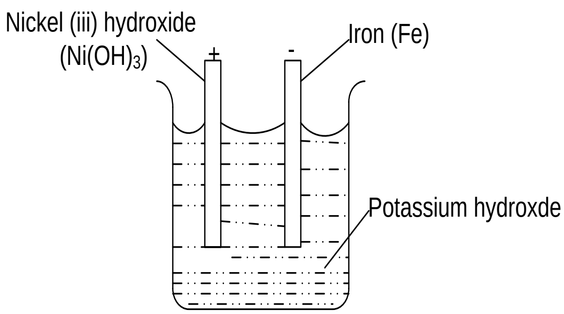
The positive plate is lead dioxide (brown) and negative plate is lead (green) with dilute sulphuric acid as the electrolyte. When the cell discharges, lead dioxide and lead from the two plates are converted into lead sulphate using up the acid which becomes weaker and less dense.

Care for the lead acid cell

- Level of the sulphuric acid should be inspected regularly and any loss from evaporation made up with distilled water.
- Lead acid cells should be charged regularly using a maker's recommended charging current.

- Avoid shorting (connecting wires across the terminals).
- Over charging should be avoided.
- They should not be left in discharge state for a long time.

b) Nickel – iron cell (alkaline cell / Nife cell)



The nickel – iron cell has potassium hydroxide as the electrolyte. The active material in the charged state are green nickel (iii) hydroxide at the positive plate and finely divided iron with a little mercury at the negative plate.

Advantages of Nife cell over Lead acid cell

- Nife cells have a longer life than lead acid cells
- Nife cells can be left in a discharge condition for a long time without any harm
- Nife cells have a higher internal resistance and can easily withstand the short circuit.
- They require no special maintenance when out of use for extended periods
- The active material of the nife cell cannot fall off during shock

Disadvantages of Nife cell

The emf of the a nife cell is only 1.25V and it tends to fall continuously on discharge

SECTION A

1. The energy stored in an accumulator is
   A. heat energy C. electrical energy
   B. chemical energy D. mechanical energy
2. Local action is simple cell is caused by the presence of
   A. Zinc amalgam coasting on zinc plate B. Manganese (iv) oxide around the copper plate
   C. Hydrogen bubbles on copper plate D. Impurities in zinc
3. In a dry cell, manganese (iv) oxide is used to
   A. Reduce the P.d across it B. Double its resistance
   C. Increase its resistance D. Keep the P.d constant .
4. The negative plates of a simple cell gradually goes into solution because of

A. Polarization B. Local action C. Charging D. Gassing

5. When brass is to be copper – plated , the suitable electrolyte used is

   A. distilled water B. sulphuric acid

   C. lead(iv) oxide D. copper – sulphate

6. In a simple cell, the source of electrons which constitute the electron currents is

   A. The zinc plate B. The copper plate

   C. Dilute sulphuric acid D. Potassium dichromate

7. In a simple cell

   A. polarization is caused by impure zinc

   B. potassium dichromate is used to prevent polarization

   C. the formation of hydrogen bubbled on the copper plate cause local action

   D. hydrogen is produced on the zinc plate arid causes polarization

8. Which one of the following pairs gives a defect and its correction in a simple cell?

	Defect	Correction
A	Local action	Using Zinc amalgam
B	Polarisation	Dilute the electrolyte
C	Local action	Add oxidising agent
D	Polarisation	Use concentrated electrolyte

SECTION B

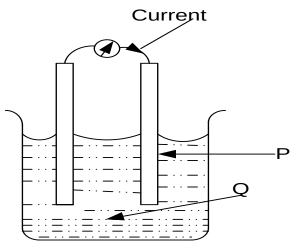
1. (a) (i) What is meant by a secondary cell?

   (ii) Give two examples of secondary cells

   (b) (i) What substance is used to top up the level of the liquid in accumulators?

   (ii) Explain briefly why this is used

2. (a)



The diagram above shows the essential parts of a simple cell. Name the parts labelled P and Q

(b) Why does the current through the cell eventually stop?

3. (a) state two advantages of a nickel – iron accumulator over a lead acid accumulator.

   (b) name the gasses evolved during the charging of a lead – acid accumulator .

   (c) why is a dry cell called primary cell?

CURRENT ELECTRICITY

Current is the rate of flow of electric charge.

If charge Q, coulombs flows through a circuit in a time t seconds, then the current I, amperes is given by ;

$$I = \frac{Q}{t}$$

$$\boxed{Q = I\,t}$$

The S.I unit of current is Amperes and current is measured using an instrument called an Ammeter.

Ampere;

Ampere is the current which, if flowing in two straight parallel wires of infinite length placed one meter apart in a vacuum, will produce on each of the wires a force of $2\ x\ 10^{-7}\text{N}m^{-1}$.

The S.I unit of charge is coulomb.

Coulomb;

Is the quantity of electricity which passes any point in a circuit in 1 second when a steady current of 1 ampere is flowing.

Examples

1. A charge of 180C flows through a lamp every 2 minutes. What is the electric current in the lamp.

Solution

$$I = \frac{Q}{t}$$

$$I = \frac{180}{2\ x\ 60}$$

$$I = 1.5A$$

2. A charge of 20 kC crosses two sections of a conductor in 1minute. Find the current through the conductor.

Solution

$$I = \frac{Q}{t}$$

$$I = \frac{20\ x\ 1000}{1\ x\ 60}$$

$$I = 333.33A$$

POTENTIAL DIFFERENCE ($P.d$)

$P.d$ is defined as the work done in moving one coulomb charge from one point to another a cross a conductor.

Current will flow through a conductor if there **a potential difference** between the ends of a conductor.

The $S.I$ unit of $P.d$ is volt and $P.d$ is measured using an instrument called a voltmeter

A volt;

A volt is the potential difference between two points when one joule of work is done in transferring one coulomb of charge from one point to another.

Electromotive force ($E.m.f$)

$E.m.f$ is defined as the terminal $p.d$ a cross **<u>an open circuit</u>**. OR

$E.m.f$ of a cell is defined as the total work done in joules per coulomb of electricity conveyed in a circuit in which the cell is connected.

$E.m.f$ is measured in volts

Resistance

This is the opposition of a conductor to the flow of current.

It is measured in ohms (Ω)

OR : Resistance of a conductor is the ratio of the potential difference across it to the current flowing through it.

A good conductor has low resistance while a good insulator has high resistance

An ohm (Ω)

An ohm (Ω) is the resistance of a conductor such that when a $p.d$ of 1 volt is applied to its ends, a current of 1 amperes flows through it.

Factors that affect resistance

a) Length

The longer the conductor, the higher the resistance and the shorter the conductor the lower résistance.

b) Cross sectional area

The thinner the conductor, the higher the resistance and the thicker the conductor, the lower the resistance

c) Temperature

An increase in temperature increases the resistance of a pure metal.

The above factors can be combined as;

$$\rho \propto {}^{L}/_{A}$$

$$\boxed{R = \frac{\rho L}{A}}$$

Where ρ is resistivity

Examples

1. A conductor of length 20 m has a cross sectional area of $2x10^{-4}\ m^2$. Its resistance at 20°C is 0.6Ω. find the resistivity of the conductor at 20°C.

Solution

$$R = \frac{\rho\, L}{A}$$

$$\rho = \frac{RA}{L}$$

$$\rho = \frac{0.6\ x\ 2x10^{-4}}{0.2}$$

$$\rho = 6x10^{-4}\ \Omega\, m$$

2. A wire of diameter 14mm and length 50cm has its resistivity as $1.0\ x10^{-7}\ \Omega\, m$. What is the resistance of the wire at room temperature?

Solution

$$d = 14mm, r = \frac{14}{2} = 7mm$$

$$l = 50cm, l = 0.5m$$

$$A = \pi\, r^2$$

$$A = \frac{22}{7}x\left(\frac{7}{1000}\right)^2$$

$$A = 1.54x\ 10^{-4}\ m^2$$

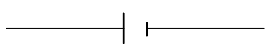
$$R = \frac{\rho\, L}{A}$$

$$R = \frac{0.5\ x\ 1x10^{-7}}{1.54x\ 10^{-4}}$$

$$R = 3.25x10^{-4}\ \Omega$$

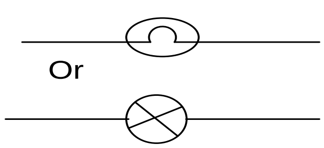
Common symbols in electricity

Cell or battery

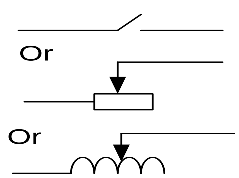


A.c supply

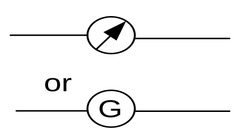
Filament lamp



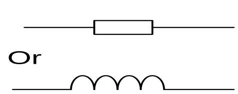
Switch



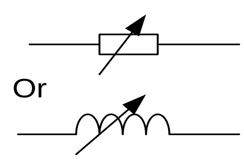
Galvanometer



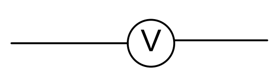
Resistor



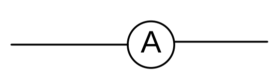
Variable resistor



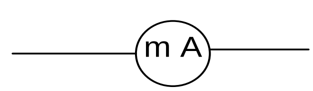
Voltmeter



Ammeter



Milliammeter



OHM'S LAW

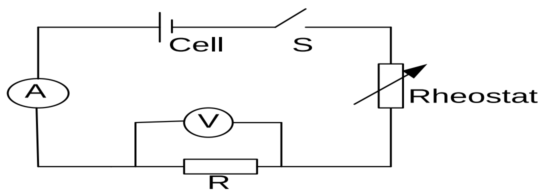
It states that the current through a wire at **constant temperature** is proportional to the potential difference across it's ends.

Ie $V \propto I$ at constant temperature

$$\boxed{V = I R}$$

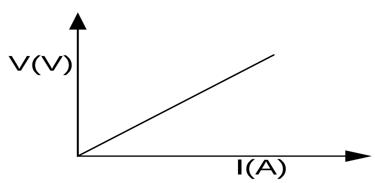
R is resistance , V is p.d, I is current

Verification of ohm's law



A-ammeter, V- voltmeter, R-resistor, S- switch

- Arrange the apparatus as shown above.
- First adjust the rheostat to a maximum value. When the switch is closed the current I is read from the ammeter and voltage V from the voltmeter noted.
- By varying the rheostat, read and record various readings of the ammeter and voltmeter
- Tabulate your results
- Plot a graph of $V(V)$ against $I(A)$



- A straight line through the origin shows that $p.d$ is directily proportional to current

Limitations of ohm's law

- It does not apply to semiconductors and gases.
- It is only obeyed if physical conditions like temperature are constant.

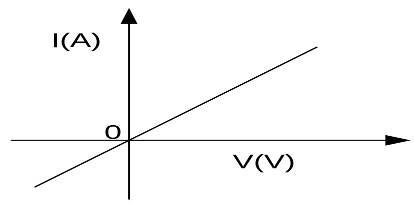
Ohmic and non ohmic conductors

An ohmic conductor is one which obeys ohm's law.

Non ohmic conductor s one which doesnot obey ohm's law.

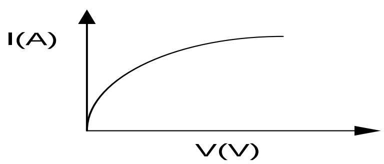
When we plot I against V between ends of a conductor, the shape of the curve is known as the characteristic of the conductor.

a) Ohmic conductors eg a metal

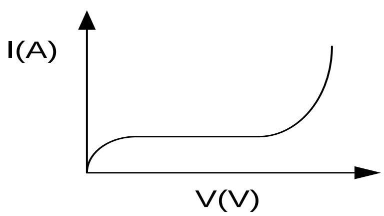


b) Non ohmic conductor

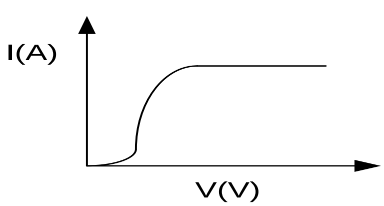
i) Filament lamp



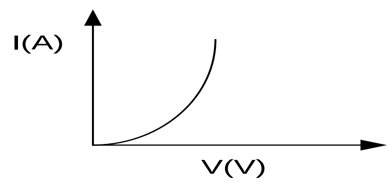
ii) Gas discharge tube



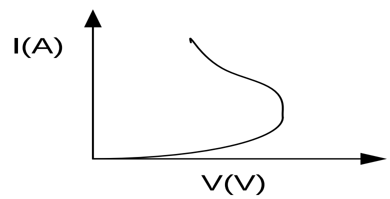
iii) Thermionic diode



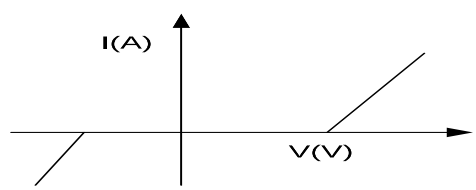
iv) Junction diode



v) Thermistor



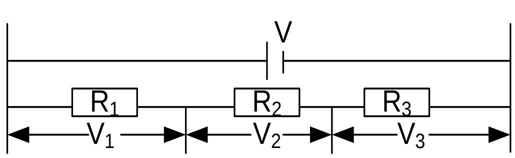
vi) Electrolyte eg dilute sulphuric acid



ARRANGEMENT OF RESISTORS

a) Resistors in series

When resistors are in series, current flowing through them is the same.



Total $P.d$, V = $V_1 + V_2 + V_3$

V = $I\,R_1 + I\,R_2 + I\,R_3$

$V = I\,(R_1 + R_2 + R_3)$

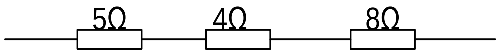
$\frac{V}{I} = R_1 + R_2 + R_3$

$\boxed{R = R_1 + R_2 + R_3}$

Example

Find the total resistance in the circuits below

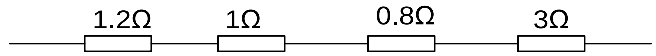
1.



Solution

$R = (5 + 4 + 8)\ \Omega$

$R = 17\Omega$



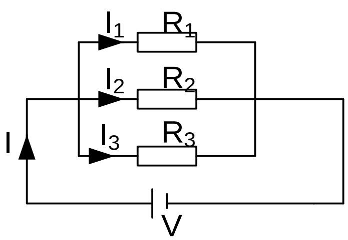
Solution

$R = (1.2 + 1 + 0.8 + 3)\ \Omega$

$R = 6\Omega$

2.

b) Resistors in parallel



Total current, I = $I_1 + I_2 + I_3$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

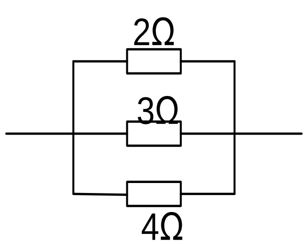
$$\frac{I}{V} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{1}{R} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

Example

a) Find the effective resistance of the following circuit

1.



Solution

$$\frac{1}{R} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{1}{R} = \left(\frac{1}{2} + \frac{1}{3} + \frac{1}{4}\right)$$

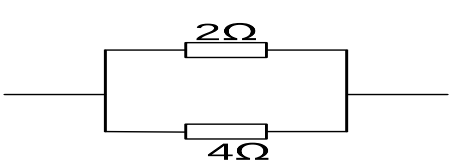
$$\frac{1}{R} = \frac{6 + 4 + 3}{12}$$

$$\frac{1}{R} = \frac{13}{12}$$

$$R = \frac{12}{13}$$

R = 0.92Ω

2.



Solution

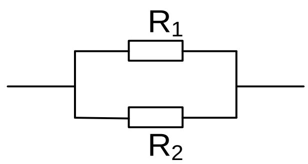
$$\frac{1}{R} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$\frac{1}{R} = \left(\frac{1}{2} + \frac{1}{4}\right)$$

$$\frac{1}{R} = \frac{3}{4}$$

$$R = \frac{4}{3} \qquad R = 1.33\Omega$$

Note for two resistors in parallel



$$\frac{1}{R} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

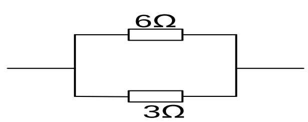
$$\frac{1}{R} = \frac{R_1 + R_2}{R_1 R_2}$$

$$R = \frac{R_1 R_2}{R_1 + R_2}$$

$$R = \frac{product\ of\ resisstance}{sum\ of\ resistance}$$

b) Calculate the effective resistance in each of the following circuits

(i)



Solution

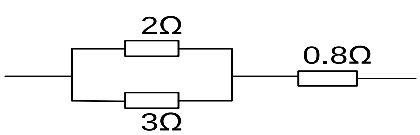
$$R = \frac{product\ of\ resisstance}{sum\ of\ resistance}$$

$$R = \frac{6x3}{6+3}$$

$$R = \frac{18}{9}$$

R = 2Ω

(ii)



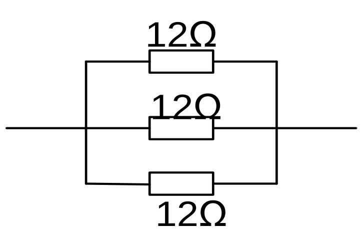
Solution

$$R = 0.8 + \frac{2x3}{2+3}$$

$$R = 0.8 + \frac{6}{5}$$

R = 2Ω

(iii)



Solution

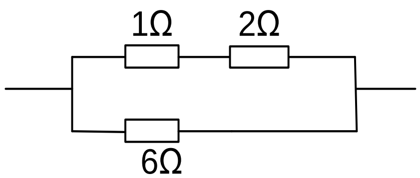
$$\frac{1}{R} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{1}{R} = \left(\frac{1}{12} + \frac{1}{12} + \frac{1}{12}\right)$$

$$\frac{1}{R} = \frac{3}{12}$$

$$R = \frac{12}{3} \qquad R = 4\Omega$$

(iv)

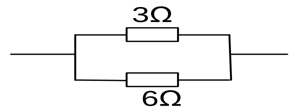


Solution

For series

R = (1 + 2)Ω

R = 3Ω



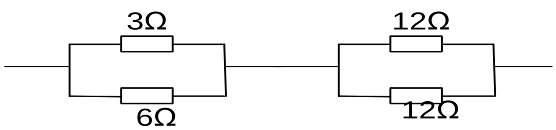
$$R = \frac{product\ of\ resisstance}{sum\ of\ resistance}$$

$$R = \frac{6x3}{6+3}$$

$$R = \frac{18}{9}$$

R = 2Ω

(v)



Solutions

For the first set of parallel resistors

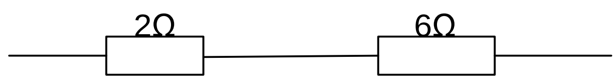
$$R = \frac{6x3}{6+3}$$

R = 2Ω

For the second set of parallel resistors

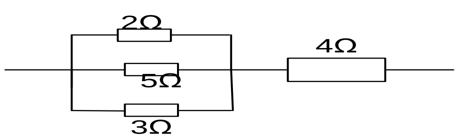
$$R = \frac{12x12}{12+12}$$

R = 6Ω



Total resistance =2 + 6 = 8Ω

(vi)



Solution

For parallel combination

$$\frac{1}{R} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

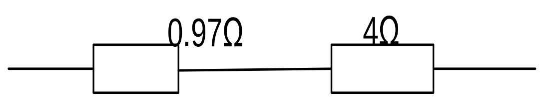
$$\frac{1}{R} = \left(\frac{1}{2} + \frac{1}{5} + \frac{1}{3}\right)$$

$$\frac{1}{R} = \frac{15+6+10}{30}$$

$$\frac{1}{R} = \frac{31}{30}$$

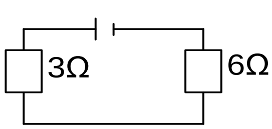
$$R = \frac{30}{31}$$

R = 0.97Ω



Total resistance =0.97 + 4 = 4.97Ω

(vii)

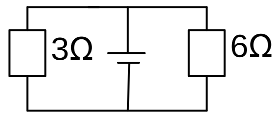


Solution

$$R = R_1 + R_2$$

$$R = (3 + 6) = 9\Omega$$

(viii)



Solution

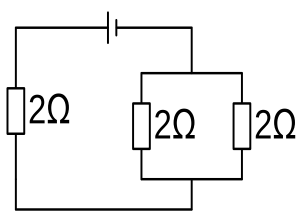
$$R = \frac{product\ of\ resisstance}{sum\ of\ resistance}$$

$$R = \frac{6x3}{6+3}$$

$$R = \frac{18}{9}$$

R = 2Ω

(ix)



Solution

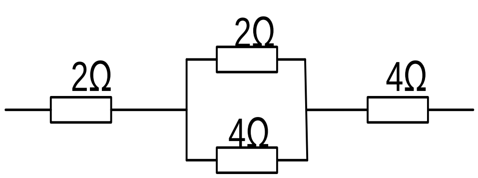
$$R = R_1 + \frac{R_2\,R_3}{R_2 + R_3}$$

$$R = 2 + \frac{2x\ 2}{2 + 2}$$

$$R = 2 + 1$$

$$R = 3\Omega$$

(xi)



Solution

$$R = R_1 + \frac{R_2\,R_3}{R_2 + R_3} + R_4$$

$$R = 2 + \frac{2x\ 4}{2+\ 4} + 4$$

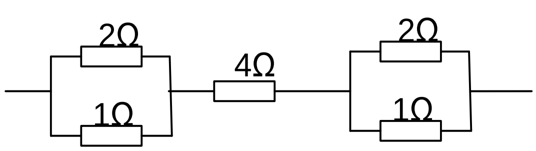
$$R = 2 + \frac{8}{6} + 4$$

$$R = 6 + \frac{4}{3}$$

$$R = \frac{18+4}{3}$$

$$R = 7.33\Omega$$

(x)



Solution

$$R = \frac{2x\ 1}{2+1} + \ 4 + \frac{2x\ 1}{2+1}$$

$$R = \frac{2}{3} + 4 + \frac{2}{3}$$

$$R = 4 + \frac{4}{3}$$

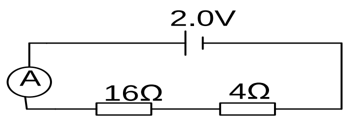
$$R = \frac{12+4}{3}$$

$$R = 5.33\Omega$$

Further examples

1. Find the ammeter readings in each of the circuits below

i)



Solution

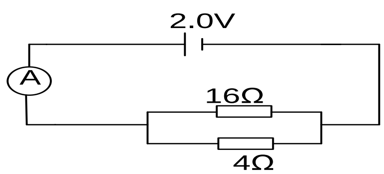
$V = IR$

$I = \frac{V}{R}$

$I = \frac{2}{16+4}$

$I = 0.1\ A$

ii)



Solution

$V = IR$

$I = \frac{V}{R}$

$R = \frac{product\ of\ resisstance}{sum\ of\ resistance}$

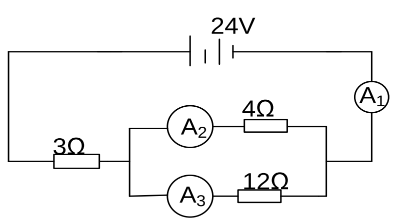
$R = \frac{16x4}{16+4}$

$R = 3.2\Omega$

$I = \frac{2}{3.2}$

$I = 0.625\ A$

iii)



Solution

$A_1 = A_2 + A_3$

A_1 reads current in the whole circuit

$V = IR$

$I_1 = \frac{V}{R}$

Total R= $\left[3 + \left(\frac{4x12}{4+12}\right)\right]$

$R = 3\Omega + 3\Omega$

$R = 6\Omega$

$I_1 = \frac{24}{6}$

$I_1 = 4A$

To find A_2 and A_3, we need to first find voltage across parallel combination

$V = IR_P$

I is the current through the parallel combination and R_P is total resistance of the parallel combination

$V = 4x\left(\frac{4x12}{4+12}\right)$

$V = 4x3$

$V = 12V$

Note : For any resistors in parallel, they have the same $p.d$

Current in A_2: $I_2 = \frac{V}{R}$

$I_2 = \frac{12}{4}$

$I_2 = 3A$

Current in A_3: $I_3 = \frac{V}{R}$

$I_3 = \frac{12}{12}$

$I_3 = 1A$

To quickly confirm the currents

Current in A_2: $I_2 = \frac{R_3}{R_2+R_3}xI$

$I_2 = \frac{12}{16}x4$

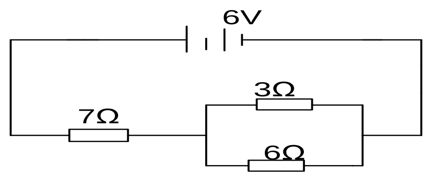
$I_2 = 3A$

Current in A_3: $I_3 = \frac{R_2}{R_2+R_3}xI$

$I_3 = \frac{4}{16}x4$

$I_3 = 1A$

2.



In the figure above find;

(i) Current through the circuit

(ii) Current across 3Ω and 6Ω resistor

(iii) $P.d$ across the 7Ω resistor

(iv) $P.d$ across the 3Ω and 6Ω resistor

Solution

i) Total resistance, R= $\left[7 + \left(\frac{6x3}{6+3}\right)\right]$

$R = 7\Omega + 2\Omega$

$R = 9\Omega$

$V = IR$

$I = \frac{V}{R}$

$I = \frac{6}{9}$

$I = 0.667\ A$

Current in the circuit is 0.667 A

ii) Voltage across the parallel combination

$V = IR_P$

$V = 0.667x\left(\frac{6x3}{6+3}\right)$

$V = 0.667x2$

$V = 1.334V$

Note : For any resistors in parallel, they have the same $p.d$

Current in 3Ω $resistor$: $I = \frac{V}{R}$

$I = \frac{1.334}{3}$

$I = 0.445A$

Current in 6Ω $resistor$: $I = \frac{V}{R}$

$I = \frac{1.334}{6}$

$I = 0.223A$

To quickly confirm the currents

Current in 3Ω $resistor$: $I = \frac{6}{6+3}x0.667$

$I = \frac{6}{9}x0.667$

$I = 0.445A$

Current in 6Ω $resistor$: $I = \frac{3}{6+3}x0.667$

$I = \frac{3}{9}x0.667$

$I = 0.223A$

iii) $P.d$ across the 7Ω resistor

0.6A Passes through the 7Ω resistor

$V = I\ R$

$V = 7x\ 0.667$

$V = 4.669V$

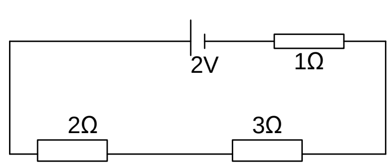
iv) $P.d$ across the 3Ω resistor and 6Ω resistor

$V = (6 - 4.669)V$

$V = 1.33V$

since the two resistors are in parallel therefore, they have the same $p.d$ of 1.33V

3. Find the $p.d$ across the resistors in the circuit below



Solution

$V = IR$

$I = \frac{V}{R}$

$I = \frac{2}{2+3+1}$

$I = \frac{2}{6}$

$I = 0.333A$

$P.d$ across the 1Ω resistor

$V = I\ R$

$V = 0.333x\ 1$

$V = 0.333V$

$P.d$ across the 2Ω resistor

$V = I\ R$

$V = 0.333x\ 2$

$V = 0.666V$

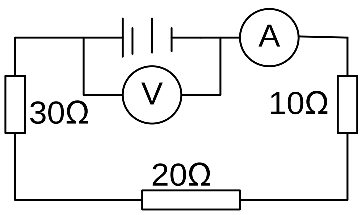
$P.d$ across the 3Ω resistor

$V = I\ R$

$V = 0.333x\ 3$

$V = 0.999V$

4. In the diagram below, the ammeter reading is 0.2A. What is the reading of the voltmeter?



Solutions

We are required to find the emf of the battery

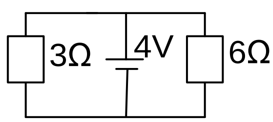
$V = I\ R$

$V = 0.2x\ (30 + 20 + 10)$

$V = 0.2x60$

$V = 12V$

5.



Two resistors of 3Ω and 6Ω are connected across a battery of emf of $4V$ as show, find

i) the combined resistance

ii) the current supplied by the battery

Solution

i) $R = \frac{product\ of\ resisstance}{sum\ of\ resistance}$

$R = \frac{6x3}{6+3}$

$R = 2\Omega$

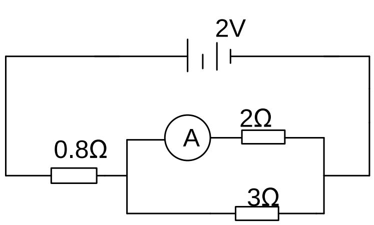
ii) $I = \frac{V}{R}$

$I = \frac{4}{2}$

$I = 2A$

Exercise

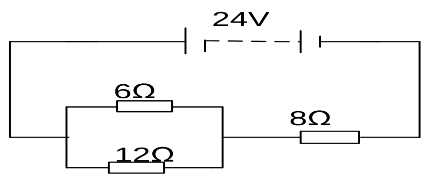
1.



Find the ammeter reading

[0.6A]

2. A $p.d$ of 24V from a battery is applied to a network of resistors as shown below

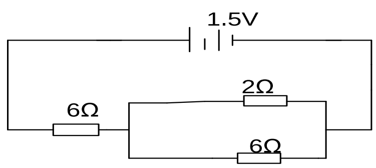


i) find the current through the circuit **[2A]**

ii) find the p.d across the 8Ω resistor **[16V]**

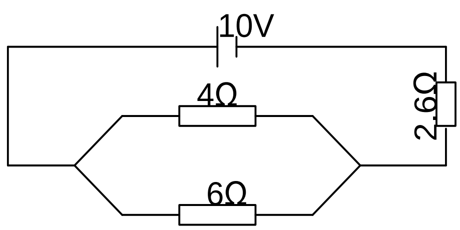
iii) find the current through the 6Ω resistor **[1.3A]**

3.



Find the current through the 2Ω resistor

4.



A battery of emf 10V and negligible internal resistance is connected across a network of resistors as shown above. calculate the current through the 6Ω resistor.

[0.8A]

INTERNAL RESISTANCE OF CELLS

Internal resistance of a cell is the opposition to flow of current within a cell.

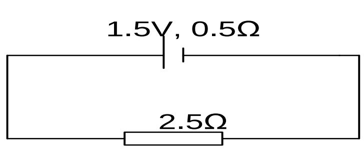
Internal resistance is represented by r.

$$\boxed{E = I\,(R + r)}$$

Examples

1. A battery of emf 1.5V and internal resistance 0.5Ω is connected in series with 2.5Ω resistor. Find;
   i) current through the circuit
   ii) $p.d$ of the 2.5Ω resistor

Solution



i) $E = I\,(R + r)$

$$I = \frac{E}{(R + r)}$$

$$I = \frac{1.5}{(2.5 + 0.5)}$$

$I = \frac{1.5}{3}$

$I = 0.5\ A$

ii) $V = IR$

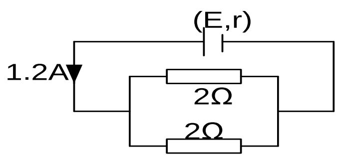
$V = 0.5x2.5$

$V = 1.25V$

2. A cell can supply a current of $1.2A$ through two 2Ω resistors connected in parralle. When they are connected in series the value of current is $0.4A$. Clculate the internal resistance and emf of the cell.

Solution

case 1



$E = I\ (R + r)$

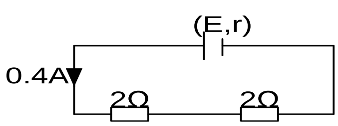
$R = \frac{2x2}{2+2}$

$R = 1\Omega$

$E = 1.2\ (1 + r)$

$E = 1.2 + 1.2\ r$........[1]

Case 2



$E = I\ (R + r)$

$R = \ 2 + 2$

$R = 4\Omega$

$E = 0.4\ (4 + r)$

$E = 1.6 + 0.4\ r$........[2]

Equating 1 and 2

$1.2 + 1.2\ r$=$1.6 + 0.4\ r$

$1.2\ r - 0.4\ r = 1.6 - 0.4$

$0.8r = 0.4$

$r = \frac{0.4}{0.8}$

$r = 0.5\Omega$

Also $E = 1.2 + 1.2\ r$

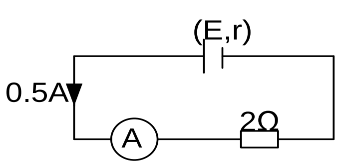
$E = 1.2 + 1.2\ x\ 0.5$

$E = 1.2 + 0.6$

$E = 1.8\ V$

3. An ammeter connected in series with a cell and a 2Ω resistor reads $0.5A$. When the 2Ω resistor is replaced by a 5Ω resistor, the ammeter reading drops to $0.25A$. Calculate the internal resistance and the emf of the cell.

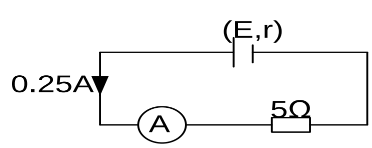
Solution



$E = I\ (R + r)$

$E = 0.5\ (2 + r)$

$E = 1 + 0.5\ r$........[1]



$E = I\ (R + r)$

$E = 0.25\ (5 + r)$

$E = 1.25 + 0.25\ r$........[2]

Equating 1 and 2

$1 + 0.5\,r = 1.25 + 0.25\,r$

$0.5\,r - 0.25\,r = 1.25 - 1$

$0.25r = 0.25$

$r = \dfrac{0.25}{0.25}$

$r = 1\,\Omega$

Also $E = 1 + 0.5\,r$

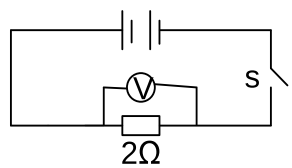
$E = 1 + 0.5\,x\,1$

$E = 1 + 0.5$

$E = 1.5\,V$

Exercise

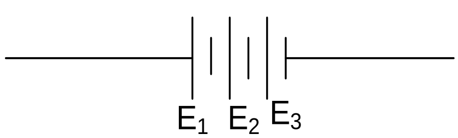
1. A cell is joined in series with a resistance of 2Ω and a current of $0.25A$ flows through it. When a second resistance of 2Ω is connected in parallel with the first, the current through the cell is$0.3A$. Calculate the internal resistance and emf of the cell. **[4Ω, $\mathbf{1.5V}$]**
2. Two cells each of e.m.f 1.5 V and internal resistance 0.5 Ω are connected in series with a resistor of 2 Ω as in the figure below.



The reading of the voltmeter V when S is closed is? **[2V]**

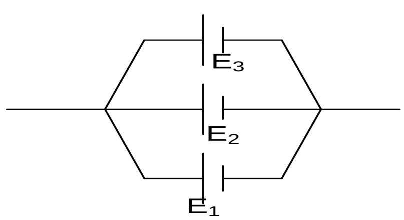
CELL ARRANGEMENTS

1. Series arrangement



Total emf $E = E_1 + E_2 + E_3$

2. Parallel arrangement



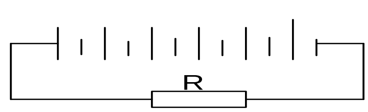
When cells of equal ***emf*** are connected in parallel

Total emf $E = E_1 = E_2 = E_3$

Example

1. Find the total emf in each of the following circuits if each cell is of emf $1.5V$

(i)

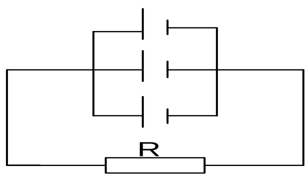


Solution

Total $emf\ E = 1.5 + 1.5 + 1.5 + 1.5 + 1.5 + 1.5$

$= 9.0V$

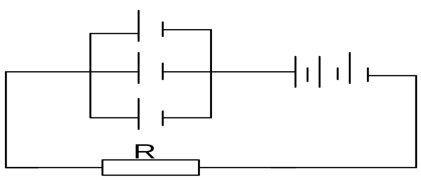
(ii)



Solution

Total $emf\ E = 1.5V$

(iii)



Solution

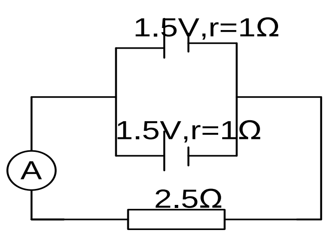
Total $emf\ E = 1.5 + 1.5 + 1.5 + 1.5$

$= 6.0V$

Note: If the cells are connected in parallel and have internal resistance, their resistance is calculated as resistors in parallel.

Examples

1. Find the ammeter reading



Solution

$E = I\ (R + r)$

$$r = \frac{1x1}{1+1}$$

$r = 0.5\Omega$

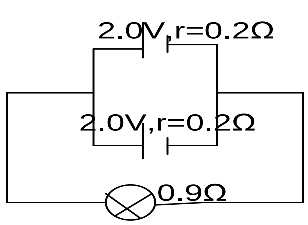
$1.5 = I\ (2.5 + 0.5)$

$$I = \frac{1.5}{3}$$

$I = 0.5A$

2. Two cells of emf 2.0V and internal resistance 0.2Ω each are connected together in parallel to form a battery. This battery is connected to a lamp of resistance0.9Ω. Calculate the current through the lamp and voltage across the lamp.

Solution



$E = I\ (R + r)$

$$r = \frac{0.2x0.2}{0.2+0.2}$$

$r = 0.1\Omega$

current through the lamp

$2 = I\,(0.9 + 0.1)$

$I = \frac{2}{1}$

$I = 2A$

voltage across the lamp

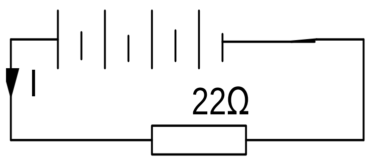
$V = IR$

$V = 2x0.9$

$V = 1.8V$

3. Four cells each of emf 1.5V and internal resistance 0.5Ω are connected in series. What current will flow through an external resistor of 22Ω

Solution



Total emf E = 1.5x4

$E = 6V$

Total internal resistance r = 0.5x4

$r = 2\Omega$

$E = I\,(R + r)$

$6 = I\,(22 + 2)$

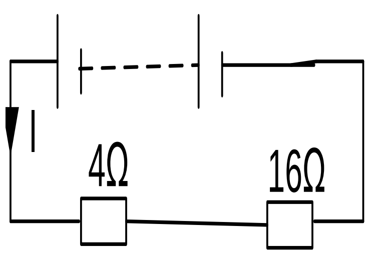
$I = \frac{6}{24}$

$I = 0.25A$

4. A battery containing 8 cells each of emf 1.5V and internal resistance 0.5Ω is connected to two other resistors of 4Ω and 16Ω . Calculate the minimum and maximum current that can flow through the battery.

Solution

For minimum current the resistors must be connected in series



Total emf E = 1.5x8

$E = 12V$

Total internal resistance r = 0.5x8

$r = 4\Omega$

Total external resistance R= 4 + 16

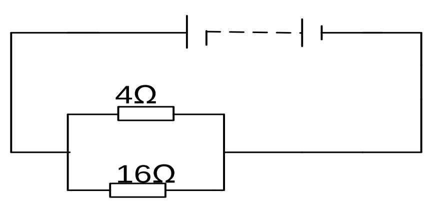
$E = I\,(R + r)$

$12 = I\,(16 + 4 + 4)$

$I = \frac{12}{24}$

$I = 0.5A$

For maximum current the resistors must be connected in parallel



Total emf E = 1.5x8

$E = 12V$

Total internal resistance r = 0.5x8

$r = 4\Omega$

Total external resistance R= $\frac{4x6}{4+6}$

$R = 3.2\Omega$

$E = I\,(R + r)$

$12 = I\,(3.2 + 4)$

$I = \frac{12}{7.2}$

$I = 1.67A$

CONNECTION OF AMMETERS AND VOLTMETERS IN A CIRCUIT

- A voltmeter measures $p.d$ between terminals, it should be connected between the two points for which p,d is required ie in parallel with that point of the circuit.
- An ammeter measures the current through the circuit, it is connected in series with the circuit, it has a low resistance so that it offers a little resistance to the circuit.

WORK DONE BY AN ELECTRIC CURRENT

If the $P.d, V$ is applied to the ends of a conductor and quantity of electricity, Q flows then

$$work\ done = Q\,V \quad \text{but } Q = It$$

$$W = It\,V$$

$$\boxed{W = IVt}$$

but $V = IR$

$$W = I\,(IR)\,t$$

$$\boxed{W = I^2\,R\,t}$$

but $I = \frac{V}{R}$

$$W = \left(\frac{V}{R}\right)^2 R\,t$$

$$\boxed{W = \frac{V^2\,t}{R}}$$

The work done is transferred into internal molecular energy accompanied by a rise in temperature subsequently, this energy may be given out in form of heat

ELECTRICAL POWER

This is the rate of doing work by an electric current.

$$power = \frac{work\ done}{time\ taken}$$

$$P = \frac{I\,V\,t}{t}$$

$$\boxed{P = I\,V}$$

Also

$$power = \frac{work\ done}{time\ taken}$$

$$P = \frac{I^2\,R\,t}{t}$$

$$\boxed{P = I^2\,R}$$

Also

$$power = \frac{work\ done}{time\ taken}$$

$$P = \frac{V^2 t}{R} \Big/ t$$

$$\boxed{P = \frac{V^2}{R}}$$

Examples

1. A lamp is rated $240V, 60W$

a) what does this statement mean

b) find (i) current taken

(ii) resistance of the filament

Solution

a) It means that the lamp is connected to a $240V$ mains to produce $60J$ per second.

b) i) $P = I\,V$

$$I = \frac{P}{V}$$

$$I = \frac{60}{240}$$

$$I = 0.25A$$

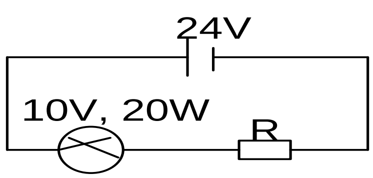
ii) $V = IR$

$$R = \frac{V}{I}$$

$$I = \frac{240}{0.25}$$

$$I = 960\Omega$$

2. A battery of emf $24V$ is connected in series with aresistance R and a lamp rated $10V, 20W$ as shown below.



if the bulb is operating normally . Find,

i) the p.d across the resistor

ii) the value of R

iii) power dissipated in the resistor

Solution

i) $p.d$ across the resistor

$$= (24 - 10)V$$

$$= 14V$$

ii) Current through the bulb

$$P = IV$$

$$I = \frac{P}{V}$$

$$I = \frac{20}{10}$$

$$I = 2A$$

Bulb and resistor have the same current

$$V = IR$$

$$R = \frac{V}{I}$$

$$R = \frac{14}{2}$$

$$R = 7\Omega$$

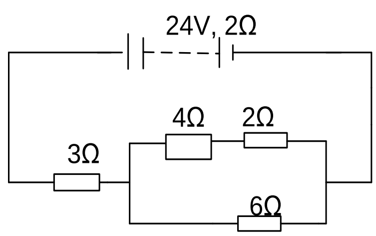
iii) power dissipated in the resistor

$$P = I^2 R$$

$$P = 2^2\ x\ 7$$

$$P = 28W$$

3. An accumulator of $emf\ 24V$ and internal resistance 2Ω is connected in a circuit as shown below.



a) calculate the current through the 6Ω resistor

b) calculate the power expended in the 6Ω resistor

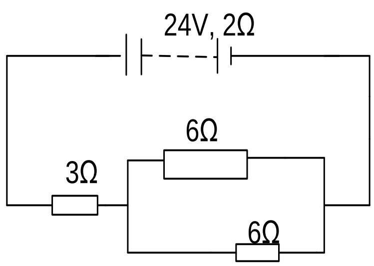
c) find the total power expended

Solution

a) for 4Ω and 2Ω resistors

total resistance $R = (4 + 2)$

$R = 6\Omega$



Total resistance= $\left[3 + \left(\frac{6x6}{6+6}\right)\right]$

$= 6\Omega$

$E = I\ (R + r)$

$24 = I\ (6 + 2)$

$I = \frac{24}{8}$

$I = 3A$

$p.d$ through parallel combination

$V = IR$

$V = 3x\left(\frac{6x6}{6+6}\right)$

$V = 9V$

Current through the 6Ω resistor

$V = IR$

$I = \frac{V}{R}$

$I = \frac{9}{6}$

$I = 1.5A$

b) power in 6Ω resistor

$P = IV$

$P = 1.5\ x\ 9$

$P = 13.5\ W$

c) total power= $I\ E$

$= 3x\ 24$

$= 72W$

PAYING FOR ELECTRICITY

UMEME charges for electricity it supplies. The board's trade unit of electrical energy is called a kilo watt hour $(k\ W\ \ h)$

Kilo watt hour:

Is the electrical energy used by 1 kilo watt appliance in 1 hour

ENERGY COST

$$Number\ of\ unit = power(kilowatt)\ \ x\ \ time\ (hours)$$

$$n\ = P\ (kW)\ x\ t\ (h)$$

$$Cost\ of\ electricity = Number\ of\ units\ x\ cost\ of\ one\ unit\ (C)$$

$$Cost\ of\ electricity = n\ x\ C$$

$$Cost\ of\ electricity = \ P\ (kW)\ x\ t\ (h)\ x\ C$$

$$\boxed{Total\ Cost\ of\ electricity = power(kilowatt)\ \ x\ \ time\ (hours)\ x\ cost\ of\ one\ unit\ (C)}$$

Examples

1. Opolot uses four $75W$ lamps for 8hours. If the electricity costs 460/= per unit. Find the total cost.

   Solution

$$Total\ Cost\ of\ electricity = power(kilowatt)\ \ x\ \ time\ (hours)\ x\ cost\ of\ one\ unit\ (C)$$

$$= \frac{75\ x\ 4}{1000} x\ 8\ x460$$

$$=\ \ 1{,}104\ sh$$

2. Find the cost of running five 60W and four 100W lamps for 8hours, if the electrical energy cost sh 480 per unit.

   Solution

$$Total\ Cost\ of\ electricity = power(kilowatt)\ \ x\ \ time\ (hours)\ x\ cost\ of\ one\ unit\ (C)$$

$$= \left[\left(\frac{5\ x60}{1000}\right) + \left(\frac{4\ x\ 100}{1000}\right)\right] x\ 8\ x480$$

$$=\ \ 2{,}688\ shs$$

3. A house has a 100 watt, two 75 watt bulbs and five 140 watt bulbs. Find the cost of having all these bulbs switched on for 5 $^1/_2$ hours each day for 45 days at a cost of 425 sh per unit

   Solution

$$Total\ Cost\ of\ electricity = power(kilowatt)\ \ x\ \ time\ (hours)\ x\ cost\ of\ one\ unit\ (C)$$

$$= \left[\left(\frac{1x100}{1000}\right) + \left(\frac{2x75}{1000}\right) + \left(\frac{5\ x\ 140}{1000}\right)\right] x\ (5\ ^1/_2\, x45)\ x425$$

$$= \frac{950}{1000} x \frac{11}{2} x45x425$$

$$=\ \ 99{,}928\ shs$$

4. Calculate the cost of running an electric fire for 2 $^1/_2$hours, if an electric fire takes a current of 13A on a 100V supply and each unit cost 440 sh

   Solution

   $P = I\ V$

   $P = 13x\ 100$

   $P = 1300W$

$$Total\ Cost\ of\ electricity = power(kilowatt)\ \ x\ \ time\ (hours)\ x\ cost\ of\ one\ unit\ (C)$$

$$= \frac{1300}{1000} x\ 2\ ^1/_2\ x440$$

$$=\ \ 1{,}430\ shs$$

5. A 4Kw electric fire is used for 10 hours each week and a 100W bulb is used for 10 hours each day. Find the total cost for each week if a unit of electricity cost 300 sh

   Solution

For electric fire

$$Cost\ of\ electricity = power(kilowatt)\ \ x\ \ time\ (hours)\ x\ cost\ of\ one\ unit\ (C)$$

$$= \frac{100}{1000} x\ (10x7)\ x300$$

$$= \ 2,100\ shs$$

For 100W bulb

$$Cost\ of\ electricity = power(kilowatt)\ \ x\ \ time\ (hours)\ x\ cost\ of\ one\ unit\ (C)$$

$$= \ 2x\ 10\ x300$$

$$= \ 6,000\ sh$$

$$Total\ Cost = 2100 + 6000$$

$$= 8100\ shs$$

6. Jane paid an electricity bill of 1800shs after using two identical bulbs for 2hours every day for 10days at a cost of 600shs per unit. Determine the power consumption by each of the bulbs

Solution

$$Total\ Cost\ of\ electricity = power(kilowatt)\ \ x\ \ time\ (hours)\ x\ cost\ of\ one\ unit\ (C)$$

$$1800 \quad = \ P(kW)x\ (2x10)\ x600$$

$$P(kW) = \ \frac{1800}{20x600}$$

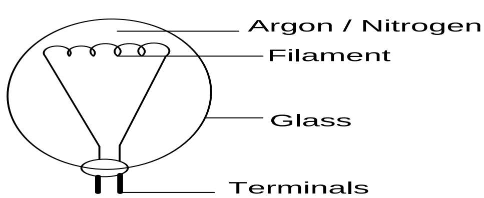
$$P(kW) = 0.15kW$$

For one bulb= $\frac{0.15}{2}$

$$= 0.075kW$$

$$= 75W$$

Filament lamp



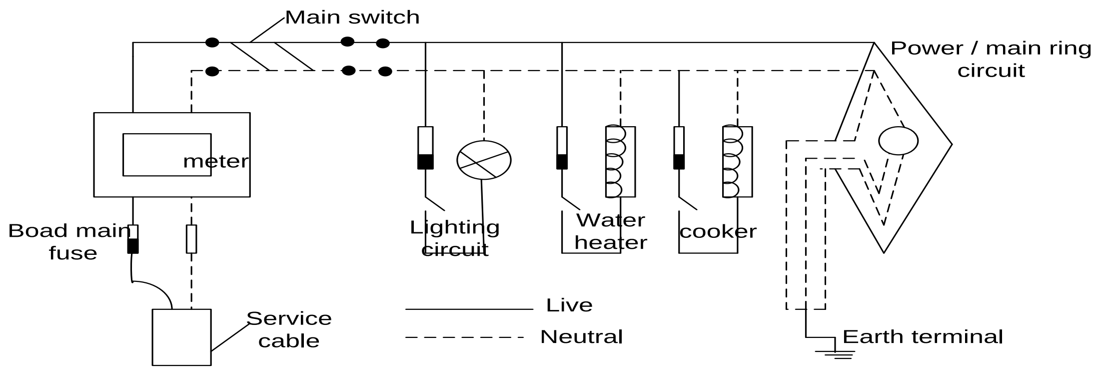
It is filled with argon or nitrogen because it reduces evaporation of tungsten which would otherwise condense o the bulb or blacken it.

HOUSE CIRCUITS

The cable bringing the main electricity supply into the house contains two wires one of which is live and the other neutral.

The neutral is earthed at the local transformer substation so that it is at zero potential.

The supply s alternating current which flows to and fro rapidly.



Fuse:

Is a device which contains a thin wire which melts and breaks the circuit when the current exceeds a safe value.

Causes of the fuse to break

- overloading
- worn insulation on connecting wires

Precautions taken when wiring a house

- Wires should be insulated
- Earthing must be provided. This prevents electrical shocks if an appliance develops a fault.
- The right colour codes must be used ie red or brown for live , black or blue for neutral and yellow or green for earth.
- The fuse should be in each and every circuit.
- The switches must be connected to the live wire

Note:

Switches are connected to the live wire so that when in off position, they are completely switched off otherwise if they were connected to the neutral line even when the switch is in off position power sockets would still remain in the live and therefore there would be a shock by touching the element of an electric fire even when it was switched off.

Section A

1. An alternative unit that could be used for current is

   A. Joule per second C. Coulomb per second
   B. Joule per coulomb D. Volt per meter

2. When a 12 V lamp is connected to a car battery, a current of 3 A passes through its filament. Calculate the energy transferred by the lamp in 20 s

   A. 720 J B. 24O J C. 60 J D. 36 J

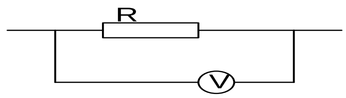
3. An electric heating element rated 120 W is used to heat water for 4 h. Find the electrical energy consumed in kWh

A. $\frac{120 \times 4}{1000}$ B. $120 \times 4 \times 1000$ C. $\frac{120 \times 1000}{4}$ D. $\frac{1000 \times 4}{120}$

4. Find the effective resistance of two resistors of 4 Ω and 6 Ω connected in parallel

A. 10.0 Ω B. 2.4 Ω C. 5.0 Ω D. 0.4 Ω

5. Figure below shows a voltmeter (V) connected across a conductor of resistance R



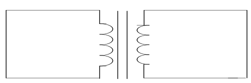
If the current through the conductor is 2.5 A and the voltmeter reads 12.5 V. Find the value of R

A. 31.2 Ω B. 15.00 Ω C. 5.00 Ω D. 0.20 Ω

What is the potential difference across a load if the energy needed to maintain a current of 0.8A in the load for 10s is 40J?

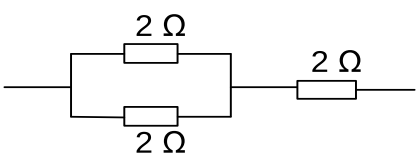
A. 0.2V B. 3.2V C. 5.0 D. 320V

6. Figure below shows an electrical symbol for a



A. Transformer B. ammeter C. rheostat D. cell

7. Three resistors each of 2 Ω are connected as shown in figure?



The effective resistance is

A. 1. 5 Ω B. 2.0 Ω

C. 3.0 Ω D. 6.0 Ω

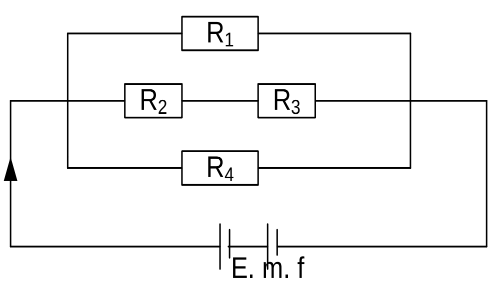
8. A fire alarm rated 240V, 1.5Kw runs for10 hrs a day. If the cost per unit of electricity is shs 380, find the daily cost of running the alarm.

A. shs 570 B. shs2400 C. shs3800 D.shs5700

9. An appliance that uses a current of 3 A is connected to the mains by wires that can carry up to 5 A. The best fuse that can be used for the appliance is

A. 2 A fuse B. 3 A fuse C. 4 A fuse D. 5 A fuse

10.



In the circuit shown above, the potential difference across

A. R_1 and R_2 are equal

B. R_2 and R_4 are equal

C. R_1 and R_4 are equal

D. R_3 and R_4 are equal

11. Calculate the charge which flows through a 600 Ω resistor when a $p.d$ of 20 V is applied for 30 s across its ends

A. 900 C   B. 600 C   C. 20 C   D. 1 C

12. Which of the following is NOT an effect of an electric current?

A. Electrolysis   B. Magnetic effect   C. Heating effect   D. Radioactivity

13. Which of the following works with a direct current only

A. Electroplating   B. Electric lamp   C. Transformer   D. Electric bell

14. Calculate the power wasted as heat in a cable of resistance 0.5 Ω, when it transmits 2 kW at 100V

A. 800 W   B. 200 W   C. 100 W   D. 50 W

15. The possible energy transfer in an electric bulb is

A. light energy to heat energy
B. heat energy to electrical energy
C. electrical energy to light energy
D. light energy to electrical energy

16.

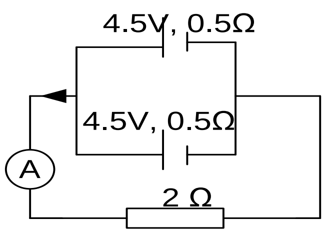


Figure above shows two cells each of $e.m.f$ 4.5 V and internal resistance 0.5 Ω, connected to a 2 Ω resistor. What is the ammeter reading?

A. 1.5 A   B. 2.0 A
C. 4.0 A   D. 9.0 A

17. A current of 6 A flows for 2 hours in a circuit. Calculate the quantity of electricity that flows in this time

A. 3 C   B. 12 C   C. 720 C   D. 43200 C

18. The rate at which electric charge flows past a point in a circuit is measured in

A. watts   B. volts   C. amperes   D. coulombs

19. What is the potential difference across a load, if the energy needed to maintain a current of 0.8 A in the load for 10 s in 40 J.

A. 0.2 V   B. 3.2 V   C. 5.0 V   D. 320 V

20. The resistance of a wire increases when its

A. Length is increased   B. Length is decreased
C. Temperature is reduced   D. Cross-sectional area is doubled.

21. Which of the following appliances consumes 5 kWh of electrical energy?

A. A 100 W lamp left on for 10 hours
B. A 250 W drill used for 2 minutes
C. A 500 W motor used for 10 minutes
D. A 250 W television left on for 20 minutes

22. The initial and final reading after one month of electricity supplied is 21000kWh and 21800 kWh, if each unit costs shs.175

A. $\frac{Shs\ 800}{175}$ B. $\frac{sh\ 42800}{175}$

C. $sh. 800\ x\ 175$ D. $sh\ 42800\ x\ 175$

23. Two appliances are rated 240V, 2kW and 240V, 500W. Find the cost of running these appliances for 3 hours, if one unit of electricity cost 70/=

A. 105/= B. 175/= C. 420/= D. 525/=

24. $A\ p.d$ of 20V is applied across two resistors of 5 Ω and 6 Ω connected in series . Determine the $p.d$ across the 6 Ω resistor if the total circuit current is 2A.

A. 1.0V B. 2.0V C. 3.3V D. 12.0V

25. An electric bulb has a resistance of 960 Ω. Find the electrical power expended when connected across a 240V supply.

A. $\frac{960}{240\ x\ 240}$ B. $\frac{240}{960}$ C. $\frac{960}{240}$ D. $\frac{240\ x\ 240}{960}$

26. Which of the following statement is / are true?

(i) When identical cells are in parallel, the total emf is the sum of individual $emfs$.

(ii) In a lead – acid accumulator, the lead peroxide acts as the positive pole

(iii) The emf of a cell is the total p. d across the external and internal resistances.

A. (i) only B. (i) and (ii) only C. (ii) and (iii) only D. (i),(ii) and (iii)

27. A cell of emf 1.5V and internal resistance,r, is connected in series with a 5 Ω resistor as shown above. If the current in the circuit is 0.25A, find r.

A. 1 Ω B. 6 Ω C. 11 Ω D. 16 Ω

28. A current of 10A flows through an electrical heater for 1 hour. If 7.2 $x\ 10^4$ J of electrical energy is converted to heat. The $P.d$ across the heater is;

A. $2.0\ x\ 10^2 V$ B. $2.0\ x\ 10^3 V$ C. $1.2\ x\ 10^4 V$ D. 7.2 $x\ 10^4$V

29. If the cost of one unit of electrical energy is 150/= , find the cost of using two 75W lamps for 2 hours.

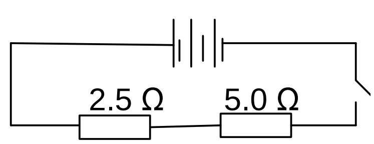
A. 0.30/= B. 4.00/= C. 22.50/= D. 45.00/=

30. An electric lamp is marked 120 W, 240V. What does 120 W mean?

A. Total energy consumed by the lamp B. Rate at which energy is consumed

C. Total current flowing through the lamp D. Potential difference across the lamp

31.



If each cell shown in the figure above has an internal resistance of 0.5 Ω , find the effective resistance in the circuit.

A. 1.25 B. 7.50 C. 8.00 D. 9.00

32. Two resistors of 2 ohms and 3 ohms are connected in series with a 10volt battery of neglible internal resistance. The potential difference across a 3 ohm resistors is

A. 2V B. 5V C. 6V D. 10V

33. A bulb is rated 240 V , 60W . Find its resistance.

A. 0.25 Ω B. 410 Ω C. 120 Ω D. 960 Ω

34. Uganda electricity Board charges sh. 90/= per kilo – watt hour of electrical energy consumed . What is the total cost of operating four light bulbs rated at 100 W for 5 hours?

A. 11.25/= B. 45/= C. 180/= D. 180.000/=

35. A current of 2A flows through a coil of resistance 3 ohms for one minute . How much energy is converted into heat?

A. 6J B. 12J C. 360J D. 720 J

36. What is the cost of running five 200 W lamps for 8 hours if electrical energy costs shs. 140 per unit?

A. Sh.1120 B. sh.700 C. sh. 224 D. sh.28

37. The device which disconnects the mains when there is a sudden increase in voltage is

A. Fuses B. Switch C. Earth wire D. Circuit breaker

38. An electric heater is connected to a 200 V supply . The heating element has a resistance of 10 Ω . The cost of using the heater for 4 hours if each unit of energy costs sh. 35 is

A. sh.5600 B. sh.1400 C. sh.500 D. sh.140

39. The resistance of a metal in the form of a wire increase with

A. Decreases in length B. Increase in temperature
C. Decrease in temperature D. Increase in cross – section area.

40. How many kilowatt hours are used to run

(i) 8 kW cooker for 1 hour
(ii) 3 kW immersion heater for 40 min
(iii) 960 W hair drier for 20 min

A. 10.32 kWh B. 147.20 kWh C. 768.00 kWh D. 971.00kWh

41. The effective resistance when two resistors of 5 Ω and 15 Ω joined in series are placed in parallel with a 20 Ω resistor is

A. 0.1 Ω B. 10 Ω C. 20 Ω D. 40 Ω

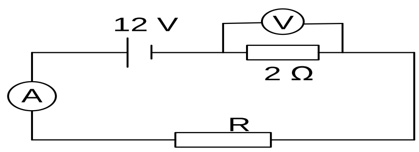
42. When a 240 V supply is connected across an electrical appliance, a current of 200 mA flows in the circuit. What electrical power supplied to the appliance?

A. 1.2 W B. 48.0 W C. 48000.0W D. 120000.0W

43. For safety in a house, a fuse and a switch are connected to

	Fuse	Switch
A.	Live wire	Neutral wire
B.	Neutral wire	Earth wire
C.	Live wire	Live wire
D.	Earth wire	Neutral wire

44. In the figure below, the ammeter A reads 4A and the voltmeter v reads 4v. Find the value of R.



A. 1Ω B. 2Ω

C. 3Ω D. 4Ω

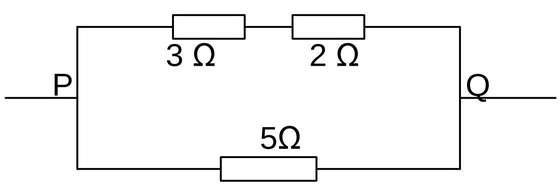
45. An electric appliance having 4 heating elements, each rated at 0.75 kW, is used on a 240 V mains. What is power rating of the appliance?

A. 80 kW B. 60 kW C. 3 kW D. 3 W

46. An electric heater is rated 240 V, 400W. if the efficiency of the heater is 80%. Find the amount of energy wasted per second.

A. 48 J B. 80J C. 192 J D. 320 J

47.



The figure shows a network of resistors . The effective resistance between points P and Q is

A. 0.97Ω B. 1.2Ω

C. 2.5Ω D. 10Ω

48. A car head lamp bulb is marked 12V , 48 W. This means that when a

A. Voltage of 12 V is applied , a current of 0.25 A flows

B. Power of 48 W is developed, the resistance is 4Ω

C. Voltage of 12 V is applied, resistance is 4Ω

D. Voltage of 12 V is applied , energy in every second is 48J.

49. Which of the following statements are true about electric wiring?

(i) The fuse is always connected into the live wire leading to a circuit

(ii) The fuse is connected into the neutral wire leading to a circuit

(iii) When a fault develops in the circuit, it is neutral wire which has to be disconnected

A. (i) only B. (iii) only C. (i) and (iii) only D. (i),(ii) and (iii)

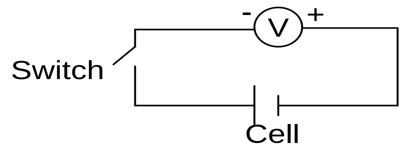
50. An electricity board charges 10 per kilowatt – hour of electrical energy supplied. What is the total cost in shs. Of operating 4 light bulbs, each rated at 100 W for 5 hours?

A. sh 2 B. sh. 20 C. sh.4,000 D. sh.20,000

51. What is the most suitable fuse for an electric heater rated 2.5 k W when connected to a voltage of 240V?

A. 5A B. 10A C. 13A D. 30A

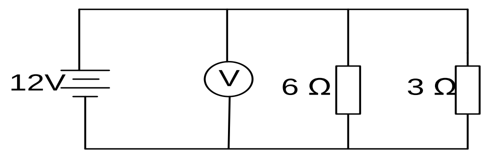
52. When the circuit in the figure above is switched on, the voltmeter



A. Show no deflection B. Deflects in the wrong direction

C. Reads the $e.m.f$ of the cell D. Reads the terminal potential difference across the cell

53.



A battery of $e.m.f$ 12 V is connected across two resistors of 6Ω and 3Ω as shown in the figure. Which one of the following statement is true about the circuit? The

A. $p.d$ across 6Ω is half the $p.d$ across 3Ω

B. $p.d$ across 6Ω is twice the $p.d$ across 3Ω

C. $p.d$ across 6Ω is the same as the $p.d$ across 3Ω

D. reading of voltmeter V is greater than 12 V

54. An electric heater which operates from 240 V mains draws 15 A for 40 minutes. Calculate the cost of electricity, given that electricity costs Sh. 9.00 per kilowatt hour.

A. shs.1.44 B. sh. 21.60 C. sh.960 D. sh. 1296

55. Two coils of wire of resistances 2Ω and 3Ω are connected in series to a 10V battery of negligible internal resistance. The current through the 2Ω resistor is

A. 0.5 A B. 2 A C. 5 A D. 50 A

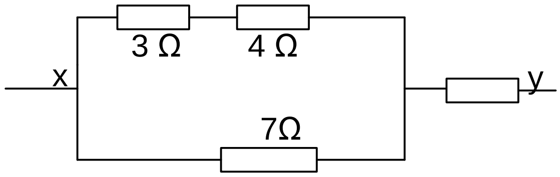
56. A bulb of resistance 1.5Ω is connected to a cell of $e.m.f$ 2.0 V. Find the energy dissipated in 45 s.

A. 60 J B. 67.5 J C. 90 J D. 120 J

57. Calculate the amount of current taken by an electric flat iron marked 250 V, 1000 W.

A. 0.25 A B. 0.40 A C. 2.50 A D. 4.00 A

58.

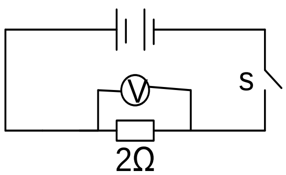


The total resistance between X and Y in the figure is

A. 20.0 Ω B. 9.50 Ω

C. 6.30 Ω D. 4.2 Ω

59. Two cells each of $e.m.f$ 1.5 V and internal resistance 0.5 Ω are connected in series with a resistor of 2 Ω as in the figure below.

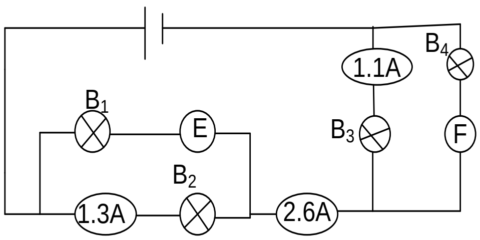


The reading of the voltmeter V when S is closed is

A. 1.0 V B. 1.5 V

C. 2.0 V D. 3.0 V

60.

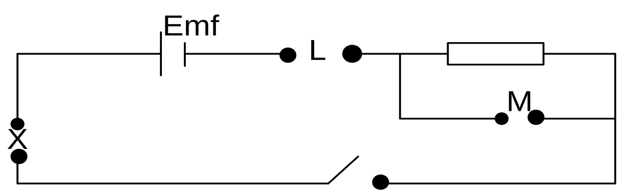


In the above circuit B_1 , B_2, B_3 and B_4 are bulbs. The readings of ammeters e and F are, respectively.

A. 1.5A, 1.3 A B. 1.3 A, 1.5 A

C. 1.3A, 1.1A D. 1.3A, 2.6A

61.



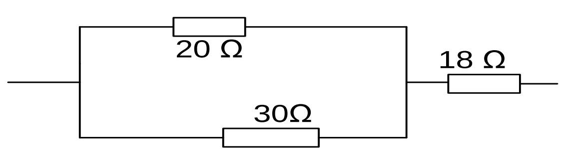
Which one of the following arrangements gives the correct circuit?

	X	**L**	**M**
A.	voltmeter	rheostat	ammeter
B.	ammeter	voltmeter	rheostat
C.	rheostat	voltmeter	ammeter
D.	ammeter	rheostat	voltmeter

62. Four bulbs each rated at 75 W operate for 120 hours . If the cost of electricity is sh. 100/= per unit, the total cost in shillings will be

A. 150 B. 900 C. 3600 D. 7500

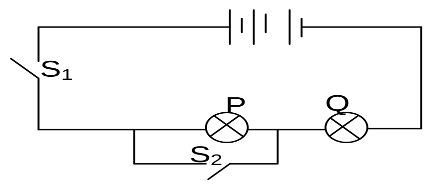
63.



Calculate the effective resistance for the arrangement in the figure above.

A. 0.7 Ω B. 2.8 Ω C. 3.0 Ω D. 6.8 Ω

64.



Which one of the following statements is true about the circuit in the figure above.

A. when S_1 and S_2 are closed both bulbs P and Q light

B. when S_1 is open and S_2 is closed , both bulbs P and Q do not light

C. when S_2 is open and S_1 and is closed , bulb P lights but bulb Q does not

D. when S_1 and S_2 are open , both bulbs P and Q light

65. A house has four 75 W lamps and five 100 W lamps. What will be the cost of running the lamps for 10 hours if the cost per kWh is sh . 50/=

A. sh. 250.00 B. sh.400.00 C. sh.500.00 D. sh.787.50

66. It is recommended that buildings should have earthed conductors in order to

A. reduce heat intensity on hot days

B. remove excess electrons from the building

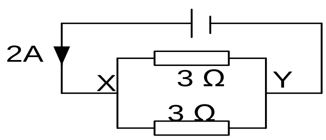
C. stabilize the current electric to the building.

D. provide more charges to electric appliance in the building

67. An electric heater is used to heat 0.2kg of water for 200 s. Find the p.d across the heater if the current through it is 0.5A and the temperature of the water rises by 25^0C

A. 145 V B. 175 V C. 210 V D. 240 V

68. A current of 2 A flows in a circuit in which two resistors , each of 3 Ω, are connected as shown in the figure below. Calculate the p.d across XY



A. 1.5 V B. 3.0 V

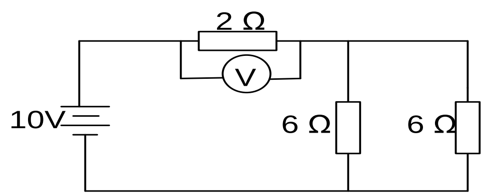
C. 6.0 V D. 12.0 V

69. In a house – wiring system, all connections to power points are in parallel so as to

A. supply the same current B. operate at the same voltage

C. minimize cost of electricity D. consume the same amount of energy

70.



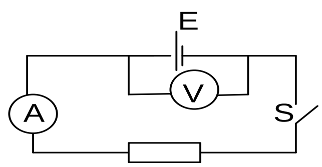
What is the reading of the voltmeter V in the circuit in the figure above?

A. 2.0 V B. 4.0 V C. 5.0 V D. 10.0V

71. A current of 5 A flows through a given point in a circuit for 2 minutes. Calculate the quantity of charge that passes the point.

A. 2.5 C B. 10 C C. 300 C D. 600 C

72.



In the figure above , the readings of the ammeter, A and voltmeter , V when switch S is open and closed respectively are as shown in the table below.

	Ammeter reading	Voltmeter reading
S is open	0.0A	4.5V
S is closed	3.0A	3.0V

The internal resistance of cell E is

A. 0.0 Ω B. 0.5 Ω C. 1.0 Ω D. 1.5 Ω

73. An electric toaster plate is 220 – 240 V, 750 W . The fuse is

A. 1A B. 3A C. 5A D. 13A

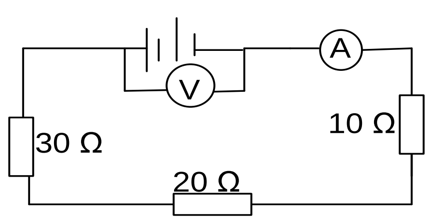
74. The power used in a 100 Ω resistor connected to a 12 V source of $e.m.f$ is

A. 0.69W B. 1.20W C. 1.44W D. 8.33 W

75. A current of 0.5 A flows when an electric lamp is connected to a battery of $e.m.f$ 12 V. When is the total resistance in the circuit?

A. 0.042 Ω B. 6.0 Ω C. 12.5 Ω D. 24.0 Ω

76.

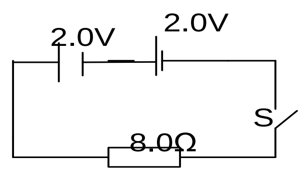


In the circuit diagram above the ammeter reading is 0.2A . The reading , in volts shown by the voltmeter is

A. 6 B. 8

C. 10 D. 12

77.

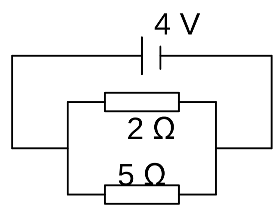


Two identical cells each of $e.m.f$ 2.0V and negligible internal resistance are connected as shown in figure above. Calculate the current through the 8 Ω resistor when switch S is closed

A. 0.25 A B. 0.50 A

C. 2.00 A D. 4.00 A

78.



Calculate the current in the 2 Ω resistor in the circuit in the figure above .

A. 0.5 A B. 0.8 A

C. 2.0 A D. 2.8 A

79. Calculate the cost of running four 40 W lamps and three 60 W lamps for 5 hours if electric energy costs shs. 10 per kilowatt – hour unit.

A. shs. 3.4 B. shs. 17 C. shs. 34 D. shs.50

80. Very high voltages are used when distributing electrical power from the power stations because

A. some electrical equipment require very high voltage

B. currents are lower so energy losses are smaller

C. very high voltages are generated at the power stations

D. there is less likelihood of the transmission lines being struck by lightening.

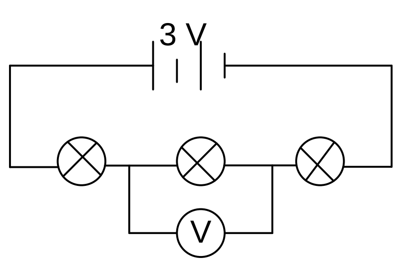
81. How many lamps marked 75 w . 240 v could light normally when connected in parallel having a 5 A fuse?

A. 1 B. 3 C. 16 D. 26

82. Two cells of $e.m.f$ 1.5 V and internal resistance 1Ω are in series with a resistor of resistance 2Ω. Calculate the value of the current in the circuit .

A. $\frac{1.5}{4}\ A$ B. $\frac{1.5}{3}\ A$ C. $\frac{3}{4}\ A$ D. 1A

83.



There identical lamps are connected as shown above. What is the reading on the voltmeter?

A. 1.0 V B. 1.5 V

C. 2.0 V D. 3.0 V

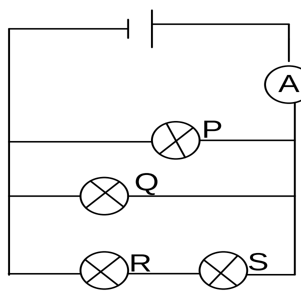
84. Which one of the following would be suitable to use the construction of transformer – core?

A. Lead B. copper C. soft iron D. aluminium

85. Which one of the following equations does not represent the expression for power P , in terms of voltage V, current I , and resistance R

A. $P = VI$ B. $P = I^2R$ C. $P = \frac{V^2}{R}$ D. $P = \frac{R^2}{I}$

86.



The ammeter in the figure above indicates the current through

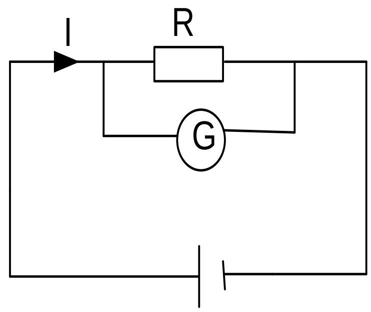
A. lamp P only B. lamps P and Q

C. lamps Q and S D. lamps P,Q ,R and S

87. An electric motor is connected by a cable to a 240 v supply. The $p.d$ across the motor is 239V when the current flowing is 5 A . The resistance of the cable is

A. 0.2Ω B. 5Ω C. 47.8Ω D. 48Ω

88.



A galvanometer G , is connected in a circuit as shown in the figure above . the galvanometer is intended to measure

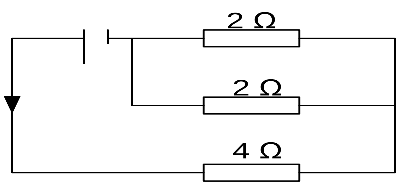
A. the potential difference across R

B. the power dissipated by R

C. the resistance of R

D. the current through R

89.



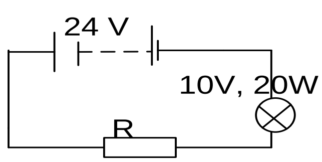
The total resistance in the above circuit is

A. 0.8Ω B. 5.0 Ω

C. 8.0Ω D. 1.25Ω

SECTION B

1. A battery of emf 24V is connected in series with a resistor R and a lamp rated 10V, 20W as shown below. If the bulb is operating normally, find



(i) The p.d across the resistor

(ii) The value of R

(iii) The power dissipated in the resistor.

2. (a) Define the ohm as a unit of resistance

(b)

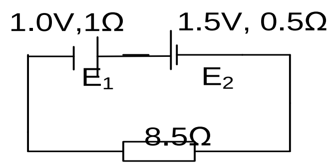


Figure above shows two cells E_1 and E_2 of $e.m.fs$ 1.0 V and 1.5 V and internal resistance of 1.0 Ω and 0.5 Ω respectively connected in series with an 8.5 Ω resistor. Calculate the current flowing through the circuit.

3. (a) What is meant by resistance in an electric circuit

(b) Three resistors 2, 4 and 3 are connected in the same circuit

(i) Draw a diagram to show how they are connected to give minimum resistance

(ii) Find the value of the minimum resistance

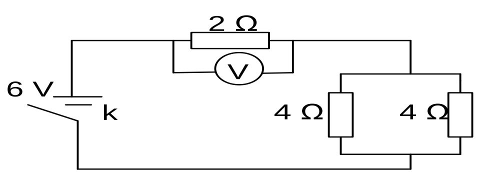
4. (a) Sketch a $p.d$ versus current graph for an *ohmic* resistor.

(b) State one example of anon−*ohmic* conductor.

(c) Find the voltage across a 3Ω resistor if a current of 4A passes through it.

5. (a) Define the volt

(b)



(i) What is the effective resistance in the circuit in the figure above? (The cell has negligible resistance)

(ii) What will be the reading of the voltmeter

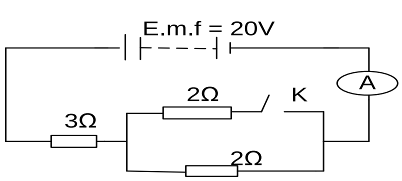
6. (a) What is meant by short circuit as applied electricity?

(b) An electric appliance is marked $240V,\ 4kW$.

(i) What does this statement mean?

(ii) Calculate the current drawn by the appliance in normal use.

7. (a) A source of $e.m.f$ 20V and negligible internal resistance is connected to resistors of 2Ω , 2Ω and 3Ω as shown below.



Find the ammeter reading when switch K is

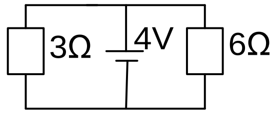
(i) Open

(ii) Closed

8. A galvanometer has a resistance of 5Ω and a range of 0 – 40 mA. Find the resistance of the resistor which must be connected in parallel with the galvanometer if a maximum current of 10A is to be measured.

9. (a) State Ohm's law

(b)



Two resistors of 3Ω and 6Ω are connected across a battery of 4v of negligible internal resistance as shown above. Find the;

(i) Combined resistance

(ii) Current supplied by the battery

10. A galvanometer of full scale deflection 15mA is converted into an ammeter of full scale deflection 3.0 A by connecting a low resistance in parallel with the galvanometer.

(a) What will be the maximum current through the shunt?

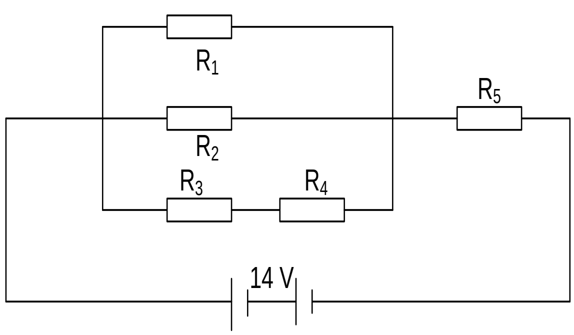
(b) Find the resistance of the shunt if the internal resistance of the galvanometer 4Ω

11. An Ammeter connected in series with a cell and a 2Ω resistor reads 0.5A when the 2Ω resistor is replaced by a 5Ω resistors, the ammeter reading drops to 0.25A. calculate the;

(i) internal resistance of the cell

(ii) emf of the cell

12.



A source of emf of 14v is connected as shown in the figure above. If $R_1 = R_2 = R_3 = R_4 = R_5 = 1\Omega$

Find ;

(i) The equivalent resistance of the circuit

(ii) The current flowing through R_5

(iii) The current through R_3

13. An electrical appliance is rated 240V, 60W.

(a) What do you understand by this statement?

(b) Calculate the current flowing through and the resistance of the appliance, when the appliance is operated at the rated values.

14. (a) Explain why a current does not flow between the electrode in a dilute sulphuric acid until a certain value of $p.d$ is exceeded.

(b) Using the same axes, sketch a graph of current against $p.d$ for;

(i) A torch bulb (ii) A carbon resistor

15. A 240V, 600W water heater is used to boil water for 5 minutes.

(a) By what means does heat spread through the water?

(b) Calculate

(i) The current that flows in the heater

(ii) The electrical energy converted into heat.

16. (a) Define the coulomb as a unit of charge.

(b) A charge of 180C flows through a lamp for 2 minutes. Find the electric current flowing through the lamp.

(c) What is the use of a voltmeter in an electric circuit?

17. (a) why is an ammeter constructed such that it has a low internal resistance.

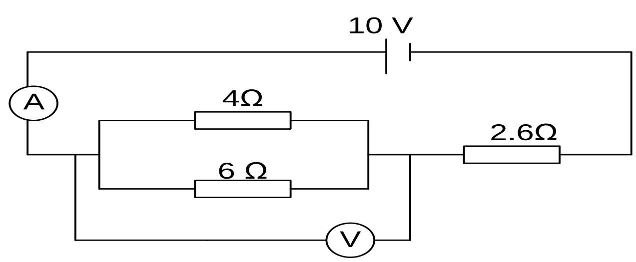
(b) A milliameter has an internal resistance of 4Ω and a full scale deflection of 0.015A. calculate the value of the resistor that must be connected to the milliammeter so that a maximum current of 5A can be measured.

PAPER TWO QUESTIONS

1. (a) Define the following terms

(i) Potential difference **(ii)** Internal resistance if a cell

(b) A battery of *emf* 10V is connected to resistors 2.6 Ω, 4 Ω and 6 Ω as shown in the figure below.



(i) Calculate the ammeter and voltmeter readings

(ii) Find the rate at which electrical energy is converted to heat energy in the 6 Ω resistor

(e) What is meant by a short circuit

(f) (i) Briefly explain how a milliammeter can be adopted to measure much higher currents

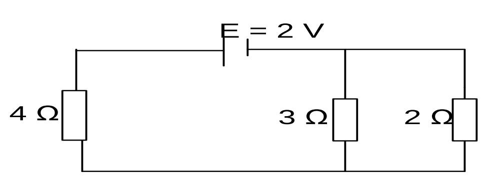
(ii) State two ways of increasing the sensivity of electrical meters

2. (a) Distinguish between **primary** and **secondary** cells and give one example of each.

(b) State two precautions one has to undertake to prolong the life of a lead- acid accumulator

(c) Define potential difference across a resistor in a circuit

(d) With the aid of a circuit diagram, describe how you can determine the internal resistance of a cell.



Calculate the current through the 4 Ω resistor

3. (a) (i) What is meant by **electromotive force?**

(ii) A dry cell supplies a current of 1.2 A through two 2 Ω resistors connected in parallel. When the resistors are connected in series, the current flowing in the circuit is 0.4 A, find the electromotive force

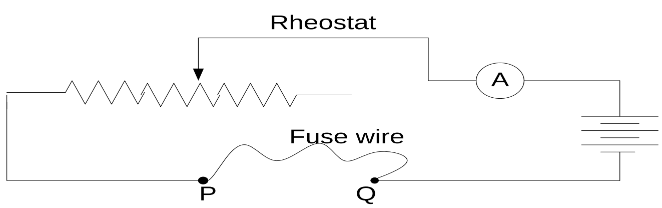
(b) An electric lamp is rated 12V, 24W

(i) Explain what is meant by this statement

(ii) How much current does the lamp draw when connected a cross a 12 V supply?

(c) With the aid of a labelled diagram, describe how four semi-conductor diodes may be used for full wave rectification

4. A student set up the circuit in the figure below to determine the maximum current which can be taken by a fuse wire.



(a) Describe briefly how this circuit could be used to determine the maximum current

(b) Explain what would happen if

(i) tow strands of the fuse wire were connected in parallel across P and Q

(ii) the length of the fuse were doubled

(c) An electric fire, a lamp and electric drill rated at 2000W, 100W and 300 W respectively are connected in parallel across a 240 V mains. Find the

(i) power taken from the mains

(ii) current supplied by the mains

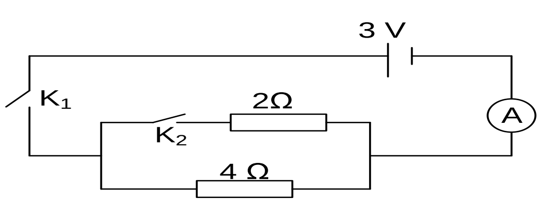
(iii) cost of running these appliances for 12 h if one unit costs Shs.200

5. (a) (i) Explain what is meant by polarization as applied to a simple cell

(ii) State how polarization can be minimized in a simple cell

(b) Explain how the life of a lead-acid accumulator may be prolonged

(c)



What will be the reading of ammeter in figure above if switch K_2 is

(i) open and K_1 closed?

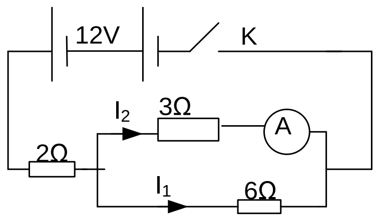
(ii) closed and K_1 is closed?

6. (a) Define the following terms

(i) the volt (ii) electrical resistance

(b) List ways by which the life of an accumulator can be prolonged

(c)



A battery of $e.m.f$ 12 V and negligible internal resistance is connected to resistances 2Ω, 3Ω and 6Ω as shown above. Find the reading of the ammeter, A, when K is closed

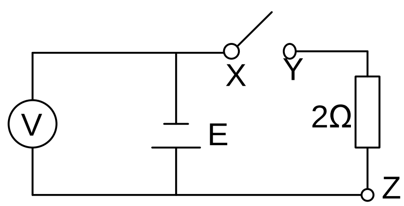
(d) State three advantages of an alternating current over a direct current in power transmission

(e) Sketch the current versus voltage variation for a semiconductor diode

7. (a) (i) Distinguish between a conductor and an insulator

(ii) Describe, stating the observations made, how a gold leaf electroscope can be charged positively

(b) A cell of $e.m.f$ E and internal resistance 1.0Ω is connected in series with a 2Ω resistor and a switch as shown below. The voltmeter reads 1.5 V when the switch is open



(i) What is meant by an $e.m.f$ of a cell?

(ii) Find the value of E

(iii) What will the voltmeter read when the switch is closed?

(iv) What will the voltmeter read if X is connected to Z?. Give reasons for your answer

8. (a) (i) Draw a labelled diagram of a lead acid accumulator

(ii) List three precautions necessary to prolong the life of an accumulator

(iii) State two advantages of a Nife cell over a lead acid cell

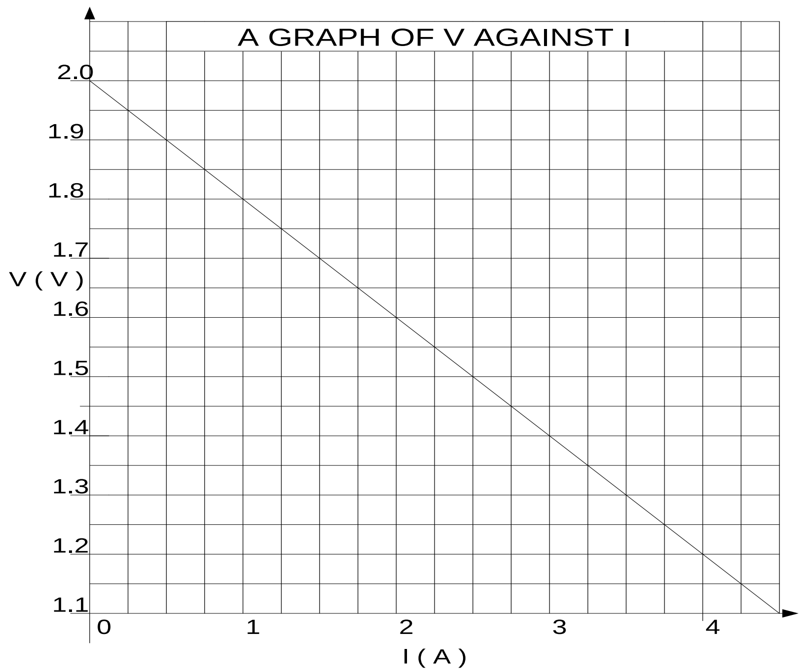
(b) What is meant by the following:

(i) electromotive force,

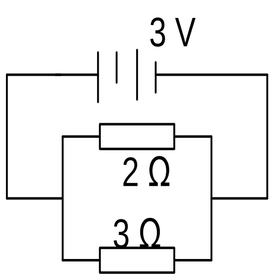
(ii) internal resistance of a cell

(c) A cell is connected in series with an ammeter and a variable resistor. The potential difference, V, across the resistor varies with current I, supplied through the resistor as shown in the graph below. Use the graph to determine the

(i) e.m.f (ii) internal resistance, of a cell



9. (a) Draw sketch graphs of p.d, V against current, I, for the following
   (i) a wire.
   (ii) an electrolyte.
   (iii) a semi-conductor diode
   (b) Explain the difference between a voltmeter and an ammeter in terms of their
   (i) construction
   (ii) use
   (c) State three physical properties that affect the resistance of a solid conductor
   (d)



Two cells each of e.m.f 1.5 V and negligible internal resistance are connected in series across two resistors of 2Ω and 3Ω as shown in the diagram above. Calculate the current
   (i) supplied by the cell
   (ii) that passes through the 3Ω resistor

ELECTROMAGNETISM

Magnetic effect of a current carrying conductors

If a straight vertical wire passing through the center of a card board held horizontally and current is passed through the wire, iron fillings sprinkled on the card board make circles when the board is tapped.

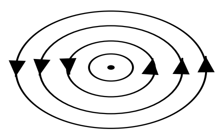
The direction of the magnetic flux depends on the direction of current in the wire, it can be determined using;

(i) Right hand grip rule
It states that if a wire is held in the right hand with the thumb pointing along the direction of the current then the direction of the finger's curvature is the direction of the magnetic flux.

(ii) Maxwell's screw rule

1. Field due to a straight wire carrying current

i) Upwards or out



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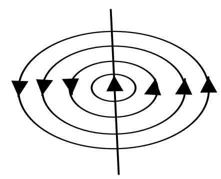
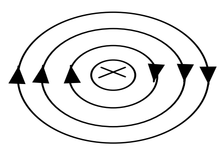


ii) Down or into



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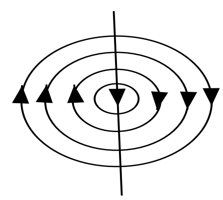
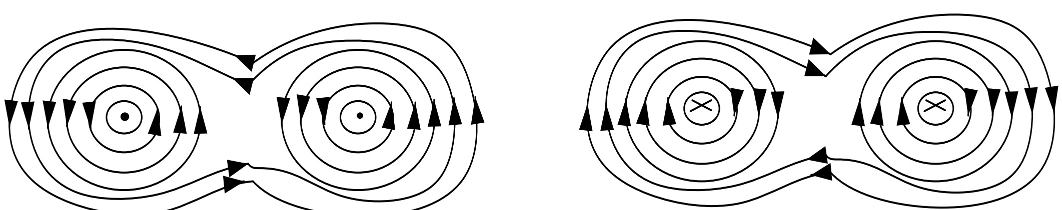
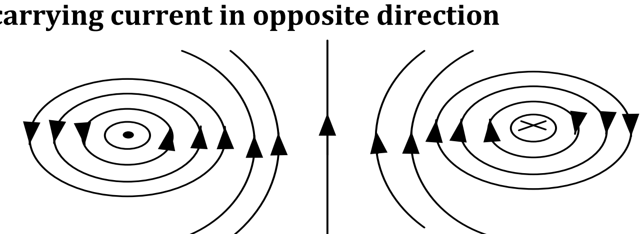


2. Two wires carrying current in the same direction



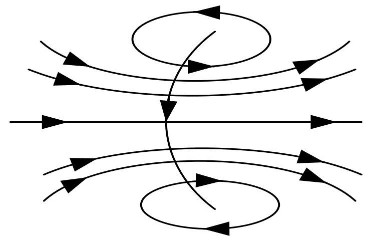
Attraction occurs

3. Two wires carrying current in opposite direction

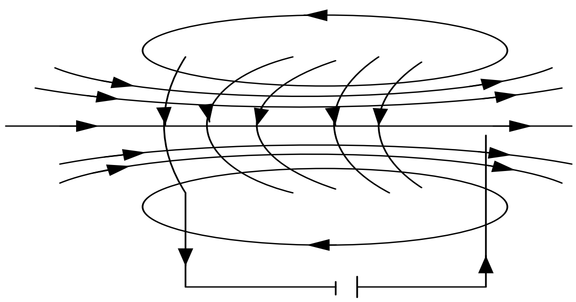


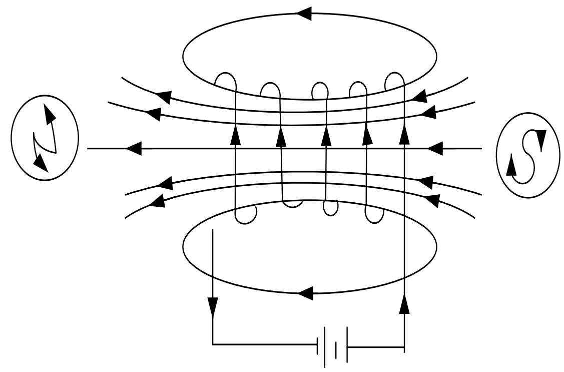
Repulsion occurs

4. **Field due to a circular coil**



5. **Field due to a solenoid carrying current.**





To tell polarity

When viewing one end of the coil, it will be **N** polarity if the current is flowing in *a**N**ticlockwise* direction and of **S** polarity if the current is flowing in clockwise direction

ELECTROMAGNETS

If a bar of pure iron is placed inside a solenoid, it becomes strongly magnetized when the current is flowing.

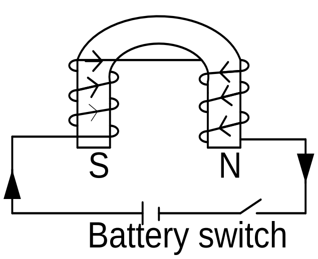
When current is switched off, the iron loses its magnetism such a device is called an **electromagnet.**

The strength of a field of an electromagnet can be increased by;

- Increasing the magnitude of the current
- Using pure iron
- Increasing the number of coils/ turns of the solenoid
- Putting the poles of the magnet closer

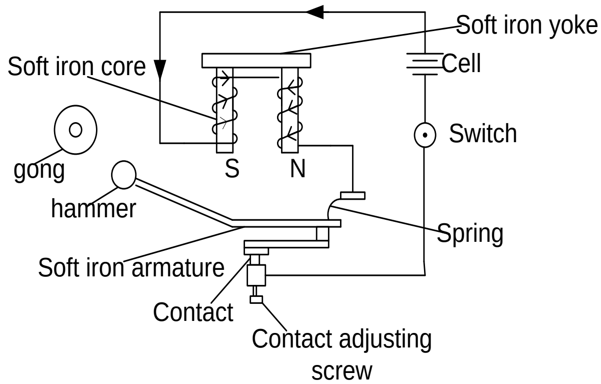
Applications of electromagnets

a) lifting magnets



In steel induction, electromagnets are used for lifting and transporting heavy steel from one part of the industry to another. The electromagnets are made up of several coils of insulated copper wires wound on a U-shaped soft iron so that opposite polarity is induced.

b) Electric bell



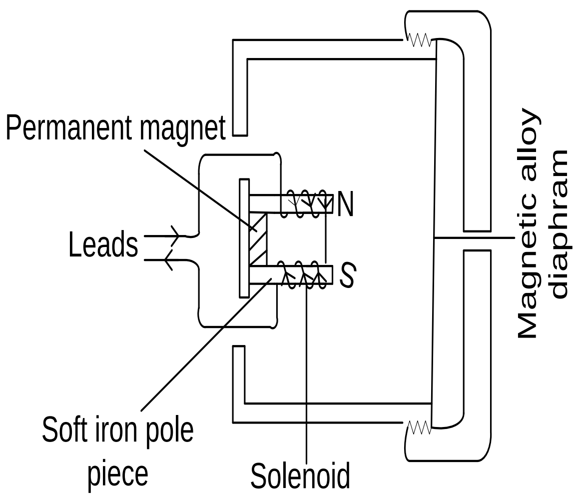
Structure

- The electric bell consist of two solenoids wound in opposite direction on two soft iron cores joined by a soft iron yoke.
- One end of the winding is connected to source of power supply and the other to a metal contact which supports a spring mounted on soft iron armature.

Operation

- As soon as current is switched on, it flows across the contact and around the coil of the electromagnets.
- The electromagnet attracts the armature and this makes the hammer to strike the gong
- But as it does so the contact separates and this stops current flowing and switches off the electromagnet.
- The armature and hammer comes back closing the contacts and this allows the current to flow again so that the whole process is repeated until the bell s switched off.

c) Telephone Receiver



Structure

- Consists of a U-shaped magnet formed by placing a short permanent bar magnet across the ends of two soft iron bars.
- This is placed so that it exerts a pull on the springy magnetic alloy diaphragm.
- Two solenoids are wound in opposite direction on the soft- iron bars.

Operation

- When a person speaks into the microphone at the other end of the line a varying electric current is set up having the same frequency as the sound waves.
- A similar electric current is caused to pass through the solenoids in the ear piece, this alters the strength of the magnetic flux in the U-shaped magnet and produces a corresponding variation in the pull of the diaphragm
- The diaphragm therefore vibration and reproduces a copy of it sounds waves which entered the microphone.

Electric currents in a magnetic fields

Electric currents cause magnetic fields around them, therefore when placed in a magnetic field the two magnetic fields interact and produce a force. The two forces can move wires and turn coils which carry electric current.

Factors affecting magnitude and direction of force

(i) Current ($F \propto I$). Increase in current increases the force

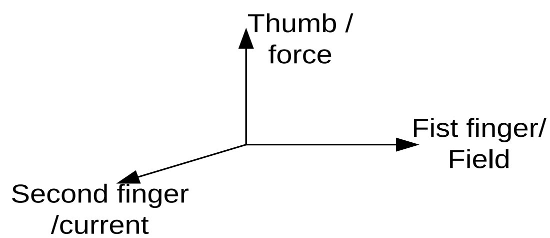
(ii) Length of wire in the field ($F \propto L$)

(iii) Strength of magnet/magnetic flux density($F \propto B$)

It is summarized by $F = B\,I\,L$

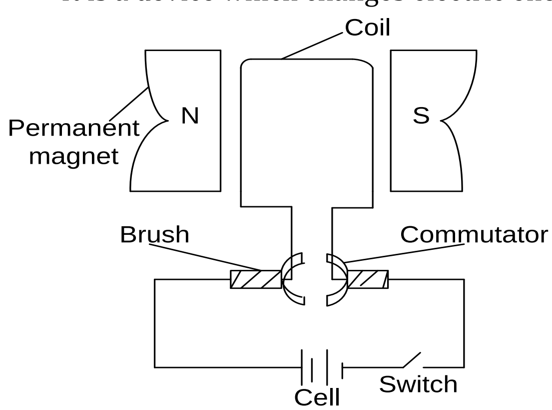
The direction of the **force** can be predicted by **Flemings left hand rule.**

It states, the thumb, the first finger and second finger are held at right angles with the **F**irst finger pointing in the direction of magnetic **F**ield and se**C**ond finger pointing in the direction of the **C**urrent, the **T**humb gives the direction of the **T**hrust /force



Simple electric motor [uses L.H.R]

It is a device which changes electric energy to mechanical energy



Structure

- Consists of a rectangular coil which can rotate between permanent magnets.
- The two ends of the coil are connected to split rings (commutators)
- Two carbon brushes are caused to press against commutators and when connected in a circuit with a battery, the coil rotates

Operation

- When currents switched on, it flows through the coil and experiences upward and downward force, these tow forces form a couple which causes the coil to rotate
- At vertical position, the brushes touch the space between halves of the commutator and current is cut off.
- However due to its momentum, the coil passes the vertical position and the two commutaotrs halves change contact from one brush to another. This reverses the current through the coil and hence the direction of force and the sides of the coil.
- The coil continues to rotate so long as current is flowing.

Note

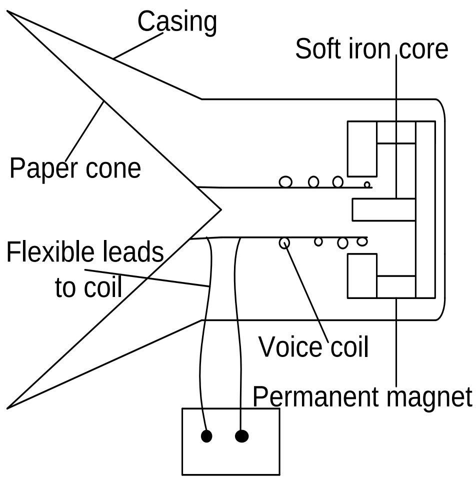
Electric motor is improved by;

i) increasing current

ii) Increasing the number of turns in the coil

iii) Using a stronger magnet

Moving coil loud speaker



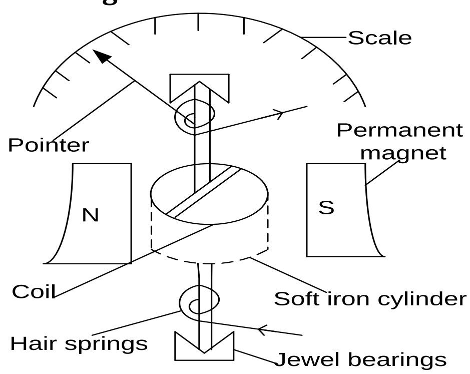
Structure

Consists of a cylindrical voice coil placed in a soft iron core attached to the permanent magnet.

Operation

- ❖ Varying current flows in the coil which is in a magnetic field. The coil experiences a varying force which causes it and the paper cone to move back and forth.
- ❖ This sets the air in contact with it into vibration so setting up a sound wave which follows the same pattern as the original electrical signal.

Moving coil Galvanometer



Structure

- ➢ It consists of coil of a wire wound on an aluminum former which is placed over an iron cylinder lying between two curved poles of a permanent magnet.
- ➢ The coil is pivoted on jeweled bearings which reduce friction when the coil rotates. Onto the coil is attached a pointer which deflects when the coil rotates
- ➢ The current to be measured enters and leaves the through the hair spring

Operation

- ❖ When current passes through the col, there is a force on t which makes it turn.
- ❖ the coil turns until the magnetic force on it is balanced by the force due to the tension of the hair springs
- ❖ The position of the pointer is then the measure of current

Note

(i) The two hair springs are wound in opposite direction so as to provide a restoring couple and they allow current to be measured to enter and leave

(ii) The coil is put in soft iron cylinder which concentrates the magnetic flux radially in the annular space. For this reason, the magnetic flux density is constant and in the plane of the coil, hence force on the sides of the coil will be proportional to the current.

Sensitivity of the galvanometer may be increased by;

i) Using a coil of large area
ii) Increase the number of turns of the coil
iii) Using a strong magnet to provide large magnetic flux density
iv) Using very weak hair springs (Small tortional constant)

Conversion of galvanometer to an ammeter

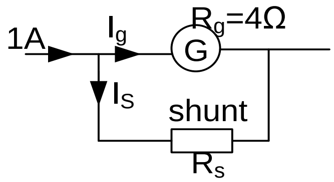
To convert a galvanometer to an ammeter, a low resistance called **a shunt** is connected in parallel with the galvanometer

Most of the current to be measured takes the path through the shunt and very small current through the galvanometer.

Examples

1. A galvanometer of resistance 4Ω and full scale deflection $(f.s.d)$ $10mA$ is to be used for the purpose of measuring current to $1.0A$. Find the value of the shunt to be used.

Solution



Current through galvanometer $I_g = 10mA$

$$I_g = \frac{10}{1000} = 0.01A$$

Current through shunt $I_S = 1 - 0.01$

$I_S = 0.99A$

Since the shunt and galvanometer are in parallel, they have the same $p.d$

$V_g = V_S$

$I_g R_g = I_S R_S$

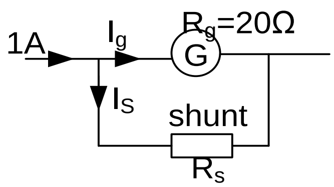
$0.01x4 = 0.99xR_S$

$R_S = \frac{0.01x4}{0.99}$

$R_S = 0.04\Omega$

2. A galvanometer has a resistance of 20Ω and gives a full scale deflection for a current of 2000μA. If the galvanometer is converted to an ammeter which can read up to $1.0A$. What is the size of the extra low resistance?

Solution



Current through galvanometer $I_g = 2000\mu A$

$$I_g = \frac{2000}{1000000} = 0.002A$$

Current through shunt $I_S = 1 - 0.002$

$I_S = 0.998A$

Since the shunt and galvanometer are in parallel, they have the same $p.d$

$V_g = V_S$

$I_g R_g = I_S R_S$

$0.002x20 = 0.998xR_S$

$R_S = \frac{0.002x20}{0.998}$

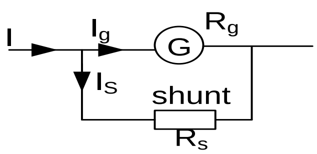
$R_S = 0.04\Omega$

3. A moving coil galvanometer of internal resistance 4 gives a maximum deflection when a current of 2mA flows through it. A shunt of resistance 0.06 is used to convert the galvanometer into an ammeter.

a) Find the current through the shunt

b) The maximum current that can be measured by the set up.

Solution



$I_g R_g = I_S R_S$

$0.002x4 = 0.06xI_S$

$I_S = \frac{0.002x4}{0.06}$

$I_S = 0.133A$

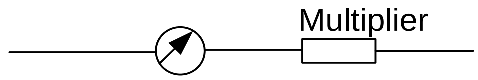
Maximum current $I = I_g + I_S$

$= 0.002 + 0.133$

$=0.135A$

Conversion of a galvanometer to a voltmeter

Large $p.d$ can be measured by placing a high resistance called **multiplier** in series with galvanometer.

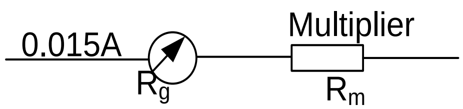


Same current passes through the galvanometer and multiplier

Example

How can you measure $a\ p.d$ of up to 30V using a galvanometer of resistance 10Ω and $f.s.d$ of 15mA.

Solution



Maximum current through the galvanometer $= 0.015A$

$Total\ p.d\ = V_g + V_m$

$30 = I_g R_g + I_S R_m$

$30 = 0.015\ x10 + 0.015 R_m$

$30 - 0.15 = 0.015 R_m$

R_m=1990Ω

Galvanometer should be connected with a high resistance multiplier of 1990Ω

Exercise

1. A moving coil galvanometer is to be used as a voltmeter. State how it can be modified for the above function. If the galvanometer s of internal resistance 10Ω and maximum $p.d$ 1000V can be measures using high resistance of 1000Ω, find the maximum current that may go through the galvanometer.
2. Consider a full scale deflection when a current of 15mA flow through it. If the resistance of the galvanometer is 5Ω, find the magnitude of the resistance (multiplier) to be used for it to measure a maximum $p.d$ of 15V **[995Ω]**
3. A moving coil galvanometer has resistance of 0.5Ω and full scale deflection of 2mA. How can it be adopted to read current to voltage 10V **[4999Ω]**
4. A moving coil galvanometer has resistance of 0.5Ω and full scale deflection of 2mA. How can it be adopted to read current 6A **[$1.67x10^{-4}$Ω]**
5. Consider a moving coil galvanometer which has resistance of 5Ω and full scale deflection when a current of 15mA. A suppose a maximum current of 3A is to be measured using this galvanometer. What is the value of the shunt required **[0.025Ω]**
6. A galvanometer of internal resistance of 20Ω and full scale deflection of 5mA. How can it be modified for use as;
   (i) 1.0A ammeter
   (ii) 100V voltmeter **[(i). 1.05Ω (ii). 1980Ω]**
7. A milliameter has a full scale reading of 0.01A and has resistance 20Ω. Show how a suitable resistor may be connected in order to use this instrument as a voltmeter reading up to 10V. **[980Ω]**

ELECTROMAGNETIC INDUCTION
INDUCED CURRENT/ *Emf*

When a conductor wire moves across a magnetic field such that it cuts the magnetic field lines, an emf / current is induced in the wire. The emf/ current produced in this way is called electromagnetic induction.

Definition

Electromagnetic induction s a process where an emf/ current is induced in a conductor when flux linking it changes.

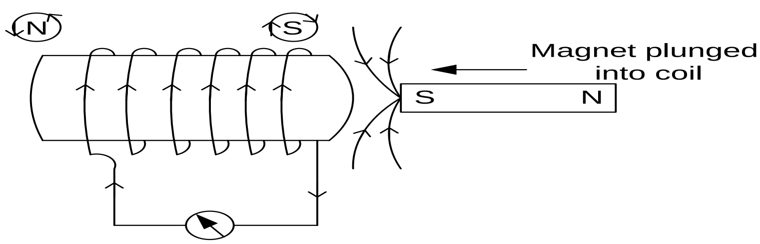
Laws of electromagnetic induction

Faraday's law: It states that the magnitude of induced emf is directly proportional to the rate of change magnetic flux linking it.

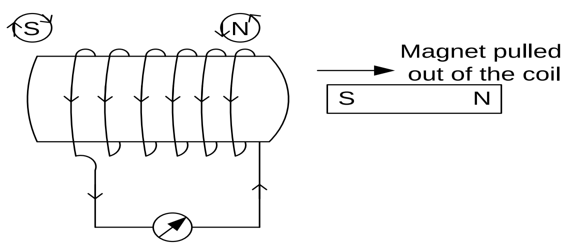
Lenz's law: The induced emf or current flows in a direction so as to oppose the change in the flux causing it.

Faraday's experiments on electromagnetic induction

- ❖ When a magnet is suddenly pushed with its south pole towards a coil connected on a galvanometer, the galvanometer shows a deflection showing that current has been induced in the coil.



- ❖ On removal of the magnet from the col, the galvanometer again deflects but in opposite direction.



Note

If both the magnet and coil are stationary, the galvanometer gives no deflection because there is no change in the magnetic flux.
Likewise no deflection when the magnet and coil move with the same speed and same direction.

Faraday's conclusion

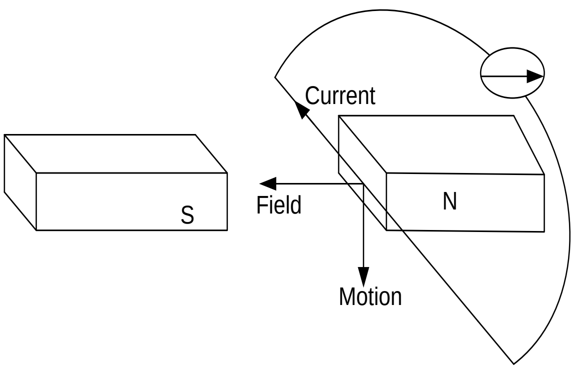
Whenever there is change in the magnetic flux linking the coil, an emf is induced in the coil and if the col has a closed circuit, the emf will produce a current.

Factors which affect magnitude of the induced *emf*/current

a) Number of turns of the coil. Many turns give a large current
b) Strength of the magnetic field. Using a stronger magnet increases the induced *emf*
c) Speed at which the magnet moves. At a high speed the deflection is high.

Direction of induced current in a straight wire

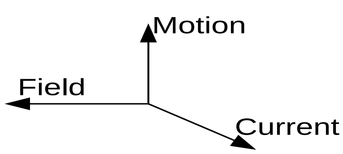
Current is induced in a straight wire when it is moved at right angles to the magnetic flux near a bar magnet



- If the wire is moved downwards, the galvanometer deflects in the direction shown, indicating that an induced current is flowing.
- If the wire is moved upwards the induced current is reversed in accordance with Fleming's right hand rule.
- When there is wire is moved horizontally (along the field), no deflection is observed since the flux is not cut.

Note:

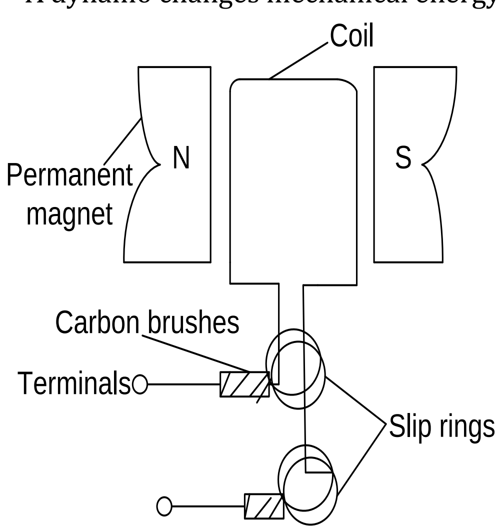
To predict the direction of induced *emf* (current), we use Fleming's right hand rule or dynamo rule.



Thumb-------motion
First finger----Field
Second finger---induced current

Alternating current ($A.C$) generator / dynamo

A dynamo changes mechanical energy to electrical energy



Structure

- Consists of a rectangular coil between permanent magnets.
- The two ends of the coil are joined to slip rings against which carbon brushes are caused to press lightly.

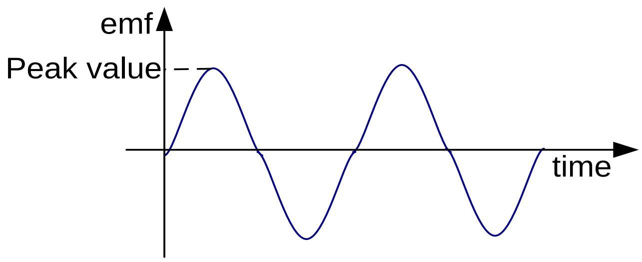
Operation

- When the coil is rotated in a uniform magnetic field, it cuts the magnetic flux and an *emf* is induced in the coil.
- The *emf* is tapped off using carbon brushes pressed against slip rings
- *emf* is produced continuously but changes direction

NB:

During rotation emf increases to maximum when a coil is in horizontal position.
Decreases and becomes zero when coil is in vertical position. It follows the same pattern but direction of emf is reversed.

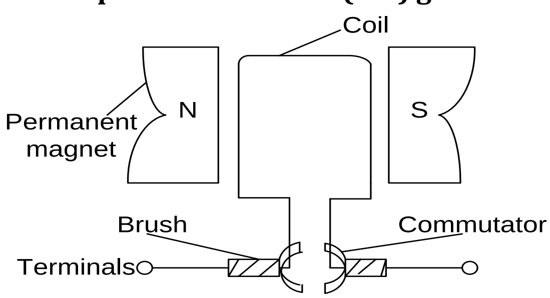
Variation of induced emf with time for A.C generator



Note;

A.C generator can be changed to $d.c$ generator by replacing slip rings with split rings (commutators).

Simple direct current ($d.c$) generator/ dynamo



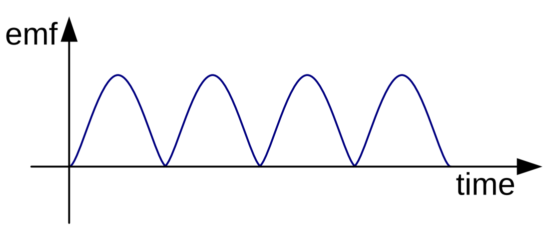
Structure

- ➢ Consists of a rectangular coil between permanent magnets.
- ➢ The two ends of the coil are joined to split rings/ commutators against which carbon brushes are caused to press lightly.

Operation

- ❖ When the coil is rotated in a uniform magnetic field, it cuts the magnetic flux and an emf is induced in the coil.
- ❖ The emf is tapped off using carbon brushes pressed against slip rings
- ❖ However as the coil rotates, the commutators change contact from one brush to another although the current is received in the coil, the change over brushes and commutators ensure that the direction of the current is maintained.

A graph of induced emf with time for $d.c$ generator



Note:

$d.C$ dynamo can be changed to $A.C$ by replacing commutators with slip rings

Factors which affect magnitude of the induced emf/current in conductor

1. Number of turns of the coil. Many turns give a large emf
2. Area of the conductors. Increasing the area of conductor increases the induced emf
3. Strength of the magnetic field. Using a stronger magnet increases the induced emf
4. Speed of rotation of the coil. At a high speed the emf is high.

Mutual induction

This is the process by which an emf is induced in a coil due to changing current in the near by coil.

Self-induction

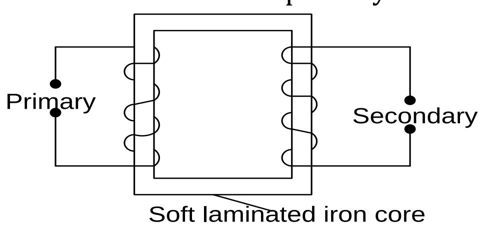
This s a process by which an emf is induced in a coil due to changing current in the same coil.

TRANSFORMER

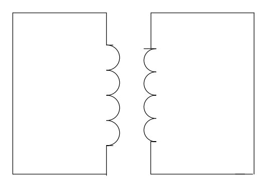
This is a device that steps up and down voltage.

A transformer that steps up voltage is called step up transformer and the one that steps down voltage is called step down transformer.

A step up transformer has more turns on the secondary coil while step down transformer has more turns on the primary.



Symbol



Structure

Primary and secondary coils are wound on a laminated soft iron core. The purpose of the soft iron core is to concentrate the magnetic fields produced.

Operation

An alternating voltage V_P is applied to the primary. This creates changing magnetic fields which links with the secondary coil.

An emf is then induced in the secondary coil whose magnitude depends on the number of turns on the secondary coil N_S.

The $p.d$ across the primary and secondary coils are found from the equation.

$$\boxed{\frac{V_S}{V_P} = \frac{N_S}{N_P}}$$

Example

1. An $a.c$ transformer is used to provide a voltage of 3000V for operating a T.V tube. If the transformer has 500 turns on primary and is connected to 240V mains supply. How many turns are in the secondary coil.

Solution

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

$$N_S = \frac{V_S}{V_P} N_P$$

$$N_S = \frac{3000x\,500}{240}$$

$$N_S = 6250\ turns$$

2. A transformer has 200 turns of the primary coil. Calculate the number of turns on the secondary coil if 240V is to be stepped up to 415V

Solution

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

$$N_S = \frac{V_S}{V_P} N_P$$

$$N_S = \frac{415x\,200}{240}$$

$$N_S = 345.8\ turns$$

Energy losses in a transformer

1. Heat lost in copper wire ($inform\ of\ I^2R$) due to resistance of wires. This can be minimized by low resistance copper wires
2. Eddy current losses. These are minimized by laminating the core
3. Hysteresis loss. It can be minimized by using a core made of a soft magnetic material.
4. Loss due to poor flux linkage between primary col and secondary coil. It can be minimized by ensuring that all primary flux is linked with the secondary.

Note:

Although there are a lot of energy losses in the transformer, the energy losses are so small such that the power, put into primary coil is equal to power got out of secondary coil for a transformer that is 100% efficient

$power\ put\ into\ primary\ coil = power\ out\ of\ secondary\ coil$

$$I_P\ \ V_P = I_S\ \ V_S$$

$$\boxed{\frac{V_S}{V_P} = \frac{I_P}{I_S}}$$

But

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

$$\boxed{\frac{I_P}{I_S} = \frac{N_S}{N_P}}$$

1. A transfer steps up its $p.d$ from 12V to 48V. If the current is flowing in the primary coil is 2A. What is the current in the secondary circuit.

   Solution

$$\frac{V_S}{V_P} = \frac{I_P}{I_S}$$

$$I_S = \frac{V_P}{V_S} I_P$$

$$I_S = \frac{12x2}{48}$$

$$I_S = 0.5A$$

2. A transformer designed to operate a 12V lamp from 240V supply has 1200 turns on the primary coil. Calculate.
   i) Number of turns on the secondary coil.
   ii) Current passing through the primary coil when the 12V lamp has a current of 2A flowing through it.

   Solution

$N_p = 1200,\ N_S = ?$

$V_P = 240V, V_S = 12V$

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

$$N_S = \frac{V_S}{V_P} N_P$$

$$N_S = \frac{12x\ 1200}{240}$$

$N_S = 60\ turns$

$$\frac{V_S}{V_P} = \frac{I_P}{I_S}$$

$$I_P = \frac{V_S}{V_P} I_S$$

$$I_P = \frac{12x2}{240}$$

$I_P = 0.1A$

Efficiency of a transformer

$$Efficiency = \frac{Power\ out\ put}{Power\ input} x\ 100\%$$

$power\ output = power\ on\ secondary\ coil = I_S\ \ V_S$

$power\ input = power\ on\ primary\ coil = I_P\ \ V_P$

$$\boxed{\eta = \frac{I_S\ \ V_S}{I_P\ \ V_P} x100\%}$$

Examples

1. A transformer is used on the 240V supply to deliver 9A at 80C to a heating coil. If 10% of the energy taken from the supply s dissipated in the transformer it self. What is the current in the primary winding

Solution

Since 10% is dissipated,

$\eta = (100 - 10) = 90\%$

$$Efficiency = \frac{Power\ out\ put}{Power\ input} x\ 100\%$$

$$\eta = \frac{I_S\ \ V_S}{I_P\ \ V_P} x100\%$$

$$90\% = \frac{8\ x\ 9}{240\ x\ I_P} x100\%$$

$$I_P = \frac{8x9x100}{240x90}$$

$I_P = 3.33A$

2. A transformer is designed to operate at 240V main supply and deliver 9V. The current drawn from the main supply is 1A if the efficiency of the transformer is 90%. Calculate
   (i) maximum power output
   (ii) power lost

Solution

$\eta = 90\%, I_P = 1A,$

$V_P = 240V,\ V_S = 9V$

$$Efficiency = \frac{Power\ out\ put}{Power\ input} x\ 100\%$$

$$90\% = \frac{Power\ out\ put}{I_P\ \ V_P} x100\%$$

$$90\% = \frac{Power\ out\ put}{240x1} x100\%$$

$$Power\ out\ put = \frac{90x\ 240x1}{100}$$

$Power\ out\ put = 216W$

Power lost $= P_{In} - P_{out}$

$= I_P\ \ V_P - 216$

$= (240x1) - 216$

Power lost $= 24\ W$

3. An electric power generator produces 24kW at 240V, the voltage is stepped up to 400V for transmission to a factory where it is stepped down to 240V. The total resistance of the transmission wire is 0.5Ω.
   (i) What is the ratio of number of turns in primary to number of turns in secondary is the transformer.
   (ii) Find the power loss in transmission lines assuming both transformers are 100% efficient.
   (iii) What power would have been lost if same had been transmitted directly without transformer.

Solution

$V_S = 240\ V,\ \ V_P = 4000\ V$

i) $\frac{V_S}{V_P} = \frac{N_S}{N_P}$

$\frac{240}{4000} = \frac{N_S}{N_P}$

$\frac{3}{50} = \frac{N_S}{N_P}$

$N_P : N_S = 50:3$

ii) power loss = I^2R

but $I = \frac{P}{V}$

$\mathrm{I} = \frac{24\ x\ 10^3}{4000}$

$I = 6A$

power loss = I^2R

power loss = $6^2 x\ 0.5$

$= 1.8W$

iii) power loss = I^2R

$I = \frac{P}{V}$

$\mathrm{I} = \frac{24\ x\ 10^3}{240}$

$I = 100A$

power loss = I^2R

power loss = $100^2 x\ 0.5$

$= 5000W$

4. A setup transformer is designed to operate from a 240V supply with delivery energy at 250V. If the transformer is 90% efficient, determine the current into the primary winding when the output terminals are connected to 250V, 100W lamp.

Solution

$V_S = 250\ V,\ \ V_P = 20\ V,$

$\eta = 90\%, P_{out} = 100W$

$Efficiency = \frac{Power\ out\ put}{Power\ input} x\ 100\%$

$90\% = \frac{100}{P_{In}} x 100\%$

$P_{In} = 111.11W$

$P_{In} = I_P\ \ V_P$

$I_P = \frac{111.11}{20}$

$I_P = 5.56A$

5. A generator with a power out put of $20kW$ at 4kV distributes power to a workshop along cables having a total resistance of 16Ω. Calculate
   (i) the current in the cables
   (ii) the power loss in the cables
   (iii) the potential drop between the ends of the cables

Solution

$P_{out} = 20kW, V_S = 4kW$

$P = I\ V$

$I = \frac{P}{V}$

$\mathrm{I} = \frac{20\ x\ 10^3}{4000}$

$I = 5A$

ii) Power loss = I^2R
Power loss = $5^2x\ 10$
$= 400W$

iii) potential drop = $I\ R$
$= 5x16$
$= 80V$

6. A transformer steps up 200V, it has 10 windings in the primary and 100 windings in the secondary. If the current in the primary winding is 1.2A. What is the current in the secondary given that the efficiency is 80%

Solution

$V_S = 200\ V,\ \ V_P =?,$
$N_S = 100,\ N_P = 10$
$I_P = 1.2A, I_P =?$
$\eta = 80\%,$
$\frac{V_S}{V_P} = \frac{N_S}{N_P}$
$V_P = \frac{200x10}{100}$
$V_P = 20V$

$Efficiency = \frac{Power\ out\ put}{Power\ input} x\ 100\%$
$80\% = \frac{I_S V_S}{I_P V_P} x100\%$
$I_S = \frac{80\ x\ I_P V_P}{100xV_S}$
$I_S = \frac{80\ x\ 1.2x20}{200x100}$
$I_S = 0.096A$

7. A transformer is designed to private an output of 220V when connected to a 25V supply. If the transformer is 80% efficient. Calculate the input current when the output is connected to a 220V,75W lamp.

Solution

$V_S = 220\ V,\ \ V_P = 25V,$
$\eta = 80\%, P_{out} = 75W$
$Efficiency = \frac{Power\ out\ put}{Power\ input} x\ 100\%$

$80\% = \frac{P_{out}}{I_P V_P} x100\%$
$I_P = \frac{75}{80x25} x100$
$I_P = 3.75A$

Exercise

1. An $a.c$ transformer operates on a 240V mains. The voltage across the secondary which has 960 turns s 20V.
   ii) find the number of turns in the primary
   iii) if the efficiency of the transformer is 80% calculate the in the primary coil when a resistor of 40Ω is connected across the secondary. **[11520turns, 0.0521A]**
2. A transformer whose secondary col has 60 turns and primary 1200 turns has its secondary connected to a 3Ω resistor if its primary is connected to a 240V $a.c$ supply. Calculate the current flowing in the primary assuming that the transformer is 80% efficient. **[0.25A]**
3. A transformer is designed to work on a 240V, 60W supply, it has 3000 turns in the primary and 200 turns in the secondary and its efficiency is 80%. Calculate the current in the secondary coil. **[3A]**
4. An a.c transformer operates on 240V mains. It has 1200 turns in the primary and gives 18V across the secondary.
   i) find the number of turns in the secondary
   ii) if the efficiency of the transformer is 90% calculate the current in the primary coil when a resistor of 50Ω is connected across the secondary
   . **[90turns, 0.03A]**

Transmission of electrical power

When power is transmitted, alternating current is used $(a.c)$.

A transformer can be used to step up a voltage before transmission and also step down at the end of the power line.

However power is lost due to heating of the cables during transmission as a result of resistance of the wires.

Power is transmitted at high voltage as this reduces the energy loss. It is transmitted using high voltage and low current because the heating effect depends on the square of current and the loss as heat is reduced by using a high voltage.

power carried by cable $= IV$

power lost in heating cables$=\ I^2R$

Note

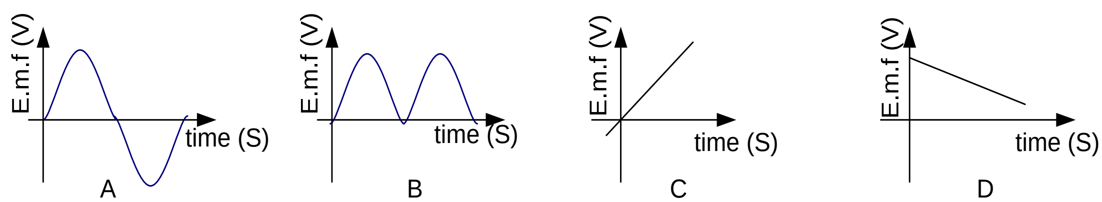
Electric cables are always thin so that low current and high voltage is transmitted with low power loss and the cost of supporting the cable is also reduced.

Advantages of $a.c$ over $d.c$ power transmission

- Alternating current can be stepped up to high voltage and transmitted over long distances with minimum power loss
- It is very easy to generate.

Section A

1. Which one of the following devices uses flow of current a conductor in magnetic field to produce motion?
   A. Loud speaker B. Alternator C. Microphone. D. D.C generator
2. The direction of the induced $e.m.f$ in a conductor moving in a magnetic field can be changed by changing the
   (i) speed of the conductor
   (ii) direction of motion of the conductor
   (iii) direction of the magnetic field
   A. (i), (ii) and (iii) C. (i) and (iii) only
   B. (ii) and (iii) only D. (i) only
3. Which one of the following graphs shows the variation of $e.m.f$ produced by a $d.c$ generator with time?



4. The energy change that occurs in a loud speaker is
   A. electrical to sound energy C. sound to electrical energy
   B. kinetic to sound energy D. potential to sound energy
5. Figure below shows two coils P and Q close to each other

When switch K is closed, the bulb lights momentarily because

(i) an emf is induced in coil Q

(ii) an emf is induced in col P

(iii) the magnetic field between P and Q changes

A. (i) only B. (ii) only C. (iii) only D. (i) and (iii) only

6. Which one of the following devices converts electrical energy to mechanical energy?

A. Thermopile B. Dynamo C. Battery D. Motor

7. The direction of the force on a current carrying conductor in a magnetic field depends on

(i) direction of current

(ii) strength of the magnetic field

(iii) direction of the magnetic field

A. (iii) only B. (i) and (ii) only C. (i) and (iii) only D. (i), (ii) and (iii) only

8. An $a.c$ generator can be modified to produce $d.c$ by

B. increasing the number of coil

C. increasing the number of turns in the coil

D. using an electromagnet instead of a permanent magnet

E. replacing the slip rings with a split ring

9. Which of the following is NOT an effect of an electric current?

A. Electrolysis B. Magnetic effect C. Heating effect D. Radioactivity

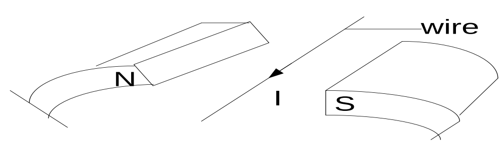
10. Which of the following works with a direct current only

A. Electroplating B. Electric lamp C. Transformer D. Electric bell

11. A voltage of 440V is applied to the primary of a transformed of 2000 turns. If the voltage across the secondary is 11KV, what is the number of turns in the secondary coil.

A. 50 B. 80 C. $5.00\,x10^4$ D. $8.00\,x\,10^4$

12. When a current I flows through a wire placed in between the poles of a U- magnet as shown above, the wire will move.



A. Upwards B. Down wards

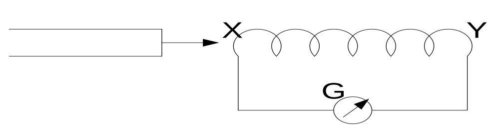
C. Towards the south pole D. Downwards the north pole

13. The direction of induced current in a conductor moving in a magnetic field can be predicted by applying

A. Faraday's law B. Maxwell's screw rule

C. Fleming's left hand rule D. Fleming's right hand rule

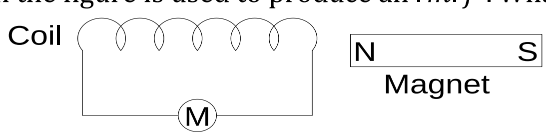
14.



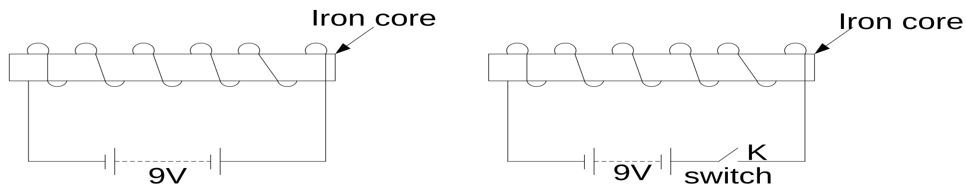
The figure above shows a coil connected to a centre zero galvanometer, G. the poles produced at the ends X and Y of the coil when the North pole of a magnet

A. X – North pole Y- south pole
B. X – South pole Y-north pole
C. X – North pole Y – North pole
D. X- South pole Y- South pole

15. The induced current in a generator
    A. Is a maximum when the coil is vertical
    B. Is a minimum when the coil is horizontal
    C. Changes direction when the coil is horizontal
    D. Increase when the speed of rotation increases.
16. The strength of the magnetic field between the poles of an electromagnet remains the same if the
    (i) Current in the electromagnet windings is doubled
    (ii) Direction of the current in the electromagnet winding are reversed
    (iii) The number of turns are halved.
    A. (i) only B. (ii) only C. (i) and (ii) only D. (ii) and (iii) only
17. Which of the following factors affect the strength of an electromagnet?
    (i) Changing magnitude of the current
    (ii) Changing direction of the current
    (iii) Doubling number of turns
    A. (ii) only B. (i) and (ii) only
    C. (i) and (iii) only D. (ii) and (iii) only
18. In which of the following devices is kinetic energy converted to electrical energy?
    A. An accumulator B. An electric motor
    C. A combustion motor D. A dynamo
19. The arrangement in the figure is used to produce an $.m.f$. What causes the $e.m.f$?

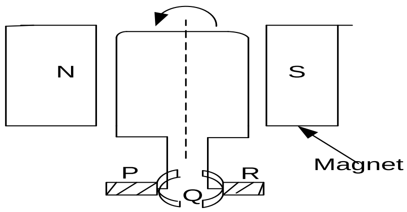


    A. The attraction between the coil and the magnet
    B. The magnetic field outside the coil
    C. The magnet placed close to the coil
    D. The variation of magnetic field lines linking the coil
20. Which of the following only works with a direct current?
    A. Electric lamp B. Transformer
    C. Electroplating D. Electric bell
21. In figure below, when switch K is closed, the two soft iron cores will



    A. Repel each other all the time
    B. Attract each all the time
    C. Attract each other for just a brief moment
    D. Has no force of attraction or reputation or repulsion between them

22. The diagram in the figure shows a simple electric motor.



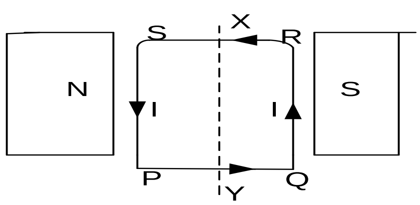
The coil continues to turn in the same direction because the commutator Q and brushes P and R

A. Reverse current in the coil every half a revolution
B. Reverse current in the coil every quarter of a revolution
C. Reverse polarity of the field produced by the magnet
D. Carry the coil past its vertical position every half a revolution.

23. Four bars of metal P,Q,R,S are tested for magnetism. Q attracts both P and R but not S. S does not attract P ,Q or R. P and R sometimes attracts one another and sometimes repel each other . Which of the following statements is correct about P,Q,R and S?

A. P,Q,R are magnets, S is a magnetic
B. P and Q are magnets, R and S magnetic
C. P and R are magnets , Q is magnetic, S is non magnetic
D. P and R are magnets, Q and S are non magnetic.

24.



The diagram in the figure above shows a current – carrying coil PQRS pivoted about XY between two magnets . Which of the statements are true about the coil?

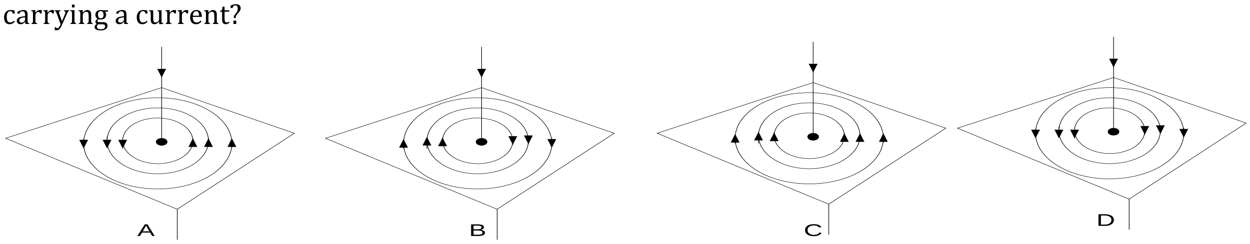
(i) the sides PQ and QR shall experience force
(ii) as seen from X the coil will rotate anticlock wise.
(iii) The force on the coil can be increased by increasing the number of turns
(iv) The coil will come to rest with PQ at right angles to magnetic field .

A. (i),(ii) and (iii) only B. (i) and (iii) only C. (ii) and (iv) only D.(iv) only

25. A moving iron meter

A. measures only direct current
B. has a permanent magnet
C. measures only alternating current
D. has the pointer attached to the soft iron

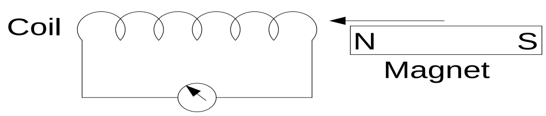
26. Which one of the following diagrams represent the correct magnetics field around a straight wire carrying a current?



27. A transformer cannot function normally with $d.c$ because a $d.c$....

A. has extremely high heating effect
B. reduces the efficiency of the transformer
C. cannot produce a changing magnetic field
D. cannot provide high voltage required for power transmission.

28.



A bar magnet is moved near a coil as shown in the figure . Which of the following ways can be used to increased the size of the induced e.m.f in the coil?

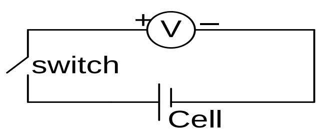
(i) Using a stronger magnet

(ii) Moving the magnet at a higher speed

(iii) Reducing the number of turns in the soil

A. (i) and (ii) only
B. (i) and (iii) only
C. (ii) and (iii)
D. (i) , (ii) and (iii)

29.



When the circuit in the figure above is switched on, the voltmeter

A. Show no deflection
B. Deflects in the wrong direction
C. Reads the e.m.f of the cell
D .Reads the terminal potential difference across the cell

30. The transformer cores are laminated to
A. Reduce eddy currents
B. Decrease the resistance of the coils
C. Determines the energy lost by the transformer
D. Distributes the voltage output equally within the transformer

31. Power loss due to eddy currents in the core of a transformer can be minimized by
A. Laminating the core
B. Using thick copper wires in the windings
C. Using soft iron core
D. Winding the secondary coil on top of the primary coil.

32. A moving coil galvanometer can be used to
A. Measure a direct current
B. Converts alternating current into direct current.
C. Converts direct current to alternating current
D. Measure the peak valve of an alternating current

33. What energy changes take place when a switch of the electrical bell is pressed?
A. chemical → electrical → kinetic → magnetic → sound
B. chemical → electrical → magnetic → kinetic → sound
C. chemical → electrical → sound
D. electrical → magnetic → sound

34. Which of these factors affect the magnitude of force on a current carrying conductor in a magnetic field?
    (i) The direction of current.
    (ii) The amount of current
    (iii) The direction of the magnetic field
    (iv) The strength of the magnetic field

A. (i) and (ii) only B. (ii) and (iii) only C. (i) and (iii) only D. (ii) and (iv) only

35. Which of the following is true about both alternating and direct?
    (i) Cause heating
    (ii) Can be stepped up or down with transformer.
    (iii) Can be used to charge a battery

A. (i) only B. (i) and (ii) only C. (ii) and (iii) only D. (i),(ii) and (iii)

36. A transformer connected to 240V $a.c$ mains is used to light a 12V, 365W lamp. What current does the lamp draw?

A. 20.0A B. 6.7A C. 3.0A D. 0.33 A

37. The energy transformations involved in a bicycle dynamo is

A. Electrical to chemical B. Potential energy to chemical energy
C. Chemical to light energy D. Kinetic energy to electrical energy

38. A 240 V mains transformer has 1000 turns in the primary. The number of turns in the secondary if it is used to supply a "12V, 24 W" lamps is

A. $2.0\ x\ 10^4$ B. 500 C. 50 D. 20

39. When transmitting electrical power over long distances , the voltage is stepped up in order to

A. Transmit it B. Reduce power loss
C. Increases current for transmission D. Prevent electric shocks.

40. Which of the following will increase the force the force on a current carrying wire?
    (i) Using a large current
    (ii) Using a stronger magnetic field
    (iii) Using a shorter length of wire in the field

A. (i) only B. (i) and (ii) only C. (i) and (iii) only D. (ii) and (iii) only

41. An alternating voltage from 240 V to 12 V. calculate the number of turns on the secondary coil if the primary coil has 1200 turns

A. 3 B. 5 C. 60 D. 100

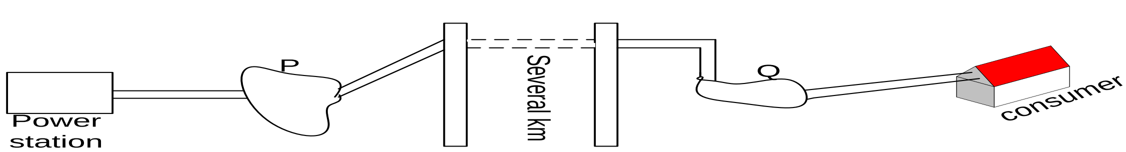
42. An electric motor of efficiency 90% operates a water pump. If it raises 0.9 kg of water through 10 m every second. Calculate the electrical power supplied to that motor.

A. 8.1 W B. 81 W C. 90 W D. 100 W

43. A transformer has twice as many turns in the secondary coil as in the primary coil. The a.c input to the primary is 4 V. Find the output.

A. 2 V B. 4 V C. 8V D. 16 V

44. The figure below shows a transmission line from a power station to a consumer several kilometers away.



Which one of the following is the correct type of transformer at P and Q

	P	**Q**
A.	step – up	step- up
B.	step – down	step – down
C.	step-up	step – down
D.	step – down	step- up

45. Which one of the following is the most economical means of transmitting electricity over long distances?
    A. At a high voltage and a low current
    B. at a high voltage and a high current
    C. at a low voltage and a high current
    D. at a low voltage and a low current
46. The magnitude of the force on the coil of a d.c motor depends on
    A. the strength of the magnetic field
    B. the number of turns on the coil
    C. the current through the coil
    D. the mass of the coil support.
47. A transformer cannot function normally with a d.c because a d.c
    A. ha an extremely high heating effect
    B. reduces the efficiency of the transport
    C. cannot produce a changing magnetics field
    D. cannot provide high voltages required for power transmission.
48. The main function of a step- up transformer is to
    A. change a.c to d.c B. change d.c to a.c
    C. increase current D. increase voltage
49. The advantage (s) of alternating current over direct current in mains supply is /are
    A. less power is lost in the transmission of a.c
    B. it is less dangerous to handle at the same voltage value
    C. it is easier to step up or down
    D. it is easier to generate.
50. Which one of the following cannot generate e.m.f?
    A. magnetization B. chemical reaction
    C. electromagnetic D. the piezo electrical effect
51. The magnitude of the force on a conductor carrying electric current in a magnetic field does not depend on the
    A. length of the conductor B. magnitude of the current
    C. magnetic field D. direction of the current
52. A galvanometer reads 0.05 A at full scale deflection and has resistance of 2.0 Ω. Calculate the resistance that should be connected in series with it to convert to a voltmeter which reads 15 V at full scale deflection.
    A. 10Ω B. 200Ω C. 298Ω D. 980Ω
53. Very high voltages are used when distributing electrical power from the power stations because
    A. some electrical equipment require very high voltage
    B. currents are lower so energy losses are smaller
    C. very high voltages are generated at the power stations
    D. there is less likelihood of the transmission lines being struck by lightening.
54. A high voltage d.c may be obtained from a low voltage d.c by use of
    A. a dynamo B. an induction coil C. a generator D. a transformer
55. Which of the following is true about a transformer?
    A. the efficiency is 100%

B. the magnitude of the e.m.f induced in the secondary does not depend on the e.m.f in the primary coil

C. there are no power losses as the core is well laminated

D. passing direct current through the primary has no effect on the secondary coil

56. An electric motor is connected by cable to a 240V supply . The p.d across the motor is 239V when the current flowing is 5 A . the resistance of the cable is

A. 0.2Ω B. 5Ω C. 47.8Ω D. 48Ω

57. Which one of the following statements is true about a transformer?

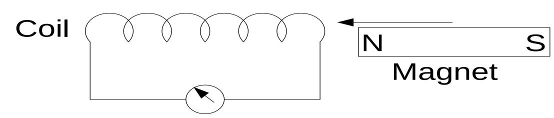
A. the efficiency is 100%

B. there are no power losses as the core is well laminated

C. the magnitude of the e.m.f induced in the secondary coil does not depend of the e.m.f in the primary coil

D. passing direct current through the primary has no effect on the secondary coil.

58.



When a magnet is moved relative to the coil as shown in the above, the magnitude of the induced current is not increased by

A. moving the magnet faster

B. using a coil with more turns

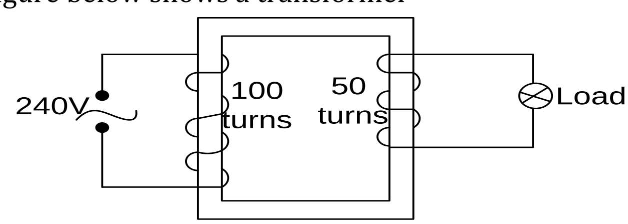
C. using a more sensitive galvanometer

D. using a strong magnet

SECTION B

1. (a) What is **a step-down** transformer?

(b) Figure below shows a transformer



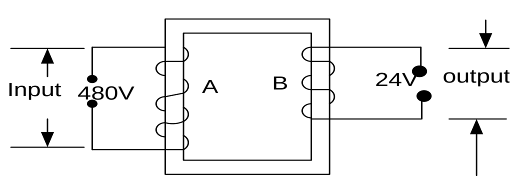
Calculate the voltage across the load

(c) Give one advantage of a.c over d.c

2. (a) State two ways by which energy losses in a transformer are minimized

(b) A 240V, 60W lamp is connected to the secondary coil of a step up transformer operating on a 24V supply. If the transformer is 100% efficient, find the current in the primary coil.

3. (a)



In the figure below shows a step down transformer. Name the coils marked

(i) A

(ii) B

(b) If the transformer is used to step down mains supply from 480V to 24V and coil A has 800 turns, determine the number of turns in coil B

4. (a) State **one** factor which affects the magnitude of the force on current carrying conductor in a magnetic field

(b)

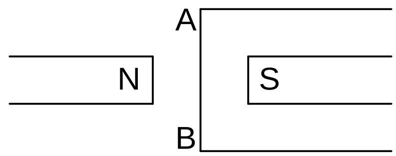


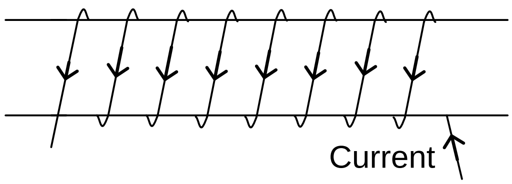
Figure above shows a wire placed in a uniform magnetic field. If the force acting on the wire is into the paper.

(i) indicate on the diagram the direction of the current through the wire

(ii) explain what happens when the battery terminals connected to wire **AB** are reversed

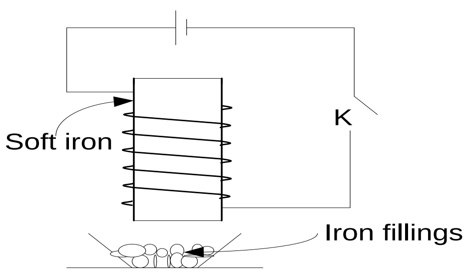
5. (a) What is a magnetic field?

(b)



The figure above shows current flowing in a solenoid. Sketch the magnetic field around the solenoid ,clearly indicating the polarities.

6.



(a) Describe what is observed when the key ,K , is closed

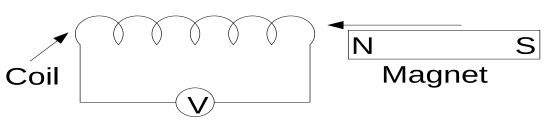
(i) closed

(ii) closed and then again opened

(b) State two ways by which the effect of what was observed in (a) (i) above can be increased

7. (a) State two differences between a.c and d.c generators.

(b)



Briefly describe what happens when a magnet is moved into the coil as shown above.

8. (a) Explain briefly how a calculator which operates on a 6.0V $d.c$ can draw power from a 240V mains supply

(b) State two sources of energy loss in a transformer

9. (a) state any two factors which determine the magnitude of the emf induced in a coil rotating in a magnetic field.

(b) Explain why soft iron is preferred to steel in making electromagnets.

10. (a) What is a transformer?

(b) A transformer whose efficiency is 80% has an out put of 12W. Calculate the input current if the input voltage is 240V.

(c) Explain briefly why bulbs in a building are connected in parallel.

11. (a) Explain why electric power is transmitted at high voltage.

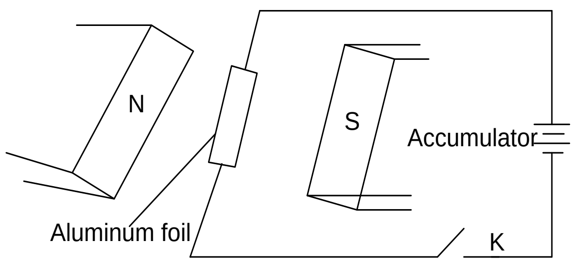
(b) An electric generator of out put 2.0 x 10^4 w supplies power through 10 identical cables. Find the current which flows through each cable if the voltage at the generator terminal is 5000V.

12. (a) Give one reason why transformer cores are

(i) made of iron (ii) laminated

(b) A transformer has 250 turns on the primary winding and 3000 turns on the secondary. A voltage of 1600V is fed on the primary. Calculate the voltage out put on the secondary.

13. (a)



An aluminium foil carrying a current is placed in a magnetic field as shown above .

When switch K is closed momentarily, a force acts on the foil.
State:

(i) The direction of the force

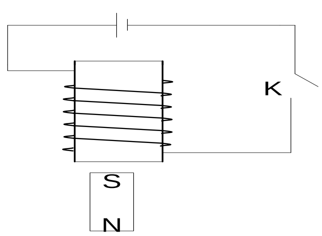
(ii) Two factor which affect the magnitude of the force.

(iii) What happens to the force when the foil is slowly turned until its ends point exactly in the north south direction of the magnetic field.

(b) Name one device which works o the principle illustrated in the diagram above.

14. (a) State two factors which affect the strength of an electromagnet.

(b)



The diagram above shows a small magnet placed near an electromagnet. Describe what happens to it when key K is closed.

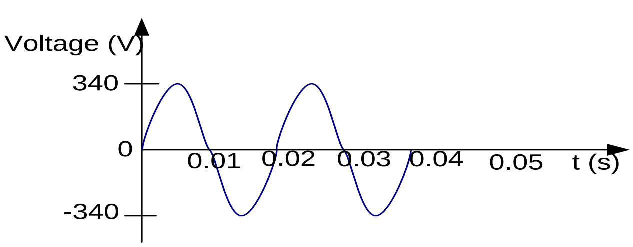
15. (a) What is meant by

(i) magnetic saturation?

(ii) neutral point in a magnetic field?

16. (a) State one advantage of a.c over d.c in mains supply.

(b)



The graph above shows the variation of an $a.c$ with time
Find;

(i) the peak voltage

(ii) the frequency

PAPER TWO TYPE

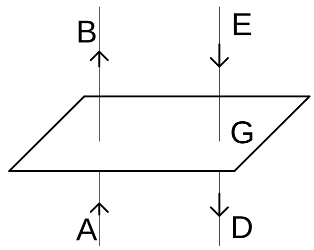
1. (a) (i) What are **ferromagnetic** materials?

   (ii) Give **two** examples of ferromagnetic materials

   (b) (i) With the aid of a diagram, describe the application of an electromagnet in magnetic relays

   (ii) Give one advantage of using a magnetic relay to switch electrical machinery on and off

   (c) Figure below shows two wires AB and DE placed parallel and close to each other, carrying current in opposite directions



   (i) Copy the diagram and sketch the magnetic field patter between the two wires

   (ii) Show the direction of the force acting on DE at G due to the current AB

2. **(a)** Define the following terms

   (i) hard magnetic materials

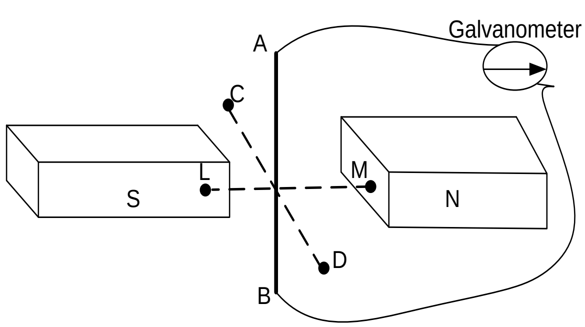
   (ii) soft magnetic materials

   (b) (i) Describe the electrical method of magnetizing a steel bar

   (ii) State any two ways of demagnetizing a bar magnet

   (c) Sketch the magnetic field pattern around a bar magnet with its S-pole pointing north in the earth's field

   (d) A stiff wire AB is held between opposite poles of two bar magnets and connected to a center-zero galvanometer as shown below



The wire AB is kept vertical and moved horizontally along the line CD

   (i) Explain what is observed on the galvanometer as the wire AB moves towards C and D.

   (ii) Explain what would be observed if the wire were moved along LM

3. (a) Describe with the aid of a labelled diagram the operation of a transformer

   (b) A 240 V step-down mains transformer is designed to light **ten** 12 V, 20 W ray box lamps and draws a current of 1 A in the primary col. Calculate the;

(i) power supplied to the primary col

(ii) power developed in the secondary coil

(iii) efficiency of the transformer

(C) With the aid of suitable diagrams, distinguish between an alternating current and direct current

(d) Explain how a fuse as a safety device achieves its function in house wiring

4. (a) Define the following terms as applied to magnetism

(i) Ferromagnetic materials

(ii) Neutral point

(b) Sketch the magnetic field patterns around a

(i) bar magnet whose axis lies along the magnetic north

(ii) circular current carrying coil

(c) With the aid of a labelled diagram, explain how an electric bell works

(d) (i) What is meant by magnetically saturated material?

(ii) State one method of demagnetizing a magnet.

5. (a) What is meant by a **magnetic field?**

(b) Explain with the aid of a diagram what happens when two vertical, parallel conductors are placed near one another and carry current in

(i) the same direction

(ii) opposite direction

(c) (i) Describe with the aid of a diagram, how a direct current generator works.

(ii) State three ways of increasing the $e.m.f$ produced by the generator

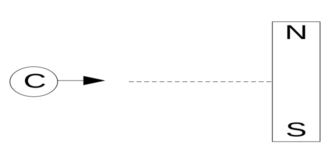
6. (a) Distinguish between **angle of dip (inclination)** and **angle of declination**

(b) Draw a diagram to show the magnetic field pattern around a bar magnet placed in the earth's field with the north pole of the magnet pointing to the earth's magnetic south

(c) (i) What is an **electromagnet?**

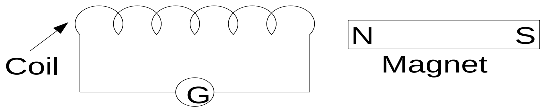
(ii) Describe with the aid of a labelled diagram how an electric bell works

(d)



Describe what happens to the compass needle, C, as it s moved closer to the bar magnet along the dotted line

7. (a) A cable is connected to a centre- zero galvanometer as shown below



(i) State what is observed when the N-pole of a bar magnet is moved towards the cable

(ii) State two ways in which the effect observed in (a) (i) can be increased

(b) (i) With the aid of a labelled diagram describe how a simple a.c generator works

(ii) Sketch the variation of the voltage from an a.c generator and use it to define the terms peak value and period

(c) With the aid of a labelled diagram, describe how full wave rectification can be obtained using four diodes

8. (a) (i) What is a magnetic field

(ii) State the law of magnetism

(b) (i) Explain with the aid of diagrams, how a steel bar can be magnetized by the single touch method

(ii) Sketch the magnetic field pattern around two bar magnets whose north pole face each other

(c) With the aid of a well labelled diagram, describe how a simple a.c generator works

9. (a) With the aid of a diagram explain, the use of keepers to store magnets

(b) (i) Describe using a labelled diagram how a telephone receiver woks

(ii) State two ways by which the strength of an electromagnet can be raised

(c) A bulb is rated 12.0 V, 36 W when used on a 12.0V supply

(i) How much current does it draw from the supply

(ii) what is its resistance

10. (a) Describe briefly the structure and action of an a.c transformer

(b) (i) State any three causes of energy losses in a transformer

(ii) How are these losses reduced in a practical transformer

(c) Explain why it is an advantage to transmit electrical power at high voltage

(d) Electric power is generated at 11kV. Transformers are used to raise the voltage to 440kV for transmission over long distances using cables. The output of the transformer is 19.8MW and they are 90% efficient. Find:

(i) the input current to the transformer

(ii) the output current to the cables

HEAT CAPACITY (H) AND SPECIFIC HEAT CAPACITY(C)

HEAT CAPACITY

Is the quantity of heat required to raise the temperature of any mass of a substance by 1 K

Its S.I unit is $J\ K^{-1}$

$$Heat\ capacity\ (JK^{-1}) = mass(kg)x\ specific\ heat\ cpacity\ (J\ kg^{-1}\ K^{-1})$$

$$\boxed{H = m\ C}$$

SPECIFIC HEAT CAPACITY

Is the quantity of heat required to raise the temperature of 1 kg mass of a substance by 1 K.

Its S.I unit is $J\ kg^{-1}\ K^{-1}$

The quantity of heat gained or lost by a body Q depends on the nature of the material of the body and is proportional to the;

- Mass, m
- Increase in temperature $\Delta\theta$

$$\boxed{Q = m\ C\ \ \Delta\theta}\ \text{or}$$

$$\boxed{Q = H\ \Delta\theta}$$

Examples

1. Find the amount of heat required to raise the temperature of a metal whose heat capacity is 150 $J\ K^{-1}$ by 25°C

Solution

$H =\ 150\ J\ K^{-1}$,

$\Delta\theta = 25$°C

$Q = m\ C\ \ \Delta\theta$

$Q = H\ \Delta\theta$

$Q = 150\ x\ 25$

$Q = 3750\ J$

2. How much heat is given out when an iron metal of mass 2 kg and specific heat capacity 460 $J\ kg^{-1}\ K^{-1}$ cools from 300°C to 200°C

Solution

$C =\ 460\ J\ kg^{-1}\ K^{-1},\ m = 2\ kg,$

$\theta_1 = 300$°C, $\theta_2 = 200$°C

$Q = m\ C\ \ \Delta\theta$

$Q = 2\ x\ 460\ (300 - 200)$

$Q = 2\ x\ 460\ x100$

$Q = 92000\ J$

3. Calculate the specific heat capacity of gold if 108 J of heat raises the temperature of a 9 g mass from 0°C and 100°C.

Solution

$Q =\ 108\ J,$

$m = \frac{9}{1000} = 0.009\ kg,$

$\theta_1 = 0$°C, $\theta_2 = 100$°C

$Q = m\ C\ \ \Delta\theta$

$C = \frac{Q}{m\ x\Delta\theta}$

$$C = \frac{108}{0.009x(100 - 0)}$$

$$C = \frac{108}{0.009x100}$$

$C = 120\ J\ kg^{-1}\ K^{-1}$,

3. $5\ kJ$ of heat is supplied to a metal whose specific heat capacity is $400\ J\ kg^{-1}\ K^{-1}$, if the temperature of the metal rises by $5\ K$. Find the mass of the metal.

Solution

$\Delta\theta = 5\ K, C = 400\ J\ kg^{-1}\ K^{-1}$,

$Q = 5kJ = 5x1000J$,

$Q = m\ C\ \ \Delta\theta$

$m = \frac{Q}{C\ x\Delta\theta}$

$m = \frac{5000}{400x5}$

$m = 2.5\ kg$

4. 1200 J of heat is supplied to $100\ g$ of water at 20°C. Calculate the final temperature of water if its specific heat capacity is $4200\ J\ kg^{-1}\ K^{-1}$.

Solution

$Q = 1200\ J, \Delta\theta = ?$

$m = 100\ g = \frac{100}{1000} = 0.1\ kg$,

$Q = m\ C\ \ \Delta\theta$

$\Delta\theta = \frac{Q}{m\ xC}$

$\Delta\theta = \frac{1200}{0.1x4200}$

$\Delta\theta = \frac{108}{0.009x100}$

$\Delta\theta = 2.9\ K$

Final temperature = 20 + 2.9

= 22.9 °C

5. $500\ g$ of a liquid cools from 70°C to 10°C, if the S.H.C of the liquid is $2000 J\ kg^{-1}\ K^{-1}$. Calculate;

(i) Heat capacity of the liquid

(ii) Quantity of heat given out

Solution

(i) $m = 500\ g = \frac{500}{1000} = 0.5\ kg$,

$\Delta\theta = (70 - 10) = 60K$,

$C = 2000\ J\ kg^{-1}\ K^{-1}$,

$H = m\ C$

$H = 0.5\ x\ 2000$

$H = 1000\ J\ K^{-1}$

(ii)

$Q = m\ C\ \ \Delta\theta$

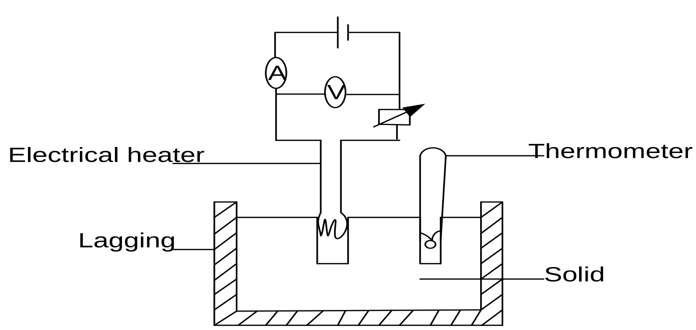
$Q = H\ \Delta\theta$

$Q = 1000\ x\ 60$

$Q = 60000\ J$

METHODS OF DETERMINING S.H.C

a) <u>Determination of S.H.C of a solid by electrical method</u>



- A material whose S.H.C is to be determined is drilled with two holes, one for thermometer and other for heater. Both the heater and thermometer must be in good thermal contact with material.
- The initial temperature of the material θ_1 is determined using thermometer and recorded before closing the circuit.
- The circuit is now closed and at the same time the stop clock started and heating is done until temperature rises to θ_2
- The time t taken for temperature to rise from θ_1 to θ_2 is recorded and currents I and voltage V for this temperature rise also recorded.
- If m is the mass of the block and C is it S.H.C, then from
- heat supplied by the heater = heat gained by the block.

$$IVt = mC[\theta_2 - \theta_1]$$

$$C = \frac{\text{I v t}}{\text{m}[\theta_2 - \theta_1]}$$

Examples

1. A steady current of 12 A and $p.d$ of 240 V is passed through a block of mass 1500g for $1\frac{1}{2}$ $minutes$. If the temperature of the block rises from 25°C to 80°C. Calculate;

   (i) S.H.C of the block

   (ii) The heat capacity of 4 kg mass of the block

   Solution

   i) $t = 1\frac{1}{2}\ minutes = 1\frac{1}{2}x60s = 90\ s,$

   $$m = 1500g = \frac{1500}{1000} = 1.5\ kg$$

   $Q = m\ C\ \ \Delta\theta$

   $I\ V\ t = m\ C\ \ \Delta\theta$

   $12x240x90 = 1.5x\ C\ \ (80 - 25)$

   $$C = \frac{12x240x90}{1.5x55}$$

   $C = 3141.82J\ kg^{-1}\ K^{-1}$

   ii) $H = m\ C$

   $H = 4\ x\ 3141.82$

   $H = 12567.28\ J\ \ K^{-1}$

2. A heater rated 2 k W is used for heating the solid of mass 6 kg, if its temperature rises from 30°C to 40°C. In 12 s, find the S.H.C of the solid.

   Solution

   $P = 2\ k\ W = 2x1000\ W, m = 6\ kg$

   $Q = m\ C\ \ \Delta\theta$

   $I\ V\ t = m\ C\ \ \Delta\theta$

   $Px\ t = m\ C\ \ \Delta\theta$

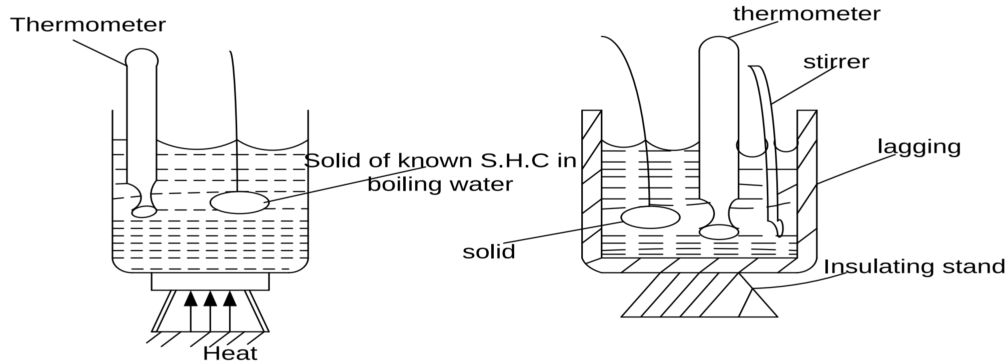
   $2x1000x12 = 6x\ C\ \ (40 - 30)$

   $$C = \frac{2x1000x12}{6x10}$$

   $C = 400\ J\ kg^{-1}\ K^{-1}$

b) S.H.C of a liquid using method of mixtures

This S.H.C of liquid can be determined using method of mixture as follows



- The solid of mass M_s and S.H.C C_S in boiling water at temperature θ_1 is transferred to liquid of mass M_L whose S.H.C $[C_L]$ is to be determined in calorimeter of mass M_C and S.H.C C_C both at a temperature θ_2.
- The mixture is stirred uniformly until final steady temperature θ_3 is obtained
- Assuming there is no heat gained by the stirrer and thermometer and no heat is lost to the surrounding.
- Heat lost by solid= heat gained by calorimeter +heat gained by liquid

$$M_S C_S(\theta_1 - \theta_3) = M_L C_L(\theta_2 - \theta_3) + M_c C_c(\theta_2 - \theta_3)$$

$$C_L = \frac{M_S C_S(\theta_1 - \theta_3) - McCc(\theta_2 - \theta_3)}{M_L(\theta_2 - \theta_3)}$$

Examples

1. What is the final temperature of the mixture if 100g of water at 70°C is added to 200g of cold water at 10°C. And well stirred (Neglect the heat absorbed by the container and S.H.C of water is $42000\, J\, kg^{-1}\, K^{-1}$).

Solution

Heat lost by hot water = heat gained by cold water

$$M_H C_H(\theta_1 - \theta_3) = M_C C_C(\theta_2 - \theta_3)$$

$$\frac{100}{1000} x\ 4200 x(70 - \theta) = \frac{200}{1000} x 4200 x(\theta - 10)$$

$$0.1x(70 - \theta) = 0.2x(\theta - 10)$$

$$7 - 0.1\theta = 0.2\theta - 2$$

$$\theta = 30°C$$

Final temperature of the mixture is 30°C

2. The temperature of 500g of a certain metal is raised to 100°C and it is then placed in 200g of water at 15°C. If the final steady temperature rises to 21°C, calculate the S.H.C of the metal.

Solution

Heat lost by metal = heat gained by water

$$M_m C_m(\theta_1 - \theta_3) = M_w C_w(\theta_2 - \theta_3)$$

$$\frac{500}{1000} x\ C_m x(100 - 21) = \frac{200}{1000} x 4200 x(21 - 15)$$

$$0.5 x C_m x\ 89 = 0.2 x 4200 x 6$$

$$C_m = \frac{0.2x4200x6}{0.5x89}$$

$$C_m = 128\, J\, kg^{-1}\, K^{-1}$$

3. The temperature of a piece of copper of mass 250g is raised to 100°C and it is then transferred to a well- lagged aluminum can of mass 10.0g containing 120g of methylated spirit at 10.0°C. calculate the final steady temperature after the spirit has been well stirred. Neglect the heat capacity of the stirrer and any losses from evaporation. (S.H.C of copper, aluminum and spirit respectively= $400\, J\, kg^{-1}\, K^{-1}, = 900\, J\, kg^{-1}\, K^{-1}, = 2400\, J\, kg^{-1}\, K^{-1}$)

Solution

Heat lost by copper = heat gained by aluminum + heat gained by spirit

$M_C C_C(\theta_1 - \theta_3) = M_A C_A(\theta_2 - \theta_3) + M_S C_S(\theta_2 - \theta_3)$

$0.25x400(100 - \theta) = 0.1x900(\theta - 10) + 0.12x2400(\theta - 10)$

$10000 - 100\theta = 297\theta - 2970$

$$\theta = \frac{12970}{397}$$

$\theta = 32.7°C$

4. A liquid of mass 200g in a calorimeter of heat capacity $500\, J\ \ K^{-1}$ is heated such that its temperature changes from 25°C to 50°C. Find the S.H.C of the liquid if the heat supplied was 14,000J.

Solution

Heat supplied = heat gained by liquid + heat gained by calorimeter

$Q = M_L C_L(\theta_2 - \theta_3) + M_C C_C(\theta_2 - \theta_3)$

$14000 = 0.2xC_L(50 - 25) + 500x(50 - 25)$

$14000 = 5xC_L + 12500$

$C_L = 300\, J\, kg^{-1}\, K^{-1}$

5. A metal of mass 0.2kg at 100°C is dropped into 0.08kg of water at 13°C contained in calorimeter of mass 0.12kg and S.H.C $400Jkg^{-1}K^{-1}$. The final temperature reached is 35°C. Determine the S.H.C of the solid.

Solution

Ms=0.2kg	θ_2=15°C	Cw =$4200Jkg^{-1}K^{-1}$
θ_1=100°C	Mc=0.12	θ_3 =35°C
Mw=0.08kg	Cc=$400Jkg^{-1}K^{-1}$	

Heat lost by the solid=heat gained by calorimeter + heat gained by water

$MsCs\ (\theta_1-\theta_2) = McCc(\theta_3-\theta_2)+Mw\ Cw\ (\theta_3-\theta_2)$

0.2x Cs (100-35)= 0.12x 400 (35-15)+0.08x4200(35-15)

13Cs =960 + 6120

Cs=590.769J $kg^{-1}K^{-1}$

6. Hot water of mass 0.4kg at 100°C is poured into calorimeter of mass 0.3kg and S.H.C 400Jkg^{-1}K^{-1} and contains 0.2kg of a liquid at 10°C. The final temperature of mixture is 40°C determines the S.H.C of a liquid.

Solution

Mw=0.4kg	Mc=0.3kg	M_L=0.2kg θ_2=10^{0}C
θ_1=100°C	Cc=400Jkg^{-1}K^{-1}	θ_3= 40°C

Heat lost by the hot water =heat gained by the colorimeter +heat gain by liquid

$MwCs\ (\theta_3-\theta_1)= McCc(\theta_3-\theta_2)+ M_LC_L\ (\theta_3-\theta_2)$

$0.4x\ 4200(100-40)=0.3x400(40-10)+0.2xC_L(40-10)$

$100800 = 3600 + 6C_L$

C_L=16200Jkg^{-1}K^{-1}

7. A 15W heating coil is immersed in 0.2kg of water and switched on for 560 seconds during which time; the temperature rises by 10°C. When water was replaced by some volume of another liquid of mass 0.15kg, the power required for same time is 8.3W. Calculate the S.H.C of the liquid.

Solution

$Ivt= M_LC_L\Delta\theta$	$C_L =[\frac{8.3x560}{0.15x10}]$
$8.3x\ 560=0.15xC_Lx10$	C_L=3.1x10^3 Jkg^{-1}K^{-1}

Assumption, same temperature rise occurs.

8. When a block of metal of mass 0.11kg and S.H.C 400Jkg^{-1}K^{-1} is heated to 100°C and quickly transferred to a calorimeter containing a liquid at 10°C, the resulting temperature is 13°C. On repeating the experiment with 0.4kg of the liquid in the same container at same temperature of 10°C, the resulting temperature is 14.5°C. Calculate;

   a) S.H.C of the liquid

   b) Thermal capacity of the container.

Solution

$M_S = 0.11kg$, Cs=400Jkg^{-1}K^{-1}	M_L=0.4kg
$\theta_1 = 100$°C θ_2=10°C θ_3=18°C	θ_2=10°C
M_L=0.2kg	θ_3=14.5°C

Heat lost by solid = heat gained by liquid + heat gained by container

$MsCs\ (\theta_1-\theta_3) = M_LC_L\ (\theta_3-\theta_2) + McCc\ (\theta_3-\theta_2)$

$0.11x400(100-18) = 0.2xC_L\ (18-10) + H(18-10)$

$3608 = 1.6C_L+8H$ ……………………………………(1)

$MsCs\ (\theta_1-\theta_3) = M_LC_L\ (\theta_3-\theta_2) + McCc\ (\theta_3-\theta2)$

$0.11x400(100-14.5) = 0.4\ x\ C_L\ (145-10) + H\ (14.5-10)$

$3762 = 1.8\ C_L + 4.5H$ ………………………………………….(2)

Solving equation1 and equation2 simultaneously

$C_L = 1935 Jkg^{-1}K^{-1}$

$H = 66JK^{-1}$[thermal capacity of the container]

Exercise

1) A piece of copper of mass 100g is heated to 100°C and is then transferred to a well lagged copper can of mass 50g containing 200g of water at 10°C. Neglecting heat loss, calculate the final steady temperature of water after it has been well stirred. Take S.H.C of copper and water to be $400Jkg^{-1}K^{-1}$ and $4200Jkg^{-1}K^{-1}$ respectively. **An[14**°C]

2) A heating coil is placed in thermal flask containing 0.6kg of water for 600s. The temperature of water rises by 25°C during this time. Water is replaced by 0.4kg of another liquid. And the same temperature rise occurs in 180s. Calculate the S.H.C of the liquid given that S.H.C of water is $4200Jkg^{-1}K^{-1}$. State any assumption. **An [1890Jkg^{-1}K^{-1}]**

3) Copper calorimeter of mass 120g contains 100g of paraffin at 15°C. If 45g of aluminum at 100°C is transferred to the liquid and the final temperature is 27°C. Calculate the S.H.C of paraffin [S.H.C of aluminum and copper are 1000 $Jkg^{-1}K^{-1}$ and 400 $Jkg^{-1}K^{-1}$ respectively**].** **An[2.4 x10^{3}Jkg^{-1}K^{-1}]**

4) A liquid of mass 250g is heated to 80°C and then quickly transferred to a calorimeter of heat capacity $380JK^{-1}$ containing 400g of water at 30°C. If the maximum temperature recorded is 55°C and specific heat capacity of water is $4200Jkg^{-1}K^{-1}$. Calculate the S.H.C of the liquid.

An [8240Jkg^{-1}K^{-1}]

5) 500g of water is put in a calorimeter of heat capacity $0.38JK^{-1}$ and heated to 60°C. It takes 2minute for the water to cool from 60°C to 55°C. When the water is replaced with 600g of a certain liquid, it takes 1 ½ minute for the liquid to cool from 60°C to 55°C. Calculate the S.H.C of the liquid.

An [2624.8kgJ^{-1}K^{-1}]

6) When a metal cylinder of mass $2.0x10^{-2}$kg and specific heat capacity $500Jkg^{-1}K^{-1}$ is heated by an electrical heater working at a constant power, the initial rate of rise of temperature is $3.0Kmin^{-1.}$ After a time the heater is switched off and the initial rate of fall of temperature is $0.3Kmin^{-1}$. What is the rate at which the cylinder gains heat energy immediately before the heater is switched off?

An[0.45W]

7) 400g of a liquid at a temperature 70°C is mixed with another liquid of mass 200g at a temperature of 25°C. Find the final temperature of the mixture, if the S.H.C of the liquid is 4200 $J\,kg^{-1}\,K^{-1}$. **An[=55**°C**]**

8) 60 kg of hot water at 82°C was added to 300 kg of cold water at 10°C. Calculate the final temperature of the mixture (S.H.C of water =4200 $J\,kg^{-1}\,K^{-1}$) **An[=22**°C**].**

9) Calculate the final steady temperature obtained when 0.8 kg of glycerine at 25°C is put into a copper calorimeter of mass 0.5 kg at 0°C (S.H.C of copper $=400\,J\,kg^{-1}\,K^{-1}, S.H.C\ of\ glycerine = 250\,J\,kg^{-1}\,K^{-1}$). **An[12.5°C]**

10) A block of metal of mass 0.01 kg at a temperature of 100°C was dropped in a container of water at 20°C. The final temperature was 40°C. Calculate the S.H.C of the metal ,if S.H.C of water $4200\,J\,kg^{-1}\,K^{-1}$. **An [7000 $J\,kg^{-1}$ °C^{-1}]**

11) A copper block of mass 250g is heated to a temperature of 145°C and then dropped into a copper calorimeter of mass 250g which contains $2500m^3$ of water at 20°C. Calculate the final temperature of water. (S.H.C of copper = 400 $J\,kg^{-1}$ °C^{-1}, S.H.C of water = 4200 $J\,kg^{-1}$ °C^{-1}). **An[30°C]**

12) The temperature of heat which raises the temperature of 0.1 kg of water from 25°C to 60°C is used to heat a metal rod of mass 1.7 kg and S.H.C of the rod was 20°C. Calculate the final temperature of the rod. **An [48.8°C]**

LATENT HEAT

This is the amount of heat required for the substance to change state at constant temperature.

$$\text{Solid} \underset{\text{Heat lost}}{\overset{\text{Heat absorbed}}{\rightleftarrows}} \text{Liquid} \quad \underset{\text{Heat absorbed}}{\overset{\text{Heat lost}}{\rightleftarrows}} \text{Gas}$$

- When melting a solid, latent heat of fusion is absorbed to break the intermolecular forces of attraction between solid molecules and increase their energy to allow molecules to move a part.
- When evaporating a liquid, latent heat of vaporization is absorbed to break the intermolecular forces of attraction and increase their energy by higher amount since their molecules become widely spaced when they are in vapour state.

LATENT HEAT OF FUSION

This is heat required to change any mass of substance from solid to a liquid at constant temperature.

SPECIFIC LATENT HEAT OF FUSION

Is the quantity of heat required to change **1kg** mass of a solid to a liquid at **constant temperature**.

It is measured in Jkg^{-1}

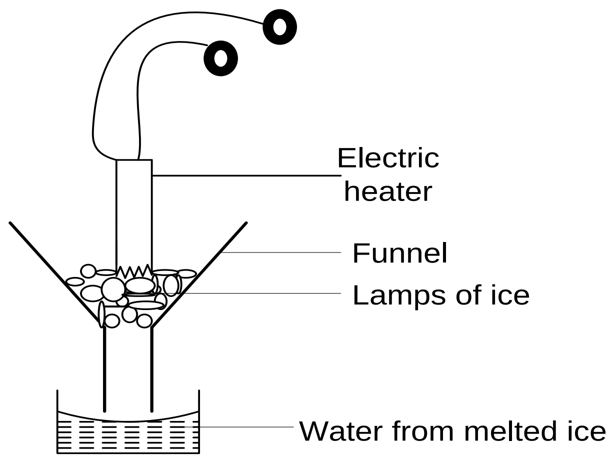
$$specific\ latent\ heat\ of\ fusion = \frac{heat}{mass}$$

$$l = \frac{\theta}{m}$$

$$\boxed{\theta = m\,l}$$

Determination of S.L.H of fusion of ice

- Measure mass (m_1) of the beaker.
- Insert heater of known power (P) in filter funnel
- Pack small pieces of dry ice in the funnel with ice
- Switch on power and place the beaker under the funnel to (collect melted ice water)



- Determine the mass of the beaker and water (m_2) collected in time, t

  Heat supplied by heat = heat gained to melt ice

  $power\ x\ time\ = l\,(m_2 - m_1)$

  $$l = \frac{P\,t}{(m_2 - m_1)}$$

LATENT HEAT OF VAPOURIZATION

Is the quantity of heat required to change any mass of substance from liquid to gas at a constant temperature.

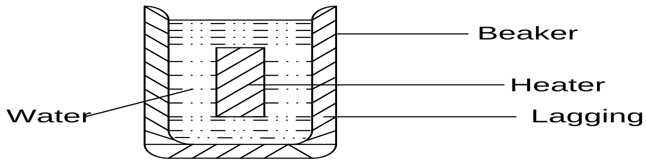
SPECIFIC LATENT HEAT OF VAPOURIZATION

Is the quantity of heat required to change **1kg** mass of liquid to gas at **a constant temperature.**

It is measured in Jkg^{-1}

Determination of S.L.H of vaporization of water

- Fill the beaker with hot water, cover it with a lid and weigh it (m_1).
- Fit the beaker in a lagging jacket.



- Insert the heater and heat the water until it just begins to boil. Remove the lid to allow steam to escape and at the same time start the stop clock.
- After time t, switch off the heater and replace the lid
- Remove the heater and lagging and weigh the set up again (m_2)

Heat supplied by heat = heat gained to melt ice

$power\ x\ time\ = l\,(m_2 - m_1)$

$$l = \frac{P\ t}{(m_2 - m_1)}$$

Examples

1. Ice has a mass of 3 kg. Calculate the heat required to melt it at 0°C. (S.L.H of fusion = $3.36x10^5$Jkg^{-1}).

Solution

$Q = m\ l$

$Q = 3\ x\ \ 3.36x10^5$

$Q = 1.008x10^6\ J$

2. Find the heat required to change 2 kg of ice at 0°C into water at 50°C.(S.L.H of fusion of ice = $3.36x10^5$Jkg^{-1} , $S.H.C\ of\ water = 4200\ J\ kg^{-1}\ K^{-1}$).

Solution

Ice at 0°C → Water 0°C + Water 50°C

$Q = m\ l + m\ C\ \Delta\theta$

$Q = 3\ x\ \ 3.36x10^5 + 2x4200x(50 - 0)$

$Q = 1.008x10^6\ + 4.2x10^6$

$Q = 1.092x10^6\ J$

3. An ice making machine removes heat from water at a rate of 20 Js^{-1}. How long will it take to convert 0.5 kg of water at 20 °C to ice at 0°C°C. (S.L.H of fusion of ice = $3.36x10^5$Jkg^{-1} , S.H.C of water=4200$J\ kg^{-1}\ K^{-1}$).

Solution

water 20°C → Water 0°C + Ice 0°C

$Q = m\ C\ \Delta\theta +\ m\ l$

$P\ x\ t\ = m\ C\ \Delta\theta +\ m\ l$

$20\ x\ t = 0.5x4200x(20 - 0) +\ 0.5x\ \ 3.36x10^5$

$20\ t = 42000\ + 168000$

$$t = \frac{210000}{20}$$

$t = 1.05x10^4$ s

4. A calorimeter with heat capacity of $80J°C^{-1}$contains 50g of water at 40°C what mass of ice at 0°C needs to be added in order to reduce the temperature to 10°C. Assume no heat is lost to the surround (S.H.C of water = $4200Jkg^{-1}°C^{-1}$, S.L.H of the of ice = $3.4x10^5Jkg^{-1}$)

Solution

$$\begin{pmatrix} Heat\ lost\ by \\ calorimeter \\ from \\ 40°C\ to\ 10°C \end{pmatrix} + \begin{pmatrix} Heat\ lost\ by \\ water \\ from \\ 40°C\ to\ 10°C \end{pmatrix} = \begin{pmatrix} Heat\ gained \\ by\ melting \\ ice \\ at\ 0°C \end{pmatrix} + \begin{pmatrix} Heat\ gained \\ by \\ melted\ ice \\ from\ 0°C\ to\ 10°C \end{pmatrix}$$

$$M_c C_c (40-10) + M_w C_w (40-10) = M_1 L + M_1 C_l x\ (10-0)$$

$$80\ x\ 30\ + \frac{50}{1000}\ x4200x30 = M_1 (3.4x10^5+4200x10)$$

$M_1 = 0.023kg$ Mass of ice required = 23g

5. An electrical heater rated 500W is immersed in liquid of mass 2.0kg contained in large thermal flask of heat capacity $840Jkg^{-1}$ at 28°C. Electrical power is supplied to heater for 10minutes. If S.H.C of liquid is $2.5x10^3\ Jkg^{-1}K^{-1}$. Its **S.L.H.V** is $8.54x10^3\ Jkg^{-1}k$ and its boiling point is 78°C. Estimate the amount of liquid which boils off.

Solution

Heat supplied by heater = heat gained by flask + heat gained by liquid + heat used for evaporating the liquid.

$Ivt = M_f C_f (\theta_2-\theta_1) + M_L C_L (\theta_2-\theta_1) + MsLv$

$500x10x60 = 840\ (78-28) + 2x2.5x10^3\ [78-28] + M_s (8.54x10^3)$

$300000 = 42000+ 250000+ 8.54x10^3 Ms$

$Ms = \frac{300000-292000}{8.54x103}$

Ms = 0.936kg

6. Steam at 100°C is passed into a copper calorimeter of mass 150g containing 340g of water at 15°C. This is done until the temperature of the calorimeter and its content is 71°C. If the mass of the calorimeter and its contents is found to be 525g. Calculate the specific latent heat of vaporization of water.

Solution

Mass of calorimeter Mc = 150g

Mass of water Mw = 340g

Mass of steam Ms = 525 – (150+340) = 35g

$$\begin{pmatrix}\text{Heat supplied}\\ \text{by steam}\\ \text{at }100°C\end{pmatrix} + \begin{pmatrix}Condensing\ steam\\ from\\ 100°C\ to\ 71°C\end{pmatrix} = \begin{pmatrix}\text{heat gained by}\\ \text{calorimeter}\\ \text{from}\\ 15°C\text{ to}71°C\end{pmatrix} + \begin{pmatrix}heat\ gained\ by\\ water\ from\\ 15°C\ to\ 71°C\end{pmatrix}$$

Ms Lv + MsCs (100-71) = McCc (71-15) + Mw Cw (71-15)

$\frac{35}{1000}$Lv + $\frac{35}{1000}$x 4200x29 =$\frac{150}{1000}$ x400x56 +$\frac{340}{1000}$x 4200 x56

Lv= 2.26X10^6 Jkg^{-1}

Exercise

1. Ice at 0°C is added to 200g of water initially at 70°C in a vacuum flask. When 50g of ice is added and has all melted, the temperature of the flask and content is 400°C. When further 80g of ice has been added and has been melted, the temperature of the whole becomes 10°C. Calculate the S.L.H of fusion of the neglecting any heat loss of surrounding. **Ans 3.78x10^5 Jkg^{-1}**
2. Calculate the heat required to melt 200g of ice at 0°C . (S.L.H of ice= 3.4x$10^5$$Jkg^{-1}$) **An 6.8x10^4 J**
3. Calculate the heat required to turn 500g of Ice at 0°C into water at 100°C. (S.L.H of ice= 3.4x$10^5$$Jkg^{-1}$ S.H.C of water = 4200Jkg^{-1}**)** **An [3.8x$10^5$$J$**]
4. Calculate the heat given out when 600g of steam at 100°C condenses to water at 20°C [S.L.H of steam = 2.26x10^6 Jkg^{-1}, S.H.C of water = 4200 Jkg^{-1}]. **An [1.56x10^6J]**
5. 1kg of vegetables, having a specific heat capacity 2200 Jkg^{-1} at a temperature 373K are plugged into a mixture of ice and water at 273K. How much is melted. [S.L.H of fusion of the = 3.3x10^5 Jkg^{-1}]

   An [0.67kg]
6. 3kg of molten lead (melting point 600K) is allowed to cool down until it has solidified. It is found that the temperature of the lead falls from 605K to 600K in 10s, remains constant at 600K for 300s, and then fall to 595K in a further 8.4 s. Assuming that the rate of loss of energy remains constant and that the specific heat capacity of solid lead is 140$Jkg^{-1}K^{-1}$. Calculate.
   (a) Rate of loss of energy from the lead.
   (b) The specific latent heat of fusion of lead.
   (c) The specific heat capacity of liquid lead **An [250W, 2.5x$10^4$$Jkg^{-1}$, 167$Jkg^{-1}K^{-1}$]**
7. 0.02kg of ice and 0.10kg water at 0°C are in a container. Steam at 100°C is passed in until all the ice is just melted. How much water is now in the container? S.L.H of steam = 2.3x$10^6$$Jkg^{-1}$, S.L.H of ice = 3.4x$10^5$$Jkg^{-1}$, S.H.C of water = 4.2 x$10^3$$Jkg^{-1}K^{-1}$ **An [0.1225kg**]
8. When apiece of ice of mass 6x10^{-4}kg at a temperature of 272K is dropped into liquid nitrogen boiling at 77K in a vacuum flask 8 x $10^{-4}m^3$ of nitrogen, measured at 294K and 0.75m mercury pressure are produced. Calculate the mean specific heat capacity of ice between 272K and 77K.

Assume that the S.L.H of vaporization of nitrogen is $2.13 \times 10^5 Jkg^{-1}$ and that the density of nitrogen at S.T.P is $1.25kgm^{-3}$.**An $1.67 \times 10^3 Jkg^{-1}K^{-1}$**

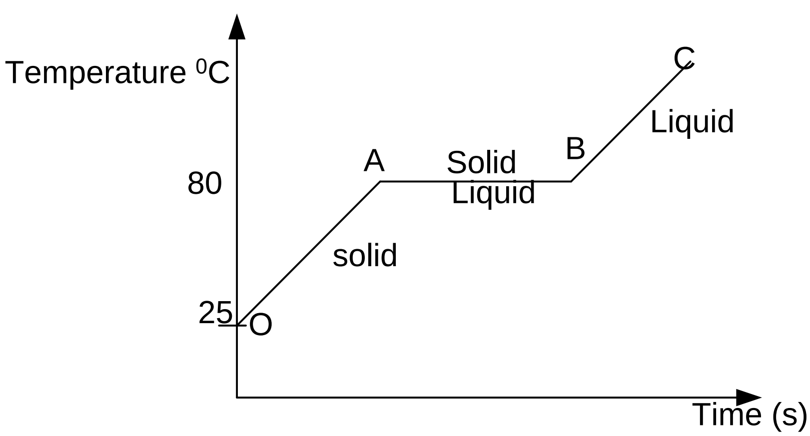
9. In a factory heating system water enters the radiators at 60°C and leaves at 38°C. *T*he system is replaced is by one in which steam at 100°C *is* condensed in the radiators, the condensed steam leaving at 82°C. What mass of steam will supply the same heat as 1.00kg of hot water in the first instance? (The S.L.H of vaporization of water is $2.26 \times 10^6 Jkg^{-1}$ at 100°C. The S.H.Cof water Is $4.2 \times 10^3 Jkg^{-1}°C^{-1}$) **An [0.0396kg]**

10. In an express coffee machines, steam at 100^0C is passed into milk to heat it. Calculate
    (i) The energy required to heat 150g of milk from room temperature (20^0C) to 80^0C.
    (ii) The mass of steam condensed. **An [$3.6 \times 10^6 J$, 15.8g]**

HEATING AND COOLING CURVES

Temperature time – graphs

Consider naphthalene whose melting point is 80°C. If it's heated from 25°C, temperature time graph below is obtained.



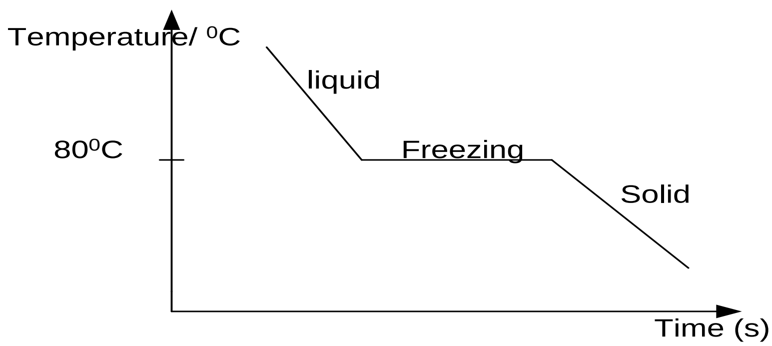
There is an increase in temperature and time, but when it starts melting the temperature remains constant until all of it has melted and the temperature rises.

OA – Solid is heating up

OB-Solid is melting [two states co-exist i.e solid+ liquid]

OC- liquid is heating up

Cooling curve of naphthalene



Examples

1. 2kg of ice at $-5°C$ was heated up to steam at 100°C.
   i) Sketch a temperature time graph curve for the ice up to steam
   ii) Find the heat at each section of the graph drawn.

S.H.C of ice = 2000 J $kg^{-1}°C^{-1}$

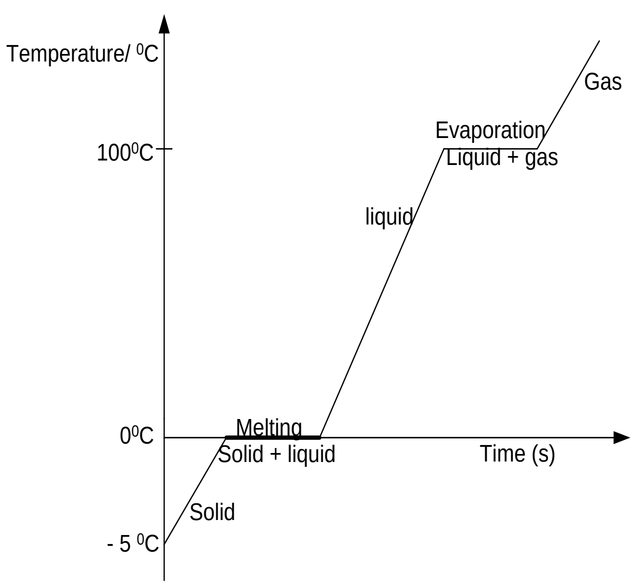
S.H.C of water = 4200 J $kg^{-1}°C^{-1}$

S.L.H. of fusion of ice = $3.36x10^5$Jkg^{-1}

S.L.H. of vaporization of water = $2.26x10^6$Jkg^{-1}

Solution

i)



ii)

For solid state

$Q = m\ C\ \Delta\theta$

$Q = 2x2000x(0 - -5)$

$Q = 20000\ J$

For solid + liquid state

$Q = m\ l$

$Q = 2x3.36x10^5$

$Q = 672000\ J$

For Liquid state

$Q = m\ C\ \Delta\theta$

$Q = 2x4200x(1000 - 0)$

$Q = 840000\ J$

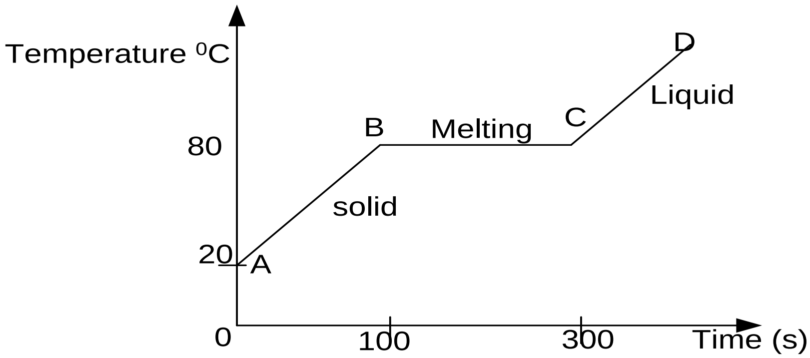
For liquid + gas state

$Q = m\ l$

$Q = 2x2.26x10^6$

$Q = 4520000\ J$

2. When a 100W heater is used to heat 1kg of solid wax, the temperature of the wax is observed to change with time as shown below



Find the S.L.H of fusion of wax

Solution

It occurs during melting

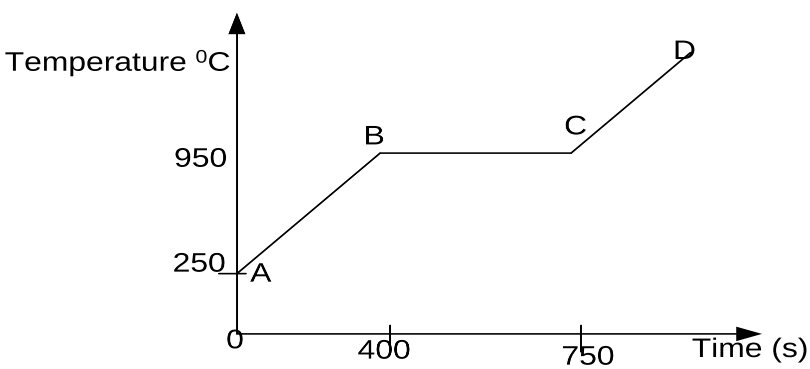
$Q = m\ l$

$P\ t = m\ x\ l$

$100x\ (300 - 100) = 1x\ l$

$l = 20000\ J\ kg^{-1}$

3. The graph below shows the variation of temperature of a metal with time.



If the metal absorbs heat at a rate of 2500 J s^{-1} and the S.H.C is 300 J kg^{-1}°C^{-1}.

(i) Calculate the mass of the metal

(ii) Find the S.H.L of fusion of the metal

Solution

i) Mass of the metal

$Q = m\ C\ \Delta\theta$

$P\ t = m\ C\ \Delta\theta$

$2500x\ 400 = mx300x(950 - 250)$

$$m = \frac{2500x400}{300x700}$$

$$m = 4.76\ kg$$

ii) S.L.H of fusion of metal

$$Q = m\ l$$

$$P\ t = m\ x\ l$$

$$2500x350 = 4.76x\ l$$

$$l = 1.84x10^5\ J\ kg^{-1}$$

GAS LAWS

1: **Boyle's law**:

It states that the volume of fixed mass of a gas is inversely proportional to its pressure at constant temperature i.e.

$P \propto \frac{1}{v}$

PV = constant

$$\boxed{P_1V_1 = P_2V_2}$$

Example

1. A given mass of a gas has a volume of 100 cm^3 at 75 $N\ m^{-2}$. At what pressure is it when the volume decreases to $60cm^3$

Solution

$P_1 = 75\ N\ m^{-2}$, $V_1 = 100\ cm^3$

$P_2 = ?$, $V_2 = 60cm^3$

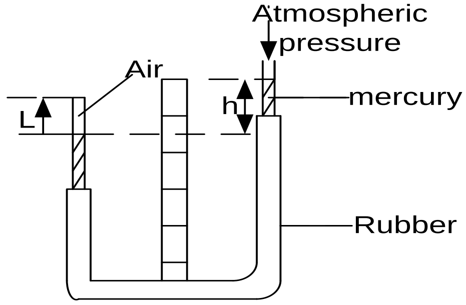
$P_1V_1 = P_2V_2$

$75\ x\ 100 = P_2\ x\ 60$

$$P_2 = \frac{75\ x\ 100}{60}$$

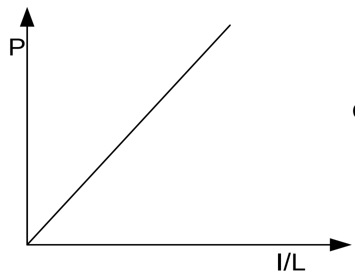
$P_2 = 125N\ m^{-2}$

EXPERIMENT TO VERIFY BOYLES LAW

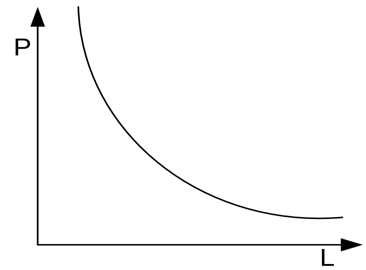


- A fixed mass of the gas is trapped inside J tube of uniform cross section using mercury.

- The pressure of the gas is varied by adding mercury to open limb
- The pressure P of air [H+h] is determined by measuring height h.
- The length L of air column is also measured using meter ruler.
- Different value of P and L are obtained and tabulated including values of $\frac{1}{L}$.
- A graph of P against $\frac{1}{L}$ is plotted and straight line graph passing through original obtained ($P \propto \frac{1}{L}$) from the graph.
- Since the tube has cross section area A then $P \propto \frac{1}{AL}$ but AL=V ie$P \propto \frac{1}{V}$



OR



This verifies Boyle's law

2: CHARLES LAW:

It states that the volume of fixed mass of gas is directly proportional to its absolute temperature at constant pressure i.e.

$V \propto T$ $\qquad \frac{V}{T} = comstant \qquad \boxed{\frac{V_2}{T_2} = \frac{V_1}{T_1}}$

Absolute zero temperature (0K) is the lowest temperature at which average kinetic energy of molecules is zero.

Examples

1. When the temperature of a gas is at 0°C, its volume is 75 cm^3. Find its volume when the gas is heated up to 273°C.

   Solution

   $V_1 = 75\ cm^3,\ T_1 = 0 + 273 = 273K$
   $V_2 = ?\ ,\ T_2 = 273 + 273 = 546\ K$
   $\frac{V_2}{T_2} = \frac{V_1}{T_1}$

   $\frac{V_2}{546} = \frac{75}{273}$

   $V_2 = \frac{75\ x\ 546}{273}$

   $V_2 = 150cm^3$

2. A tube containing air of volume 0.12 cm^3 was placed in water when the temperature was 27°C. Calculate the volume of air when the temperature of air was raised to 77°C.

Solution

$V_1 = 0.12\ cm^3$, $T_1 = 27 + 273 = 300K$

$V_2 = ?$, $T_2 = 77 + 273 = 350\ K$

$\frac{V_2}{T_2} = \frac{V_1}{T_1}$

$\frac{V_2}{350} = \frac{0.12}{300}$

$V_2 = \frac{0.12\ x350}{300}$

$V_2 = 0.14cm^3$

3. The volume of a fixed mass of a gas at 27°C is 150 cm^3. What is its temperature at $200cm^3$

Solution

$V_1 = 150\ cm^3$, $T_1 = 27 + 273 = 300K$

$V_2 = 200cm^3$, , $T_2 = ?$

$\frac{V_2}{T_2} = \frac{V_1}{T_1}$

$\frac{200}{T_2} = \frac{150}{300}$

$T_2 = \frac{300\ x\ 200}{150}$

$T_2 = 400\ K$

Temperature = 400 -273 =127°C

4. The temperature of a fixed mass of a gas is 27°C. If the volume is halved, find its new temperature.

Solution

$V_1 = V$, $T_1 = 27 + 273 = 300K$

$V_2 = \frac{V}{2}$, $T_2 = ?$

$\frac{V_2}{T_2} = \frac{V_1}{T_1}$

$\frac{V/2}{T_2} = \frac{V}{300}$

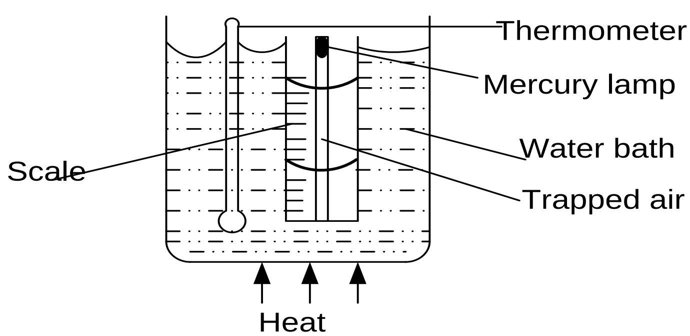
$\frac{V}{2\ T_2} = \frac{V}{300}$

$T_2 = \frac{300\ x\ 1}{2}$

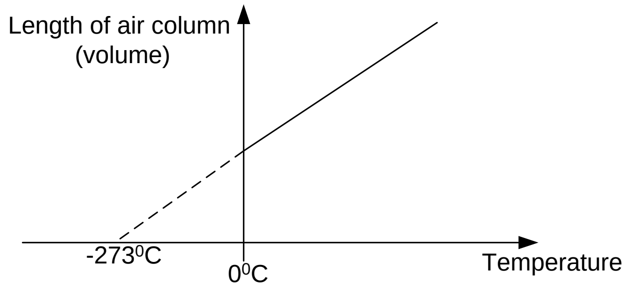
$T_2 = 150K$

$Temperature = 150 - 273 = -123$°C

Experiment to verify Charles' law



- ❖ Trapped air is obtained by using thread of mercury
- ❖ Fit the capillary tube on a ruler using rubber bands so that its ends lie on the zero mark
- ❖ Heat the water bath and read and record the length of the air column at different temperatures
- ❖ Plot a graph of air column against temperature



❖ The straight line through the origin on the kelvin temperature scale shows that volume is directly proportional to its absolute temperature.

3: PRESSURE LAW/ GAY LUSSAC LAW

It states that the pressure of fixed mass of gas is directly proportional to its absolute temperature at constant volume i.e.

P∝T

$\frac{P}{T} = constant$ $\boxed{\frac{P_1}{T_1} = \frac{P_2}{T_2}}$

Example

1. The pressure of a gas is $75N\ m^{-2}$ at -73°C. What is its pressure when a gas is heated up to 127°C

Solution

$P_1 = 75\ N\ m^{-2}, T_1 = -73 + 273 = 200\ K$

$P_2 = ?, T_2 = 127 + 273 = 400K$

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{75}{200} = \frac{P_2}{400}$

$P_2 = \frac{75x\ 400}{200}$

$P_2 = 150\ N\ m^{-2}$

2. A sealed flask contains a gas at a temperature of 27°C and a pressure of 90 kPa. If the temperature rises to 127°C. What will be the new pressure?

Solution

$P_1 = 90\ kPa, T_1 = 27 + 273 = 300\ K$

$P_2 = ?, T_2 = 127 + 273 = 400K$

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{90}{300} = \frac{P_2}{400}$

$P_2 = \frac{90x\ 400}{300}$

$P_2 = 120\ kPa$

EQUATION OF STATE

The combination of the three gas laws give **general gas equation**

$\frac{P\ V}{T} = constant$ $\boxed{\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}}$

The general gas equation is used to solve problems about a gas pressure, volume and absolute temperature when all the three quantities change

Examples

1. A bicycle pump holds 60 cm^3 of air at 0°C and a pressure 1 Nm^{-2}, when the piston is drawn out. Calculate the pressure of the air forced into the tyre when the volume of the air in the pump reduces to 15 cm^3 at a temperature of 273°C

Solution

$P_1 = 1\ N\ m^{-2}, V_1 = 60cm^3,$

$T_1 = 0 + 273 = 273\ K$

$P_2 = ?,\ V_2 = 15cm^3,$

$T_2 = 273 + 273 = 546\ K$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{1\ x\ 60}{273} = \frac{P_2\ x\ 15}{546}$$

$$P_2 = \frac{1\ x\ 60\ x\ 546}{273\ x\ 15}$$

$P_2 = 8\ N\ m^{-2}$

2. When the pressure of $1m^3$ of a gas at -73 °C is increased to 3 times its original value, the temperature becomes 27 °C. Find the new volume of the gas

Solution

$P_1 = P\ N\ m^{-2}, V_1 = 1m^3,$

$T_1 = -73 + 273 = 200\ K$

$P_2 = 3\ P\ ,\ V_2 = ?,$

$T_2 = 27 + 273 = 300\ K$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{P\ x\ 1}{200} = \frac{3\ PxV_2}{300}$$

$$\frac{1}{200} = \frac{3\ xV_2}{300}$$

$$V_2 = \frac{1\ x\ 300}{200x\ 3}$$

$V_2 = 0.5m^3$

3. A litre of gas at 0°C and 10^5 Nm^{-2} pressure is suddenly compressed to $\frac{1}{4}$ of its volume and its temperature rises to 273°C. Calculate the resulting pressure of the gas.

Solution

$P_1 = 10^5\ Nm^{-2}, V_1 = 1\ l,$

$T_1 = 0 + 273 = 273\ K$

$P_2 = ?\ ,\ V_2 = \frac{l}{4},$

$T_2 = 273 + 273 = 546\ K$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{10^5\ x\ 1}{273} = \frac{P_2x\ ^1/_4}{546}$$

$$\frac{100000}{273} = \frac{1\ x\ P_2}{546\ x\ 4}$$

$$P_2 = \frac{100000\ x\ 546\ x\ 4}{273}$$

$P_2 = 800000\ Nm^{-2}$

Note:

At standard temperature and pressure (s.t.p) a gas has an absolute temperature and normal pressure ie. T = 273 K, P = 76 cmHg

Example

1. 240 cm^3 of oxygen gas was collected when a temperature is 20°C at a pressure of 50 cmHg. Calculate its volume at s.t.p.

Solution

$P_1 = 50\ cmHg, V_1 = 240\ cm^3,$

$T_1 = 20 + 273 = 293K$

$P_2 = 76\ cmHg\ ,\ V_2 = ?,$

$T_2 = 273K$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{50\ x\ 240}{293} = \frac{V_2\ x\ 76}{273}$$

$$V_2 = \frac{50\ x\ 240\ x\ 273}{293\ x\ 76}$$

$V_2 = 147.12\ cm^3$

2. The volume of hydrogen at 273°C is 10 cm^3 at a pressure of 152 cmHg. What is its volume at s.t.p

Solution

$P_1 = 152cmHg, V_1 = 10\ cm^3,$

$T_1 = 273 + 273 = 546K$

$P_2 = 76\ cmHg\ ,\ V_2 = ?,$

$T_2 = 273K$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{152\ x\ 10}{546} = \frac{V_2\ x\ 76}{273}$$

$$V_2 = \frac{152x\ 10\ x\ 273}{546\ x\ 76}$$

$V_2 = 10\ cm^3$

KINETIC THEORY AND GAS LAWS

Kinetic theory of gases states that, the molecules of a gas are in continuous random motion, colliding with each other and with the walls of the container

1. Effect of temperature

If the temperature of a gas is raised, it receives heat energy, their kinetic energy s raised and they move faster and the volume increases. This explains why the volume of a gas is directly proportional to the absolute temperature (Charles' law).

2. Effect of pressure

Decrease in the volume of the gas, increases the number of times the molecules bombard the walls of the container and so raises pressure. If the gas is compressed, the volume decreases until the gas pressure equals the pressure outside.

This explains Boyle's law.

Explain using kinetic theory why the pressure of fixed mass of gas rises when its temperature is increased at constant volume.

- When gas temperature increases, the average kinetic energy of molecules increases. So the number of collisions made by molecules with walls of the container per second increases. The momentum change per second also increases and this leads to an increase in impulsive force exerted on walls thereby increasing pressure exerted by the gas on the walls.

VAPOURS

A vapour is gaseous state of substance below its critical temperature. A vapour can either be saturated or unsaturated

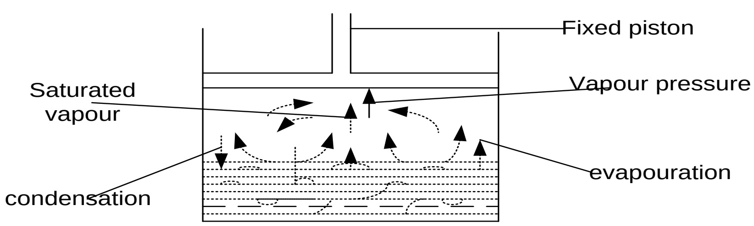
A gas is a gaseous state of substance above it's critical temperature

SATURATED AND UNSATURATED VAPOUR

- A saturated vapour is one which is in contact or in equilibrium with it's own liquid.
- Unsaturated vapour is one which is not in contact or equilibrium with it's own liquid.

SATURATED VAPOUR PRESSURE (S.V.P)

1. **Explanation of occurrence of S.V.P using kinetic theory**



- Consider a liquid confined in the container with fixed piston, the liquid is in contact with its vapour. The liquid molecules are moving randomly with mean kinetic energy determined by liquid temperature. The most energetic molecules have sufficient K.e to overcome the attraction by other molecules and leave the surface of liquid to become vapour molecules. The process is called evaporation and it rate is determined by the liquid temperature.
- The molecules of the vapour are also moving randomly with a mean kinetic. The vapour molecule collide with walls of the vessel giving rise to vapour pressure and others bombard the surface of the liquid and re-enter the liquid. The process is called condensation. The process of condensation and vapour pressure depend on density of the vapour.

- A state of dynamic equilibrium is attained when the rate of condensation equals to rate of evapouration. At this point the density of vapour and hence vapour pressure is maximum at that temperature of the vapour and this is called S.V.P.

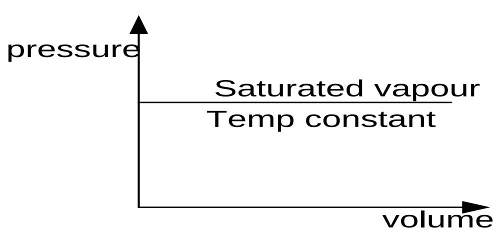
NB:

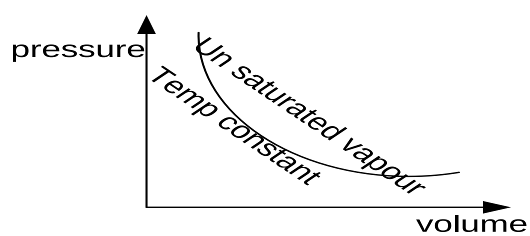
- The rate of evapouration depend on temperature of the liquid
- The rate of condensation depends on density of vapour
- Vapour pressure depends on density of the vapour
- Saturated vapour pressure depends on density of the vapour
- S.V.P is the maximum vapour pressure at any temperature

2. Effect of volume change on S.V.P at constant temperature

- When the volume of saturated vapour is decreased at constant temperature, the density of vapour, the rate of condensation and S.V.P momentarily increases but the rate of evapouration remains constant.
- An increase in the rate of condensation with out any increase in rate of evapouration. Causes the vapour density, the rate condensation and SVP to decrease therefore dynamic equilibrium is retained at original value.

NB: Volume change at constant temperature has no effect on SVP

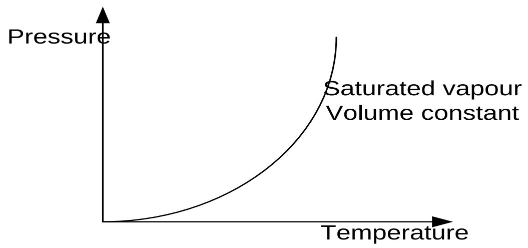




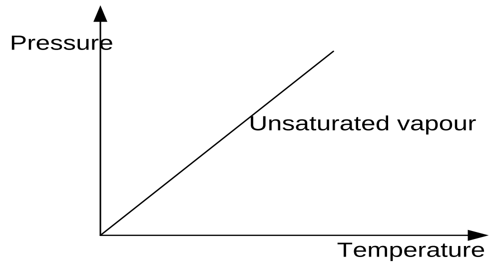
Saturated vapours do not obey Boyle's law, unsaturated vapour obey Boyle's law

3. Effects of increasing temperature on SVP at constant volume

An increase in temperature increases the average kinetic energy of molecules and therefore evapouration rate increases. This causes an increase in vapour density which in turn increases the rate of condensation and eventually equilibrium and saturation are re-obtained at higher saturated vapour pressure than before.



Saturated vapour increases almost exponentialy with temperature. Saturated vapour donot obey Pressure law



Pressure increases linearly with temperature. Unsaturated vapours obey pressure law

EVAPOURATION

This is the process by which a liquid become a vapour.

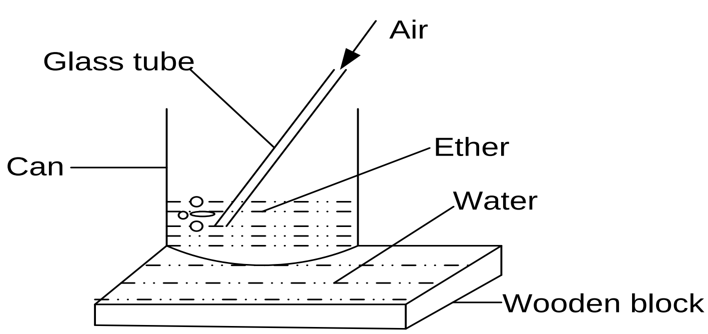
It can take place at all temperatures and only at the surface but it is greatest when the liquid is at it's boiling point.

Explanation using kinetic theory

- In kinetic theory, the molecules of liquid are in continuous motion and make frequent collision with each other. As they continue colliding with each other, they gain kinetic energy and those which have acquired sufficient kinetic energy move up to the surface of the liquid and over come the attractive forces holding them together and therefore escape from the surface.
- Since the fast moving molecules which cause numerous collisions with in the liquid tending to increased liquid temperature have escaped and leaving behind slow cold molecules this lead to the cooling of the liquid.

Experiment to demonstrate cooling by evapouration

- Place a beaker filled with ether (volatile liquid) on the film of water on a wooden block and blow air through a glass tube



- ❖ Ether will evapourate when it gets the necessary heat from water under the beaker and loss of heat makes the water to freeze
- ❖ It is then observed that water under the beaker turns in a solid ice because of evapouration of ether takes place

Ways of increasing evapouration

- Increasing surface area of liquid

  Increasing the surface area increases the rate of evaporation because a larger surface area exposes many energetic molecules to escape.
- Increasing temperature of the liquid

  Increase in temperature increases the rate of evapouration because at higher temperatures more moelcules will move faster to the liquid surface where they will escape
- Reducing air pressure above the liquid

  At low pressure there is low exertion on the liquid surface hence allowing more molecules to escape.
- Wind or air currents

  The rate of evapouration increases when there is too much wind blowing since wind blows away more energetic molecules which have already escaped from the liuid so they can not return back to the liquid

BOILING

Boiling is a process which occurs when vapour pressure is equal to external atmospheric pressure.
Boiling point of liquid is the temperature at which liquid vapour pressure is equal to external atmospheric pressure.
A liquid boils when its temperature is such that bubble of vapour forms through out it's volume.

Explanation of boiling using kinetic theory

- ❖ In kinetic theory, the molecules of a liquid are in continuous motion and make frequent with each other. As they continue colliding with each other they gain kinetic energy and those which have acquired sufficient kinetic energy move up to the surface of the liquid and overcome the attractive forces holding them together at boiling.

- ❖ At boiling point the saturated vapour pressure of the liquid is equal to the external pressure (atmospheric pressure plus hydrostatic pressure plus the pressure due to surface tension). The bubbles grows and rise to the surface where they burst and give off the vapour to the atmosphere.

Factors that affect boiling point of a liquid

1. **Pressure**

   Increase in external pressure increases increases the boiling point of a liquid . This because boiling takes place only when external pressure is equals to internal saturated vapour pressure.

   Explain why;

   (i) Cooking takes longer at very high altitudes

   Boiling of liquid occurs when the vapour pressure from boiling liquid equal the atmospheric pressure and atbhigh altitudes atmospheric pressure (external pressure) is low. Therefore, at higher altitudes liquid boil at low boiling point. As a result cooking takes longer at higher altitude than at lower altitudes.

   (ii) Food cooks more quickly using a pressure cooker

   Food cooks more quickly in a pressure cooker because the pressure cooker has a lid that prevents steam from escaping therefore the inter steam pressure from boiling liquid causes the saturated steam (wet steam) to bombard the food

2. **Impurities**

   Addition of impurities like salt raises the boiling point of a liquid

Differences between evaporation and boiling

- ➢ Boiling occurs through out the volume of the liquid while evaporation occurs at the surface.
- ➢ A liquid boils at single temp for any given external pressure whereas evaporation occurs at any temperature.

Question: Explain why at a given external pressure a liquid boils at a constant temp.

Solution

A liquid boils when it's saturated vapour pressure is equal to the external pressure. But since the saturated vapour pressure is dependent on the temp of the liquid, then it implies that for a given external pressure the boiling will occur at a constant temperature.

Question: Explain why the temperature of a liquid does not change when the liquid is boiling.

Solution

At boiling point all the heat supplied is used in increasing the potential energy of the molecules by increasing their distances of separation as they change from liquid phase to the gaseous phase and also in doing work against external atmospheric pressure during expansion. So there is no change in the kinetic energy of the liquid molecules therefore the temperature of the liquid remains constant

FREEZING AND MELTING POINT

Freezing point is the temperature at which a substance changes from liquid state to solid state

Melting point is the temperature at which a substance changes from sold to liquid state

Factors that affect freezing point

(i) Pressure:

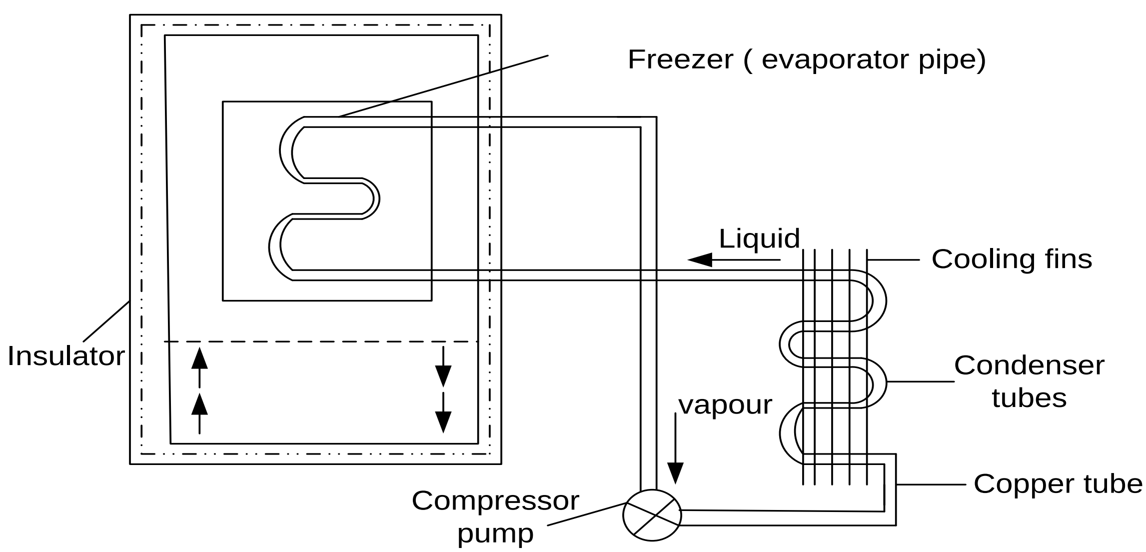
Increasing pressure lowers the freezing point and melting point of a substance

(ii) Impurities

Addition of impurities like salt lowers the freezing and melting point of a liquid

REFRIGERATOR

In a refrigerator heat is taken in at one place and given out at another by refrigerating substance as it is pumped round a circuit.



Mode of operation

- The coiled copper pipe round the freezer contains a highly volatile liquid and as it enters the. This evaporates and takes latent heat from the refrigerator content so causing cooling

- The vapour formed formed is compressed into a liquid and heat is taken to the tube by conduction and lost through the cooling fins by convection and radiation. The liquid returns to the coils round the freezer and the cycle is repeated.

Function of parts

(i) Compressor pump

This removes the vapour formed in the freezer and forces the vapour to condenser tube.

(ii) Condenser tube (heat exchanger)

This where the vapour is compressed and liquefies giving out latent heat of vapourisation to the surrounding air

(iii) Cooling fins

These gives out latent heat of vaporization to the surrounding air. They are painted black because black surfaces are good emitters of heat radiations

(iv) **Insulators**

This prevents the heat exchange between the inside and outside of the refrigerator.

(V) **Evaporator pipe**

This cools the liquid by evaporating volatile liquid under reduced pressure in the pipe

SECTIONA

1. The amount of heat absorbed by a body of mass 2 kg at constant temperature is called

   A. latent heat B. heat capacity C. specific latent heat D. specific heat capacity

2. The lowest possible temperature on Kelvin scale is called the

   A. Ice-point B. Steam point C. Absolute zero D. Dew-point

3. A heater rated 100 W melts 17.9 g of ice every minute. Find the specific latent heat of fusion of ice

   A. $\frac{1000\ x\ 1\ x\ 100}{17.9}$ B. $\frac{100\ x\ 60\ x\ 1000}{17.9}$ C. $\frac{100\ x\ 1000}{17.9\ x\ 60}$ D. $\frac{17.9\ x\ 1000}{100\ x\ 1}$

4. A heater rated 240V, 500W boils off water at 100°C in 6 minutes. Find the mass of the steam formed. (specific latent heat of vaporization of water is $2.26\ x\ 10^6\ J\ kg^{-1}$)

   A. $\frac{6\ x\ 60\ x\ 2.26\ x10^6}{500}kg$ B. $\frac{500\ x\ 2.26\ x10^6}{6x60}\ kg$ C. $\frac{6\ x\ 2.26x\ 10^6}{500}\ kg$ D. $\frac{500x\ 6\ x60}{2.26\ x\ 10^6}\ kg$

5. The rate of evaporation of a liquid increases when

   (i) temperature increases

   (ii) pressure increases

   (iii) its surface area increases

   A. (i) and (ii) only B. (i) and (iii) only C. (ii) and (iii) only D. (i), (ii) and (iii)

6. A mass of 800 g of molten metal at 1200°C gives out $4\ x\ 10^5 J$ of heat on solidification. Find the specific latent heat of fusion of the metal

   A. $3.3\ x\ 10^2 Jkg^{-1}$ B. $2.7\ x\ 10^5 Jkg^{-1}$ C. $5.0\ x\ 10^5 Jkg^{-1}$ D. $6.0\ x\ 10^5 Jkg^{-1}$

7. The specific heat capacity of a substance is the quantity of heat

   A. needed to change 1 kg mass from solid to liquid

   B. needed to change 1 kg mass from liquid to gas

   C. needed to change the temperature of 1 kg mass by 1 K

   D. given out when 1 kg mass changes from liquid to solid

8. A given mass of gas occupies a volume of 200 cm^3 at a temperature of 27°C and a pressure of one atmosphere. Find the volume when its temperature rises to 54°C at constant temperature

   A. $\frac{200\ x\ 1\ x\ 327}{300}$ B. $\frac{300\ x\ 327}{200\ x\ 1}$ C. $\frac{200\ x300}{327\ x\ 1}$ D. $\frac{327\ x\ 1}{200\ x\ 300}$

9. The specific heat capacity of a substance is the amount of

   A. heat required to raise it through 1°C

   B. heat required to raise the temperature of 1 kg mass of the substance through 1°C

   C. heat required to change 1 kg mass of the substance into liquid at the same temperature

   D. heat required to raise its temperature a specific number of degrees.

10. Calculate the amount of heat required to change 100 g of water at 100°C to steam at 100°C [specific heat capacity of steam = $2.26x\ 10^6\ J\ kg^{-1}$]

    A. $2.26x\ 10^8\ J$ B. $2.26x\ 10^7\ J$ C. $2.26x\ 10^5 J$ D. $2.26x\ 10\ J$

11. The amount of heat required to raise the temperature of 0.5 kg of salt solution from -5°C to 15°C is (specific heat capacity of salt solution is 4000 J k$g^{-1}K^{-1}$)

    A. 8000 J B. 20,000 J C. 40,000 J D. 160,000 J

12. A 100 g quantity of water at 24 °C is added to 50 g of water at 36 °C. The final temperature of the mixture is

    A. 28°C B. 32°C C. 30°C D. 34°C

13. The volume of a fixed mass of gas at 27.0°C and a pressure of 750 mm of mercury is 300 cm^3. What is its volume when the pressure is raised to 900 mm of mercury and the temperature is 327°C

    A. 125 cm^3 B. 180cm^3 C. 500cm^3 D. 720cm^3

14. The amount of heat required to raise the temperature of 0.5 kg of iron from 25°C to 50°C is (specific heat capacity of iron is 460 J k$g^{-1}\ K^{-1}$)

    A. $\frac{0.5\ x\ 460}{25}$ **B.** $\frac{460\ x\ 25}{0.5}$ **C.** $\mathbf{0.5\ x\ 460\ x\ 25}$ **D.** $\frac{0.5\ x\ 25}{460}$

15. A block of lead of mass 1000 g hits a hard surface without rebounding with a velocity of 23 m/s. If its temperature rises from 25°C to 27°C, calculate the specific heat capacity of lead

A. 5.75 J kg^{-1}°C^{-1} B. 9.79 J kg^{-1}°C^{-1} C. 132.25 J kg^{-1}°C^{-1} D. 264.5 J kg^{-1}°C^{-1}

16. 450 g of water at 60 °C is to be cooled to 35°C by addition of cold water at 20°C. . How much cold water is to be added.

A. 0.169 kg B. 0.270 kg C. 0.281 kg D. 0.75 kg

17. Calculate the time required for a kettle taking 10A from a 240V supply, to heat 5 kg of water through 80°C. Assuming no heat loss.

A. 700s B. 292 s C. 8.8 s D. 1.7 s

18. When 1 kg of a certain liquid is heated for 10 s its temperature rises by 25°C, if the power supplied is 1000W, find the specific heat capacity of the liquid.

A. 40 J $kg^{-1}K^{-1}$ B. 400 J $kg^{-1}K^{-1}$ C. 1000 J $kg^{-1}K^{-1}$ D. 2500 J $kg^{-1}K^{-1}$

SECTION B .

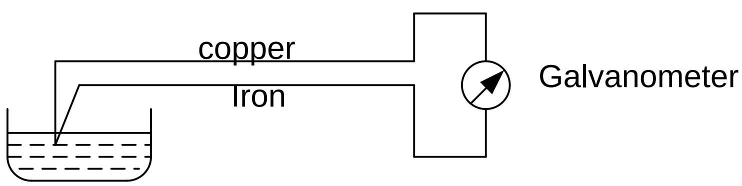
1. (a) What is meant by **heat capacity**

(b) State two thermal quantities of a substance that can be measured in the laboratory

(c) Calculate the amount of heat needed to raise the temperature of a metal of mass 4 kg through 10°C if the specific heat capacity of the metal is 390 J kg K^{-1}

2. (a) What is meant by temperature of a body?

(b) Diagram below shows a thermometer



(i) Name the type of thermometer

(ii) State the physical property it uses to measure temperature

(iii) What is the use of the galvanometer?

3. (a) What is meant by **absolute zero temperature?**

(b) A sealed flask contains gas at a temperature of 27°C and a pressure of 90 k Pa. If the temperature rises to 127°C what will be new pressure

4. (a) What is meant by **specific latent heat of vaporization**

(b)

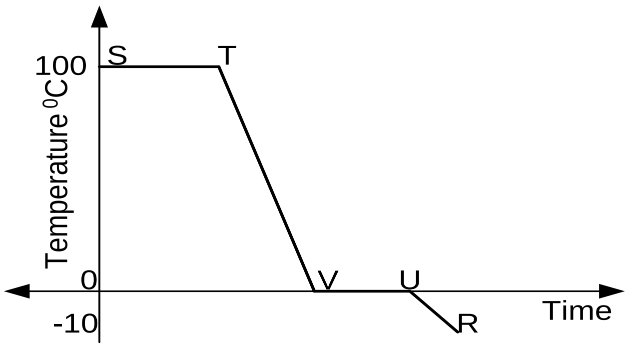


Figure above represents a cooling curve of steam. State what takes place over regions

(c) Why is a burn from steam is more harmful than one due to boiling water?

5. (a) What is meant by boiling point of a liquid

(b) Why is cooking faster with a pressure cooker

(c) State two differences between boiling and evapourization

6. (a) Sketch a graph of volume against absolute temperature for a gas which obeys Charles' law

(b) The volume of a gas is 58 cm^3 at a temperature of 290 K and a pressure of 8.0 x 10^4 Pa. Find the volume of the gas at s.t.p [standard pressure = 1.01x 10^5Pa]

7. **(a)** State **Boyle's law**

(b) A volume of fixed mass of a gas increases from 300 cm^3 to 500 cm^3 at a constant temperature. Find the new pressure if the initial pressure is 70 cm Hg

8. (a) What is meant by specific latent heat vaporization?

(b) State two factors which affect the boiling point of water

(c) Calculate the heat required to convert 0.8 kg of water at 100°C to steam [specific latent heat of vaporization of water =2.26x 10^6 Jkg^{-1}]

9. (a) Name any two physical properties which change with temperature

(b) Convert a temperature of 25°C to kelvin

(c) Explain why evaporation causes cooling

10. (a)

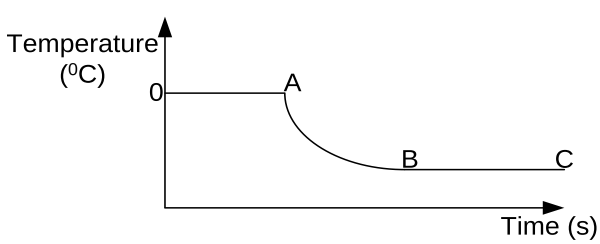


Diagram above shows temperature versus time curve for a liquid. State what is happening along BC

(b) Use the kinetic theory of matter to explain what is along OA

11. (a) Sketch the variation of volume with temperature in kelvin, for a gas at constant pressure

(b) State any two advantages of mercury as thermometric substance.

(c) What is **a saturated vapour?**

12. (a) What is meant **specific latent capacity** of a substance

(b) When a block of iron of mass 2 kg absorbs 19 kJ of heat, its temperature rises by 10°C. Find the specific heat capacity of the iron

13. (a) The specific heat capacity of water is 4200 J$kg^{-1}K^{-1}$. What is meant by the above statement

(b) State two reasons why water is used in the cooling system of a car engine

PAPER TWO TYPE

1. (a) Define **specific latent heat of vaporization of** a substance

(b) (i) A calorimeter of mass 20g and specific heat capacity 800 $J\ kg^{-1}K^{-1}$ contains 500 g of water at 30 °C. Dry steam at 100°C is passed through the water in the calorimeter until the temperature of water rises to 70°C. If the specific latent heat of vaporization of water is 2260000 $J\ kg^{-1}$, calculate the mass of steam condensed

(ii) Water initially at 25°C was heated. Sketch a graph to show how its temperature varies with time

(c) Describe briefly one application of evaporation

2. (a) Distinguish between **specific heat capacity** and **heat capacity**

(b) Explain how a hot object standing on a metallic table on the surface of the moon loses heat

(c) Outline the steps and precautions needed in measuring the specific heat capacity of a liquid by method of mixtures

(d) The 0°C and 100°C marks on a liquid- glass thermometer are 10 cm apart. What would be the temperature if the liquid fell 2 cm below the 0°C mark?

3. (a) What is the **absolute zero of temperature**

(b) Explain, using the kinetic theory, why the pressure of air inside a car tyre increases on a hot day

(c) Describe with the aid of a labelled diagram an experiment to investigate the effect of temperature on the volume of a fixed mass of gas at constant pressure

(d) The same quantity of heat was supplied to 5.0 kg of sea water and 12.0 kg methylated spirit. The temperature rise was 3.0°C and 2.0°C respectively. Find the ratio of the specific heat capacity of sea water to that of methylated spirit

4. (a) What is the **absolute zero of temperature**

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5. (a) (i) Define latent heat of fusion

(ii) Describe with aid of a labelled diagram, an experiment to show the effect of increase in pressure on the melting point of ice

(iii) If the melting of point of lead is 327°C, find the amount of heat required to melt 200 g of lead initially at 27°C. [specific heat capacity of lead is 140 J$kg^{-1}K^{-1}$, specific latent heat of fusion of lead is $2.7\ x\ 10^5$J kg^{-1}]

(b) What is meant by the terms;

(i) temperature, (ii) heat?

(c) The fundamental interval of mercury in glass is 192mm. Find the temperature in degrees celcius when the mercury thread is 67.2mm long

(d) State two physical properties which change with temperature.

6. (a) Define **specific latent heat of vaporization of** a substance

(b) A calorimeter of mass 35.0 g and specific heat capacity 840 $J\ kg^{-1}K^{-1}$ contains 143.0 g of water at 7 °C. Dry steam at 100°C is bubbled through the water in the calorimeter until the temperature of water rises to 29°C. If the mass of steam condensed is 5.6 g,

(i) calculate the heat gained by the water and calorimeter

(ii) obtain an expression for the heat lost by the steam in condensing at 100°C and in cooling 29°C.

(iii) find the specific latent heat of vaporization of water

(c) Explain, in terms of molecules, what is meant by saturated vapour.

7. (a) What is an equation of state of a gas

(b) (i) With the aid of a sketch graph, describe how absolute zero of temperature can be defined

(ii) Use the kinetic theory of gases to explain the existence of absolute zero of temperature

(c) A volume of 2500 cm^3 of hydrogen gas is collected at 67°C at a pressure of 730 mm Hg.

Calculate the volume of the gas at s.t.p

(d) Smoke is confined in a smoke cell and observe through a microscope. Explain what is observed when the temperature of the smoke cell is raised.

8. (a) With the aid of a labelled diagram, describe an experiment to show how the volume of a gas varies with pressure at constant temperature.

(b) A gas of volume 1000 cm^3 at a pressure of $4 \, x \, 10^5$ Pa and temperature 17°C is heated to 89.5 °C at constant pressure. Find the new volume of the gas.

(c) A balloon is filled with 50 cm^3 of hydrogen and tied to the ground. The balloon alone, and the container which it carries have a mass of 2.0 kg. If the densities of hydrogen and air are $9.0 \, x \, 10^{-2} \, kg \, m^{-3}$ and $1.29 kg \, m^{-3}$ respectively, how much load can the balloon lift when released?

9. (a) What is meant by **specific latent heat of vaporization**

(b) With the aid of a labelled diagram describe how a refrigerator works

(c) The cooling system of a refrigerator extracts 0.7 kW of heat. How long will it take to convert 500 g of water at 20°C into ice

(d) Explain how evaporation takes place

10. (a) Define **specific latent heat of vaporization of** a substance

(b) Describe an experiment to determine the specific latent heat of vaporization of steam

(c) A copper container of heat capacity 60 $J \, kg^{-1}$ contains 0.5 kg of water at 20 °C. Dry steam is passed into the water in the calorimeter until the temperature of water rises to 50°C. Calculate the mass of steam condensed

(d) (i) What is meant by saturated vapour pressure

(ii) Explain what may happen when one is to cook food from a very high altitude

DENSITY AND RELATIVE DENSITY

Density of a substance is defined as the mass per unit volume of a substance.

$$\rho = \frac{m}{v}$$

S.I unit's kgm^{-3}

Relative density

Definition

It is the ratio of the density of a substance to density of an equal volume of water at 4^{0}c

It is at 4^{0}c because water has maximum density of 1000kgm^{-3} at that temperature

$$R.D = \frac{density\ of\ asubstance}{density\ of\ water\ at\ 4°C} \qquad R.D = \frac{m_s/v_s}{m_w/v_s} \qquad R.D = \frac{m_s}{m_w}$$

It can also be defined as the ratio of the mass of a substance to mass of an equal volume of water

$R.D = \frac{m_s}{m_w}$ for $\qquad \frac{w_s/g}{w_w/g} \qquad$ R.D = $\frac{w_s}{w_w}$

W = mg

It can also be defined as the ratio of weight of a substance to weight of an equal volume of water.

Note: Relative density has no units.

ARCHIMEDE'S PRINCIPLE

It states that when a body is wholly or partially immersed in a fluid, it experiences an up thrust equals to the weight of the fluid displaced.

I.e. Up thrust = weight of fluid = apparent loss of weight of the object in a fluid.

Definition

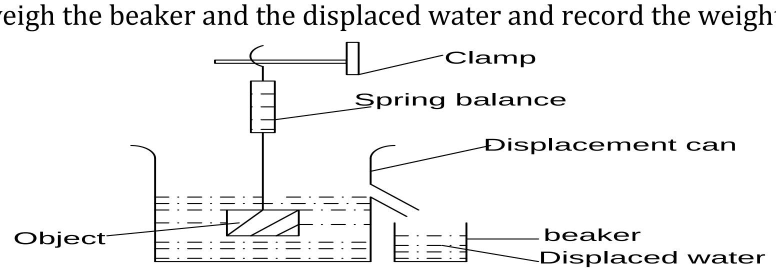
Up thrust is the apparent loss of weight of an object immersed in a fluid

Or

It is the resultant upward force on the body due to the fluid.

Verification of Archimedes's principle using a spring balance.

- Fill the displacement can with water till water flows through the spout and wait until the water stops dripping.
- Weigh a solid object in air using a spring balance and record its weight W_a
- Place a beaker of known weight beneath the spout of the can.
- With the help of the spring balance, the solid object is carefully lowered into the water in the displacement can and wait until water stops dripping when it is completely immersed, its weight (apparent weight) is then read and recorded from the spring balance as W_w.
- Re weigh the beaker and the displaced water and record the weight as $W_{(b+w)}$



Results

Let the weight of the empty beaker be W_b

Weight of water displaced = weight of (beaker +water) – weight of beaker

Weight of water displaced = $W_{(b+w)} - W_b$……………………….1

Apparent loss of weight of object = weight of object in air – weight of object in water

Apparent loss of weight of the object = W_a - W_w

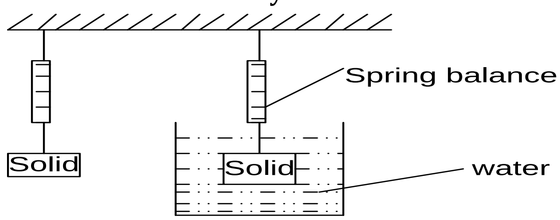
If (W_a - W_w) = ($W_{(b+w)} - W_b$), then Archimedes's principle is verified

Application of Archimedes's principle

It can be used to determine density and relative density of a solid and a liquid.

a) **Determination of density and relative density of a solid**

- Weigh the solid in air and its weight (W_a) recorded using a spring balance.
- Immerse the solid wholly in water and record its apparent weight from balance (W_w)



- Up thrust in water = W_a - W_w
- $R.D = \frac{Weight\ of\ a\ substance}{Up\ thrust\ in\ water}$
- $R.D = \frac{W_a}{W_a - W_w}$
- Density of solid = RD of solid x density of water

Example

1. An object suspended from the spring balance is found to have a weight of 4.92N in air and 3.87N when immersed in water. Calculate the density of the material from which the object is made of the density of water is 1000kgm^{-3}

Solution

W_a = 4.92, W_w = 3.87N

$$R.D = \frac{W_a}{W_a - W_w}$$

$$R.D = \frac{4.92}{4.92 - 3.87}$$

RD = 4.686

Density of substance = RD x ρ of water

= 4.686 x 1000

= 4686kgm^{-3}

Exercise :

1. A piece of glass weighs 0.5N in air and 0.30N in water. Find the density of the glass. **An[2500kgm^{-3}]**
2. A glass block weighs 25N in air. When wholly immersed in water, the block weighs 15N. calculate

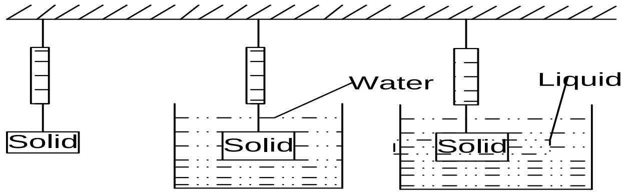
i. The up thrust on the block

ii. The density of the glass in kgm^{-3} **[ans 10N, 2500kgm^{-3}]**

b) **Determination of density and relative density of a liquid**

- Weigh a solid (sinker) in air and record its weight W_a using a spring balance.
- Immerse the solid (sinker) wholly in water and record the apparent weight W_w

- Wipe the surface of the solid (sinker) with a piece of dry cloth and immerse it wholly in the liquid whose relative density is to be measured, read and record its apparent weight in the liquid W_L



Weight of water displaced (up thrust in water) = W_a - W_w
Weight of liquid displaced (up thrust in liquid) = W_a - W_L
Relative density = $\frac{upthrust\ in\ Liquid}{upthrus\ in\ water}$

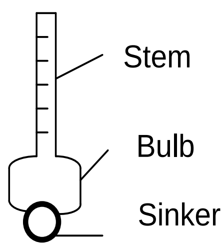
- $R.D\ of\ the\ liquid\ = \frac{W_a - W_L}{W_a - W_w}$

Density of liquid = R.D of liquid x density of water

HYDROMETER

A hydrometer is an instrument used to measure relative density of liquids.

It consists of stem, bulb and sinker.



Stem – Carries the scale

Bulb – Increases the buoyancy

Sinker – Enables the hydrometer to float vertically

A hydrometer is placed in a liquid whose R.D is required and the scale read at the level of the liquid surface.

A hydrometer floats deeper in a lighter liquid than in a liquid of high density.

Uses of a hydrometer

(i) Car hydrometer ; used to test the R.D of a car battery

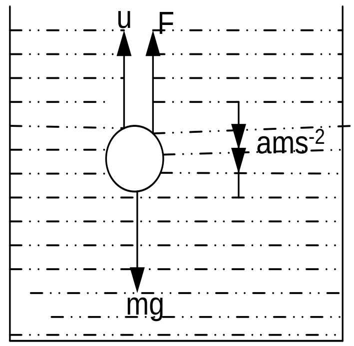
(ii) Lactometer : used to test the purity of milk

Terminal velocity

Terminal velocity is the maximum constant speed attained by a body falling through a fluid

Consider a sphere falling from rest through a viscous fluid.

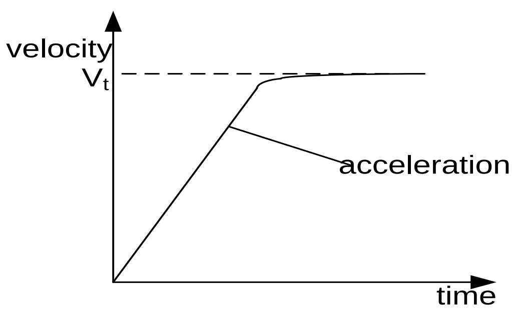
- The forces acting on the sphere are its weight (mg), up thrust due to the displaced fluid and the viscous drag, F.
- Initially the downward force mg is greater than the upward force(U + F) and the sphere increases so too does the viscous drag and eventually U+F becomes equal to mg.
- The sphere continues to move downwards but because there is now no net force acting on it. Its velocity has a constant maximum value known as ***terminal velocity***.



At the terminal velocity

Mg = U + F…………………………..(1)

A graph of velocity against time for an object falling in a fluid



Revision questions: Section A

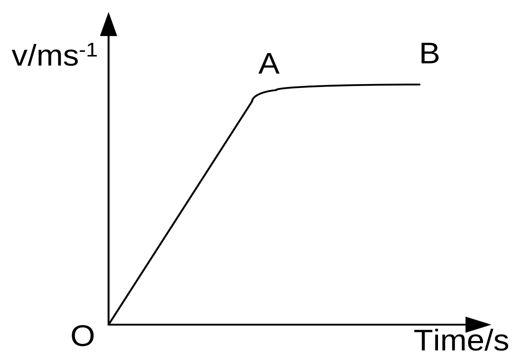
1) A parachute released from an aero plane will fall with a constant velocity when
   A. Its weight is equal to the up thrust
   B. Its weight is equal to the air resistance
   C. Air resistance is equal to the up thrust
   D. The up thrust plus the air resistance are equal to its weight

2) When a balloon filled hydrogen is released into the air on a calm day, it
   A. Rises to definite height when the pressure inside and outside are equal
   B. Rises until the pressure inside reduces to zero
   C. Rises for a while and then bursts
   D. Comes to the ground and darts around.

3) When a metal sphere is dropped in a viscous fluid, it eventually attains a steady velocity called

A. Turbulence velocity
B. Terminal velocity
C. Viscous velocity
D. Streamline velocity

4) The graph below shows a velocity- time graph for a moving body



Which of the following statements is true about the motion?

A. Velocity of the body is constant between O and A
B. Velocity of the body is constant between A and B
C. The body is accelerating between A and B
D. The body is not accelerating between O and A

5) Which of the following statements are true about hydrometer?

(i) It measures density of a liquid
(ii) Its sensitivity is improved by narrowing its stem
(iii) Its reading increases upwards on the stem
(iv) Its buoyancy is provided by the large bulb

A. (i) (ii) and (iii)
B. (ii) (iii) and (iv)
C. (i) (ii) and (iv)
D. (ii) and (iv) only

6) A hollow glass sphere of mass $60g$ floats in water such that two-thirds of its volume is under water of density$g\ cm^{-3}$. Find the volume in cm^3 of the sphere.

A. 20 B. 40 C. 60 D. 90

7) When an inflated balloon is released in air with its neck open, it will

A. Rise up
B. Drop to the ground instantly
C. Move in the opposite direction to the escaping air
D. Remain in one position

Section: B

8) (a) (i) What is meant by terminal velocity

(ii) State a factor that affects terminal velocity of a body falling in a fluid

(b) A ball bearing is released at the surface of a viscous liquid and allowed to sink through the liquid. Draw a velocity- time graph for the motion of the ball bearing.

9) (a) state

(i) Archimedes' principle

(ii) The law of floatation

(b) When a metal is completely immersed in a liquid A, its apparent weight is 20N . When its immersed in another liquid B , the apparent weight is 16N. If the density of B is $\frac{9}{8}$ times that of A, calculate the mass of the metal.

10) A balloon filled with $50m^3$ of hydrogen weighs 40kg. the balloon is held in place by a rope fixed to the ground. If the density of air is 1.2kgm^{-3}, find

a. The up thrust on the balloon

b. The force needed to hold the balloon in place

(density of hydrogen = 0.089kgm^{-3},)

11) **(**a) (i) state Archimedes' principle

(ii) Describe an experiment to verify the law of floatation

(iii) Give one example where the law of floatation is applied

(b) (i) Define density

(ii) A piece of glass weighs 0.50N in air and 0.30N in water. Find the density of the glass

12) (a) State the following :

(i) Archimede's principle

(ii) The law of floatation

(a) A wooden sphere of mass 6kg and volume $0.02m^3$ floats on water. Calculate the;

(i) Volume of the sphere below the surface of water

(ii) Density of the wood

(iii) Fraction of the volume of the sphere that would be submerged if it floats in a liquid of density $800kgm^{-3}$

(b) Explain why a cork stopper held below the surface of water rises when released.

(c) Describe an experiment to measure atmospheric pressure.

13) (a) Define density and state it S.I units

(b) With the aid of a labeled diagram, describe the motion of a ball bearing which is dropped centrally into a tall jar containing oil.

(c) (i) State Archimedes' principle

(ii) A n object weighs 30N in air and 20N when immersed in water of density $1000kgm^{-3}$. If the same object weighs 22N when immersed in methylated spirit, what is the density of the spirit?

(d) Explain why a ship is able to float on water in spite of being made of metal.

14) (a) State Archimedes' principle

(b) (i) Describe an experiment to verify the law of floatation.

(ii) Give one example where the law of floatation is applied

(b) (i) Define density

(ii) A piece of glass weighs 0.5N in air and 0.30N in water. Find the density of glass

15) (a) State Archimedes' principle

(b) A rubber balloon of mass $5x10^{-3}$kg is inflated with hydrogen and held stationary by means of a string. If the volume of the inflated balloon is $5x10^{-3}m^3$, calculate the tension in the string.(Density of hydrogen=0.080kgm^{-3}, Density of air=1.150kgm^{-3})