Thermometry

1. Public Health and Fever Diagnosis
   A community health center in a remote area lacks digital thermometers. Instead, they use liquid-in-glass thermometers. However, during a malaria outbreak, many patients show high fevers, and accurate temperature readings become crucial for treatment.

   (a) Explain how a liquid-in-glass thermometer functions and its thermometric property.

   (b) Discuss the limitations of using this thermometer in a high-patient flow setting and suggest an alternative.

2. Industrial Temperature Control
   A dairy processing plant needs to pasteurize milk by heating it to 72°C and holding it at this temperature for 15 seconds. Workers rely on a platinum resistance thermometer for accurate temperature measurement.

   (a) Describe how the platinum resistance thermometer works in monitoring the temperature.

   (b) Explain why a constant-volume gas thermometer would not be suitable for this process.

3. Fire Safety and Temperature Measurement
   A fire department is testing a new fire-resistant suit for firefighters. They need to measure the temperature inside the suit when exposed to a fire of 800°C.

   (a) Identify a suitable thermometer for this application and justify your choice.

   (b) Explain how the selected thermometer operates and how it withstands high temperatures.

4. Climate Change and Environmental Monitoring
   Scientists studying climate change need to record air temperature in a desert where temperatures range from -5°C at night to 50°C during the day.

   (a) Which type of thermometer would be best suited for this purpose? Explain your choice.

   (b) Discuss how different thermometric properties may lead to discrepancies in readings when using different thermometer types.

5. Energy Efficiency in Homes
   A homeowner wants to reduce energy consumption by adjusting their air conditioning system efficiently. They need a highly sensitive thermometer to monitor room temperature changes.

   (a) Compare the effectiveness of a thermocouple thermometer and a resistance thermometer for this purpose.

   (b) Suggest a practical solution for automating the air conditioning system using temperature sensors.

6. Food Storage and Preservation
   A grocery store uses a refrigeration system to store perishable food items at 4°C. However, power outages frequently occur, and the store manager needs to determine how long food can remain safe at higher temperatures.

   (a) Explain the role of a thermometric property in monitoring temperature changes during a power outage.

   (b) How can the concept of heat transfer be applied to improve food preservation during power outages?

7. Medical and Industrial Use of Thermocouples
   A pharmaceutical company manufactures vaccines that must be stored at -70°C. They use thermocouple thermometers to monitor storage temperatures.

   (a) Explain the principle of operation of a thermocouple thermometer.

   (b) Discuss why a liquid-in-glass thermometer would not be suitable for this application.

Calorimetry

1. Heat Energy in Cooking (Specific Heat Capacity)
   A chef wants to heat **2 litres of soup** in an aluminium pot over a gas stove. He notices that using a **copper pot** heats the soup faster than the aluminium pot.

   (a) Explain how the specific heat capacity of the pot material affects the heating process.

   (b) Which pot is more energy-efficient for heating the soup? Justify your answer with calculations.

2. Cooling and Climate Adaptation (Latent Heat of Fusion)
   A community in an arid region stores **ice blocks** in underground coolers to preserve vegetables. During the hottest part of the day, the ice melts completely.

   (a) Explain how the **latent heat of fusion** plays a role in keeping the vegetables cool.

   (b) If **20 kg of ice at 0°C** is used, how much heat is absorbed before it completely melts? (Assume **latent heat of fusion of ice = 3.34×10^5 J/kg**).

3. Firefighting and Heat Absorption (Specific Heat Capacity of Water)
   A **firefighter** sprays **water** on a burning wooden house to control the fire. Water is preferred because it absorbs large amounts of heat before evaporating.

   (a) Explain why **water is more effective** than other liquids for absorbing heat.

   (b) Calculate the **heat energy absorbed** by **100 litres of water** when its temperature rises from **20°C to 100°C**. (**Specific heat capacity of water = 4200 J/kg·K**)

4. Energy Use in Water Heating Systems (Specific Heat Capacity and Latent Heat of Vaporization)
   A **solar water heater** is used in a household where water enters at **20°C** and is heated to **60°C** before use.

   (a) Calculate the **energy required** to heat **50 kg** of water to this temperature. (**Specific heat capacity of water = 4200 J/kg·K**)

   (b) If a gas boiler is used instead, which **produces steam at 100°C**, explain why **boiling water before use would require additional energy**.

5. Steam Power Plants and Efficiency (Latent Heat of Vaporization)
   In a **steam power plant**, water is heated to steam at **100°C** and used to turn turbines before being condensed back to water.

   (a) Explain why **steam has more energy** than hot water at the same temperature.

   (b) Calculate the **energy required** to convert **1 kg of water at 100°C** into steam. (**Latent heat of vaporization of water = 2.26×10^6 J/kg**)

6. Winter Survival Strategies (Latent Heat of Fusion and Specific Heat Capacity)
   In **cold climates**, people **heat bricks or stones** and place them in beds to stay warm overnight.

   (a) Explain why materials with a **high specific heat capacity** are better for this purpose.

(b) A **5 kg stone** at **90°C** is used to warm a bed. If its **specific heat capacity** is **900 J/kg·K**, calculate the **heat released** as it cools to **30°C**.

7. Ice Preservation in Transportation (Latent Heat of Fusion)
   A **fish vendor** transports fresh fish in **ice boxes** over long distances. The ice helps maintain low temperatures even after the electricity in the cooler fails.

   (a) Explain how **latent heat of fusion** helps maintain the freshness of the fish.

   (b) If **15 kg of ice at 0°C** melts during the trip, calculate the **heat absorbed** by the ice. (**Latent heat of fusion of ice = 3.34×10^5 J/kg**)

8. Food Industry and Pasteurization (Specific Heat Capacity and Latent Heat of Vaporization)
   A dairy company **pasteurizes milk** by heating it to **72°C** and then cooling it rapidly. The process requires precise heat control.

   (a) Explain how **calorimetry** principles apply in this process.

   (b) If **30 litres of milk** (density = **1 kg/L**) is heated from **20°C to 72°C**, calculate the **energy required**. (**Specific heat capacity of milk ≈ 3900 J/kg·K**)

Photoelectric Emission

1. Solar Panel Efficiency in Rural Areas
   A village in Uganda installs solar panels for electricity. However, they notice that power generation is affected on cloudy days.

   (a) Explain how the **photoelectric effect** relates to the operation of solar panels.

   (b) Discuss why increasing **light intensity** affects the **current** but not the **voltage** of a solar panel.

2. Automatic Doors and Security Systems
   Supermarkets use **photoelectric sensors** for automatic doors. The doors open when a person approaches and blocks a light beam.

   (a) Explain how **photoelectric cells** detect the presence of a person.

   (b) Why does **infrared light** not trigger the same effect as ultraviolet light in some systems?

3. Digital Cameras and Image Sensors
   A digital camera uses a **photoelectric sensor** to capture images by converting light into an electronic signal.

(a) Explain how the **photoelectric effect** is applied in digital cameras.

(b) Discuss how the energy of emitted electrons depends on **frequency** rather than **intensity** of light.

Nuclear Structure

1. Medical Use of Radioisotopes in Cancer Treatment
   A hospital uses **Cobalt-60** to treat cancer by emitting **gamma radiation** to destroy cancer cells.

   (a) Explain why **gamma rays** are used for this purpose.

   (b) How does the **half-life** of Cobalt-60 affect the frequency of hospital equipment replacement?

2. Nuclear Power and Energy Crisis
   Some countries rely on **nuclear fission** for electricity. However, nuclear power plants require **fuel rods** made of **Uranium-235**.

   (a) Explain how **nuclear fission** produces energy.

   (b) Discuss the risks of **nuclear waste disposal** and possible solutions.

3. Carbon-14 Dating in Archaeology
   A museum wants to determine the age of an ancient artifact using **radiocarbon dating**.

   (a) Explain how the **radioactive decay of Carbon-14** helps in estimating the artifact's age.

   (b) Given that the **half-life of Carbon-14** is **5730 years**, how much of an original sample remains after **17,190 years**?

Kinetic Theory of Gases

1. Cooking with Gas: Why Gas Expands in a Cylinder
   A gas cylinder at home gets cold after continuous use.

   (a) Use the **kinetic theory of gases** to explain why gas expansion causes cooling.

   (b) Apply **Boyle's Law** to explain why gas pressure decreases when the cylinder is nearly empty.

2. Tire Pressure in Changing Weather
   A motorcyclist notices that **tire pressure increases** on a hot day.

   (a) Use **Charles's Law** to explain why tire pressure increases.

(b) Why do tires sometimes burst in extremely hot conditions?

3. Air Conditioning and Cooling Effect
   Air conditioners work by compressing and expanding a **refrigerant gas** to cool a room.

   (a) Explain how **kinetic theory** accounts for the cooling effect when gas expands.

   (b) Why does increasing the **molecular speed** of gas particles affect temperature?

Thermodynamics

1. Efficient Car Engines and Heat Transfer
   Engineers design car engines to maximize fuel efficiency. However, some of the energy is lost as heat.

   (a) Use the **First Law of Thermodynamics** to explain energy transfer in an engine.

   (b) Discuss how **adiabatic compression** helps increase engine efficiency.

2. Solar Water Heaters and Energy Conservation
   A school installs a **solar water heater** to reduce electricity costs.

   (a) Explain how the **Second Law of Thermodynamics** applies to this heating system.

   (b) How does increasing the **surface area** of the solar panels improve efficiency?

3. Refrigeration and Entropy
   A refrigerator removes heat from food items and expels it into the surrounding air.

   (a) Explain how a **refrigerator** works based on **entropy changes**.

   (b) Why does a refrigerator's **compressor** get hot while cooling food inside?

X-Rays and Applications

1. X-Ray Scanners at Airports
   Airports use **X-ray machines** to scan luggage.

   (a) Explain how **X-rays** are generated in an X-ray tube.

   (b) Why are **dense materials** such as metal more visible in X-ray images?

2. Medical X-Rays and Radiation Exposure
   A hospital uses **X-ray machines** for diagnosing fractures but limits the number of scans per patient.

   (a) Explain how **X-rays penetrate human tissues** to produce images.

(b) Why should frequent X-ray exposure be minimized for patients and technicians?

3. Industrial Use of X-Rays for Material Inspection
   A manufacturing company uses **X-rays** to check for cracks in airplane parts.

   (a) Explain how **X-ray diffraction** helps detect structural defects.

   (b) Why must workers wear **protective shields** when working with X-ray machines?

Radioactivity and Half-Life

1. Handling Radioactive Waste from Nuclear Plants
   A nuclear power station produces **radioactive waste** that needs safe disposal.

   (a) Explain why **some radioactive isotopes remain hazardous** for thousands of years.

   (b) Suggest a practical method for storing nuclear waste safely.

2. Smoke Detectors and Radioactive Decay
   Smoke detectors contain a **small amount of Americium-241**, a radioactive element that emits **alpha particles**.

   (a) Explain how **radioactive decay** is used in smoke detection.

   (b) Why are **alpha particles** safe inside the smoke detector but harmful if inhaled?

3. Effects of Radiation Exposure on Human Health
   Workers in uranium mines are exposed to **ionizing radiation** over long periods.

   (a) Explain how prolonged exposure to **gamma rays** can damage body cells.

   (b) Why do workers wear **radiation badges** and protective suits?

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