SEMINAR QUESTIONS

INORGANIC CHEMISTRY

1. The elements beryllium, magnesium, calcium, strontium and barium belong to group II of the periodic table.
   (a) Write a general outermost electron configuration for the elements.
   (b) The table below shows the variation in first ionisation energy and melting points of group II elements.

Element	Be	Mg	Ca	Sr	Ba
Atomic number	4	12	20	38	56
First ionization energy$(kJmol^{-1})$	899	738	589	549	502
Melting point(K)	1553	923	1123	1043	993

   (i) On the same axes, plot graphs of first ionization energy and melting points of the elements against atomic number.
   (ii) Explain the shapes of each of the graphs in (b)(i) above.
   (c) Describe the reaction of the elements with;
      (i) Water
      (ii) Sulphuric acid
      (iii) hydrochloric acid
      (iv) chlorine
      (v) sodium hydroxide

   (b) Explain the trend in
   (i) Solubility of their hydroxides
   (ii) thermo stability of carbonates
   (c) Write the equation for the reaction between:
   (ii) Beryllium carbide with water
   (ii) calcium carbide with water

(d) Describe the reactions of the oxides and hydroxides of the elements with;

(i) Water

(ii) Sulphuric acid

(iii) Hydrochloric acid

(iv) Sodium hydroxide

(e) State and explain the trend in the melting points of the chlorides of the elements.

(f) Beryllium behaves differently from other elements. Give the reasons for this anomalous behavior and state three chemical properties in which beryllium behaves differently from other elements.

2. Fluorine is in group VII of the periodic table but behaves differently from the rest of the group members.

(a) (i) State three reasons why fluorine behaves anomalously.

(ii) Describe three chemical properties in which fluorine behaves differently from the rest of the group members. Illustrate your answer with equations.

(iii) Sketch a graph of variation of first electron affinity of group VII elements with atomic number and explain the shape of the graph.

(b) The table below shows the hydrides of group VII elements and their boiling points.

Period number	2	3	4	5
Hydride	HF	HCl	HBr	HI
Boiling point(°C)	$+20$	-85	-67	-35

(i) Plot a graph of boiling point against period number.

(ii) Explain the shape of the graph.

(c) Describe briefly how the following hydrides are prepared in the laboratory. *(Illustrate your answers with equations)*

(i) hydrogen chloride

(ii) hydrogen iodide

(d) Discuss the reactions of the hydrides with:

(i) sodium hydroxide

(ii) sulphuric acid

(iii) silicon dioxide

3. (a) (i) State the names and formulae of the two ores from which zinc can be extracted.

(ii) Briefly describe how pure zinc is obtained from any of the ores in (a) (i) above.

(b) Describe the reactions of zinc with;

(i) air

(ii) sulphuric acid

(iii) sodium hydroxide

(c) A few drops of potassium hexacyanoferrate(III) solution were added to zinc sulphate solution.

(i) State what was observed.

(ii) Write equation for the reaction.

4. (a) Write the formula and name of the main ore of aluminium.

(b) Describe how:

(i) the ore is purified

(ii) pure aluminium is obtained from the purified ore.

(c) Describe the reaction of aluminium with:

(i) air

(ii) hydrochloric acid

(iii) sulphuric acid

(iv) sodium hydroxide

(d) State what you will observe and write equations for the reactions that take place when;

(i) sodium carbonate solution is added to an aqueous solution of aluminium sulphate.

(ii) sodium hydroxide solution is added to aqueous aluminium sulphate dropwise until in excess.

5. (a) (i) Define the term an **ore**.

(ii) Write the formula and name of the sulphide ore from which iron can be extracted.

(b) Describe how iron is extracted from the ore in (a) (ii) above.

(c) Describe the reaction of iron with:

(i) water

(ii) chlorine

(iii) sulphuric acid

6. (a) (i) Describe the industrial manufacture of nitric acid starting from nitrogen and hydrogen as raw materials.

(ii) State **two** uses of nitric acid.

(b) State the conditions and write equations for the reaction(s) of nitric acid and:

(i) magnesium

(ii) phosphorus

(iii) Sulphur

ORGANIC CHEMISTRY

7. Write mechanisms for the following reactions

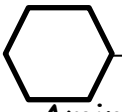
(a) Methylbenzene is heated with aqueous sodium hydroxide solution

(b) Methylbenzene is reacted with chlorine in presence of ultraviolet light.

(c) Coversion of propanal to propanaloxime

(d) Ethanoyl chloride is reacted with propylamine
(e) Warm fuming sulphuric acid and benzene
(f) Propanone is reacted with a saturated solution of sodium hydrogensulphite.
(g) Conversion of benzene to nitrobenzene
(h) Propan-2-ol and ethanoylchloride
(i) 2-methylpropene and chlorine water
(j) 2-chloro-2-methylbutane is heated with sodium ethoxide solution in ethanol
(k) Conversion of 1-chloropropane to propylmethylamine

8. Without using equations, briefly describe how the following conversions can be effected
   (a) Propyne from propan-2-ol
   (b) Phenol from benzene
   (c) Ethanoylchloride from ethane
   (d) Methylphenylamine from benzene
   (e) Methylpropanoate from bromoethane
9. Write equations to show how the following conversions can be effected.

(a)  —CHO from benzenediazonium salt
(b) Aminoethane from propanoic acid
(c) Phenol to cyclohexane-1,2-diol
(d) Butane-1,4-dioic acid from ethene
(e) Propene from ethanal
(f) Ethoxyethane from but-2-ene
(g) Propyne to 2-methylpropanoic acid
(h) Benzoylchloride from ethyne
(i) Ethoxybenzene from methylbenzene

10. A hydrocarbon, ***G***, on complete combustion forms 67.95g of water and 172.58 dm^3 of carbon dioxide gas. When 3.34g of ***G*** was vapourised, it was found to occupy a volume of 790cm^3 at 27^0C at a pressure of 760mmHg.
    (a) Determine the;
        (i) empirical formula of ***G***
        (ii) molecular formula of ***G***.
    (b) ***G*** instantly decolourises a solution of bromine in tetrachloromethane. When ***G*** is refluxed with alkaline manganate(VII) solution and the resultant solution acidified, a white crystalline solid **Q** was formed, which when heated with a mixture of solid sodium hydroxide and calcium hydroxide, a compound ***R*** was formed. ***R*** gives no apparent reaction with bromine until a little iron powder is added to it.
        Identify ***G***, **Q** and ***R***.
    (c) Write equations and outline possible mechanisms for the reaction between bromine and;
        (i) ***G*** in tetrachloromethane
        (ii) ***R*** and a little iron powder.
    (d) Write equations to show how **Q** can be obtained from ***R***
11. (a) A compound **Q** contains 60.0% carbon, 13.3 % hydrogen and the rest being oxygen. Calculate the simplest formula of **Q**.
    (b) when 0.698g of **Q** was dissolved in 100g of a solvent, there was 0.19 °C depression in freezing point of the solution. (K_f of the solvent = 1.63^0C)
    Calculate;
        (i) the molecular formula of **Q**.
        (ii) the molecular formula of **Q**.

(c)Write the names and structural formulae of all possible isomers of **Q**.

(d) When **Q** was reacted with iodine in aqueous sodium hydroxide, a yellow precipitate was formed.

(i) Identify **Q**

(ii) Write equation for the reaction between **Q** and iodine in aqueous sodium hydroxide.

(iii) State what would be observed when Q is reacted with acidified potassium dichromate(VI) solution and name the major organic product.

(e)When **Q** was heated with excess concentrated sulphuric acid, a gas ***W*** which turned the purple solution of acidified manganate(VII) to colourless was evolved. Write equation for the reaction between:

(i) **Q** and sulphuric acid and suggest a mechanism for the reaction.

(ii) ***W*** and acidified manganate(VII) ions and name the product. Suggest a plausible mechanism for the reaction between ***W*** and hydrogen iodide.

12. (a) $1.781g$ of a bromoalkane, **D**, was heated with excess sodium hydroxide solution. The resulting mixture was cooled and acidified with dilute nitric acid and the solution diluted to $100cm^3$. $10.0cm^3$ of this solution required 13.0cm^3 Of 0.1M silver nitrate solution for complete precipitation of bromide ions as silver bromide.

(i) Calculate formula mass of **D**

(ii) Deduce the molecular formula of **D**

(iii) Write the structural formulae and names of all possible isomers of **D**

(b) When **D** was reacted with sodium hydroxide, compound **E** was formed. **E** formed two layers within 10 minutes when shaken with a mixture of concentrated hydrochloric acid and anhydrous zinc chloride.

(i) Identify **D**

(ii) Write the equation and state the conditions for the reaction between **D** and sodium hydroxide.

(c) **E** can be oxidized by chromium trioxide in the presence of concentrated sulphuric acid to give compound **G**, which reacts with iodine in the presence of sodium hydroxide solution. State what would be observed and write the equation for the:

(i) oxidation of **E**

(ii) reaction between **G** and iodine in the presence of sodium hydroxide.

(d) One of the isomers of **D** undergoes a unimolecular reaction when treated with aqueous sodium hydroxide.

(i) Name the isomer

(ii) Write an equation for the reaction in (d) and outline a mechanism for the reaction.

13. (a) Briefly describe how;

(i) a sample of soap can be prepared

(ii) a soapless detergent can be prepared

(ii) Write equation(s) for the reaction leading to the formation of soap

(b) Explain why soap cannot be used effectively in:

(i) hard water

(ii) strongly acidic solution

(c) Write equations to show how alkylbenzenesulphonate can be prepared from octadecan-1-ol, $CH_3(CH_2)_{16}CH_2OH$.

(d) Explain why the following compound are added to soapless detergents:

(i) polyphosphates

(ii) disodium sulphate

PHYSICAL CHEMISTRY

14. (a) Define the terms;

(i) **Relative atomic mass**

(ii) **Relative abundance**

(b) Briefly describe how the relative atomic mass of an element is determined by spectrometry with aid of a well labeled diagram.

(c) The mass spectrum of element **Y** shows four peaks of heights in ratio 2.1 : 4 : 2.2 : 1.6 with isotopic masses 10.692, 11.291, 10.928 and 12.029 a.m.u respectively. Determine the;

(i) relative abundances of the isotopes of **Y**.

(ii) relative atomic mass of **Y**.

15. (a) What is meant by **freezing point constant of a substance?**

(b) (i) Describe an experiment to determine the molecular mass of naphthalene by freezing point depression method. (Diagram not required)

(ii) State four limitations of the method in (b)(i) above.

(c) The freezing points of solutions of various concentrations of naphthalene at 760 mmHg are shown in the table below.

Concentration $(g(1000g)^{-1}\ of\ cyclohexane)$	10	20	30	40	50	60
Freezing point$(°C)$	4.93	3.36	1.79	0.22	-1.35	-2.92

(i) Plot a graph of freezing point against concentration.

(ii) Use your graph to determine the freezing point of pure cyclohexane.

(ii) Determine the slope of the graph and use it to determine the relative molecular mass of naphthalene.

$(K_f\ for\ cyclohexane\ \ is\ 20.1°Ckg^{-1}mol^{-1})$

16. (a) Distinguish between the terms **hydration energy** and **lattice energy**.

(b) Explain briefly how the two energy terms in (a) affect the solubility of ionic compounds.

(c) Given the following thermodynamic data;

Standard enthalpy of formation of aluminium fluoride= $-1301\ kJmol^{-1}$

Enthalpy of atomization of aluminium $= +314\ kJmol^{-1}$

Bond dissociation energy of fluorine $= +158\ kJmol^{-1}$

First ionisation energy of aluminium $= +577\ kJmol^{-1}$

Second ionisation energy of aluminium $= +1820\ kJmol^{-1}$

Third ionisation energy of aluminium $= +2740\ kJmol^{-1}$

First electron affinity of fluorine= $-348\ kJmol^{-1}$

(i) Draw an energy level diagram for the formation of aluminium fluoride

(ii) Calculate the lattice energy of aluminium fluoride

(iii) If the hydration energies of aluminium ions and fluoride ions are 4690 and 364 $kJmol^{-1}$ respectively, calculate the enthalpy of solution of aluminium fluoride.

(d) State and explain **two** factors that affect hydration energy.

17. (a) Define the following terms;

(i) Bond energy

(ii) Standard enthalpy of reaction

(iii) Standard enthalpy of formation

(iv) standard enthalpy of combustion

(b) Describe an experiment to determine heat of combustion of butanol.

(c) Describe an experiment to determine heat of combustion of coke

(d) (i) State **Hess' law**.

(ii) Ammonia reacts with fluorine according to the following equation;

$NH_3(g) + 3F_2(g) \longrightarrow 3HF(g) + NF_3(g)$

Given that the enthalpies of formation of NH_3, HF and NF_3 are -46, -269 and -114 respectively. Calculate the enthalpy change for the above reaction.

(e) The standard enthalpies of combustion of coke, hydrogen and naphthalene ($C_{10}H_8$) are -393, -286 and -515 kJmol^{-1} respectively.

(i) Calculate the standard enthalpy of formation of naphthalene.

(ii) Sketch a potential energy diagram for the formation of naphthalene.

(f) The standard enthalpies of atomisation of hydrogen, chlorine and graphite are 434.7, 246.6 and $714.8\ kJmol^{-1}$ respectively. Calculate the standard enthalpy of formation of chloromethane if the $C-Cl$ and $C-H$ bond energies are 334.4 and $412.6\ kJmol^{-1}$ respectively.

18. (a) Discuss the effect of each of the following factors on the position of the equilibrium and the value of the equilibrium constant for a reversible reaction in a gaseous system.

(i) Temperature

(ii) Pressure

(b) 1 mole of nitrogen and 2 moles of hydrogen were reacted in a 2 litre vessel at 400℃ and 50 atmosphere pressure. At equilibrium, 0.8 moles of ammonia were present.

(i) Write the expressions for the concentration equilibrium constant(K_c) and the pressure equilibrium constant(K_p).

(ii) Determine the values of the equilibrium constants K_c and K_p .State the units in each case.

(c) Ammonia decomposes according to the equation:

$$\boldsymbol{2NH_3(g) \rightleftharpoons 3H_2(g) + N_2(g)}$$

If the degree of dissociation of ammonia is α, derive an expression for K_p in terms of α and the total pressure , p of the system using the stoichiometric equation.

19. (a) State;

(i) Raoult's law

(ii) Limitations of the law.

(b) Benzene and Methylbenzene form a liquid mixture which obeys Raoult's law. The liquid mixture is made by dissolving 55.4g of methylbenzene in 15.8g benzene at 25 °C . The vapour pressures of pure benzene and pure methylbenzene are 1520mmHg and 570mmHg respectively at the same temperature. (Boiling points of benzene and methylbenzene are 180 °C and 110 °C respectively)

Calculate the:

(i) Vapour pressure of the mixture

(ii) Composition of the vapour above the mixture.

(c) Explain why the mixture of benzene and methylbenzene in (b) is ideal.

(d) (i) Sketch a boiling point-composition diagram for the mixture of benzene and methylbenzene in (b) and label it.

(ii) Using the sketch diagram above, describe what happens when a liquid mixture containing 50% benzene is distilled.

20. (a) (i) What is meant by the term **solvent extraction**?

(ii) State **two** limitations of solvent extraction.

(i) State why small proportions are preferred to big volumes during solvent extraction.

(b) A solute Q is three times as soluble in ethoxyethane as in water. An aqueous solution containing 4.5g of Q per litre of solution was shaken with ethoxyethane in a separating funnel. Calculate the mass of Q that is extracted by;

(i) 50.0 cm^3 of ethoxyethane.

(ii) two successive 25.0cm^3 portions of ethoxyethane.

(c) (i) Describe briefly how the formula of the silver complex, $\boldsymbol{Ag(NH_3)_n^+}$ can be determined in the laboratory.

(ii) 25.0 cm^3 of excess ammonia solution was mixed with 25 cm^3 of 0.1M silver nitrate solution. The resultant mixture containing the complex, $\boldsymbol{Ag(NH_3)_n^+}$, was shaken with 50 cm^3 of trichloromethane until the system was allowed to reach equilibrium at room temperature. The aqueous layer required 27.5 cm^3 of 1.0M hydrochloric acid while the organic layer required 18.0 cm^3 of 0.05M hydrochloric acid. Determine the value of n (k_D of ammonia between water trichloromethane is 25.0 at 25 ℃).

21. The table below shows the variation in pH of the solution when $30\ cm^3$ of 0.2M ammonia solution was titrated with hydrochloric acid.

Volume of hydrochloric acid(cm^3)	0	4	8	12	16	19	19.4	19.8	20.2	20.6	21	22	26	28
pH	10.8	9.9	9.4	9.1	8.7	8.0	7.8	7.3	3.9	3.5	3.2	2.9	2.5	2.4

(a) Plot a graph of pH against volume of hydrochloric acid.

(b) Using the graph in (a) to determine the:

(i) pH and volume at endpoint.

(ii) molarity of hydrochloric acid.

(ii) hydrolysis constant of ammonium chloride formed at the endpoint.

(iii) ratio of $[NH_4Cl]:[NH_3]$ when $10\ cm^3$ of hydrochloric acid has been added to ammonia solution.

($K_b = 1.8 \times 10^{-5}\ and\ K_w = 1 \times 10^{-14}\ at\ 25℃$)

22. (a) Explain what is meant by the terms;

(i) Solubility

(ii) Solubility product

(iii) Common ion effect

(b) Describe an experiment to determine the solubility product of silver sulphate.

(c) The solubility of silver sulphate in 0.1M sodium sulphate at 25^0C is $2.0399gdm^{-3}$. Calculate the solubility product of silver sulphate at 25^0C.

(d) State and explain what happens to the solubility of silver sulphate when the following were added to its saturated solution.

(i) Silver nitrate solution

(ii) Ammonia solution

23. (a) Define the terms:

(i) Order of reaction

(ii) Molecularity of a reaction

(iii) Rate constant

(iv) Rate equation

(v) Rate law

(vi) Activation energy

(b) Describe an experiment that can be carried out to show that the reaction between hydrochloric acid and sodium thiosulphate is first order with respect to sodium thiosulphate.

(c) The rate of reaction between ***A*** and ***B*** is $\boldsymbol{ate = k[A][B]^2[C]}$.

The table below shows the kinetics data for the reaction between ***A*** and ***B***.

Experiment number	$[A](\boldsymbol{moldm^{-3}})$	$[B](\boldsymbol{moldm^{-3}})$	Initial rate$(\boldsymbol{moldm^{-3}s^{-1}})$
1	0.02	0.02	1.2×10^{-4}
2	0.04	0.04	*u*
3	*S*	0.04	2.4×10^{-4}
4	0.06	0.02	*v*
5	0.04	*t*	7.2×10^{-4}

Determine the values of ***s,t,u*** and ***v***. Give reason(s) for your answers.

(d) Propanone reacts with iodine according to the equation:

$$CH_3COCH_3 + I_2 \longrightarrow CH_2ICOCH_3 + HI$$

The reaction is first order with respect to propanone and zero order with respect to iodine.

Describe an experiment to determine the rate of the reaction.

(e)The table below shows the concentration of bromine at various intervals of time for the reaction;

$$Br_2(aq) + HCOOH(aq) \longrightarrow 2HBr(aq) + CO_2(g)$$

Time (s)	0	30	60	90	120	180	240	360	480	600
$[\boldsymbol{Br_2}] \times \mathbf{10^{-3}}(\boldsymbol{moldm^{-3}})$	10	9	8.1	7.3	6.6	5.3	4.4	2.8	2.0	1.3

(i) Plot a graph of concentration of bromine against time

(ii) Use the graph to find the order of reaction. Explain your answer.

(iii) Calculate the rate constant.

(f)The table below shows the results for the hydrolysis of a bromoalkane, C_4H_9Br with sodium hydroxide solution. The enthalpy for the reaction is $-160kJmol^{-1}$.

Experiment	$[\boldsymbol{C_4H_9Br}](\boldsymbol{moldm^{-3}})$	$[\bar{\boldsymbol{O}}\boldsymbol{H}](\boldsymbol{moldm^{-3}})$	**Initial rate** $(\boldsymbol{moldm^{-3}s^{-1}})$
1	0.05	0.10	1.0×10^{-5}
2	0.20	0.10	4.0×10^{-5}
3	0.20	0.05	4.0×10^{-5}

(i) Determine the order of the reaction with reasons to explain your answer.

(ii) Write the structural formula and name of the alkylhalide

(iii) Draw a well labelled energy diagram for the reaction. (c)

24. (a) (i) With the aid of a labeled diagram, describe how the standard electrode potential of an aluminium electrode can be determined.

(ii) The electrode potentials of copper and aluminium are given below;

$$Cu^{2+}(aq) + 2e \longrightarrow Cu(s) \qquad E^{\theta} = +0.34V$$
$$Al^{3+}(aq) + 3e \longrightarrow Al(s) \qquad E^{\theta} = -1.66V$$

Write a cell convention for the cell made up of the two half cells hence determine the emf of the cell.

(b) Sketch a graph to show the conductivity change during the titration of 0.01M ethanoic acid with 0.1M sodium hydroxide. Explain the shape of the graph.

MIXED QUESTION

25. Explain the following observations

(a) Aluminium fluoride has a higher melting point than aluminium chloride.

(b) Boron trichloride is non-polar whereas nitrogen trichloride is polar.

(c) The bond angle in an ammonia molecule is $107°$ whereas that in phosphine is $94°$.

(d) When anhydrous magnesium sulphate is added to water, the temperature rises and yet when hydrated magnesium sulphate is used, the temperature falls.

(e) Both 2-nitrophenol and 4-nitrophenol exhibit hydrogen bonding and yet the boiling points of the two compounds differ greatly.

(f) Carbonic acid $(H_2CO_3)$and sulphorous acid$(H_2SO_3)$are both weak acids but their molecules exhibit different bond angles.

(g) Aminobenzene is more reactive towards bromination that benzene.

(h) The apparent relative molecular mass of ethanoic acid obtained by elevation of boiling point of benzene is 120.

(i) When sodium hydroxide solution is added to a solution of manganese(II) sulphate , a white precipitate is formed which is insoluble in excess alkali. The precipitate turns brown on standing.

(j) The boiling point of a solution containing 0.3075g of nitrobenzene in 100g of benzene is the same as that of a solution containing 0.38g of camphor in 100g of benzene.

(k) When concentrated hydrochloric acid was added to an aqueous solution cobalt(II) chloride, the colour of the solution changed from pink to blue and back to pink on when diluted with water.

END