2025- Chemistry Revision

Model Paper - 8

Time- 60 minutes

1.

a. i. Data related to standard entropies of various species are given below.

$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$

Species	Standard enthalpy of formation/ ΔH_f°/kJ mol^{-1}	Standard Entropy / S°/ J mol^{-1} K^{-1}
$H_2(g)$	0	131
$CH_4(g)$	-76.2	186
$H_2O(g)$	-242	189
CO(g)	-110	198

a. Use the data provided to calculate the standard entropy change in the reaction given in (i) above.

b. Use the data provided to calculate the standard Gibbs energy change in the reaction given in (i) above.

c. Will the reaction take place spontaneously at standard temperature (25 ℃)?

b. i. Use the following thermodynamic parameters to construct a Born Haber cycle and determine the standard lattice enthalpy of $K_2O(s)$.

$\Delta H_f^\circ(K_2O(s))$ = -363 kJ mol^{-1}

$\Delta H_{atm}^\circ(K(s))$ = +89 kJ mol^{-1}

$\Delta H_{I1E}^\circ(K(g))$ = +419 kJ mol^{-1}

$\Delta H_D^\circ(O_2(g))$ = +496 kJ mol^{-1}

$\Delta H_{EG1}^\circ(O(g))$ = -139 kJ mol^{-1}

$\Delta H_{EG2}^\circ(O(g))$ = 798 kJ mol^{-1}

ii. The standard enthalpy change of neutralization of 1 mol of HCl(aq) is half the standard enthalpy of neutralization of 1 mol $H_2SO_4(aq)$. Explain this statement.

iii. The standard enthalpy of neutralization of H_2SO_4 using NaOH is much lower than the neutralization enthalpy determined using $Ba(OH)_2$.

c. A balloon has been constructed into a hot air balloon by attaching a propane burner on to it. As the temperature increase the volume of the balloon does not change and is at 150 m^3.

1. If the gas inside the balloon act as an ideal gas at 283 K and 1.01×10^5 Pa pressure, calculate the number of mols of the gas present inside the balloon.

2. If the molecular mass of the gas is 29 g mol^{-1}, then calculate the mass of the gas present inside the balloon.

3. It is known that 1 J of energy is needed to increase the temperature of 1 g of the gas by 1 K. If the standard enthalpy of combustion of $C_3H_8(g)$ is -2220 kJ mol^{-1}, then calculate the mass of $C_3H_8(g)$ required to increase the temperature by 50 K.

2. a. 1. Draw the Lewis structure of H_2O_2.

2. Write down the balanced chemical equation for a reaction that forms H_2O_2 as a product.

3. Write down reactions to demonstrate 1. Oxidizing properties 2. Reducing properties of H_2O_2.

4. What is meant by '20 volume' H_2O_2 when indicating the concentration of H_2O_2?

5. 10 mL of H_2O_2 dissociates under neutral conditions in the presence of catalyst MnO_2 to evolve 220 mL of O_2 at 27 ℃ and 1×10^5 Pa.

a. Write down the balanced chemical equation for the reaction.

b. Express the composition of H_2O_2 as a "x volume".

c. Calculate the molarity of H_2O_2 in mol dm^{-3}. The molar volume of O_2 under these conditions is 22.4 dm^3.

d. Calculate the volume of 0.04 mol dm^{-3} acidic $KMnO_4$ required to oxidize 25 mL of the above solution.

b. A gaseous mixture contains only N_2 and CO. 1 dm^3 of this gaseous mixture at 25 ℃ was treated with excess $I_2O_5(s)$. CO(g) reacts with $I_2O_5(s)$ to form CO_2 and I_2 as products. I_2 liberated was titrated with 0.1 mol dm^{-3} $Na_2S_2O_3$ and the volume required was 30.0 mL. The density of the gaseous mixture at 25 ℃ is 0.7 g dm^{-3}. {C =12, O = 16}

i. Write down the balanced chemical equation for the reaction between CO(g) and $I_2O_5(s)$

ii. Write down the reaction between I_2 and $S_2O_3^{2-}$.

iii. What is the indicator used for the titration?

iv. What is the colour change at the end point?

v. What is the correct time to add the indicator and why?

vi. Calculate the mass percentage of CO(g) in the sample.

vii. Is $Na_2S_2O_3$ a primary standard? Explain.

c. To analyze a $Na_2C_2O_4$ containing a neutral compound a 7.5 g of the sample was reacted with 50 mL of dilute H_2SO_4. When this was titrated with a standard 0.9 mol dm^{-3} $KMnO_4$ solution, volume of 20 mL was consumed. (Na = 23, C =12, O =16)

1. What is colour change at the end point?
2. Calculate the mass percentage purity of $Na_2C_2O_4$ by mass.

3. A. This question is based on an element "**A**" in the p block of the periodic table. Several reactions based on the chemistry of "**A**" is shown below.

A $\xrightarrow{\text{Heating with } Cl_2 \text{ gas}}$ **B** – Solid

B(aq) $\xrightarrow{\text{Add } NH_3(aq)}$ **C** (White gelatinous precipitate)

C $\xrightarrow{\text{Strong Heating}}$ **D** (white solid)

D $\xrightarrow{\text{Add NaOH solution}}$ **E**(Colorless solution)

E $\xrightarrow[\text{Dropwise manner}]{\text{Add dil. HCl solution}}$ Precipitate **C** $\xrightarrow[\text{Excess amounts}]{\text{Add dil. HCl solution}}$ Solution **B**

A + NaOH (aq) $\longrightarrow$ **E + F (Colourless gas)**

1. Identify the compounds **A**, **B**, **C**, **D**, **E** and **F** by giving their chemical symbols.
2. Write down the balanced chemical equation for the reaction between **D** and NaOH.
3. The aqueous solution of **B** changes the colour of blue litmus to red. Use the relevant chemical reaction to explain the statement.
4. The relative molecular mass of **B** is twice that of the gaseous state than when it is the solid state. Explain this phenomenon.

b. Certain metal ore contains financially important components as copper (II) sulfide and iron (II) sulfide. In order to determine the percentages of Copper, Iron and Sulphur by their weight, following procedure was used.

Procedure

1.000 g of the metal ore was heated with conc HNO_3 until all the sulfide ions to sulphate ions and ferrous ions to ferric ions. The resulting solution was filtered, and all the remaining solid residue was removed. The resulting solution was diluted to 250 mL with water and solution is named as **S**.

25.00 mL of this solution **S** was acidified with dil. HNO_3 and was treated with excess $BaCl_2$. The resulting precipitate X was filtered, washed, and dried. The total dry mass of **X** was 0.1864 g.

Another 25.00 mL portion of **X** was treated with 5% KI after acidifying with conc. H_2SO_4. Liberated I_2 required 20.00 mL of 0.04 mol dm^{-3} $Na_2S_2O_3$ for complete titration using starch as the indicator.

The white precipitate remaining at the end of the titration was filtered, dried, and weighed to get a white precipitate (**Y**) having a mass of 0.0381 g.

1. Identify **X** and **Y**.
2. Write down balanced chemical equations to describe all the reactions took place.
3. Determine the mass percentages of Cu, Fe and S in the sample. (Cu =63.5, Fe =56, S =32, O =16, Ba =137, I =127)

4. a. Predict the product of the following reactions and give balanced equations.

1. $H_2O_2 + Ag_2O \rightarrow$

2. $MnO_4^- + C_2O_4^{2-} + H^+ \rightarrow$

3. $Cu + H_2S \rightarrow$(Under heat)

4. S + conc. $H_2SO_4 \rightarrow$(Under heat)

5. $Cu^{2+} + I^- \rightarrow$

b. The following procedure has been used to standardize a $Na_2S_2O_3$ solution. 1.07 g of KIO_3 was measured accurately and was dissolved in water to prepare a solution of 250 mL. 25 mL of this solution pipetted out to prepare a solution of 250 mL. 25 mL of this solution was pipetted out and mixed with 1 g of KI and 5 mL of 1 mol dm^{-3} H_2SO_4 which is in excess. This solution was titrated with the $Na_2S_2O_3$ solution kept in the burette. The burette reading was 10.15 mL.

1. What is meant by a primary standard?

2. Write down balanced chemical equations for the reaction that would take place in the procedure described.

3. What is the indicator used in this titration?

4. What is the colour change at the end point?

5. The indicator is usually added near the end point, explain.

6. Calculate the molarity of the given $Na_2S_2O_3$ solution. (K = 39, I =127, O=16)

c. **A** and **B** are two coordination compounds with molecular formula $CoN_5H_{12}Br_2O_2$. H atoms exists as NH_3 only. In both compounds cobalt is in the same oxidation state. Only compound **B** gives a pale yellow precipitate with $AgNO_3$(aq) that is insoluble in dilute NH_3 but soluble in conc.NH_3.

I. Of above compounds what is the oxidation state of Co?
II. Write the complete electronic configuration of Co ion given in above.
III. Identify common ligands coordinated in compounds **A** and **B**.
IV. Give the structural formule of compounds **A** and **B** giving reasons.
V. Give a chemical test to identify the anion in compound **A**.

d. It was planned to determine the relative atomic mass of magnesium experimentally using the molar volume value of $H_{2(g)}$.

i. Draw the experimental setup of the apparatus used for this purpose in which magnesium and dilute HCl are used

ii. The results obtained in the experiment are given below.

room temperature	=	27°C
atmospheric pressure	=	1.013×10^5 Pa
Saturated vapour pressure of water	=	0.036×10^5 Pa
Volume of H_2 gas formed	=	50 cm^3
Mass of the piece of Mg	=	0.05 g

Using the above values, calculate the relative atomic mass of Mg.

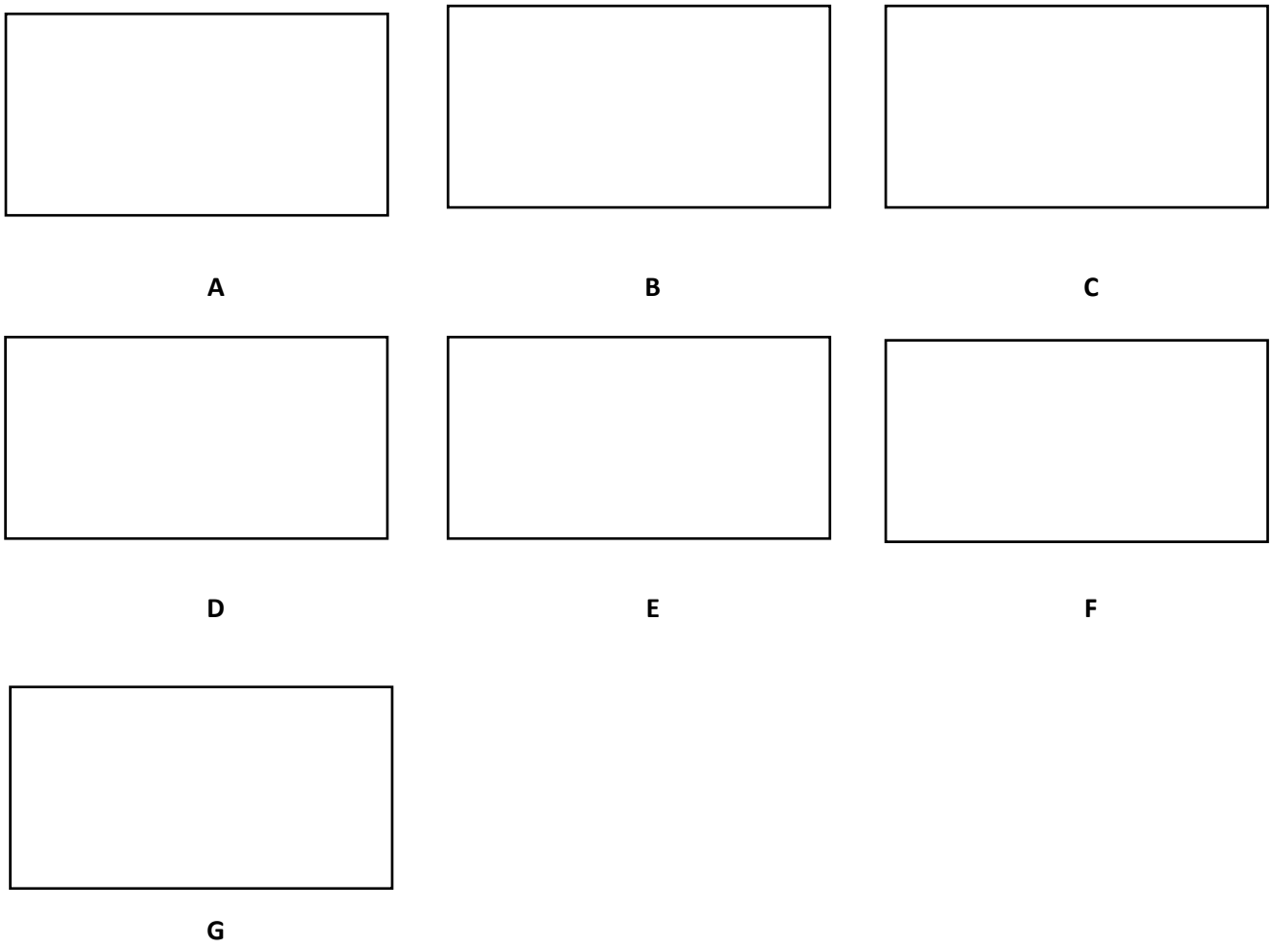
5.

(*a*) **A**, **B**, **C** and **D** are four compounds which are isomers of molecular formula C_4H_9Br. Only **A** shows optical isomerism. The carbon skeletons of **B** and **D** are same and it differs from the skeleton of **A**. Dehydrobromination followed by addition of HBr to **D** produces **B**.

(i) Draw the structures of **A**, **B**, **C** and **D** in the boxes given below.

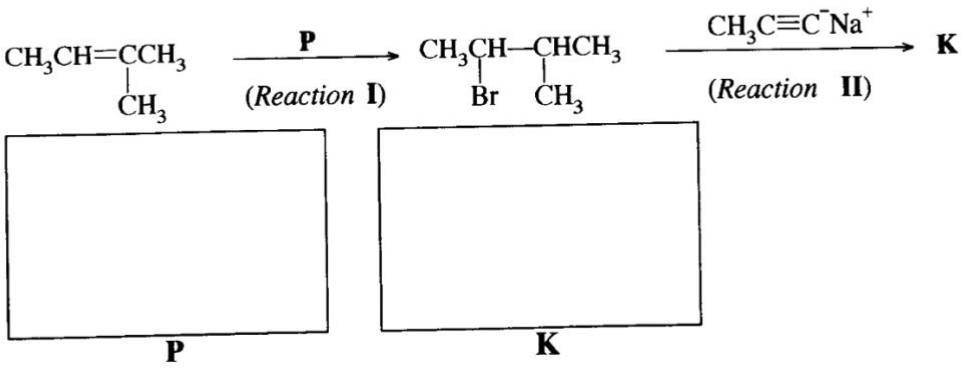
A	**B**
C	**D**

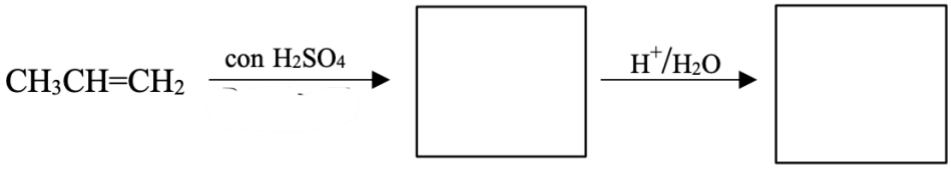
(b) **A**, **B**, **C** are structural isomers of molecular formula $C_5H_{11}Br$. All 3 isomers show optical isomerism. When reacts with alcoholic KOH, **A**, **B** and **C** gives **D**, **E** and **F** respectively. **D** shows geometric isomerism while **E** and **F** do not show geometric isomerism. **E** and **F** give the same compound **G** when reacted with HBr. Compound **G** is structural isomers of **A**, **B** and **C**. **G** does not show optical isomerism. The IUPAC name of **C** is 1-bromo-2-methylbutane. Draw the structures of **A, B, C, D, E, F** and **G** in the boxes given below.



c. (i) Complete the following three reaction sequences by drawing structures of compounds **K, L** and **M** and giving the reagents/catalysts

Sequence 1:





(ii) Write the mechanism of the ***reaction II*** above.

d) A student conducted three experiments to investigate the kinetics of the following reaction at a constant temperature.

$$2I^-(aq) + S_2O_8^{2-}(aq) \longrightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

i) In the first experiment, 500 cm^3 of 0.160 mol dm^{-3} solution of $I^-(aq)$ and 500 cm^3 of 0.040 mol dm^{-3} solution of $S_2O_8^{2-}$ (aq) were mixed to allow the above reaction to proceed. It was found that 2.8×10^{-5} mols of I_2 have been formed at the end of the initial 5 second period.

I. Calculate the rate of production of $I_2(aq)$.
II. Calculate the rate of consumption of $I^-(aq)$.
III. Calculate the rate of consumption of $S_2O_8^{2-}$ (aq).

ii) In the second experiment, 500 cm^3 of 0.320 mol dm^3 solution of $I^-(aq)$ and 500 cm^3 of 0.040 mol dm^{-3} solution of $S_2O_8^{2-}$ (aq) were mixed. The rate of the production of I_2 was then determined to be 1.12×10^{-5} mol dm^{-3} s^{-1}. Calculate the order of the reaction with respect to $I^-(aq)$ using the information given in Parts (i) and (ii).

iii) The order of the reaction with respect to $S_2O_8^{2-}(aq)$ was determined to be 1 in the last experiment conducted by changing the concentration of $S_2O_8^{2-}(aq)$.

I. Write the rate law for this reaction.
II. Calculate the rate of the reaction when the volumes of both solutions in Part (ii) are doubled by adding distilled water and the solutions are then mixed?

iv)

I. What is meant by the half-life of a first order reaction?
II. The half-life of the above reaction when the concentration of $I^-(aq)$ is kept constant, is independent of the initial concentration of $S_2O_8^{2-}(aq)$. Explain this statement with the help of a graphical representation.