General Certificate of Education (Adv. Level) Examination, 2025

Chemistry -II

One hour and 10 minutes

- ***This question paper consists of 08 pages.***
- ***Answer all the questions.***
- ***The use of calculators is not permitted.***
- ***Write your examination number in the space provided on the answer script***

Name:

Universal gas constant: $R = 8.314\ J \cdot K^{-1} \cdot mol^{-1}$ **Planck's constant = 6.626×10^{-34} J s**

Avogadro Constant, $N_a = 6.022 \times 10^{23}\ mol^{-1}$ **Speed of light: $c = 3 \times 10^8\ ms^{-1}$**

Section A – Structured Essay

01. (a) State whether the following statements are **true** or **false.**

i. All linear molecules are non-polar. ( )

ii. Ionic bonds are generally stronger than covalent bonds. ( )

iii. The shape of a molecule is determined solely by the bonded atoms. ( )

iv. In an atom, electrons with higher principal quantum numbers have lower energy. ( )

v. The Pauli Exclusion Principle states that no two electrons in an atom can have the same set of four quantum numbers. ( )

vi. The emission spectrum of hydrogen is continuous. ( )

vii. In the Bohr model, electrons in higher energy levels have lower potential energy. ( )

(b) Structure of a certain compound is given below. All atoms except hydrogen (**H**) are *p*-block elements from the first 20 elements (Periods 2–3). Elements **Y** and **Z** belong to the same group, with **Z** in Period 2 and **Y** in Period 3. Elements **X** and **Z** are consecutive elements in the periodic table. All atoms satisfy the octet rule, and the electronegativity of **X, Y**, and **Z** is greater than that of hydrogen. Both **Z** atoms one bonded to **X** and **Y** and other one bonded to **Y** and **H** exhibit sp^2 hybridization.

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X — Z — Y = Z — H
    ||
    X
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i) Identify elements **X, Y**, and **Z** specifying their groups and periods.

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ii) Assign formal charges to the two charged atoms and justify your reasoning.

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iii) Draw the Lewis structure, including lone pairs and charges, and propose one acceptable resonance structure.

iv) Predict the molecular geometry and electron-pair geometry for both **Z** atoms**, Y,** and **X** using VSEPR theory.

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v) Given that the oxidation state of **Z** which is bonded to **X** and **Y** is +3, determine the oxidation state of **Z** which is bonded to **Y** and H and arrange **X, Y**, and **Z** in order of increasing of electronegativity.

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(c) A neutron is moving with a velocity of 1.5×10^4 ms^{-1}. Take plank constant (h) = 6.6×10^{-34} Js, mass of neutron (m_n) = 1.6×10^{-27} kg, and mass of electron (m_e) = 9×10^{-31} kg.

i) Calculate the momentum of the neutron.

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ii) Find the de Broglie wavelength of the neutron.

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iii) An electron has the same wavelength as this neutron. Without calculating, compare their velocities. Justify your answer.

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02.) a) Na_2CO_3, NaOH and inert material are present in a solid mixture. A 250 cm^3 of solution made by dissolving 5 g of mixture dissolved in water. The molarity of Na_2CO_3, and NaOH in the solution is 0.08 mol dm^{-3} and 0.2 mol dm^{-3} respectively.

i) Calculate the number of moles of Na_2CO_3, and NaOH present in the solution.

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ii) Calculate the mass percentage of Na_2CO_3, and NaOH in the solid mixture.

($Na=23\ g\ mol^{-1}$, $H= 1\ g\ mol^{-1}$, $O=16\ g\ mol^{-1}$, $C= 12\ g\ mol^{-1}$)

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iii) Report the concentration of Na_2CO_3 in ppm.

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b) At 300 K and $3.0 \times 10^5\ Nm^{-2}$, a vessel of $2.0\ m^3$ contains gas **X**. At 300 K and $5.0 \times 10^5\ Nm^{-2}$, a vessel of $3.0\ m^3$ contains gas **Y**. Both vessels are connected through a thin tube allow both gases to mix with each other completely. They do not react with each other. Assume that the volume of the thin tube is negligible.

i) If the temperature is unchanged, calculate the total pressure of the connected vessels.

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ii) Calculate the mole fraction of gas **X** in the mixture.

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iii) Calculate the partial pressure of gas **Y** present in the mixture.

iv) By keeping the total volume of the two vessels constant, calculate the total pressure of the gas **X**, inside the connected vessels, when the temperature of the gas mixture is increased up to 350K.

v) Write two assumptions you made here.

Section B – Essay

03.) a) i.) Write the Charles law.

ii) CH_4 (g) contains in a rigid vessel A of 4.157 dm^3 at 227 ^oC and 1.5×10^{5} Pa pressure. 1 mol of O_2(g) contains in another rigid vessel B at 27 ^oC and 2×10^{5} Pa. Both vessels joined using thin tube of negligible volume. The tap was closed initially.

I) Calculate,

i) Number of moles of CH_4(g) in vessel A.

ii) Volume of Vessel B.

II) Temperature of the whole system was reduced to 7 ^oC after opening the tap. There is no reaction between CH_4 (g) and O_2(g) Calculate following.

i) Total pressure of the system.

ii) Mole fractions of CH_4 (g) and O_2 (g).

III) Temperature of the above system was taken to 127 ^oC after open the tap. CH_4 (g) undergoes combustion with O_2 (g) and from CO_2 (g) and H_2O (g).

Consider this system and calculate,

i) Calculate number of moles of each gas in the system.

ii) Calculate total number of moles in the system.

iii) Calculate the total pressure of the system

b) Solid sulfur (S) reacts with nitric acid (HNO_3) to produce sulfuric acid solution (H_2SO_4), nitrogen dioxide gas (NO_2), and water (H_2O).

i) Assign the oxidation numbers of sulfur and nitrogen in the reactants and products.

ii) Identify which elements are oxidized and reduced.

iii) Balance the chemical equation using half reaction method.

c) The PO_4^{3-} ion concentration in a K_3PO_4 solution is 285 ppm. The temperature of the solution is 25 °C. (Atomic masses: K = 39 g mol^{-1}, P = 31 g mol^{-1}, O = 16 g mol^{-1})

i) Find the molarity of PO_4^{3-} ions in $moldm^{-3}$.

ii) Find the composition of K^+ ions in ppm.

d) A sample of iron (II) is suspected to be partially oxidized to iron (III) ions (Fe^{3+}). An experiment was performed to determine the amount of Fe^{2+} present using a standard solution of potassium permanganate ($KMnO_4$). So that, Fe (II) oxidized to Fe (III) by reducing MnO_4^- to Mn^{2+}.
(Fe = 56 g mol^{-1})

- **Procedure:** 27.00 cm^3 of the iron solution is reacted against a 0.6 mol dm^{-3} solution of $KMnO_4$. It requires 2.25 cm^3 of the $KMnO_4$ solution to react completely.

  Answer the following questions.

i) Write the balanced chemical equation for the reaction between MnO_4^- and Fe^{2+} in acidic medium.

ii) Calculate the number of moles of MnO_4^- used in the experiment.

iii) Calculate the number of moles of Fe^{2+} that reacted with the MnO_4^- solution.

iv) If the original iron solution was assumed to be 0.30 mol dm^{-3} Fe^{2+}, calculate the number of moles of Fe^{2+} that would have been present in the 27.00 cm^3 solution if it were pure.

v) Calculate the percentage purity (by moles) of the Fe^{2+} solution.

The Periodic Table

1 **H**																	2 **He**
3 **Li**	4 **Be**											5 **B**	6 **C**	7 **N**	8 **O**	9 **F**	10 **Ne**
11 **Na**	12 **Mg**											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 **K**	20 **Ca**	21 **Sc**	22 **Ti**	23 **V**	24 **Cr**	25 **Mn**	26 **Fe**	27 **Co**	28 **Ni**	29 **Cu**	30 **Zn**	31 **Ga**	32 **Ge**	33 **As**	34 **Se**	35 **Br**	36 **Kr**
37 **Rb**	38 **Sr**	39 **Y**	40 **Zr**	41 **Nb**	42 **Mo**	43 **Tc**	44 **Ru**	45 **Rh**	46 **Pd**	47 **Ag**	48 **Cd**	49 **In**	50 **Sn**	51 **Sb**	52 **Te**	53 **I**	54 **Xe**
55 **Cs**	56 **Ba**	**La- Lu**	72 **Hf**	73 **Ta**	74 **W**	75 **Re**	76 **Os**	77 **Ir**	78 **Pt**	79 **Au**	80 **Hg**	81 **Tl**	82 **Pb**	83 **Bi**	84 **Po**	85 **At**	86 **Rn**
87 **Fr**	88 **Ra**	**Ac- Lr**	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**	110 **Ds**	111 **Rg**	112 **Cn**	113 **Nh**	114 **Fl**	115 **Mc**	116 **Lb**	117 **Ts**	118 **Og**

57 **La**	58 **Ce**	59 **Pr**	60 **Nd**	61 **Pm**	62 **Sm**	63 **Eu**	64 **Gd**	65 **Tb**	66 **Dy**	67 **Ho**	68 **Er**	69 **Tm**	70 **Yb**	71 **Lu**
89 **Ac**	90 **Th**	91 **Pa**	92 **U**	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lr**