G.C.E.(A. L.) Support Seminar - 2014

Chemistry I

Two hours

Important
* Answer all the questions.
* Select the **correct** or **most appropriate** response.

$$Universal\ gas\ constant,\ R\ =\ 8.314\ J\ K^{-1}\ mol^{-1}$$
$$Avogadro\ constant,\ N_A\ =\ 6.022 \times 10^{23}\ mol^{-1}$$
$$Plank\ constant\ =\ 6.624 \times 10^{-34}\ J\ s$$
$$Velocity\ of\ light\ =\ 3 \times 10^{8}\ m\ s^{-1}$$

1. Non transition element X forms the see-saw shaped ion XCl_4^-. Which of the following is the common electronic configuration of the free X atom at its ground state?
   (1) ns^2np^1　　　(2) ns^2np^2　　　(3) ns^2np^3　　　(4) ns^2np^4　　　(5) ns^2np^5

2. Which one of the following elements releases the highest amount of heat when one mole of its gaseous atoms are provided with one mole of electrons under the same conditions?
   (1) Li　　　(2) Be　　　(3) N　　　(4) F　　　(5) Cl

3. Which answer gives the correct sequence of the compounds to represent the bond nature, polar covalent, ionic and non-polar covalent respectively ?
   (1) SiO_2, CaO, I_2　　　　　(2) CaO, SiO_2, I_2　　　　　(3) I_2, CaO, SiO_2
   (4) CaO, I_2, SiO_2　　　　　(5) SiO_2, I_2, CaO

4. Which gives the correct variation of O - O bond length in the species, O_2, O_2^{2-} and O_3?
   (1) $O_2 < O_3 < O_2^{2-}$　　　　　(2) $O_3 < O_2 < O_2^{2-}$　　　　　(3) $O_2 < O_2^{2-} < O_3$
   (4) $O_3 < O_2^{2-} < O_2$　　　　　(5) $O_2^{2-} < O_3 < O_2$

5. The relative atomic mass of Pb is approximately four times greater than that of Cr. The mass percentage of Pb in a mixture containing only Pb and Cr is 80%. What is the mole fraction of Pb in the mixture?
   (1) 0.20　　　(2) 0.25　　　(3) 0.50　　　(4) 0.65　　　(5) 0.80

6. What is the approximate mean square velocity of N_2 gas at $77°C$? (r.a.m. N - 14)
   (1) $1.77 \times 10^{1}\ m\,s^{-1}$　　　　　(2) $3.12 \times 10^{2}\ m\,s^{-1}$　　　　　(3) $5.58 \times 10^{2}\ m\,s^{-1}$
   (4) $7.89 \times 10^{2}\ m\,s^{-1}$　　　　　(5) $3.12 \times 10^{5}\ m\,s^{-1}$

7. The binary solution prepared by mixing the two liquids A and B behaves ideally. Which one of the following graphs represents the variation of the Gibb's energy change against the mole fraction(X_A) of A, that takes place while mixing A and B together?
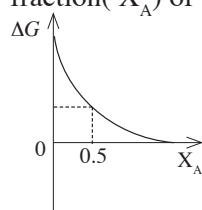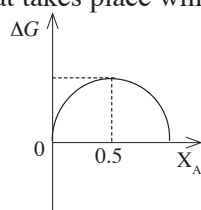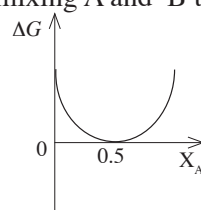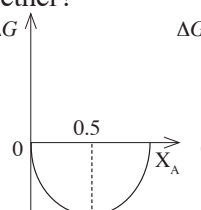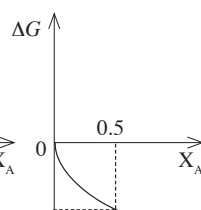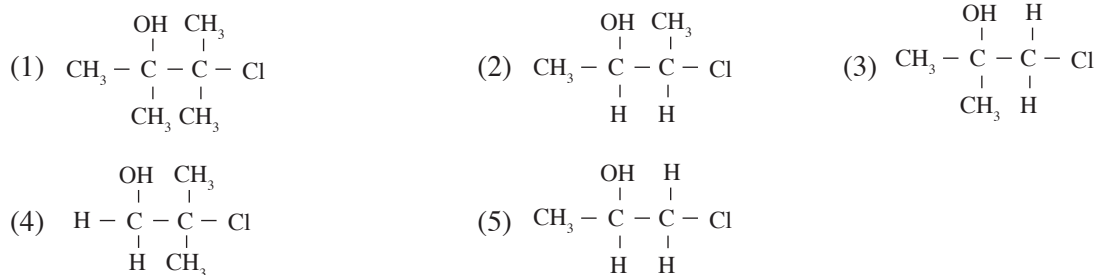

(1)　　　　　(2)　　　　　(3)　　　　　(4)　　　　　(5)

8. The set of quantum numbers (n, l, m_l, m_s) can be used to describe the identity of an electron in an atom. How many sets of quantum numbers are possible for an atom with $(n + l) = 3$?
   (1) 2　　　　(2) 3　　　　(3) 4　　　　(4) 6　　　　(5) 8

9. Which gives the correct increasing order of the hydration enthalpies of the following ions?
   (1) $Cl^- < Na^+ < Mg^{2+} < Al^{3+}$　　　　　(2) $Al^{3+} < Mg^{2+} < Na^+ < Cl^-$
   (3) $Na^+ < Cl^- < Mg^{2+} < Al^{3+}$　　　　　(4) $Na^+ < Cl^- < Al^{3+} < Mg^{2+}$
   (5) $Mg^{2+} < Al^{3+} < Cl^- < Na^+$

10. Which one is most true, regarding the reaction takes place when $(NH_4)_2SO_4$(aq) solution is treated with Mg powder?
    (1) Only NH_3 gas liberates.　　　　　(2) Only N_2 gas liberates.
    (3) Only H_2 gas liberates.　　　　　(4) Both SO_2 and NH_3 gases liberate.
    (5) Both H_2 and NH_3 gases liberate.

11. Reaching the excited state by the gaseous ions in the flame test can be represented as,
    $M(g) \longrightarrow M^*(g)$. If the energy change for the above process is 180.66 kJmol^{-1}, what is the wave length of the electromagnetic radiation emitted in the process.
    $M^*(g) \longrightarrow M(g)$?
    (1) 110.0 nm　　(2) 497.2 nm　　(3) 662.6 nm　　(4) 1100.0 nm　(5) 6626.0 nm

12. The organic compound **X** decolourizes the brown colour of Br_2 water and **X** reacts with Na liberating H_2. Which one of the following could be **X**?
    (1) $CH_2 = CHCl$　　　　(2) $C_2H_5NH_2$　　　　(3) C_6H_5OH
    (4) CH_3COOH　　　　(5) $CH_3C \equiv CCH_3$

13. Which one of the following statements is true regarding the catalysis of a chemical reaction taking place at a constant temperature?
    (A) Minus value of Gibb's energy change (ΔG) increases.
    (B) Rate constant at the given temperature increases.
    (C) Activation energy of the reaction decreases.
    (D) Fraction of the effective collisions does not change.
    (1) A and B only.　　　　(2) B and C only.　　　　(3) C and D only.
    (4) D and A only.　　　　(5) A, B and D only.

14. Zn sheet with 50.00 g mass was dipped in 100 cm^3 volume of aqueous $AgNO_3$ solution. The mass of the metal sheet was found to be 53.02 g after a certain time period. What is the concentration of Zn^{2+} in the solution at this instance? (r.a.m. Zn = 65, Ag = 108)
    (1) 0.020 mol dm^{-3}　　　　(2) 0.140 mol dm^{-3}　　　　(3) 0.200 mol dm^{-3}
    (4) 0.285 mol dm^{-3}　　　　(5) 0.464 mol dm^{-3}

15. Consider the first order reaction A $\longrightarrow$ B. The initial concentration of A was 0.8 mol dm^{-3} and after 120 seconds its concentration was 0.2 mol dm^{-3}. What is the half life of this reaction?
    (1) 15 seconds　(2) 30 seconds　　(3) 40 seconds　　(4) 60 seconds (5) 120 seconds

16. A substance which is **not** used to purify water is,
    (1) chlorine　　　　(2) chlorine dioxide　　　　(3) ozone
    (4) hydrogen peroxide　　(5) potash alum

17. Number of stereo isomers possible for $CH_3CHBrCH = CHCH_3$ is,
    (1) 2　　　　(2) 3　　　　(3) 4　　　　(4) 5　　　　(5) 6

18. What is the correct IUPAC name of $[Fe(CN)_5NO]^{3-}$?
    (1) pentacyanidonitrosyl ferrate (II) ion
    (2) pentacyanidonitrosylferrate(II) ion
    (3) pentacyanidonitrosylferrate(III) ion
    (4) pentacyanido nitrosylferrate(II) iron
    (5) pentacyanido nitrosylferrate (II) ion

19. If you are provided with PCl_3 and Na as the only reagents, which of the following compound/s can be prepared using CH_3CH_2OH?
    (A) CH_3CH_2Cl (B) $CH_3CH_2O^-Na^+$ (C) $CH_3CH_2 - O - CH_2CH_3$ (D) $CH_2 = CH_2$
    (1) A only.
    (2) B only.
    (3) A and B only.
    (4) A, B and D only.
    (5) A, B, C and D all.

20. IUPAC name of the following compound is,

$$H_2N - CH_2 - \underset{\underset{CH_3}{|}}{CH} - \underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}} - CH = CH_2$$

    (1) 5 - amino - 4 - methylpent - 1 - en - 3 - ol
    (2) 1 - amino - 2 - methylpent - 4 - en - 3 - ol
    (3) 5 - amino - 3 - hydroxy - 4 - methylpent - 1 - ene
    (4) 5 - amino - 4 - methylpent - 1 - ene - 3- ol
    (5) 5 - amino - 4 - methyl - 3 - hydroxypent - 1 - ene

21. When the organic compound A is heated with conc.NH_3, a molecule of the resulting compound possesses one more H atoms than that in a molecule of A. When A, upon treatment with PCl_3 followed by the reaction with NH_3, forms a compound which possesses two more H atoms in a molecule compared to that in A. Which of the following compound/s is possible to be A?

    (A) $CH_3 - \underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}} - CH_2CH_2OH$ (B) $CH_3 - \underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}} - CH_2COOH$

    (C) $CH_3 - \underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}} - CH_2 - \overset{\overset{O}{||}}{C} - Cl$ (D) $CH_3 - \underset{\underset{H}{|}}{\overset{\overset{Cl}{|}}{C}} - CH_2 - \overset{\overset{O}{||}}{C} - Cl$

    (1) A only.
    (2) B only.
    (3) A and B only.
    (4) A, B and D only.
    (5) A, B, C and D all.

22. Which one of the following is a linear, condensation polymer which possesses a benzene ring for all its repeating units?
    (1) Nylon 6 : 6
    (2) Urea formaldehyde
    (3) Poly styrene
    (4) Terrylene
    (5) Bakelite

23. Which one of the following processes is **not** contributed by the gas NO?
    (1) Formation of SO_3.
    (2) Increasing the pH value of soil.
    (3) Depletion of the ozone layer.
    (4) Increasing the concentration of NO_3^- in the soil.
    (5) Formation of the substances responsible for the photo chemical smog.

24. Organic compound **A** reacts with $ZnCl_2$ and conc. HCl acid forming the product **B**. When **B** is warmed with alcoholic potassium hydroxide, the resulting product gives a brown precipitate with ammonical cuprous chloride. Which of the following is most possible to be the compound **A**?

(1) $CH_3 - \underset{\underset{CH_3}{|}}{\overset{\overset{OH}{|}}{C}} - \underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}} - Cl$

(2) $CH_3 - \underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}} - \underset{\underset{H}{|}}{\overset{\overset{CH_3}{|}}{C}} - Cl$

(3) $CH_3 - \underset{\underset{CH_3}{|}}{\overset{\overset{OH}{|}}{C}} - \underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}} - Cl$

(4) $H - \underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}} - \underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}} - Cl$

(5) $CH_3 - \underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}} - \underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}} - Cl$

25. 4 mol of gas **A** is kept in a rigid vessel and allowed to reach the following equilibrium.

$$2\,A(g) \rightleftharpoons A_2(g)$$

At $127\,^{\circ}C$, the total pressure of the equilibrium system is $8.314 \times 10^5\,Pa$ and the density of the gas mixture is $10\,kg\,m^{-3}$. If r.a.m. ot A is 30, the partial pressure of $A_2\,(g)$ is,

(1) $2.77 \times 10^5\,Pa$ (2) $4.16 \times 10^5\,Pa$ (3) $5.54 \times 10^5\,Pa$
(4) $8.31 \times 10^5\,Pa$ (5) $1.25 \times 10^6\,Pa$

26. The ascending order of the feasibility of the following compounds to undergo bromination with $Br_2/\,FeBr_3$ is correctly given by,

(a) NH_2 ... CHO (b) $CONH_2$ ... CH_3 (c) NH_2 ... CHO (d) $NHCH_3$ ... CH_3
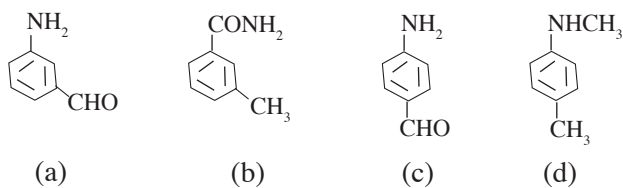
     (a)   (b)   (c)   (d)

(1) $a < b < c < d$ (2) $b < a < c < d$ (3) $b < c < a < d$
(4) $c < b < a < d$ (5) $d < a < c < b$

27. Out of the following compounds, the pair with strong and weak electrolytes respectively is,

(1) $NaCl$ and $PbSO_4$ (2) HF and $Ca(OH)_2$ (3) Na_2SO_4 and $MgCl_2$
(4) NH_4OH and $(NH_4)_2SO_4$ (5) $PbSO_4$ and CH_3COOH

28. $SO_2(g) + NO_2\,(g) \rightleftharpoons SO_3\,(g) + NO\,(g)$ is a closed equilibrium system. At the temperature $T^{\circ}\,C$, its equilibrium constant, $K_c = 16$. If 1.0 mole of each of the gases SO_2, NO_2, SO_3 and NO are mixed together in a vessel of 1.0 dm^3 volume, what could be the amount of NO gas in the equilibrium mixture, at the given temperature?

(1) $0.6\,mol$ (2) $0.8\,mol$ (3) $1.0\,mol$ (4) $1.6\,mol$ (5) $1.8\,mol$

29. $0.04\,mol$ of the compound $M(OH)_2$, which is sparingly soluble in water, was added into $1.00\,dm^3$ of $0.07\,mol\,dm^{-3}$ HCl solution and stirred well. At the given temperature, the solubility product (K_{sp}) of $M(OH)_2$ is $3.5 \times 10^{-10}\,mol^3\,dm^9$. If MCl_2 is water soluble, what is the concentration of OH^- in the solution?

(1) $1.0 \times 10^{-5}\,mol\,dm^{-3}$ (2) $1.0 \times 10^{-4}\,mol\,dm^{-3}$ (3) $1.0 \times 10^{-2}\,mol\,dm^{-3}$
(4) $8.0 \times 10^{-2}\,mol\,dm^{-3}$ (5) $2.0 \times 10^{-5}\,mol\,dm^{-3}$

30.	If the standard electromotive force of the cell A(s)/ A^{2+}(aq) // B^{2+}(aq) / B(s) is 0.85 V and the standard electromotive force of the cell A (s)/ A^{2+}(aq) // C^{2+}(aq) / C(s) is 1.25 V, what could be the standard electromotive force of the cell formed by the combination of the two electrodes B(s)/ B^{2+}(aq) and C(s)/ C^{2+}(aq)?

(1)	−2.10 V		(2)	−0.40 V		(3)	0.40 V		(4) 1.05 V		(5) 2.10 V

o	For each of the question **31** to **40**, four responses (*a*), (*b*), (*c*) and (*d*) are given out of which one or more of these is/ are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, mark

(1)	if only (*a*) and (*b*) are correct.
(2)	if only (*b*) and (*c*) are correct.
(3)	if only (*c*) and (*d*) are correct.
(4)	if only (*d*) and (*a*) are correct.
(5)	if **any other** number or combination of responses is/ are correct.

Summary of above Instructions

(1)	(2)	(3)	(4)	(5)
Only (*a*) and (*b*) correct.	Only (*b*) and (*c*) correct.	Only (*c*) and (*d*) correct.	Only (*d*) and (*a*) correct.	**Any other** number or combination of responses correct.

31.	Assume that carbon disulphide and acetone are mixed together forming an ideal solution.
A solution formed by mixing of carbon disulphide and acetone is at equilibrium with its vapour phase at 27 $^\circ$C, Consider the instance when its solution phase is equi-molar. The total pressure of the system was found to be 6.5 $\times 10^5$ Pa.

At 27 $^\circ$C, the saturated vapour pressures of carbon disulphide and acetone are 5.15 $\times 10^5$ Pa and 3.35 $\times 10^5$ Pa respectively. The attraction forces between the molecules of carbon disulphide is given as f_c whereas the attraction forces between the molecules of acetone is given as f_a.
Select the true statement/s given below.

(a)	The solution shows positive deviation from Roult's Law.
(b)	The solution shows negative deviation from Roult's Law.
(c)	$f_c - f_c$ attractive forces $> f_c - f_a$ attractive forces $< f_a - f_a$ attractive forces
(d)	$f_c - f_c$ attractive forces $< f_c - f_a$ attractive forces $> f_a - f_a$ attractive forces

32.	Which of the following statement/s is/ are true?
(a)	$\Delta S > 0$ for all the spontaneous processes.
(b)	$\Delta H > 0$ for all the spontaneous processes.
(c)	Exothermic processes with $\Delta S > 0$, takes place spontaneously.
(d)	Endothermic processes with $\Delta S < 0$, does not take place spontaneously.

33.	Which of the following can reduce Cu^{2+} ion into Cu^{+} ion?
(a) H$_2$S			(b) SO$_2$			(c) KI			(d) C$_2$O$_4^{2-}$

34. Select the true statement/ s regarding the hydrocarbons.
    (a) When an alkene undergoes an addition reaction with a molecule of HBr, the type of the hybridization of some of the carbon atoms of the alkene changes.
    (b) $CH_3CHBrCH_3$ is formed as the main product, when HBr reacts with $CH_3CH = CH_2$, in the presence of peroxides.
    (c) Under the normal conditions, all the hydrocarbons undergo electrophillic addition reactions.
    (d) In the presence of Hg^{2+} ions as catalysts, all the alkynes react with dil.H_2SO_4 forming ketones.

35. When a mixture of C_6H_5CHO and CH_3CHO is reacted with aqueous sodium hydroxide, followed by de-hydration, which of the following product/s could be the possible to form by the addition condensation?
    (a) $(CH_3)_2C = CHCHO$
    (b) $C_6H_5CH = CHCHO$
    (c) $CH_3CH = CHCHO$
    (d) $CH_2 = CHCHO$

36. Some information regarding the kinetics of the reaction, $2A + B \longrightarrow C$ is given below.
    - Rate of the reaction is increased by four times when the concentration of A is doubled while keeping the concentration of B constant, at a constant temperature.
    - At 25° C, the rate constant for the reaction is $48\,dm^6 mol^{-2}$.

    Based on the given information, the conclusion/s that can be made definitely, regarding the above reaction, is/ are,
    (a) an elementary reaction.
    (b) a second order reaction.
    (c) a first order reaction with respect to B.
    (d) When the concentrations of A and B are 0.1 mol dm^{-3} at 25 °C, the rate constant of the reaction is $4.8 \times 10^{-4}\,mol\,dm^{-3}\,s^{-3}$.

37. Consider the following system which is at the dynamic equilibrium.

    $2A\,(g) + B\,(g) \rightleftharpoons 2C\,(g)\quad \Delta H > 0$

    Which of the following statement/s is/are true?

    (a) Rate of the backward reaction decreases when the temperature is increased.
    (b) At constant temperature, equilibrium point is not changed, when the concentration of **A** is doubled and the concentration of **B** is halved.
    (c) At constant temperature, when the overall volume of the system is increased, partial pressure of **C** increases.
    (d) At constant temperature, when the concentration of **A** is increased, the concentration of **C** increases whereas the concentration of **B** decreases.

38. Correct statement/ s regarding the electrolysis in which a gas to be liberated at the anode and metal deposition to be taken place at the cathode is/ are,
    (a) Electrolysis of an aqueous $CuSO_4$ solution using inert electrodes.
    (b) Electrolysis of molten NaCl and $MgCl_2$ using inert electrodes.
    (c) Electrolysis of an aqueous $AgNO_3$ solution using Ag as the anode.
    (d) Electrolysis of dil. Na_2SO_4 solution using inert electrodes.

39. Which is/are insoluble in water but soluble in conc. HCl?
    (a) $PbCl_2$
    (b) BiOCl
    (c) $Ba(OH)_2$
    (d) $CoCl_2$

40. $25.00 \, cm^3$ of $0.2 \, mol dm^{-3}$ HCl solution was titrated with $0.1 \, mol dm^{-3}$ Na_2A solution. True statement/s regarding this titration is/are, (H_2A is a stable dibasic weak acid in which $pKa_1 = 5$ and $pKa_2 = 10$.)

    (a)   Only one equivalence point is given.

    (b)   The reaction $Na_2A + H_2A \longrightarrow 2NaHA$ also takes place.

    (c)   At the instance when $12.50 \, cm^3$ of Na_2A has been added, the solution in the titration flask can be considered as a mixture of H_2A and HCl.

    (d)   The indicator phenolphthalein cannot be used to determine the equivalence point of the titration.

❖   In questions No. 51 to 60, two statements are given in respect of each question.
From the Table given below, select the response out of the responses (1), (2), (3), (4) and (5) that best fits the two statements given for each of the questions and mark appropriately on your answer sheet.

Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement.
(2)	True	True, but does **not** explains the first statement correctly.
(3)	True	False.
(4)	False	True.
(5)	False	False.

	First statement	Second statement
41.	Chlorine gas evolves when MnO_2 is added into a conc.HCl solution.	HCl can act as an oxidizing agent.
42.	Compressibility factor of a gas increases, when the temperature is increased.	When the temperature is increased, critical temperature of a substance increases.
43.	When NaOH is produced by the membrane cell method, water should also be passed in to the cell.	Also water acts as a reactant, when NaOH is produced by membrane cell method.
44.	Chlorobenzene reacts with NaOH(aq).	OH^- is a good nucleophile.
45.	The only method by which the s block elements can be extracted, is the electrolysis of their molten chlorides.	When NaCl solution is electrolyzed, Na^+ are discharged at the cathode whereas Cl^- are discharged at the anode.
46.	CO_2 gas liberates when $CH_3CH = CH_2$ is warmed with acidic potassium permanganate.	When organic compounds are oxidized by $KMnO_4$, the resultant products are always derived from the maximum oxidation state of carbon.
47.	When an aqueous ammonia solution with pH value 11 is diluted hundred times using water, its pH value is approximately 12.	When a weak base is diluted using water, its degree of dissociation increases.
48.	None of the chlorides forms a basic solution when it is hydrolyzed.	HCl is a strong acid in the aqueous solution.
49.	pH value of buffer solution which is made of ethanoic acid and its sodium salt, is proportional to the ratio of [salt] / [acid].	When a buffer solution is diluted, its pH value does not change considerably.
50.	In NH_3 production by Haber process, the temperature of the system is lowered to separate NH_3 from the resultant equilibrium gas mixture.	Dissolution of gases in water is exothermic.

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G.C.E. (A.L.) Support seminar - 2014

Chemistry II | *Three hours*

Important :

* Answer **all** the questions in part **A** .
* Answer **four** questions selecting **two** questions from part **B** and **three** questions from part **C**.

Universal gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

Avogadro constant, $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

PART A - STRUCTURED ESSAY
Answer all **four** questions. Each question carries **10 marks.**

1. (*a*) Complete the following blanks in (i) to (v) in a suitable way.

   (i) Atomic radii of He, O, Mg and Cl vary in the ascending order,

   .... < ....< .... < ....

   (ii) Out of Li, Be and Ne, the second ionization enthalpy is highest in ....

   (iii) Out of the gases nitrogen, chlorine and argon, the boiling point is highest in ....

   (iv) When consider CO, CO_2 and CH_4, the electronegativity of carbon increases as,

   .... < .... < ....

   (v) The bond length of $N - O$ in the species NO_2^+, NO_2^- and NO_3^- increases as,

   .... < .... < ....

   (2.0 marks)

(*b*) Atomic skeleton of the cationic species CNO_3^+ is given below.

$$O_a - C - N \begin{array}{c} \nearrow O_b \\ \searrow O_c \end{array}$$
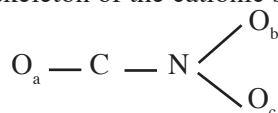
   Some information of a possible Lewis structure of this ion is given in the table given below.

Atom	Hybridization
O_a	sp
O_b	sp^3
O_c	sp^2
C	sp
N	sp^2

   (i) Draw the Lewis structure for CNO_3^+ in accordance with the data given in the table above.

(ii) Draw the resonance structures possible for the above mentioned ion. Giving reasons, comment on the stability of those ions.

(iii) Under the certain conditions, the cationic species given above dissociates into NO_2^+ and a gaseous compound.
What could be that gaseous compound?

....

(4.0 marks)

(*c*)

$$H-\underset{a}{O}-\underset{a}{\overset{\overset{\displaystyle O_b}{\|}}{N}}-C\equiv N_b$$
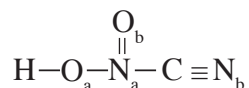
Complete the following table by considering the structure given above.

Atom	Hybridization	Electron pair geometry around the atom
O_a		
N_a		
C		

(2.0 marks)

(*d*) Explain the reasons for the following observations.
(It is sufficient to consider the main reason only).

(i) Melting point of Zn is less than that of Co.

(ii) Boiling point of CH_3COOH is higher than that of CH_3CH_2CHO.

(2.0marks)

2. (*a*)   **A** and **B** are 2 consecutive elements in a same period of the periodic table. First ionization energy of **B** is greater than that of **A**. Salts of **B** do not show a specific colour in the flame test. The element **A** vigorously reacts with cold water forming the solution **C** and a gas, **D**. The element **B** reacts with steam, forming the compound **E** and liberating the gas **D**.

   (i)   Identify the elements **A** and **B**.

   A ....   **B** ....

   (ii) Identify the solution **C** and the compound **E**.

   C ....   **E** ....

   (iii) What could be the gas **D**?

   ....

   (iv) Write the balanced chemical equations for possible chemical changes that would undergo when **A** is in the presence of excess oxygen gas.

   (v) Give balanced chemical equations, for the reactions of **B** with diluted sulphuric acid and concentrated sulphuric acid.

   (vi) The products formed by **A** in above (iv) were dissolved in water and excess chlorine gas was bubbled through the resulting diluted solution. Identify the products.

   (vii) State the hydroxides formed by the elements in the period in which **A** and **B** are present. Comment on their acidic/basic/amphoteric nature using the list given below.
   (very strongly acidic, strongly acidic, weakly acidic, very weakly acidic, basic, strongly basic, amphoteric)

   (5.5 marks)

(*b*)   **X** is a transition metal which possesses 3 unpaired electrons in its atom. In the aqueous medium, **X** forms X^{n+} ion, which is pink in colour.

   (i)   Identify the element, **X**.

   (ii)   Write the electron configuration of **X**.

(iii) State **two** oxides derived from the stable oxidation numbers of **X**.

....

(iv) Write the formula of the pink coloured complex ion of X^{n+} in the aqueous medium.

....

(v) When an aqueous solution containing X^{n+} is treated drop-wise with a dil. NH_4OH solution, blue precipitate is formed and when it is treated with excess NH_3 solution, a yellow brown solution is formed.

(a) What are the compounds responsible for the colours mentioned above?

....

(b) Write the appropriate balanced chemical equations, responsible for the colour changes above.

....

....

(vi) What could be observed, when H_2O_2 is bubbled through the solution containing the yellow brown complex in (v) above? Give reasons for that.

....

....

(4.5 marks)

3. (*a*) Under the constant pressure and at temperature **T**, a rigid vessel with area of its cross section *A* and length *l*, contains the two gasses He and Ne.

(i) The total pressure of the system is P_1. Deduce an expression for the total number of moles, n_T in the system

....

....

....

....

....

(ii) When the temperature of the the rigid vessel is doubled, the new pressure is P_2. If no volume change occurs, deduce an expression for P_2, in terms of P_1.

....

....

....

....

....

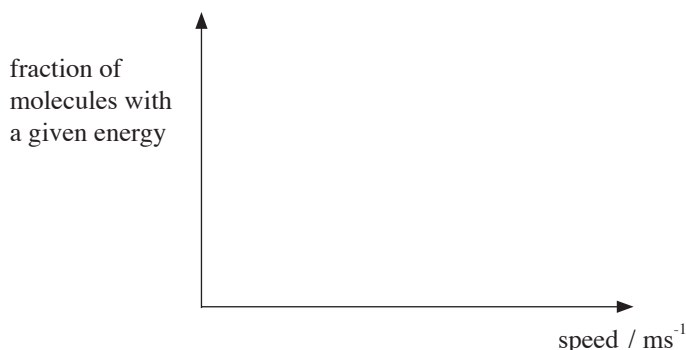...

(iii) Draw the Baltzman distribution curves for a gas (He or Ne) at each of the above temperatures, in the graph given below.

fraction of
molecules with
a given energy

speed / ms^{-1}

(4.0 marks)

(*b*) A, B and C are three volatile liquids which are miscible with each other. The partial pressures and the saturated vapour pressures of each of the components are P_A, P_B, P_C and $P°_A$, $P°_B$, $P°_C$ respectively. The mole fractions of A, B and C in the liquid phase are as x_A, x_B and x_C respectively. The volatility of each of the components varies as A > B > C.

Attractive forces between the molecules in the mixtures vary as,

A – A
B – B   < A - B   and   A – A
C – C   > A – C

1.0 mol each of A and B, as well as 1.0 mol each of A and C are mixed in 2 closed vessels, separately and allowed each system to reach the equilibrium.

(i) Mark $P°_A$, $P°_B$ and $P°_C$ in the appropriate axes of the diagrams given below.

(ii) Draw the variation of P_A, P_B and P_C against the composition in those diagrams.

(iii) Draw the variation of the total pressure (P_{AB}) in the gaseous phase of A and B mixture, in the appropriate diagram.

(iv) Draw the variation of the total pressure (P_{AC}) in the gaseous phase of A and C mixture, in the appropriate diagram.

(v) Fill in the blanks given below.

The mixture AB shows .... deviation from the ideal condition and the mixture AC shows .... deviation from the ideal condition.

vapour pressure		vapour pressure	vapour pressure		vapour pressure

x_A 0   1 x_C 0   1
x_B 1   0 x_A 1   0
diagram (1)   diagram (2)
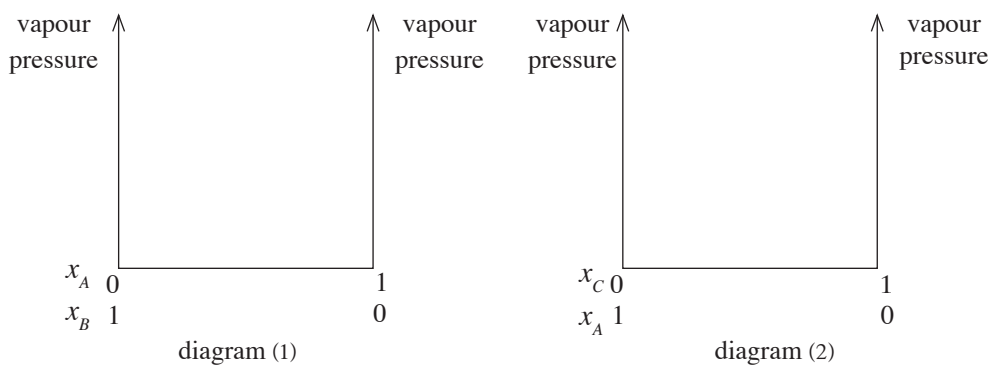
(6.0 marks)

4. (*a*)   **A**, **B** and **C** are isomers of three primary amines with the molecular formula $C_4H_{11}N$. When these compounds were reacted with $NaNO_2$ and dil.HCl, the products **D**, **E** and **F** respectively were obtained. **F** does not react with pyridinium chlorochromate (PCC).

(i)   Draw the structures of **C** and **F** in the boxes given below.
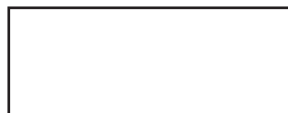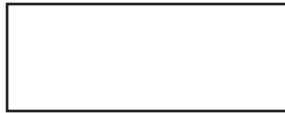
C	**F**

(ii)   **D** and **E** react with PCC forming **X** and **Y** respectively. **Y** does not answer Feiling's reagent. Draw the structures of **B**, **E** and **Y**.
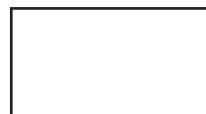
B	**E**	**Y**

(iii) State the possible structures for **A** in the boxes given below.
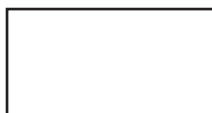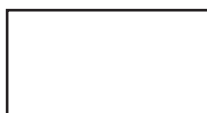
(iv)   When **D** is heated with conc.H_2SO_4 and the resulting product is reacted with aqueous H_2SO_4 , **F** is given. State the structures of **A, D** and **X** in the boxes given below.
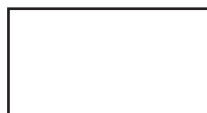
A	**D**	**X**

(4.0 marks)

(*b*)   Consider the reaction scheme given below.
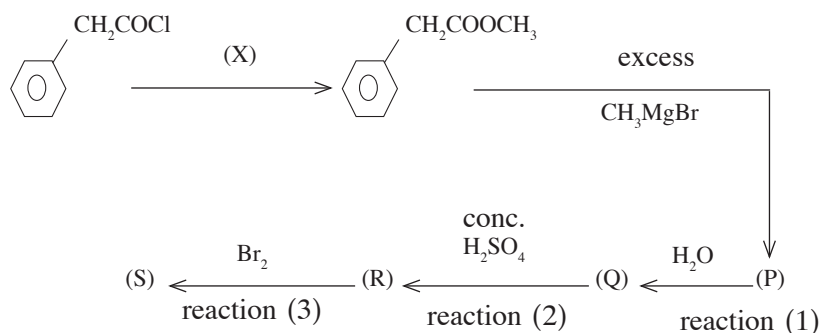
(i)   What is the structure of the reagent, **X** ?

(ii) Write down the products **P**, **Q**, **R** and **S** .

P	**Q**	**R**	**S**

(iii) Consider the reactions from 1 to 3 given above. State whether each of the reactions belongs to nucleophilic addition (A_N) nucleophilic substitution (S_N), electrophilic addition (A_E), electrophilic substitution (S_E), elimination (E) or any other mechanism (O).

Reaction	Reaction type
1.	....
2.	....
3.	....

(3.4 marks)

(*c*) (i) When alkyl halide $(CH_3)_3 CBr$ is treated with dil. NaOH solution, a reaction takes place in 2 steps. Write the steps in the mechanism of the above reaction.

(ii) The reaction takes place between CH_3CH_2Br and dil. NaOH has a single step. Explain the reason for this compared to the reaction (i) given above.

(2.6 marks)

* *

PART B - ESSAY
Answer **two** questions only. Each question carries **15 marks.**

5. (*a*) At the temperature 700 K, a rigid, closed vessel with $2.5\,dm^3$ volume, contained 0.15 mol of gas X_2. H_2 gas was inserted into the vessel until the final pressure became $8.5 \times 10^5\,Nm^{-2}$. Then there was no change in heat or change in volume. When the catalyst is introduced into the closed vessel, it reached the following equilibrium.

$$X_2(g) + 2\,H_2(g) \rightleftharpoons 2\,H_2X(g)$$

In the equilibrium system, 0.08 mol of $H_2X_{(g)}$ has been formed.

(i) Calculate the partial pressure of X_2, before the equilibrium is reached.

(ii) Calculate the total number of gas moles in the system at the equilibrium.

(iii) How many moles of H_2 is introduced into the system?

(iv) Write the expressions for K_c and K_p for the equilibrium system above.

(v) Calculate the values for K_c and K_p at 700 K.

(6.0 marks)

(*b*) The equilibrium, $H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$ exists in any aqueous solution.

(i) Write an expression for the ionic product, K_w of water.

(ii) Show that $pH + pOH = pK_w$, for any aqueous solution.

(iii) In the aqueous solution, BOH is a mono acidic weak base. Deduce the expression for the pH of a BOH solution with the concentration, $C\,mol\,dm^{-3}$ at 25 °C as,
$$pH = 14 - \frac{1}{2}\,pK_b + \frac{1}{2}\log C.$$
K_b is the base ionization constant of BOH.

(iv) Calculate the pH value of 0.1 $mol\,dm^{-3}$ BOH solution, at 25 °C .
(K_b of BOH $= 1 \times 10^{-5}\,mol\,dm^{-3}$)

(v) BCl is the salt formed when BOH reacts with HCl. The solution **X** is prepared by treating 25.00 cm^3 of BCl solution of concentration C_1 mol dm^{-3} with 25.00 cm^3 of NaOH solution of concentration C_2 mol dm^{-3}. Exactly, half the volume of solution **X** was taken into a titration flask and titrated with 0.1 mol dm^{-3} HCl solution in the presence of the indicator, methyl orange. The burette reading obtained was 35.00 cm^3. Write the balanced chemical equations for all the reactions mentioned above.

(vi) The remaining portion of the solution **X** was also taken into a titration flask and titrated with 0.1 mol dm^{-3} HCl solution in the presence of the indicator, phenolphthalein. The burette reading obtained was 15.00 cm^3.

I. Plot the variations of the pH values against the volume of HCl added, during the titrations (v) and (vi) above, in a same graph. Mark the approximate pH ranges of the two indicators, phenolphthalein and methyl orange as well as the burette readings, in your graph.

II. Calculate the values, C_1 and C_2 .

(9.0 marks)

6. (*a*) (i) "Solubility product" can be applied for strong electrolytes which are sparingly soluble in water.

   I.   What is meant by "strong electrolytes" ?

   II. For the compounds such as NaCl which are readily soluble in water, the term "solubility product" is not applicable. Explain.

(ii) A certain mass of solid Ag_2CrO_4 is added into a given volume (excess) of water and stirred well. After a certain time period, the concentrations of each of the ions in the solution become constant. When this system is treated with conc. NH_3 solution, the yellow colour intensity of the solution increases. Using the basic concepts in chemical equilibrium, explain the above facts.

(iii) At 27 °C, molar solubility of Ag_2CrO_4 is $1 \times 10^{-4} \, mol \, dm^{-3}$. At this temperature, calculate the solubility product of Ag_2CrO_4.

(iv) By dissolving solid Ag_2CrO_4 in water, a saturated aqueous solution was prepared. $250.00 \, cm^3$ portion of this solution was treated with $250.00 \, cm^3$ of $2.0 \, mol \, dm^{-3} \, Na_2CrO_4$ solution. Calculate the number of moles of Ag_2CrO_4 precipitated at $27 \,°C$?

(v) What is the minimum number of moles of NH_3 that could be dissolved in the solution of (iv) above, without initiating the formation of a precipitate. State the assumptions you made in the calculation.

   $Ag^+(aq) + 2NH_3(aq) \rightleftharpoons [Ag(NH_3)_2]^+(aq)$
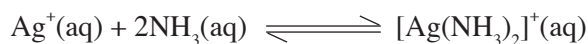
   For the reaction given above, the equilibrium constant, $K_c = 1.0 \times 10^8 \, dm^6 \, mol^{-2}$.

   (9.0 marks)

(*b*) X and Y are two elements which form monovalent and divalent cations respectively. Given below is some thermochemical data of   X and Y, at $25 \,°C$.

Chemical species	X(s)	Y(s)	X^+(aq)	Y^{2+}(aq)
standard molar enthalpy / $kJ \, mol^{-1}$	0	0	105	−89
standard molar entropy/ $J K^{-1} \, mol^{-1}$	42	27	72	−137

   $2X(s) + Y^{2+}(aq) \longrightarrow 2X^+(aq) + Y(s)$
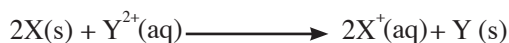
(i) For the above reaction at $25 \,°C$,

   I.   Calculate ΔH^θ.

   II. Calculate ΔS^θ.

   III. Calculate ΔG^θ.

(ii) State the relative positions of each of the electrode given below, in the electrochemical series, compared to the position of that of hydrogen. State clearly that how did you come across your answer.

   $X^+(aq) + e \longrightarrow X(s)$

   $Y^{2+}(aq) + 2e \longrightarrow Y(s)$

(iii) In a cell formed by the above two electrodes,

    I.   State the anode and the cathode.

    II.   Write down the anodic reaction.

    III.   Write down the cathodic reaction.

   IV.   Write down the standard notation of the above cell.

(6.0 marks)

7. (*a*) (i) Write the balanced chemical equation for the reaction that takes place between the compound,


and Na.
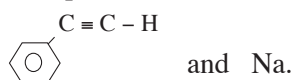
(ii) The resultant salt of the above reaction can act as a nucleophile. Using your knowledge on the reaction that takes place between carbonyl compounds and Grignard reagent, write down the reaction that takes place between the salt formed in (i) above, with CH_3CHO.

(iii) Using as the only organic compound, show how you would synthesize the following compound, with less than 6 steps.
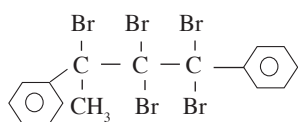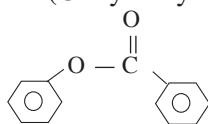

(7.5 marks)

(*b*)
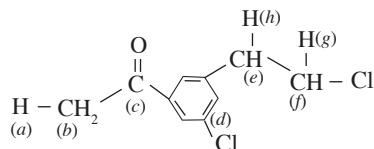
(i) Out of the positions marked as *a* to *h* in the compound given above, which positions react with OH^- to form a stable compound ?

(ii) At the instances where a stable product is formed in (i) above, state the type of the reaction undergone by OH^-.

(2.5 marks)

(*c*) (i) Using **A** as the only organic compound, show how you would synthesize the organic compound **B** given below. (Carry out your synthesis using less than 6 steps.)
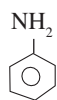
A   **B**

(ii) State, how could be prepared a sample of -COOH experimentally, by using the compound, .

(5.0 marks)

PART C - ESSAY

Answer **two** questions only. Each question carries **15 marks.**

8. (*a*) (i) When a coloured solid mixture, containing two simple ionic compounds, is heated with water, a colourless solution and a pink precipitate were formed. The resulting hot solution when filtered and cooled, a dark yellow precipitate was formed. The pink precipitate given above, dissolves in conc. HCl forming a blue solution. Giving reasons, identify the components in the initial solid mixture.

   (ii) Write the formula of the blue species formed above and write its IUPAC name.

   (3.0 marks)

   (*b*) The aqueous solution **X** contains four anions as their sodium salts. Some experiments carried out to identify those anions are given below.

   (i) When a small portion of **X** was treated with excess amount of lead acetate solution, a white precipitate was formed. When it was separated and heated, it turned black on heating.

   (ii) The filtrate obtained from (i) was treated with NaCl solution and all the Pb^{2+} ions remained, were precipitated as $PbCl_2$ and removed. The resulting filtrate (Y) can decolourize an acidic $KMnO_4$ solution. When filtrate Y was treated with **excess** $CaCl_2$ solution, a precipitate is formed. When it is filtered, a new filtrate, Z is obtained but it cannot decolourize acidic $KMnO_4$.

   (iii) A white precipitate is formed, when the filtrate Z is heated.

   (iv) When the filtrate obtained from above (iii) is heated with NaOH and Al powder, NH_3 gas liberates.

   Identify the four anions in the solution X, by stating the conclusions you made in each of the four experiments.

   (5.0 marks)

   (*c*) Solution Q contains the ions Fe^{3+}, Cl^- and H^+. Concentrations of those ions were determined by following the methods (A, B and C) given below.

   (A) $25.00\,cm^3$ of solution Q was treated with excess $AgNO_3$ solution. The dry mass of the precipitate formed was $0.287\,g$.

   Calculate the concentration of Cl^- in the solution Q, in $mol\,dm^{-3}$.

   (r.a.m. of Ag - 108, Cl - 35.5)

   (B) $25.00\,cm^3$ portion from the solution Q was taken and bubbled with sufficient amount of H_2S for the complete precipitation of Fe^{3+} ions as FeS. It was filtered to remove the sulphur containing only two products FeS and S, (The resultant filtrate was kept aside to be used in the method (C)).

   The precipitate formed above was dried and then roasted in air. The gas, SO_2 liberated was passed into $50.00\,cm^3$ of $0.048\ mol\,dm^{-3}$ acidic $KMnO_4$ solution.

   $25.00\ cm^3$ of $0.12\ mol\ dm^{-3}$ $H_2C_2O_4$ solution was consumed for the complete reaction with un-reacted $KMnO_4$ solution. Calculate the concentration of Fe^{3+} in solution Q.

   (C) H_2S was completely removed from the filtrate obtained from method B and it was titrated with $0.60\ mol\,dm^{-3}$ NaOH solution. Volume of $20.00\ cm^3$ of NaOH consumed. Calculate the concentration of H^+ in the solution Q.

   (7.0 marks)

9. (*a*)   Phosphorus is an essential nutrient for all the beings. Super phosphate is an important fertilizer which provides phosphorus to plants. As a source of phosphorus, it is not suitable to use apatite directly for short-term cultivations. Therefore, apatite is first reacted with acids and then used as a fertilizer for short-term crops.

   (i)   What is the main chemical compound in apatite?

   (ii)   Why it is not suitable to use apatite directly for short-term cultivations?

   (iii)   Write the balanced chemical equation to represent the reaction that takes place between apatite and acids, considering nitric acid as example.

   (iv)   Explain why the main product formed by the above reaction is more suitable as a phosphorus fertilizer for short-term cultivations.

   (v)   The flow chart given below shows how super phosphate to be produced in Sri Lanka, by using the natural raw materials.
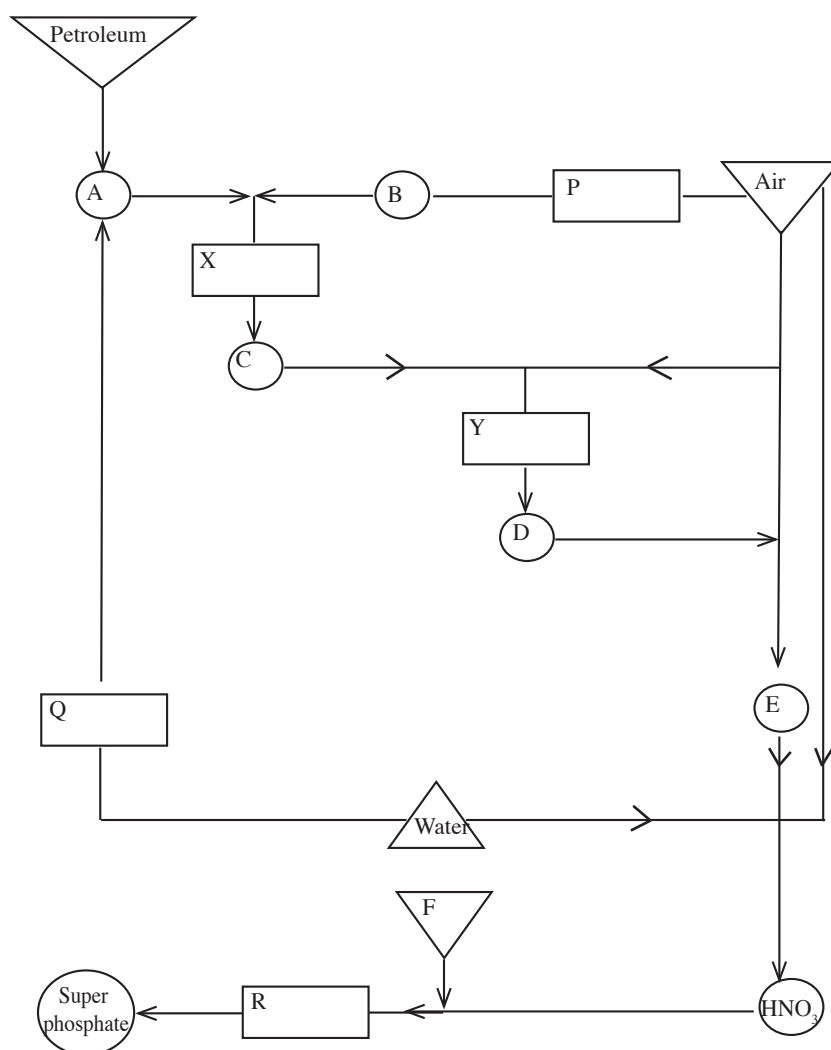
   I.   Identify the chemical species from **A** to **F**.

   II.   Name the processes **P**, **Q** and **R**.

   III.   State the appropriate reaction conditions (temperature, pressure and catalysts) in the two boxes **X** and **Y**.

(7. 0 marks)

(*b*) Membrane cell is used, in the industrial production of NaOH.
  (i) State the substances used as the anode and the cathode, in the above mentioned electrolysis process.
  (ii) Write the balanced chemical equations for the half reactions that take place at the anode and the cathode.
  (iii) How is the electroneutrality of solutions maintained in the above electrolysis process?
  (iv) In the production process, it is a disadvantage for the major product to be in contact with byproducts. What are the precautions taken, to prevent this ?
  (v) Give **four** uses of NaOH. (other than using in the laboratory)
  (3.0 marks)

(*c*) For the sustainability in the existence of the earth, it is important to maintain the optimum compositions in the atmosphere, hydrosphere and the earth surface to keep the environmental equilibrium. Presence of oxygen makes the atmosphere activated while confirming the existence of the life on the earth.
  (i) Give **two** ways by which the atmosphere gets usable O_2 .
  (ii) Name **three** intermediate ions containing nitrogen, that are formed while animal proteins are converted into atmospheric N_2.
  (iii) State **four** environmental issues created in associated with the atmosphere, due to the breakdown of the above mentioned equilibrium.
  (iv) Acid rain water when fallen into the soil, living and non-living systems are affected. State **two** effects of it on the living systems.
  (v) State **two** components of the photochemical smog.
  (vi) State more appropriate **two** actions, that can be taken to control the level of atmospheric CO_2.
  (vii) State **two** steps, that can be taken to control the exhaust gas formed by the combustion of fuel in vehicles.
  (5.0 marks)

10. (*a*) In the acidic medium, the species X^{n+} is completely oxidized into XO_2^+ by IO_3^- ions. $12.0\,cm^3$ of $0.1\,mol\,dm^{-3}$ KIO_3 solution was consumed to react with $10.0\,cm^3$ of $0.2\,mol\,dm^{-3}$ X^{n+} aqueous solution. Find the value n.
  (2.5 marks)

(*b*) Major products formed by the reactions of a certain solid element of p block and one of its gaseous compounds are given below.
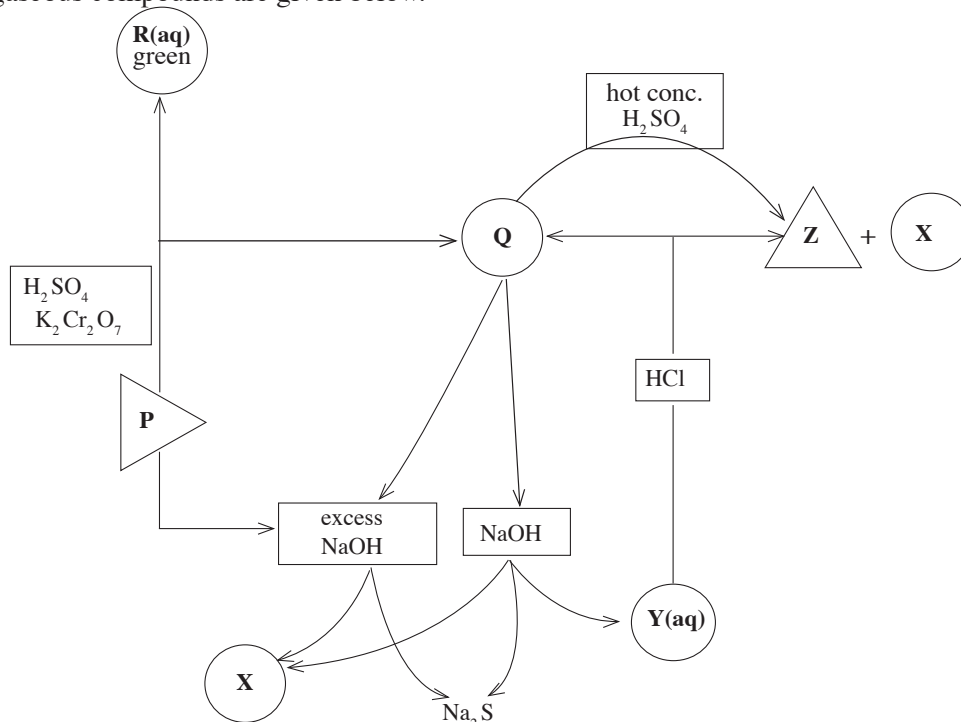
(i) Identify **P, Q, R, X, Y** and **Z**.

(ii) Write the balanced chemical equations for the following instances, including all the products formed. (Other than the given products, some other products also formed).

I. $\quad$ **P** $\longrightarrow$ **Q** + **R**

II. $\quad$ **P** $\xrightarrow[\text{NaOH}]{\text{excess}}$ Na_2S + **X**

III. $\quad$ **Q** $\xrightarrow{\text{NaOH}}$ Na_2S + **X** + **Y**

IV. $\quad$ **Y** $\xrightarrow{\text{HCl}}$ **Q** + **Z**

V. $\quad$ **Q** $\xrightarrow[\text{H}_2\text{SO}_4]{\text{hot conc.}}$ **Z**

(iii) Give the appropriate balanced half equation for the decolorization of flower petals by **Z**.

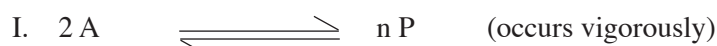**(5.0 marks)**

(*c*) $\quad$ 2 A + B + C $\longrightarrow$ products

The appropriate data of an experiment, carried out to study the kinetics of the above reaction, is given in the table below.

Experiment	Initial concentration of A mol dm^{-3}	Initial concentration of B mol dm^{-3}	Initial concentration of C mol dm^{-3}	Initial rate of the formation of products mol dm^{-3} s^{-1}
1	0.05	0.05	0.05	1.0×10^{-3}
2	0.15	0.05	0.05	3.0×10^{-3}
3	0.15	0.15	0.05	9.0×10^{-3}
4	0.15	0.15	0.05	9.0×10^{-3}

(i) $\quad$ I. $\quad$ Write a mathematical expression for the rate of the reaction.

II. $\quad$ Calculate the order of the reaction with respect to the concentrations of each of the reactant A, B and C.

III. $\quad$ Write the appropriate rate equation for the reaction.

(ii) Answer the questions given below, considering that the above reaction takes place via the following main steps.

I. $\quad$ 2 A $\rightleftharpoons$ n P $\qquad$ (occurs vigorously)

II. $\quad$ P + B $\longrightarrow$ n Q $\qquad$ (occurs slowly)

III. $\quad$ Q + n C $\longrightarrow$ Products $\quad$ (occurs vigorously)

Variation of the concentrations of A and P against the time, in step I, is given below.
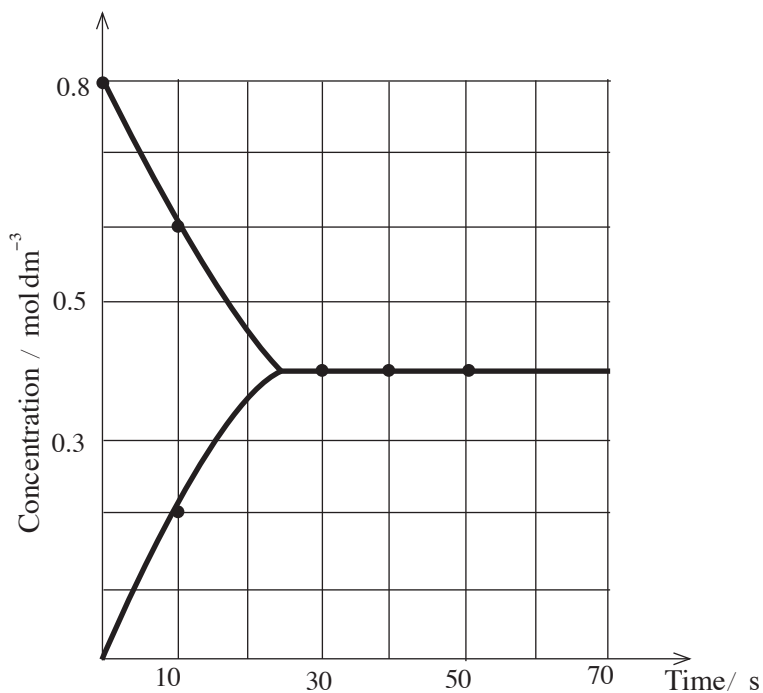
I.   Calculate the value **n** of the reaction, using, the concentration of A consumed and the concentration of P formed, in 10 s time period after the reaction has started.

II. Calculate the equilibrium constant, K_c for the equilibrium step of the above reaction.

III. Write the rate law for the rate determining step of the above reaction.

IV. With the help of the above answers, show that, for the rate determining step, the rate, $R = K K_c [A] [B]$.
     K is the rate constant.

(7.5 marks)

* * *