අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2023 (2024)
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2023 (2024)
General Certificate of Education (Adv. Level) Examination, 2023 (2024)

රසායන විද්‍යාව I இரசாயனவியல் I **Chemistry I**	**02 E I**	පැය දෙකයි இரண்டு மணித்தியாலம் ***Two hours***

Instructions:

- *This paper consists of* **08** *pages.*
- *A Periodic Table is also provided.*
- *Answer* ***all*** *the questions.*
- ***Use of calculators is not allowed.***
- *Write your* ***Index Number*** *in the space provided in the answer sheet.*
- *Follow the instructions given on the back of the answer sheet carefully.*
- *In each of the questions* **1** *to* **50**, *pick one of the alternatives from* (1), (2), (3), (4), (5) *which is* ***correct*** *or* ***most appropriate*** *and* ***mark your response on the answer sheet with a cross*** (×) ***in accordance with the instructions given on the back of the answer sheet.***

Universal gas constant $R = 8.314\ J\ K^{-1}\ mol^{-1}$ Planck's constant $h = 6.626 \times 10^{-34}\ J\ s$
Avogadro constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$ Velocity of light $c = 3 \times 10^{8}\ m\ s^{-1}$

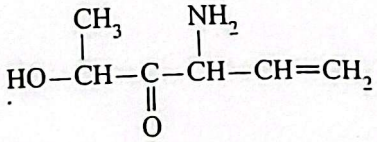
1. If the wave length of radiation used in a microwave oven to heat food is 1.1 cm, the energy of one photon of this microwave radiation is,
(**Note** : Use Planck's constant, $h = 6.6 \times 10^{-34}$ J s for the calculation.)
(1) 6.0×10^{-26} J (2) 1.8×10^{-24} J (3) 1.8×10^{-23} J (4) 1.8×10^{-22} J (5) 6.0×10^{-20} J

2. From the list given below, identify the emission lines in the hydrogen spectrum that have the highest frequency and the lowest frequency respectively.
Emission line list (n = Principal quantum number)
$n = 3 \rightarrow n = 1$, $n = 2 \rightarrow n = 1$, $n = 3 \rightarrow n = 2$, $n = 4 \rightarrow n = 2$, $n = 4 \rightarrow n = 3$
(1) $n = 3 \rightarrow n = 1$, $n = 2 \rightarrow n = 1$ (2) $n = 3 \rightarrow n = 1$, $n = 4 \rightarrow n = 3$
(3) $n = 2 \rightarrow n = 1$, $n = 4 \rightarrow n = 3$ (4) $n = 3 \rightarrow n = 1$, $n = 3 \rightarrow n = 2$
(5) $n = 2 \rightarrow n = 1$, $n = 3 \rightarrow n = 2$

3. When the compounds given below are heated, they decompose according to the reaction,
$MCO_3(s) \xrightarrow{\Delta} MO(s) + CO_2(g)$
Identify the compound with the lowest decomposition temperature.
(1) $BeCO_3$ (2) $MgCO_3$ (3) $CaCO_3$ (4) $SrCO_3$ (5) $BaCO_3$

4. The electron pair geometries around the central atoms of $F_2IO_2^+$, $F_2BrO_2^-$ and $IBrCl_3^-$ are respectively,
(1) see-saw, tetrahedral and octahedral.
(2) tetrahedral, see-saw and square pyramidal.
(3) trigonal bipyramidal, square planar and square pyramidal.
(4) tetrahedral, see-saw and octahedral.
(5) tetrahedral, trigonal bipyramidal and octahedral.

5. What is the IUPAC name of the following compound?



(1) 4-amino-3-oxohex-5-en-2-ol
(2) 5-hydroxy-4-oxohex-1-en-3-amine
(3) 3-amino-5-hydroxyhex-1-en-4-one
(4) 4-amino-2-hydroxyhex-5-en-3-one
(5) 3-amino-5-hydroxy-4-oxohex-1-ene

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6. Solubility products of some metal chlorides at a given temperature are listed below.

Metal chloride	Solubility product
A : $PbCl_2$	5.00×10^{-7} $mol^3\ dm^{-9}$
B : CuCl	1.60×10^{-7} $mol^2\ dm^{-6}$
C : AgCl	1.60×10^{-10} $mol^2\ dm^{-6}$
D : Hg_2Cl_2	1.08×10^{-16} $mol^3\ dm^{-9}$

In which sequence are the metal chlorides arranged in the order of **increasing** chloride ion concentration of their saturated aqueous solutions?

(1) A < B < C < D (2) B < A < C < D (3) A < B < D < C
(4) D < C < B < A (5) D < C < A < B

7. Select the **incorrect** statement.

(1) Ionic radii of isoelectronic monoatomic ions decrease when nuclear charge increases.
(2) He (Helium) atom is the smallest among all atoms.
(3) The radius of Na^+ is larger than the atomic radius of Li.
(4) KF shows the greatest ionic character among LiI, KF and KI.
(5) Xe has the highest boiling point among noble gases.

8. The **increasing** order of electronegativity of the underlined carbon atom (C) in $CH_3\underline{C}H_2Br$, $CH_2{=}\underline{C}HF$, $CH_2{=}\underline{C}HCl$ and $HC{\equiv}\underline{C}F$ is

(1) $CH_3\underline{C}H_2Br < CH_2{=}\underline{C}HF < CH_2{=}\underline{C}HCl < HC{\equiv}\underline{C}F$
(2) $HC{\equiv}\underline{C}F < CH_2{=}\underline{C}HCl < CH_2{=}\underline{C}HF < CH_3\underline{C}H_2Br$
(3) $CH_2{=}\underline{C}HF < CH_2{=}\underline{C}HCl < CH_3\underline{C}H_2Br < HC{\equiv}\underline{C}F$
(4) $CH_3\underline{C}H_2Br < CH_2{=}\underline{C}HCl < CH_2{=}\underline{C}HF < HC{\equiv}\underline{C}F$
(5) $CH_3\underline{C}H_2Br < CH_2{=}\underline{C}HF < HC{\equiv}\underline{C}F < CH_2{=}\underline{C}HCl$

9. Which of the following represents a chain propagation step in the free radical chlorination reaction of methane?

(1) $CH_3Cl + \dot{C}l \longrightarrow CH_2Cl_2 + \dot{H}$ (2) $CH_2Cl_2 + \dot{C}l \longrightarrow \dot{C}HCl_2 + HCl$
(3) $\dot{C}H_3 + \dot{C}l \longrightarrow CH_3Cl$ (4) $CHCl_3 + \dot{C}l \longrightarrow CCl_4 + HCl$
(5) $\dot{C}l + \dot{C}l \longrightarrow Cl_2$

10. The experimentally determined rate law of the reaction $A_2 + B_2 \longrightarrow A_2B_2$ is, rate = $k\,[A_2]$. Here k is the rate constant. The following mechanisms are proposed for this reaction.

(I)
$A_2 \longrightarrow 2A$ (slow)
$A + B_2 \longrightarrow AB_2$ (fast)
$AB_2 + A \longrightarrow A_2B_2$ (fast)

(II)
$A_2 \longrightarrow 2A$ (slow)
$2A + B_2 \longrightarrow A_2B_2$ (fast)

(III)
$A_2 \longrightarrow 2A$ (slow)
$A + B_2 \longrightarrow AB + B$ (fast)
$A + AB \longrightarrow A_2B$ (fast)
$A_2B + B \longrightarrow A_2B_2$ (fast)

Which of the following statements is correct regarding the above reaction?

(1) Only the mechanisms I and II are consistent with the rate law.
(2) Only the mechanisms II and III are consistent with the rate law.
(3) Only the mechanisms I and III are consistent with the rate law.
(4) No mechanism is consistent with the rate law.
(5) All the mechanisms are consistent with the rate law.

11. Identify the **incorrect** statement with regard to the thermal decomposition of the salts given below.
NH_4Cl, NH_4NO_2, NH_4NO_3, $(NH_4)_2CO_3$ and $(NH_4)_2Cr_2O_7$

(1) Only two of the salts give NH_3 as a product.
(2) Only two of the salts give N_2 as a product.
(3) Only two of the salts give an acidic gas as a product.
(4) Only one of the salts gives a product that exists as a solid at room temperature.
(5) Only two of the salts give H_2O as a product.

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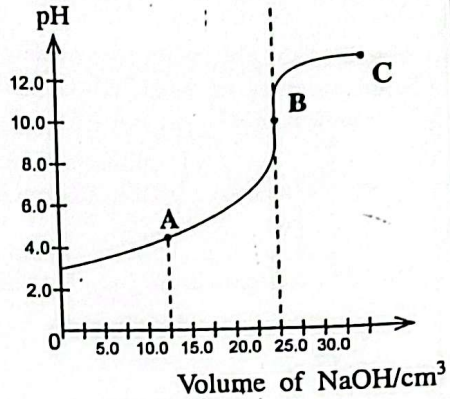
12. The titration curve given was obtained for the titration of a monobasic weak acid with NaOH. Of the statements given below, identify the **incorrect** statement.



(1) At point **A**, the pH of the titration mixture is equal to the pK_a of the weak acid.

(2) At point **A**, the concentrations of the remaining weak acid and its conjugate base in the titration mixture are equal.

(3) At point **B**, the concentrations of H^+ and OH^- in the titration mixture are equal.

(4) Phenolpthalein can be used as an indicator for this titration.

(5) At point **C**, the pH of the titration mixture is lower than the pH of the NaOH solution used.

13. An organic compound **A** gives a coloured precipitate with 2,4-dinitrophenylhydrazine. When compound **A** is reacted with acidified potassium dichromate, compound **B** is formed and the solution becomes green. The compound **B** did not give a coloured precipitate with 2,4-dinitrophenylhydrazine. The structure of **A** could be:

(1) $CH_3\overset{O}{\overset{\|}{C}}CH_2CH_2CH_2\overset{OH}{\overset{|}{C}}HCH_3$ (2) $CH_3\overset{O}{\overset{\|}{C}}CH_2CH_2CH_2CH_2OH$ (3) $HOCH_2CH_2CH_2CH_2CHO$

(4) $HO\overset{CH_3}{\overset{|}{C}}HCH_2CH_2CH_2CHO$ (5) $HO\overset{CH_3}{\overset{|}{C}}HCH_2CH_2CH_2CH_2OH$

14. The volume of 5.0 mol dm^{-3} H_2SO_4 required to react completely with 20.0 cm^3 of 30% NaOH by mass and density 1.4 g cm^{-3} is,
(H = 1, O = 16, Na = 23)
(1) 15.0 cm^3 (2) 21.0 cm^3 (3) 30.0 cm^3 (4) 42.0 cm^3 (5) 84.0 cm^3

15. A closed rigid container at room temperature contains equal masses of He and Ne gases. The total pressure of the container is P. The partial pressure of He is,
(He = 4, Ne = 20)
(1) P (2) $\frac{5P}{6}$ (3) $\frac{6P}{5}$ (4) $\frac{P}{2}$ (5) $\frac{P}{6}$

16. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
The above reaction is at equilibrium in a closed rigid container at constant temperature. Which of the following statements correctly explains the change in the rates of forward and reverse reactions, immediately after the addition of a certain quantity of $I_2(g)$ in to the container?
(1) The rates of forward and reverse reactions decrease.
(2) The rates of forward and reverse reactions increase.
(3) The rates of forward and reverse reactions do not change.
(4) The rate of the forward reaction increases, the rate of the reverse reaction does not change.
(5) The rate of the forward reaction decreases, the rate of the reverse reaction does not change.

17. A solution was prepared by mixing 100.0 cm^3 of 1.0 mol dm^{-3} $CH_3COOH(aq)$ and 100.0 cm^3 of 1.0 mol dm^{-3} $CH_3COONa(aq)$. The pH of the resulting solution at 25 °C was 4.8. When a few drops of 0.10 mol dm^{-3} HCl(aq) was added to this solution and mixed well, the pH still remained at 4.8. Which of the following reactions would have taken place to prevent the pH from changing?
(1) $H_3O^+(aq) + OH^-(aq) \longrightarrow 2H_2O(l)$
(2) $H_3O^+(aq) + CH_3COO^-(aq) \longrightarrow CH_3COOH(aq) + H_2O(l)$
(3) $H_3O^+(aq) + Cl^-(aq) \longrightarrow HCl(aq) + H_2O(l)$
(4) $H_3O^+(aq) + CH_3COOH(aq) \longrightarrow CH_3COOH_2^+(aq) + H_2O(l)$
(5) $H_3O^+(aq) + OH^-(aq) + CH_3COOH(aq) \longrightarrow CH_3COO^-(aq) + 2H_2O(aq) + H^+(aq)$

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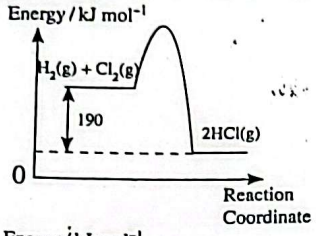
18. Which of the following represents the energy diagram of the reaction $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$? Bond energies of H–H, Cl–Cl and H–Cl are 430, 240 and 430 kJ mol^{-1} respectively.

(1)


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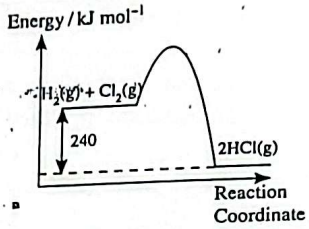
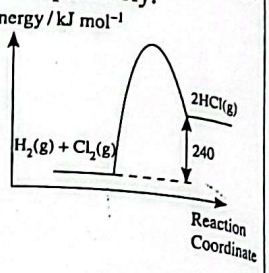


(3)


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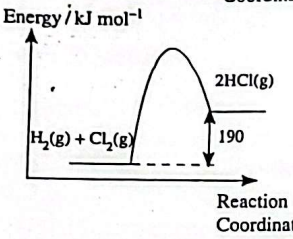
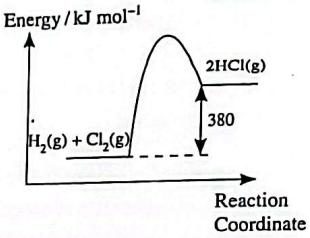


(5)


19. Consider the reactions given below. The ΔG values at temperature T are given.

$4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$ $\quad \Delta G = -1010$ kJ mol^{-1}

$2NO_2(g) \longrightarrow 2NO(g) + O_2(g)$ $\quad \Delta G = 70$ kJ mol^{-1}

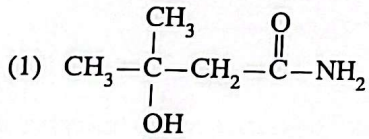
$4NO_2(g) + O_2(g) + 2H_2O(l) \longrightarrow 4HNO_3(aq)$ $\quad \Delta G = -170$ kJ mol^{-1}

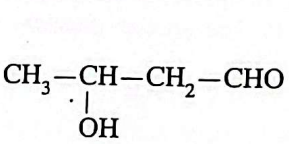
ΔG (kJ mol^{-1}) for the reaction $NH_3(g) + 2O_2(g) \longrightarrow HNO_3(aq) + H_2O(l)$ at temperature T is,

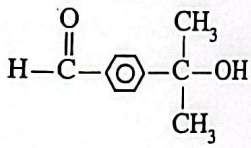
(1) –1320 (2) –1250 (3) –1110 (4) –580 (5) –330

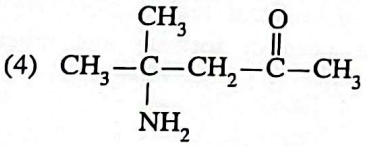
20. Which of the given compounds will undergo all three of the reactions (I, II and III) given below?

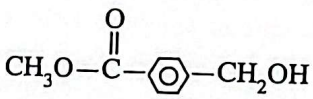
I Reacts with PCl_5 to give a chloro compound.
II Undergoes self-condensation in the presence of aqueous NaOH.
III Undergoes a reduction reaction with $LiAlH_4$.

(1) 

(2) 

(3) 

(4) 

(5) 

21. Consider the following reversible reaction.

$FeF_2(s) + 2H^+(aq) \rightleftharpoons Fe^{2+}(aq) + 2HF(aq)$

(K is the equilibrium constant of the above reaction.)

This equilibrium is reached through the following mechanism.

$FeF_2(s) \rightleftharpoons Fe^{2+}(aq) + 2F^-(aq)$ $\quad K_1 = 2.0 \times 10^{-6}$ mol^3 dm^{-9}

$F^-(aq) + H^+(aq) \rightleftharpoons HF(aq)$ $\quad K_2 = 1.0 \times 10^3$ mol^{-1} dm^3

Which of the following statements is correct regarding the overall equilibrium?

(1) The position of equilibrium lies close to products because $K_2 > 1$.
(2) The position of equilibrium lies close to reactants because $K_1 < 1$.
(3) The position of equilibrium lies close to products because $K > 1$.
(4) The position of equilibrium lies close to reactants because $K < 1$.
(5) Cannot determine the position of equilibrium from the given information.

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Which of the following statements regarding carboxylic acids is **incorrect?**

(1) Carboxylic acids cannot be reduced to alcohols with $NaBH_4$.
(2) The boiling points of carboxylic acids are higher than the boiling points of alcohols with comparable relative molecular masses.
(3) Carboxylic acids react with aqueous NaOH, with the evolution of $CO_2(g)$.
(4) Carboxylic acids can form dimeric structures due to hydrogen bonding.
(5) The water solubility of carboxylic acids decreases with increasing relative molecular mass.

$$CH_3OH(g) \longrightarrow CO(g) + 2H_2(g) \quad \Delta H^\circ = 91 \text{ kJ mol}^{-1}$$

The above reaction occurs to completion in a thermally insulated closed rigid container. Which of the following is correct regarding
(i) the temperature of the contents in the container,
(ii) the sign of ΔS° of the reaction?

	Temperature	**Sign of ΔS°**
(1)	Increases	+
(2)	Decreases	+
(3)	Decreases	−
(4)	Increases	−
(5)	Does not change	+

24. A closed container equipped with a piston contains an ideal gas at temperature T and pressure P_1. The volume occupied by the gas is 2.0 dm^3. When the volume is increased to 5.0 dm^3 at the same temperature, the pressure is changed to P_2. Which of the following statements is correct regarding this system?
(1) The average kinetic energy of the gas remains the same and $P_2 = 0.4\ P_1$
(2) The average kinetic energy of the gas increases and $P_2 = 2.5\ P_1$
(3) The average kinetic energy of the gas increases and $P_2 = 0.4\ P_1$
(4) The average kinetic energy of the gas remains the same and $P_2 = 2.5\ P_1$
(5) The average kinetic energy of the gas decreases and $P_2 = 2.5\ P_1$

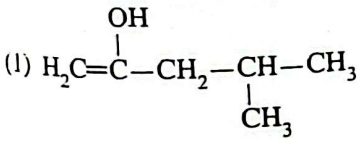
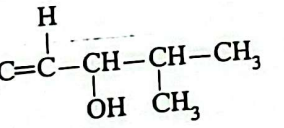
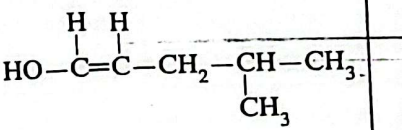
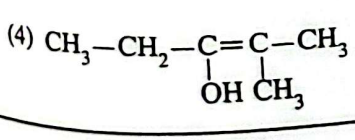
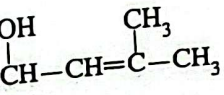
25. Consider the reaction below occuring at a given temperature.

$$N_2O(g) + CO(g) \rightarrow N_2(g) + CO_2(g)$$

The rate of the reaction is increased when this reaction is carried out in the presence of a small amount of Pd powder. Which of the following best explains this observation?
(1) Pd powder decreases the activation energy of the reaction.
(2) Pd powder supplies energy to the reaction.
(3) Pd powder helps to decrease the concentration of products.
(4) One of the products bonds to Pd and increases the rate of the reaction by decreasing the concentration of products.
(5) At least one of the reactants bonds to Pd and the reaction occurs through an alternative path having low activation energy.

26. The number of moles of electrons given out when one mole of C_2H_5OH is oxidized to CO_2 under suitable conditions is,
(1) 4 (2) 5 (3) 7 (4) 10 (5) 12

27. Consider the reaction of an alkyne with dil. H_2SO_4 / $HgSO_4$ giving a ketone. A structure that could be formed during this reaction is,

(1) 
(2) 
(3) 
(4) 
(5) 

[See page six

28. Consider the following half reactions at 298 K.

$Mg^{2+}(aq) + 2e \rightarrow Mg(s)$ $E^\circ = -2.37$ V

$Cr^{3+}(aq) + 3e \rightarrow Cr(s)$ $E^\circ = -0.74$ V

Which of the following gives the overall cell reaction and the electromotive force (E°_{cell}) of an electrochemical cell formed by the above electrodes?

		E°_{cell} (V)
(1)	$2Cr^{3+}(aq) + 3Mg(s) \rightarrow 2Cr(s) + 3Mg^{2+}(aq)$	5.63
(2)	$3Mg^{2+}(aq) + 2Cr^{3+}(aq) \rightarrow 3Mg(s) + 2Cr(s)$	1.63
(3)	$3Mg^{2+}(aq) + 2Cr(s) \rightarrow 3Mg(s) + 2Cr^{3+}(aq)$	1.63
(4)	$3Mg^{2+}(aq) + 2Cr(s) \rightarrow 3Mg(s) + 2Cr^{3+}(aq)$	5.63
(5)	$2Cr^{3+}(aq) + 3Mg(s) \rightarrow 2Cr(s) + 3Mg^{2+}(aq)$	1.63

29. $TiCl_4$ is an important industrial chemical. This can be prepared by reacting $TiO_2(s)$, $Cl_2(g)$ and C(s). The **unbalanced** chemical equation for the reaction is given below.

$TiO_2(s) + Cl_2(g) + C(s) \rightarrow TiCl_4(s) + CO_2(g)$

When 160 g of $TiO_2(s)$, 213 g of $Cl_2(g)$ and 60 g of C(s) are made to react, the maximum quantity of $TiCl_4$ that can be formed is,

(C = 12, O = 16, Cl = 35.5, Ti = 48)

(1) 190 g (2) 285 g (3) 380 g (4) 570 g (5) 950 g

30. Consider the reaction below at constant temperature.

$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$ $K_C = 6.5\ mol^{-1}\ dm^3$

1.5 mol of $PCl_3(g)$, 1.0 mol of $Cl_2(g)$ and 2.5 mol of $PCl_5(g)$ were introduced in to a previously evacuated closed rigid container having a volume 1.0 dm^3. Which of the following best explains the way the measured pressure of the container changes as the reaction approaches equilibrium?

(Q_C = reaction quotient, K_C = equilibrium constant)

(1) The pressure increases because $Q_C < K_C$
(2) The pressure increases because $Q_C > K_C$
(3) The pressure decreases because $Q_C < K_C$
(4) The pressure decreases because $Q_C > K_C$
(5) The pressure does not change because $Q_C = K_C$

● For each of the questions **31** to **40**, one or more responses out of the four responses (*a*), (*b*), (*c*) and (*d*) given 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 correct.

Summary of above Instructions

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

31. Which of the following statements correctly explain/explains why an increase in temperature increases the rate of a chemical reaction?

(*a*) At high temperature, the activation energy of the reaction is decreased.
(*b*) At high temperature, the activation energy of the reaction is increased.
(*c*) At high temperature, products are formed from every collision of reactant molecules.
(*d*) At high temperature, the fraction of collisions having energy greater than the activation energy of the reaction is increased.

[See page seven

32. Of the following, which alkyne/alkynes can give 3-ethylhexane on catalytic hydrogenation?

(a) $CH_3-CH_2-\underset{\displaystyle CH_2-CH_3}{\underset{|}{CH}}-CH_2-C\equiv CH$

(b) $HC\equiv C-CH_2-CH_2-\underset{\displaystyle CH_2-CH_3}{\underset{|}{CH}}-CH_3$

(c) $HC\equiv C-\underset{\displaystyle CH_2-CH_3}{\underset{|}{CH}}-CH_2-CH_2-CH_3$

(d) $CH_3-CH_2-\underset{\displaystyle CH_2-CH_3}{\underset{|}{CH}}-C\equiv C-CH_3$

33. Which of the following statements is/are correct?
(a) Boiling point of a liquid decreases when the pressure is increased.
(b) Boiling point of a liquid increases when the pressure is increased.
(c) On the top of Mount Everest, water can be boiled at a temperature less than 100 °C.
(d) Water cannot be evaporated in a closed rigid container.

34. Which of the following statements is/are true with regard to *p*-block elements and their compounds?
(a) The reaction of PCl_5 and SCl_2 with water gives $H_3PO_4(aq)$ and S(s) as one of the products respectively.
(b) Reaction of $Cl_2(g)$ with water and decomposition of $H_2O_2(aq)$ are examples of disproportionation reactions.
(c) A product obtained in the reaction of $Cl_2(g)$ with excess $NH_3(g)$ can be used to disinfect water.
(d) $SO_2(g)$ cannot act as a reducing agent.

35. Which of the following statements is/are correct regarding the reactions of alcohols?
(a) The leaving group of the reaction between alcohols and HBr giving bromoalkanes is OH^-.
(b) Some alkenes can be prepared by heating alcohols with conc. H_2SO_4.
(c) Alcohols react with HI to give alkyliodides only when Lewis acids are present.
(d) Primary alcohols do not produce turbidity when subjected to the Lucas test, because primary alcohols are soluble in water.

36. Which of the following statements is/are correct with regard to colours observed for precipitates / solutions when (i) excess NaOH(aq) and (ii) excess $NH_4OH(aq)$ are added separately to aqueous solutions of each of the following cations Co^{2+}, Ni^{2+}, Cu^{2+} and Zn^{2+}?
(a) Co^{2+} gives (i) a brown precipitate and (ii) a red solution respectively.
(b) Ni^{2+} gives (i) a blue precipitate and (ii) a green solution respectively.
(c) Cu^{2+} gives (i) a blue precipitate and (ii) a dark blue solution respectively.
(d) Zn^{2+} gives (i) a colourless solution and (ii) a colourless solution respectively.

37. Which of the following statements is/are correct?
(a) Addition of phosphate fertilizers to soil contributes to increase in N_2O level in the atmosphere.
(b) Respiration of farm animals such as cattle and goats contributes to the increase in CO_2 level in the atmosphere.
(c) Fossil fuel burning contributes to the increase in CH_4 level in the atmosphere.
(d) Burning of bio-fuel does not contribute to the increase in CO_2 level in the atmosphere.

38. Which of the following statements is/are correct regarding the reaction given below?

$$Cu(OH)_2(s) \rightleftharpoons Cu^{2+}(aq) + 2OH^-(aq)$$

(a) Increasing the pH of the solution decreases the solubility of $Cu(OH)_2(s)$.
(b) Addition of NaOH(s) into the solution does not change the solubility of $Cu(OH)_2(s)$.
(c) Solubility of $Cu(OH)_2(s)$ is independent of temperature.
(d) Addition of more $Cu(OH)_2(s)$ to the solution does not change the solubility of $Cu(OH)_2(s)$.

39. Which of the following statements is/are correct regarding the transesterification reaction of biodiesel production?
(a) Glycerol is a by-product.
(b) Bases cannot be used as catalysts.
(c) Presence of free fatty acids is favourable for the reaction.
(d) Activity of the catalyst is decreased due to the formation of soap.

[See page eight

40. Which of the following statements is/are correct regarding the gases present in a liquid fossil fuel burning vehicle exhaust?

(*a*) The exhaust contains gases that contribute to photochemical smog.
(*b*) The exhaust contains gases that contribute to global warming.
(*c*) The exhaust contains gases that contribute to acid rain.
(*d*) The exhaust contains gases that contribute to ozone layer depletion.

- In question Nos. **41** to **50**, 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 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** explain the first statement correctly
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	Second statement
41.	$H_2S(g)$ can act as a reducing agent as well as an oxidizing agent under suitable conditions.	Sulphur is a non metal with oxidation numbers in the range –2 to +6.
42.	Boiling point of propanone is less than the boiling point of butane.	Propanone contains a pi (π) bond whereas butane does not contain a π bond.
43.	Under certain conditions, the pressure of a real gas sample could be lower than that predicted by the ideal gas equation.	Inter molecular attractive forces are present among real gas molecules.
44.	The electronegativity of Mn is lower than the electronegativity of Cr and Fe.	The electronic configuration of Mn is more stable than the electronic configurations of Cr and Fe.
45.	Aromatic diazonium salts when warmed with water, form phenols.	Aromatic diazonium ions are electrophiles.
46.	In an electrochemical cell, the electrode having the lower reduction potential acts as the anode.	In an electrochemical cell electrons are easily released from the electrode with comparatively low reduction potential.
47.	In the production of nitric acid using Ostwald method $NO(g)$ is reacted with $O_2(g)$ at a temperature higher than the temperature at which $NH_3(g)$ is reacted with $O_2(g)$.	High temperatures are not favourable for reactions with negative entropy changes.
48.	The partition coefficient of a solute is temperature dependent.	The solubility of a solute in different solvents changes by the same amount with temperature.
49.	During the production of sulphuric acid, $SO_2(g)$ is converted to $SO_3(g)$ in several steps.	Complete conversion of $SO_2(g)$ to $SO_3(g)$ in a single step is not spontaneous under the conditions used in sulphuric acid production.
50.	HFC (hydrofluorocarbon) gas does not contribute to ozone layer depletion in the upper atmosphere.	HFC is quickly destroyed in the upper atmosphere by breaking the C–F bond.

* * *

PART A — STRUCTURED ESSAY

*Answer **all four** questions on this paper itself. (Each question carries **100** marks.)*

Do not write in this column.

1. (*a*) Write the answers to the questions given below on the dotted lines.

(i) Of the following sets of quantum numbers I, II and III, which one is **not** acceptable in describing an atomic orbital?
(I) $n=2$ $l=1$ $m_l=-1$ (II) $n=3$ $l=1$ $m_l=+2$ (III) $n=4$ $l=3$ $m_l=-3$ .....

(ii) Of the three ions Na^+, K^+ and Ca^{2+}, which one has the **largest** ionic radius? .....

(iii) Of the three cations Li^+, Na^+ and Mg^{2+}, which one has the **least** polarizing power? .....

(iv) Of the three elements Li, Be and B, which one has the **lowest** second ionization energy? .....

(v) Of the three elements Li, C and Na, which one has the **most** negative value for electron gain energy? .....

(vi) Of the three compounds CH_3OH, CH_3CH_2OH and $CH_3CH_2CH_2OH$, which one has the **strongest** intermolecular forces? .....

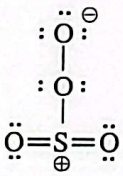
(24 *marks*)

(*b*) (i) Draw the **most** acceptable Lewis dot-dash structure for the molecule $FBrO_3$.

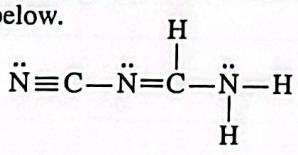
(ii) Give (I) the shape around the central atom and (II) the oxidation number of the central atom of the structure drawn in (i) above.

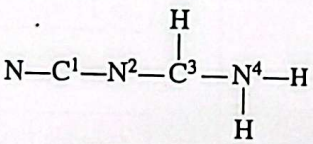
(I) ..... (shape) (II) ..... (oxidation number)

(iii) The compound SO_4 can be prepared by the reaction of SO_3 and O_3. An acceptable (stable) Lewis dot-dash structure for the molecule SO_4 is given below. Draw **three** more Lewis dot-dash structures (resonance structures) for this molecule and indicate their stabilities relative to the structure given by writing **stable** or **less stable** or **unstable** under these structures.



(iv) Complete the given table based on the Lewis dot-dash structure and its labelled skeleton given below.





		C^1	N^2	C^3	N^4
I.	the number of VSEPR pairs around the atom				
II.	electron pair geometry around the atom				
III.	shape around the atom				
IV.	hybridization of the atom				

[see page three

Do not write in this column.

Parts (v) to (viii) are based on the Lewis dot-dash structure given in part (iv) above. Labelling of atoms is as in part (iv).

(v) Identify the atomic/hybrid orbitals involved in the formation of σ bonds between the two atoms given below.

I. $N-C^1$ N ..... C^1 .....

II. C^1-N^2 C^1 ..... N^2 .....

III. N^2-C^3 N^2 ..... C^3 .....

IV. C^3-N^4 C^3 ..... N^4 .....

V. N^4-H N^4 ..... H .....

VI. C^3-H C^3 ..... H .....

(vi) Identify the orbitals involved in the formation of π bonds between the two atoms given below.

I. $N-C^1$ N ..... C^1 .....

N ..... C^1 .....

II. N^2-C^3 N^2 ..... C^3 .....

(vii) State the approximate bond angles around the C^1, N^2, C^3 and N^4 atoms.

C^1....., N^2 ....., C^3 ....., N^4.....

(viii) Arrange the atoms C^1, N^2, C^3 and N^4 in the **increasing** order of electronegativity.

..... < ..... < ..... < ..... **(56 *marks*)**

(c) State whether the following statements are **true** or **false**. Give reasons for your choice.

(i) An acceptable Lewis dot-dash structure **cannot** be drawn for the OF_4 molecule.

(ii) The **increasing** order of electronegativity of nitrogen in NO_2^+, NBr_3, NO_2Cl and HNO_2 is $NBr_3 < NO_2Cl < HNO_2 < NO_2^+$.

(20 *marks*)

100

[see page four

Do not write in this column.

2. (*a*) **A** is a *s*-block element in the Periodic Table. Its atomic number is less than 20. When **A** is heated with nitrogen and oxygen separately, two stable compounds **B** and **C** are formed respectively. **B** reacts with water to give the basic compound **D**, and a colourless gas **E** with a pungent odour that turns red litmus blue. Reaction of **A** with water at room temperature also gives **D**, and liberates a colourless, odourless, homonuclear diatomic gas **F**. **A** reacts with dil. H_2SO_4 and gives salt **G** and gas **F**. Compound **H** is formed on reaction of **D** with CO_2. **H** decomposes on heating to give compound **C** and CO_2.

(i) Identify species **A** to **H**. (Give chemical formulae.)

A ..... **E** .....

B ..... **F** .....

C ..... **G** .....

D ..... **H** .....

(ii) Write balanced chemical equations for the following reactions.

I. **A** with water .....

II. **A** with dil. H_2SO_4 .....

III. **B** with water .....

IV. Decomposition of **H** .....

(iii) Write the colour of the flame given by salts of **A** in the flame test.

.....

(65 *marks*)

(*b*) Write the chemical formulae of **P**, **Q**, **R** and **S**.

(i) **P** is a colourless solution. When CO_2 is bubbled through **P**, the solution turns milky. When excess CO_2 is bubbled through the milky solution, a clear colourless solution is obtained. **P** gives an orange-red flame when subjected to the flame test. Identify **P**.

P .....

(ii) The metal **M** belongs to the third row of the Periodic Table. **M** reacts with dilute aqueous strong acids and bases. When **M** reacts with a certain dilute aqueous strong acid, it gives the salt **Q** as one of the products. When aqueous $BaCl_2$ is added to this solution, a white precipitate is formed. The precipitate is insoluble in dilute acids. Identify **Q**.

Q .....

(iii) **R** is an ionic compound. When **R** is reacted with dil HCl, a colourless, odourless, linear triatomic gas is evolved as one of the products. **R** gives a yellow colour flame when subjected to the flame test. The metal ion in **R** is found in borax. Identify **R**.

R .....

(iv) **S** is an ionic compound. When **S** is heated, a red-brown gas is evolved. The metal in **S** burns with a bright light in air. The metal reacts slowly with hot water, to give a basic compound and $H_2(g)$. The metal ion contributes to hardness of water. Identify **S**.

S .....

[*see page five*

(v) Give balanced chemical equations for the following reactions. Indicate precipitates with the symbol ↓.

I. **P** with **Q** .....

II. **P** with **R** .....

III. **R** with **S** .....

(35 *marks*)

Do not write in this column.

100

(a) (i) A closed non-rigid container contains n moles of an ideal gas at a given temperature (T) and pressure (P). Write the relationship between the number of moles of the gas and volume V.

(ii) A closed non-rigid container of volume 150 cm^3, contains 3.75 g of $O_2(g)$ at a given temperature and pressure. If another 1.25 g of $O_2(g)$ is introduced into this container at the same temperature and pressure, what will be the new volume of the container? (O = 16)

(iii) At constant temperature and pressure, show that the molar mass (M) of an ideal gas is directly proportional to its density (d).

(40 *marks*)

[*see page six*

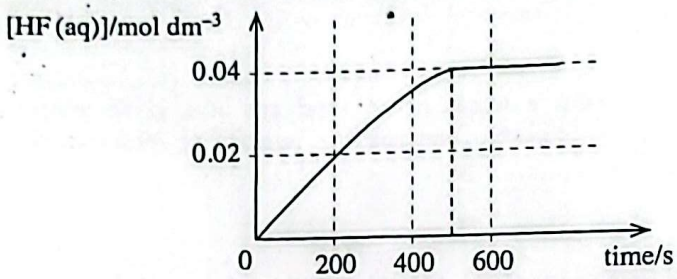
Do not write in this column.

(*b*) Consider the reversible reaction given below.

$$BF_4^-(aq) + H_2O(l) \rightleftharpoons BF_3OH^-(aq) + HF(aq)$$

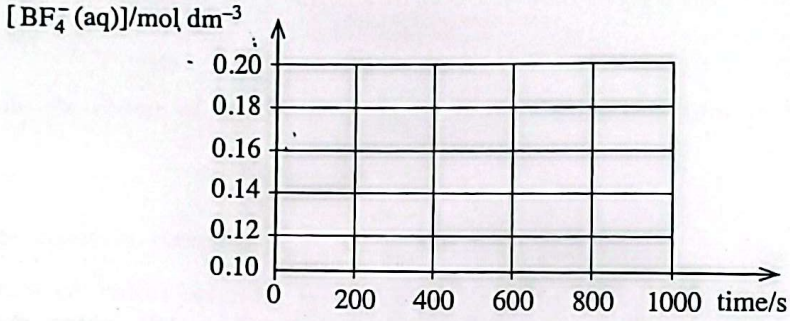
(**Note:** Neglect the ionization of HF.)

In an experiment carried out to study the kinetics of the above reaction, 0.20 mol dm^{-3} $BF_4^-(aq)$ was used and the concentration of the product HF(aq) was measured with time, at a constant temperature. The results obtained are shown in the graph below.



Concentration of HF(aq) reached the constant value of 0.04 mol dm^{-3} at the equilibrium. It was found that the forward reaction follows the rate law, rate = $k_f[BF_4^-(aq)]$ and the value of k_f is 1.0×10^{-5} s^{-1}.

(i) Draw a graph to show the variation of $[BF_4^-(aq)]$ with time.



(ii) At this temperature, calculate the rate of the forward reaction after 600 s.

(iii) It was found that the reverse reaction is first order with respect to $[BF_3OH^-(aq)]$ and first order with respect to [HF(aq)]. Taking k_r as the rate constant of the reverse reaction, write the rate law of the reverse reaction and calculate the value of k_r at this temperature.

(iv) State whether the initial rate method can be used to find the rate law of the reverse reaction in the above experiment. Give reasons for your answer.

100

(60 *marks*)

[*see page seven*

Do not write in this column.

(a) **A**, **B** and **C** are structural isomers having the molecular formula $C_5H_{10}O$. None of them show optical isomerism. All three compounds **A**, **B** and **C** give coloured precipitates with 2,4-dinitrophenylhydrazine (2,4-DNP). Of the three compounds **A**, **B** and **C**, only **B** gives a silver mirror with ammonical $AgNO_3$. When **A**, **B** and **C** are reacted separately with $NaBH_4/CH_3OH$, compounds **D**, **E** and **F** are produced respectively. When **D** is heated with conc. H_2SO_4, compounds **G** and **H**, which are diastereomers of each other are formed. When **E** and **F** are heated separately with conc. H_2SO_4, compound **E** gives **I** while compound **F** gives all three compounds **G**, **H** and **I**. Compounds **G**, **H** and **I** decolourize Br_2/H_2O.

Draw the structures of **A**, **B**, **C**, **D**, **E**, **F**, **G**, **H** and **I** in the boxes given below.

A

B

C

D

E

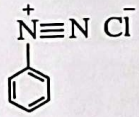
F

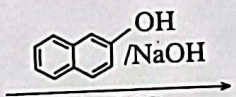
G and **H**

I

(54 *marks*)

(b) (i) Draw the structures of the products **J**, **K**, **L**, **M** and **N** of the following reactions (I–V) in the given boxes.

(I) 



J

(II) $CH_3—C\equiv C—CH_3$

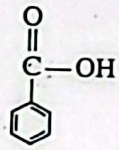
$\xrightarrow[\text{Quinoline}]{H_2/\text{Pd-BaSO}_4}$

K

[*see page eight*

Do not write in this column.

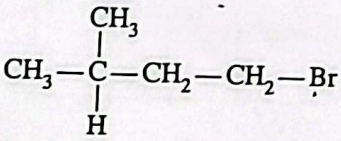
(III) $CH_3-\overset{\overset{O}{\|}}{C}-CH_3$ $\xrightarrow[(2)\ H^+/H_2O]{(1)\ C_2H_5MgBr/\text{dry ether}}$ L

(IV)  $\xrightarrow{PCl_3}$ M

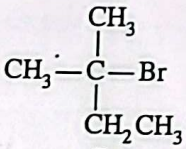
(V) $CH_3-CH_2-\overset{\overset{O}{\|}}{C}-NH_2$ $\xrightarrow[(2)\ H^+/H_2O]{(1)\ LiAlH_4/\text{dry ether}}$ N

(25 marks)

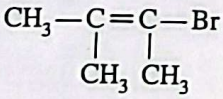
(*c*) Consider the compounds **P**, **Q** and **R** given below.



P



Q



R

(i) When compounds **P**, **Q** and **R** are separately treated with aqueous NaOH;

I. Which compound is least likely to undergo a nucleophilic substitution reaction?

.....

II. Which compound is most likely to undergo a nucleophilic substitution reaction which takes place in **one step**?

.....

III. Which compound is most likely to undergo a nucleophilic substitution reaction which takes place in **two steps**?

.....

(12 marks)

(ii) Give the mechanism and the structure of the product formed relevant to the reaction in (*c*)(i)III above.

100

(09 marks)

* *

[see page nine

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2023 (2024)
கல்விப் பொதுத் தராதரப் பத்திர (உயர் தர)ப் பரீட்சை, 2023 (2024)
General Certificate of Education (Adv. Level) Examination, 2023 (2024)

රසායන විද්‍යාව II
இரசாயனவியல் II
Chemistry II

02 E II

* Universal gas constant $R = 8.314\ J\ K^{-1}\ mol^{-1}$
* Avogadro constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$

PART B — ESSAY

Answer two questions only. (*Each question carries* **150** *marks.*)

5. (*a*) CaO(s) reacts with water as shown below.

$$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(s)\ \Delta H^\circ = -64\ kJ\ mol^{-1}$$

The following questions are based on the reaction given above.

(i) When 200 g of $H_2O(l)$ was reacted with a certain mass of CaO(s), the temperature of water changed from 25 °C to 75 °C. Calculate the amount of heat (in kJ) absorbed by water. Specific heat capacity of water is $4.2\ J\ g^{-1}\ °C^{-1}$.
(Note: Disregard the change in the mass of water due to the formation of $Ca(OH)_2$.)

(ii) What is the minimum mass of CaO(s) needed to make the temperature change that occurred in (i) above? (O = 16, Ca = 40)

(iii) Standard entropy values of CaO(s), $H_2O(l)$ and $Ca(OH)_2(s)$ are 40, 70 and 80 $J\ K^{-1}\ mol^{-1}$ respectively. Calculate the entropy change of the reaction.

(iv) Predict the spontaneity of the reaction at 300 K. State any assumptions made.

(v) Predict the spontaneity of the reaction at 400 K if steam ($H_2O(g)$) is used instead of liquid water.

$$H_2O(g) \longrightarrow H_2O(l)\ \Delta H^\circ = -44\ kJ\ mol^{-1}$$
$$S^\circ_{H_2O(g)} = 190\ J\ K^{-1}\ mol^{-1}$$

(80 *marks*)

(*b*) (i) At temperature 570 °C, the equilibrium given below exists in a closed rigid container.

$$Ca(OH)_2(s) \rightleftharpoons CaO(s) + H_2O(g)$$

The pressure of the container was found to be 7.0×10^5 Pa.
Calculate K_P and K_C for the reaction at the temperature 570 °C (at 570 °C, RT = 7000 $J\ mol^{-1}$).

(ii) Giving reasons briefly explain the effect on the equilibrium in (*b*)(i) above when the following changes are done.

I. When $Ca(OH)_2(s)$ is added.

II. When some amount of $H_2O(g)$ is removed.

(iii) To determine the relationship between the pressure of the water vapour produced (P_{H_2O}) and the mass of $Ca(OH)_2(s)$ introduced into the container ($M_{Ca(OH)_2}$), the pressure was measured introducing small quantities of $Ca(OH)_2(s)$ into an evacuated rigid container at 570 °C. Draw the expected graph for the variation of P_{H_2O} with $M_{Ca(OH)_2}$ and briefly describe it.

(40 *marks*)

(*c*) (i) Write the reversible reaction for the dissolution of $Ca(OH)_2(s)$ in water at temperature 25 °C.

(ii) At temperature 25 °C the solubility product (K_{sp}) of $Ca(OH)_2(s)$ is $4.0 \times 10^{-6}\ mol^3\ dm^{-9}$.
Calculate the molar solubility of $Ca(OH)_2(s)$ at this temperature.

(iii) State giving reasons whether the solubility of $Ca(OH)_2(s)$ will be higher, lower or the same in aqueous solutions of NaOH, NaCl and $Ca(NO_3)_2$ (concentrations of solutions 0.1 $mol\ dm^{-3}$) when compared with the solubility of $Ca(OH)_2(s)$ in water.

(30 *marks*)

[*see page ten*

6. (*a*) At 25 °C the methanoate ion, $HCOO^-(aq)$ reacts with water to form methanoic acid, $HCOOH(aq)$ and $OH^-(aq)$ as shown below.

$$HCOO^-(aq) + H_2O(l) \rightleftharpoons HCOOH(aq) + OH^-(aq)$$

(i) Given that $[OH^-(aq)] = 1.0 \times 10^{-6}$ mol dm^{-3} in a solution prepared by dissolving 0.10 mol of HCO_2Na in 1.0 dm^3 of water, calculate the following at 25 °C.

I. The value of K_b of methanoate ion.

II. The value of K_a of methanoic acid.

($K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6} at 25 °C)

(ii) Calculate the pH of a methanoic acid solution of concentration 0.10 mol dm^{-3}.

(iii) When 3.40 g of HCO_2Na was dissolved in 50.00 cm^3 of 0.10 mol dm^{-3} $HCOOH(aq)$ solution, it was observed that there was no change in volume.
(H = 1, C = 12, O = 16, Na = 23)

I. Determine the pH of this solution.

II. Explain how this solution acts as a buffer solution.

(80 *marks*)

(*b*) (i) This question is in respect of a solution that could be made by mixing two completely miscible liquids **A** and **B**. Copy the following table on to your answer script and fill in the blanks. Different types of solutions (ideal, non-ideal/positive deviation, non-ideal/negative deviation) that could be made are given in the table.

While the mole fractions of **A** and **B** in the solution are X_A and X_B, and the vapour pressures of **A** and **B** at a given temperature are P_A and P_B respectively.

The saturated vapour pressures of **A** and **B** at this temperature are P_A° and P_B° respectively.

Intermolecular forces between **A** and **A**, **B** and **B** and **A** and **B** are f_{A-A}, f_{B-B} and f_{A-B} respectively.

Property	Ideal solution	Non-ideal solution	
		Positive deviation from Raoults law	Negative deviation from Raoults law
ΔH of mixing			
relationship among f_{A-A}, f_{B-B} and f_{A-B}			
relationship among P_A°, P_A and X_A			

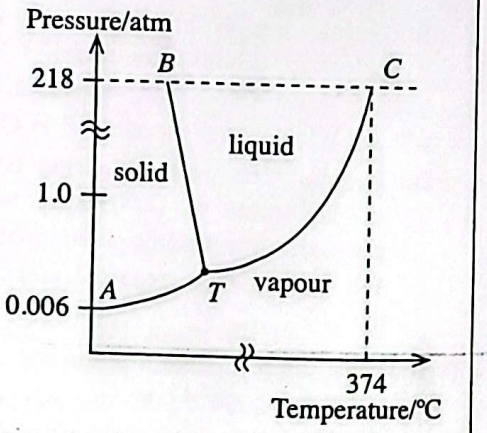
(ii) The phase diagram of pure water is given below.

Copy the diagram on to your answer script and answer the following questions.

I. Mark the normal boiling point (V) and melting point (L) of pure water.

II. What are represented by lines BT, TC and point T?

III. Assume that a small amount of salt (NaCl) is added to the pure water sample. After the addition of salt, positions of the lines BT and TC in the phase diagram were changed. Their new positions are $B'T'$ and $T'C'$ respectively. Draw their new positions on the phase diagram you have copied and label them as $B'T'$ and $T'C'$. Mark the new boiling point (V') and the new melting point (L') on the phase diagram.



(70 *marks*)

[*see page eleven*

(a) A Daniel cell consists of Zn and Cu rods immersed in $ZnSO_4$(aq, 1.0 mol dm^{-3}) and $CuSO_4$(aq, 1.0 mol dm^{-3}) respectively. The solutions are separated by a porous membrane. The overall cell reaction when the cell is operating is given below.

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

(i) Identify the anode and the cathode.

(ii) Write the anodic half reaction of the cell.

(iii) Write the cathodic half reaction of the cell.

(iv) Give the cell notation of the cell above.

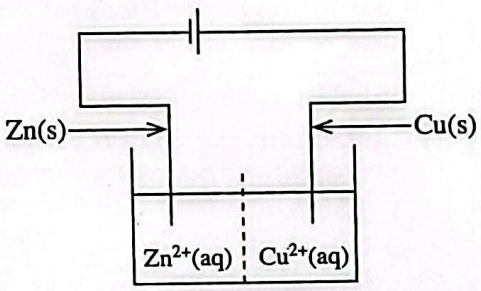
(v) Calculate the electromotive force (E°_{cell}) of the Daniel cell given above at 25 °C.
$E^{\circ}_{Cu^{2+}(aq)/Cu(s)} = 0.34$ V $\quad E^{\circ}_{Zn^{2+}(aq)/Zn(s)} = -0.76$ V

(vi) Calculate the time in seconds required to deposit 3.175 g of Cu(s) when a current of 5.0 A flows through the cell. (Cu = 63.5, 1 F = 96500 C mol^{-1})

(vii) How does the conductivity of the solution in the cell compartment containing the Zn-rod change when a current is drawn from the cell? Explain giving reasons.

(viii) It was observed that when a current is drawn from the cell, the intensity of the colour of the solution in the cell compartment containing the Cu-rod changes. Explain this observation.

(ix) As shown in the diagram, an external voltage higher than the calculated electromotive force in (v) above, was applied to the Daniel cell using another electrochemical cell. Write the overall cell reaction of the Daniel cell under this condition.



(75 *marks*)

(b) **A**, **B**, **C** and **D** are coordination compounds of iron with an octahedral geometry. The molecular formulae of the compounds are **(not in order)** $FeH_{14}N_2O_4Br_3$, $FeH_{15}N_5Br_2$, $FeKH_4O_2Br_4$ and $FeH_{15}N_3O_3Br_2$.

In each compound **two** types of ligands are coordinated to the metal ion.

Compound **A** : Gives three ions in aqueous solution. When $AgNO_3$(aq) is added to an aqueous solution of **A**, two moles of a yellow precipitate are formed per mole of **A**.

Compound **B** : Gives four ions in aqueous solution. When $AgNO_3$(aq) is added to an aqueous solution of **B**, three moles of a yellow precipitate are formed per mole of **B**.

Compound **C** : Gives two ions in aqueous solution. When $AgNO_3$(aq) is added to an aqueous solution of **C** one mole of a yellow precipitate is formed per mole of **C**.

Compound **D** : Gives two ions in aqueous solution. A yellow precipitate is not formed when $AgNO_3$(aq) is added to an aqueous solution of **D**.

(i) What are the common oxidation states of iron (Fe)?

(ii) Identify the yellow precipitate. (Give chemical formula.) Name a chemical reagent that can dissolve this precipitate.

(iii) Identify the ligands coordinated to the metal ion in each compound **A**, **B**, **C** and **D**.

(iv) In each of the compounds **A**, **B**, **C** and **D**,

I. write the oxidation state of iron.

II. write the electronic configuration of iron.

(v) Give the structures of **A**, **B**, **C** and **D**.

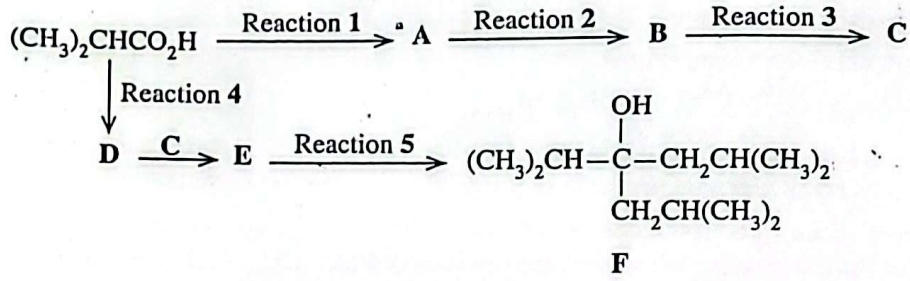
(75 *marks*)

[*see page twelve*

PART C — ESSAY

Answer two questions only. (Each question carries **150** *marks.)*

8. (*a*) $(CH_3)_2CHCO_2H$ has been converted to compound **F** by using the reaction scheme given below.



Complete the above reaction scheme by giving the structures of compounds **A**, **B**, **C**, **D** and **E** and the reagents required for the reactions **1** - **5**. Only the chemical substances given below should be used (either singly or as combinations) as reagents.

Chemical substances:
C_2H_5OH, dry ether, $LiAlH_4$, Mg, PBr_3, conc. H_2SO_4, dil. H_2SO_4

(45 *marks)*

(*b*) (i) Using C_2H_2 as the only starting compound, show how you would prepare compound **G** using not more than **four (04)** steps.

$$CH_3CH_2{-}C{\equiv}CH$$

G

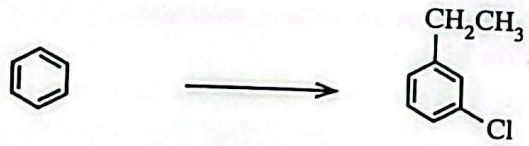
(ii) Give the structure of the compound **H** which is formed when compound **G** is reacted with excess Cl_2.

(30 *marks)*

(*c*) Write the product and the mechanism of the reaction of benzene with conc. HNO_3/conc. H_2SO_4.

(25 *marks)*

(*d*) Show how you would carry out each of the following conversions in not more than **three (03)** steps.

(i) 

(ii) $CH_3CH(OH)CH_3 \longrightarrow CH_3CH_2CH_2OH$

(50 *marks)*

[*see page thirteen*

(a) (i) Aqueous solutions of compounds $MgSO_4$, NaOH, $BaCl_2$, Na_2SO_4 and $Zn(NO_3)_2$ are contained in five 100 cm^3 beakers labelled **A, B, C, D** and **E (not in order)**. Identify **A, B, C, D** and **E** based on the observations given below. (Reasons **not** required.)

Note : Small portions of the solutions are mixed in test tubes.

On mixing **D** and **E** a white precipitate is formed. When excess **E** is added to the precipitate, the precipitate dissolves giving a colourless solution. A white precipitate is formed when **E** is added to **C**. Precipitates are not formed when **E** is added to **A** and when **E** is added to **B**. On mixing **A** and **B** a white precipitate is formed. When **C** is added to **A**, a white precipitate is formed. However, a precipitate is not formed when **C** is added to **B**.

(25 marks)

(ii) An aqueous solution **M** contains **three** cations. The following tests (1-5) were carried out to identify these cations.

Test No.	Test	Observation
1	Dilute HCl was added to solution **M**.	A white precipitate (P_1)
2	P_1 was separated by filtration and H_2S was bubbled through the solution.	No precipitate
3	The solution was boiled until all the H_2S was removed and then cooled. NH_4Cl/NH_4OH was added.	No precipitate
4	H_2S was bubbled through this solution.	A pale pink precipitate (P_2)
5	P_2 was separated by filtration and the solution was boiled until all the H_2S was removed. $(NH_4)_2CO_3$ solution was added.	A white precipitate (P_3)

The following tests were carried out for the precipitates P_1, P_2 and P_3.

Precipitate	Test	Observation
P_1	Dilute ammonia solution was added to P_1.	P_1 dissolved.
P_2	P_2 was dissolved in dil. HNO_3 and excess dilute NaOH was added to the solution.	A white precipitate which turns brown on standing
P_3	P_3 was dissolved in conc. HCl and the solution was subjected to the flame test.	A green colour flame

I. Identify the **three** cations in solution **M**. (Reasons **not** required.)

II. Write the chemical formulae of the precipitates P_1, P_2 and P_3. ***(24 marks)***

(iii) **X, Y** and **Z** are ionic solids. Sodium is the cation in all three compounds. The following tests were carried out to identify the anions in **X, Y** and **Z**.

Test No.	Test	Observation
1	(i) A portion of **X** was dissolved in water in a test tube.	A colourless solution
	(ii) $Pb(CH_3COO)_2$ solution was added to the colourless solution.	A yellow precipitate
	(iii) The resulting mixture (yellow precipitate and solution) was heated.	The precipitate dissolved giving a colourless solution.
	(iv) This colourless solution was cooled.	A yellow precipitate (as golden yellow plates)

[see page fourteen

2	(i) A portion of **Y** was dissolved in water in a test tube.	A colourless solution
	(ii) A $BaCl_2$ solution was added to the colourless solution.	A white precipitate
	(iii) Dilute HCl was added to the resulting mixture (white precipitate and solution).	A clear colourless solution with the evolution of a gas
	(iv) The gas evolved was tested by holding a filter paper moistened with acidified $K_2Cr_2O_7$ over the mouth of the test tube.	Orange filter paper turned green.
3	(i) A portion of **Z** was dissolved in water in a test tube.	A colourless solution
	(ii) $AgNO_3$ solution was added to the colourless solution.	A black precipitate
	(iii) Dilute HCl was added to a portion of **Z** in a test tube.	A colourless gas evolved.
	(iv) The gas evolved was tested by holding a filter paper moistened with $Pb(CH_3COO)_2$ solution over the mouth of the test tube.	Filter paper turned black

I. Identify the anions in **X**, **Y** and **Z**. (Reasons **not** required.)

II. Write balanced chemical equations for the reactions taking place in the above tests.

(26 *marks*)

(*b*) A solid sample **X** contains the compounds **P**, **Q** and an inert substance. Here **P** = Fe_2O_3 and **Q** = Fe_3O_4. **Q** is a **single** compound and contains iron in Fe^{2+} and Fe^{3+} oxidation states. It reacts with I^- in an acidic medium as follows.

$$Fe_3O_4 + 2I^- + 8H^+ \longrightarrow 3Fe^{2+} + 4H_2O + I_2$$

The following experimental procedure was used to determine the mass percentages of **P** and **Q** in **X**.

When 3.2 g of sample **X** was treated with excess KI solution in the presence of dilute H_2SO_4, all the Fe^{3+} in it was converted to Fe^{2+} with the liberation of iodine. The resulting solution was diluted to 100.00 cm^3 (labelled as S). To convert the iodine to iodide in a 25.00 cm^3 volume of this diluted solution (S), 15.00 cm^3 of 0.50 mol dm^{-3} $Na_2S_2O_3$ was required.
After complete removal of iodine from another 50.00 cm^3 volume of the diluted solution (S), in dil. H_2SO_4 medium, 14.00 cm^3 of 0.25 mol dm^{-3} $KMnO_4$ was required to oxidize all the Fe^{2+} contained in it.

(i) Write balanced chemical equations for the reactions taking place in the above procedure.

(ii) Calculate the mass percentages of **P** and **Q** in **X**.
(O = 16, Fe = 56)

(75 *marks*)

[*see page fifteen*

(a) The following questions are based on the extraction of magnesium by the Dow process.

(i) State the raw materials used.

(ii) Give balanced chemical equations/half reactions in the sequence they occur in the Dow process. Appropriate conditions must be stated as required.

(iii) Give **two** industrial uses of magnesium.

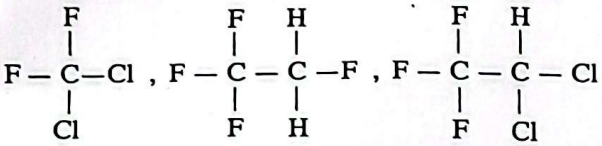
(iv) Give **two** ways in which the Dow process has a **negative** impact on the environment.

(50 *marks*)

(b) Given below are some pollutants that exist in the atmosphere.

Pollutant List

$CH_4, CO_2, NO, NO_2, N_2O, SO_2, SO_3, CH_3CH_2CH_2CH_2CH_3$,



The following questions are based on the pollutant list given above.

(i) Identify the pollutant that directly contributes towards increasing the level of ozone in the atmosphere.

(ii) Explain using balanced chemical equations how the pollutant you identified in (i) above increases the ozone level in the atmosphere.

(iii) Identify **two** pollutants that contribute to the reduction of ozone level in the upper atmosphere.

(iv) Briefly explain using balanced chemical equations how one of the pollutants you identified in (iii) above contributes to the reduction of ozone level in the upper atmosphere.

(v) Identify **two** pollutants that cause photochemical smog.

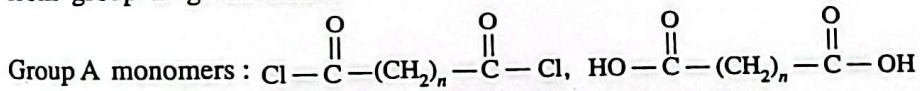
(vi) Identify **four** pollutants that can absorb infrared radiation in the atmosphere and remain stable in the atmosphere for a long period of time.

(vii) What is the commonly used name that describes the behaviour of the pollutants you identified in (vi) above?

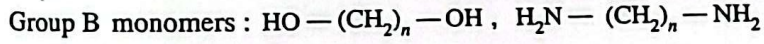
(viii) Identify **two** pollutants that contribute to make a significant change in some water quality parameters when dissolved in water. State the water quality parameter(s) that will be affected by the pollutants you identified.

(50 *marks*)

(c) Consider the polymerization reactions between one monomer from group A and one monomer from group B given below.



Group A monomers : $Cl-C(=O)-(CH_2)_n-C(=O)-Cl$, $HO-C(=O)-(CH_2)_n-C(=O)-OH$

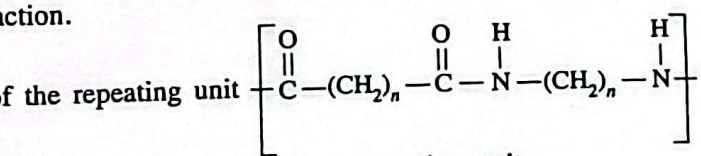


Group B monomers : $HO-(CH_2)_n-OH$, $H_2N-(CH_2)_n-NH_2$

where n is an integer.

(i) Write the pair/pairs of monomers that would release an acidic molecule during the polymerization reaction.

(ii) Write the pair/pairs of monomers that would release a neutral molecule during the polymerization reaction.

(iii) The molar mass of the repeating unit  is 226 g mol^{-1}.

Calculate the number of $-CH_2-$ units in a repeating unit.

(50 *marks*)

[*see page sixteen*

* * *

The Periodic Table

1	1 H																2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	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
5	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
6	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
7	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 Lv	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