Competency Focused Practice Questions

Chemistry (Volume 2) | Grade 12

Co-created by

CBSE Centre for Excellence in Assessment

and

Educational Initiatives

PREFACE

Assessments are an important tool that help gauge learning. They provide valuable feedback about the effectiveness of instructional methods; about what students have actually understood and also provide actionable insights. The National Education Policy, 2020 has outlined the importance of competency-based assessments in classrooms as a means to reform curriculum and pedagogical methodologies. The policy emphasizes on the development of higher order skills such as analysis, critical thinking and problem solving through classroom instructions and aligned assessments.

Central Board of Secondary Education (CBSE) has been collaborating with Educational Initiatives (Ei) in the area of assessment. Through resources like the Essential Concepts document and A- Question-A-Day (AQAD), high quality questions and concepts critical to learning have been shared with schools and teachers.

Continuing with the vision to ensure that every student is learning with understanding, Question Booklets have been created for subjects for Grade 10th and 12th. These booklets contain competency-based items, designed specifically to test conceptual understanding and application of concepts.

Process of creating competency-based items

All items in these booklets are aligned to the NCERT curriculum and have been created keeping in mind the learning outcomes that are important for students to understand and master. Items are a mix of Free Response Questions (FRQs) and Multiple-Choice Questions (MCQs). In case of MCQs, the options (correct answer and distractors) are specifically created to test for understanding and capturing specific errors/misconceptions that students may harbour. Each incorrect option can thereby inform teachers on specific gaps that may exist in student learning. In case of subjective questions, each question also has a detailed scoring rubric to guide evaluation of students' responses.

Each item has been reviewed by experts, to check for appropriateness of the item, validity of the item, conceptual correctness, language accuracy and other nuances.

How can these item booklets be used?

There are 157 questions in this booklet.

The purpose of these item booklets is to provide samples of high-quality competency-based items to teachers. The items can be used to–

- get an understanding of what good competency-based questions could look like
- give exposure to students to competency-based items
- assist in classroom teaching and learning
- get inspiration to create more such competency-based items

Students can also use this document to understand different kinds of questions and practice specific concepts and competencies. There will be further additions in the future to provide competency focused questions on all chapters.

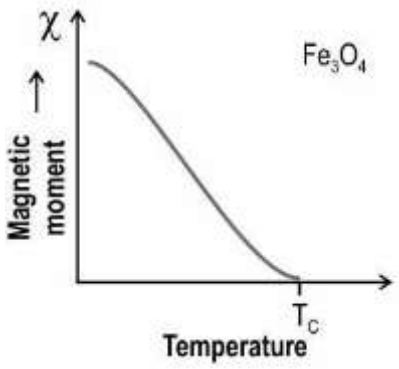
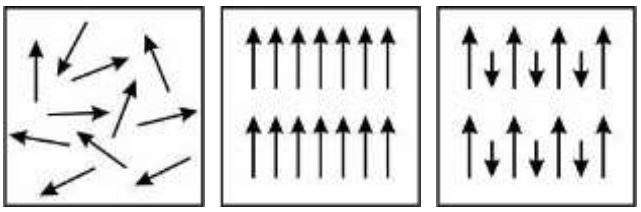
The item booklets are aligned with the 2022-23 curriculum. However, a few questions from topic which got rationalized in 2023-24 syllabus are also there in the booklet which may be used as a reference for teachers and students.

Please write back to us to give your feedback.

Team CBSE

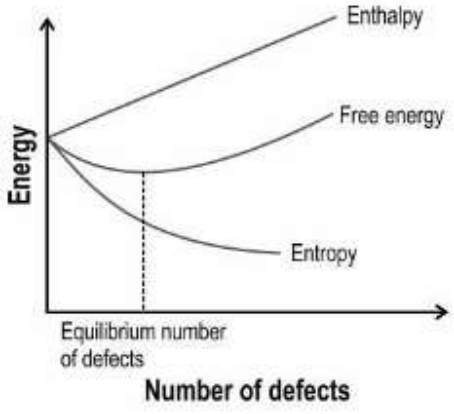
CONTENTS

1. THE SOLID STATE

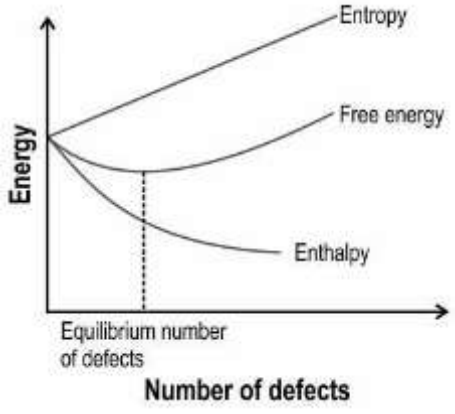
Q.No.	Question	Marks
	Multiple Choice Question	
Q.1	The below graph shows the variation of the magnetic property of magnetite (Fe_3O_4) with respect to temperature.  Based on this graph, which of the following represents the alignment of the magnetic moment of Fe_3O_4 at T >Tc?  none of the above A B C D	1
Q.2	Given below are two statements labeled as Assertion (A) and Reason (R). Assertion (A): Frenkel defect is shown by compounds having a low r+/r- ratio and low dielectric constant. Reason (R): Frenkel defect maintains the neutrality of a crystal. Select the most appropriate answer from the options given below: A. Both A and R are true and R is the correct explanation of A. B. Both A and R are true but R is not the correct explanation of A. C. A is true but R is false.	1

	D. A is false but R is true.	
Q.3	Which combination of the characteristics of element X, a metal, and Y, a non-metal, is most likely to lead to ionic bonding? **Element X** / **Element Y** A: Low ionization energy / High electronegativity value B: Low ionization energy / Low electronegativity value C: High ionization energy / High electronegativity value D: High ionization energy / Low electronegativity value	1
Q.4	Which of the following combinations is INCORRECT? A: GeP / n-type B: SbSi4 / n-type C: GeAs / p-type D: AlSi4 / p-type	1
Q.5	Which of the following statements is/are true? (i) A non-stoichiometric compound $Fe_{0.94}O$ is formed when 18% of Fe^{2+} ions are replaced by Fe^{3+} ions. (ii) The conductivity of both intrinsic and extrinsic semiconductors is directly proportional to temperature. (iii) The BCC structure is the densest crystal structure. A. i and iii	1

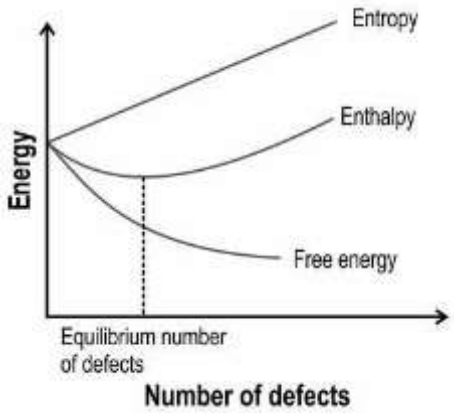
	B. ii and iii C. only i D. i and ii	
Q.6	Which of the following graphs correctly represents the enthalpy, free energy, and entropy during the formation of Schottky defects in solids? (Hint: The overall change in free energy is given by ΔG = ΔH - TΔS)	1



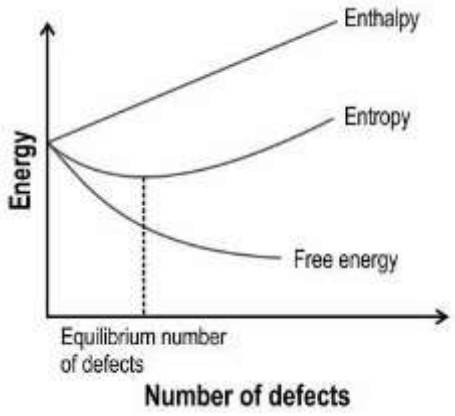
A.



B.

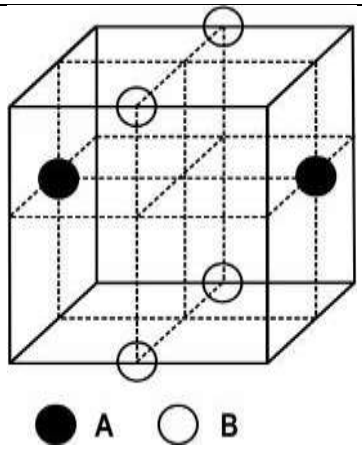


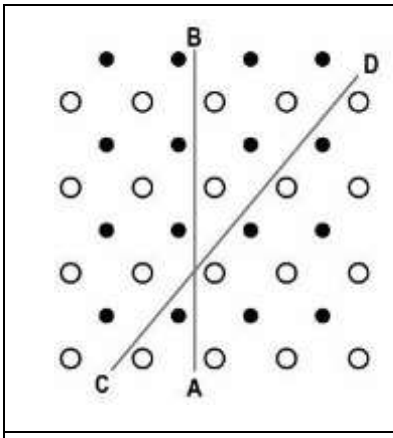
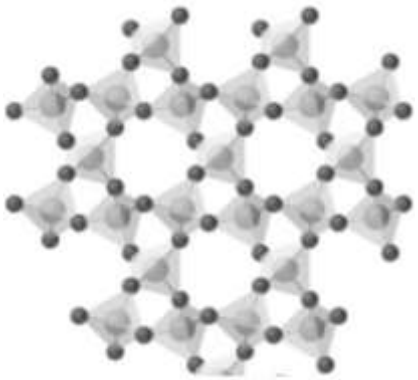
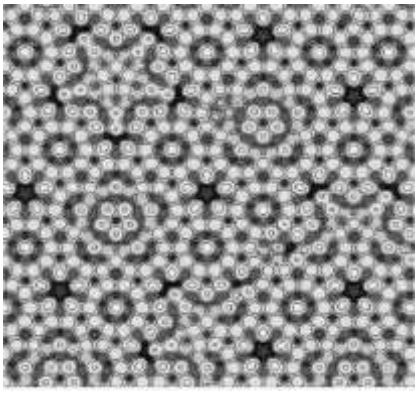
C.

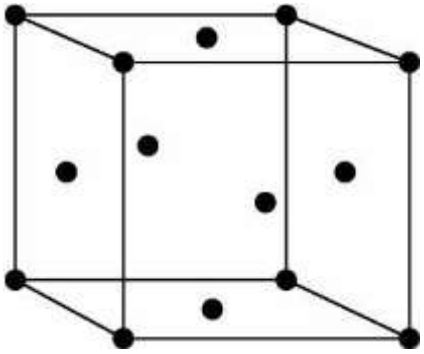
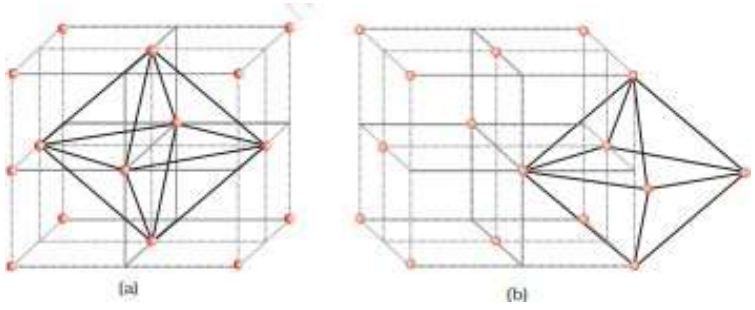


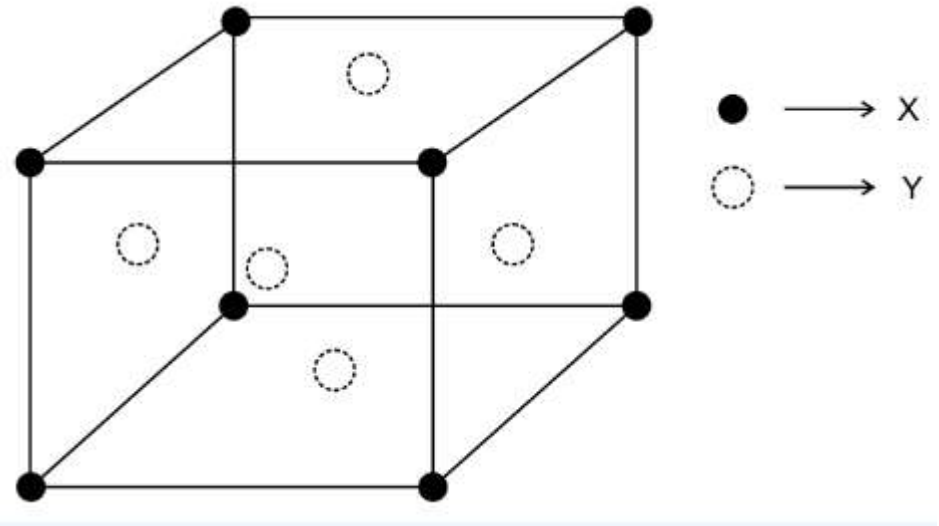
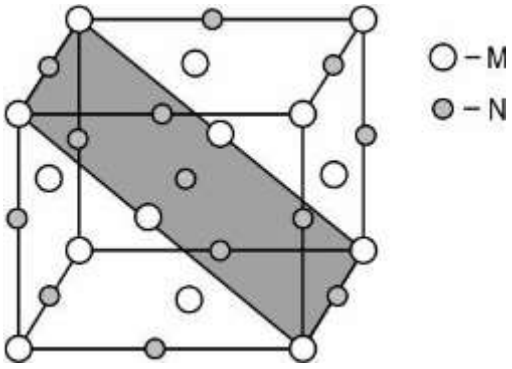
D.

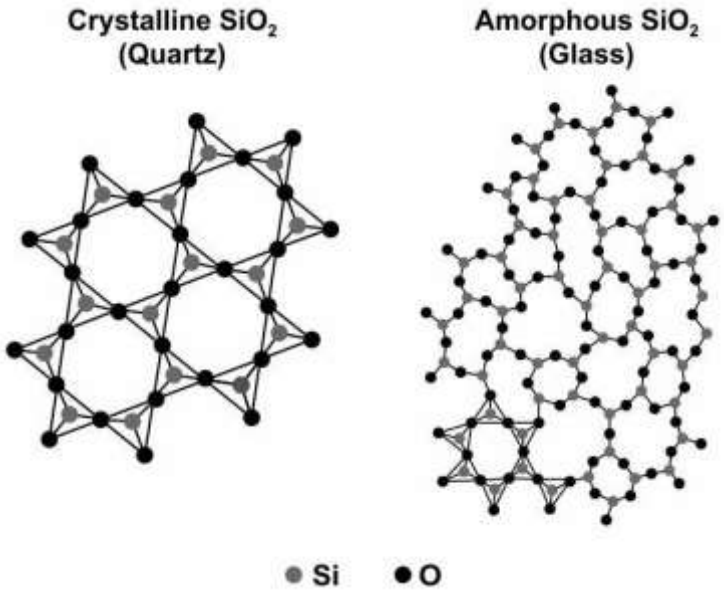
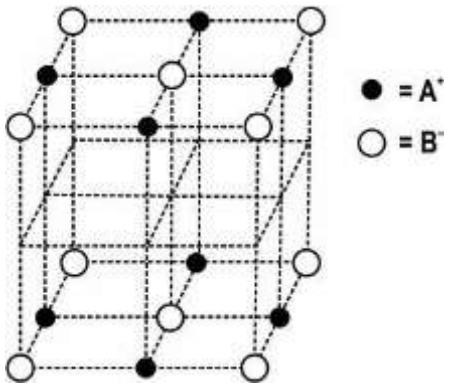
Q.7	A compound is formed by two ions A and B in a cubic unit cell. The radius of A+ is smaller than that of B-. (as shown below)	1

	 Which of the following statement is/are correct? (i) The radius ratio, r+/r- is 0.414. (ii) The cations and anions have different coordination geometry. (iii) The ratio of A-B bond length to unit cell edge length is 0.866. (iv) The formula of the compound is AB. A. i and iii B. iii and iv C. ii and iv D. All of them	
Q.8	On the morning of 8 April 1982, an image counter to the laws of nature appeared in Dan Shechtman's electron microscope. In all solid matter, atoms were believed to be packed inside crystals in symmetrical patterns that were repeated periodically over and over again. For scientists, this repetition was required in order to obtain a crystal. Shechtman's image, however, showed that the atoms in his crystal were packed in a pattern that could not be repeated. Such a pattern was considered just as impossible as creating a football using only six-cornered polygons when a sphere needs both five- and six-cornered polygons. His discovery was extremely controversial. In the course of defending his findings, he was asked to leave his research group. (Source:https://www.nobelprize.org/prizes/chemistry/2011/press-release/) Which of the following patterns could illustrate the finding of Shechtman's crystal?	1

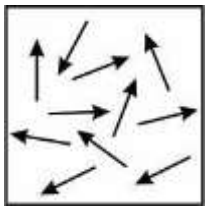
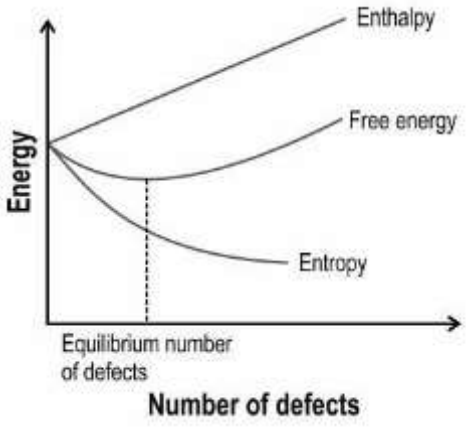
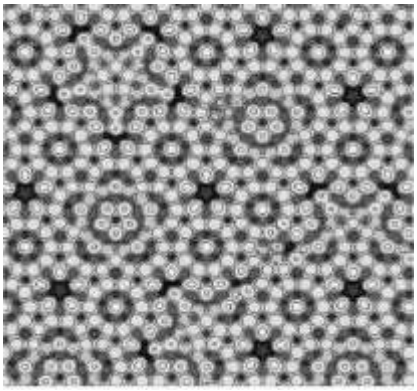
<table>
<tr><td></td><td>
<table>
<tr><td> 
</td><td>  </td></tr>
<tr><td>A.</td><td>B.</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>C.</td><td>D.</td></tr>
</table>
</td><td></td></tr>
<tr><td colspan="3">Free Response Question/ Subjective Question</td></tr>
<tr><td>Q.9</td><td>Read the statements below and answer the question based on them:
- Graphite conducts electricity and is used as a lubricant.
- Diamond is hard and does not conduct electricity.
Explain these statements on the basis of the structure and bonding present in these two solids.</td><td>4</td></tr>
<tr><td>Q.10</td><td>If the unit cell length of NaCl is a=563.1 pm and the density of NaCl is measured to be 2.17×10^{3} kg m^{-3}. Calculate Z, the number of formula units in the unit cell.
(The atomic masses of sodium and chlorine are 22.99 and 35.45, respectively.)</td><td>3</td></tr>
<tr><td>Q.11</td><td>The figure shown below represents a unit cell of a face-centered cubic structure.</td><td>3</td></tr>
</table>

	 How many atoms are in a FCC cell? (i) Draw diagrams to represent 100, 110, and 111 planes. (ii) Calculate the relative density per unit area for the above three planes. (Hint: Calculate the area of each plane assuming a cell length a. Decide the fractional contribution made by each atom to the plane.)	
Q.12	KCl crystallizes in the same type of lattice as NaCl. If rNa+/rCl- = 0.5 and rNa+/rK+ = 0.7. What is the ratio of the side of the NaCl unit cell to that of the KCl unit cell?	2
Q.13	Explain why crystalline solids are generally MORE DEFECTIVE at high temperatures. (Hint: Use the Gibbs energy equation)	2
Q.14	The diagram below shows the location of octahedral void per unit cell at the body center and at the center of one edge of the unit.  (a) (b) If the distance between the two nearest octahedral voids is 'ν2p' cm, where p is any positive number. (i) What is the minimum distance between the two tetrahedral voids in the same unit cell? (ii) What is the maximum distance between the two tetrahedral voids in the same unit cell?	3

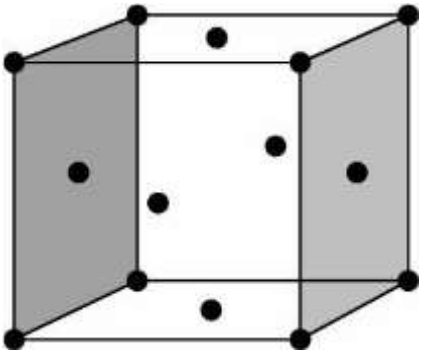
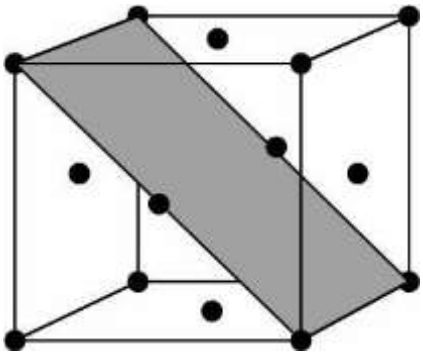
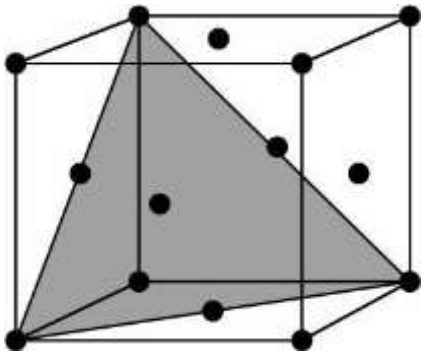
Q.15	In a face-centered cubic lattice, atom X is at the corners of the cube, and atom Y is at the face center position. If one atom of Y is missing from the face-centered positions as shown below, then what is the formula of the solid? 	2
Q.16	In an FCC lattice, with the help of a diagram, show that the minimum distance between an octahedral void and a tetrahedral void is (√3/4)a. (Note: a is the side length of the unit cell)	4
Q.17	In a crystal, there are N possible cation and anion sites. If there are nc cation vacancies and na anion vacancies in the same crystal, then what is the number of ways in which one can distribute: (i) Cation vacancies (ii) Anion vacancies (iii) Total number of ways of distributing these defects	2
Q.18	A compound is formed by two elements M and N. The element M forms fcc lattice and N occupies all the octahedral voids. If all the atoms along the 011 plane (as shown below in grey) are missing, then derive the formula of the compound? 	3

Q.19	In a chemistry laboratory, a quartz crystal is taken and heated above its melting point. Post that the solid was allowed to cool down rapidly. After cooling the solid, SiO2 loses its crystalline structure and became quartz glass (amorphous solid) as shown below:  (i) Explain why do quartz crystals, on heating and then rapid cooling, lose their crystalline property and become amorphous? (ii) Draw the temperature-time graph to illustrate the melting point of amorphous and crystalline solids.	5
Q.20	The diagram below shows a part of the structure of a crystal with some ions missing.  (i) Complete the diagram by placing cation A and anion B at appropriate sites. (ii) Identify the formula of this crystal.	3

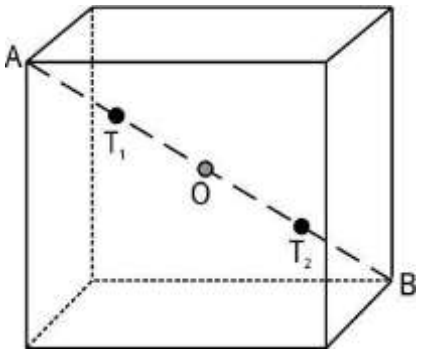
Answer Key & Marking Scheme

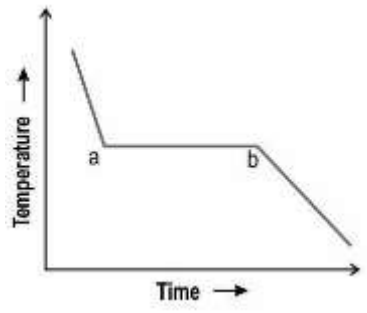
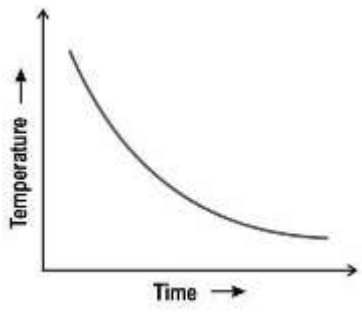
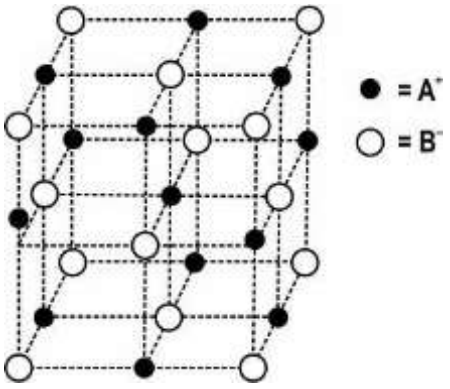
Q.No	Answers	Marks
Q.1	A. 	1
Q.2	D. A is false but R is true.	1
Q.3	A. A	1
Q.4	C. C	1
Q.5	C. only i	1
Q.6	A. 	1
Q.7	B. iii and iv	1
Q.8	D. 	1
Q.9	Graphite:	4

	- Each carbon atom is covalently bonded to three other carbon atoms forming flat, hexagonal rings which are arranged in layers [0.5] - C has sp^2 hybridization. Due to this the fourth valence electron is delocalized and is free to move. Free moving electrons make it a good conductor. [0.5] - Graphite is used as a lubricant because the layers of graphite are held together by weak intermolecular/ 'Van der Waals' forces and hence these layers can slide over each other [1 mark] Diamond: - Each carbon atom is covalently bonded to 4 other carbon atoms, forming a tetrahedral structure around C. C has sp^3 hybridization [1 mark] - The strong covalent bonds and tetrahedral structure and absence of delocalized electrons make diamond hard and an electrical insulator. [1 mark]	
Q.10	Step 1: Noting down what's given and what needs to be calculated. If the mass of the unit cell contents is M and the unit cell volume is V then the density, ρ is given by $\rho = M/V = 2.17 \times 10^3$ kg m^{-3} but $V=(563.1\times10^{-12})^3$ m^3 Step 2: - The mass of one mole of NaCl=$(22.99+35.45)\times10^{-3}$ kg - Dividing the mass by the Avogadro constant we get that the mass of one formula unit of NaCl= $(22.99+35.45)\times10^{-3})/(6.022 \times 10^{23})$ kg [0.5 marks] - and if there are Z formula units in one unit cell, then the mass of the unit cell contents is M= z x $(22.99+35.45)\times10^{-3})/(6.022 \times 10^{23})$ kg [0.5 marks] Step 3: Substituting the value of M and V in density formula and solving to get z=3.99, or z=4 (rounding to the nearest whole number)	3
Q.11	(i) Draw diagrams to represent 100, 110, and 111 planes:	3

	<table><tr><td>100 plane</td><td>110 plane</td></tr><tr><td>  </td><td>  </td></tr><tr><td colspan="2">111 plane</td></tr><tr><td colspan="2">  </td></tr></table> (ii) Calculate the density of atoms per unit area for each type of plane: - The area of the 100 plane shown, is a^2 and contains (1+4×¼)=2 atoms.[0.5] - The 110 plane contributes an area of $a^2\sqrt{2}$ and contains (2×½+4×¼)=2 atoms.[0.5] - The 111 plane contributes an area of ($a^2\sqrt{3}$)/2) and contains (3×1/2+3×1/6)=2 atoms.[0.5] - The relative densities per unit area for these three planes are thus: 100:110:111=2:1.414:2.31.[0.5]	
Q.12	Calculating ratio of the side of NaCl to that of KCl: - NaCl crystallizes in fcc unit such that $r_{Na+} + r_{Cl-} = a/2$ (assuming a is side length of an unit cell for NaCl)[0.5 marks] - Given that $r_{Na+} / r_{Cl-} = 0.5$ and $r_{Na+}/r_{K+} = 0.7$, thus $(r_{Na+} + r_{Cl-})/r_{Cl^-} = 1.5$ and $r_{K+}/r_{Cl-} = 0.5/0.7$ [0.5 marks] - Using the above equations:	2

	$(r_{K+} + r_{Cl-})/(r_{Na+} + r_{Cl-}) = (1.2/0.7) \times (1/1.5)$ $\therefore a_{NaCl} : a_{KCl} = 1:1.143$ [1 mark]	
Q.13	- As per the Gibbs-Helmholtz equation: $\Delta G = \Delta H - T\Delta S$; To create defects, the enthalpy of formation must be provided. [1 mark] - A large positive increase in entropy will be associated with the defect. - At high temperatures, it is more likely that the term $T\Delta S > \Delta H$, and thus $\Delta G < 0$ and defects may form at thermodynamic equilibrium. [1 mark]	2
Q.14	(i) minimum distance between the two tetrahedral voids - minimum distance between the two octahedral voids = $a/\sqrt{2}$; where a is the side of the unit cell. - $a/\sqrt{2} = \sqrt{2}p$; p is a positive number $\therefore a = 2p$ [1 Mark] So, the minimum distance between the two tetrahedral voids = $a/2 = p$ [1 mark] (ii) the maximum distance between the two tetrahedral voids - the maximum distance between the two tetrahedral voids = $\sqrt{3}a/2$; where a is the side length of unit cell - so maximum distance = $\sqrt{3}p$ [1 mark]	3
Q.15	**Calculating the formula of the solid**: - No. of atoms (X) in the corner of the solid = $8 \times 1/8 = 1$ [0.5 mark] - No of atoms (Y) at the face centers of the solid = $(6-1) \times 1/2 = 2.5$ [0.5 mark] $\therefore$ The formula of the solid = $XY_{2.5}$ that is X_2Y_5 [1 mark for correct formula]	2
Q.16	**Calculating the shortest distance between an octahedral void and a tetrahedral void in FCC solid**: - Draw the diagram of one-unit cell showing the position of the octahedral void, and tetrahedral void as below: [1 mark]	4

	 - In the above figure, AB is the diagonal of the cube, T1 and T2 are tetrahedral voids, and O is the octahedral void at the centre of the cube. [0.5 mark] - In FCC, tetrahedral voids are located at 1/4th distance from the corner along the diagonal. So, $AT_1 = AB/4$ - Since $AB = \sqrt{3}a$; $AT_1 = \sqrt{3}a/4$ [1 mark] - Since the octahedral void is at the centre of the cube/diagonal. So, AO = AB/2 ∴ $AO = \sqrt{3}a/2$ [0.5 mark] - Now the distance between an octahedral void and a tetrahedral void = $AO - AT_1$ $= \sqrt{3}a/2 - \sqrt{3}a/4 = \sqrt{3}a/4$ [1 mark]	
Q.17	(i) No. of ways one can distribute cation vacancies: - Probability theory shows that the no. of ways of distributing n defects over N sites = N!/(N-n)!n! ∴ No. of ways one can distribute cation vacancies = $N!/(N-n_c)!n_c!$ [0.5 mark] (ii) Similarly, No. of ways one can distribute anion vacancies = $N!/(N-n_a)!n_a!$ [0.5 mark] (iii) Total number of ways of distributing these defects = $N!/(N-n_c)!n_c!$ x $N!/(N-n_a)!n_a!$ [1 mark]	2
Q.18	**Finding the formula of the compound**: - In the new arrangement the no of atoms of M = (1/8 x 8 + 1/2 x 6) - (1/8 x 4 + 1/2 x 2) = 5/2 [1 mark] - the no. of atoms of N = (1/4 x 12 +1) - (1/4 x 2 +1) = 5/2 [1 mark] - So the new formula = MN [1 mark for correct answer]	3
Q.19	**(i) Conversion of the quartz crystal to quartz glass**: - Upon heating the quartz crystal, the *Bravais lattice structure of the crystal breaks*, and atoms that are arranged at a fixed position start to move randomly. [1 mark]	5

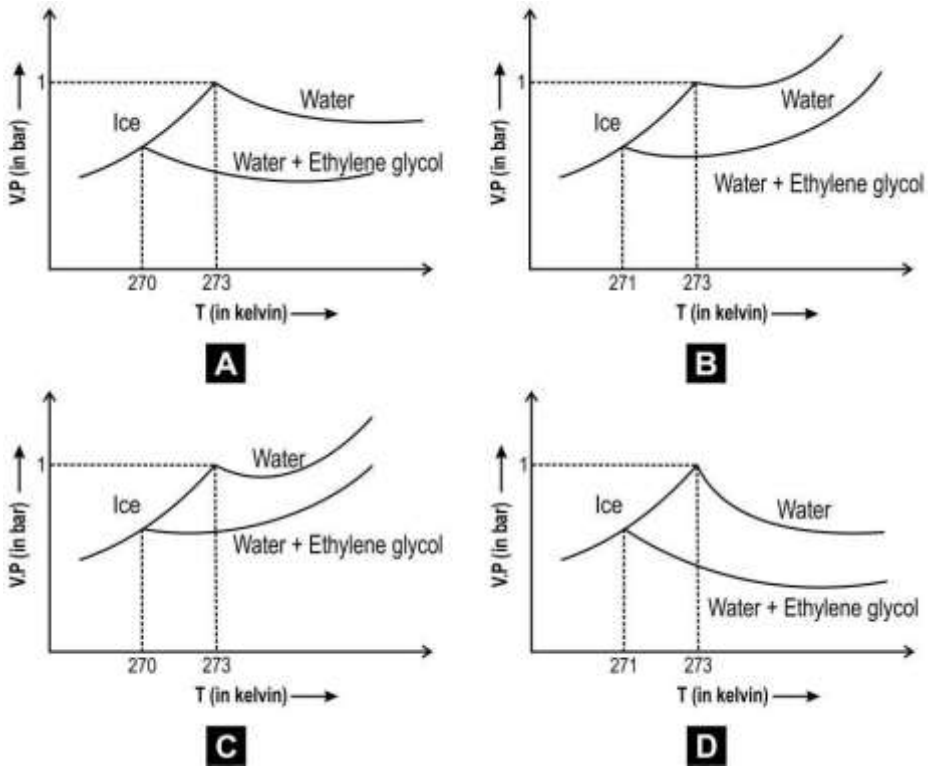
	- For molten material to solidify as a crystalline solid the atoms have to *come together during cooling and need to arrange themselves in a periodic fashion that occurs by diffusion*. [1 mark] - If the cooling rate is very high it will not allow the diffusion to occur; not allow the atoms to move, come together and form a cluster that solidifies as crystalline solids. [1 mark] *(Note: Keywords are: breakdown of Bravais lattice, diffusion, rate of cooling/solidification vs diffusion or long-range order)* **(ii) Temperature-time curve for solids:** **Crystalline solid [1 mark]** / **Amorphous solid [1 mark]**  	
Q.20	(i) Diagram  (ii) Formula: -No. of atoms A = (1/4 x 12 + 1) = 4 [0.5 mark] - No. of atoms B = 1/8 x 8 + 1/2 x 6 = 4 [0.5 mark] - Formula = AB [1 mark]	3

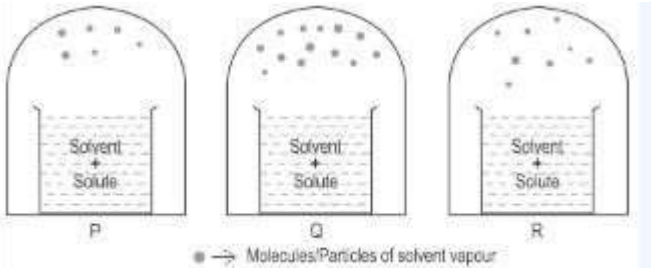
2. SOLUTIONS

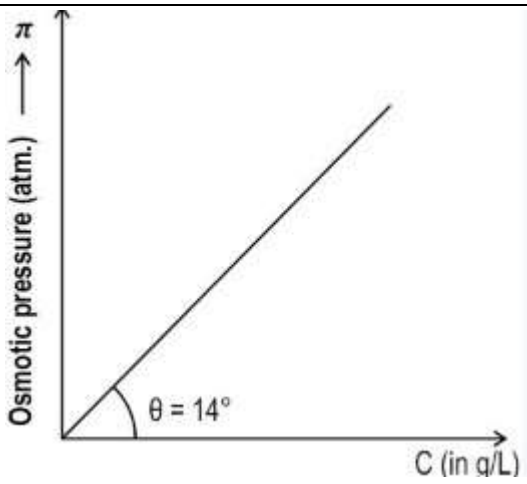
Q.No	Question	Marks
	Multiple Choice Question	
Q.21	In a chemistry laboratory, Richa took 5g of a solute from an unknown box and prepared a 0.25 M basic solution. The volume of the solution was 500 ml. Based on the above data, which of the following is likely to be the unknown substance used by Richa? *(Approx. Atomic masses of Ca = 40 u; Na = 23 u; Li = 7 u; Cs = 133 u; O = 16 u; H = 1 u)* A. Ca(OH)2 B. NaOH C. LiOH D. CsOH	1
Q.22	A glycerine solution, at 293 K, has a molality of 3.89 molal and molarity of 5.33 M. Which of these would be CORRECT for molarity and molality of the same glycerine solution at 450K? A. Molarity < 5.33 M; Molality = 3.89 molal B. Molarity < 5.33 M; Molality < 3.89 molal C. Molarity > 5.33 M; Molality = 3.89 molal D. Molarity = 5.33 M; Molality = 3.89 molal	1
Q.23	A mixture of acetone and chloroform forms a maximum boiling azeotrope at a specific composition. Which of these is CORRECT for the mixture? A. Change in volume on mixing will be positive. B. Change in enthalpy on mixing will be positive. C. Interaction between unlike molecules is stronger than that between like molecules in the mixture. D. The proportion of acetone and chloroform in the mixture in the liquid phase is not the same as in the vapor phase.	1

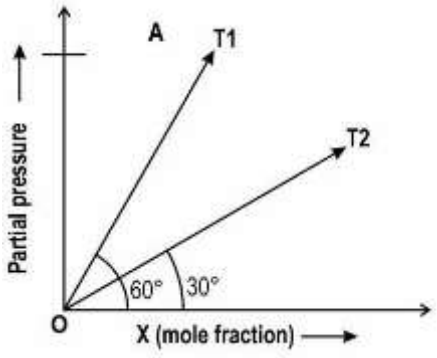
Q.24	In a chemistry laboratory, a student has 0.01 L of 10^{-2} mol dm^{-3} sulphuric acid solution. The lab assistant asked the student to reduce its concentration to 2×10^{-4} mol dm^{-3} by adding water into it. What should be the volume of the water added? A. 200 ml B. 490 ml C. 500 ml D. 510 ml	1
Q.25	As per Henry's law $K_H = p/x$; where p is the partial pressure, x is the mole fraction of the gas, and K_H is the Henry law constant. If, the concentration of N_2 gas in water at constant pressure increases quadratically, how will the value of K_H change? A. Increases linearly B. Decreases quadratically C. Decreases linearly D. Remains the same	1
Q.26	342.3 g of sucrose is dissolved in 1 kg of water in a pot to form a solution. The boiling point of water (solvent) is 373.15 K. Which of the following is likely to be the boiling point of the solution? *(Molar mass of sucrose= 342.3 g/mol; Atmospheric pressure= 1.013 bar; K_H= 0.52 K kg mol^{-1})* A. 373 K B. 373.15 K C. 373.67 K D. 372.63 K	1
Q.27	The molarity of a solution of NaOH in water is '5p' during the winter season (Temperature = 275K). Which of the following could be the molarity of the same solution in terms of p during the warm days in summer (Temperature = 325K)?	1

	[Note: p is an integer] A. 5p + 50 B. 5p C. 4.95p D. 250p	
Q.28	Which of the following statements is/are true: (i) The freezing point of 0.1M KCl is higher than that of 0.1M C_2H_5OH. *(ii)* The freezing point of a 4% aqueous solution of X having molecular weight as "m" is equal to the freezing point of 12% aqueous solution of Y having molecular weight "3m" *(assume that i=1 for both X and Y)* (iii) The boiling point of pure water at sea level is greater than that at Mt. Everest. A. i and ii B. i, ii, and iii C. ii and iii D. i and iii	1
Q.29	Which of the following statements is/are correct? (i) Sea water boils at a lower temperature than fresh water. (ii) ΔS is higher for the vaporization of pure solvent than the vaporization of solvent from a solution containing a non-volatile electrolytic solute. (iii) The boiling point of water is lower than that of glucose water. A. i and iii B. ii and iii C. i, ii, and iii D. i only	1
Q.30	Which of the following should be done to change 100 ml of 0.1M KCl solution to 0.2M? (i) Reduce volume of solution to half by evaporation	1

	(ii) Add 50 ml water (iii) Add 0.1 mol KCl (iv) Add 0.01 mol KCl A. i and iii B. i and iv C. ii and iv D. Any of i, ii, iii, and iv	
Q.31	93 g of ethylene glycol is added with 1 kg of water to change the freezing point of the solution. If the freezing point of water is 273 K at 1 bar, and K_f of water is 2 K kg/mol, which of the following graphs represents the depression in the freezing point of the water-ethylene glycol solution? *(molar mass of ethylene glycol is 62 g/mol)*  A. A B. B C. C D. D	1

Free Response Question/ Subjective Type		
Q.32	Some countries use the colligative property of solutions to remove the snow from the roads. The snow is salted with NaCl or $CaCl_2$, lowering its freezing point and causing it to melt and clear the space. Assuming that NaCl dissolves completely in ice and forms an ideal solution, what mass of NaCl must be dissolved in 5.5 kg of ice on the road to decrease the melting point of water to -10°C? *(K_f = 1.86 °C kg/mole; atomic mass of sodium = 23 g/mol, atomic mass of chlorine = 35.44 g/mol)*	2
Q.33	Rakesh took 20 g of solute A to prepare a 50 ml solution. This solution is isotonic to another solution of the same volume with a weight of 40 g of a different solute B. (i) If both the solution is prepared at the same temperature, then what is the ratio of molecular mass of solute A to that of B? (ii) If the two solutions are placed at different temperatures, keeping all other variables constant, and separated by SPM, will the osmosis happen, and why?	2
Q.34	The images below show the evaporation of the solvent on account of the presence of non-volatile solutes. In each of the three cases, the solvent taken is of the same type. The solvent is volatile and its quantity is the same in all three cases.  Which of the above three solutions has the least amount of solute in it? How did you reach that conclusion?	2
Q.35	Use the graph below (osmotic pressure vs concentration) of the Compound X to answer the following.	3

	 (Image is not to scale and only for representation) (i) Identify the molecular formula of X. (ii) What will happen to the molecular weight of the same X if the temperature is increased and why? *(use R = 8.31, T = 300 K, tan14° = 249.3 x 10^{-3})* *Note:* tan θ gives the slope of the graph	
Q.36	One of the key ingredients in some toothpastes is Sodium Fluoride. However, the concentration of this chemical compound is very low. This concentration can be expressed in ppm (parts per million) that is 1 ppm represents a concentration of 1 mg of sodium fluoride in 1 kg of the toothpaste. (i) A 1.00 g sample of toothpaste was found to contain 2.88 x 10^{-5} mol of sodium fluoride. What is the concentration of sodium fluoride, in ppm, for this sample of toothpaste? (ii) Sodium fluoride is toxic in high concentrations. Major health problems can occur if concentrations of sodium fluoride are greater than 3.19 x 10^{-2} g per kilogram of body mass. Deduce the maximum mass of sodium fluoride, in mg, that a 75 kg person could swallow without reaching the toxic concentration. (iii) The concentration of sodium fluoride in a prescription toothpaste is 2800 ppm. Use your answer to Question (ii) to deduce the mass of toothpaste, in kg, that a 75.0 kg person could swallow without reaching the toxic concentration.	4
Q.37	Aquatic animals feel more comfortable in cold water than warm water as the solubility of oxygen in cold water is more than that in warm water. The graph	2

	below shows the solubility of oxygen in the water as a function of pressure at different temperatures T1 and T2.  (i) Based on the above graph, what is the ratio of K_H at T1 and T2? (ii) Between T1 and T2, which one is greater?	
Q.38	Radiators with water are used in car engines to transfer the excess heat from the engine to the air outside. In a cold winter, the temperature suddenly dips down to -2 °C. If the water in a car's radiator freezes, the engine will not function properly after some time. To avoid the freezing of water, a certain amount of ethylene glycol is used to lower the freezing point of water in the radiator. If the capacity of your car's radiator to hold water is 1 kg, how many grams of ethylene glycol must you add to lower the freezing point of water from 0 ° to -2 °C? *(K_f of water = 1.86 K kg/mol; molecular weight of ethylene glycol= 62 g/mol)*	3
Q.39	An aqueous solution of 500 ml is prepared by mixing a 2g mixture of a protein 'x' (molar mass = 80 g/mol) and sucrose (molar mass = 342 g/mol. The osmotic pressure of the solution is 1 atm at 300 K. (i) What is the amount of protein 'x' in the mixture? (ii) If sucrose is replaced by the same amount of glucose, will the solution have a higher or lower osmotic pressure than the original solution? Justify your answer.	4
Q.40	A solution containing two non-interacting solid solutes A and B in the mass ratio 5:1 is isotonic with another solution of A and B (with the same volume) having a mass ratio of 3:5. What is the ratio of the molar mass of A: B?	2

<table>
<tr><td>Q.41</td><td>Two solutions A and B are prepared. Both solutions A and B contain an equal amount of organic compounds P and Q respectively as solutes in 500 g benzene (as a solvent).

The boiling point of solution A is 0.4^{o}C higher than that of pure benzene and the boiling point of solution B is 0.8^{o}C higher than that of pure benzene.

(i) Calculate the ratio of molecular weight of P: Q

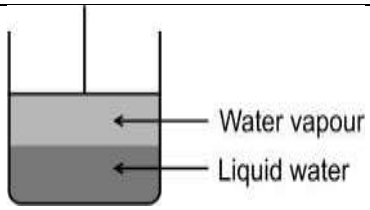
(ii) If the molecular weight of P is 200, what is the minimum value of the sum of molecular weights of P and Q?</td><td>3</td></tr>
<tr><td>Q.42</td><td>The osmotic pressure of a protein solution is 0.6 atm at 283 K. If the temperature of the solution is increased to room temperature (298 K) and a few glasses of water are added to it to make it more dilute, the osmotic pressure becomes 0.3 atm.

Find the volume of the final solution in terms of the initial volume of the solution.</td><td>2</td></tr>
<tr><td>Q.43</td><td>The table below shows the degree of dissociation/association along with constant i for different solutes.

<table><tr><th>Solute</th><th>Degree of association or dissociation</th><th>i</th></tr><tr><td>H_2SO_4</td><td>1</td><td>3</td></tr><tr><td>CH_3COOH (in water)</td><td>0.2</td><td>-</td></tr><tr><td>CH_3COOH (in benzene)</td><td>0.5</td><td>-</td></tr><tr><td>Urea</td><td>No association or dissociation</td><td>1</td></tr></table>
Based on the table:

(i) What is the Vant Hoff factor i for CH_3COOH in two different solvents? (Assume 100% association or dissociation)

(ii) Why does Urea show no association or dissociation in any solvent?</td><td>3</td></tr>
<tr><td>Q.44</td><td>Water vapor and liquid water are in equilibrium in the image shown below. At room temperature, the vapor pressure of water is 25 mmHg. The volume of water vapor is V.</td><td>3</td></tr>
</table>

	 What will be the vapor pressure of the water if the volume of water vapor becomes (i) 2V when the piston is moved upwards (ii) V/2 when the piston is moved downwards (iii) Explain the reasons for your answers for i and ii.	
Q.45	In a chemistry lab, Riya wants to find the difference between theoretical molar mass and observed molar mass of an unknown compound MN_2. For this, she prepares a solution by adding 0.2 moles of the unknown compound MN_2 in 4 litres of water. She finds that the compound ionized to: $MN_2 > M^{2+} + 2N^-$ If the molar mass of M is 48 and that of N is 64 and the observed osmotic pressure is 6 atm, then (i) What is the value of the observed molar mass of the unknown compound? (ii) What is the difference between observed molar mass and theoretical molar mass? *(Assume T= 300K; R = 0.2)*	4
Q.46	The osmotic pressure of NaCl in water is 3 times that of the solution of 0.2M $MgCl_2$. If NaCl dissociates completely in water, then calculate the concentration of NaCl. *(Assume the value of R and T as the same for both the solutions)*	2
Q.47	The vapor pressure of compound A at 90°C is 526 mm Hg and that of compound B is 11250 mm of Hg. (i) What will be the total concentration (in terms of mole fraction) of the boiling mixture of A and B at 90° C if the two liquids are completely miscible with each other? *(ii)* Using i, calculate X_A and X_B. *(Round off to two decimal places)* *(Take P_{total} = 760 mm Hg)*	4

Q.48	During a titration, 240 ml of NaOH reacted completely with 100 ml of H_2SO_4 solution. The weight of H_2SO_4 taken was 9.8 g. i) What is the molarity of the NaOH used? ii) Calculate the amount of NaOH dissolved in solution. iii) How many grams of NaOH should be added to the original NaOH solution to make one litre of 0.5M NaOH solution? (*Molecular mass of NaOH is 40g/mol and molecular mass of H_2SO_4 is 98 g/mol.*)	3

Answer Key & Marking Scheme

Q.No	Answers	Marks
Q.21	B. NaOH	1
Q.22	A. Molarity < 5.33 M; Molality = 3.89 molal	1
Q.23	C. Interaction between unlike molecules is stronger than that between like molecules in the mixture.	1
Q.24	B. 490 ml	1
Q.25	D. remains the same	1
Q.26	C. 373.67 K	1
Q.27	C. 4.95p	1
Q.28	C. ii and iii	1
Q.29	B. ii and iii	1
Q.30	B. i and iv	1
Q.31	C. C	1
Q.32	- Depression in the freezing point is given by $\Delta t = K_f m$; where Δt is the change in the freezing point, K_f is constant and m is the molality) => 10 = 1.86 x n_{NaCl}/mass of ice ; where n is the number of moles of NaCl [1 mark] => 10 = 1.86 x n_{NaCl}/5.5 => n_{NaCl} = 29.56 moles => mass of NaCl = 29.56 x 58.44 g = 1727.4 g [1 mark]	2
Q.33	(i) For any solution, osmotic pressure is given by $\pi = (w/MV) \times RT$; w= weight of the solute, V= volume of solution, R = gas constant and T is temperature - For two solutions to be isotonic, $\pi 1 = \pi 2$ [0.5] => 20/M1 = 40/M2 => M1/M2 = 1/2 [0.5] (ii) Yes,	2

	- because at different temperatures the solutions are no longer isotonic and hence there will be movement of particles through osmosis	
Q.34	Solution B - Reason: The evaporation rate of molecules of a given solvent is the highest in B as there is more number of particles outside the solution responsible for vapor pressure. - Higher the vapor pressure, the higher will be mole fraction of the solvent and the lower will be the amount of solute	2
Q.35	Molecular formula: => π = CRT ; where C is molarity => π = (w/MV)RT; V is volume of solution From the graph, slope = π/(w/V) [2 mark] => slope = RT/M => M = (8.31 x 300)/249.3 x 10^{-3} => M = 10000 g/mol [1 mark] - Molecular weight remains the same as it is independent of temperature Not able to delete this box	3
Q.36	(i) Concentration of NaF: - Molar mass of NaF = 42g/mol, so the mass of NaF in 1g toothpaste= 42 x 2.88 x 10^{-5} g [1 mark] - Mass of NaF in 1 kg toothpaste = 42 x 2.88 x 10^{-2} g = 1.210g [0.5 mark] - Mass in mg = 1210 mg = 1210 ppm [0.5 mark] (ii) Maximum mass of NaF for toxic concentration: - Toxic mass = 75 x 10^{3} x 3.19 x 10^{-2} = 2392 mg [1 mark] (iii) maximum mass of toothpaste that can be swallowed: - Mass of toothpaste needed = 2392/2800 kg = 0.854 kg [1 mark]	4
Q.37	(i) Ratio of K_H (T1): K_H(T2) - As per Henry's law, p = K_Hx. So the slope of the p vs x curve will be the Henry law constant. - K_{H1} : K_{H2} = tan60/tan30 = $\sqrt{3}$/(1/$\sqrt{3}$) = 3 [1.5 mark] (ii) T1>T2 [0.5 mark]	2

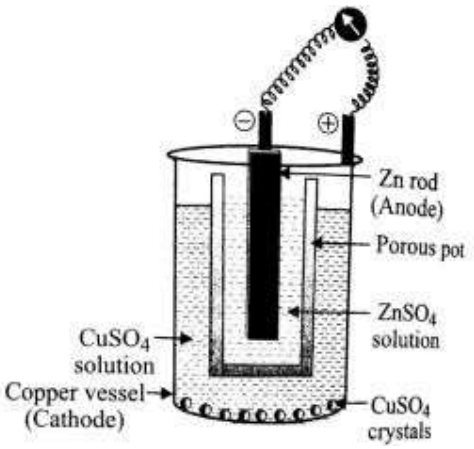
Q.38	**Calculation of the amount of ethylene glycol**: - $\Delta T_f = i \times K_f \times m$. equation (i) - Given that $\Delta T_f = 2$ °C, K_f of water = 1.86 K kg/mol , i =1 as ethylene glycol is a non-electrolyte, weight of solvent = 1kg, molecular weight of solute = 62 [1.5 mark] - Let the weight of solute= P grams ∴from equation (i) $2 = 1 \times 1.86 \times P/62$ or P = 66.67 g So, the amount of ethylene glycol to be used = 66.67 g [1.5 mark]	3
Q.39	(i) Amount of protein 'x' - Let the amount of protein and sucrose in the mixture be p and q consecutively. so, p + q = 2 ---------Equation 1 - Applying osmotic pressure formula $\pi V = [p/80 + q/342] \times 0.08 \times 300$ That is $1 \times 500/1000 = [p/80 + q/342] \times 0.08 \times 300$-------- Equation 2 - Solving equations 1 and 2, we get p= 1.564 g (ii) Higher - As osmotic pressure is inversely proportional to molar mass. On replacing sucrose (molar mass = 342 g/mol) with glucose (molar mass = 180 g/mol), osmotic pressure will increase. *(Note: No marks to be awarded if justification is not given)*	4
Q.40	The ratio of molar mass A:B: - Let the molar mass of A is M_A and B is M_B - Since the solutions are isotonic, so $C_1RT = C_2RT$ (equal osmotic pressure) [1 mark] $\Rightarrow 5/M_A + 1/M_B = 3/M_A + 5/M_B$ $\Rightarrow 2/M_A = 4/M_B$ $\Rightarrow M_A/M_B = 1/2$ [1 mark]	2
Q.41	(i) Ratio of molecular weight of P and Q: - For solution A, $\Delta T_b = k_b \times m \times i$ $\Rightarrow 0.4 = k_b \times$ (mass of P/molecular weight of P) x 1000/(weight of benzene) x 1.... (equation 1) [1 mark]	3

	- For solution B, $\Delta T_b = k_b \times m \times i$ $0.8 = k_b$ x (mass of Q/molecular weight of Q) x 1000/(weight of benzene) x 1... equation 2) [0.5 mark] - Since Mass of P = Mass of Q and k_b is the same as both are formed in benzene solution with equal weights, equations i and ii gives - Molecular weight of P/Molecular weight of Q = 2/1 [0.5 mark] (ii) Minimum value of the sum of molecular weights of P and Q: - Since P:Q = 2:1 and molecular weight of P is 200, so Q = 100 - Minimum value= 200+100 = 300	
Q.42	- Initially p1 = 0.6 atm, T1 = 283K and let the volume be V1; Finally, p2 = 0.3, T2= 298K, and let the volume be V2 - Applying osmotic pressure formula =>p1 x V1/p2 x V2 = nRT1/nRT2 [1mark] => 0.6 x V1/0.3 x V2 = 283/298 => V1/V2 = 283/298 x 0.3/0.6 => V1/V2 = 0.474 So V2 = 2.10 V1 [1 mark]	2
Q.43	(i) Vant Hoff factor of acetic acid in water: - Acetic acid in water dissociates to: $CH_3COOH + H_20$ ---> $CH_3COO^- + H_30^+$ [1 mark] i = 1 + α (n-1) [Where α =1 for 100 percent dissociation; n is no. of ions in the product] => i = 2 (in water) [1 mark] Vant Hoff factor of acetic acid in Benzene: - Acetic acid in Benzene associates to: $2[CH_3COOH]$ ----> $[CH_3COOH]_2$ [1 mark] For association, i is given by i = 1 + α ((1/n)-1) [here n is no. of moles in the reactant] => i = 0.5 (in benzene) [1 mark] (ii) Urea is an organic molecule having covalent bonds. It does not split into ions in the presence of a solvent.	3
Q.44	(i) When the piston is moved upwards:	3

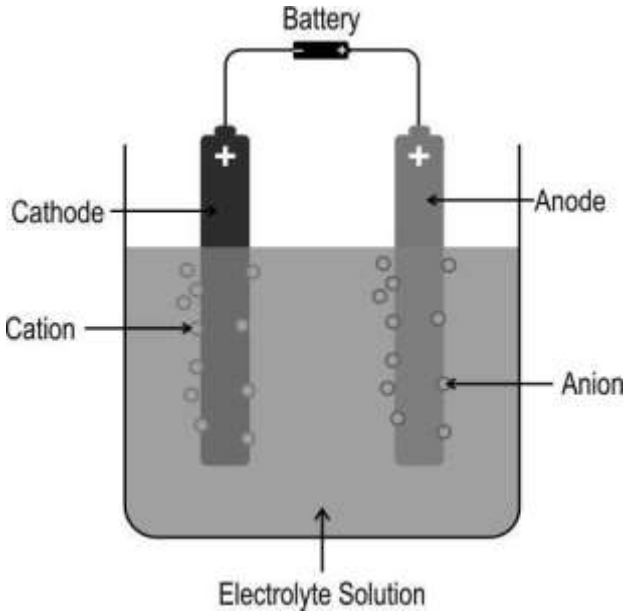
	- vapor pressure of water = 25 mmHg (ii) When the piston is moved downwards: - vapor pressure of water = 25 mmHg (iii) Explanation: - Vapor pressure is independent of the volume of water. [1 mark] - When the volume of vapor is changed, for example - decreased, some of the vapor in the container turns into its liquid state. Increasing volume has no effect on vapor pressure. [1 mark] - Furthermore, if the volume of vapor is increased, some of the liquid will change into its vapor state. Decreasing volume has no effect on vapor pressure. [1 Mark]	
Q.45	(i) Calculating observed molar mass: => $\pi = i \times c \times R \times T$ => $6 = i \times 0.2/4 \times 0.2 \times 300$ [1 mark] => $i = 2$ [0.5 marks] Since, $i = M_{theory}/M_{Observed}$ => $2 = (48 + 2 \times 64)/M_{Observed}$ [1 mark] => $M_{Observed} = 88$ [0.5 marks] (ii) Difference between observed molar mass and theoretical molar mass = 176 -88 = 88	4
Q.46	The concentration of NaCl: - Given that $\pi_{NaCl} = 3 \times \pi_{MgCl2}$----- (i) - Since NaCl, and $MgCl_2$ are ionic compounds, the value of i is 2 and 3 respectively. [1 mark] From equation (i): => $2 \times C_{NaCl} \times RT = 3 \times C_{MgCl2} \times RT$ => $C_{NaCl} = 3 \times 0.2/2 = 0.3$ M [1 mark]	2
Q.47	(i) For binary solution, $X_A + X_B = 1$; where A and B are any two liquids/compounds that are mixed. - So the total concentration of A and B = 1 [1 mark] (ii) Using Raoult's law, $P_{total} = P^0_A.X_A + P^0_B.X_B$ => $760 = 526\ X_A + 11250\ X_B$ --- equation 1 [1 mark]	4

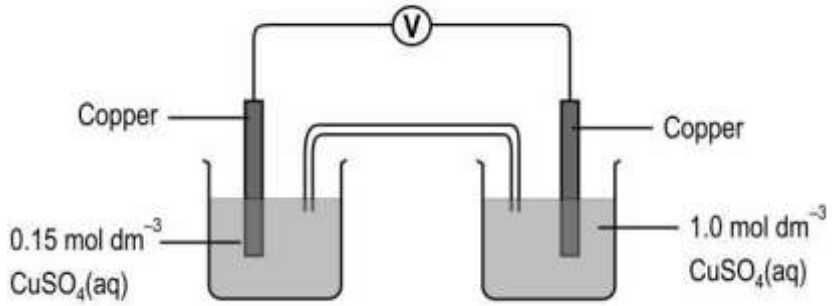
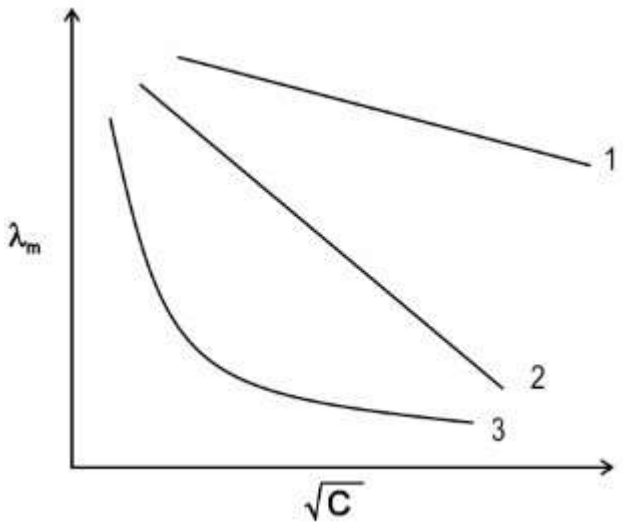
	Also => $X_A + X_B = 1$------ equation 2 Solving equations 1 and 2, we get $X_A = 0.98$; $X_B = 0.02$ [2 mark]	
Q.48	i) 9.8 g of H_2SO_4 is 0.1 mole. 1 mole of H_2SO_4 reacts with 2 moles of NaOH. [1 mark] 0.2 moles of NaOH reacts with 0.1 moles of H_2SO_4. Molarity of NaOH = 0.2 × 1000/240 = 0.83 M/litre [0.5 mark] ii) Moles = amount of NaOH/Molar mass Amount of NaOH = Molar mass × moles Amount of NaOH = 40 × 0.2 = 8 grams [0.5 marks] iii) 0.5 M of 1 litre NaOH solution will have 0.5 moles of NaOH. Therefore 20 grams of NaOH needs to be present. Therefore, 12 g of NaOH needs to be added [1 mark]	3

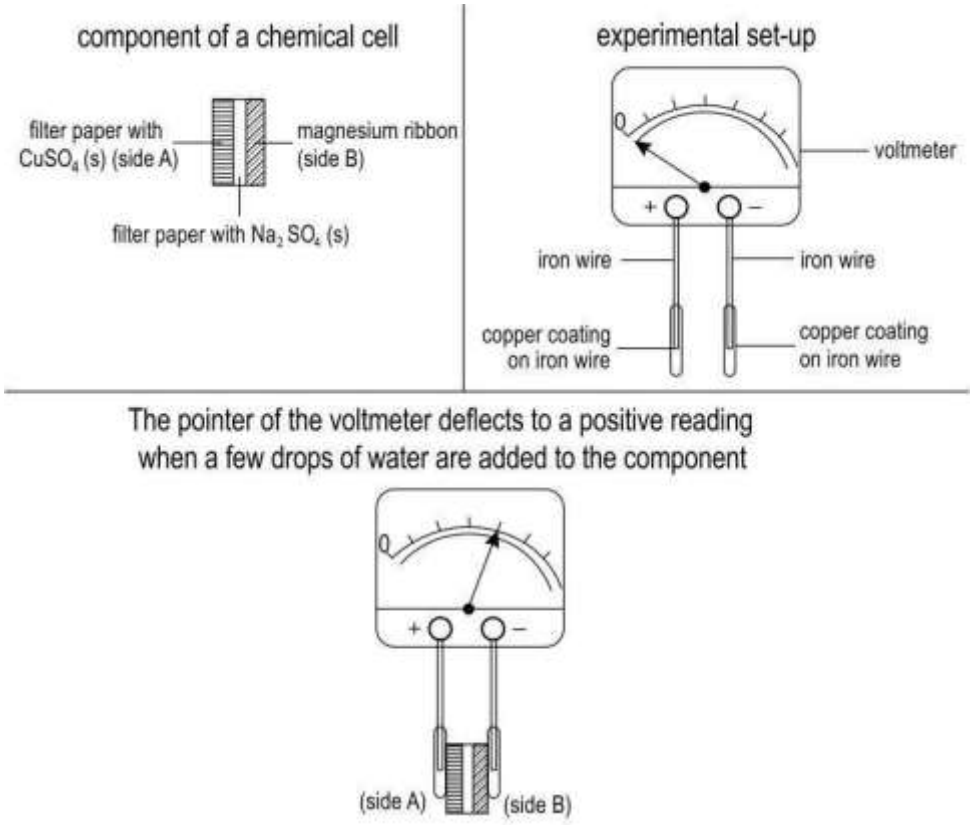
3. ELECTROCHEMISTRY

Q.No	Question	Marks
	Multiple Choice Question	
Q.49	If the standard emf of Galvanic cell–I: $Cu_{(s)}/Cu^{2+}_{(aq)}$II $Ag^{+}_{(aq)}/Ag_{(s)}$ is 0.46V, and the standard emf of Galvanic cell–II: $3\ Cu_{(s)} + 6\ Ag^{+}_{(aq)} \rightarrow 3Cu^{2+}_{(aq)} + 6\ Ag\ (s)$ is 0.46q V. What is the value of q? A. 3 B. 2 C. 1 D. Infinite	1
Q.50	The electrochemical cell made up of Zn and Cu half-cell is called Daniell cell. The emf of a Daniell cell is 1.10V.  When an external voltage greater than 1.10 V is applied to this cell, which of the following change will be observed in the cell? A. Zn electrode will act as an anode. B. Current will flow from Cu half cell to Zn half cell. C. Electrochemical cell continue to work fast. D. Cell will act as electrolytic cell.	1
Q.51	An electrolytic cell has an anode and cathode made up of graphite. At the anode, Cl_2 gas is released and at the cathode, H_2 gas is released. Which of the following electrolytes in the cell can produce these gases? A. $NH_4Cl_{(aq)}$	1

	B. Molten NH_4Cl C. NaCl (aq) D. Molten NaCl	
Q.52	There are two beakers 'A' and 'B' containing KCl and CH_3COOH solutions respectively. On adding water to beakers A and B, which of the following change in Λ_m of the solutions will be correct? A. It increases sharply in beaker A and slowly in beaker B B. It increases slowly in beaker A and sharply in beaker B C. It decreases in beaker A but no change in beaker B. D. There is no change in beaker A but it decreases slowly in beaker B.	1
Q.53	Copper metal is purified by electrolytic refining. If the electrolyte used for refining of copper in an electrolytic cell is aq.salt solution of copper, which out of the following statement about this cell is INCORRECT? A. The impure Copper rod undergoes oxidation. B. Oxidation takes place at the anode. C. Impure copper rod acts as the negative electrode. D. Pure copper rod acts as a cathode.	1
Q.54	Given that the standard reduction potential for Fe^{3+}/Fe^{2+}= 0.77 V and I_2/I^-= 0.54V. Which of the following is correct when the cell is made by using Fe^{3+} and I^- salt solutions? A. The standard emf of the cell is −0.23 V B. The standard emf of the cell is +0.23 V C. The standard emf of the cell is 1.31 V D. The standard emf of the cell is -1.31 V	1
Q.55	Under which of the following conditions will the chemical reaction in an electrochemical cell will be spontaneous? A. E^0_{cell} = +ve, ΔG= +ve B. E^0_{cell} = −ve, Δ G= −ve C. E^0_{cell} = +ve, Δ G= −ve D. E^0_{cell} = −ve, ΔG= +ve	1

Q.56	How much electricity in Faraday is required for the complete reduction of MnO_4^- ions present in 500 ml of 0.5 M solution to Mn^{2+}? A. 5 F B. 2.5 F C. 2.25 F D. 1.25 F	1
Q.57	The image below shows electrolysis of an electrolyte using a DC voltage source.  Based on this, Which of the following statements is/are correct? (i) The solution remains electrically neutral during electrolysis. (ii) Electrons flow from the current source towards the solution at one electrode, and an equal number of electrons flow away from the solution at the other electrode. (iii) The number of positive ions moving towards one electrode is always equal to the number of negative ions moving towards the other electrode. A. i only B. i and ii only C. ii and iii only D. all- i, ii, and iii	1
Free Response Question/ Subjective Type		
Q.58	In the chemistry lab, Zoya set up an electrochemical cell as shown below:	2

	 At room temperature, she found that the initial voltmeter reading was +0.16v. (i) The standard electrode potential for the Cu^{2+}/Cu electrode is given by $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$; $E^o = +0.34$ V Calculate the electrode potential of the electrode on the left-hand side of the above electrochemical cell. (ii) Explain the importance of the salt bridge between the two solutions.	
Q.59	(i) The molar conductivity vs √c curve for NaCl, HCl, and NH_4OH are shown below in random order.  Identify which graph corresponds to HCl, NaCl, and NH_4OH. (ii) Give reasons to justify your answer in (i).	3
Q.60	The value of E^0 for two half cells are given as: $O_2 + 4e^- + H^+ \rightarrow 2H_2O$; $E^0 = 1.228$V and, $E^0Ce^{4+}/Ce^{3+} = 1.60$ V	4

	Based on the above data, will Ce ion undergo oxidation or reduction in water? Explain it with the help of overall cell reaction. Also, find the emf of the cell.	
Q.61	There are four electrodes A, B, C, and D. E^0 values of the electrodes are as follows. **Electrodes** / **Electrode Potential** A / $A/A^- = 0.96$ V B / $B^-/B^{2-} = -0.12$V C / $C^+/C = 0.18$V D / $D^{2+}/D = -1.12$V The combination of which of two electrodes will give the largest cell potential? Justify your answer. Also, find the emf of the cell.	3
Q.62	The diagrams below show the component of a chemical cell, an experimental set-up, and how the pointer of the voltmeter deflects when the set-up is connected to the component. Note that in the chemical cell, a filter paper with Na_2SO_4 acts as a salt bridge.  	2

	Why does the pointer of the voltmeter deflect as shown when a few drops of water are added to the component?	
Q.63	In a galvanic cell when the potential difference becomes zero, the cell is said to be in an equilibrium state. Establish the relation between E^0 and equilibrium constant at 298 k in a Daniell cell. The E^0 value of the Daniell cell is 1.10V. *(R= 8.314 j/k/mol, F = 96500 C)*	3
Q.64	i) Write down the complete cell reactions taking place at anode and cathode in a zinc/carbon dry cell. ii) Is the above given cell a primary cell or a secondary cell? Explain.	2
Q.65	How much time does it require to reduce 3 moles of iron (III) to 3 moles of iron (II) ion by passing a 2.0 amp current? *(Note: For calculations use 1 Faraday = 96500 Coulombs.)*	2
Q.66	A rusted piece of iron undergoes electrochemical reactions. Write the chemical reactions taking place at the following spots of that rusting piece of iron: a) At the spot that behaves as an anode b) At the spot that behaves as a cathode c) The overall balanced chemical reaction d) Further oxidation of ferrous ion into rust	2
Q.67	The Gibbs energy change for the reduction of Al_2O_3 at 500°c is given as: $2/3\ Al_2O_3$ ----- > $4/3\ Al^3 + O_2$; $\Delta G = +960KJ$ Calculate the minimum potential difference required to reduce 2/3 mole of Al_2O_3 at 500°C. (*1F = 96500C)*	3
Q.68	In an experiment, the electrolysis of copper sulfate solution takes place under the following conditions- - Electrolysis time (t) = 10 min. - Current passed (I) = 1.5 amp. What mass of copper will be deposited at the cathode in this experiment? *(Note: atomic mass Cu= 63.5g; For calculation use 1 Faraday = 96500 Coulombs.))*	3

Q.69	The electrolytic conductivity of $BaCl_2$ solution is 0.580 Sm^{-1}. Find out molar concentration of the solution if molar conductivity of this solution is 2.416×10^{-2} Sm^2/mol.	2
Q.70	The molar conductivity of a dilute solution of methanoic acid is 46.1 S cm^2/mol. Calculate its degree of dissociation. *(Given $\lambda^0(H^+)$ = 349.6 S cm^2/mol and $\lambda^0(HCOO^-)$ = 54.6 S cm^2/mol)*	2
Q.71	Two electrolytic cells A and B containing electrolytic solutions of $CuSO_4$ and $AgNO_3$ respectively are connected in a series. A steady current of 1.5 amperes is passed through them. Based on this information, answer the following questions. a) Find out the time 't 'in minutes required to deposit 1.34 g of the silver in cell 'B'. b) What mass of copper will be deposited at the cathode of cell A under the same experimental condition. *(Given - Atomic mass Cu=63.5 g, Ag= 108 g and 1F= 96500 C)*	3
Q.72	Given is an electrochemical cell; $Mg/Mg^{2+}_{(aq)}$ || $Cu^{2+}_{(aq)}/Cu_{(s)}$ Calculate the equilibrium constant of the cell at 25°C when the emf of the cell is zero. *(E^0 Mg^{2+}/Mg= -2.37V, Cu^{2+}/Cu= 0.34V, 2.303RT/F= 0.0591)* *Use log and antilog table if needed.*	2
Q.73	For an experiment, Aman prepared a 1-litre $FeSO_4$ solution of 1 M concentration and stored the solution in a glass jar. Before starting the experiment, Aman wants to stir the solution. Which of the following spoons should he use for this purpose and why? Aluminium spoon (Al^{3+}/Al = -1.66V) Copper spoon (Cu^{2+}/Cu = 0.34V) (*Given: E^0/V Fe^{2+}/Fe = -0.44V*)	2
Q.74	The potential of Zn, Cu and Ag half cells are given below; $Zn_{(s)}$ -----> $Zn^{2+}_{(aq)}$ + $2e^-$; E^0= +0.76V $Cu_{(s)}$ ------> $Cu^{2+}_{(aq)}$ + $2e^-$; E^0= -0.34V $Ag_{(s)}$ --------> $Ag^+_{(aq)}$ + $1e^-$; E^0 = -0.80V. Using the data above given, i) Write the correct cell representation of a cell with a cell potential equal to 0.46V.	2

	ii) Calculate the value of standard free energy change (ΔG^0) for the cell above given. (F = 96500 C/mol)	
Q.75	Predict the feasibility of the following reaction. Justify your answer. $Ag(s) + Fe^{3+}_{(aq)} \text{------>} Ag^{+}_{(aq)} + Fe_{(s)}$ (Given: $Ag^{+}_{(aq)}/Ag_{(s)} = 0.80V$, $Fe^{3+}/Fe_{(s)} = 0.77V$)	2
Q.76	In a Standard Hydrogen Electrode (SHE), the platinum wire is normally dipped in 1 M con. HCl solution. Find out the potential of SHE if the platinum wire is dipped in a solution containing 1×10^{-10} M H^+ concentration.	2
Q.77	Calculate the charge required in coulombs to reduce 0.5 moles of $Cr_2O_7^{2-}$ ion to Cr^{3+} in acid solution. *(1 Faraday = 96500C)*	2
Q.78	One Faraday of electric charge is passed through the electrolytic cells placed in a series containing solution of Ag^+, $Cu^{2+}$and Al^{3+}respectively.Find out the simple mass ratio of the metals deposited at the respective electrodes. (Given - Atomic mass Ag=108g, Cu=63.5g. Al=27g)	2
Q.79	Imagine you are in a chemistry lab and the teacher is explaining the electrolysis of $CuSO_4$ solution and the products liberated after electrolysis. The teacher made two Setups for the electrolysis process. In Set up-i electrolysis of $CuSO_4$ solution is done by using Pt electrodes and in Set up-II electrolysis of $CuSO_4$ solution is done by using Cu electrodes. Answer the following questions based on this: i) In which Set up I or II will the colour of $CuSO_4$ solution fades away and why? ii) Write the chemical reaction taking place at the Cu anode in Set up II. iii) Name the product obtained at the anode in Set up I. iv) Which out of Set up I or II depict refining of crude copper?	3

Answer Key & Marking Scheme

Q.No	Answers	Marks
Q.49	C. 1	1
Q.50	D. Cell will act as electrolytic cell.	1
Q.51	C. NaCl (aq)	1
Q.52	B. It increases slowly in beaker A and sharply in beaker B	1
Q.53	C. Impure copper rod acts as the negative electrode.	1
Q.54	B. The standard emf of the cell is +0.23 V	1
Q.55	C. E^0_{cell} = +ve, Δ G= −ve	1
Q.56	D. 1.25 F	1
Q.57	B. i and ii only	1
Q.58	(i) Electrode potential of the electrode on the left-hand side is given by: => $E^o_{cell} = E^o_{cathode} - E^o_{anode}$ => $0.16 = 0.34 - E^o_{anode}$ => E^o_{anode} = +0.18 V (ii) It allows mobile ions to move through it between the solutions and maintain the charge balance.	2
Q.59	(i) From the above graph, 1 corresponds to HCl 2 corresponds to NaCl 3 corresponds to NH_4OH (ii) Explanation: - When the above compounds dissociate, H+ has the highest mobility in comparison with Na, because the Molar mass of H+ is less than Na+ ion. - HCl and NaCl are strong electrolytes compared to NH_4OH which is a weak base. [1 mark]	3

	- Strong electrolytes are already completely dissociated and there is a small increase (change) in dissociation on dilution. For weak electrolytes, the degree of dissociation increases to a greater extent/abruptly and follows the non-linear curve. - so at a given concentration, molar conductivities of HCl>NaCl>NH_4OH [1 mark]	
Q.60	$Ce^{4+} + e^- \rightarrow Ce^{3+}$; $E^0 = 1.60V$ ...(i) $O_2 + 4e^- + 4H^+ \rightarrow 2H_2O$; $E^0 = 1.228V$ ...(ii) Since the reduction potential of the Ce half cell is more than that of water, Ce will undergo reduction. [1 mark] **Explanation using reaction and emf of cell:** Multiplying eq(i) by 4: $4Ce^{4+} + 4e^- \rightarrow 4Ce^{3+}$; $E^0 = 1.60V$ Reversing eq(ii): $2H_2O \rightarrow O_2 + 4e^- + 4H^+$; $E^0 = -1.228V$ Adding the two eqs give: $2H_2O + 4Ce^{4+} \rightarrow O_2 + 4H^+ + 4Ce^{3+}$; $E^0 = 0.372V$; [1 mark] Since E^0 is positive, the reaction is spontaneous. Ce^{4+} will undergo reduction. [1 mark]	4
Q.61	A combination of electrodes A and D will give the largest cell potential. **Justification**: - Since, $E_{cell} = E_{red} - E_{ox}$ - For the largest cell potential, we need an electrode with very high (+ve) reduction potential at the cathode and another electrode with very low (-ve) reduction potential at the anode. [1 mark] => Electrode A/A^- = 0.96V shows highest reduction potential; Electrode D^{2+}/D = -1.12V shows least reduction potential => emf of the cell = 0.96 - (-1.12) V = 2.08 V [1 mark]	3
Q.62	- When a few drops of water are added, it acts as an electrolyte solution to form an electrochemical cell. [0.5 marks] - $CuSO_4$ ionizes to form Cu^{2+} and SO_4^{2-} ions. [0.5 marks] - Mg ionises to $Mg^{2+} + 2e^-$ [0.5 marks]	2

	- The presence of free electrons in the cell gives rise to emf and hence the pointer deflects. [0.5 marks]	
Q.63	Nernst equation (Daniell cell) : $E_{cell} = E^0_{cell} - 2.303\ RT/nF \log [Zn(aq.)^{2+}]/[Cu_{(aq.)}^{2-}]$; where R=8.314 j/k/mol F=96500 Cmol^{-1} T= 298 K - On substituting value $E_{cell} = E_{cell}^0 - 0.059/n \log [Zn^{2+}]/[Cu^{2+}]$ [1 M] - At equilibrium E_{cell}=0,and $[Zn^{2+}/Cu^{2+}] = \log k_c$ Then, $E^0_{cell} = (0.059/n) \times \log k_c$ [1] - For Daniell cell => E_{cell}^0= 1.10V, n=2 So, $1.10 = (0.059/2) \times \log K_c$ => $\log k_c = 2.20/0.059$ [1] or =>$\log k_c$=37.28	3
Q.64	i)In a Zinc/Carbon dry cell complete cell reaction is: $Zn_{(s)} + 2MnO_{2(s)} + 2 NH_4^+(aq) \rightarrow Zn^{2+}(aq) + Mn_2O_{3(s)} + 2NH_{3(aq)} + H_2O_{(l)}$ or $Zn_{(s)} + MnO_{2(s)} + NH_4^+ \rightarrow Zn^{2+}(aq) + MnO(OH)_{(s)} + NH^3(aq)$ *(give 1 mark for any)* ii) The Zinc/Carbon dry cell is a primary cell. - A primary cell is one in which redox reaction cannot be reversed. The Zinc/Carbon cell becomes dead after a long time of use i.e.it stops working. This shows it is a primary cell. *(give 0 marks if explanation not given)*	2
Q.65	As Q = I x t ...(i) where Q= charge (coulomb) I = current(amp) t = time(sec) Required equation:	2

	$3Fe^{3+} + 3e$ --- > $3Fe^{2+}$ charge required is = 3 F Substituting the value in eq.(i) => 3 x 96500 C = 2 amp. x t t = 144750 s Or t = 2412.5 minutes Or t = 40.21 hrs	
Q.66	Chemical reactions are as follows: a) At anode: $Fe_{(s)}$ ---> $Fe^{2+}{}_{(aq)} + 2e^-$ b) At cathode: $O_2(g) + 4H^+{}_{(aq)} + 4e^-$ --> $2H_2O_{(l)}$ c) Over all reaction: $2Fe_{(s)} + O_{2(g)} + 4H^+{}_{(aq)}$ --> $2Fe^{2+}(aq) + 2H_2O_{(l)}$ d) Further oxidation : $2Fe^{2+}{}_{(aq)} + 2H_2O_{(l)} + 1/2O_{2(g)}$ --> $Fe_2O_3{}_{(s)} + 4H^+{}_{(aq)}$	2
Q.67	Given is : $\Delta G = +960 \times 10^3$ J ; F = 96500 C Required formula: $\Delta G = - n E F$ Calculating n for 2/3 moles of Al_2O_3 $Al_2O_3 > 2Al^{3+} + 3/2\ O_2$ $(2\ Al^{3+} + 6e > 2Al)$ $2/3\ Al_2O_3 > 4/3\ Al + O_2$ ∵ 1 mole Al_2O_3 is reduced by 6 mol e^- ∴ 2/3mole Al_2O_3 is reduced by e^- = 6x2/3= $4e^-$ Substituting the value in formula 960×10^3 J = - 4 x E x 96500 C E= (- 960×10^3 J/ 4 x 96500 C) E = - 2.487 V Hence minimum potential difference required= 2.487V OR ≈ 2.5 V	3
Q.68	Charge=current x time Q = I x t	3

	Q = 1.5 amp x 10 x 60s Q = 900 C Calculating charge and amount of copper For 1 mole Cu^{2+}ion Cu^{2+}+ 2e ----> Cu 2F 63.5 [0.5 marks] - Charge required to deposit 1 mol copper = (2 x 96500 C) [0.5 marks] ∵ 2 x 96500 C charge deposit mass of Cu = 63.5gr. ∴ 900 C charge will deposit mass of Cu = (63.5 g x 900 C)/(2 x 96500) C [0.5 marks] Amount of Cu at cathode = 0.296 g [0.5 marks]	
Q.69	Step-I Calculation of Concentration $\Lambda_m = k/C$ Where; k= electrolytic conductivity C=molar concentration Λ_m=molar conductivity Substituting values; $C = 0.580/2.416x10^{-2}$ $C = 0.24x10^2 mol/m^3$ Step II molar concentration $C= 0.24x10^2 mol/m^3$ $(1m^3=1000L)$ $C= 0.24x10^2 mol/1000L$ C= 0.0240 mol/L	2
Q.70	Calculating the degree of dissociation: $\alpha = \Lambda_m / \Lambda_m^0$ $\Lambda_{m = 46.1}$ Λ_m^0 = ? - Calculating Λ_m^0 using Kohlrausch law $\Lambda_m^0 = \lambda(H)^+ + \lambda(HCOO)^-$	2

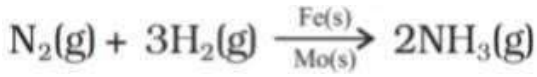
	Λ_m^0 = 349.6 + 54.6 Λ_m^0 = 404.2 S cm ^{2}/mol $\alpha = \Lambda_m / \Lambda_m^0$ α = 46.1/404.2 =0.114 Degree of dissociation = 0.114	
Q.71	a) Step-I. Calculating charge available Ag^+ (aq) + 1e-----> $Ag_{(s)}$ (1mol e^- = 1F charge) (Atomic mass of 1 mole of Ag = 108g) ∵ 108 gr. of Ag is deposited by 1F electric charge ∴ 1.34 gr. of Ag is deposited by electric charge = 96500/108 x 1.34 =1260 C (0.5marks) Step-II. Calculating time 't' for deposition of Ag We know - Q = I X t (0.5) Thus t= Q/I = 1260C/1.5amp t = 840 seconds. (0.5) In minutes; 840/60 = 14 minutes. (0.5) b) Calculating mass of Cu deposited in cell A. Cu^{2+} (aq.) + 2e-------> Cu(s) (2 mole e^- = 2 F charge) (mass of 1 mole of Cu = 63.5gram) We know- ∵ 96500 X 2 C charge deposits mass of Cu=63.5 gram ∴ 1260 C charge will deposit mass of Cu= 63.5gram/96500x2 C X 1260 C =0.414 gram (1)	3
Q.72	The cell reaction is- Mg(s) + $Cu^{2+}_{(aq)}$----- > $Mg^{2+}_{(aq)}$ + Cu (s) here n = 2 (0.5)	2

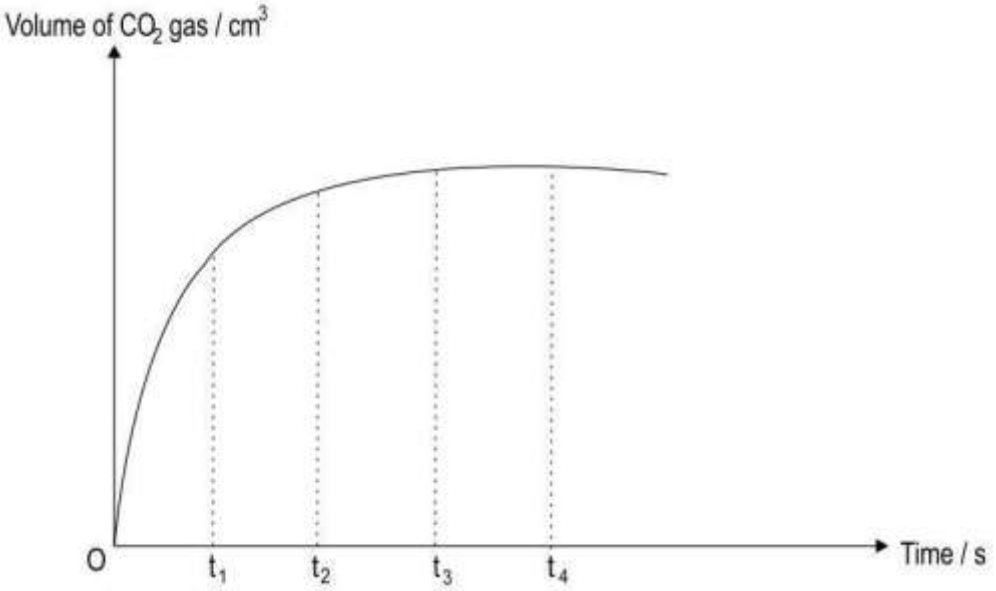
	We know - $E^0_{cell} = E^0_{red.}(R) - E^0_{red.}(L)$ $E^0_{cell} = 0.34V - (-2.37V)$ $E^0_{cell} = 2.71V$ (0.5) Calculating equilibrium constant(K_c) $E^0 = 0.0591/n \times \log K_c$ ($E^0 = 2.303RT/nF$ at 298 K) $2.71 = 0.0591/2 \times \log K_c$ $\log K_c = 2.71 \times 2/0.0591$ $\log K_c = 91.7089$ (0.5) K_c = antilog 91.7089 (Take antilog $n.x = 0.x \times 10^n$) $K_c = 5.116 \times 10^{91}$ (0.5)	
Q.73	-Aman should use the Copper spoon. (0.5) -The reduction potential of Aluminium is lower than Fe metal hence Aluminium spoon (metal) cannot be used as it undergoes oxidation i.e.it would lose e^-. $Al_{(s)} \text{----> } Al^{3+}_{(aq)} + 3e^-$ (0.5) Thus, the solution will slowly turn into Aluminium sulphate and it will not serve the purpose. -Copper, on the other hand, has a reduction potential higher than Fe (both in ionic state) or we can say it is less reactive than Fe. $Cu^{2+} + 2e^- \text{----> } Cu_{(s)}$ (0.5) -Moreover, Cu here is in the solid state. Hence Cu spoon can be used to stir the solution as it will not bring any change in the $FeSO_4$ solution. (0.5)	2
Q.74	i) $Cu_{(s)}/Cu^{2+}_{(aq)}$ II $Ag^+_{(aq)}/Ag_{(s)}$ (1) ii) $\Delta G^0 = -n E^0 F$ n=2, $E^0 = 0.46V$ F= 96500C $\Delta G^0 = -2 \times 0.46V \times 96500C/mol$ $\Delta G^0 = -88780$ C.V/mol or -88780 J/mol (1C.V=1 Joule) or	2

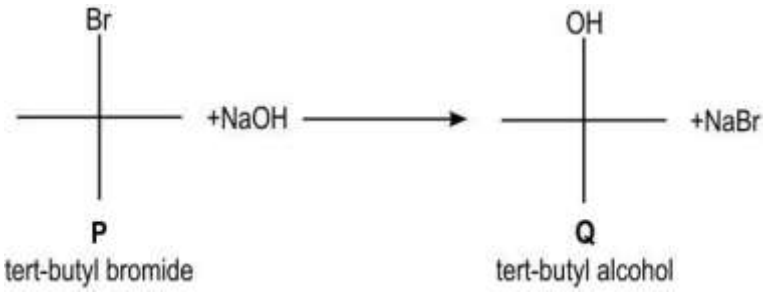
	ΔG^0= - 88.78 kJ/mol (1)	
Q.75	A chemical reaction is feasible if E^0_{cell} is positive i.e. if potential of the cell is positive. We know- $E^0 = E^0_{red.(C)} - E^0_{red.(A)}$ (0.5) In the given equation ; $Ag_{(s)}$ ----> $Ag^+_{(aq.)} + e^-$ (oxidation) $Fe^{3+}_{(aq)} + 3e^-$ ---> $Fe_{(s)}$ (Reduction) (0.5) $E^0_{(cell)}$= 0.77V - 0.80V (values given) $E^0_{(cell)}$= - 0.03V (0.5) Since $E^0_{(cell)}$ is negative, reaction is not feasible. (0.5)	2
Q.76	For SHE: $H^+ + e$--- >$1/2H_2$ Applying Nernst eq. $E = E^0 - (0.0591V/n) (\log 1/[H^+])$ (1) $E = 0 - (0.0591V/1) (\log 1/1x10^{-10})$ E = 0.0591V x 10 log 10 E = 0.591V (log10=1) (1)	2
Q.77	- Charge required for the Reduction of 1 mole of $Cr_2O_7^{2-}$ ion is $Cr_2O_7^{2-} + 6e^- + H^+$---> $2Cr^{3+}$ 6 Faraday (0.5) - Therefore, charge required for 0.5 mole ion is $Cr_2O_7^{2-} + 3e^- + H^+$---> Cr^{3+} 3 Faraday (0.5) i.e. 96500C x 3 = 289500C (1 F= 96500C) (1)	2
Q.78	We know 1 Faraday electric charge deposits 1g equivalent of any substance on the electrodes kept in a series (According to Faraday's second law) Equivalent mass of Ag = 108/1 = 108g Equivalent mass of Cu = 63.5g/2 = 31.75g	2

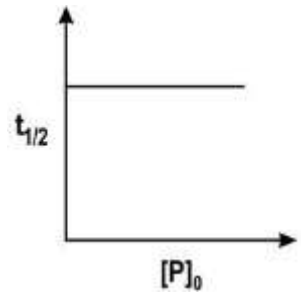
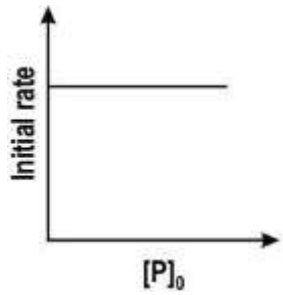
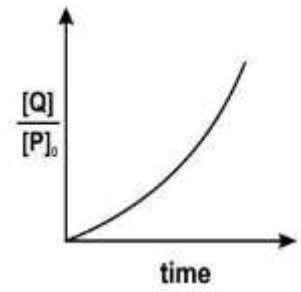
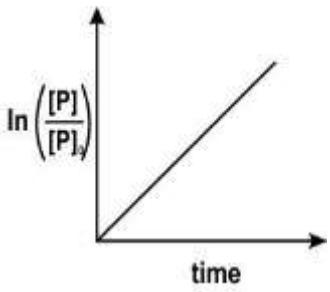
	Equivalent mass of A l= 27/3 = 9.0g (1) Hence simple mass ratio deposited at respective electrodes are Ag : Cu : Al 108g : 31.75g : 9.0g 12 : 4 : 1 (Cu = 3.527 ≈ 4) (1)	
Q.79	i) In experimental Set up I, the blue colour of $CuSO_4$ solution will fade away. It is because $CuSO_4$ solution will turn into H_2SO_4 solution. Oxidation of water leaves behind H^+ and reduction of Cu^{2+} ion leaves SO_4^{2-} ion in the solution. $2H^+ + SO_4^{2-} \text{-----} > H_2SO_4$ ii) $Cu_{(s)} \text{-----} > Cu^{2+}_{(aq)} + 2e^-$ iii)Oxygen (O_2) ($2OH \text{-----} > O_2 + 2H^+ + 4e^-$) iv) Set up II depict the refining of Cu metal. In this setup, an impure copper rod is made anode, where oxidation takes place, At anode- $Cu_{(s)} \text{-----} > Cu^{2+}_{(aq)} + 2e^-$ and a pure thin wire of copper is made cathode. At cathode- $Cu^{2+}_{(aq)} + 2e \text{----} > Cu(s)$	3

4. CHEMICAL KINETICS

Q. No	Question	Marks
	Multiple Choice Question	
Q.80	The reaction shown below illustrates the Haber process for manufacturing ammonia:  $N_2(g) + 3H_2(g) \xrightarrow[Mo(s)]{Fe(s)} 2NH_3(g)$ In this reaction, molybdenum acts as a promoter, and iron is used as a catalyst. Which of these is TRUE for the reaction? A. Iron changes the activation energy of reaction and molybdenum increases theefficiency of the catalyst. B. Iron changes the equilibrium constant and molybdenum changes the Gibbs energy ofthe reaction. C. Iron changes the enthalpy of reaction and molybdenum changes the equilibriumconstant. D. Iron and molybdenum change the Gibbs energy of the reaction.	1
Q.81	Which of the following can INCREASE the rate of a chemical reaction? P) increasing the temperature Q) increasing the concentration of products R) adding a catalyst S) increasing the concentration of reactants A. Q and S B. P and Q C. P, R, and S D. All- P, Q, R, and S	1
Q.82	The graph below shows the volume of carbon dioxide formed with time during a chemical reaction:	1

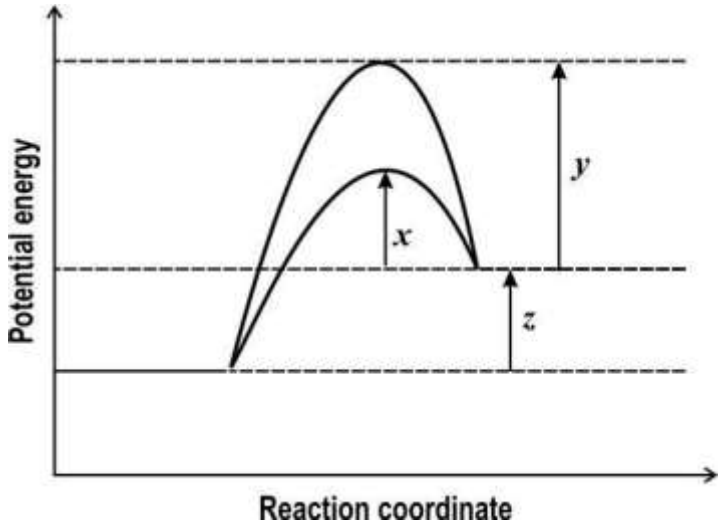
	 Based on the graph, at what time is the rate of reaction the highest? A. t1 B. t2 C. t3 D. t4	
Q.83	A living organism takes in different amounts of different isotopes of the same element from the environment. The organism takes these isotopes in the same relative proportion that existed naturally in the environment. For example, it takes carbon-12 and carbon-14 and once the organism dies, it stops replenishing its carbon supply, and the total carbon-14 content in the organism slowly disappears. This is because C-14 is radioactive in nature and it decays as it's less stable whereas C-12 is very stable and does not decay. Scientists can determine how long ago an organism died by measuring how much carbon-14 is left relative to carbon-12. Similarly, the organism's age can also be found by measuring how much potassium-40 or beryllium-10 is present in relation to potassium-39 and beryllium-9. Below is the half-life of: Carbon-14 = 5730 years Potassium-40 = 1.26 billion years Beryllium-10 = 1.52 billion years Based on the above data, which of the following dating methods can be used to determine the exact age of a living organism from its remains which are estimated to be 100,000 years old?	1

	(I) Carbon dating (II) Potassium dating (III) Beryllium dating A. I only B. I and II only C. II and III only D. All- I, II, and III	
Q.84	The hydrolysis of tert-butyl bromide with an aqueous NaOH solution (as shown below) is an example of SN1 reaction.  Which of the following graph correctly represents the above reaction?	1

 	
A	B
 	

	C	D

Q.85 The diagram below shows the potential energy variation for a reaction using a catalyst and for the same reaction without a catalyst.



Which of the following represents the enthalpy change (ΔH) and activation energy (Ea) for the reaction with a catalyst?

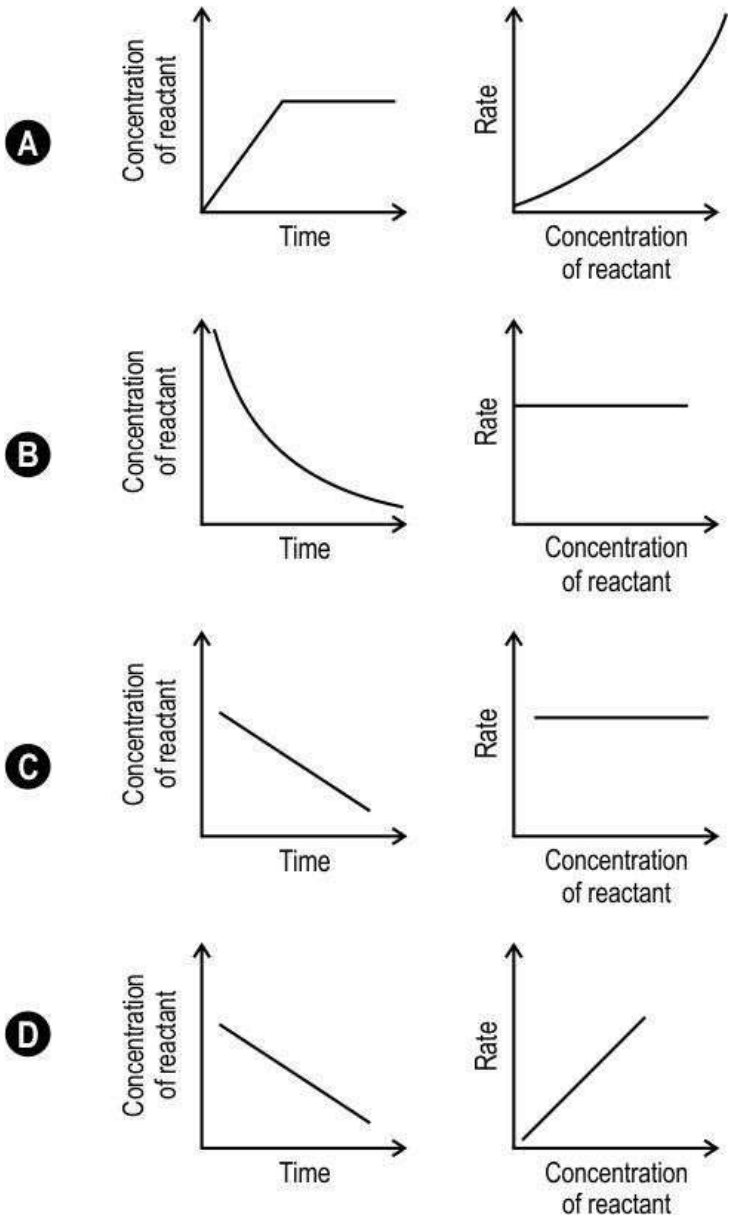
Option	ΔH	Ea with catalyst
P	z	x+z
Q	z	y+z
R	z+x	x
S	z	y

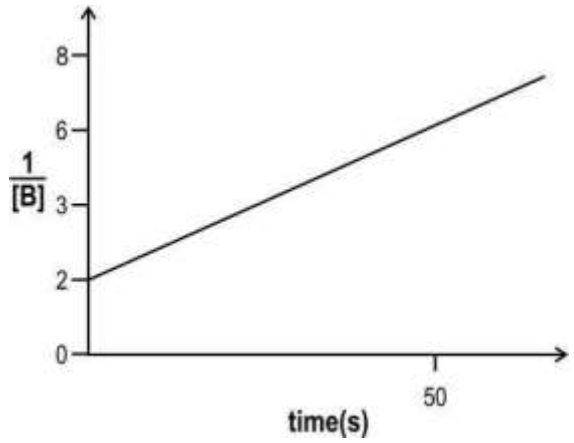
A. P

B. Q

C. R

D. S

Q.86	If the rate of a reaction 2A + 3B----- > C + 2D is $k[A]^0[B]$. By what factor will the rate of reaction increase if the concentration of A increases by a factor of 2 and that of B by a factor of 3? A. 5 B. 6 C. 3 D. 2	1
Q.87	Which of the following pairs of graphs represents the same order of reaction?  	1

	A. A B. B C. C D. D	
Q.88	Which of the following statements is/are correct? (i) A catalyst lowers the activation energy of a reaction. (ii) A catalyst allows the same rate of reaction to be achieved at a lower temperature. (iii) A catalyst mixes with the reactants and increases the overall concentration of reactants in the rate equation. A. i only B. i and ii only C. ii and iii only D. All- i, ii, and iii	1
Q.89	For a first order reaction A + B ----> C the rate of reaction depends only on the concentration of B.  If the reaction is 50% complete after 5.82 hours when the initial concentration of B is 4.46 mol/L, how much time will it take for the reaction to be 75% complete? A. 5.82 hours B. 17.5 hours C. 11.64 hours D. 8.71 hours	1
Free Response Question/ Subjective Type		

<table>
<tr><td>Q.90</td><td>The data in the table was obtained in a series of experiments on the rate of the reaction between compounds A and B at a constant temperature.

<table><tr><th>Experiment</th><th>The initial concentration of A / mol dm^{-3}</th><th>The initial concentration of B / mol dm^{-3}</th><th>Initial rate / mol dm^{-3} s^{-1}</th></tr><tr><td>1</td><td>0.12</td><td>0.26</td><td>2.10 x 10^{-4}</td></tr><tr><td>2</td><td>0.36</td><td>0.26</td><td>1.89 x 10^{-3}</td></tr><tr><td>3</td><td>0.72</td><td>0.13</td><td>3.78 x 10^{-3}</td></tr></table>
Show how this data can be used to derive the rate expression for the reaction between A and B.</td><td>3</td></tr>
<tr><td>Q.91</td><td>The manufacturers of canned food use anti-microbial compounds as preservatives to control the concentration of microbes, maintaining the quality of food. The food corporation of India mandates that the concentration of a microbe in any particular canned food would be unacceptable (and the food will be expired) with a maximum +40% change from the initial concentration value of the microbe.

Mitra bought canned food. She noted that the manufacturing date on the can was 1st April 2022. Based on this, what should be the expiry date of this food?

(Note: The average rate constant of microbial decay is 4 day^{-1}.)</td><td>2</td></tr>
<tr><td>Q.92</td><td>Carbon dating is used by archaeologists to date trees, plants, and animal remains as well as human artefacts made from wood and leather.

If an archaeologist found that the percentage of carbon-14 in the remains of an animal was 10% of what carbon-14 was in the animal's body when the animal died, find the age of this sample.

(Given the half-life of carbon-14= 5730 years)</td><td>2</td></tr>
<tr><td>Q.93</td><td>The gas-phase decomposition reaction of ethane is given below:

C_2H_6------ >C_2H_2 + 3H_2

This reaction is investigated at constant temperature and volume. The table below shows the partial pressure (PC_2H_6) observed for the above reaction at different times.</td><td>3</td></tr>
</table>

#	Time (in mins)	PC_2H_6 (in mm of Hg)
1	0	800
2	100	400
3	200	200

Based on the above data,

(i) What is the order of the reaction? Justify with reason.

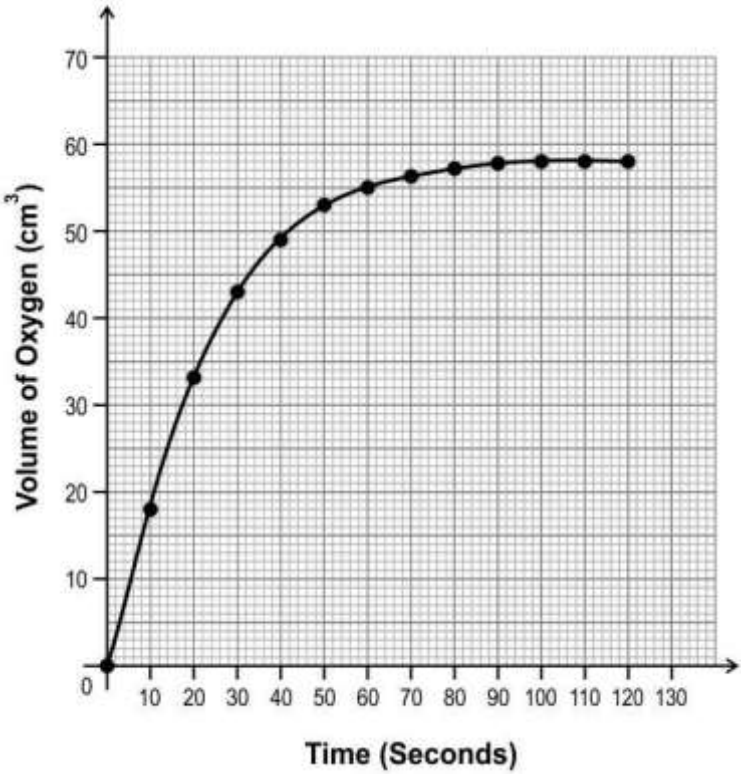
(ii) Calculate the rate constant of the reaction.

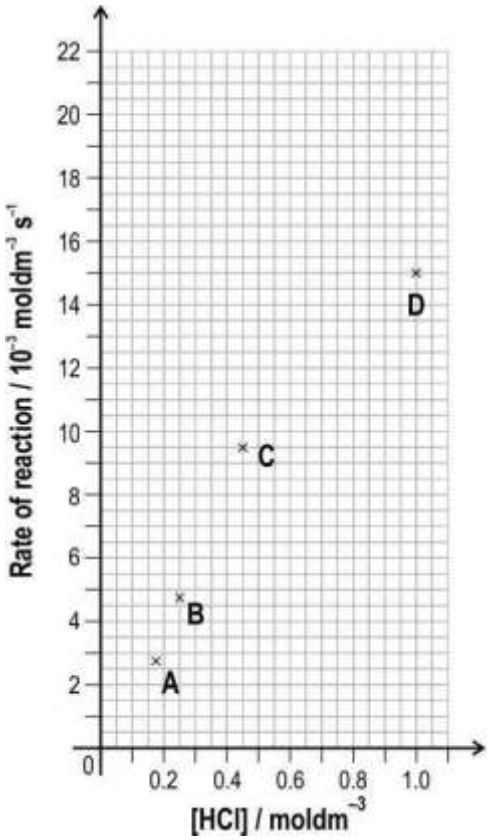
(iii) What is the ratio of the time required for the completion of 50% of the reaction to that of 75% of the reaction?

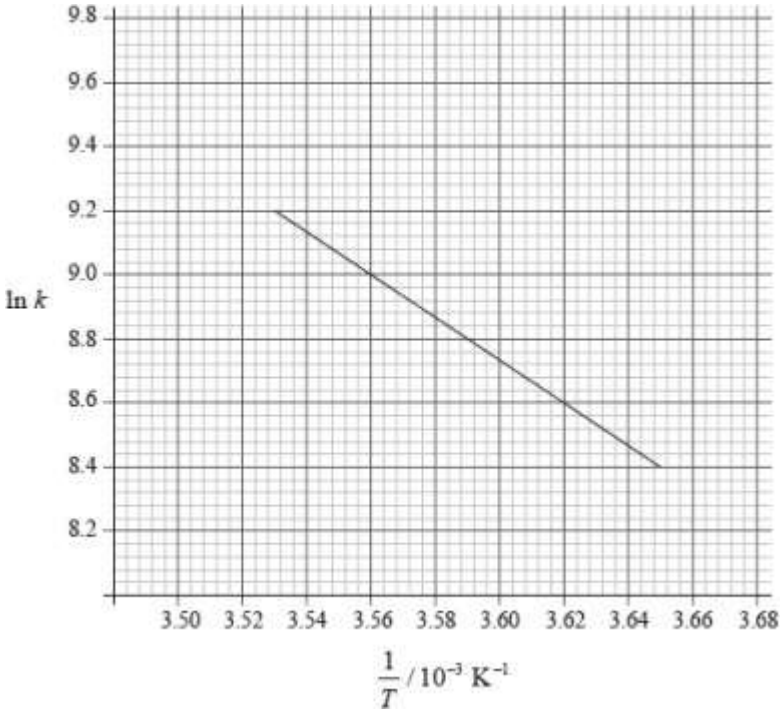
Q.94 The reaction shown below is the decomposition reaction of hydrogen peroxide. 3

$2H_2O_2\,(aq.) \text{-------} > 2H_2O\,(l) + O_2\,(g)$

The rate of decomposition can be monitored by measuring the volume of oxygen gas released. The graph shows the results obtained when a solution of hydrogen peroxide decomposed in the presence of a CuO catalyst.



	(i) Outline how the initial rate of reaction can be found from the graph. (ii) Explain how and why the rate of reaction changes with time.	
Q.95	Rohit wants to check how the rate of the reaction shown below is affected by changing the concentration of HCl. $CaCO_3$ (s) + 2HCl(aq) → $CaCl_2$ (aq) + H_2O(l) + CO_2 (g) He took 4 readings of rate of reaction vs concentration and plotted them as shown below.  (i) Based on his readings and assuming there is no human error, give one reason for point D being so far away from the other three points A, B, and C. (ii) Draw the best fit line for the above reaction.	2
Q.96	Nitrogen dioxide reacts differently with carbon monoxide at different temperatures. The equation below shows the original reaction and reaction mechanism at two different temperatures. Original reaction: NO_2 + CO > NO + CO_2 Reaction mechanism at T > 770 K:	2

	$NO_2 + CO$ ----> $NO + CO_2$ (slow) Reaction mechanism at T < 770 K: $2NO_2$---- > $NO + NO_3$ (slow) $NO_3 + CO$ ----> $NO_2 + CO_2$ (fast) Write down the equation for the rate of the reaction for: (a) T > 770 K (b) T < 770 K	
Q.97	Consider the following reaction: N_20_4----- > $2NO_2$ Based on the above reaction a graph of ln k vs 1/T is plotted as shown below.  (i) Calculate the activation energy for this reaction. (use R = 8.31 $Jmol^{-1}K^{-1}$) (ii) List two cases in which the rate of a reaction is equal to the rate constant. *(Note: This is not specific to only the reaction above.)*	3
Q.98	Calcium carbonate decomposes to CaO and CO2 as shown below: CaCO3---- > CaO + CO2 Liya took two different forms (as shown below) of CaCO3 as reactants to carry out this reaction and compare the rate of reaction for these two forms. In both forms, the mass of CaCO3 is the same.	3

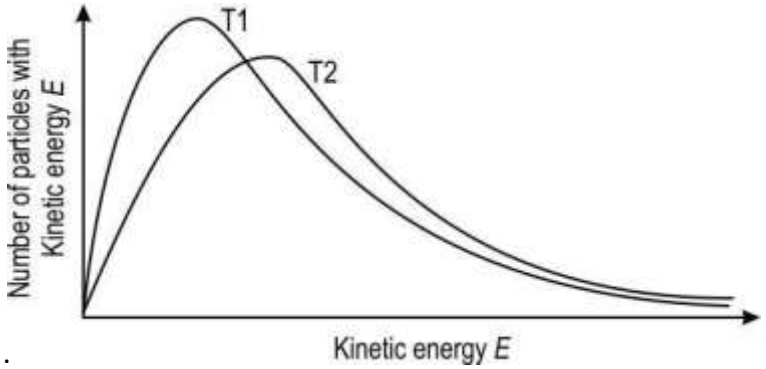
Form I

Form II

(i) Compare the rate of reaction for forms I and II.

(ii) Explain the reason behind the difference for both these two forms.

Q.99 The graph below shows the Maxwell-Boltzmann curve for a sample of nitrogen gas at temperatures T1 and T2. 3



.

(i) Between T1 and T2, which is the higher temperature?

(ii) Based on your answer to part (i), explain the reason behind the two curves at different temperatures.

Q.100 For the equation, 4

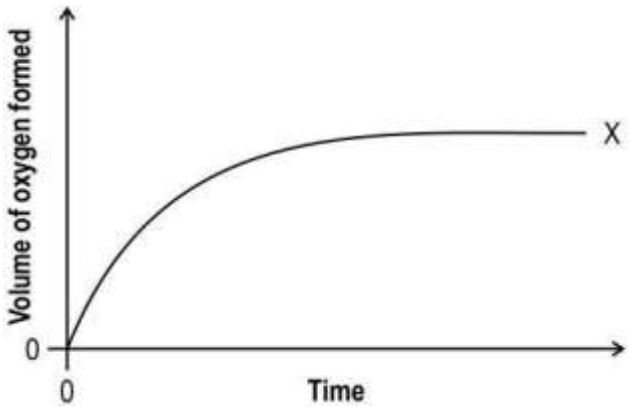
A + 2B -----> C + D + E

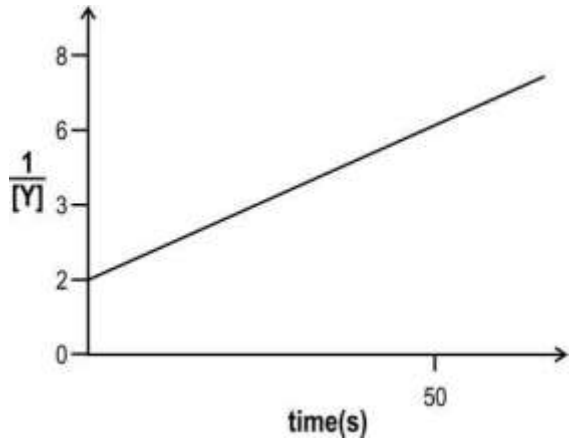
The following results were obtained to determine the initial rate of the reaction.

Experiment	[A] / mol dm^{-3}	[B] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	4	1	0.50
2	4	0.5	0.50
3	2	0.5	0.25

(i) What is the order of reaction with respect to A and B? Justify.

(ii) Write down the overall rate equation.

	(iii) Find the value of the rate constant for this reaction.	
Q.101	Graphically represent: (i) Concentration of a reactant X vs time for a ZERO order reaction. (ii) Rate of reaction vs concentration of a reactant X for a ZERO order reaction. (iii) Rate of reaction vs concentration of a reactant X for a FIRST order reaction.	3
Q.102	The rate of a reaction at 700K is 4 times faster than the rate at a lower temperature T. The energy of activation is 20.19×10^3 J/mol and the rate constant at 700K is $0.08s^{-1}$. (i) Calculate the rate constant at temperature T. (ii) Find temperature T. *(use R = 8.31 J/mol K)*	3
Q.103	In the following reaction K_3PO_4 ---- > $3K^+ + PO_4^{3-}$ the rate of formation of PO_4^{3-} is 50 mol $litre^{-1}s^{-1}$. (i) What is the rate of formation of potassium ions? (ii) What is the rate of loss of K_3PO_4?	3
Q.104	For the following reaction $2H_2O_2$---- > $O_2 + 2H_2O$ the curve below shows how the volume of oxygen formed varies with time.  (i) Explain the shape of the graph in terms of the rate of formation of oxygen.	2
Q.105	.For the first order reaction, X + Y ---- > Z the rate of reaction depends only on the concentration of Y.	3



(i) Identify the rate equation for this reaction. *(assume k as rate constant)*

(ii) If the above reaction is 75% complete in 1 hour then calculate the value of k?

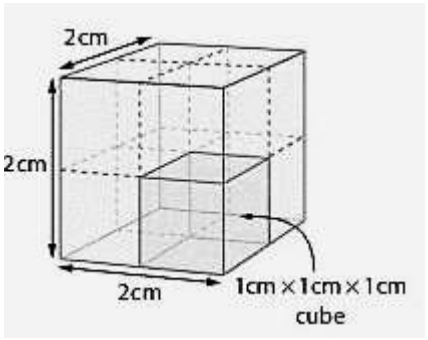
Q.106 The table below shows the result when 2g of powdered calcium carbonate were added to 50 cm^3 of 0.1 $moldm^{-3}$ HCl. — 3

Time/s	10	20	30	40	50	60	70	80
Volume of CO_2 given off/cm^3	25	45	60	70	75	78	80	80

(i) Plot a graph of the result and explain its shape.

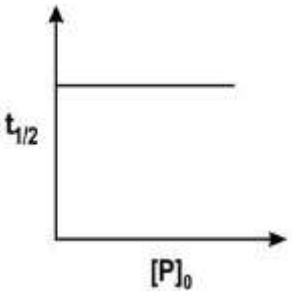
(ii) What is the rate at the start of the reaction?

Q.107 Calcium carbonate reacts with dilute HCl to produce CO_2. The image below shows a block of calcium carbonate with a dimension 2cm x 2cm x 2 cm. — 1

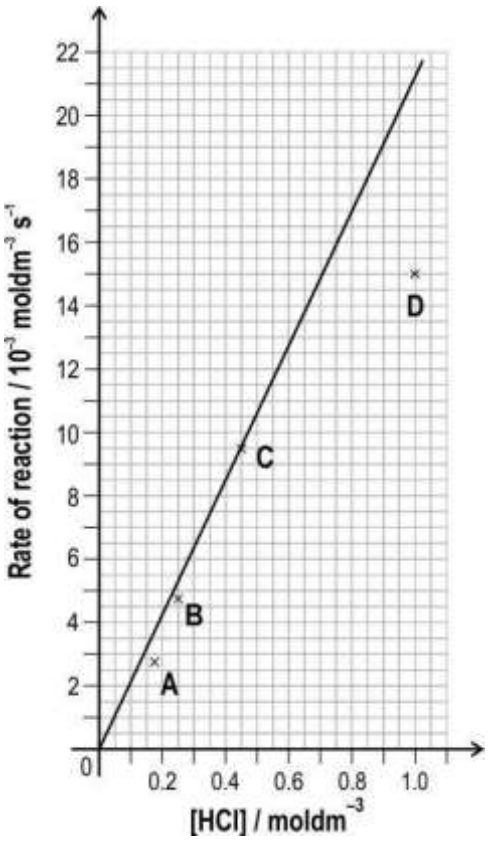


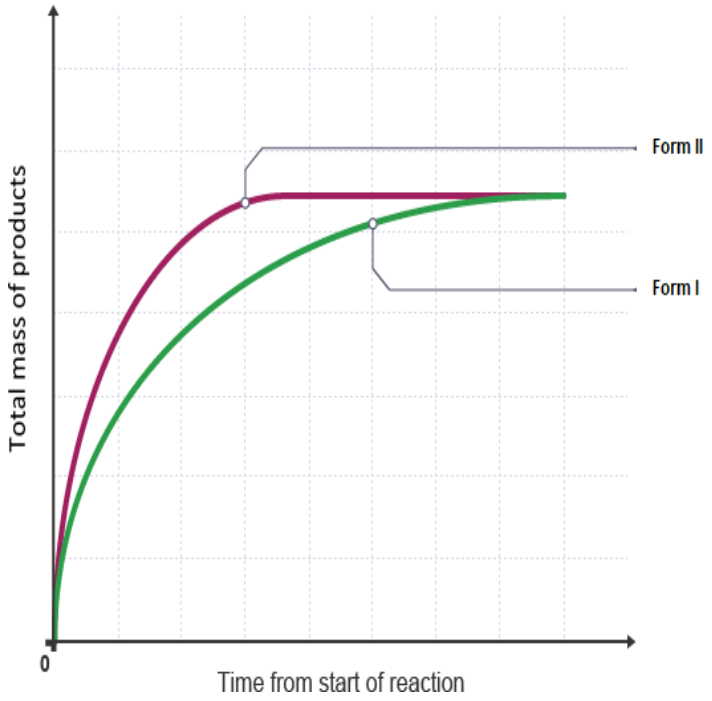
Suppose this cube is cut along the dashed line to make smaller cubes of 1cm x 1cm x 1cm. How will the rate of reaction of the bigger cube compare with that using all of the smaller cubes and why?

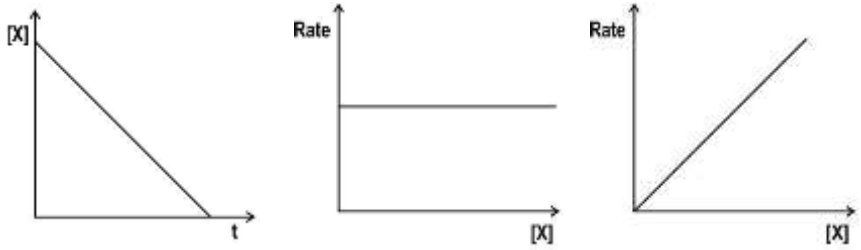
Answer Key & Marking Scheme

Q. No	Answers	Marks
Q.80	A. Iron changes the activation energy of reaction and molybdenum increases the efficiency of the catalyst.	1
Q.81	C. P, R, and S	1
Q.82	A. t1	1
Q.83	C. II and III only	1
Q.84	A. 	1
Q.85	A. P	1
Q.86	C. 3	1
Q.87	C. C	1
Q.88	B. i and ii only	1
Q.89	B. 17.5 hours	1
Q.90	Deducing rate expression: - Consider experiments 1 and 2: [B] = constant; [A] increases by 3; rate increases by 3^2 therefore 2^{nd} order with respect to A [1 mark] - Consider experiments 2 and 3: [A] increases by 2; the rate should increase × 2^2 but only increases × 2. Therefore, halving [B] halves rate and so 1^{st} order with respect to B [1 mark] - Rate equation: rate = $k[A]^2[B]$ [1 mark]	3
Q.91	The expiry date of food:	2

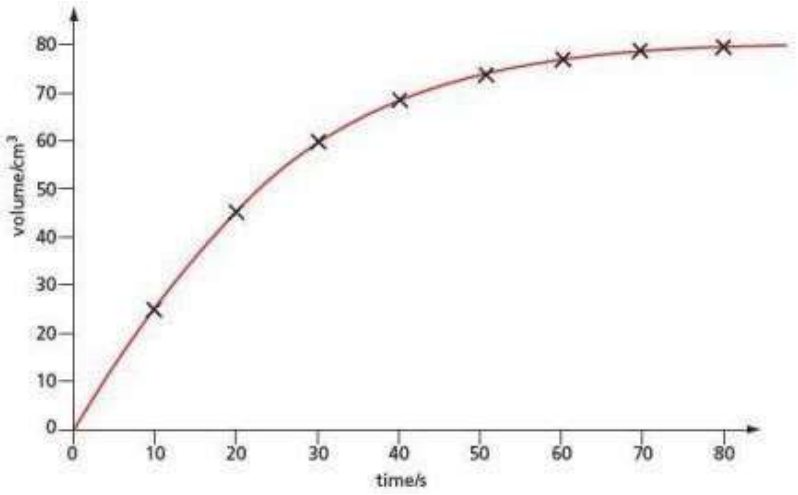
	- Average rate of reaction = average change in concentration/Δt [1 mark] - Δt = 40/4 per day = 10 days - Expiry date = 10th April 2022 [1 mark]	
Q.92	**Age of sample** - Since the concentration of ^{14}C decays with time at a particular rate (which depends on initial concentration), the kinetics for first-order could be used to identify the time required to change in the concentration of ^{14}C. => k = 0.693/ $t_{1/2}$ = 0.693 / 5730 [1 mark] => t = (2.303/k) log(A_0/A) => t = (2.303 x 5730/0.693) x log 100/10 => t = 19042 years (approx) [1 mark]	2
Q.93	(i) Order of reaction: - Based on the table, the decrease in partial pressure of ethane is constant over time that is $t_{1/2}$ is constant. So it's a first-order reaction. [1 mark] *(No marks if the reason is not given)* (ii) Rate constant: - For first-order reaction, rate constant (k) is given by 0.693/$t_{1/2}$ => k = 0.693/100 = 0.00693 min^{-1} or => k = 0.00011 s^{-1} [1mark] *give 1 mark for any value in mins or seconds* (iii) Ratio: - Time required for the completion of 50% of the reaction = 1 x $t_{1/2}$ - Time required for the completion of 75% of the reaction = 2 x $t1_{/2}$ - So the ratio = 1/2 [1 mark]	3
Q.94	(i) how to find the rate of reaction from a graph: - Draw a tangent to the curve at (0,0) - Calculate the slope of the tangent. The slope of the tangent is the rate of reaction (ii) Reason for rate change: - Rate decreases with time	3

	- concentration/number of (reactant) molecules per unit volume decreases (with time) *[Do not accept "number of molecules decreases" or "amount of reactant decreases".]* - collisions (between reactant molecules/reactant and catalyst) become less frequent.	
Q.95	(i) Give 1 mark for writing any one of the following: -Reaction is fast at high concentration and may be difficult to measure accurately - The large quantity of bubbles of CO_2 produced inhibit contact of HCl(aq) with $CaCO_3$ (s) - Calcium carbonate has been used up/is a limiting reagent and there is not enough calcium carbonate to react with the high concentration of HCl - HCl is in excess (ii) Draw a straight line going through the origin and as close to A, B, C as possible  	2
Q.96	Rate of reaction for T > 770 K Rate = k $[NO_2][CO]$ Rate of reaction for T < 770 K Rate = k $[NO_2]^2$	2

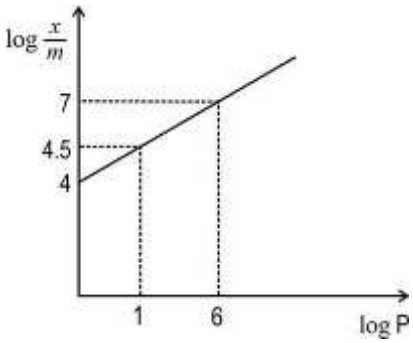
Q.97	(i) Activation energy: - Since it's a first-order reaction, the slope of the curve is equal to $-E_a/R$ (where Ea is activation energy and R is the gas constant) [1 mark] => Slope = $(9.2 - 8.4)/(3.53 \times 10^{-3} - 3.65 \times 10^{-3}) = -6.67 \times 10^3$ => So $E_a = 8.31 \times 6.67 \times 10^3 = 55.4$ kJ/mol [1 mark] (ii) Two cases are: - When the concentration of all reactants is 1 unit [0.5] - When the order of the reaction is 0 [0.5]	3
Q.98	(i) Graph:  - give 0.5 mark for representing form I with the proper label - give 0.5 mark for representing form II with the proper label *Deduct 0.5 marks if labels are absent* (ii) Reason: - For the given mass/volume of solid, Form I has a smaller surface area than Form II. [1] - More reactant particles are exposed at the surface in Form II, increasing the collision rate, and hence the rate increases. [1] - Higher the rate, the higher will be the value of the tangent of the curve during the initial phase. [1]	3

Q.99	(i) T2>T1 (ii) Explanation: - Mean Kinetic energy of the gaseous particle is directly proportional to the temperature of the reaction mixture. So higher energy means a wider spread of values. - Higher the energy, the higher will be the proportion of successful collisions. -This means, a higher proportion of the particles possess the minimum amount of energy (activation energy) to cause a chemical reaction - Hence, with higher temperatures, the Boltzmann distribution curve flattens, and the peak shifts to the right. *Note: give 0.5 marks for each point*	3
Q.100	(i) Order of reaction: - For exp. 1 and 2, [A] is constant, but [B] is halved. However, rate is constant. So, it's zero-order wrt B. [1 mark] - For experiments 2 and 3, [A] is halved with constant [B] and rate is also halved, so it's 1st order wrt A. [1 mark] (ii) Rate of reaction = k[A] (iii) k = 0.50/4 = 0.125 s^{-1}	4
Q.101	 (i) (ii) (iii)	3
Q.102	(i) Let the rate constant at 700K be k1 and that at T be k2. => k1/k2 = 4 => k2 = 0.08/4 = 0.02 [1 mark] (ii) Temperature: => As per the Arrhenius equation, $k1/k2 = e^{-Ea/(R \times 700)} / e^{-Ea/(R \times T)}$ => $4 = e^{-Ea/(R \times 700)} / e^{-Ea/(R \times T)}$ [1mark]	3

	Solving for T gives, T = 500 K [1 mark]	
Q.103	The overall rate of a reaction is given by: $-1/1\ \Delta[K_3PO_4]/\Delta t = +1/3\ \Delta[K^+]/\Delta t = +1/1\ \Delta[PO_4^{3-}]/\Delta t$ [1 mark] (i) rate of formation of potassium ions $\Rightarrow +1/3\ \Delta[K^+]/\Delta t = +50$ $\Rightarrow \Delta[K^+]/\Delta t = 150$ mol litre^{-1}s^{-1}[1 mark] (ii) Rate of loss of K_3PO_4 $\Rightarrow -1/1\ \Delta[K_3PO_4]/\Delta t = +50$ $\Rightarrow \Delta[K_3PO_4]/\Delta t = -50$ gs^{-1} [1 mark]	3
Q.104	(i) Explanation: - the slope of the curve defines the rate of formation of oxygen. Initially, the slope is high which means the rate of formation is high. [0.5] - After some time slope is constant/zero, which means the reactants are exhausted and the reaction is completed so the volume is constant. [0.5]	2
Q.105	(i) Rate equation Rate = $k[Y]^2$ (ii) Time for completion to 75% For second order, $1/[A_0] = 1/[A] + kt$; where A is initial concentration, A_0 is concentration of A left after 1 hour. [1 mark] $\Rightarrow 1/0.25 = 1/1 + k \times 1$ $\Rightarrow k = 3$ Lmol^{-1}h^{-1} [1 mark]	3
Q.106	(i) Graph:	3

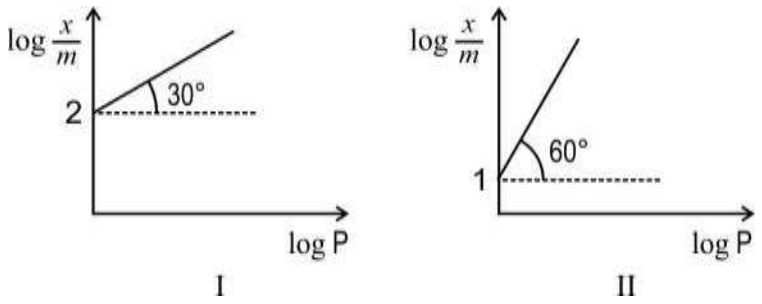
	 [1] Explanation: - The rate decreases with time because the acid becomes more dilute. The reaction stops when all acid is used up. [1] (ii) From the graph, the rate at the start = 25/10 = 2.5 cm^3s^{-1} [1]	
Q.107	(i) Rate of the reaction using smaller cubes will be faster than that using bigger cube. - Breaking up the solid increases its surface area in contact with reactant gas and liquid. This results in more collision per second and hence faster rate.	1

5. SURFACE CHEMISTRY

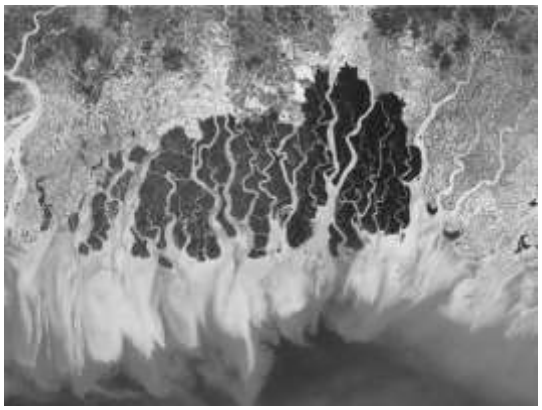
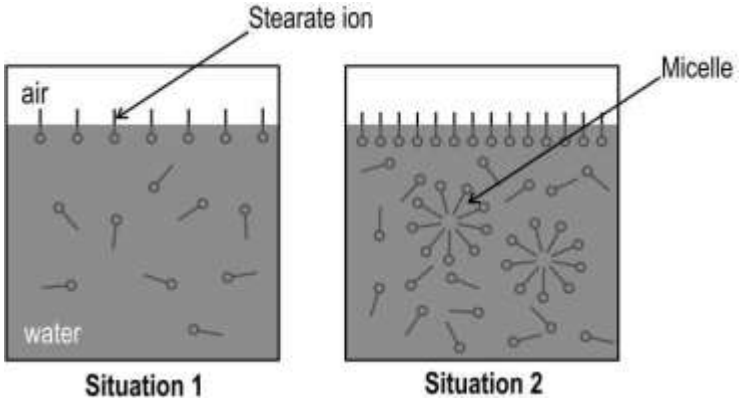
Q. No	Question	Marks
	Multiple Choice Questions	
Q.108	Which of the following is/are correct? (i) At high pressure and temperature, physisorption may change to chemisorption and the gas on a solid surface can't be retrieved. (ii) Freezing point of the colloidal solution is lower than the true solution at the same concentration of a solute. A. only i B. only ii C. both i and ii D. all- i, ii, and iii	1
Q.109	Which of the following is/are correct for Freundlich's adsorption isotherm? (i) the quantity of adsorbed particles on the adsorbent is directly proportional to k (ii) the quantity of adsorbed particles on the adsorbent can be independent of p (iii) the quantity of adsorbed particles on adsorbent is directly proportional to 1/n A. ii only B. ii and iii only C. i and iii only D. all- i, ii, and iii	1
Q.110	The graph below shows the variation in the "quantity" of "gas adsorbed" with pressure as per the Freundlich adsorption isotherm.  Based on this graph, which of the following is directly proportional to x/m?	1

	A. p B. $\sqrt{p}$ C. p^2 D. $p^{4.5}$	
Q.111	Which of the following is correct for the adsorption of methane on coal? A. $\Delta H > 0; \Delta S > 0$ B. $\Delta H > 0; \Delta S < 0$ C. $\Delta H < 0; \Delta S < 0$ D. $\Delta H < 0; \Delta S > 0$	1
Q.112	Look at the given information. Surface area of charcoal: 4.73 m^2/g Surface area of activated charcoal: 950 m^2/g Which of the following is TRUE about their adsorption capacity for nitrogen gas if 100 g of both the substances are taken at 273 K and 2 atm? A. Adsorption capacity of activated charcoal > adsorption capacity of charcoal B. Adsorption capacity of activated charcoal < adsorption capacity of charcoal C. Adsorption capacity of activated charcoal = adsorption capacity of charcoal D. Adsorption capacity can't be compared with the given information	1
Q.113	Which of the following is/are correct? (i) In an enzyme-catalysed reaction, the enzyme reacts completely with the substrate and is consumed by the substrate to form products (ii) Dispersed particles with a wavelength of 10 nm can show the Tyndall effect in the presence of light with the frequency of 3×10^{-16} Hz (iii) The smoke coming out of the chimney to a Cottrell smoke precipitator is always charged (either positively or negatively) A. i only B. ii only C. ii and iii only D. all- i, ii, iii	1
Q.114	Which of the following statements is/are correct?	1

<table>
<tr><td></td><td>(i) Rusting of iron is an example of physical adsorption.
(ii) In the case of chemical adsorption, energy is released.
(iii) The degree of adsorption for different gases by the same adsorbent is always the same.
A. i only
B. ii only
C. ii and iii only
D. all- i, ii, and iii</td><td></td></tr>
<tr><td>Q.115</td><td>Which of the following is/are example(s) of the Tyndall effect?
(i) the blue colour of the sky
(ii) formation of deltas
(iii) coagulation
(iv) visibility of a comet's tail
A. i only
B. i and iv only
C. iii and iv only
D. all- i, ii, iii, and iv</td><td>1</td></tr>
<tr><td colspan="3">Free Response Question/Subjective Type</td></tr>
<tr><td>Q.116</td><td>(i) The table below shows the volumes of nitrogen adsorbed by a sample of 3g of activated charcoal at 0°C:
<table><tr><td>pressure (mm)</td><td>180</td><td>540</td></tr><tr><td>volume (cm^3/g)</td><td>16.5</td><td>38.1</td></tr></table>Evaluate the constants k and n if the above data fits Freundlich's adsorption isotherm.
(ii) Draw the adsorption vs temperature curve for the above case at p= 180 mm.</td><td>3</td></tr>
<tr><td>Q.117</td><td>(i) Draw a graph between the quantity of gas adsorbed vs temperature at constant pressure for physical adsorption.
(ii) Explain the reason behind the variation in the quantity of gas adsorbed with temperature.</td><td>3</td></tr>
</table>

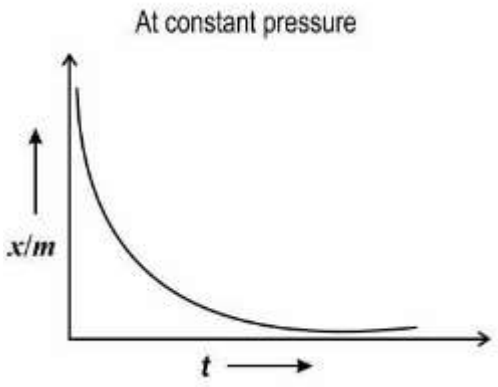
<table>
<tr><td>Q.118</td><td>The graphs shown below show the variation of the quantity of adsorption with pressure for two different cases I and II.
 

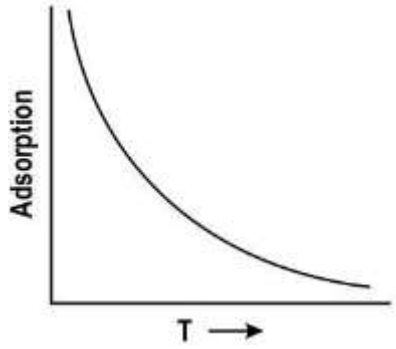
In which case the quantity of adsorption is more for a constant value of 'p' where p >1 unit? Justify.</td><td>3</td></tr>
<tr><td>Q.119</td><td>The table below shows the experimental data of a Freundlich's adsorption isotherm:
<table><tr><td>log x/m (cm^3/g)</td><td>10</td><td>10</td><td>10</td><td>10</td></tr><tr><td>log p (mm of Hg)</td><td>50</td><td>100</td><td>150</td><td>200</td></tr></table>
Based on the above data, calculate the value of constant k and n as per Freundlich's adsorption isotherm.</td><td>2</td></tr>
<tr><td>Q.120</td><td>The table below shows the mass of oxygen adsorbed by a sample of 10 g of activated charcoal at 10°C.
<table><tr><th>Mass (in g)</th><th>Pressure (in mm)</th></tr><tr><td>15</td><td>150</td></tr><tr><td>40</td><td>400</td></tr></table>
Calculate the value of constants k and n if the above data fits Freundlich's adsorption isotherm.</td><td>2</td></tr>
<tr><td>Q.121</td><td>(i) The image shown below is a satellite image of Sundarbans, the largest delta in the world, in the coastal region of West Bengal and Bangladesh.</td><td>2</td></tr>
</table>

	 With reference to the location and underlying surface chemistry phenomena, explain why and how the Sundarbans deltas are formed? (ii) Which of the following is the most effective for the coagulation of a sol which is formed when dilute KI solution is added to the $AgNO_3$ solution and why? H_3PO_4, H_2SO_4, HCl	
Q.122	Look at the arrangement of stearate ions in two different situations and answer the questions based on it.  (i) Based on the arrangement of the ions, what is the difference in the concentration of soap in situations 1 and 2? (ii) Explain how the formation of micelle helps while cleaning clothes?	2
Q.123	Explain the reason: (i) When a beam of light is passed through a solution of NaCl, there is no scattering but when it is passed through a blood solution there is a scattering of light. (ii) There is more effective coagulation when K_3PO_4 is added to an aluminium hydroxide sol than when NaCl is added to an aluminium hydroxide sol.	2
Q.124	The extent of chemisorption is directly proportional to temperature. To verify this in a chemistry lab, Amy found that the ratio of the extent of chemisorption of nitrogen gas on ferrous catalyst at 500 K and 300 K was 10.	2

	Calculate the activation energy for this chemisorption. *[use R = 8.31 Joule mol^{-1}K^{-1}]*	

Answer Key & Marking Scheme

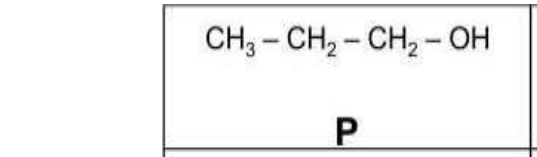
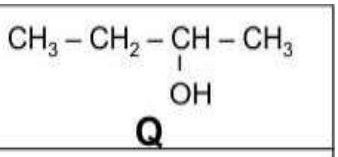
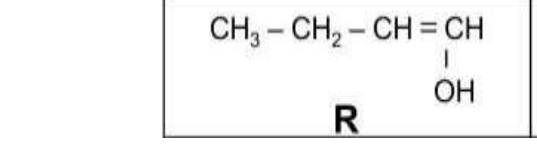
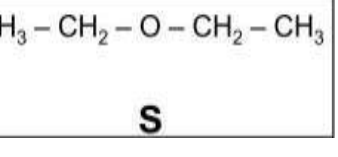
Q.No	Answers	Marks
Q.108	C. both i and ii	1
Q.109	A. ii only	1
Q.110	B. √p	1
Q.111	C. $\Delta H < 0; \Delta S < 0$	1
Q.112	A. Adsorption capacity of activated charcoal > adsorption capacity of charcoal	1
Q.113	B. ii only	1
Q.114	B. ii only	1
Q.115	B. i and iv only	1
Q.116	(i) Evaluate the constants k and n: - As per Freundlich's adsorption isotherm, $x1/x2 = (p1/p2)^{1/n}$ - So log (16.5/38.1) = (1/n) log (180/540) - Solving for n gives 1.31 [1 mark] - Since $x/m = k\ p^{1/n}$ - So, $16.5/3 = k\ (180)^{1/1.31}$ - Solving for k gives 0.104 [1 mark] - Since the adsorption of nitrogen on charcoal is an example of physical adsorption, the curve will be 	3
Q.117	(i) Curve for physical adsorption:	3

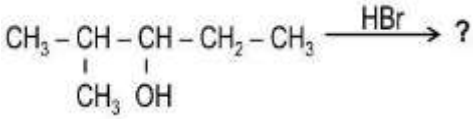
	 (ii) Reason: - For physical adsorption, the quantity of gas adsorbed decreases with an increase in temperature. This is because adsorbed particles are held to the adsorbent by weak van der wall forces. [1 mark] - At higher temperatures, the van der wall force is weaker, leading to a sharp decrease in adsorption. However, even at a very high temperature, the adsorption can't be zero as there will be some force acting between the particles [1 mark]	
Q.118	- The quantity of adsorption is more in case II [1 mark] Justification: - Using Freundlich's adsorption isotherm, log(x/m) = logk + (1/n) logp For graph I: => log(x/m) = 2 + tan30 x logp => log(x/m) = 2 + 0.57 logp [0.5 marks] For graph II: => log(x/m) = 1 + tan60 x logp => log(x/m) = 1 + 1.71 logp [0.5 marks] Comparing the values of x/m for both the cases, it's clear that for p > 1, 1 + 1.71 logp > 2 + 0.57 logp [1 mark]	3
Q.119	As per Freundlich's adsorption isotherm, log x/m = log k + 1/n log p Since log x/m is constant for different values of log p, 1/n should be 0. => So, n = infinite [1 mark] Also log k = 10 => k =10^{10} [1 mark]	2

Q.120	- As per Freundlich's adsorption isotherm, log (x/m) = log k + 1/n log p. So, $x/m = kp^{1/n}$ $\therefore x1/x2 = (p1/p2)^{1/n}$ - So log (15/40) = (1/n) log (150/400) - Solving for n gives 1 [1 mark] - Since $x/m = k\ p^{1/n}$ - So, $15/10 = k\ (150)^{1/1}$ - Solving for k gives 0.01 [1 mark]	2
Q.121	(i) Delta formation: - The Sundarbans delta is formed at the meeting point of the rivers Ganga, Brahmaputra, and the Bay of Bengal. [0.5] - River water is a colloidal solution of clay and seawater contains a number of electrolytes. [0.5] - When river water meets the seawater, the electrolytes present in the seawater coagulate the colloidal solution of clay resulting in its deposition with the formation of the delta. [1] (ii) H_3PO_4 - When dilute KI solution is added to the $AgNO_3$ solution, positively charged sols are formed due to the adsorption of Ag^+ ions. [1] - For the coagulation of a positively charged sol, as per Hardy Schulze rule, the greater the valency of flocculating ion, the better will be the coagulation. Hence, PO_4^{3-} is the most effective. [1]	2
Q.122	(i) Explains the difference between situation 1 and situation 2: - Situation 1 has the arrangement of stearate ions on the water's surface at low concentrations of soap [0.5] - whereas situation 2 has an arrangement of stearate ions inside the bulk of water (ionic micelle) at critical micelle concentrations of soap. [0.5] (ii) Explains how micelle can be used for cleaning clothes such as: - Soap molecules form micelle around the oily dirt on clothes so that the hydrophobic part of the stearate ions is in the dirt and the hydrophilic part projects out of it. - Since the polar groups can interact with water, it is now pulled in water and removed from the dirty surface	2

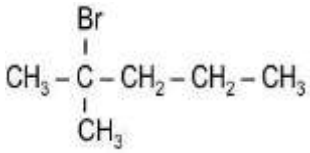
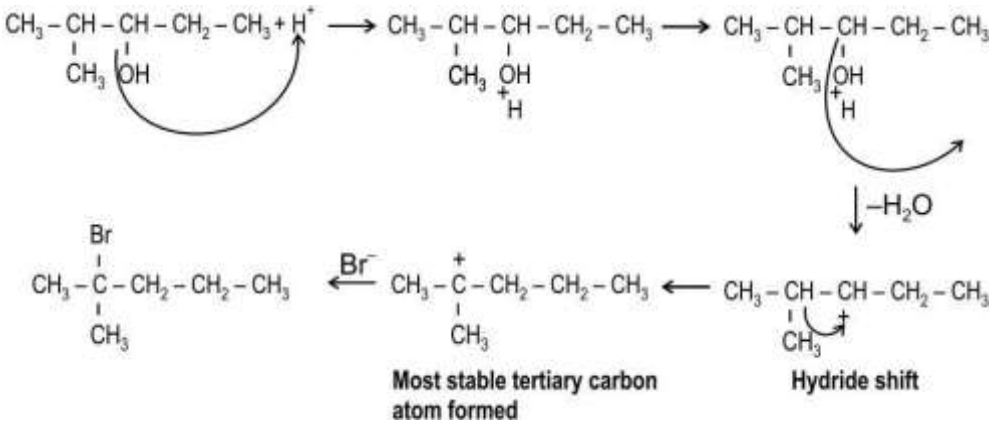
Q.123	(i) - NaCl is a true solution, while an aqueous solution of blood is a colloidal solution. [0.5] - Colloidal solutions scatter light in all directions due to the Tyndall effect, but the particle size of true solutions is comparatively smaller to do the same. [0.5] (ii) For coagulation to happen effectively, anion with maximum charge is effective. Hence, K_3PO_4 gives more effective coagulation than NaCl.	2
Q.124	The activation energy for this chemisorption: => ln (k2/k1) = $-E_a/R$ [1/T2 - 1/T1] => ln 10 = $-E_a/R$ [1/500 - 1/300] [1 mark] => E_a = 1913.44 Joule/mol [1 mark]	2

6. ALCOHOLS, PHENOLS AND ETHERS

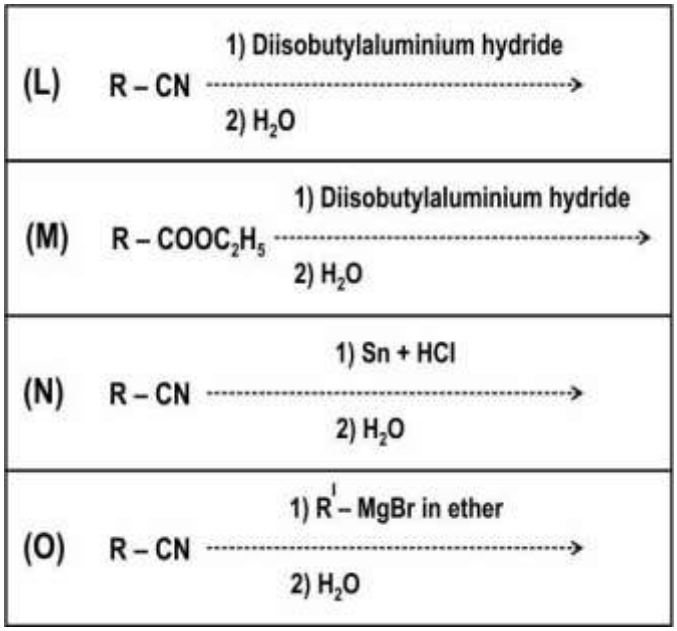
<table>
<tr><th>Q.No</th><th>Question</th><th>Marks</th></tr>
<tr><td colspan="3">Multiple Choice Question</td></tr>
<tr><td>Q.125</td><td>In which of these compounds is the length of the carbon-oxygen bond the shortest?
<table><tr><td> 
P</td><td> 
Q</td></tr><tr><td> 
R</td><td> 
S</td></tr></table>A. P
B. Q
C. R
D. S</td><td>1</td></tr>
<tr><td>Q.126</td><td>The boiling points of four compounds, an ether, an aldehyde, an alcohol, and a haloalkane of comparable molecular weights, are given (not necessarily in the same order) in the table below.
<table><tr><th>Compound</th><th>Boiling point</th></tr><tr><td>P</td><td>35 °C</td></tr><tr><td>Q</td><td>76 °C</td></tr><tr><td>R</td><td>47 °C</td></tr><tr><td>S</td><td>118 °C</td></tr></table>Identify which of the four compounds is the alcohol.
A. P
B. Q
C. R
D. S</td><td>1</td></tr>
</table>

Q.127	Two statements are given - one labelled Assertion (A) and the other labelled Reason (R). Read the statements carefully and choose the option that correctly describes statements A and R. Assertion (A): The boiling point of propanol is much higher than that of butane. Reason (R): Propanol exhibits intramolecular hydrogen bonding. A. Both A and R are true and R is the correct explanation for A. B. Both A and R are true but R is not the correct explanation for A. C. A is true but R is false. D. A is false but R is true.	1
Free Response Question/ Subjective Type		
Q.128	(a) Predict the main product of the following reaction.  (b) Write the reaction mechanism to explain why this isomer (the main product in the above reaction) predominates.	4
Q.129	Write the steps to show how you will convert nitrobenzene to phenol.	3
Q.130	Priyanka is comparing the solubility of 1-butanol and 1-pentanol in water. Which is likely to be LESS soluble in water and why?	2

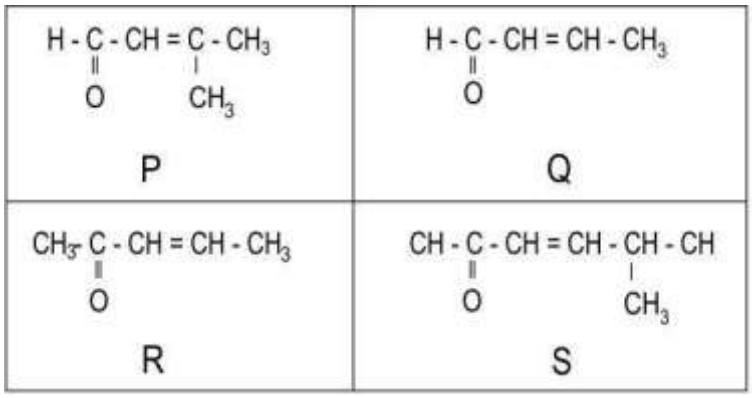
Answer Key & Marking Scheme

Q.No	Answers	Marks
Q.125	C. R	1
Q.126	D. S	1
Q.127	C. A is true but R is false.	1
Q.128	 0.5 marks for each of the following steps:  Most stable tertiary carbon atom formed Hydride shift	4
Q.129	(i) reduction of nitrobenzene to aniline with tin/HCl or Fe/HCl (ii) diazotisation of aniline to benzenediazonium chloride with sodium nitrite and hydrochloric acid at 0 to 5 °C (iii) hydrolysis of benzenediazonium chloride to phenol with water	3
Q.130	1-pentanol The larger alkyl group makes 1- pentanol more hydrophobic than 1-butanol	2

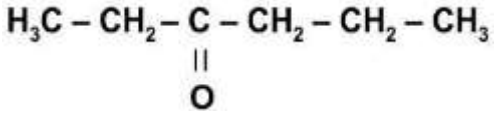
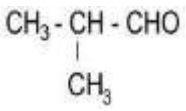
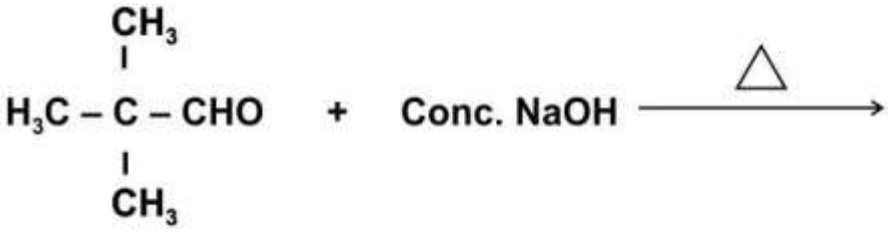
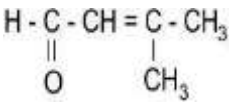
7. ALDEHYDES, KETONES AND CARBOXYLIC ACIDS

<table>
<tr><th>Q.No</th><th>Question</th><th>Marks</th></tr>
<tr><td colspan="3">Multiple Choice Question</td></tr>
<tr><td>Q.131</td><td>Given below are four examples in which the reactants and the reactions they are subjected to are stated.
 
(L) $R-CN \xrightarrow[2)\ H_2O]{1)\ \text{Diisobutylaluminium hydride}}$
(M) $R-COOC_2H_5 \xrightarrow[2)\ H_2O]{1)\ \text{Diisobutylaluminium hydride}}$
(N) $R-CN \xrightarrow[2)\ H_2O]{1)\ Sn + HCl}$
(O) $R-CN \xrightarrow[2)\ H_2O]{1)\ R^{I}-MgBr \text{ in ether}}$
Identify the example(s) in which the major product obtained will be an aldehyde and in which example(s) it is a ketone.
<table><tr><th>Option</th><th>Examples in which an aldehyde is formed</th><th>Examples in which a ketone is formed</th></tr><tr><td>A</td><td>L, N</td><td>M, O</td></tr><tr><td>B</td><td>L, N, O</td><td>M</td></tr><tr><td>C</td><td>L, M</td><td>N, O</td></tr><tr><td>D</td><td>L, M, N</td><td>O</td></tr></table>A. A
B. B
C. C
D. D</td><td>1</td></tr>
</table>

Q.132	A carbonyl compound X does NOT give a reddish-brown precipitate on heating with Fehling's solution. Which of the following could compound X be? (i) Propanal (ii) Diethyl ketone (iii) 4-Nitrobenzaldehyde A. only (iii) and (iv) B. only (ii) C. either (i) or (iii) D. either (ii) or (iii)	1
Q.133	A carbonyl compound produces iodoform on reaction with sodium hypoiodite. Which of the following could the carbonyl compound be? (i) CH_3 - CH_2- CHO (ii) CH_3 - CH_2 - CO - CH_2 - CH_3 (iii) CH_3 - CHO (iv) CH_3 - CH_2 - CO - CH_3 A. only (i) B. only (i) and (iii) C. only (ii) and (iv) D. only (iii) and (iv)	1
Q.134	Which of the following compounds are produced in an aldol condensation reaction of acetaldehyde and propanone?	1

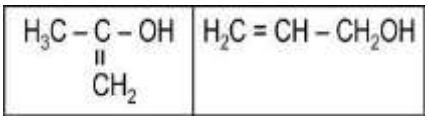
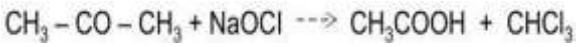
	 A. only P B. only P and Q C. only P, Q and R D. all - P, Q, R and S	
Q.135	Electrophilic substitution in benzoic acid takes place at the meta position. Which of the following is the reason for the reaction above? A. The carboxyl group activates only the meta position. B. The carboxyl group deactivates only the ortho and para positions. C. The carboxyl group activates the meta position more than the ortho and para positions. D. The carboxyl group deactivates the meta position less than the ortho and para positions.	1
Q.136	A carbonyl compound X undergoes the reactions given in the table below. **Reaction** / **Result**: Tollens' test / +ve; Iodoform test / +ve; Aldol condensation / Forms aldol product. Which of the following could compound X be? A. $CH_3 - CH_2 - CHO$ B. $CH_3 - CO - CH_3$ C. $CH_3 - CHO$	1

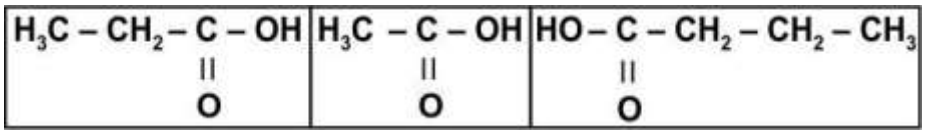
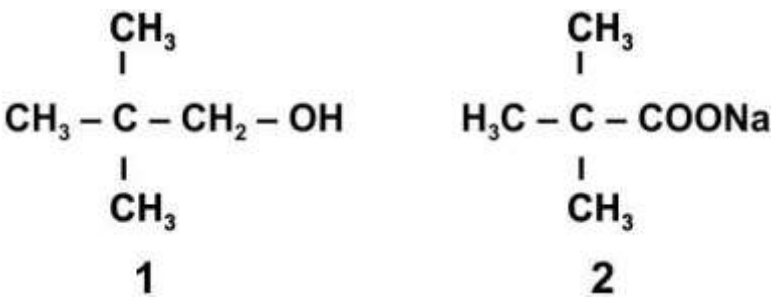
	D. H-CHO	
Q.137	Which of the following will give benzoic acid (C_6H_5 -COOH) on heating with alkaline potassium permanganate followed by acidification of the reaction mixture? P) C_6H_5 - CH_3 Q) C_6H_5 - CH_2 - CH_2 - CH_3 R) C_6H_5 - CO - CH_3 A. only P B. only P and Q C. only P and R D. all - P, Q and R	1
Q.138	One mole of a carboxylic acid on heating gives one mole of the anhydride. Identify the carboxylic acid. A. benzoic acid B. ethanoic acid C. phthalic acid D. methanoic acid	1
Free Response Question/ Subjective Type		
Q.139	Tushar has a mixture of two powders one of which is an aldehyde and the other an alkane. Both the powders are insoluble in water. The two powders can be separated by a method based on a chemical property of aldehydes. Describe the steps in this method to separate the two powders.	2
Q.140	A carbon compound of molecular formula C_3H_6O contains a ketone functional group. Draw the structural formulae of two compounds having the same molecular formula as above but with a different functional group containing an oxygen atom.	2
Q.141	(a) Write the chemical equation for the Haloform reaction of acetone with sodium hypochlorite solution. (b) Will 3-pentanone undergo the Haloform reaction with sodium hypochlorite? Justify your answer.	3

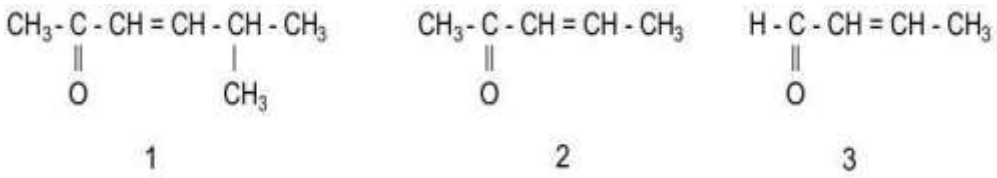
	(c) Name the one aldehyde that also undergoes the Haloform reaction.	
Q.142	Both aldehydes and ketones produce carboxylic acids on oxidation. (a) With respect to the number of carbon atoms, state the difference in the carboxylic acids formed when: (i) an aldehyde is used as a reactant (ii) a ketone is used as a reactant. (b) Give one reason for this difference in each case.	2
Q.143	Between 4-nitrobenzaldehyde and benzaldehyde, which will be more reactive to nucleophilic addition reactions? Explain why.	2
Q.144	The compound shown below is oxidised under vigorous conditions.  (a) How many different types of products will be formed in the reaction? (b) Write the structural formulae of all the products.	4
Q.145	State if the compound given below will produce chloroform ($CHCl_3$) on reaction with sodium hypochlorite. Justify your answer. 	1
Q.146	Write the structures of the products of the reaction given below. 	1
Q.147	One of the products of an aldol reaction is given below.  (a) Name and write the structures of the reactants. (b) Name the electrophile involved in the formation of the product above.	3

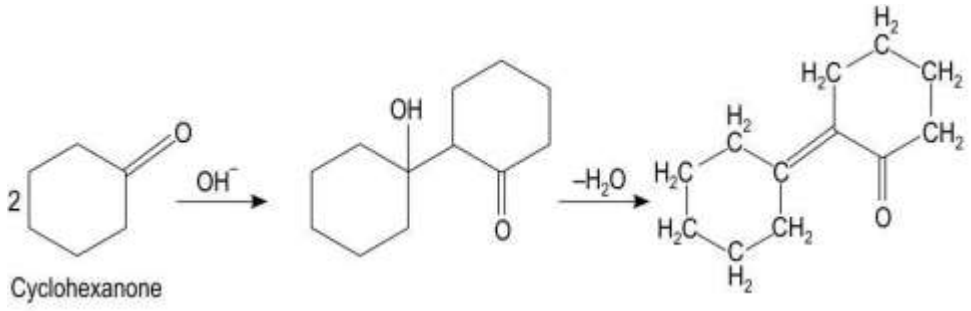
<table>
<tr><td></td><td>(c) Write the structures of all the other products possible in the reaction.</td><td></td></tr>
<tr><td>Q.148</td><td>(a) Is benzaldehyde less or more reactive to electrophilic substitution reactions than benzene (C_6H_6)? Give an explanation for your answer.
(b) State the position on the ring at which electrophilic substitution is likely to predominate in benzaldehyde. Explain why.</td><td>3</td></tr>
<tr><td>Q.149</td><td>A mixture of 0.5 moles acetaldehyde and 0.5 moles diethyl ketone is treated with 1 mole of sodium cyanide (NaCN).
What will be the major product in this reaction? Give two reasons for your answer.</td><td>3</td></tr>
<tr><td>Q.150</td><td>Esterification of a carboxylic acid with an alcohol in the presence of mineral acid as catalyst is a reversible reaction.
Suggest two things that can be done with the products formed to push the reaction in the forward direction.</td><td>1</td></tr>
<tr><td>Q.151</td><td>A compound X consisting of C and H atoms and one oxygen atom in a carbonyl group, undergoes the reactions as given in the table below.
<table><tr><th>Reaction</th><th>Result</th></tr><tr><td>Tollens' test</td><td>+ve</td></tr><tr><td>Iodoform test</td><td>+ve</td></tr></table>
Identify the product(s) that compound X will produce on undergoing the Aldol condensation reaction followed by dehydration. Justify your answer.</td><td>2</td></tr>
<tr><td>Q.152</td><td>Write the structure of the intermediate and the final product formed by the self aldol condensation of cyclohexanone.</td><td>2</td></tr>
</table>

Answer Key & Marking Scheme

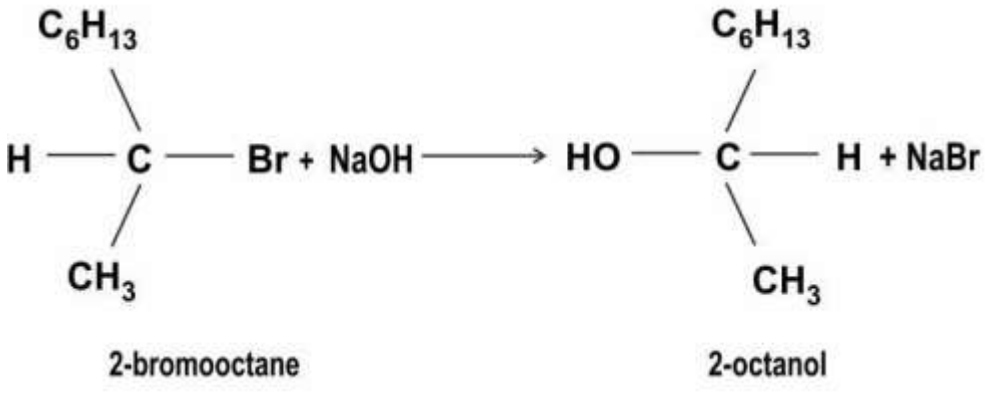
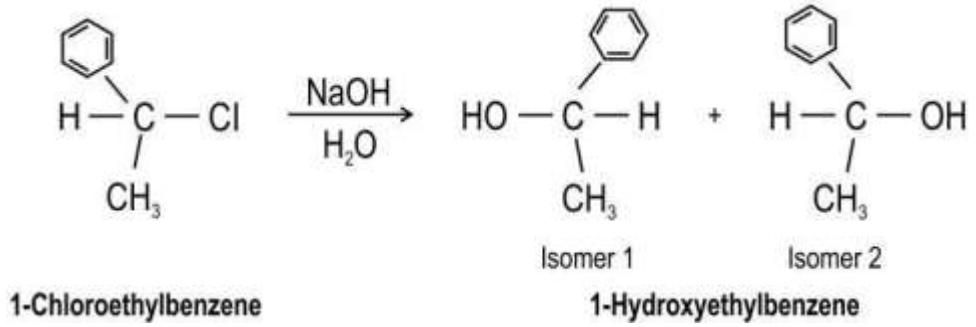
Q.No	Answers	Marks
Q.131	D. D	1
Q.132	D. either (ii) or (iii)	1
Q.133	D. only (iii) and (iv)	1
Q.134	D. all - P, Q, R and S	1
Q.135	D. The carboxyl group deactivates the meta position less than the ortho and para positions.	1
Q.136	C. CH_3 - CHO	1
Q.137	D. all - P, Q and R	1
Q.138	C. phthalic acid	1
Q.139	1 mark for each of the following steps: - Stir the mixture with an aqueous solution of sodium bisulphite (sodium hydrogen sulphite). - Filter off the insoluble alkane. - Add dilute mineral acid / alkali to the filtrate to obtain the aldehyde.	2
Q.140	1 mark for each of the following structures: 	2
Q.141	(a) 0.5 marks for each of the following reactants and products:  (b) 0.5 marks for each of the following: - No - The carbonyl group in 3-pentanone is not linked to a methyl group which gets converted to chloroform in the reaction. (c) acetaldehyde / ethanal	3

Q.142	(a)(i) Aldehydes produce carboxylic acids having the same number of carbon atoms as the aldehyde. (a)(ii) Ketones produce carboxylic acids having less carbon atoms than the ketone. (b) 0.5 marks each for the following: - Aldehydes undergo oxidation without breaking of carbon-carbon bonds. - Carbon-carbon bonds undergo cleavage on oxidation of ketones.	2
Q.143	4-nitrobenzaldehyde would be more reactive to nucleophilic reactions than benzaldehyde. 1 mark for each of the following: - The electron-withdrawing nitro group prevents resonance of the ring electrons with the carbonyl group. - This makes the carbonyl carbon atom more positive in 4-nitrobenzaldehyde than in benzaldehyde and therefore more reactive to nucleophiles.	2
Q.144	(a) three (b) 1 mark each for the following: 	4
Q.145	It will not form chloroform. The carbonyl carbon atom in this compound does not have a methyl group on it to get converted to chloroform.	1
Q.146	1 mark each for the following: 	1
Q.147	(a) 0.5 marks each for the names and 0.5 marks each for the structures: - acetaldehyde : CH_3 - CHO - acetone / propanone: CH_3 - CO - CH_3	3

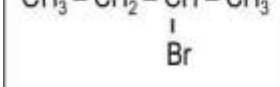
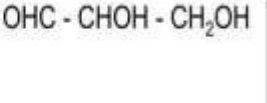
	(b) acetone OR propanone (1 mark) (c) 1 mark each for the following structures:  1 2 3	
Q.148	(a) - less reactive [0.5 marks] - The aldehyde group is an electron withdrawing group and destabilises the intermediate carbocation formed in electrophilic substitution reactions. [1 mark] (b) - meta position [0.5 marks] - Of the three positions meta, ortho and para, the meta position is the least deactivated.	3
Q.149	The cyanohydrin formed by reaction of CN^- with acetaldehyde will be the major product. 1 mark each for the following: - Due to greater steric hindrance of the ethyl groups in diethyl ketone, the nucleophilic substitution reaction of CN^- with acetaldehyde is favoured over that with diethyl ketone. - The greater electron releasing effect of the ethyl groups in diethyl ketone reduces the electrophilicity of the carbonyl carbon atom more than the methyl group in acetaldehyde.	3
Q.150	1 mark each for the following: - Remove the water as it is formed. - Remove the ester as it is formed. OR - Reduce the concentration of the products formed. [2 marks]	1
Q.151	Compound X will form CH_3 - CH = CH - CHO (but-2-enal) (No marks to be awarded if justification is not given or is incorrect.) 1 mark each for the following:	2

	- Since compound X undergoes the iodoform reaction, it has a methyl group linked to the carbonyl group. - Since compound X gives a positive Tollens' test it is an aldehyde. - Acetaldehyde (ethanal) is the only aldehyde with a methyl group linked to the carbonyl group.	
Q.152	1 mark each for writing the structure of the intermediate and final product of the reaction:  	2

8. HALOALKANES AND HALOARENES

Q.No	Question	Marks
	Free Response Question/Subjective Type	
Q.153	2-bromooctane reacts with alcoholic NaOH to give 2-octanol as shown below.  2-bromooctane 2-octanol (a) Identify the type of substitution reaction mechanism. Justify your answer. (b) What effect will it have on the rate of the reaction if: (i) the concentration of NaOH is reduced by half? (ii) the concentration of 2-bromooctane is reduced by half?	2
Q.154	1-chloroethylbenzene undergoes hydrolysis by aqueous sodium hydroxide to give a mixture of two isomers as shown below.  Isomer 1 Isomer 2 1-Chloroethylbenzene 1-Hydroxyethylbenzene (a) State if the reaction follows the SN1 or SN2 mechanism. (b) Draw the structure of the intermediate formed in the reaction. (c) Explain why two isomers are formed and which one will predominate. (d) Compare the rate of hydrolysis of 1-chloroethylbenzene with that of 1-bromoethylbenzene under similar conditions. Justify your answer.	4

Q.155	(a) Which of the following two compounds has a chiral centre?	2

Compound P	Compound Q
	

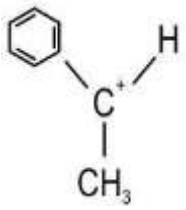
(b) Two compounds X and Y are enantiomers of each other.

Name one physical property that:

(i) is the same for X and Y.

(ii) is different for X and Y.

Answer Key & Marking Scheme

Q.No	Answers	Marks
Q.153	(a) 0.5 marks for each of the following: - SN_2 mechanism - The configuration of the product is opposite to that of the reactant. (b) 0.5 marks each for the following: (i) The rate of reaction will be reduced by half. (ii) The rate of reaction will be reduced by half.	2
Q.154	(a) SN1 mechanism (b)  (c) 0.5 marks for each of the following: - The intermediate carbonium ion has a planar structure. - The OH^- ion can attack the intermediate either from the rear or from the front (side of departing Cl^- ion) - Isomer 1 will predominate. - The departing Cl^- ion shields the front side from attack by the OH^- nucleophile. (d) 0.5 marks for each of the following: - The rate of reaction would be faster with 1-bromoethylbenzene. - The bromonium ion Br^- is a more stable leaving group as it is larger in size than the Cl^- ion and the charge is spread over a larger area.	4
Q.155	(a) Both, compound P and compound Q have a chiral centre. (b) (i) 0.5 marks each for any one example such as: - melting point - boiling point	2

	- refractive index (ii) direction of rotation of plane of polarized light [0.5 marks]	

9. THE P-BLOCK ELEMENTS

Q.No	Question	Marks
	Multiple Choice Question	
Q.156	Which of the following statements is/are true regarding the acidic strength of oxides? i) N_2O_3 is less acidic than N_2O_5 as the electron-withdrawing ability of nitrogenin +5 oxidation state is more than that in +3 oxidation state. ii) P_2O_5 is more acidic than N_2O_5 as the electron-withdrawing ability of phosphorous is more than that of Nitrogen. iii) N_2O_3 reacts with water to give nitric acid which makes N_2O_3 the strongest oxo-acid of nitrogen. A. i only B. ii only C. i and ii only D. ii and iii only	1
Q.157	Which of the following is the strongest reducing agent? A. I- B. I2 C. F- D. F2	1

Answer Key & Marking Scheme

Q.No	Answers	Marks
Q.156	A. i only	1
Q.157	A. I^-	1

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