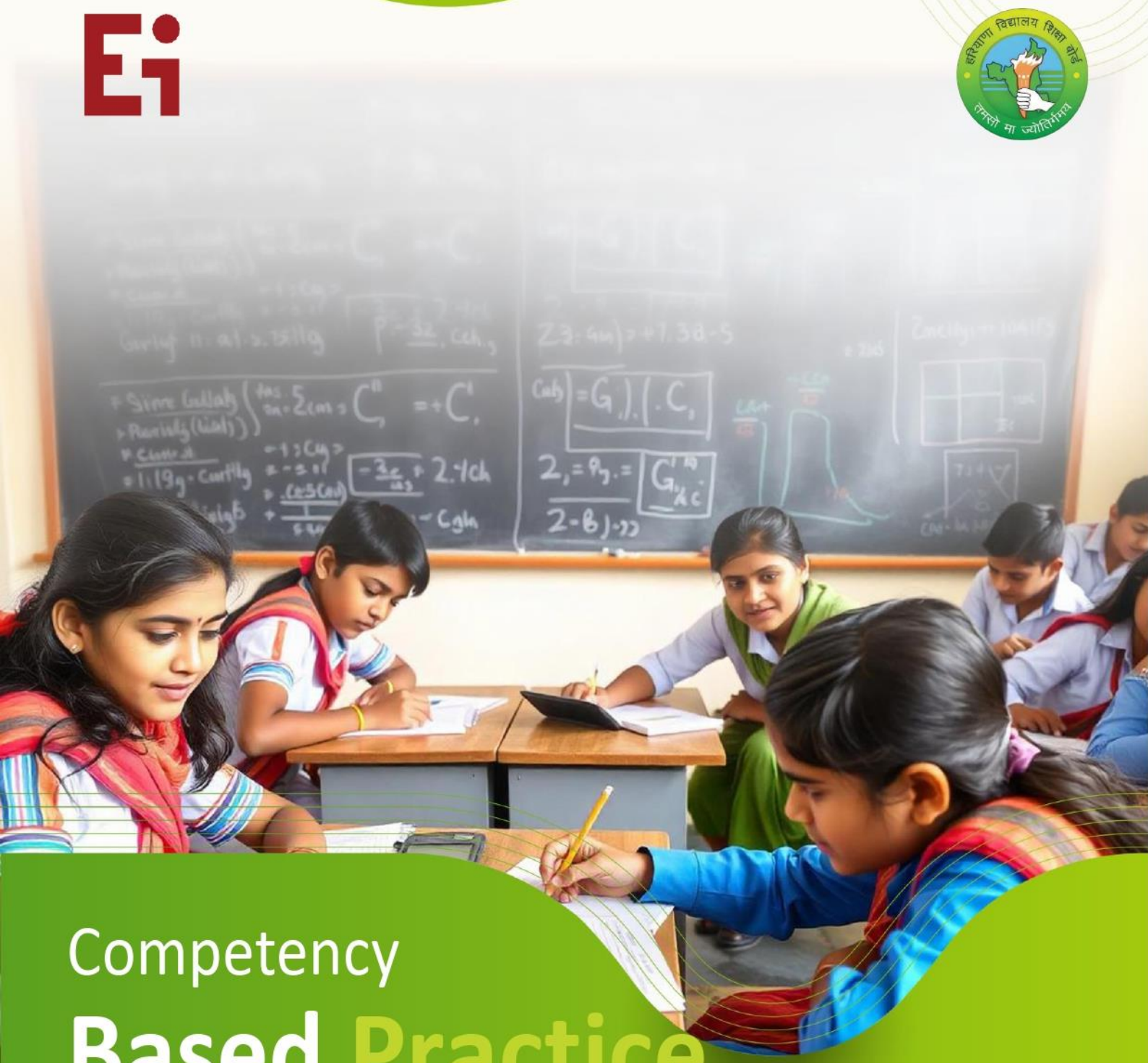


Competency Based Practice Questions

Chemistry - XII

Co-created by

Board of School Education Haryana
and
Educational Initiatives

HOW TO USE THIS BOOKLET

Dear Teachers and Students,

The **Board of School Education Haryana** is pleased to present the **Competency-Based Practice Questions** booklet. This resource has been thoughtfully designed to help you deepen your understanding of key concepts and enhance your problem-solving skills. It includes **50 exemplar questions** carefully aligned with the curriculum to familiarize students with the format of **Competency-Based Questions**. These questions are intended to support targeted practice and develop the skills necessary to confidently approach a variety of question types in assessments.

Best Ways for Teachers to Utilise This Resource

1. Integrate into Classroom Teaching

- Use these questions to demonstrate how theoretical concepts translate into practical applications.
- Encourage group discussions to explore reasoning and understanding of concepts taught.

2. Scaffold Student Learning

- Start with simpler questions and guide students through the thought process.
- Gradually introduce more complex questions to build confidence and familiarity.

3. Incorporate into Assessments

- Use these questions in classroom quizzes or homework to help students adapt to the format.
- Provide feedback that emphasises reasoning over correctness, encouraging students to refine their understanding.

4. Focus on Skill Development

- Highlight how these questions nurture understanding, analysis and critical thinking.
- Use student responses to identify and address misconceptions effectively.

Best Ways for Students and Parents to Utilise This Resource

1. Focus on Conceptual Understanding

- Approach each question as a way to understand *why* and *how* a concept works, rather than simply finding the correct answer.

2. Practice Purposefully

- Don’t rush—break down the question, identify the concept it addresses, and plan your approach before solving it.

3. Use Feedback to Improve

- Treat mistakes as learning opportunities. Review incorrect answers to understand *what went wrong* and *how to improve*.
- Revisit similar questions to build confidence and mastery over the topic.

Best Ways for Parents to Utilise This Resource

1. Encourage Critical Thinking

- Spend time discussing questions and concepts, asking “Why?” and “How?”.

2. Create a Positive Environment

- Celebrate effort and curiosity, not just grades.
- Help your child view mistakes as opportunities to learn and grow.

3.Collaborate with Teachers

- Stay informed about competency-based assessments through school communications.
- Share observations and work with teachers to address any concerns or challenges.

Final Message

These practice questions are an excellent opportunity to strengthen your conceptual understanding and boost your confidence in solving competency-based questions. For students, each question builds skills that will help you tackle similar challenges with ease. For teachers, this is a chance to mentor students in developing their thinking and problem-solving skills.

Start today—every effort you invest will prepare you not only for exams but for a lifetime of meaningful learning and success. Let’s make this journey toward competency-based education a meaningful and successful one!

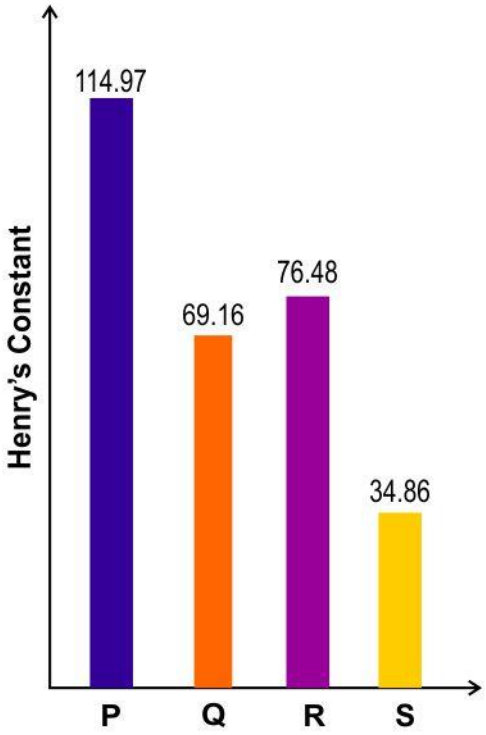
Board of School Education, Haryana

Contents

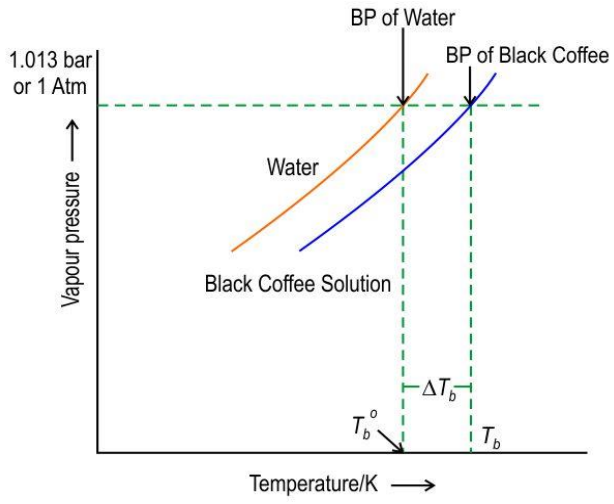
Chemistry | XII

Solutions

Q.No.	Question	Marks
1	If 50% of a substance X dimerises when dissolved in a solvent with K_f value 25 $^oC/m$, what is Van't Hoff 'i' factor of the solute present in the solution? *(The depression in the freezing point is 15 K.)* (A) 0.25 (B) 0.50 (C) 0.75 (D) 1.00 ***[Skill: Mechanical]***	1
2	What is the molarity of the solution of NaOH that has a concentration equivalent to 0.15% w/v? *(Note: Molecular weight of Na = 40)* ***[Skill: Understanding]***	1
3	The solution with the highest osmotic pressure among the given solutions is _____. **0.2 M of KCl, 0.1M of $Fe_2(SO_4)_3$, 0.2M glucose, 0.1M urea** *(Assume 100% dissociation wherever applicable.)* ***[Skill: Mechanical]***	1

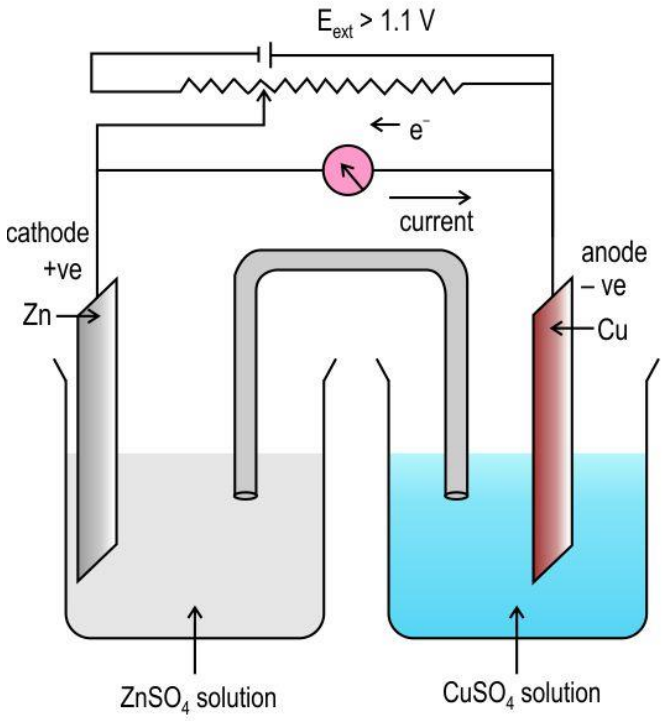
4	(a) The graph below gives the variation of Henry's constant in water for four gases at 298 K at atmospheric pressure.  Arrange the gases in the decreasing order of solubility in water with a reason. (b) Pure water and an aqueous solution of black coffee are taken in two cups. Draw a graph (qualitative only) of vapour pressure vs temperature for pure water and for the aqueous solution of the black coffee. Also, mark the boiling point for pure water and for the aqueous solution of the black coffee in the graph. ***[Skill: Application]***	1+2
5	(a) The molality of 1.5 litres of a 92% H_2SO_4 solution (w/v) is 8.20 mol/kg. Calculate the density of the solution. *(Relative atomic mass of H=1, S= 32, O= 16)* (b) Mr. Jain added some ethylene glycol to his car radiator. The temperature at his place at that time of the year was around -30.74 ^oF. Can you explain his activity with proper reason? ***[Skill: Understanding]***	3+2

Marking Scheme

Q No.	Rubric	Marks
1	**Correct Answer:** C Assume 1 mole of substance X was dissolved in water. As the degree of dimerization is 0.50, then the number of moles of dimerized phenol: 0.50/2 (since two monomers combine to form one dimer) The number of moles of undimerized phenol: 1− 0.50 = 0.50 The Van't Hoff factor i is given by: => i = (0.50 + 0.50/2) / 1 = 0.75	1
	A: Students choosing this option may lack the understanding of abnormal colligative properties.	
	B: Students choosing this option may lack the understanding that substance X dimerized.	
	D: Students choosing this option may lack the understanding of abnormal colligative properties.	
2	0.15% w/v means 0.15g of NaOH is dissolved in 100 mL of solution. Molarity (M) = mass of solute/(molar mass x volume of solution) *[0.5 marks]* = 0.15/(40 x 0.10) = 0.15/ 4 = 0.0375 mol/L = 0.0375 M *[0.5 marks]*	1
3	0.1M of $Fe_2(SO_4)_3$	1
4	(a) The decreasing order of solubility of the gases from the graph is: S>Q>R>P *[0.5 marks]* According to Henry' law, the gas with the lowest Henry's constant is the most soluble and the gas with the highest constant is the least soluble. *[0.5 marks]*	1
	 where T_b^o is the boiling point of water and T_b is the boiling point of aqueous solution of black coffee. *[0.5 marks for correctly labelling the axis, 1 mark for drawing both the curves and labelling them correctly, and 0.5 marks for labelling the boiling point of both the liquids]*	2

5	(a) Volume of the solution, V = 1.5 L Mass percentage of H_2SO_4 in the solution, w/v=92% (i.e., 92 g of H_2SO_4 per 100 mL of solution) Molality, m = 8.20 mol/kg Molar mass of H_2SO_4, $M_{H_2SO_4}$ = 98g/mol *[0.5 marks]* Mass of H_2SO_4 in the solution = (92/100) * 1500 = 1380 g = 1.38 kg *[0.5 marks]* No. of moles of H_2SO_4 in the solution = 1380/98 = 14.08 mol *[0.5 marks]* Mass of solvent (kg) = No. of moles/molality of the solution = 14.08/8.20 = 1.717 kg *[0.5 marks]* Thus, total mass of solution = 1.38 + 1.717 = 3.097 kg *[0.5 marks]* Density = Mass in kg/volume in L = 3097/1500 = 2.065 kg/L = 2.07 kg/L *[Award 0.5 marks for the correct answer with proper units.]*	3
	(b) In cold countries the water in the car radiator freezes. *[1 mark]* Adding substances like ethylene glycol to the car radiators, decreases the freezing point of the aqueous solution, ensuring that the car radiator functions properly in cold temperatures. *[1 mark]*	2

Electrochemistry

Q.No.	Question	Marks
6	The electric potential of a standard Daniel cell is 1.1 V. The image below shows a standard Daniel cell connected to an external circuit.  Which of the following sentence is true for the given image? (A) Zinc undergoes oxidation at the cathode, and copper undergoes reduction at the anode. (B) Zinc undergoes oxidation at the anode, and copper undergoes reduction at the cathode. (C) Copper undergoes oxidation at the cathode, and zinc undergoes reduction at the anode. (D) Zinc undergoes reduction at the cathode, and copper undergoes oxidation at the anode. ***[Skill: Application]***	1

7	Two statements are given - one labelled Assertion (A) and the other labelled Reason (R). Assertion (A): The electrical conductance for copper wire decreases with increase in temperature. Reason (R): The number of free electrons in copper decreases significantly with increase in temperature. Which of the following is correct? (A) Both A and R are true, but R is the correct explanation of the A. (B) Both A and R are true, but R is not the correct explanation of the A. (C) A is true, but R is false. (D) A is false, but R is true. ***[Skill: Understanding]***	1
8	The standard reduction potentials for Cu and Zn electrodes are 0.350 V and - 0.763 V respectively. Consider the following cell: Zn I Zn^{+2}(1.0 M) II Cu^{+2}(1.0 M) I Cu Is the cell reaction spontaneous? Give a reason. ***[Skill: Application]***	1
9	Class XII students set up a galvanic cell with a 100 g copper bar and 1 litre of 1M $ZnSO_4$ solution. If the cell operates with a steady current of 2A, calculate the time (in seconds) needed to deposit 5 g of zinc on the cathode. *(Molar mass of Cu = 64; Zn = 65; 1F = 96500 C)* ***[Skill: Application]***	2
10	Answer the following questions considering hydrogen fuel cell. (a) Write the chemical equation for the overall reaction in a hydrogen fuel cell. (b) Mention one advantage and one limitation of using hydrogen fuel cells for energy generation. (c) Explain why fuel cells are considered more efficient than traditional combustion engines. (d) State one real life application of this cell. (e) Discuss one strategy to overcome the challenges associated with hydrogen fuel cells. ***[Skill: Mechanical]***	1+1+1 +1+1

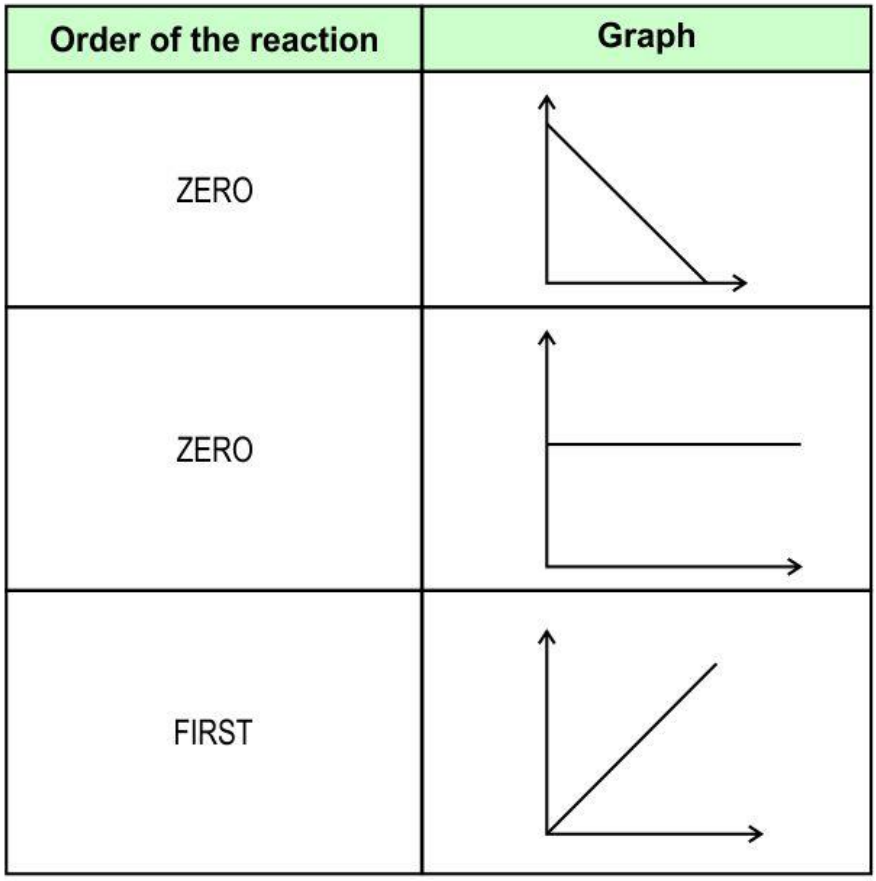
Marking Scheme

Q No.	Rubric	Marks
6	**Correct Answer:** D From the image we see electrons flow from the anode to the cathode. So, oxidation occurs at the Cu electrode and reduction occurs at the Zn electrode. Zn gets deposited at the cathode the Cu moves to the solution as Cu^{+2} ions.	1
	A: Students choosing this option may lack the understanding that an increase in the E_{ext} above 1.1 V starts the reaction in the opposite direction.	
	B: Students choosing this option may lack the understanding that oxidation occurs at the cathode.	
	C: Students choosing this option may lack the understanding that oxidation occurs at the cathode.	
7	**Correct Answer:** C The electrical conductance for copper wire decreases with increase in temperature, as resistivity increases with temperature. The number of free electrons in copper does not change significantly with increase in temperature but but their ability to move freely is reduced.	1
	A: Students choosing this lack understanding of factors effecting electrical conductance of a metallic conductor.	
	B: Students choosing this lack understanding of factors effecting electrical conductance of a metallic conductor.	
	D: Students choosing this lack understanding of factors effecting electrical conductance of a metallic conductor.	
8	$E_{cell} = E_{cathode} - E_{anode} = [0.350-(-0.763)] = 1.113$ V *[0.5 marks]* As the E_{cell} is positive the cell reaction will be spontaneous. *[0.5 marks]*	1
9	Cathode reaction involved is: $Zn^{+2} + 2e^{-}$ ---> Zn(s) *[0.5 marks]* 2 moles of electrons are required to deposit 1 mole of Zn. Moles of Zn to be deposited: Mass of Zn/Molar mass of Zn = 5/65 = 1/13 moles *[0.5 marks]* To deposit 1 mole of Zn 2F charge is needed. So, to deposit 1/13 mole of Zn = no. of moles x 2F charge is needed = (1/13) x 2 x 96500 = 14846.15 C *[0.5 marks]* Current passed is 2A Time required = Q/I = 14846.15/2 = 7423.08 secs *[0.5 marks]*	2
10	(a) The chemical equation is $2H_2 + O_2$ -> $2H_2O$ + energy	1

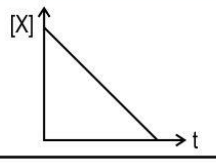
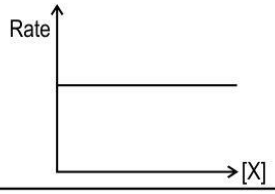
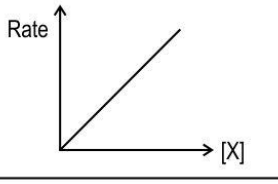
	(b) Advantage: Produces only water as a by-product. Limitation: Expensive catalysts like platinum are required. *[0.5 marks for each correct answer.]* *[Accept any other valid answer.]*	1
	(c) Fuel cells directly convert chemical energy into electrical energy with minimal energy loss, avoiding the intermediate step of combustion. *[Accept any other valid answer]*	1
	(d) The cell was used for providing electrical power in the Apollo space programme.	1
	(e) Using cheaper and more abundant materials like carbon-based electrodes that can reduce the cost of fuel cells. *[Accept any other valid answer.]*	1

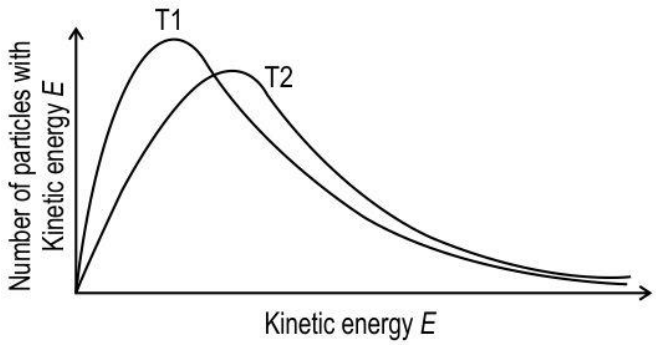
Chemical Kinetics

Q.No.	Question	Marks
11	Shamoita compiled a list of rate expressions for several reactions she studied during her lab classes: I. Rate = $k [P]^{3/2} [Q]^{-1}$ II. Rate = $k [P]^{1} [Q]^{1}$ III. Rate = $k [P]^{1} [Q]^{0}$ Which of the following arranges the reactions in the increasing order of their overall reaction order? (A) I, II, III (B) I, III, II (C) II, III, I (D) III, II, I ***[Skill: Application]***	1
12	During hydrolysis of ethyl acetate, the order of the reaction changes from _____ to _____ when the amount of water is reduced considerably. ***[Skill: Mechanical]***	1
13	Carbon dating is a technique used by archaeologists to determine the age of organic materials, such as trees, plants, animal remains, and human artifacts made from wood and leather, by measuring the amount of carbon-14 present. An archaeologist discovered that the carbon-14 content in the remains of an animal was 25% of the original carbon-14 present in the plant's body when it died. What is the age of this sample? *(Given the half-life of carbon-14= 5730 years and log 4 = 0.6)* ***[Skill: Mechanical]***	2

14	Redraw the graphs labelling the axes correctly:  ***[Skill: Application]***	3
15	(a) How is the time required for 90% completion of a first-order reaction related to its half-life? (b) Draw Maxwell-Boltzmann curve showing the distribution for temperatures T_1(70^{o}C) and T_2(80^{o}C) for a sample of nitrogen gas. ***[Skill: Understanding]***	3+2

Marking Scheme

<table>
<tr><th>Q No.</th><th>Rubric</th><th>Marks</th></tr>
<tr><td>11</td><td>Correct Answer: B
To determine the overall reaction order for each of the reactions listed, we need to sum the exponents of the concentrations in the rate expression for each reaction.
order of I = ½; order of II = 2; order of III= 1.</td><td>1</td></tr>
<tr><td></td><td>A: Students choosing this option may lack the understanding that order of a reaction is the sum of powers of the concentration of the reactants in the rate law expression is called the order of that chemical reaction.</td><td></td></tr>
<tr><td></td><td>C: Students choosing this option may have got confused about the mode of arranging the reactions.</td><td></td></tr>
<tr><td></td><td>D: Students choosing this option may lack the understanding that order of a reaction is the sum of powers of the concentration of the reactants in the rate law expression is called the order of that chemical reaction.</td><td></td></tr>
<tr><td>12</td><td>During hydrolysis of ethyl acetate, the order of the reaction changes from <u>pseudo first order</u> to <u>second order</u> when the amount of water is reduced considerably.</td><td>1</td></tr>
<tr><td>13</td><td>Decay of ^{14}C is a first order reaction.
=> k = 0.693/ $t_{1/2}$ = 0.693 / 5730 [0.5 marks]
=> t = (2.303/k) log(A_0/A) [0.5 marks]
=> t = (2.303 × 5730/0.693) × log 100/25
=> t = 11425.27 years (approx.) [1 mark]</td><td>2</td></tr>
<tr><td>14</td><td><table><tr><th>Order of the reaction</th><th>Graph</th></tr><tr><td>ZERO</td><td> 
</td></tr><tr><td>ZERO</td><td> 
</td></tr><tr><td>FIRST</td><td> 
</td></tr></table>[X] - represents concentration of the reactant.
[Award 1 mark for each correct answer.]
[Accept any other valid answer.]</td><td>3</td></tr>
</table>

15	(a) For a first-order reaction, the time required to complete a certain fraction of the reaction can be calculated using the integrated rate law: $t = (1/k)\ln([A]_0/[A])$ -----(i) *[0.5 marks]* where: t = time k = rate constant $[A]_0$ = initial concentration [A] = remaining concentration at time t To find the time for 90% completion, $[A] = 0.1[A]_0$. *[0.5 marks]* Substituting in eqn (i), $t_{90\%} = (1/k)\ln([A]_0/[A]) = (1/k) \ln ([A]_0/0.1[A]_0) = (1/k)\ln 10$ ------(ii) *[0.5 marks]* For a first-order reaction, the half-life is: $t_{1/2} = \ln 2/k$ ------(iii) *[0.5 marks]* Dividing (ii)/(iii), $t_{90\%}/ t_{1/2} = \ln 10/\ln 2 = 2.303/0.693$ *[0.5 marks]* $=3.32$*[0.5 marks]* Thus, the time for 90% completion of a first-order reaction is approximately 3.32 times the half-life.	3
	(b)  *[0.5 marks for the labelling of each axes and 0.5 mark for each curve with correct labelling with temperature]*	2

<table>
<tr><th>Q.No.</th><th>Question</th><th>Marks</th></tr>
<tr><td>16</td><td>Which of the following options correctly completes the given reaction?

Reaction L:
$5S^{2-} + 2MnO_4^- + 16H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 5S$

Reaction M:
$8MnO_4^- + 3S_2O_3^{2-} + H_2O \longrightarrow 8MnO_2 + 6SO_4^{2-} + 2OH^-$

<table>
<tr><th>Option</th><th>Reaction L</th><th>Reaction M</th></tr>
<tr><td>A</td><td>pH < 7</td><td>pH > 7</td></tr>
<tr><td>B</td><td>pH = 7</td><td>pH > 7</td></tr>
<tr><td>C</td><td>pH = 7</td><td>pH = 7</td></tr>
<tr><td>D</td><td>pH > 7</td><td>pH < 7</td></tr>
</table>

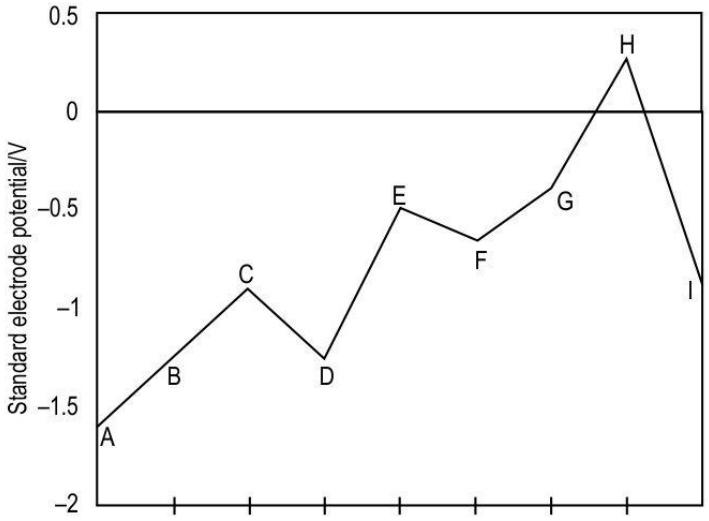
[Skill: Mechanical]</td><td>1</td></tr>
<tr><td>17</td><td>Two statements are given - one labelled Assertion (A) and the other labelled Reason (R).

Assertion (A): $Ni(CO)_4$ and $Fe(CO)_5$ show dsp^3 hybridisation.
Reason (R): Nickel and iron's oxidation state is zero in $Ni(CO)_4$ and $Fe(CO)_5$.

Which of the following is correct?

(A) Both A and R are true, and R is the correct explanation of the A.
(B) Both A and R are true, but R is not the correct explanation of the A.
(C) A is true, but R is false.
(D) A is false, but R is true.

[Skill: Understanding]</td><td>1</td></tr>
</table>

18	The observed colour of an aq. solution of P^{+2} ion is colourless. P belongs to the first transition series. The graph below gives the standard electrode potential values of the successive elements of the first transition series.  Which of the positions on the graph is most likely to represent P? Why is P^{+2} colourless? ***[Skill: Application]***	1
19	Beena made the following point about the two oxoanions of chromium. I) The bond angle of chromate ion is 126 and that of dichromate is 109.5 II) The magnetic moment of chromate and dichromate is the same. III) Sodium dichromate has lower lattice energy and higher hydration energy than potassium dichromate. Identify the statement(s) that is/are correct with a reason. ***[Skill: Application]***	2
20	Ti^{3+} in an aqueous solution forms a complex that absorbs light with a wavelength of 5000 Å. Complete the table given below: ***[Skill: Application]***	3

	Wavelength (shorter than/greater than) 5000 Angstrom	Reason
The initial ligand in Ti^{+3} complex is replaced with CN^-		
The initial ligand in Ti^{+3} complex is replaced with Cl^-		

21	Answer the questions based on the table given below:	2+1.5 +1.5

Element		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Atomic number		21	22	23	24	25	26	27	28	29	30
Electronic configuration											
	M	$3d^1 4s^2$	$3d^2 4s^2$	$3d^3 4s^2$	$3d^5 4s^1$	$3d^5 4s^2$	$3d^6 4s^2$	$3d^7 4s^2$	$3d^8 4s^2$	$3d^{10} 4s^1$	$3d^{10} 4s^2$
	M^+	$3d^1 4s^1$	$3d^2 4s^1$	$3d^3 4s^1$	$3d^5$	$3d^5 4s^1$	$3d^6 4s^1$	$3d^7 4s^1$	$3d^8 4s^1$	$3d^{10}$	$3d^{10} 4s^1$
	M^{2+}	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	$3d^8$	$3d^9$	$3d^{10}$
	M^{3+}	[Ar]	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	–	–
Enthalpy of atomisation, $\Delta_a H^O$/kJ mol^{-1}		326	473	515	397	281	416	425	430	339	126
Ionisation enthalpy /$\Delta_a H^O$/kJ mol^{-1}											
$\Delta_a H^O$	I	631	656	650	653	717	762	758	736	745	306
$\Delta_a H^O$	II	1235	1309	1414	1592	1509	1561	1644	1752	1958	1734
$\Delta_a H^O$	III	2393	2657	2833	2990	3260	2962	3243	3402	3556	3837
Metallic/ionic radii/pm	M	164	147	135	129	137	126	125	125	128	137
	M^{3+}	73	67	64	62	65	65	61	60	–	–
Standard electrode potential E^o /V	M^{2+}/M	–	–1.63	–1.18	–0.90	–1.18	–0.44	–0.28	–0.25	+0.34	–0.76
	M^{3+}/M^{2+}	–	–0.37	–0.26	–0.41	+1.57	+0.77	+1.99	–	–	–
Density/g cm^{-3}		3.43	4.1	6.07	7.19	7.21	7.8	8.7	8.9	8.9	7.1

(a) Refer to the table and comment on the standard electrode potential of Sc^{+3}/Sc^{+2}.

(b) How does the enthalpy of hydration of the elements of the first transition series vary across the period? Give a reason for your answer.

(c) Why do the last two elements not show +3 oxidation state?

[Skill: Application]

Marking Scheme

Q No.	Rubric	Marks
16	**Correct Answer:** A This is the correct answer as oxidation of hydrogen sulphide to sulphur occurs in an acidic medium and thiosulphate is oxidised to sulphate in an alkaline medium. Thus, L represents pH<7 and m represents pH>7.	1
	B: Students choosing this option may lack the understanding about the various reactions of transition elements and the reaction conditions.	
	C: Students choosing this option may lack the understanding about the various reactions of transition elements and the reaction conditions.	
	D: Students choosing this option may lack the understanding about the various reactions of transition elements and the reaction conditions.	
17	**Correct Answer:** D CO is strong field ligand. In Ni, the 4s and 3d orbitals rearrange to form sp^3 hybrid orbitals. Thus, $Ni(CO)_4$ shows sp^3 hybridisation. In Fe, the 4s,4p and 3d orbitals create the hybrid orbitals showing dsp^3 hybridisation. Thus, $Fe(CO)_5$ shows dsp^3 hybridisation. So, assertion is false. Nickel and iron's oxidation state is zero in $Ni(CO)_4$ and $Fe(CO)_5$ as (CO) has no charge.	1
	A: Students choosing this lack understanding of structure of $Ni(CO)_4$ and $Fe(CO)_5$	
	B: Students choosing this lack understanding of structure of $Ni(CO)_4$ and $Fe(CO)_5$	
	C: Students choosing this lack understanding of structure of $Ni(CO)_4$ and $Fe(CO)_5$	
18	P is most likely to represent position I in the graph. *[0.5 marks]* P^{+2} does not have any unpaired d--electrons. So, due to the absence of the d-d transitions it appears colourless. *[0.5 marks]*	1
19	The statement(s) that is/are correct are: II) The magnetic moment of chromate and dichromate is the same. *[0.5 marks]* The oxidation state of chromium in chromate and dichromate is the same. *[0.5 marks]* III) Sodium dichromate has lower lattice energy and higher hydration energy than potassium dichromate. *[0.5 marks]* The ionic radius of the sodium ion is less than that of the potassium ion. *[0.5 marks]*	2

<table>
<tr><td>20</td><td>
<table>
<tr><th></th><th>Wavelength (shorter than/greater than) 5000 Angstrom</th><th>Reason</th></tr>
<tr><td>The initial ligand in Ti^{+3} complex is replaced with CN^-</td><td>Wavelength shorter than 5000 Angstrom</td><td>CN^- is a strong field ligand. This means the energy gap between the lower and the higher energy levels in d- orbital becomes larger. We know, E = hc/λ. So higher value of E results in the absorption of light with a shorter wavelength.</td></tr>
<tr><td>The initial ligand in Ti^{+3} complex is replaced with Cl^-</td><td>Wavelength greater than 5000 Angstrom</td><td>Cl^- is a weak field ligand. Thus, the energy gap between the d-orbitals is reduced. We know, E = hc/λ. So lower value of E results in the absorption of light with a longer wavelength</td></tr>
</table>

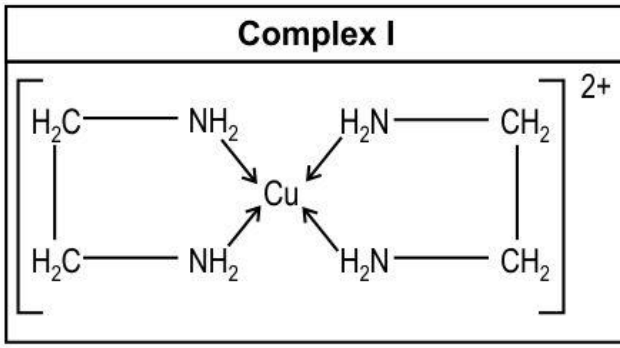
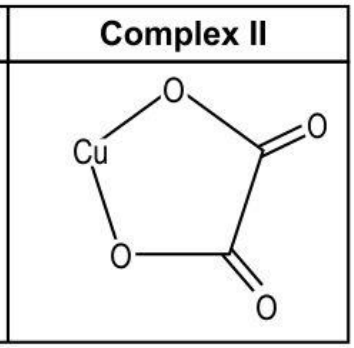
[Award 0.5 mark each for correctly identifying the nature of wavelength and 1 mark each for the reason]
</td><td>3</td></tr>
<tr><td>21</td><td>(a) The electronic configuration of Sc is $3d^1,4s^2$. Sc^{+2} is formed by losing only the $4s^2$ electrons, which is an unstable electronic configuration. But if Scandium loses one more electron then it will attain a noble gas configuration of argon that is most stable. So, the Sc^{+3}/Sc^{+2} potential is difficult to measure as the Sc^{+2} state is unstable in aqueous solutions.

[Award 1 mark for showing/mentioning the electronic configuration of the Sc^{+3} and Sc^{+2} ions and 1 mark for stating "Sc^{+2} state is unstable in aqueous solutions']</td><td>2</td></tr>
<tr><td></td><td>(b) The enthalpy of hydration increases across the period from left to right. [0.5 mark]

As we move across the period, the ionic charge increases while the ionic radius decreases. This leads to a higher charge density, which enhances the attraction between the metal ions and water molecules, resulting in more negative enthalpy of hydration. [1 mark]</td><td>1.5</td></tr>
<tr><td></td><td>(c) Zn and Cu are the last two elements of the first transition series. The electronic configuration of Zn and Cu is ($[Ar]3d^{10}4s^2$) and ($[Ar]3d^{10}4s^1$) results in a stable d-subshell, making higher oxidation states (+3) unlikely because of the stability of the configuration in the d orbital.

[0.5 mark for each identification and 0.5 mark for reason]</td><td>1.5</td></tr>
</table>

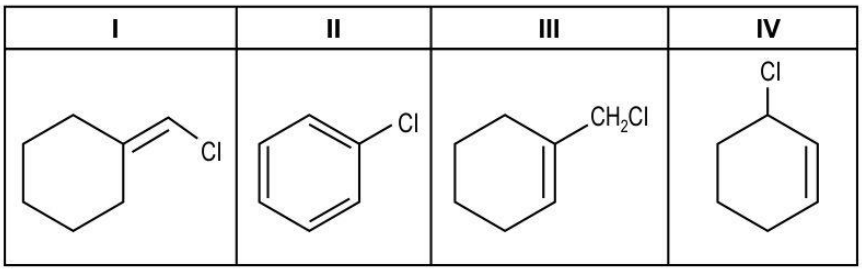
Coordination Compounds

Q.No.	Question	Marks
22	Which two compounds are expected to form same number of unique ions? (A) $K_4[Fe(CN)_6]$ and $KAl(SO_4)_2.12H_2O$ (B) $KAl(SO_4)_2.12H_2O$ and $K_4[Fe(CN)_6]$ (C) $FeSO_4.(NH_4)_2SO_4.6H_2O$ and $K_3[Fe(CN)_6]$ (D) $KCl.MgCl_2.6H_2O$ and $FeSO_4.(NH_4)_2SO_4.6H_2O$ ***[Skill: Mechanical]***	1
23	The number of moles of AgCl precipitated per mole of the compound cisplatin with excess $AgNO_3$ is _____. ***[Skill: Mechanical]***	1
24	Soumya observed that $[MnCl_6]^{-3}$ and $[Mn(CN)_6]^{-3}$ both contain Mn(III) as the central metal ion with a difference in the colour of their solutions. Which complex is coloured and which is colourless? Give a reason for your answer. ***[Skill: Understanding]***	2
25	Look at the two complexes given below and answer the questions that follow: **Complex I**  **Complex II**  (a) Identify the nature of the ligands in both the complexes. (b) Calculate the magnetic moment of complex I and complex II. (c) What are the electronic configurations of the t_{2g} and e_g orbitals of Cu^{+2} in both these complexes? (d) Can complex I show geometrical isomerism? Give a reason for your answer. ***[Skill: Application]***	1+1.5 +1 +1.5

Marking Scheme

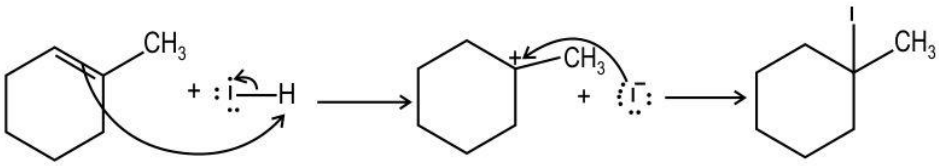
Q No.	Rubric	Marks
22	**Correct Answer:** D Both compounds dissociate to form 5 ions thus these two compounds are expected to form the same number of ions.	1
	A: Students choosing this option may lack the understanding about the difference between the complex and double salts.	
	B: Students choosing this option may have got confused between the number of ions being furnished by these salts.	
	C: Students choosing this option may have got confused between the number of ions being furnished by these salts.	
23	2	1
24	In $[MnCl_6]^{-3}$ chloride is a weak field ligand, allowing d-d transitions to occur. These transitions are responsible for the colour of the complex. Hence, $[MnCl_6]^{-3}$ is coloured complex. *[1 mark for correct answer with reason.]* In $[Mn(CN)_6]^{-3}$, CN- is a strong field ligand. All the electrons pair up in the lower-energy t_{2g} orbitals. Thus, no unpaired electrons are available for d-d transitions, making the complex colourless. Hence, $[Mn(CN)_6]^{-6}$ is colourless complex. *[1 mark for correct answer with reason.]*	2
25	(a) -Complex I: Ligand is both chelating and bidentate -Complex II: Ligand is both chelating and bidentate *[0.5 marks to be awarded if either chelating or bidentate is mentioned.]*	1
	(b) The oxidation state of copper in both the complexes is +2, so, its EC is $3d^9$. Thus, in both the complexes the number of unpaired electrons is 1. *[0.5 marks]* So, the magnetic moment of both the complex is = $\sqrt{n(n+2)}$ [n is the number of unpaired electrons *[0.5 marks]* = $\sqrt{1(1+2)} = \sqrt{3} = 1.73$ BM *[0.5 marks]*	1.5
	(c) The electronic configuration of the t_{2g} and e_g orbitals in complexes I and II will be t_{2g}^6, e_g^3 as in both these complexes, the ligands are strong field ligands. *[1 mark]*	1
	(d) None of the complexes will show geometrical isomerism because the ethane-1,2-diamine and the dioxime ligands are bidentate and form rigid chelate rings that prevent cis and trans forms from existing. *[Award 0.5 marks for writing not possible and 1 mark for writing the correct reason]*	1.5

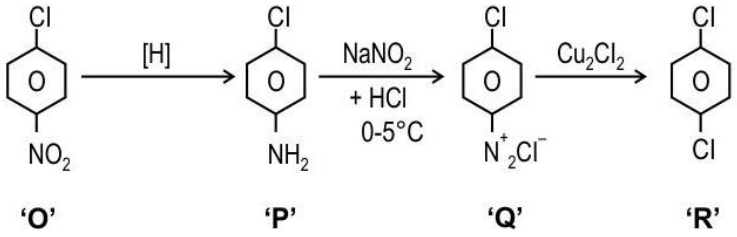
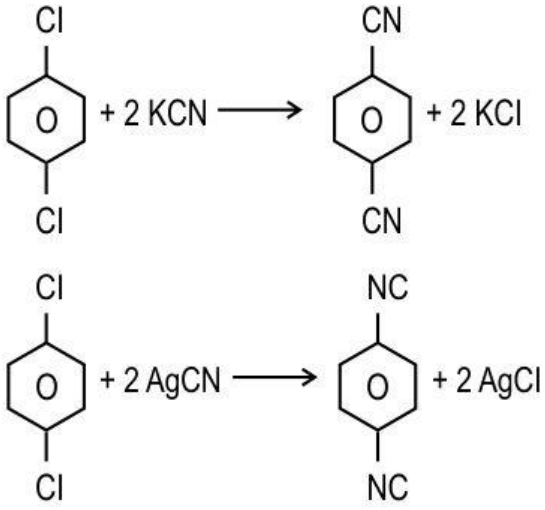
Haloalkanes and Haloarenes

Q.No.	Question	Marks
26	Two statements are given - one labelled Assertion (A) and the other labelled Reason (R). Assertion(A): The hydrolysis of 1-chlorobutane occurs faster than 2-chloro-2-methylpropane in S_N1 mechanism. Reason(R): 2-chloro-2-methylpropane is a tertiary haloalkane and 1-chlorobutane is a primary haloalkane. Which of the following is correct? (A) Both A and R are true, and R is the correct explanation of the A. (B) Both A and R are true, but R is not the correct explanation of the A. (C) A is true, but R is false. (D) A is false, but R is true. ***[Skill: Understanding]***	1
27	Which of the following compounds contains a halogen atom attached to sp^3 hybridised carbon atom?  (A) I and II (B) II and III (C) I and IV (D) III and IV ***[Skill: Understanding]***	1
28	Compound P reacts with hydroiodic acid to form 1-iodo-1-methylcyclohexane. Identify P and write the chemical equation showing the formation of the mentioned product. ***[Skill: Application]***	2

29	1-Bromopentane reacts with an iodide ion to form 1-iodopentane. (a) Identify the reaction mechanism. Give reason. (b) What will be the effect on the rate of the reaction if the concentration of iodide ion is doubled assuming the concentration of 1-bromopentane is constant? Explain your answer. ***[Skill: Understanding]***	1.5+ 1.5
30	Diya took three different isomers of chlorobutane (primary, secondary, and tertiary) named as L, M, N in three test tube. The boiling point of M is more than that of L. N has lower boiling point than L. She carried out a series of tests with the haloalkanes. Answer the questions that follow: (a) Give the IUPAC names of the three compounds identifying them. Give a reason for your answer. (b) Write an equation identifying the alkene which on addition of HCl yields only compound L? (c) State the IUPAC name of the product formed when M reacts with Mg in dry ether? Write an equation justifying your answer. ***[Skill: Application]***	2.5+1 +1.5
31	Compound 'O' with the formula p-$NO_2C_6H_4Cl$, on reduction yields compound 'P'. 'P' when suspended in cold aqueous mineral acid, and treated with sodium nitrite, yields, Q. Q when treated with cuprous chloride yields 'R'. (a) Write equations showing the conversions from O to P; P to Q and Q to R. (b) Write equations showing the reaction of KCN and AgCN with R. ***[Skill: Application]***	3+2

Marking Scheme

Q No.	Rubric	Marks
26	**Correct Answer:** D 2-chloro-2-methylpropane is a tertiary haloalkane and 1-chlorobutane is the primary haloalkane. So, the hydrolysis of the tertiary haloalkane occurs faster by the S_N1 mechanism than the primary.	1
	A: Students choosing this may lack understanding of hydrolysis reaction of haloalkanes.	
	B: Students choosing this may lack understanding of hydrolysis reaction of haloalkanes.	
	C: Students choosing this may be guessing.	
27	**Correct Answer:** D In option I the compound does not contain halogen atom attached to sp^3 hybridised carbon atom. In option II the halogen is directly attached to a carbon atom in a benzene ring. Carbon atoms in benzene are sp^2 hybridised. In option III the halogen is attached to a CH_2 group. This compound contains halogen atom attached to sp^3 hybridised carbon atom. In option IV the compound contains a halogen atom attached to sp^3 hybridised carbon atom.	1
	A: Students choosing this option may have the misconception about the hybridisation of carbon atoms.	
	B: Students choosing this option may have the misconception about the hybridisation of carbon atoms.	
	C: Students choosing this option may have the misconception about the hybridisation of carbon atoms.	
28	Compound P is 1-methylcyclohexene. *[1 mark]* P reacts with hydroiodic acid to give 1 -iodo-1-methylcyclohexane.  *[0.5 marks each for the intermediate and final product.]*	2
29	(a)This is S_N2 mechanism. *[0.5 marks]* The combination of 1-bromopentane's primary structure, low steric hindrance, and ability of bromide to act as a good leaving group makes it ideal to undergo S_N2 mechanism. *[1 mark]*	1.5
	(b) If the concentration of iodide ion is doubled, the rate will also be doubled, assuming the concentration of 1-bromo pentane remains constant. *[0.5 marks]* The rate law for the given reaction is Rate = k[1-Bromopentane] $[I^-]$	1.5

	Hence the rate of the reaction is directly proportional to the concentration of the iodide ion. *[1 mark]*	
30	(a) The boiling point of M is more than L and N is less than L. So, M is 1-chlorobutane as it has the highest boiling point. The boiling point of N is least so it is 2-chloro-2-methylpropane. L has the moderate boiling point so it is 2-chlorobutane. [*0.5 marks for each correct identification]* M has a straight-chain structure, leading to stronger van der Waals forces and a higher boiling point. L has a branched structure but less branching than the tertiary isomer, so its boiling point is intermediate. N has the most branched structure, resulting in the weakest van der Waals forces and the lowest boiling point. *[1 mark for the reason]*	2.5
	(b)$CH_3CH=CHCH_3$ + HCl ----> $CH_3CH(Cl)CH_2CH_3$ *[1 mark]*	1
	(c) The product formed when M reacts with Mg in dry ether is butyl magnesium chloride. *[0.5 marks]* $CH_3CH_2CH_2CH_2Cl + Mg \xrightarrow{\text{dry ether}} CH_3CH_2CH_2CH_2MgCl$ *[1 mark]*	1.5
31	(a)  **'O'** **'P'** **'Q'** **'R'** *[Award 1 mark for each conversion]*	3
	(b)  *[Award 1 mark for each conversion]* *[Accept any other valid answer.]*	2

Alcohols, Phenols and Ethers

<table>
<tr><th>Q.No.</th><th>Question</th><th>Marks</th></tr>
<tr><td>32</td><td>In a science quiz the following two statements were displayed:
Statement 1 - Reaction L: Anisole reacts with excess hydrogen chloride to form phenol and methyl chloride.
Statement 2 - Reaction M: Anisole reacts with propanoyl chloride to form methoxypropiophenone.

The question asked to the teams for a 10-point bonus points were:

What is the bond that cleaves in Reaction L and what is the directive property of the methoxy group in Reaction M?

The table below shows the answers given by four teams:

<table>
<tr><th>Team</th><th>In reaction L the bond that cleaves</th><th>In reaction M methoxy group is</th></tr>
<tr><td>Red</td><td>Aryl oxygen bond</td><td>meta, para directing</td></tr>
<tr><td>Blue</td><td>Alkyl oxygen bond</td><td>only ortho directing</td></tr>
<tr><td>Green</td><td>Alkyl oxygen bond</td><td>ortho, para directing</td></tr>
<tr><td>Yellow</td><td>Aryl oxygen bond</td><td>ortho, meta directing</td></tr>
</table>

Which team is correct?

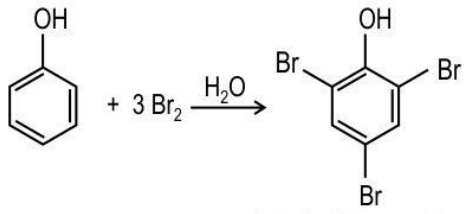
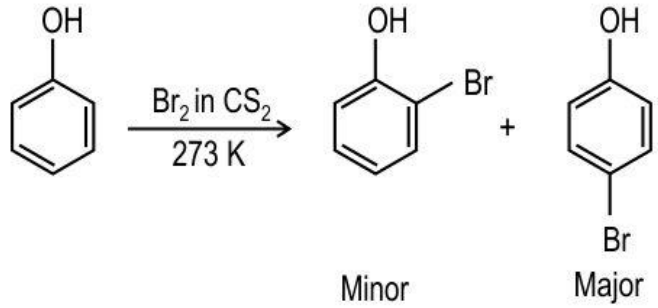
(A) Team red
(B) Team blue
(C) Team green
(D) Team yellow

[Skill: Understanding]</td><td>1</td></tr>
<tr><td>33</td><td>An aqueous solution of butan-1-ol has a _____ pH than an aqueous solution of butan-2-ol.

[Skill: Mechanical]</td><td>1</td></tr>
</table>

34	Phenol reacts with bromine under different sets of conditions to form different products. (a) Write the reaction of phenol reacting with bromine in: (i) polar solvent (ii) non-polar solvent. (b) In one of the reactions stated in (a), a mixture of products 'P' and 'Q' is formed. Identify the major product with a reason. (c) Three different brominated products are obtained due to bromination of phenol under different conditions as stated in (a). Arrange them in the increasing order of boiling point with a reason. ***[Skill: Understanding]***	2+1+2

Marking Scheme

Q No.	Rubric	Marks
32	**Correct Answer:** C The alkyl oxygen bond breaks in reaction L as aryl oxygen bond is more stable and in reaction M the methoxy group is ortho para directing as in the resonating structures, the electron density at ortho and para position are increased.	1
	A: Students choosing this option may lack the understanding that the alkyl oxygen bond breaks in reaction L as aryl oxygen bond is more stable and in reaction M the methoxy group is ortho para directing as in the resonating structures, the electron density at ortho and para position are increased.	
	B: Students choosing this option may lack the understanding that the alkyl oxygen bond breaks in reaction L as aryl oxygen bond is more stable and in reaction M the methoxy group is ortho para directing as in the resonating structures, the electron density at ortho and para position are increased.	
	D: Students choosing this option may lack the understanding that the alkyl oxygen bond breaks in reaction L as aryl oxygen bond is more stable and in reaction M the methoxy group is ortho para directing as in the resonating structures, the electron density at ortho and para position are increased.	
33	An aqueous solution of butan-1-ol has a <u>lower</u> pH than an aqueous solution of butan-2-ol. *[Accept any other valid answer.]*	1
34	(a) (i)  2, 4, 6 - Tribromophenol (ii)  Minor Major *[1 mark + 1 mark]*	2
	(b) p-bromo phenol is the major product. *[0.5 marks]* The para position is electronically more stable and less sterically hindered than the ortho position, making substitution at the para position more favourable. *[0.5 mark]*	1

	(c) The increasing order of boiling points of the three brominated products is: ortho-bromophenol< para-bromo phenol<2,4,6-tribromophenol *[0.5 marks]* Ortho-bromophenol has the lowest boiling point due to intramolecular hydrogen bonding. para-bromophenol has higher boiling point than ortho due to stronger intermolecular hydrogen bonding. 2,4,6-Tribromophenol has the highest boiling point due to the increased molecular weight and the greater strength of intermolecular forces resulting from multiple bromine atoms. *[0.5 marks for each explanation]*	2

Aldehydes, Ketones and Carboxylic Acids

<table>
<tr><th>Q.No.</th><th>Question</th><th>Marks</th></tr>
<tr><td>35</td><td>Benzyl magnesium bromide reacts with carbon dioxide (dry ice) in presence of dry ether to form:

(A) Benzoic acid
(B) Benzaldehyde
(C) Acetophenone
(D) Phenyl acetic acid

[Skill: Understanding]</td><td>1</td></tr>
<tr><td>36</td><td>The table below gives the pK_a values of four carboxylic acids P, Q, R, and S.

<table><tr><th>Acid</th><th>pK_a value</th></tr><tr><td>P</td><td>0.70</td></tr><tr><td>Q</td><td>3.41</td></tr><tr><td>R</td><td>4.46</td></tr><tr><td>S</td><td>10.3</td></tr></table>
If 10 mL of equimolar solutions of acids P, Q, R, and S are added to the same amount of potassium metal, which acid will cause the potassium metal to react the fastest and completely?

[Skill: Understanding]</td><td>1</td></tr>
<tr><td></td><td>Answer questions 37-38 based on the information given below.

A 40% solution of an aldehyde ‘M’ is used to preserve biological specimens. Aldehyde ‘M’ is gas at room temperature.</td><td></td></tr>
<tr><td>37</td><td>(a) Identify aldehyde 'M'. Give any two of its uses other than the one specified.

(b) Identify the compound which on oxidation with pyridinium chlorochromate yields aldehyde 'M' .

[Skill: Mechanical]</td><td>1.5+
0.5</td></tr>
<tr><td>38</td><td>(a) Write the reaction when aldehyde 'M' is treated with Zn amalgam and concentrated HCl.

(b) Explain why aldehyde ‘M’ undergoes only the Cannizzaro reaction and not aldol condensation.

[Skill: Understanding]</td><td>1+2</td></tr>
</table>

39	An organic compound 'M' has the molecular formula as C_7H_6O. A student carried out the following tests with the compound and tabulated her observations. Complete the table by filling up the last two columns: **Experiment** / **Observation** / **Inference** / **Supporting equations** P) 'M' is treated with 2,4-DNP reagent — Forms an orange-red precipitate — _____ — _____ Q) 'M' is warmed with Tollen's reagent. — Forms a bright silver mirror. — _____ — _____ R) 'M' undergoes a disproportionation reaction when heated with concentrated alkali. — Forms an alcohol and a sodium salt — _____ — _____ S) 'M' treated with sodium borohydride — Forms the same alcohol as formed in test (R) — _____ — _____ T) 'M treated with potassium permanganate — Forms a compound with molecular formula $C_7H_6O_2$ — _____ — _____ ***[Skill: Understanding]***	5
40	The table below lists the boiling points in kelvin, of four compounds: a primary alcohol, an aldehyde, and an ether, each containing three carbon atoms, and an alkane containing four carbon atoms, not listed in any particular order. Compounds: P, Q, R, S Boiling point: 272, 370, 280, 322 (a) Identify P, Q, R and S as the four compounds mentioned above. (b) Write the hybridisation of the carbon atom attached to oxygen atom in compounds R and S. (c) Which two compounds can react in the presence of HCl gas to form the corresponding acetal? Write the corresponding reaction. ***[Skill: Application]***	2+1+2

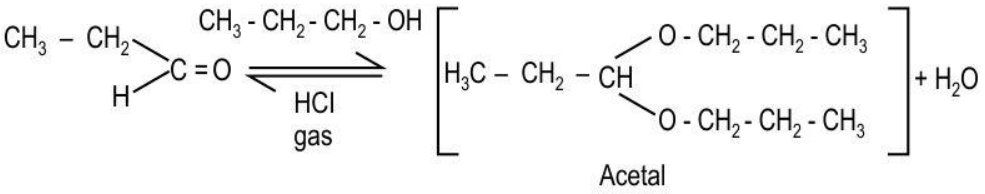
Marking Scheme

Q No.	Rubric	Marks
35	**Correct Answer:** D This is the correct answer as Benzyl magnesium bromide reacts with CO_2 to produce magnesium carboxylate intermediate, which on acidifying is converted to Phenyl acetic acid.	1
	A: Students choosing this option may lack the understanding that toluene forms when benzyl magnesium bromide reacts with water or other proton sources, but not with carbon dioxide.	
	B: Students choosing this option may lack the understanding that Aldehydes generally form from specific reduction reactions, not from Grignard reagents reacting with CO_2.	
	C: Students choosing this option may lack the understanding that acetophenone ($C_6H_5COCH_3$) is a ketone, which is formed when a Grignard reagent reacts with an ester or acyl chloride, not with carbon dioxide.	
36	Potassium will react the fastest and completely in acid P.	1
37	(a) Compound 'M' is methanal. *[0.5 marks]* -To prepare bakelite (a phenol-formaldehyde resin) -To prepare glues and other polymeric products with urea. *[0.5 marks + 0.5marks]*	1.5
	(b) Methanol	0.5
38	(a) $HCHO \xrightarrow{Zn(Hg)/HCl} CH_4 + H_2O$	1
	(b) The Cannizzaro reaction occurs with aldehydes that do not have alpha-hydrogen atom. Formaldehyde (aldehyde 'M') has no alpha-hydrogen (hydrogen on the carbon adjacent to the carbonyl group), making it ideal for the Cannizzaro reaction. *[1 mark]* Formaldehyde (aldehyde 'M') cannot undergo the aldol condensation reaction as it does not have an alpha-hydrogen needed to form the enolate ion. *[1 mark]*	2

39		5

Experiment	Observation	Inference	Supporting equations
P) 'M' is treated with 2,4-DNP reagent	Forms an orange-red precipitate	'M' is an aldehyde or a ketone	$-\underset{\vert}{C}=O + C_6H_3(NO_2)_2NHNH_2 \rightarrow -\underset{\vert}{C}=N\text{-}NHC_6H_3(NO_2)_2 + H_2O$
Q) 'M' is warmed with Tollen's reagent.	Forms a bright silver mirror.	'M' is an aldehyde	$C_6H_5CHO + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow C_6H_5COO^- + 2Ag + 4NH_3 + 2H_2O$
R) 'M' undergoes a disproportionation reaction when heated with concentrated alkali.	Forms an alcohol and a sodium salt	'M' lacks alpha H- atom	$2C_6H_5CHO + NaOH \rightarrow C_6H_5COONa + C_6H_5CH_2OH$
S) 'M' treated with sodium borohydride	Forms the same alcohol as formed in test (R)	'M' is benzaldehyde	$C_6H_5CHO + NaBH_4 + H_2O \rightarrow C_6H_5CH_2OH + NaBO_2$
T) 'M treated with potassium permanganate	Forms a compound with molecular formula $C_7H_6O_2$	'M' is benzaldehyde	$C_6H_5CHO + [O] \rightarrow C_6H_5COOH$

[Award 0.5 marks for each correctly filled inference and supporting equations]

40	(a) P is butane, Q is 1-propanol, R is methoxyethane and S is propanal. *[0.5 marks for each correct identification.]*	3
	(b) Hybridisation of carbon atom attached to oxygen atom in R is sp^3 and in S is sp^2. *[0.5 marks for each correct identification.]*	1
	(c) S (propanal), and Q (1- propanol), react in the presence of HCl gas to form the corresponding acetal. *[0.5 marks for each correct identification]*  *[1 mark]*	2

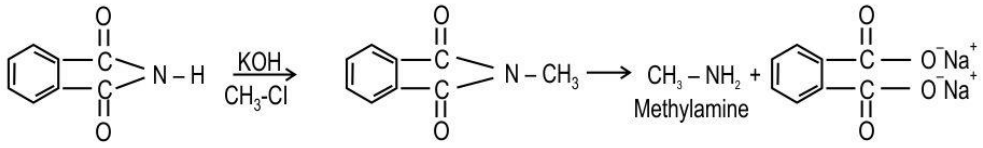
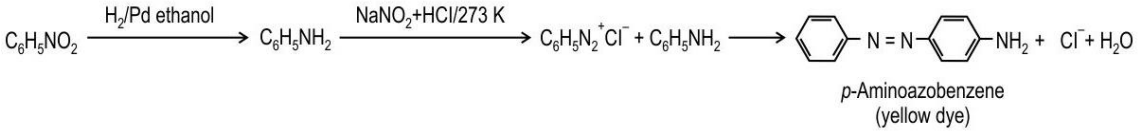
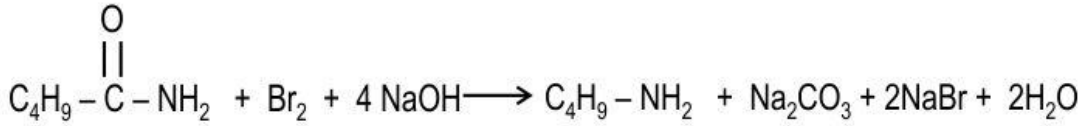
Amines

Q.No.	Question	Marks
41	Two statements are given - one labelled Assertion (A) and the other labelled Reason (R). Assertion (A): The diazonium salts are very good intermediates for the introduction of groups into the aromatic ring. Reason (R): Diazonium salts undergo diverse substitution reactions with good yields. Which of the following is correct? (A) Both A and R are true, and R is the correct explanation of the A. (B) Both A and R are true, but R is not the correct explanation of the A. (C) A is true, but R is false. (D) A is false, but R is true. ***[Skill: Mechanical]***	1
42	In which of the following options are the following amines arranged in the increasing order of bond angles (C-N-C or C-N-H): methylamine, aniline, dimethylamine, triethylamine? (A) methylamine, aniline, dimethylamine, trimethylamine (B) aniline, methylamine, dimethylamine, trimethylamine (C) trimethylamine, dimethyl amine, methyl amine, aniline (D) trimethylamine, aniline, dimethylamine, methylamine ***[Skill: Understanding]***	1
	Answer questions 43-44 based on the information given below: An organic compound 'P' undergoes the following reactions: - reacts with benzene sulphonyl chloride to form a compound 'Q'. - reacts with benzoyl chloride to form N-methylbenzamide. - reacts with nitrous acid to form an unstable aliphatic diazonium salt. - reacts with CH_3COCl to form a compound 'R'.	
43	(a) Will 'P' undergo the carbylamine test? If not, give a reason for your answer. If yes, write a reaction showing the reaction. (b) Compare the pK_b of 'P' with that of ammonia. ***[Skill: Understanding]***	1.5 + 0.5
44	Identify the molecular formula of 'P', Q' and R with suitable reasons/reactions. ***[Skill: Understanding]***	3

45	(a) Carry out the following conversions as directed: (i) Prepare methylamine using the Gabriel phthalimide synthesis method. (ii) Nitrobenzene to a yellow dye. (iii) Prepare butanamine using the Hoffmann bromamide reaction. (b) Krishan created a list of the isomers of the aliphatic amine, C_3H_9N. Which of these isomers will take the least time to undergo neutralisation reaction with sulphuric acid and why? ***[Skill: Understanding]***	3+2

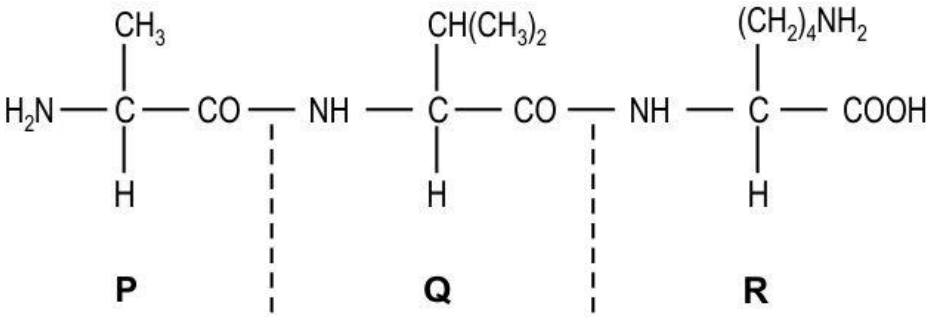
Marking Scheme

Q No.	Rubric	Marks
41	**Correct Answer:** A Assertion is correct as diazonium salt is used as it is an important intermediate for conversions due to their stability, versatility in substitution reactions, clean reaction mechanisms, and ability to introduce a wide range of functional groups into aromatic rings efficiently. Thus, reason is also correct and explains the assertion.	1
	B: Students choosing this may lack understanding of the reason for diazonium salts acting as good intermediates for the introduction of groups into the aromatic ring.	
	C: Students choosing this may lack understanding of the reason for the versatility of diazonium ions.	
	D: Students choosing this may lack understanding of the reason for the versatility of diazonium ions.	
42	**Correct Answer:** B Aniline has the smallest angle due to lone pair delocalization. Methylamine has a standard lone pair-bond pair repulsion, yielding a slightly larger angle. Dimethylamine has enhanced electron density from two methyl groups, increasing bond angle. Trimethylamine has maximum steric and electronic effects, giving the largest bond angle.	1
	A: Students choosing this option may lack the understanding of the relation of bond angle with structure of amines.	
	C: Students choosing this option may lack the understanding of the relation of bond angle with structure of amines.	
	D: Students choosing this option may lack the understanding of the relation of bond angle with structure of amines.	
43	(a) Yes. ‘P’ being a primary amine on heating with chloroform and ethanolic potassium hydroxide forms corresponding isocyanide. *[0.5 marks]* $CH_3 - NH_2 + CHCl_3 + 3\ KOH \xrightarrow{Heat} CH_3 - NC + 3\ KCl + 3\ H_2O$ *[1 mark]*	1.5
	(b)The pK_b of ‘P’ is less than that of ammonia.	0.5
44	‘P’ reacts with benzoyl chloride to form N-methylbenzamide. So, ‘P’ is most likely to be CH_3NH_2 (methylamine). *[1 mark]* ‘P’ reacts with benzene sulphonyl chloride ($C_6H_5SO_2Cl$) to form ‘Q’ that is $C_6H_5SO_2NHCH_3$ $C_6H_5SO_2Cl + CH_3NH_2 \text{ ----> } C_6H_5SO_2NHCH_3 + HCl$ *[1 mark]* ’P’ reacts with CH_3COCl to form ‘R' that is $CH_3NHCOCH_3$ $CH_3COCl + CH_3NH_2 \text{ ----> } CH_3NHCOCH_3 + HCl$ *[1 mark]*	3

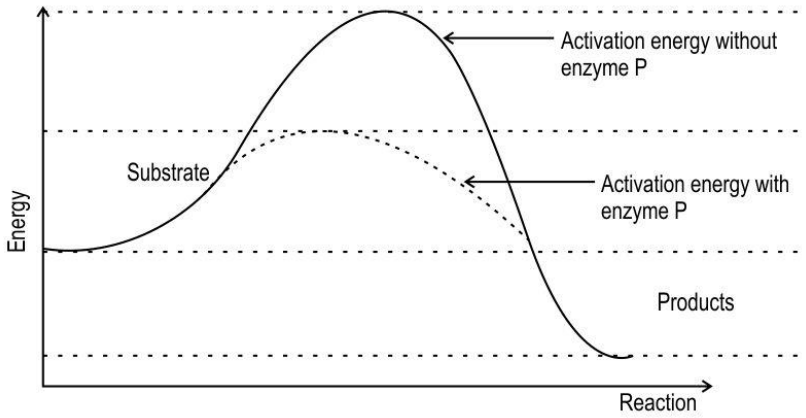
45	(a) (i)  (ii)  (iii)  *[Award 1 mark for each conversion]*	3
	(b) Propylamine ($CH_3CH_2CH_2NH_2$) will take the least time to undergo neutralization with sulfuric acid. *[1 mark]* This is because it has the most accessible lone pair and minimal steric hindrance. *[1 mark]*	2

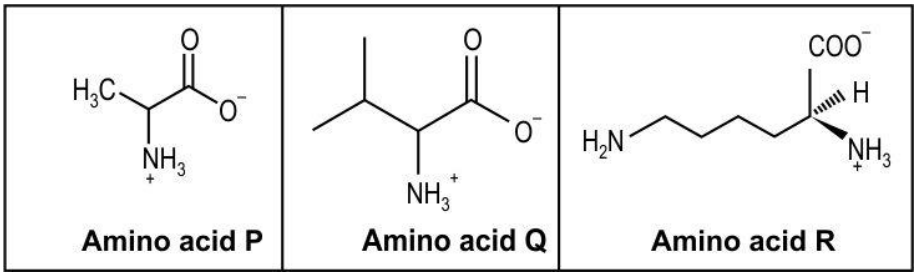
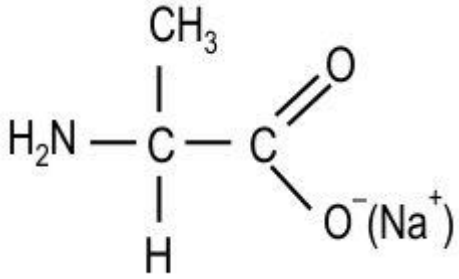
Biomolecules

Q.No.	Question	Marks
46	Which of the following statements about protein denaturation is correct? (A) Denaturation of a protein breaks the bonds between carbon and hydrogen atoms in the backbone. (B) Denaturation affects the three-dimensional shape but not the primary structure of the protein. (C) Denaturation of a protein causes it to lose its amino acid sequence. (D) Denaturation of a protein changes its primary structure. ***[Skill: Mechanical]***	1
47	The sweetness of a lemonade can be increased by heating a sugar solution with a little lemon juice. Write a balanced equation showing the above reaction. ***[Skill: Understanding]***	1
	Answer questions 48-49 based on the information given below. The optimum pH of an enzyme P is 'x'. Enzyme 'P' is used in the hydrolysis of a substrate.	
48	How will the reactivity of the enzyme change at pH 'z' (value of z > value of x) and at pH 'y' (value of y < value of x)? Give a reason for your answer. ***[Skill: Mechanical]***	2
49	(a) Express the following graphically: 'The activation energy for the hydrolysis of a substrate is more in absence of the specific enzyme P than in its presence' (b) Experimentally a linkage is found between C_1 of galactose and C_4 of glucose in the substrate. Identify the substrate and the enzyme P that might be used in this reaction to convert substrate to glucose and galactose. ***[Skill: Understanding]***	2+1

50	Shown below is the tripeptide formed by three amino acids P, Q and R.  (a) Draw the structure of the corresponding Zwitter ions for P, Q, and R that will be formed when the tripeptide is hydrolysed. (b) Are these amino acids optically active? Justify tour answer. (c) Draw the structure of the organic products formed when amino acid P reacts with sodium carbonate. ***[Skill: Application]***	3+1+1

Marking Scheme

Q No.	Rubric	Marks
46	**Correct Answer:** B Denaturation disrupts the secondary, tertiary, and quaternary structures of a protein by breaking Hydrogen bonds, altering its 3D conformation without changing the amino acid sequence.	1
	A: Students choosing this option may have the misunderstanding that the denaturation breaks the covalent bonds like C-H or peptide bonds in the protein's backbone; it affects weaker bonds like hydrogen bonds and ionic interactions.	
	C: Students choosing this option may have the misunderstanding that the denaturation alters the amino acid sequence; only the functional and structural integrity of the protein is affected.	
	D: Students choosing this option may have the misunderstanding that the primary structure of a protein, which refers to the sequence of amino acids held together by peptide bonds, changes during denaturation.	
47	$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{acid}} C_6H_{12}O_6 + C_6H_{12}O_6$ Sugar — Glucose Fructose	1
48	The reactivity of the enzyme decreases at pH 'z'. *[0.5 mark]* The reactivity of the enzyme decreases at pH 'y'. *[0.5 mark]* When an enzyme in its native form, is subjected to chemical change like change in pH, the hydrogen bonds are disturbed. Due to this, globules unfold and helix get uncoiled and protein loses its biological activity. *[1 mark]*	2
49	(a)  *[0.5 marks for correct labelling of each axis in the graph, 0.5 marks each for drawing correctly the catalysed and uncatalysed curve]*	2

	(b) The substrate is lactose. *[0.5 marks]* The enzyme P is lactase. *[0.5 marks]*	1
50	(a)  *[Award 1 mark for each structure]*	3
	(b) These acids are optically active. *[0.5 marks]*. In these amino acids the alpha-carbon atom is asymmetric so they all are optically active. *[0.5 marks]*	1
	(c)  [*1 mark for the correct structure]*	1

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