
SAMPLE PAPER (2024 -25)
CHEMISTRY THEORY (043)

Max. Marks:70

Time: 3 hours

GENERAL INSTRUCTIONS:

Read the following instructions carefully.

- (a) There are **33** questions in this question paper with internal choice.
- (b) SECTION A consists of 16 multiple-choice questions carrying 1 mark each.
- (c) SECTION B consists of 5 short answer questions carrying 2 marks each.
- (d) SECTION C consists of 7 short answer questions carrying 3 marks each.
- (e) SECTION D consists of 2 case-based questions carrying 4 marks each.
- (f) SECTION E consists of 3 long answer questions carrying 5 marks each.
- (g) All questions are compulsory.
- (h) Use of log tables and calculators is not allowed.

SECTION A

The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.

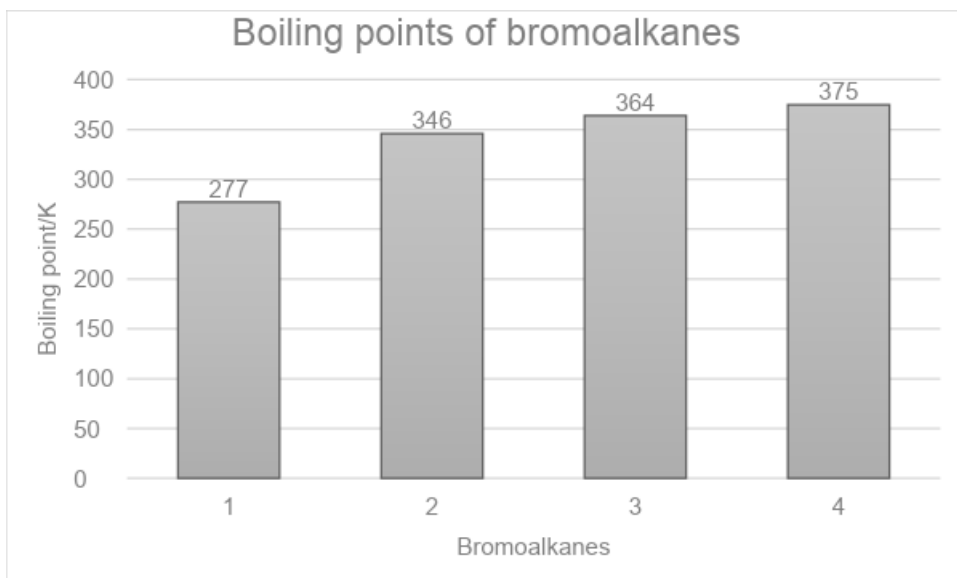
- 1 Ammonolysis of ethyl chloride followed by reaction of the amine so formed with 1 mole of methyl chloride gives an amine that 1
- a. reacts with Hinsberg reagent to form a product soluble in an alkali.
 - b. on reaction with Nitrous acid, produced nitrogen gas.
 - c. reacts with Benzenesulphonyl chloride to form a product that is insoluble in alkali.
 - d. does not react with Hinsberg reagent.
- 2 Which one of the following has the highest dipole moment? 1
- a. CH_3F
 - b. CH_3Cl
 - c. CH_3I
 - d. CH_3Br

- 3 Match the properties given in column I with the metals in column II 1
- | Column I | Column II |
|---|-----------|
| (i) Actinoid having configuration $[\text{Rn}] 5f^7 6d^1 7s^2$ | (A) Ce |
| (ii) Lanthanoid which has $4f^{14}$ electronic configuration in +3 oxidation state. | (B) Lu |
| (iii) Lanthanoid which show +4 Oxidation state | (C) Cm |

- a. (i)-(C), (ii)-(B), (iii)-(A)
- b. (i)-(C), (ii)-(A), (iii)-(B)
- c. (i)-(A), (ii)-(B), (iii)-(C)
- d. (i)-(B), (ii)-(A), (iii)-(C)

4 Study the graph showing the boiling points of bromoalkanes and identify the compounds.

1



- a. 1 = Bromomethane, 2= 2-Bromobutane, 3= 1-Bromobutane, 4= 2-Bromo-2-methylpropane
- b. 1 =1-Bromobutane, 2= 2-Bromo-2-methylpropane, 3= 2-Bromobutane, 4= Bromomethane
- c. 1 = Bromomethane, 2=1-Bromobutane, 3= 2-Bromo-2-methylpropane, 4= 2-Bromobutane,
- d. 1 =Bromomethane, 2= 2-Bromo-2-methylpropane, 3=2- Bromobutane, 4= 1-Bromobutane

(for visually challenged learners)

Which of the following haloalkanes has the highest boiling point?

- a. 2-Bromo-2-methylpropane
- b. 2-Bromobutane
- c. Bromomethane
- d. 1-Bromobutane

- 5 The initial concentration of R in the reaction $R \rightarrow P$ is $4.62 \times 10^{-2} \text{ mol/L}$. What is the half life for the reaction if $k = 2.31 \times 10^{-2} \text{ molL}^{-1}\text{s}^{-1}$ 1
- 30 s
 - 3 s
 - 1 s
 - 10 s

- 6 When $\text{C}_6\text{H}_5\text{COOCOCH}_3$ is treated with H_2O , the product obtained is : 1
- Benzoic acid and ethanol
 - Benzoic acid and ethanoic acid
 - Acetic Acid and phenol
 - Benzoic anhydride and methanol

7 1

Formulation of Cobalt(III) Chloride-Ammonia Complexes		
Colour	Formula	Solution conductivity corresponds to
Yellow	$[\text{Co}(\text{NH}_3)_6]^{3+}3\text{Cl}^-$	Y
Purple	$[\text{CoCl}(\text{NH}_3)_5]^{2+}2\text{Cl}^-$	1:2 electrolyte
Green	X	1:1 electrolyte

'X' and 'Y' in the above table are:

- $\text{X}=[\text{Co}(\text{NH}_3)_6]^{2+}3\text{Cl}^-$, $\text{Y}= 1:3$
 - $\text{X}= [\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+\text{Cl}^-$, $\text{Y}= 1:3$
 - $\text{X}=[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+\text{Cl}^-$, $\text{Y}= 1:1$
 - $\text{X}=[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^{3+}3\text{Cl}^-$, $\text{Y}= 1:1$
- 8 Which of the following contains only β -D- glucose as its monosaccharide unit: 1
- Sucrose
 - Cellulose
 - Starch
 - Maltose
- 9 Which one of the following sets correctly represents the increase in the paramagnetic property of the ions? 1
- $\text{Ti}^{3+} < \text{Fe}^{2+} < \text{Cr}^{3+} < \text{Mn}^{2+}$
 - $\text{Ti}^{3+} < \text{Mn}^{2+} < \text{Fe}^{2+} < \text{Cr}^{3+}$
 - $\text{Mn}^{2+} < \text{Fe}^{2+} < \text{Cr}^{3+} < \text{Ti}^{3+}$
 - $\text{Ti}^{3+} < \text{Cr}^{3+} < \text{Fe}^{2+} < \text{Mn}^{2+}$

- 10 A first-order reaction is found to have a rate constant, $k = 5.5 \times 10^{-14} \text{ s}^{-1}$. The time taken for completion of the reaction is: 1
- $1.26 \times 10^{13} \text{ s}$
 - $2.52 \times 10^{13} \text{ s}$
 - $0.63 \times 10^{13} \text{ s}$
 - It never goes to completion
- 11 A student was preparing aniline in the lab. She took a compound "X" and reduced it in the presence of Ni as a catalyst. What could be the compound "X" 1
- Nitrobenzene
 - 1-Nitrohexane
 - Benzonitrile
 - 1-Hexanenitrile
- 12 Which of the following compound gives an oxime with hydroxylamine: 1
- CH_3COCH_3
 - CH_3COOH
 - $(\text{CH}_3\text{CO})_2\text{O}$
 - CH_3COCl
- 13 **Assertion (A):** $[\text{Mn}(\text{CN})_6]^{3-}$ has a magnetic moment of two unpaired electrons while $[\text{MnCl}_6]^{3-}$ has a paramagnetic moment of four unpaired electrons. 1
Reason (R): $[\text{Mn}(\text{CN})_6]^{3-}$ is inner orbital complexes involving d^2sp^3 hybridisation, on the other hand, $[\text{MnCl}_6]^{3-}$ is outer orbital complexes involving sp^3d^2 hybridisation.
- Select the most appropriate answer from the options given below:
- Both A and R are true and R is the correct explanation of A
 - Both A and R are true but R is not the correct explanation of A.
 - A is true but R is false.
 - A is false but R is true.
- 14 **Assertion (A):** For strong electrolytes, there is a slow increase in molar conductivity with dilution and can be represented by the equation 1
- $$\Lambda_m^\circ = \Lambda_m - A c^{1/2}$$
- Reason (R):** The value of the constant 'A' for NaCl, CaCl_2 , and MgSO_4 in a given solvent and at a given temperature is different.
- Select the most appropriate answer from the options given below:
- Both A and R are true and R is the correct explanation of A
 - Both A and R are true but R is not the correct explanation of A.
 - A is true but R is false.
 - A is false but R is true.

- 15 **Assertion (A)** Glucose does not form the hydrogensulphite addition product with NaHSO_3 . 1
Reason (R): Glucose exists in a six-membered cyclic structure called pyranose structure.

Select the most appropriate answer from the options given below:

- Both A and R are true and R is the correct explanation of A
- Both A and R are true but R is not the correct explanation of A.
- A is true but R is false.
- A is false but R is true.

- 16 **Assertion (A):** The half- life for a zero order reaction is independent of the initial concentration of the reactant. 1
Reason (R): For a zero order reaction, Rate = k

Select the most appropriate answer from the options given below:

- Both A and R are true and R is the correct explanation of A
- Both A and R are true but R is not the correct explanation of A.
- A is true but R is false.
- A is false but R is true.

SECTION B

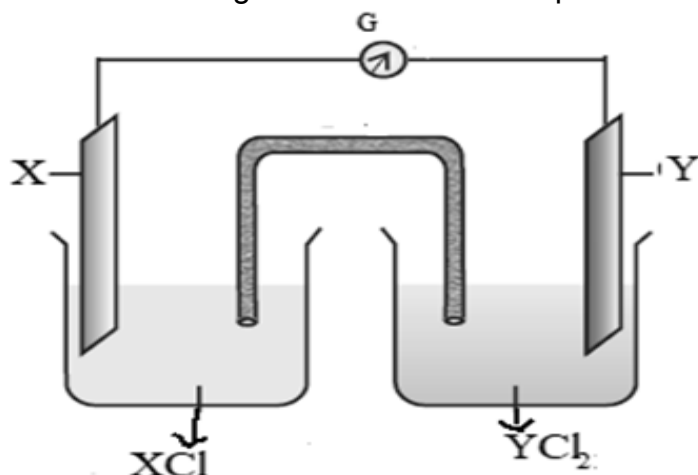
This section contains 5 questions with internal choice in one question. The following questions are very short answer type and carry 2 marks each.

- 17 a. Nitrogen gas is soluble in water. At temperature 293 K, the value of K_H is 76.48 kbar . How would the solubility of nitrogen vary (increase, decrease or remain the same) at a temperature above 293 K , if the value of K_H rises to 88.8 kbar. 1
 b. Chloroform (b.p. 61.2°C) and acetone (b.p. 56°C) are mixed to form an azeotrope. The mole fraction of acetone in this mixture is 0.339. Predict whether the boiling point of the azeotrope formed will be (i) 60°C (ii) 64.5°C or (iii) 54°C . Defend your answer with reason. 1

OR

- a. A soda bottle will go flat (lose its fizz) faster in Srinagar than in Delhi. Is this statement correct? Why or why not? 1
 b. How does sugar help in increasing the shelf life of the product? 1
- 18 a. Write the IUPAC name of the following complex: $\text{K}[\text{Cr}(\text{H}_2\text{O})_2(\text{C}_2\text{O}_4)_2]\text{H}_2\text{O}$ 1
 b. Name the metal present in the complex compound of
 (i) Haemoglobin (ii) Vitamin B-12 $\frac{1}{2} + \frac{1}{2}$

- 19 Observe the following cell and answer the questions that follow:

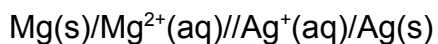


- Represent the cell shown in the figure.
- Name the carriers of the current in the salt bridge
- Write the reaction taking place at the anode.

1
½
½

(for visually challenged learners)

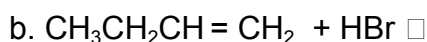
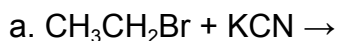
For the cell represented as:



- Identify the cathode and the anode
- Write the overall reaction

1
1

- 20 Complete the following reactions by writing the major and minor product in each case (any 2)



1
1
1

- 21 The presence of Carbonyl group in glucose is confirmed by its reaction with hydroxylamine. Identify the type of carbonyl group present and its position. Give a chemical reaction in support of your answer.

1
1

SECTION C

This section contains 7 questions with internal choice in one question. The following questions are short answer type and carry 3 marks each.

- 22 a. Write down the reaction occurring on two inert electrodes when electrolysis of copper chloride is done. What will happen if a concentrated solution of copper sulphate is replaced with copper chloride?

2

- b. Write an expression for the molar conductivity of aluminium sulphate at infinite dilution according to Kohlrausch law. 1

23 Account for the following:

- a. The lowest oxide of transition metal is basic, and the highest is acidic. 1
b. Chromium is a hard metal while mercury is a liquid metal 1
c. The ionisation energy of elements of the 3d series does not vary much with increasing atomic number. 1

- 24 a. Give the chemical reaction involved when p-nitrotoluene undergoes Etard reaction. 1
b. Why does Benzoic acid exist as a dimer in an aprotic solvent? 1
c. Benzene on reaction with methylchloride in the presence of anhydrous AlCl_3 forms toluene. What is the expected outcome if benzene is replaced by benzoic acid? Give a reason for your answer. 1

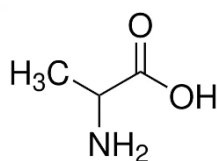
OR

An organic compound 'X', does not undergo aldol condensation. However 'X' with compound 'Y' in the presence of a strong base react to give the compound 1,3-diphenylprop-2-en-1-one.

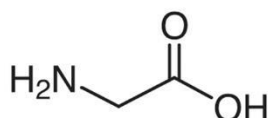
- a. Identify 'X' and 'Y' 1
b. Write the chemical reaction involved. 1
c. Give one chemical test to distinguish between X and Y. 1

- 25 a. Give the structure of all the possible dipeptides formed when the following two amino acids form a peptide bond. 2

Alanine



Glycine



- b. Keratin, insulin, and myosin are a few examples of proteins present in the human body. Identify which type of protein is keratin and insulin and differentiate between them based on their physical properties. 1

- 26 Neeta was experimenting in the lab to study the chemical reactivity of alcohols. She carried out a dehydration reaction of propanol at 140°C to 180°C. Different products were obtained at these two temperatures.
- Identify the major product formed at 140°C and the mechanism followed in this case. 1+½
1+½
 - Identify the major product formed at 180°C
- 27 Various isomeric haloalkanes with the general formula C₄H₉Cl undergo hydrolysis reaction. Among them, compound "A" is the most reactive through S_N¹ mechanism. Identify "A" citing the reason for your choice. Write the mechanism for the reaction. 3
- 28 The equilibrium constant of cell reaction :
 $\text{Sn}^{4+}(\text{aq}) + \text{Al}(\text{s}) \rightarrow \text{Al}^{3+} + \text{Sn}^{2+}(\text{aq})$ is 4.617×10^{184} , at 25 °C
- Calculate the standard emf of the cell. 2
 (Given: $\log 4.617 \times 10^{184} = 184.6644$)
 - What will be the E° of the half cell Al³⁺/Al, if E° of half cell Sn⁴⁺/Sn²⁺ is 0.15 V. 1

SECTION D

The following questions are case-based questions. Each question has an internal choice and carries 4 (2+1+1) marks each. Read the passage carefully and answer the questions that follow.

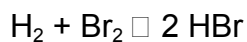
- 29 Dependence of the rate of reaction on the concentration of reactants, temperature, and other factors is the most general method for weeding out unsuitable reaction mechanisms. The term mechanism means all the individual collisional or elementary processes involving molecules (atoms, radicals, and ions included) that take place simultaneously or consecutively to produce the observed overall reaction. For example, when hydrogen gas reacts with bromine, the rate of the reaction was found to be proportional to the concentration of H₂ and to the square root of the concentration of Br₂. Furthermore, the rate was inhibited by increasing the concentration of HBr as the reaction proceeded. These observations are not consistent with a mechanism involving bimolecular collisions of a single molecule of each kind. The currently accepted mechanism is considerably more complicated, involving the dissociation of bromine molecules into atoms followed by reactions between atoms and molecules:

It is clear from this example that the mechanism cannot be predicted from the

overall stoichiometry.

(source: Moore, J. W., & Pearson, R. G. (1981). *Kinetics and mechanism*. John Wiley & Sons.)

a. Predict the expression for the rate of reaction and order for the following:



1

What are the units of rate constant for the above reaction?

1

b. How will the rate of reaction be affected if the concentration of Br_2 is tripled?

1

OR

What change in the concentration of H_2 will triple the rate of reaction?

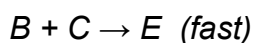
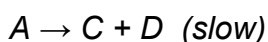
c. Suppose a reaction between A and B, was experimentally found to be first order with respect to both A and B. So the rate equation is:

1

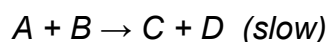
$$\text{Rate} = k[\text{A}][\text{B}]$$

Which of these two mechanisms is consistent with this experimental finding? Why?

Mechanism 1



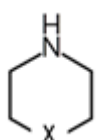
Mechanism 2



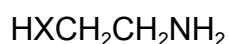
30

Amines are basic in nature. The pK_b value is a measure of the basic strength of an amine. Lower the value of pK_b , more basic is the amine. The effect of substituent on the basic strength of amines in aqueous solution was determined using titrations. The substituent "X" replaced " $-\text{CH}_2$ " group in piperidine (compound 1) and propylamine $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$, (compound 2).

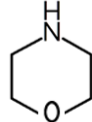
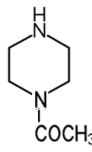
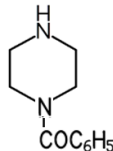
Compound 1:



Compound 2:



The experimental data is tabulated below:

Substituent "X"	Electro-negativity of X	substituted piperidine compound	pK _a	Substituted propylamine compound	pK _a
CH ₂	2.55		11.13	CH ₃ CH ₂ CH ₂ NH ₂	10.67
NH	3.12		9.81	NH ₂ CH ₂ CH ₂ NH ₂	10.08
O	3.44		8.36	HOCH ₂ CH ₂ NH ₂	9.45
CH ₃ CON	3.6		7.94	CH ₃ CONHCH ₂ CH ₂ NH ₂	9.28
C ₆ H ₅ CON	3.7		7.78	C ₆ H ₅ CONHCH ₂ CH ₂ NH ₂	—

(source: Hall Jr, H. K. (1956). Field and inductive effects on the base strengths of amines. *Journal of the American Chemical Society*, 78(11), 2570-2572.)

Study the above data and answer the following questions:

a. Plot a graph between the electronegativity of the substituent vs pK_b value of the corresponding substituted propyl amine (given that pK_a + pK_b = 14). Is there any relation between the electronegativity of the substituent and its basic strength? 2

b. The electronegativity of the substituent "C₆H₅CON" is 3.7, what is the expected pK_a value of compound C₆H₅CONHCH₂CH₂NH₂? 1

(i) 9.9 (ii) 9.5 (iii) 9.3 (iv) 9.1

c. The pK_a value of the substituted piperidine formed with substituent "X" is found to be 8.28. What is the expected electronegativity of "X" 1

(i)3.5 (ii)3.4 (iii)3.8 (iv) 3.1

OR

What is the most suitable pK_a value of the substituted propylamine formed with substituent "X" with electronegativity 3.0

(i)10.67 (ii)10.08 (iii)10.15 (iv)11.10

(for visually challenged learners)

a. How does the electronegativity of the substituent affect the pK_b value and the basic strength of the substituted propyl amine (given that pK_a + pK_b = 14)? Give a reason to support your answer. 2

b. The electronegativity of the substituent "C₆H₅CON" is 3.7, what is the expected pK_a value of compound C₆H₅CONHCH₂CH₂NH₂? 1

(i) 9.9 (ii) 9.5 (iii) 9.3 (iv) 9.1

c. The pK_a value of the substituted piperidine (compound 1) formed with substituent "X" is found to be 8.28. What is the expected electronegativity of "X" 1

(i)3.5 (ii)3.4 (iii)3.8 (iv) 3.1

OR

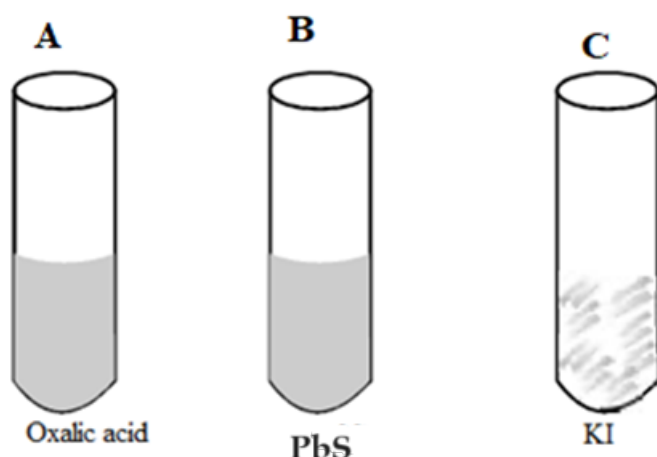
What is the most suitable pK_a value of the substituted propylamine formed with substituent "X" with electronegativity 3.0

(i)10.67 (ii)10.08 (iii)10.15 (iv)11.10

SECTION E

The following questions are long answer types and carry 5 marks each. All questions have an internal choice.

- 31 a. A purple colour compound A, which is a strong oxidising agent and used for bleaching of wool, cotton, silk and other textile fibres was added to each of the three test tubes along with H₂SO₄. It was followed by strong heating.



In which of the above test tubes; A,B or C:

- Violet vapours will be formed 1
- The bubbles of gas evolved will extinguish a burning matchstick. Write an equation for each of the above observations. 1

b. A metal ion M^{n+} of the first transition series having d^5 configuration combines with three didentate ligands. Assuming $\Delta_0 < P$:

- Draw the crystal field energy level diagram for the 3d orbital of this complex. 1
- What is the hybridisation of M^{n+} in this complex and why? 1
- Name the type of isomerism exhibited by this complex. 1

OR

a. Using, Valence Bond Theory identify A, B, C, D, E and F in the following table

S.No	Complex	central metal ion	configuration of metal ion	Hybridization of Metal ion	Geometry of the Complex	Number Of Unpaired Electron	Magnetic Behaviour
i	$[\text{CoF}_4]^{2-}$	A	$3d^7$	sp^3	tetrahedral	B	Paramagnetic
ii	$[\text{Cr}(\text{H}_2\text{O})_2\text{C}_2\text{O}_4]_2$	Cr^{3+}	$3d^3$	C	octahedral	3	D
iii	$[\text{Ni}(\text{CO})_4]$	Ni	$3d^8 4s^2$	E	F	0	Diamagnetic

b. Write the ionic equations for the reaction of acidified $\text{K}_2\text{Cr}_2\text{O}_7$ with (i) H_2S and (ii) FeSO_4 2

32

a. Give reasons for the following:

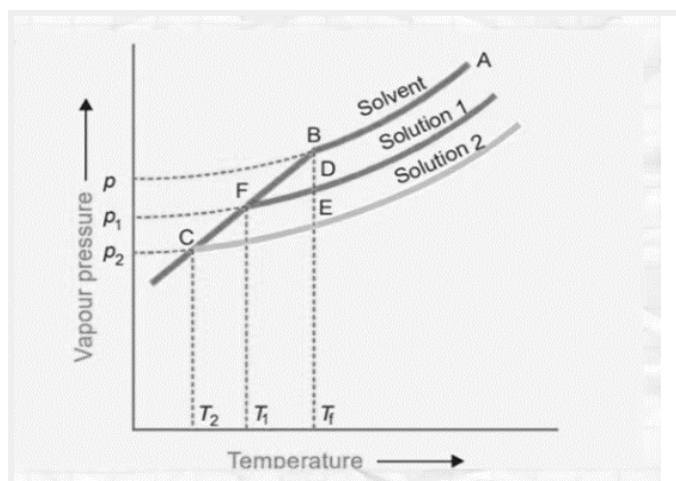
- The reaction of ethanol with acetyl chloride is carried out in the presence of pyridine. 1

- (ii) Cresols are less acidic than phenol. 1
- b. Williamson's process is used for the preparation of ethers from alkyl halide. 1
Identify the alkyl bromide and sodium alkoxide used for the preparation of 2-Ethoxy-3-methylpentane
- c. Convert: 1
(i) Toluene to 3-nitrobenzoic acid. 1
(ii) Benzene to m-nitroacetophenone. 1

OR

- a. Out of formic acid and acetic acid, which one will give the HVZ reaction? 2
Give a suitable reason in support of your answer and write the chemical reaction involved.
- b. Alcohols are acidic but they are weaker acids than water. Arrange various isomers of butanol in the increasing order of their acidic nature. Give a reason for the same. 1
- c. An organic compound A which is a Grignard reagent is used to obtain 2-methylbutan-2-ol on reaction with a carbonyl compound 'B'. Identify A' and 'B'. Write the equation for the reaction between A and B. 2

- 33 a. An experiment was carried out in the laboratory, to study depression in freezing point. 1M aqueous solution of $\text{Al}(\text{NO}_3)_3$ and 1 M aqueous solution of glucose were taken. From the given figure identify solution 1 and solution 2. 2
Give a plausible reason for your answer.



- b. The osmotic pressure of a solution of cane sugar was found to be 2.46 atm at 300 K. If the solution was diluted five times, calculate the osmotic pressure at the same temperature. 3
How can the osmotic pressure of the given cane sugar solution be decreased without changing its volume? Give a reason for your answer.

OR

- a. While giving intravenous injections to the patients, the doctors take utmost care of the concentration of the solution used. Why is it necessary to check the concentration of the solution? 2
- b. A solution of phenol was obtained by dissolving 2×10^{-2} kg of phenol in 1 kg of benzene. Experimentally it was found to be 73 % associated. Calculate the depression in the freezing point recorded. 3

(for visually challenged learners)

- a. Which of the two solutions : 1M aqueous solution of $\text{Al}(\text{NO}_3)_3$ or 1M aqueous solution of glucose will show a greater depression in freezing point? Give a plausible reason for your answer. 2
- b. The osmotic pressure of a solution of cane sugar was found to be 2.46 atm at 300 K. If the solution was diluted five times, calculate the osmotic pressure at the same temperature. 3
- How can the osmotic pressure of the given cane sugar solution be decreased without changing its volume? Give a reason for your answer.

OR

- a. While giving intravenous injections to the patients, the doctors take utmost care of the concentration of the solution used. Why is it necessary to check the concentration of the solution? 2
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