

**Chemistry (Theory)**

[Time allowed: 3 hours]

[Maximum marks:70]

**General Instructions:**

- (i) All questions are compulsory.
- (ii) Marks for each question are indicated against it.
- (iii) Question number **1** to **8** are very short-answer questions and carry **1** mark each.
- (iv) Question number **9** to **18** are short-answer questions and carry **2** marks each.
- (v) Question number **19** to **27** are also short-answer questions and carry **3** marks each.
- (vi) Question number **28** to **30** are long-answer questions and carry **5** marks each.
- (vii) Use Log Tables, if necessary. Use of calculators is not allowed.

**Q9.** Define the following terms:

- (a) Order of a reaction
- (b) Activation energy of a reaction

**2****Ans:** (a) **Order of a reaction:** The sum of the powers of the concentrations of the reactants of a chemical reaction in the rate law expression is called the order of that chemical reaction.

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

$$\text{Order of reaction} = x + y$$

(b) **Activation energy of a reaction:** The energy required to form unstable intermediate (called activated complex) during a chemical reaction, is known as activation energy ( $E_a$ ).**Q10.** (a) Define any two of the following terms:

- (i) van't Hoff factor
- (ii) Mole fraction
- (iii) Ebullioscopic constant

(b) State Raoult's law

**OR**

The density of water of a lake is  $1.25 \text{ g(mL)}^{-1}$  and one kg of this water contains 92 g of  $\text{Na}^+$  ions. What is the molarity of  $\text{Na}^+$  ions in the water of the lake? (Atomic mass of Na = 23.00 u)**2**

**Ans:** (a)(i) **van't Hoff factor :**

It is defined as the ratio of the experimental value of colligative property to the calculated value of the colligative property. It is used to find out the extent of dissociation or association. Mathematically, it is represented as:

$$\begin{aligned}
 i &= \frac{\text{Normal molar mass}}{\text{Abnormal molar mass}} \\
 &= \frac{\text{Observed colligative property}}{\text{Calculated colligative property}} \\
 &= \frac{\text{Total number of moles of particles after association/dissociation}}{\text{Number of moles of particles before association/dissociation}}
 \end{aligned}$$

**Value of  $i$  :**

For association,  $i < 1$

For dissociation,  $i > 1$

No association or dissociation,  $i = 1$

- (ii) **Mole fraction:** The mole fraction of a component in a mixture is defined as the ratio of the number of moles of the component to the total number of moles of all the components in the mixture. Mathematically, it is represented as:

$$\text{Mole fraction of a component} = \frac{\text{Number of moles of the component}}{\text{Total number of moles of all components}}$$

Mole fraction is denoted by ' $x$ '.

- (iii) For dilute solutions, the elevation of boiling point ( $\Delta T_b$ ) is directly proportional to the molal concentration of the solute in a solution. Thus,

$$\begin{aligned}
 \Delta T_b &\propto m \\
 \Delta T_b &= K_b m
 \end{aligned}$$

$K_b$  is called **Ebullioscopic Constant**. It is also called Boiling Point Elevation Constant or Molal Elevation Constant. It depends upon the nature of the solvent. The unit of  $K_b$  is  $\text{Kkg mol}^{-1}$ .

- (b) **Raoult's law:** For a solution of volatile liquids, the partial vapour pressure of each component in the solution is directly proportional to its mole fraction. Thus, for any component, partial vapour pressure ( $P$ )

$$P \propto x$$

$$P = p^0 x$$

where  $p^0$  is the vapour pressure of pure component and  $x$  is mole fraction of that component.

OR

**Ans:** The density of solution =  $1.25 \text{ g(mL)}^{-1}$

Mass of water = 1000g

Mass of solute =  $w = 92 \text{ g}$

Molar mass of Na = 23g

Volume = mass/density =  $1000/1.25$

molarity of ions =  $M = ?$

$$\begin{aligned} \text{Molarity} &= \frac{w \times 1000}{M_b \times V} \\ &= \frac{92 \times 1000 \times 1.25}{23 \times 1000} \\ &= 5M \end{aligned}$$

**Q11.** Explain the following:

- (i) The chemical reactivity of nitrogen is much less than that of phosphorus.
- (ii)  $\text{SF}_6$  is kinetically inert.

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**Ans:** (i) Nitrogen is chemically less reactive. This is because of the high stability of its molecule,  $\text{N}_2$ . In  $\text{N}_2$ , the two nitrogen atoms form a triple bond. This triple bond has very high bond strength, which is very difficult to break. It is because of nitrogen's small size that it is able to form  $p\pi-p\pi$  bonds with itself. This property is not exhibited by phosphorus.

(ii) Sulphur hexafluoride ( $\text{SF}_6$ ) is kinetically inert as 6 F atoms protect the sulphur atom from attack by reagents to such an extent that even thermodynamically most favourable reactions like hydrolysis do not occur.

**Q12.** Name one chief ore each of copper and aluminium. Name the method used for the concentration of these two ores.

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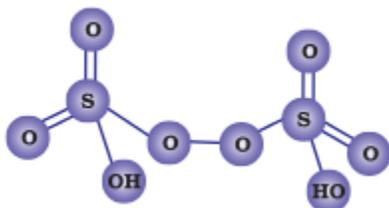
**Ans:** One chief ore of copper is copper pyrite ( $\text{Cu}_2\text{S}$ ) and aluminium is bauxite ( $\text{Al}_x\text{O}_x(\text{OH})_{3-2x}$ ). Froth floatation is used for the concentration of copper pyrite and leaching is used for the concentration of bauxite.

**Q13.** Draw the molecular structures of the following species:

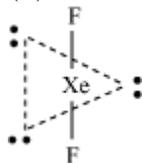
- (i)  $\text{H}_2\text{S}_2\text{O}_8$
- (ii)  $\text{XeF}_2$

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**Ans:** (i)



(ii)



**Q14.** Explain as to why

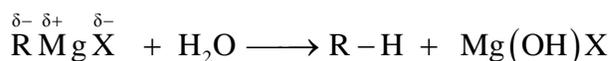
- (i) Alkyl halides, though polar, are immiscible with water.

(ii) Grignard's reagents should be prepared under anhydrous conditions.

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**Ans:** (i) To be miscible with water, the solute-water force of attraction must be stronger than the solute-solute and water-water forces of attraction. Alkyl halides are polar molecules and so held together by dipole-dipole interactions. Similarly, strong H-bonds exist between the water molecules. The new force of attraction between the alkyl halides and water molecules is weaker than the alkyl halide-alkyl halide and water-water forces of attraction. Hence, alkyl halides (though polar) are immiscible with water.

(ii) Grignard reagents are very reactive. In the presence of moisture, they react to give alkanes.



Grignard  
reagent

Alkane

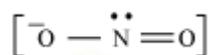
Therefore, Grignard reagents should be prepared under anhydrous conditions.

**Q15.** What are ambident nucleophiles? Explain giving an example.

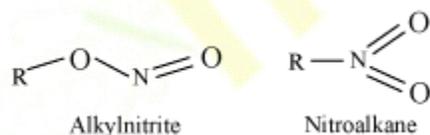
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**Ans:** Ambident nucleophiles are nucleophiles having two nucleophilic sites. Thus, ambident nucleophiles have two sites through which they can attack.

For example, nitrite ion is an ambident nucleophile.

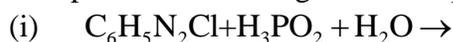


Nitrite ion can attack through oxygen resulting in the formation of alkyl nitrites. Also, it can attack through nitrogen resulting in the formation of nitroalkanes.

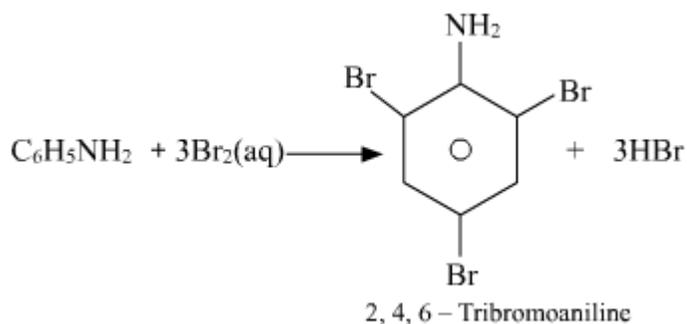


**Q16.** Complete the following reaction equations:

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**Ans:** (i)  $\text{C}_6\text{H}_5\text{N}_2\text{Cl} + \text{H}_3\text{PO}_2 + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_6 + \text{N}_2 + \text{H}_3\text{PO}_3 + \text{HCl}$   
 (ii)



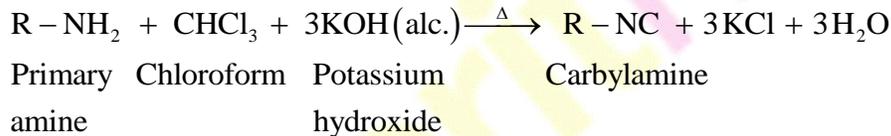
**Q17.** Describe the following giving the chemical equation in each case:

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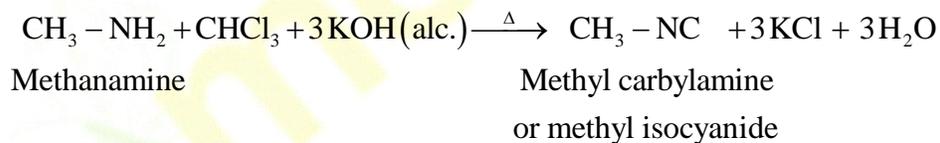
- (i) Carbylamine reaction
- (ii) Hofmann's bromamide reaction

**Ans:** (i) **Carbylamine reaction**

Carbylamine reaction is used as a test for the identification of primary amines. When aliphatic and aromatic primary amines are heated with chloroform and ethanolic potassium hydroxide, carbylamines (or isocyanides) are formed. These carbylamines have very unpleasant odours. Secondary and tertiary amines do not respond to this test.

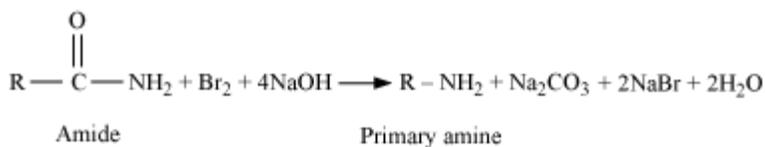


For example,

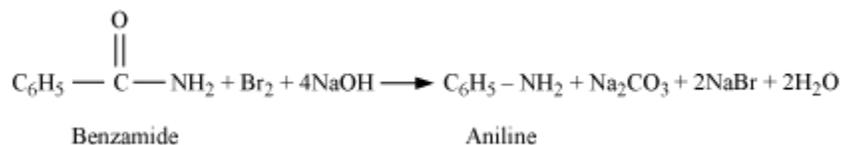
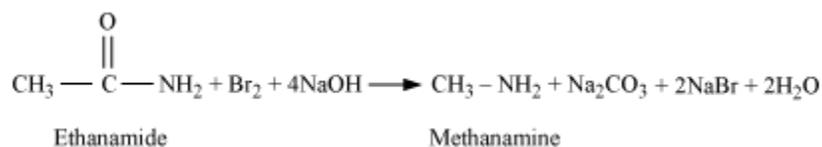


### Hoffmann bromamide reaction

When an amide is treated with bromine in an aqueous or ethanolic solution of sodium hydroxide, a primary amine with one carbon atom less than the original amide is produced. This degradation reaction is known as Hoffmann bromamide reaction. This reaction involves the migration of an alkyl or aryl group from the carbonyl carbon atom of the amide to the nitrogen atom.



For example,



**Q18.** What are biodegradable and non-biodegradable detergents? Give one example of each. **2**

**Ans: Biodegradable Detergents:** Detergents that can be degraded by bacteria are called biodegradable detergents. Such detergents have straight hydrocarbon chains.  
Example: sodium lauryl sulphate.

**Non-biodegradable Detergents:** Detergents that cannot be degraded by bacteria are called non-biodegradable detergents. Such detergents have highly-branched hydrocarbon chains.  
Example: sodium -4- (1, 3, 5, 7- tetra methyl octyl) benzene sulphonate