CHEMISTRY

Q.1 Amongst the following, the form of water with the lowest ionic conductance at 298 K is:
(1) sea water  
(2) distilled water  
(3) saline water used for intravenous injection  
(4) water from a well
Ans. [2]
Sol. The form of H₂O with the lowest ionic conductance at 298 K is distilled water.

Q.2 The correct order of the spin-only magnetic moments of the following complexes is:
(I) [Cr(H₂O)₆]Br₂  
(II) Na₄[Fe(CN)₆]  
(III) Na₃[Fe(C₂O₄)₃](Δ₀ > P)  
(IV) (Et₄N)₂[CoCl₄]
(1) (I) > (IV) > (III) > (II)  
(2) (II) ≈ (I) > (IV) > (III)  
(3) (III) > (I) > (IV) > (II)  
(4) (III) > (I) > (II) > (IV)
Ans. [1]
Sol. [Cr(H₂O)₆]Br₂ : Cr²⁺ = [Ar] 4s⁰ 3d⁴
  \[ t^3_{2g} e^1 \]
  \[ n = 4, \mu = \sqrt{n(n+2)} = \sqrt{24} \text{ BM} \]
Na₄[Fe(CN)₆] : Fe²⁺ = [Ar] 4s⁰ 3d⁶
  \[ t^6_{2g} e^0 \]
  \[ n = 0, \mu = 0 \]
Na₃[Fe(C₂O₄)₃] : Fe³⁺ = [Ar] 3d⁵
  \[ t^5_{2g} e^0 \]
  \[ n = 1, \mu = \sqrt{3} \text{ BM} \]
(Et₄N)₂[CoCl₄] : Co²⁺ = [Ar] 3d⁷
  \[ e^4_{g} t^3_{2g} \]
  \[ n = 3, \mu = \sqrt{15} \text{ BM} \]

Q.3 Which polymer has 'chiral' monomer(s)?
(1) Nylon 6, 6  
(2) Neoprene  
(3) PHBV  
(4) Buna-N
Ans. [3]
PHBV: \[
\begin{array}{c}
\text{O–CH–CH}_2\text{–C}–O–\text{CH–CH}_2\text{–C}– \\
\text{CH}_3\quad \text{O} \quad \text{C}_2\text{H}_5\quad \text{O}
\end{array}
\]_n

Monomer: \[\text{CH}_3\text{–CH–CH}_2\text{–COOH}\] and \[\text{CH}_3\text{–CH}_2\text{–CH–CH}_2\text{–COOH}\]

3-Hydroxybutanoic acid

3-Hydroxypentanoic acid

Q.4 The first and second ionisation enthalpies of a metal are 496 and 4560 kJ mol\(^{-1}\), respectively. How many moles of HCl and H\(_2\)SO\(_4\), respectively, will be needed to react completely with 1 mole of the metal hydroxide?

(1) 1 and 1
(2) 1 and 2
(3) 2 and 0.5
(4) 1 and 0.5

Ans. [4]

Sol. Metal: First ionization enthalpies = 496 kJ/mole
Second ionization enthalpies = 4560 kJ/mol
According to the given information, ionization enthalpies Metal belong to 1\textsuperscript{st} group i.e. Monovalent cation

\[\text{MOH} + \text{HCl} \rightarrow \text{MCl} + \text{H}_2\text{O}\]

\[2\text{MOH} + \text{H}_2\text{SO}_4 \rightarrow \text{M}_2\text{SO}_4 + \text{H}_2\text{O}\]

Q.5 Among the statements (a) – (d), the correct ones are:
(a) Lithium has the highest hydration enthalpy among the alkali metals.
(b) Lithium chloride is insoluble in pyridine.
(c) Lithium cannot form ethynide upon its reaction with ethyne
(d) Both lithium and magnesium react slowly with H\(_2\)O

(1) (a), (b) and (d) only
(2) (a) and (d) only
(3) (b) and (c) only
(4) (a), (c) and (d) only

Ans. [4]

Sol. *Lithium has the highest hydration enthalpy among the alkali metals due to small size.

*Lithium chloride is covalent in nature so it’s soluble in non-polar solvent.

*Lithium and Magnesium react slowly with H\(_2\)O.

Q.6 The solubility product of Cr(OH)\(_3\) at 298 K is \(6.0 \times 10^{-31}\). The concentration of hydroxide ions in a saturated solution of Cr(OH)\(_3\) will be:

(1) \(18 \times 10^{-31}\)^{\frac{1}{4}}
(2) \(4.86 \times 10^{-29}\)^{\frac{1}{4}}
(3) \(18 \times 10^{-31}\)^{\frac{1}{2}}
(4) \(2.22 \times 10^{-31}\)^{\frac{1}{4}}

Ans. [1]

Sol. \[\text{Cr(OH)}_3 \rightleftharpoons \text{Cr}^{3+} + 3\text{OH}^-\]

\[K_{sp} = [\text{Cr}^{3+}] [\text{OH}^-]^3\]

\[6 \times 10^{-31} = S \times (3S)^3\]

\[6 \times 10^{-31} = 27 S^4\]

\[S = \left(\frac{6}{27} \times 10^{-31}\right)^{\frac{1}{4}}\]

\[[\text{OH}^-] = 3S\]

\[= 3 \left(\frac{6}{27} \times 10^{-31}\right)^{\frac{1}{4}} = (18 \times 10^{-31})^{\frac{1}{4}} \text{ M}\]
Q.7 5 g of zinc is treated separately with an excess of  
(a) dilute hydrochloric acid and  
(b) aqueous sodium hydroxide.  
The ratio of the volumes of H₂ evolved in these two reactions is : -  
(1) 1 : 4  
(2) 1 : 1  
(3) 1 : 2  
(4) 2 : 1  
Ans. [2]  
Sol.  
\[
\begin{align*}
\text{Zn + 2dil. HCl} & \rightarrow \text{ZnCl}_2 + \text{H}_2 \\
\text{Zn + 2NaOH} & \rightarrow \text{Na}_2\text{ZnO}_2 + \text{H}_2 \\
\text{Mole of Zn} & = \frac{\text{Mole of dil HCl}}{2} = \frac{\text{Mole of NaOH}}{2} \\
\frac{\text{volume of HCl}}{\text{volume of NaOH}} & = \frac{1}{1} \\
\end{align*}
\]

Q.8 If the figure shown below reactant A (represented by square) is in equilibrium with product B (represented by circle). The equilibrium constant is :  
(1) 8  
(2) 2  
(3) 4  
(4) 1  
Ans. [2]  
Sol.  
A \rightarrow B  
\[
K_{eq} = \frac{[B]}{[A]} = \frac{11}{6} 
\]

Q.9 A mixture of gases O₂, H₂ and CO are taken in a closed vessel containing charcoal. The graph that represents the correct behaviour of pressure with time is :  
(1)  
(2)  
(3)  
(4)  
Ans. [4]
on increasing time, pressure will be decreases.

Q.10 The number of sp² hybrid orbitals in a molecule of benzene is -
(1) 18 (2) 6 (3) 12 (4) 24
Ans. [1]
Sol. Benzene : C₆H₆

In Benzene, Each carbon is sp² Hybridize
Total number of carbon = 6(sp² Hybrid.)
∴ Total Hybrid orbital = 6 × 3 = 18

Q.11 Biochemical Oxygen Demand (BOD) is the amount of oxygen required (in ppm) :
(1) for the photochemical breakdown of waste present in 1 m³ volume of a water body.
(2) for sustaining life in a water body.
(3) by bacteria to break-down organic waste in a certain volume of a water sample.
(4) by anaerobic bacteria to breakdown inorganic waste present in a water body.
Ans. [3]
Sol. Biochemical oxygen demand (BOD)
The amount of oxygen required by bacteria to break down the organic matter present in a certain volume of a sample of water.

Q.12 The true statement amongst the following is :
(1) S is a function of temperature but ΔS is not a function of temperature.
(2) Both ΔS and S are functions of temperature.
(3) S is not a function of temperature but ΔS is a function of temperature.
(4) Both S and ΔS are not functions of temperature.
Ans. [2]
Sol. \[ S = \int \frac{dq}{T} \]
\[ ΔS = nC \int_{T_i}^{T_f} dT \]
Both ΔS and S are function of temperature.
Q.13 A, B and C are three biomolecules. The results of the tests performed on them are given below:

<table>
<thead>
<tr>
<th>A</th>
<th>Molisch’s Test</th>
<th>Barfoed Test</th>
<th>Biuret Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Positive</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>C</td>
<td>Negative</td>
<td>Negative</td>
<td>Positive</td>
</tr>
</tbody>
</table>

A, B and C are respectively:

(1) A = Lactose, B = Glucose, C = Alanine
(2) A = Lactose, B = Glucose, C = Albumin
(3) A = Glucose, B = Fructose, C = Albumin
(4) A = Lactose, B = Fructose, C = Alanine

Ans. [2]
Sol. Lactose : Molisch’s Test
Glucose : Molisch’s Test and Barfoed Test
Alumin : Biuret Test

Q.14 Consider the following reactions,

(i) $\text{NaNO}_2/\text{HCl, 0-5}^\circ\text{C}$
(ii) $\beta$-naphthol/NaOH

\[\text{Br}_2/\text{H}_2\text{O} \quad \rightarrow \quad \text{C}_7\text{H}_6\text{NBr}_3 \quad \text{Colored Solid}\]

The compound [P] is:

(1) \[
\begin{array}{c}
\text{NH}_2 \\
\text{CH}_3 \\
\end{array}
\]
(2) \[
\begin{array}{c}
\text{NH}_2 \\
\text{CH}_3 \\
\end{array}
\]
(3) \[
\begin{array}{c}
\text{NH}_2 \\
\text{CH}_3 \\
\end{array}
\]
(4) \[
\begin{array}{c}
\text{NHCH}_3 \\
\end{array}
\]

Ans. [2]
Sol.
Q.15 Which of the following reactions will not produce a racemic product?

(1) \( \text{H}_3\text{C} \quad \text{HCl} \quad \text{H}_3\text{C} \quad \text{CH} \quad \text{CH}_3 \)

(2) \( \text{CH}_3\text{CH}_2\text{CH} = \text{CH}_2 \quad \text{HBr} \quad \text{CH}_3 \quad \text{CH}_2\text{CH} = \text{CH}_2 \)

(3) \( \text{CH}_3\text{-C} = \text{CH}_2 \quad \text{HCl} \quad \text{CH}_3\text{-C} = \text{CH}_2 - \text{CH}_3 \)

(4) \( \text{CH}_3\text{-C} = \text{CH} - \text{CH}_2 \quad \text{HCl} \quad \text{CH}_3\text{-C} = \text{CH} - \text{CH}_2 \quad \text{CH}_2\text{-CH} = \text{CH}_2 \)

Ans. [4]

Sol. CH₃CH=CH₂ → CH₃ –CH₂ –CH₃

optical inactive

Q.16 Which of the following has the shortest C–Cl bond?

(1) Cl–CH=CH–NO₂
(2) Cl–CH≡CH–CH₃
(3) Cl–CH=CH–OCH₃
(4) Cl–CH=CH₂

Ans. [1]

Sol. Cl–CH=CH–N⁺O⁻ \[ \rightarrow \] Cl=CH–CH=N⁺O⁻ double bond char.

Q.17 The decreasing order of basicity of the following amines is:

(I) \( \quad \text{NH₂} \)
(II) \( \quad \text{NH₂} \)
(III) \( \quad \text{NH₂} \)
(IV) \( \quad \text{NH₂} \)

(1) (III) > (I) > (II) > (IV)
(2) (II) > (III) > (IV) > (I)
(3) (I) > (III) > (IV) > (II)
(4) (III) > (II) > (I) > (IV)

Ans. [4]

Sol. \( \quad \text{NH₂} \quad \text{NH₂} \quad \text{NH₂} \quad \text{NH₂} \)

- Nitrogen \( \ell.p. \) not participate in resonance.
- Nitrogen \( \ell.p. \) participate in resonance.
- Nitrogen \( \ell.p. \) participate in resonance and increase the stability of the compound due to aromaticity.
- Nitrogen \( \ell.p. \) not participate in resonance due to increase the stability of the compound.
Q.18 The reaction of $\text{H}_3\text{N}_3\text{B}_3\text{Cl}_3$ (A) with LiBH$_4$ in tetrahydrofuran gives inorganic benzene (B). Further, the reaction of (A) with (C) leads to $\text{H}_3\text{N}_3\text{B}(\text{Me})_3$. Compounds (B) and (C) respectively, are:

(1) Borazine and MeBr  
(2) Boron nitride and MeBr  
(3) Diborane and MeMgBr  
(4) Borazine and MeMgBr  

Ans. [4]  
Sol.  
\[
\begin{align*} 
\text{B}_3\text{N}_3\text{H}_3\text{Cl}_3 + \text{LiBH}_4 & \rightarrow \text{B}_3\text{N}_3\text{H}_6 \quad \text{(B) Inorganic Benzene or Borazine} \\
\text{B}_3\text{N}_3\text{H}_3\text{Cl} + \text{MeMgBr} & \rightarrow \text{B}_3\text{N}_3\text{H}_3(\text{CH}_3)_3 + 3\text{MgBrCl} 
\end{align*}
\]

Q.19 In the following reaction A is:

(i) Br$_2$, hv  
(ii) KOH (alc.)  
(iii) O$_3$  
(iv) (CH$_3$)$_2$S  
(v) NaOH(aq) + $\Delta$

\[A\]  

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

Ans. [2]  
Sol.  

Q.20 The isomer(s) of $[\text{Co(NH}_3)_4\text{Cl}_2]$ that has/have a Cl–Co–Cl angle of 90º, is/are:

(1) meridional and trans  
(2) cis only  
(3) trans only  
(4) cis and trans

Ans. [2]  
Sol.  

Q.21 The sum of the total number of bonds between chromium and oxygen atoms in chromate and dichromate ions is _____

Ans. [12]
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Sol. Chromate = $\text{CrO}_4^{2-}$

dichromate = $\text{Cr}_2\text{O}_7^{2-}$

Total number of Cr–O bond = 12

Q.22 A sample of milk splits after 60 min. at 300 K and after 40 min. at 400 K when the population of lactobacillus acidophilus in it doubles. The activation energy (in kJ/mol) for this process is closest to _____

(Given, $R = 8.3 \text{ J mol}^{-1}\text{K}^{-1}$, $\ln \left(\frac{2}{3}\right) = 0.4$, $e^{-3} = 4.0$)

Ans. [3.98]

Sol. 

\[
\ln \frac{K_2}{K_1} = \frac{E_a}{R} \left[ \frac{1}{T_1} - \frac{1}{T_2} \right]
\]

\[
\ln \frac{60}{40} = \frac{E_a}{8.3} \left[ \frac{1}{300} - \frac{1}{400} \right]
\]

$E_a = 3.98 \text{ kJ/mol}$.

Q.23 A Cylinder containing an ideal gas (0.1 mol of 1.0 dm$^3$) is in thermal equilibrium with a large volume of 0.5 molal aqueous solution of ethylene glycol at its freezing point. If the stoppers $S_1$ and $S_2$ (as shown in the figure) are suddenly withdrawn, the volume of the gas in litres after equilibrium is achieved will be ______.

(Given, $K_f(\text{water}) = 2.0 \text{ K kg mol}^{-1}$, $R = 0.08 \text{ dm}^3\text{ atm K}^{-1}\text{ mol}^{-1}$)

Ans. [2.18]

Sol. 

$\Delta T_f = K_f \times i \times m$

$\Delta T_f = 2.0 \times 1 \times 0.5$

$\Delta T_f = 1$

$273 - T_1 = 1$

$T_1 = 272 \text{ K}$

$P = \frac{nRT}{V}$

$P = \frac{0.1 \times 0.08 \times 272}{1}$

$P = 2.176 \text{ atm}$

Apply Boyle’s law

$P_1V_1 = P_2V_2$

$2.176 \times 1 = 1 \times V_2$

$V_2 = 2.17$
Q.24 Consider the following reactions

\[ A \xrightarrow{(i) \text{CH}_3\text{MgBr}, \text{H}_2\text{O}} B \xrightarrow{\text{Cu}, 573\, \text{K}} 2\text{-methyl-2-butene} \]

The mass percentage of carbon in A is ________.

**Ans.** \([66.66]\)

**Sol.**

\[
\begin{align*}
\text{CH}_3\text{-C-CH}_2\text{-CH}_3 + \text{CH}_3\text{MgBr} & \xrightarrow{\text{H}_2\text{O}} \text{CH}_3\text{-C-CH}_2\text{-CH}_3 + \text{OH} \\
& \xrightarrow{\text{Cu}, 573\, \text{K}} \text{CH}_3\text{-C=CH-CH}_3 + \text{CH}_3
\end{align*}
\]

\[
\% \text{ carbon} = \frac{\text{Atomic mass} \times \text{Atomicity}}{\text{Molar mass}} \times 100
\]

\[
= \frac{12 \times 4}{72} \times 100 = 66.66\%
\]

Q.25 10.30 mg of \(\text{O}_2\) is dissolved into a liter of sea water of density 1.03 g/mL. The concentration of \(\text{O}_2\) in ppm is ________.

**Ans.** \([10]\)

**Sol.**

\[
\text{PPM} = \frac{\text{Mass of } \text{O}_2}{\text{Mass of water}} \times 10^6
\]

\[
= \frac{10.30 \times 10^{-3}}{1030} \times 10^6 = 10
\]