CHEMISTRY

Q.1 Among the statements (a)-(d), the incorrect ones are:
(a) Octahedral Co(III) complexes with strong field ligands have very high magnetic moments
(b) When $\Delta_0 < P$, the d-electron configuration of Co(III) in an octahedral complex is $t_{eg}^4 e_{eg}^2$
(c) Wavelength of light absorbed by $[\text{Co(en)}_3]^{3+}$ is lower than that of $[\text{CoF}_6]^{3-}$
(d) If the $\Delta_0$ for an octahedral complex of Co(III) is 18,000 cm$^{-1}$, the $\Delta_t$ for its tetrahedral complex with the same ligand will be 16,000 cm$^{-1}$

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

Ans. [2]

Sol. Strong field ligands have high pairing energy.
For strong field ligand : $-\Delta_0 = \Delta_t \times 1.125$
$\frac{18000}{1.125} = \Delta_t$
$16000 = \Delta_t$

Q.2 If the following reaction sequence,

\[ \text{NH}_2 \xrightarrow{Ac_2O} A \xrightarrow{B_2/\text{AcOH}} B \]

the major product B is:

(1) NHCOCH$_3$
(2) NHCOCH$_3$
(3) Br
(4) NHCOCH$_3$

Ans. [4]

Sol. 1
\[ \text{NH}_2 \xrightarrow{Ac_2O} A \xrightarrow{B_2/\text{AcOH}} B \]

\[ \text{NH}_2 \xrightarrow{Ac_2O} A \xrightarrow{B_2/\text{AcOH}} B \]
Q.3 Two open beakers one containing a solvent and the other containing a mixture of that solvent with a non volatile solute are together sealed in a container. Over time:
(1) the volume of the solution decreases and the volume of the solvent increases
(2) the volume of the solution and the solvent does not change
(3) the volume of the solution increases and the volume of the solvent decreases
(4) the volume of the solution does not change and the volume of the solvent decreases

Ans. [3]
Sol. Lowering of V.P in second Beaker will take place.

Q.4 Among statement (a) – (d), the correct ones are:
(a) Decomposition of hydrogen peroxide gives dioxygen.
(b) Like hydrogen peroxide, compound, such as KClO₃, Pb(NO₃)₂ and NaNO₃ when heated liberate dioxygen.
(c) 2-Ethylanthraquinone is useful for the industrial preparation of hydrogen peroxide.
(d) Hydrogen peroxide is used for the manufacture of sodium perborate.

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

Ans. [2]
Sol. Theory Based

Q.5 The correct order of stability for the following alkoxides is:

(A)  \( \text{NO}_2^− \)  \( \text{NO}_2^− \)
(B)  \( \text{O}_2\text{N}−−\text{NO}_2^− \)
(C)  \( \text{NO}_2^−−\text{NO}_2^−−\text{NO}_2^− \)

(1) (C) > (A) > (B)  (2) (B) > (C) > (A)  (3) (B) > (A) > (C)  (4) (C) > (B) > (A)

Ans. [4]
Sol.
\( \text{O}−\text{CH}=\text{CH}−\text{N}\text{O}_2^− \) (stable by –M of NO₂)

\( \text{O}\text{C}=\text{CH}_2 \) (stable by Resonance)

Q.6 A chromatography column, packed with silica gel as stationary phase, was used to separate a mixture of compounds consisting of (A) benzanilide (B) aniline and (C) acetophenone. When the column is eluted with a mixture of solvent, hexane : ethyl acetate (20 : 80), the sequence of obtained compounds is:

(1) (B), (C) and (A)  (2) (C), (A) and (B)  (3) (A), (B) and (C)  (4) (B), (A) and (C)

Ans. [2]
Sol.
\( \text{Acetophenone} \)  \( \text{Acetanilide} \)  \( \text{Anniline} \)

Anniline has higher viscosity due to efficient H-Bonding.
Q.7 In the following reactions, products (A) and (B), respectively, are:

\[
\text{NaOH} + \text{Cl}_2 \rightarrow (A) + \text{side products}
\]
(hot and conc.)

\[
\text{Ca(OH)}_2 + \text{Cl}_2 \rightarrow (B) + \text{side products}
\]
(dry)

(1) NaClO$_3$ and Ca(ClO$_3$)$_2$
(2) NaClO$_3$ and Ca(OCl)$_2$
(3) NaOCl and Ca(OCl)$_2$
(4) NaOCl and Ca(ClO$_3$)$_2$

Ans. [2]

Sol. 
6NaOH + 3Cl$_2$ $\rightarrow$ 5NaCl + NaClO$_3$ + 3H$_2$O
2Ca(OH)$_2$ + Cl$_2$ $\rightarrow$ Ca(OCl)$_2$ + CaCl$_2$ + H$_2$O

Q.8 The ammonia (NH$_3$) released on quantitative reaction of 0.6 g urea (NH$_2$CONH$_2$) with sodium hydroxide (NaOH) can be neutralized by:

(1) 200 ml of 0.4 N HCl
(2) 200 ml of 0.2 N HCl
(3) 100 ml of 0.1 N HCl
(4) 100 ml of 0.2 N HCl

Ans. [4]

Sol. 
2 $\times$ moles of urea = moles of NH$_3$
moles of NH$_3$ = moles of HCl

\[
\frac{100 \times 0.2}{1000} = \text{moles of HCl} = 0.02 \text{ mole of HCl}
\]

Q.9 For the following reactions

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + Z^- \xrightarrow{k_s} \text{CH}_3\text{CH}_2\text{CH}_2Z + \text{Br}^-
\]

\[
\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} \xrightarrow{k_e} \text{CH}_3\text{CH}=$CH$_2 + \text{Hz} + \text{Br}^-
\]

where,

\[
Z^- = \text{CH}_3\text{CH}_2\text{O}^- \text{ (A) or H}_3\text{C}$\text{C}$\text{C}$\text{O}^- \text{ (B)},
\]

$k_s$ and $k_e$ are, respectively, the rate constants for substitution and elimination, and $\mu = \frac{k_s}{k_e}$, the correct option is ______.

(1) $\mu_B > \mu_A$ and $k_s(A) > k_s(B)$
(2) $\mu_B > \mu_A$ and $k_e(B) > k_e(A)$
(3) $\mu_A > \mu_B$ and $k_e(B) > k_e(A)$
(4) $\mu_A > \mu_B$ and $k_s(A) > k_s(B)$

Ans. [3]

Sol. Bulkier the base, elimination will be favoured

\[
\mu_A = \frac{k_{ks}}{k_{se}} \text{ (For } A : k_s > k_e)
\]

\[
\mu_B = \frac{k_{ks}}{k_{se}} \text{ (For } B : k_s < k_e)
\]
Q.10 Identify the correct labels of A, B and C in the following graph from the option given below:

![Graph showing relationship between number of molecules and speed]

Root mean square speed ($V_{rms}$); most probable speed ($V_{mp}$); Average speed ($V_{av}$)

1. A - $V_{rms}$, B - $V_{mp}$, C - $V_{av}$
2. A - $V_{mp}$, B - $V_{av}$, C - $V_{rms}$
3. A - $V_{mp}$, B - $V_{rms}$, C - $V_{av}$
4. A - $V_{av}$, B - $V_{rms}$, C - $V_{mp}$

**Ans.** [2]

**Sol.** $V_{rms} > V_{avg} > V_{mp}$

Q.11 The equation that is incorrect is:

1. $(\Lambda_m^0)_{NaBr} - (\Lambda_m^0)_{NaCl} = (\Lambda_m^0)_{KBr} - (\Lambda_m^0)_{KCl}$
2. $(\Lambda_m^0)_{H_2O} = (\Lambda_m^0)_{HCl} + (\Lambda_m^0)_{NaOH} - (\Lambda_m^0)_{NaCl}$
3. $(\Lambda_m^0)_{NaBr} - (\Lambda_m^0)_{NaI} = (\Lambda_m^0)_{KBr} - (\Lambda_m^0)_{NaBr}$
4. $(\Lambda_m^0)_{KCl} - (\Lambda_m^0)_{NaCl} = (\Lambda_m^0)_{KBr} - (\Lambda_m^0)_{NaBr}$

**Ans.** [3]

**Sol.**

$\Lambda_m^0_{NaI} - \Lambda_m^0_{NaBr} = \Lambda_m^0_{I} - \Lambda_m^0_{Br}$

$\Lambda_m^0_{NaBr} - \Lambda_m^0_{KBr} = \Lambda_m^0_{Na} - \Lambda_m^0_{K}$

Q.12 The redox reaction among the following is:

1. combination of dinitrogen with dioxygen at 200 K
2. reaction of $H_2SO_4$ with $NaOH$
3. formation of ozone from atmospheric oxygen in the presence of sunlight
4. reaction of $[Co(H_2O)_6]Cl_3$ with $AgNO_3$

**Ans.** [1]

**Sol.**

$N_2 + O_2 \rightarrow 2NO$ (Ox. state charge)

$3O_2 \rightarrow 2O_3$

$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

$AgNO_3 + NaCl \rightarrow NaNO_3 + AgCl$

Q.13 For the reaction

$2H_2(g) + 2NO(g) \rightarrow N_2(g) + 2H_2O(g)$

the observed rate expression is, rate = $k_1[NO]^2[H_2]$. The rate expression for the reverse reaction is:

1. $k_2[N_2][H_2O]^2$  
2. $k_3[N_2][H_2O]$  
3. $k_4[N_2][H_2O]^2[NO]$  
4. $k_5[N_2][H_2O]^2$
Ans.  [1]

Sol.  \[ 2\text{H}_2(g) + 2\text{NO}(g) \rightarrow \text{N}_2(g) + 2\text{H}_2\text{O}(g) \]

According to Rate expression forward
2NO + H₂ are Reactants
Hence one mole of H₂ is reacted in second step
\[ k_b[N_2][\text{H}_2\text{O}]^2/[\text{H}_2] \]

Q.14 The bond order and the magnetic characteristics of CN⁻ are:
(1) 2\(\frac{1}{2}\), diamagnetic  (2) 3, paramagnetic  (3) 2\(\frac{1}{2}\), paramagnetic  (4) 3, diamagnetic

Ans.  [4]

Sol.  CN⁻ has 14 electron
\[ \sigma_1s^2, \sigma^*1s^2 \sigma_2s^2 \sigma^*2s^2 \pi^22\text{py} = \pi^22\text{pz} \pi^*2\text{py} = \pi^*2\text{pz} \]

Bond order = \[ \frac{N_b - N_a}{2} = 3 \text{ (C}^\equiv \text{N)} \]
diamagnetic → all electrons are paired

Q.15 In the following reaction sequence, structures of A and B, respectively will be:

\[ \text{BrCH}_2\text{Br} \xrightarrow{\text{HBr} \Delta} \text{A} \xrightarrow{\text{Na + Ether}} \text{(Intramolecular Product) B} \]

\(\text{OH} \& \text{BrCH}_2\text{Br} \)
\(\text{BrCH}_2\text{Br} \& \text{CH}_2\text{Br} \)

(1) (2)

(3) (4)

Ans.  [4]

Sol.  \[ \text{CH}_2\text{Br} \xrightarrow{\text{HBr} \text{Sn}^2} \text{A} \xrightarrow{\text{(i) Br}^0 \text{(ii) Na + ether}} \text{OH} \]

(1) (2)

(3) (4)

Q.16 Which of the following statements is correct?
(1) Gluconic acid is obtained by oxidation of glucose with HNO₃
(2) Gluconic acid is a partial oxidation product of glucose
(3) Gluconic acid can form cyclic (acetal/hemiacetal) structure
(4) Gluconic acid is a dicarboxylic acid

Ans.  [2]
Q.17 Within each pair of element F & Cl, S & Se, and Li & Na, respectively, the elements that release more energy upon and electron gain are:

(1) Cl, S and Li
(2) F, Se and Na
(3) Cl, Se and Na
(4) F, S and Li

Ans. [1]

Sol.

Cl > F (exception)
S > Se (exception) \{3^{rd} \text{ period} > 2^{nd} \text{ period}\}
Li > Na (small size)

Q.18 The refining method used when the metal and the impurities have low and high melting temperatures, respectively, is:

(1) distillation
(2) liqation
(3) zone refining
(4) vapour phase refining

Ans. [2]

Sol. Theory Based

Q.19 The number of possible optical isomers for the complexes MA₂B₂ with sp³ and dsp² hybridized metal atom, respectively, is:

Note: A and B are unidentate neutral and unidentate monoanionic ligands, respectively.

(1) 0 and 1
(2) 0 and 0
(3) 0 and 2
(4) 2 and 2

Ans. [2]

Sol. MA₂B₂ shows geometrical isomerism not optical isomerism.

Q.20 Consider the following reaction:

(a) \[
\text{anhyd. AlCl}_3 + \text{anhyd. AlCl}_3 \rightarrow \text{anhyd. AlCl}_3
\]

(b) \[
\text{anhyd. AlCl}_3 \rightarrow \text{anhyd. AlCl}_3
\]

(c) \[
\text{anhyd. AlCl}_3 \rightarrow \text{anhyd. AlCl}_3
\]

(d) \[
\text{anhyd. AlCl}_3 \rightarrow \text{anhyd. AlCl}_3
\]

Which of these reactions are possible?

(1) (a) and (b)
(2) (b) and (d)
(3) (a) and (d)
(4) (b), (c) and (d)
Ans. [2]

Sol. Vinyl halides and Aryl halides do not give Friedel Craft Reaction due to partial double bond character.

Q.21 The flocculation value of HCl for arsenic sulphide sol. is 30 m mol L$^{-1}$. If H$_2$SO$_4$ is used for the flocculation of arsenic sulphide, the amount, in grams, of H$_2$SO$_4$ in 250 ml required for the above purpose is _______. (molecular mass of H$_2$SO$_4$ = 98 g/mol)

Ans. [0.3675]

Sol. → 1 litre solution of 30 m mol of HCl is required
→ For 1 litre solution 15 m mol H$_2$SO$_4$ is required.

250 ml of solution required :
\[
\frac{15}{4} \times 10^{-3} \text{ (m mol)} \text{ of H}_2\text{SO}_4
\]
\[= 0.3675 \text{ gm}\]

Q.22 3 g of acetic acid is added to 250 mL of 0.1 M HCl and the solution made up to 500 mL. To 20 mL of this solution $\frac{1}{2}$ mL of 5 M NaOH is added. The pH of the solution is _______.

[Given : pKa of acetic acid $= 4.75$, molar mass of acetic acid $= 60$ g/mol, log3 $= 0.4771$]

Neglect any changes in volume.

Ans. [5.22]

Sol. 

m mole of acetic acid in 20 ml $= 2$

m mole of HCl in 20 ml $= 1$

m mole of NaOH 20 ml $= 2.5$

NaOH + CH$_3$COOH $\rightarrow$ CH$_3$COONa + H$_2$O (left)

\[
\begin{array}{cccc}
\text{mol} & 1.5 & 2 & 0 & 0 \\
\text{mol} & 0 & 0.5 & 1.5 & \\
\end{array}
\]

pH $= $ pKa $+ \log \left( \frac{3/2}{2} \right)$

$= 4.74 + \log 3 = 5.22$

Q.23 Consider the following reactions:

NaCl + K$_2$Cr$_2$O$_7$ + H$_2$SO$_4$ $\rightarrow$ (A) + side products (Conc.)

(A) + NaOH $\rightarrow$ (B) + side products

(B) + H$_2$SO$_4$ + H$_2$O$_2$ $\rightarrow$ (C) + Side products (dilute)

The sum of the total number of atoms in one molecule each of (A), (B) and (C) is _________.

Ans. [18]

Sol. NaCl $\xrightarrow{K_2Cr_2O_7/H^+}$ CrO$_2$Cl$_2$ (A) $\xrightarrow{NaOH}$ NaCrO$_4$ (B) $\xrightarrow{H_2O_2/H^+}$ CrO$_5$

CrO$_2$Cl$_2$ $\rightarrow$ 5

NaCrO$_4$ $\rightarrow$ 7

CrO$_5$ $\rightarrow$ 6

\[
18 \text{ atoms}
\]
Q.24 The standard heat of formation ($\Delta_f H_{298}^0$) of ethane (in kJ/mol), if the heat of combustion of ethane, hydrogen and graphite are –1560, –393.5 and –286 kJ/mol, respectively is ________.  

Ans. [192.5]  

Sol.  

\[
\begin{align*}
2\text{C(graphite)} + 3\text{H}_2\text{(g)} & \rightarrow 1\text{C}_2\text{H}_6 \quad \Delta H_f(\text{C}_2\text{H}_6) \\
(1) \quad \text{C}_2\text{H}_6 + \frac{7}{2}\text{O}_2 & \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} \quad \Delta H_C = -1560 \\
(2) \quad \text{H}_2 + \frac{1}{2}\text{O}_2 & \rightarrow \text{H}_2\text{O} \quad \Delta H_C = -393.5 \\
(3) \quad \text{C(graphite)} + \text{O}_2 & \rightarrow \text{CO}_2 \quad \Delta H_C = -286 \text{ kJ/mol} \\
\Delta H_f(\text{C}_2\text{H}_6) &= 3(-393.5) + 2(-286) + 1560 \\
&= -1180.5 + (-572) + 1560 \\
&= 192.5
\end{align*}
\]

Q.25 The number of sp\(^2\) hybridised carbons present in "Aspartame" is _____.  

Ans. [9]  

Sol.  

![Aspartame structure]