CHEMISTRY

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. If a rocket runs on a fuel ($C_{15}H_{30}$) and liquid oxygen, the weight of oxygen required and CO_2 released for every litre of fuel respectively are :

(Given : density of the fuel is 0.756 g/mL)

(A) 1188 g and 1296 g (B) 2376 g and 2592 g

(C) 2592 g and 2376 g (D) 3429 g and 3142 g

Answer (C)

Sol. $C_{15}H_{30} + \frac{45}{2}O_2 \rightarrow 15CO_2 + 15H_2O$

One litre of fuel has a mass (0.756) × 1000 g.

$\therefore$ moles of $C_{15}H_{30} = \frac{756}{210}$

Moles of O_2 required = $\frac{45}{2} \times \frac{756}{210}$

Mass of O_2 required = $\frac{45}{2} \times \frac{756}{210} \times 32\text{ g} = 2592\text{ g}$

Mass of CO_2 formed = $15 \times \frac{756}{210} \times 44 = 2376\text{ g}$

2. Consider the following pairs of electrons

(A) (a) $n = 3, l = 1, m_l = 1, m_s = +\frac{1}{2}$

(b) $n = 3, l = 2, m_l = 1, m_s = +\frac{1}{2}$

(B) (a) $n = 3, l = 2, m_l = -2, m_s = -\frac{1}{2}$

(b) $n = 3, l = 2, m_l = -1, m_s = -\frac{1}{2}$

(C) (a) $n = 4, l = 2, m_l = 2, m_s = +\frac{1}{2}$

(b) $n = 3, l = 2, m_l = 2, m_s = +\frac{1}{2}$

The pairs of electrons present in degenerate orbitals is /are:

(A) Only (A) (B) Only (B)

(C) Only (C) (D) (B) and (C)

Answer (B)

Sol. For degenerate orbitals, only the value of m must be different. The value of 'n' and 'l' must be the same.

Hence, the pair of electrons with quantum numbers given in (B) are degenerate.

3. Match **List-I** with **List-II** :

List-I	List-II
(A) $[PtCl_4]^{2-}$	(I) sp^3d
(B) BrF_5	(II) d^2sp^3
(C) PCl_5	(III) dsp^2
(D) $[Co(NH_3)_6]^{3+}$	(IV) sp^3d^2

Choose the **most appropriate** answer from the options given below.

(A) (A)-(II), (B)-(IV), (C)-(I), (D)-(III)

(B) (A)-(III), (B)-(IV), (C)-(I), (D)-(II)

(C) (A)-(III), (B)-(I), (C)-(IV), (D)-(II)

(D) (A)-(II), (B)-(I), (C)-(IV), (D)-(III)

Answer (B)

Sol.

Complex/compound	Hybridisation of central atoms
(A) $[PtCl_4]^{-2}$	(III) dsp^2
(B) BrF_5	(IV) sp^3d^2
(C) PCl_5	(I) sp^3d
(D) $[Co(NH_3)_6]^{+3}$	(II) d^2sp^3

Hence, the most appropriate answer is given in option (B)

4. For a reaction at equilibrium

$$A(g) \rightleftharpoons B(g) + \frac{1}{2}C(g)$$

the relation between dissociation constant (K), degree of dissociation (α) and equilibrium pressure (p) is given by :

(A) $K = \dfrac{\alpha^{\frac{1}{2}} p^{\frac{3}{2}}}{\left(1+\frac{3}{2}\alpha\right)^{\frac{1}{2}}(1-\alpha)}$

(B) $K = \dfrac{\alpha^{\frac{3}{2}} p^{\frac{1}{2}}}{(2+\alpha)^{\frac{1}{2}}(1-\alpha)}$

(C) $K = \dfrac{(\alpha p)^{\frac{3}{2}}}{\left(1+\frac{3}{2}\alpha\right)^{\frac{1}{2}}(1-\alpha)}$

(D) $K = \dfrac{(\alpha p)^{\frac{3}{2}}}{(1+\alpha)(1-\alpha)^{\frac{1}{2}}}$

Answer (B)

Sol.

	$A(g)$	$\rightleftharpoons$	$B(g)$	$+$	$\frac{1}{2}C(g)$
$t = 0$	p_i		–		–
$t = t$ (eq. m conditions)	$p_i - p_i\alpha$		$p_i\alpha$		$\frac{p_i\alpha}{2}$

$\therefore$ P (equilibrium pressure) $= p_i - p_i\alpha + p_i\alpha + \dfrac{p_i\alpha}{2}$

$= p_i\left(1+\dfrac{\alpha}{2}\right)$

$\therefore \quad p_i = \dfrac{p}{\left(1+\frac{\alpha}{2}\right)}$

$$K_P = \frac{\left(p_i\frac{\alpha}{2}\right)^{\frac{1}{2}} \times p_i\alpha}{p_i(1-\alpha)} = \frac{p^{\frac{1}{2}}\alpha^{\frac{3}{2}}}{\left(1+\frac{\alpha}{2}\right)^{\frac{1}{2}}(1-\alpha)} \times \frac{1}{2^{\frac{1}{2}}}$$

$$= \frac{p^{\frac{1}{2}}\alpha^{\frac{3}{2}}}{(2+\alpha)^{\frac{1}{2}}(1-\alpha)}$$

Hence the correct option is (B)

5. Given below are two statements:

Statement I : Emulsion of oil in water are unstable and sometimes they separate into two layers on standing.

Statement II : For stabilisation of an emulsion, excess of electrolyte is added.

In the light of the above statements, choose the most appropriate answer from the options given below:

(A) Both **Statement I** and **Statement II** are correct

(B) Both **Statement I** and **Statement II** are incorrect.

(C) **Statement I** is correct but **Statement II** is incorrect.

(D) **Statement I** is incorrect but **Statement II** is correct.

Answer (C)

Sol. Oil in water emulsions can sometimes separate into two layers on standing.

The most relevant example for the above case is milk, which can separate into two layers on standing for a longer time. Therefore, statement (I) is correct.

On adding excess of electrolyte, coagulation occurs and emulsion is further destabilised.

Therefore, statement (II) is incorrect.

6. Given below are the oxides:

Na_2O, As_2O_3, N_2O, NO and Cl_2O_7

Number of amphoteric oxides is:

(A) 0 (B) 1

(C) 2 (D) 3

Answer (B)

Sol. Oxides

$Na_2O \longrightarrow$ Basic

$As_2O_3 \longrightarrow$ Amphoteric

$N_2O \longrightarrow$ Neutral

$NO \longrightarrow$ Neutral

$Cl_2O_7 \longrightarrow$ Acidic

Hence, only one amphoteric oxide is present.

7. Match **List-I** with **List -II** :

List-I	**List-II**
(A) Sphalerite	(I) $FeCO_3$
(B) Calamine	(II) PbS
(C) Galena	(III) $ZnCO_3$
(D) Siderite	(IV) ZnS

Choose the **most appropriate** answer from the options given below:

(A) (A)-(IV), (B)-(III), (C)-(II), (D)-(I)

(B) (A)-(IV), (B)-(I), (C)-(II), (D)-(III)

(C) (A)-(II), (B)-(III), (C)-(I), (D)-(IV)

(D) (A)-(III), (B)-(IV), (C)-(II), (D)-(I)

Answer (A)

Sol.

	Ores	Formula
(A)	Sphalerite	(IV) ZnS
(B)	Calamine	(III) $ZnCO_3$
(C)	Galena	(II) PbS
(D)	Siderite	(I) $FeCO_3$

Hence, the most appropriate option is (A).

8. The highest industrial consumption of molecular hydrogen is to produce compounds of element:

(A) Carbon (B) Nitrogen

(C) Oxygen (D) Chlorine

Answer (B)

Sol. Hydrogen combines with nitrogen to produce Ammonia in Haber's process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

In this process, iron oxide is used with small amounts of K_2O and Al_2O_3 to increase the rate of attainment of equilibrium.

Optimum conditions for the production of ammonia are a pressure of 200 atm and a temperature of 700K.

Earlier, iron was used as a catalyst with molybdenum as promoter in this reaction.

9. Which of the following statements are **correct**?

(A) Both LiCl and $MgCl_2$ are soluble in ethanol.

(B) The oxides Li_2O and MgO combine with excess of oxygen to give superoxide.

(C) LiF is less soluble in water than other alkali metal fluorides.

(D) Li_2O is more soluble in water than other alkali metal oxides.

Choose the **most appropriate** answer from the options given below:

(A) (A) and (C) only (B) (A), (C) and (D) only

(C) (B) and (C) only (D) (A) and (D) only

Answer (A)

Sol. (A) Both LiCl and $MgCl_2$ are covalent in nature due to high polarizing power of Li^+ and Mg^{+2} ions. Hence, they are soluble in ethanol.

(A) Oxides of Li_2O and MgO do not form superoxide

(B) LiF is least soluble among all other alkali metal fluorides due to high lattice energy of LiF

(C) Li_2O is least soluble among all other alkali metal oxides.

Hence, Statements (A) and (C) are correct.

10. Identify the correct statement for B_2H_6 from those given below:

(A) In B_2H_6, all B-H bonds are equivalent.

(B) In B_2H_6, there are four 3-centre-2-electron bonds.

(C) B_2H_6 is a Lewis acid.

(D) B_2H_6 can be synthesized from both BF_3 and $NaBH_4$.

(E) B_2H_6 is a planar molecule.

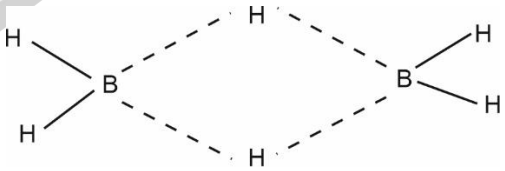
Choose the **most appropriate** answer from the options given below:

(A) (A) and (E) only (B) (B), (C) and (E) only

(C) (C) and (D) only (D) (C) and (E) only

Answer (C)

Sol. Structure of B_2H_6



It has two 3-centre-2-electron bonds and four 2-centre-2-electron bonds.

Hence, all B–H bonds are not equivalent.

It is an electron deficient compound as the octet of boron is incomplete.

Hence, it can behave as a Lewis acid.

It can be synthesized from both BF_3 and $NaBH_4$

$$2BF_3 + 6NaH \xrightarrow{450\,K} B_2H_6 + 6NaF$$

$$2NaBH_4 + I_2 \longrightarrow B_2H_6 + 2NaI + H_2$$

It is a non-planar molecule.

Hence, only Statements (C) and (D) are correct.

11. The most stable trihalide of nitrogen is:

(A) NF_3 (B) NCl_3

(C) NBr_3 (D) NI_3

Answer (A)

Sol. The most stable trihalide is NF_3

Order of stability: $NF_3 > NCl_3 > NBr_3 > NI_3$

NCl_3 is explosive is nature.

NBr_3 and NI_3 are known only as ammoniates. The stability of trihalides decreases down the group due to weakening of N – X bond and inability of N to accommodate large sized halogen atoms (Cl, Br, I) around it.

12. Which one of the following elemental forms is **not** present in the enamel of the teeth?

(A) Ca^{2+}

(B) P^{3+}

(C) F^-

(D) P^{5+}

Answer (B)

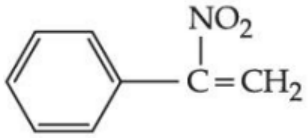
Sol. P^{+3} is not present is enamel of teeth.

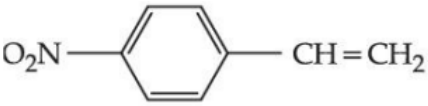
Th compound present is $[3Ca_3(PO_4)_2 \cdot CaF_2]$

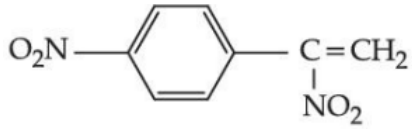
Which contains Ca^{+2}, P^{+5} & F^-

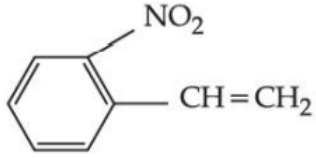
13. In the given reaction sequence, the major product 'C' is:

$$C_8H_{10} \xrightarrow[H_2SO_4]{HNO_3} A \xrightarrow[\Delta]{Br_2} B \xrightarrow[KOH]{\text{alcoholic}} C$$

(A) 

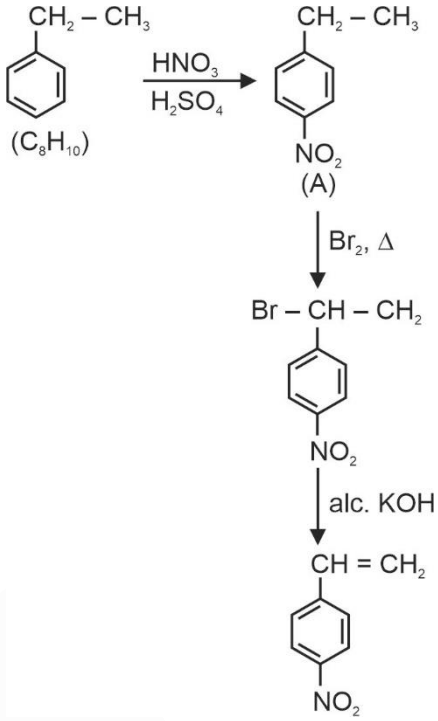
(B) 

(C) 

(D) 

Answer (B)

Sol.



14. Two statements are given below:

Statement I: The melting point of monocarboxylic acid with even number of carbon atoms is higher than that of with odd number of carbon atoms acid immediately below and above it in the series.

Statement II: The solubility of monocarboxylic acids in water decreases with increase in molar mass.

Choose the **most appropriate** option:

(A) Both **Statement I** and **Statement II** are correct.

(B) Both **Statement I** and **Statement II** are incorrect.

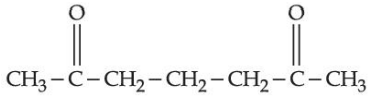
(C) **Statement I** is correct but **Statement II** is incorrect.

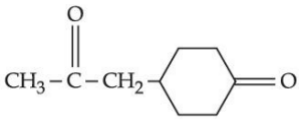
(D) **Statement I** is incorrect but **Statement II** is correct.

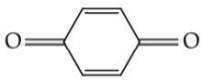
Answer (A)

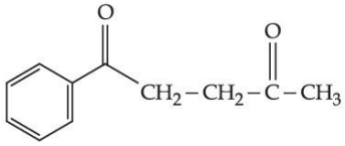
Sol. Statement (I) is correct as monocarboxylic acids with even number of carbon atoms show better packing efficiency in solid state, statement (II) is also correct as the solubility of carboxylic acids decreases with increase in molar mass due to increase in the hydrophobic portion with increase in the number of carbon atoms.

15. Which of the following is an example of conjugated diketone?

(A) 

(B) 

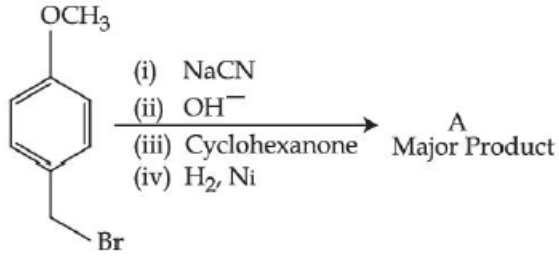
(C) 

(D) 

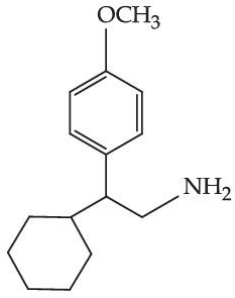
Answer (C)

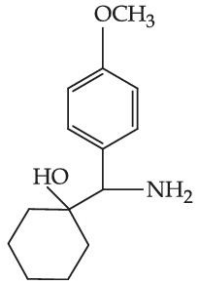
Sol.  is a conjugated diketone.

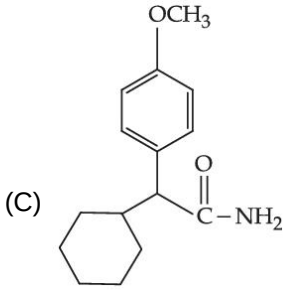
In rest of the diketones given in the question, the two (C = O) groups are not in conjugation with each other.

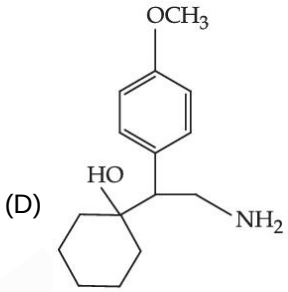
16. 

The major product of the above reactions is :

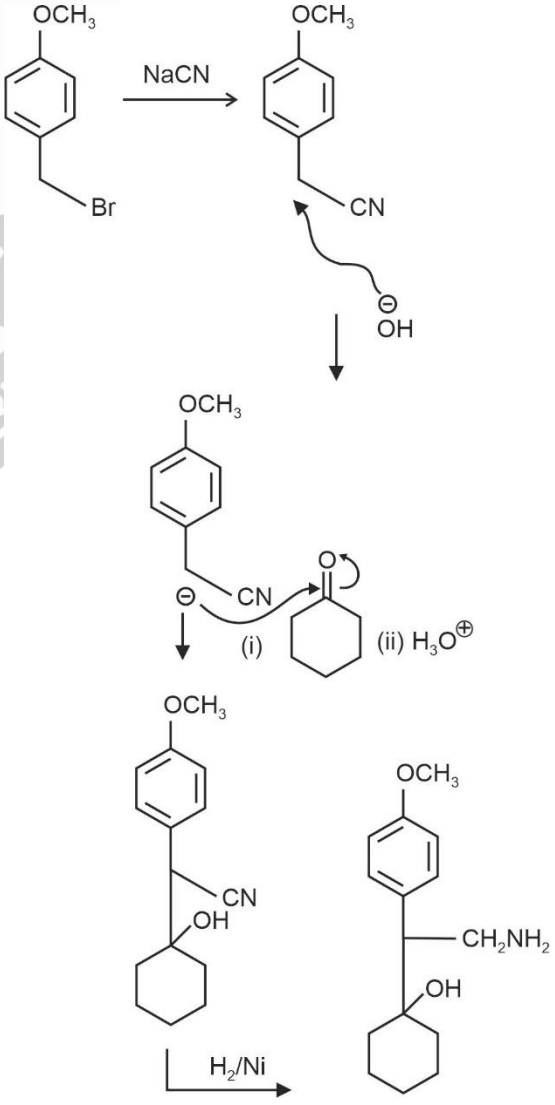
(A) 

(B) 

(C) 

(D) 

Answer (D)

Sol. 

Hence, the correct option is (D).

17. Which of the following is an example of polyester?

(A) Butadiene-styrene copolymer

(B) Melamine polymer

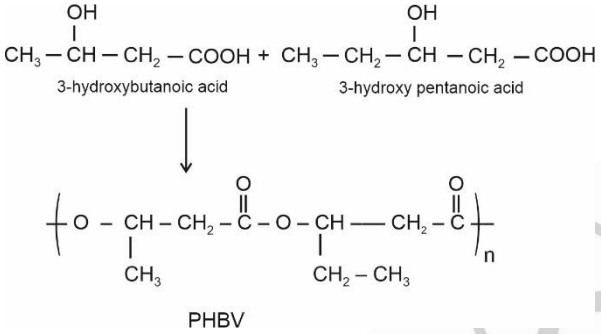
(C) Neoprene

(D) Poly-β-hydroxybutyrate-co-β-hydroxy valerate

Answer (D)

Sol. Polyesters are formed by condensation reaction between alcohols and carboxylic acid.

Poly-β-hydroxybutyrate-co-β-hydroxy valerate (PHBV) is a polymer obtained by condensation reaction of 3-hydroxybutanoic acid with 3-hydroxypentanoic acid.



Hence, PHBV is a polyester.

18. A polysaccharide 'X' on boiling with dil. H_2SO_4 at 393 K under 2-3 atm pressure yields 'Y'. 'Y' on treatment with bromine water gives gluconic acid. 'X' contains β-glycosidic linkages only. Compound 'X' is:

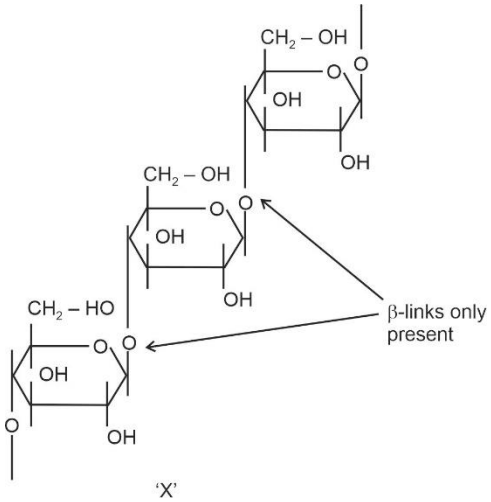
(A) starch (B) cellulose

(C) amylose (D) amylopectin

Answer (B)

Sol. Cellulose contains β-glycosidic linkages only.

Structure of cellulose



On boiling with dil. H_2SO_4 at 393 K under 2-3 atm, 'X' forms glucose, which given gluconic acid on treatment with bromine water.

19. Which of the following is not a broad-spectrum antibiotic?

(A) Vancomycin

(B) Ampicillin

(C) Ofloxacin

(D) Penicillin G

Answer (D)

Sol. Penicillin G is a narrow spectrum antibiotic. (Based on fact)

20. During the qualitative analysis of salt with cation y^{2+}, addition of a reagent (X) to alkaline solution of the salt gives a bright red precipitate. The reagent (X) and the cation (y^{2+}) present respectively are:

(A) Dimethylglyoxime and Ni^{2+}

(B) Dimethylglyoxime and Co^{2+}

(C) Nessler's reagent and Hg^{2+}

(D) Nessler's reagent and Ni^{2+}

Answer (A)

Sol. On addition of dimethylglyoxime to alkaline solution of Ni^{+2}, a bright red ppt. is obtained.

$Ni^{+2} + 2dmg \rightarrow [Ni(dmg)_2]^{+2}$ (Bright red ppt)

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

1. Atoms of element X form hcp lattice and those of element Y occupy $\frac{2}{3}$ of its tetrahedral voids. The percentage of element X in the lattice is _____ . (Nearest integer)

Answer (43)

Sol. Since X occupies hcp lattice,

Number of particles of type X in a unit cell = 6

Number of particles of type Y = $\frac{2}{3} \times 12 = 8$

$\therefore$ Percentage of element X = $\frac{6}{14} \times 100$

$= \frac{300}{7}$

$= 42.85$

$\simeq 43\%$

2. $2O_3(g) \rightleftharpoons 3O_2(g)$

At 300 K, ozone is fifty percent dissociated. The standard free energy change at this temperature and 1 atm pressure is (–) ____ J mol^{-1}. (Nearest integer)

[Given: ln 1.35 = 0.3 and R = 8.3 J K^{-1} mol^{-1}]

Answer (747)

Sol. $\underset{1-x}{2O_3(g)} \rightleftharpoons \underset{\frac{3x}{2}}{3O_2(g)}$

Given, x = 0.5

$\therefore\ k_p = \frac{[3(0.5)]^3 \times 1}{[2]^3 \times (0.5)^2 \times 1.25}$

$\therefore\ k_p = \frac{27}{8} \times \frac{0.5}{1.25} = 1.35$

$\Delta G^\circ = -2.303\ RT \log k_p$

$= -2.303 \times 8.3 \times 300 \log 1.35$

$= -8.3 \times 300 \ln(1.35)$

$= -747$ J mol^{-1}

3. The osmotic pressure of blood is 7.47 bar at 300 K. To inject glucose to a patient intravenously, it has to be isotonic with blood. The concentration of glucose solution in gL^{-1} is _____. (Molar mass of glucose = 180 g mol^{-1}

R = 0.083 L bar K^{-1} mol^{-1}) (Nearest integer)

Answer (54)

Sol. $7.47 = C \times 0.083 \times 300$

($\pi = CRT$)

(Where C represents the concentration of glucose solution and π represents osmotic pressure)

$C = \frac{7.47}{0.083 \times 300} (\text{mol L}^{-1})$

which in gm/L = $\frac{7.47}{0.083 \times 300} \times 180$

= 54 gm/l

4. The cell potential for the following cell

Pt $|H_2(g)|H^+(aq)||\ Cu^{2+}$ (0.01 M)|Cu(s)

is 0.576 V at 298 K. The pH of the solution is ___ . (Nearest integer)

(Given: $E^0_{Cu^{2+}/Cu} = 0.34$ V and $\frac{2.303\,RT}{F} = 0.06$ V)

Answer (5)

Sol. $E_{cell} = E^0_{cell} - \frac{0.06}{2} \log \frac{\left[H^\oplus\right]^2}{\left[Cu^{+2}\right]}$

$0.576 = 0.34 - 0.03 \log \frac{\left[H^\oplus\right]^2}{[0.01]}$

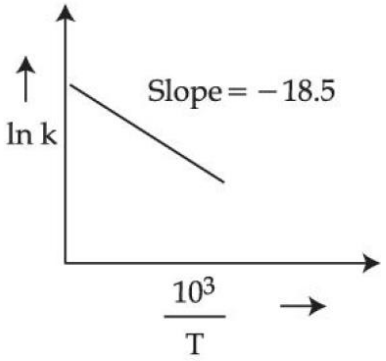
$0.576 - 0.34 = -0.03 \log \left[H^\oplus\right]^2 + 0.03 \log(0.01)$

$= 0.06\ pH - 0.06$

$pH \simeq 4.93 \simeq 5$

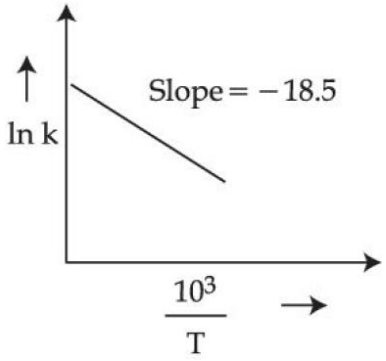
5. The rate constants for decomposition of acetaldehyde have been measured over the temperature range 700 – 1000 K. The data has been analysed by plotting ln k vs $\frac{10^3}{T}$ graph. The value of activation energy for the reaction is _____ kJ mol^{-1}. (Nearest integer)

(Given : R = 8.31 J K^{-1} mol^{-1})



Answer (154)

Sol.



$$\ln k = \ln A - \frac{E_a}{RT}$$

$$\therefore \text{ Slope of the graph} = -\frac{E_a}{R\times 10^3} = -18.5$$

$$\therefore \quad E_a = 18.5\times 8.31\times 1000 \simeq 154 \text{ kJ mol}^{-1}$$

6. The difference in oxidation state of chromium in *chromate* and *dichromate* salts is _____,

Answer (0)

Sol. Chromate ion $\rightarrow CrO_4^{2-}$, oxidation state of Cr = +6

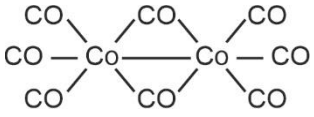
Dichromate ion $\rightarrow CrO_4^{2-}$, oxidation state of Cr = +6

$\therefore$ Difference in oxidation state = zero

7. In the cobalt-carbonyl complex: $[Co_2(CO)_8]$, number of Co-Co bonds is "X" and terminal CO ligands is "Y". X + Y = _____.

Answer (7)

Sol. Structure of $Co_2(CO)_8$



Number of Co – Co bonds = 1 = X

Number of terminal CO ligands = 6 = Y

$\therefore$ X + Y = 1 + 6 = 7

8. A 0.166 g sample of an organic compound was digested with conc. H_2SO_4 and then distilled with NaOH. The ammonia gas evolved was passed through 50.0 mL of 0.5 N H_2SO_4. The used acid required 30.0 mL of 0.25 N NaOH for complete neutralisation. The mass percentage of nitrogen in the organic compound is _____.

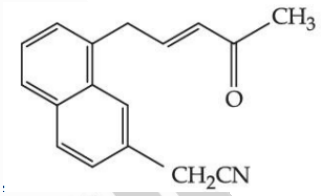
Answer (63)

Sol. Millimoles of used acid = $\frac{30\times 0.25}{2}$

Millimoles of NH_3 = 30 × 0.25 = 7.5

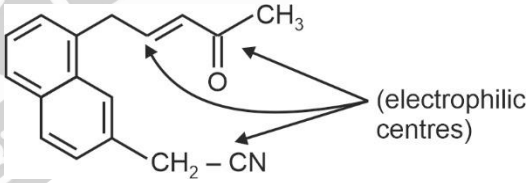
Mass% of nitrogen = $\frac{7.5}{0.166}\times 10^{-3}\times 14\times 100 \simeq 63\%$

9. Number of electrophilic centres in the given compound is _____.



Answer (3)

Sol. Given compounds :



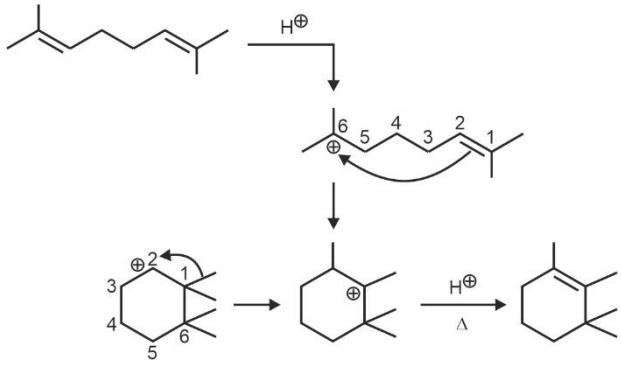
Number of electrophilic centres = 3

10. The major product 'A' of the following given reaction has _____ sp^2 hybridized carbon atoms.

2, 7-Dimethyl-2, 6-octadiene $\xrightarrow{H^+}$ A (Major Product)

Answer (2)

Sol.



Number of sp^2 hybridised carbon atoms = 2