JEE–MAIN EXAMINATION – JANUARY 2025

(HELD ON FRIDAY 24th JANUARY 2025) **TIME : 9 : 00 AM TO 12 : 00 NOON**

CHEMISTRY

TEST PAPER WITH SOLUTIONS

SECTION-A

51. For the given cell

$Fe^{2+}(eq) + Ag^{+}(aq) \rightarrow Fe^{3+}(aq) + Ag(s)$

The standard cell potential of the above reaction is

Given :

$Ag^{+} + e^{-} \rightarrow Ag$ $\quad E^0 = xV$

$Fe^{2+} + 2e^{-} \rightarrow Fe$ $\quad E^0 = y\ V$

$Fe^{3+} + 3e^{-} \rightarrow Fe$ $\quad E^0 = zV$

(1) $x + y - z$

(2) $x + 2y - 3z$

(3) $y - 2x$

(4) $x + 2y$

Ans. **(2)**

Sol. $Fe^{2+}(aq) + Ag^{+}(aq) \rightarrow Fe^{3+}(aq) + Ag(s)$

$Fe \xrightarrow{\Delta G_1^0} Fe^{+2} \xrightarrow{\Delta G_2^0} Fe^{+3}$, $Fe \xrightarrow{\Delta G_3^0} Fe^{+3}$

$\Delta G_3^0 = \Delta G_1^0 + \Delta G_2^0$

$-3F(-z) = -2F(-y) + \Delta G_2^0$

$\Delta G_2^0 = 3Fz - 2Fy$

Also $\Delta G_2^0 = -nFE^0_{Fe^{+2}/Fe^{+3}}$

$3Fz - 2Fy = -1F(E^0_{Fe^{+2}/Fe^{+3}})$

$E^0_{Fe^{+2}/Fe^{+3}} = 2y - 3z$

E^0_{Cell} for reaction will be

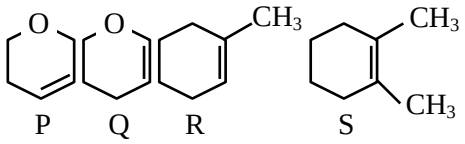
$E^0_{Ag^{+}/Ag} + E^0_{Fe^{+2}/Fe^{+3}}$

$= x + 2y - 3z$

Option (2)

52. Following are the four molecules "P", "Q", "R" and "S".

Which one among the four molecules will react with H-Br(aq) at the fastest rate ?

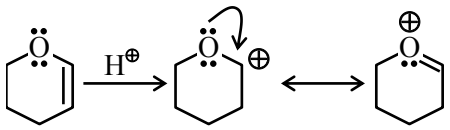


(1) S (2) Q

(3) R (4) P

Ans. **(2)**

Sol. Addition of H-$Br_{(aq)}$ to alkene follows electrophilic addition mechanism. In the rate determining step a carbocation intermediate is formed. Among P, Q, R & S compound Q will form most stable carbocation intermediate since it is resonance stabilized.



53. One mole of the octahedral complex compound $Co(NH_3)_5Cl_3$ gives 3 moles of ions on dissolution in water. One mole of the same complex reacts with excess of $AgNO_3$ solution to yield two moles of $AgCl_{(s)}$. The structure of the complex is :

(1) $[Co(NH_3)_5Cl]Cl_2$

(2) $[Co(NH_3)_4Cl].Cl_2.NH_3$

(3) $[Co(NH_3)_4Cl_2]Cl.NH_3$

(4) $[Co(NH_3)_3Cl_3].2NH_3$

Ans. **(1)**

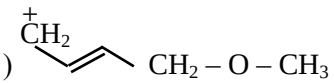
Sol.

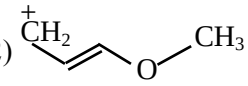
$$\left[Co(NH_3)_5Cl\right]Cl_2 \rightarrow \underbrace{\left[Co(NH_3)_5Cl\right]^{2+}(aq.) + 2Cl^{-}(aq.)}_{\text{3 ions in water}}$$

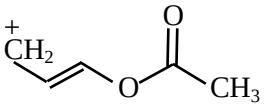
$[Co(NH_3)_5Cl]Cl_2(aq.) + 2AgNO_3(aq.) \rightarrow$

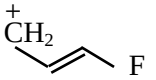
$[Co(NH_3)_5Cl](NO_3)_2(aq.) + 2AgCl(s)$

54. Which one of the carbocations from the following is most stable ?

(1) 

(2) 

(3) 

(4) 

Ans. **(2)**

Sol. Carbocation intermediate is stabilised by +I, +M & hyperconjugation effect. Since in option 2 carbocation is in conjugation with stronger +M group $-OCH_3$ hence it will be most stable.

55. Which of the following linear combination of atomic orbitals will lead to formation of molecular orbitals in homonuclear diatomic molecules [internuclear axis in z-direction] ?

A. $2p_z$ and $2p_x$

B. 2s and $2p_x$

C. $3d_{xy}$ and $3d_{x^2-y^2}$

D. 2s and $2p_z$

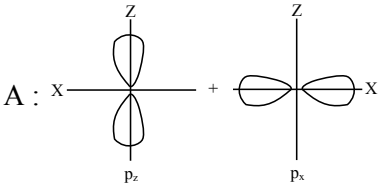
E. $2p_z$ and $3d_{x^2-y^2}$

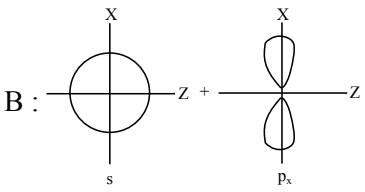
(1) E Only (2) A and B Only

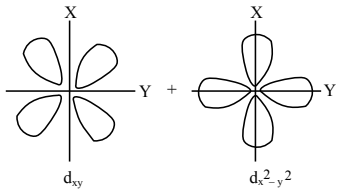
(3) D Only (4) C and D Only

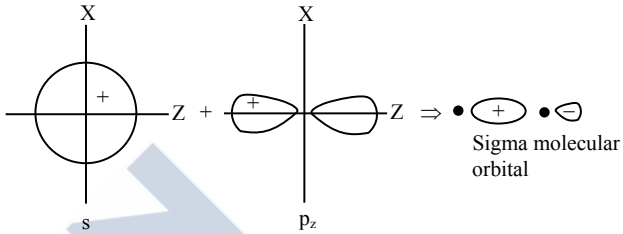
Ans. **(3)**

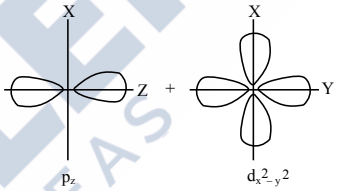
Sol.

A :  ⇒ no molecular orbital

B :  ⇒ no molecular orbital

C :  ⇒ no molecular orbital

D : 
Sigma molecular orbital

E :  ⇒ no molecular orbital

56. Which of the following ions is the strongest oxidizing agent ?

(Atomic Number of Ce = 58, Eu = 63, Tb = 65, Lu = 71]

(1) Lu^{3+} (2) Eu^{2+}

(3) Tb^{4+} (4) Ce^{3+}

Ans. **(3)**

Sol. Tb^{4+} is strongest oxidising agent

57. Ksp for $Cr(OH)_3$ is 1.6×10^{-30}. What is the molar solubility of this salt in water?

(1) $\sqrt[4]{\frac{1.6\times10^{-30}}{27}}$ (2) $\frac{1.8\times10^{-30}}{27}$

(3) $\sqrt[5]{1.8\times10^{-30}}$ (4) $\sqrt[2]{1.6\times10^{-30}}$

Ans. **(1)**

Sol. $Cr(OH)_{3\,(s)} \rightleftharpoons Cr^{+3}_{(aq)} + 3OH^-_{(aq)}$

At eq : s 3s

$K_{sp} = (s).(3s)^3 = 27s^4$

$27s^4 = 1.6 \times 10^{-30}$

$s = \left(\frac{1.6}{27}\times10^{-30}\right)^{1/4}$

Option (1)

58. Let us consider an endothermic reaction which is non-spontaneous at the freezing point of water. However, the reaction is spontaneous at boiling point of water. Choose the correct option.

(1) Both ΔH and ΔS are (+ve)

(2) ΔH is (–ve) but ΔS is (+ve)

(3) ΔH is (+ve) but ΔS is (–ve)

(4) Both ΔH and ΔS are (–ve)

Ans. **(1)**

Sol. Reaction is spontaneous at relatively high temperature and non-spontaneous at low temperature $\Delta G = \Delta H - T\Delta S$

It is only possible when ΔH and ΔS both are positive.

Option (1)

59. Given below are two statements I and II.

Statement I : Dumas method is used for estimation of "Nitrogen" in an organic compound.

Statement II : Dumas method involves the formation of ammonium sulphate by heating the organic compound with conc H_2SO_4.

In the light of the above statements, choose the ***correct*** answer from the options given below

(1) Both Statement I and Statement II are true

(2) Statement I is false but Statement II is true

(3) Both Statement I and Statement II are false

(4) Statement I is true but Statement II is false

Ans. **(4)**

Sol. In Dumas method nitrogen present in organic compound is converted into N_2 gas whose volumetric analysis gives the percentage of nitrogen atom in the organic compound.

60. Which of the following Statements are NOT true about the periodic table?

A. The properties of elements are function of atomic weights.

B. The properties of elements are function of atomic numbers.

C. Elements having similar outer electronic configuration are arranged in same period.

D. An element's location reflects the quantum numbers of the last filled orbital.

E. The number of elements in a period is same as the number of atomic orbitals available in energy level that is being filled.

Choose the correct answer from the options given below:

(1) A, C and E Only (2) D and E Only

(3) A and E Only (4) B, C and E Only

Ans. **(1)**

Sol. Properties of elements are periodic function of their atomic number. Elements having similar outer electronic configuration are arranged in same group. Number of elements in a period is not equal to number of atomic orbitals available in energy level that is being filled.

Hence, A, C & E are incorrect

61. The carbohydrates "Ribose" present in DNA, is

A. A pentose sugar

B. present in pyranose from

C. in "D" configuration

D. a reducing sugar, when free

E. in α-anomeric form

Choose the correct answer from the options given below :

(1) A, C and D Only

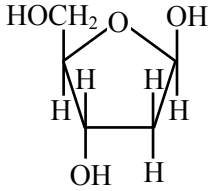
(2) A, B and E Only

(3) B, D and E Only

(4) A, D and E Only

Ans. **(1)**

Sol. In Ribose carbohydrate present in DNA is β-2-Deoxy-D-Ribose whose structure is



which is a reducing D-sugar in β anomeric form & it is a pentose sugar.

62. Preparation of potassium permanganate from MnO_2 involves two step process in which the 1st step is a reaction with KOH and KNO_3 to produce

(1) $K_4[Mn(OH)_6]$ (2) K_3MnO_4

(3) $KMnO_4$ (4) K_2MnO_4

Ans. **(4)**

Sol. $MnO_2 \xrightarrow[KNO_3,\Delta]{KOH} K_2MnO_4$

63. The large difference between the melting and boiling points of oxygen and sulphur may be explained on the basis of

(1) Atomic size (2) Atomicity

(3) Electronegativity (4) Electron gain enthalpy

Ans. **(2)**

Sol. Oxygen exists as O_2 (Atomicity = 2)

Sulphur exists as S_8 (Atomicity = 8)

Hence, Melting point & Boiling point of sulphur are significantly large compared to oxygen.

64. For a reaction, $N_2O_{5(g)} \rightarrow 2NO_{2(g)} + \frac{1}{2} O_{2(g)}$ in a constant volume container, no products were present initially. The final pressure of the system when 50% of reaction gets completed is

(1) 7/2 times of initial pressure

(2) 5 times of initial pressure

(3) 5/2 times of initial pressure

(4) 7/4 times of initial pressure

Ans. **(4)**

Sol

$$N_2O_{5(g)} \longrightarrow 2NO_{2(g)} + \frac{1}{2}O_{2(g)}$$

t = 0	P_0	–	–
t = t	P_0–x	2x	$\frac{x}{2}$

$$x = \frac{P_0}{2}$$

$$P_{total} = P_0 - \frac{P_0}{2} + P_0 + \frac{P_0}{4} = \frac{7}{4}P_0$$

Option (4)

65. Which of the following arrangements with respect to their reactivity in nucleophilic addition reaction is correct?

(1) benzaldehyde < acetophenone < p-nitrobenzaldehyde < p-tolualdehyde

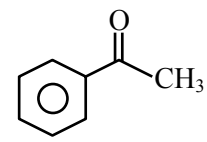
(2) acetophenone < benzaldehyde < p-tolualdehyde < p-nitrobenzaldehyde

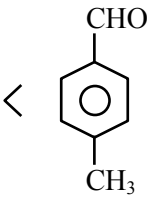
(3) acetophenone < p-tolualdehyde < benzaldehyde < p-nitrobenzaldehyde

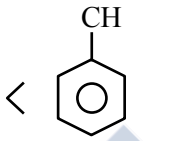
(4) p-nitrobenzaldehyde < benzaldehyde < p-tolualdehyde < acetophenone

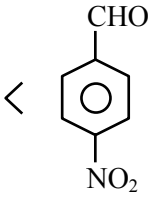
Ans. **(3)**

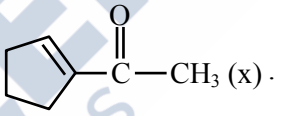
Sol. The rate of nucleophilic addition decreased due to steric crowding around carbonyl carbon & increased by electron withdrawing group if the steric crowding is same hence the reactivity towards nucleophilic addition will be

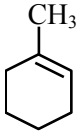

(Acetophenone)

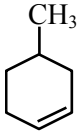

(p-tolualdehyde)

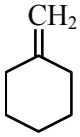

(benzaldehyde)

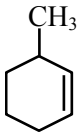

(p-nitrobenzaldehyde)

66. Aman has been asked to synthesise the molecule  (x). He thought of preparing the molecule using an aldol condensation reaction. He found a few cyclic alkenes in his laboratory. He thought of performing ozonolysis reaction on alkene to produce a dicarbonyl compound followed by aldol reaction to prepare "x". Predict the suitable alkene that can lead to the formation of "x".

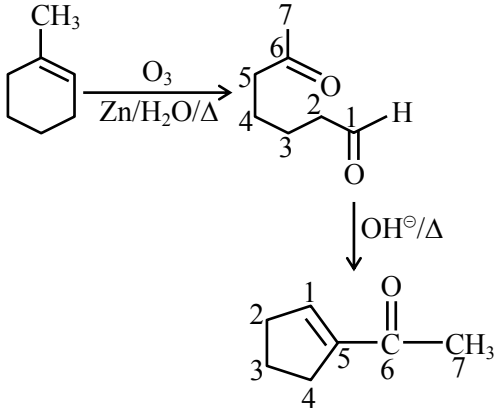
(1) 

(2) 

(3) 

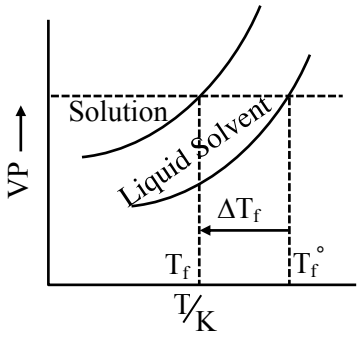
(4) 

Ans. **(1)**

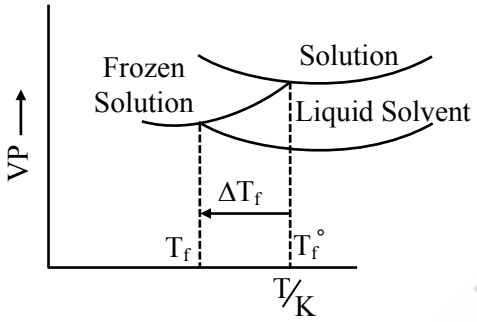
Sol. 

67. Consider the given plots of vapour pressure (VP) vs temperature (T/K) Which amongst the following options is correct graphical representation showing ΔT_f, depression in the freezing point of solvent in a solution ?

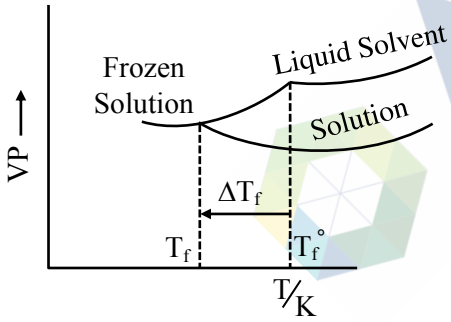
(1)



(2)



(3)



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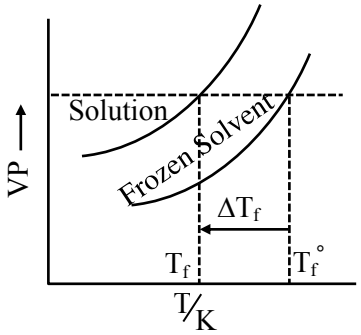


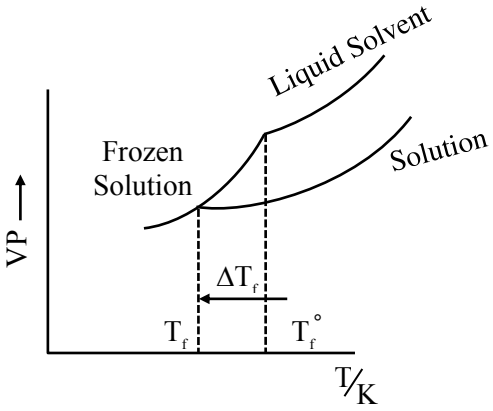
Ans. **(3)**

Sol. On adding non-volatile solute in a solvent, the freezing point of solution decreases.

$T_f < T_f^0$

F.P. of solution < F.P. of pure solvent

Also V.P. of solution decreases on adding non-volatile solute in a solvent.



68. Which of the following statement is true with respect to H_2O, NH_3 and CH_4?

A. The central atoms of all the molecules are sp^3 hybridized.

B. The H–O–H, H–N–H and H–C–H angles in the above molecules are 104.5°, 107.5° and 109.5° respectively.

C. The increasing order of dipole moment is $CH_4 < NH_3 < H_2O$.

D. Both H_2O and NH_3 are Lewis acids and CH_4 is a Lewis base

E. A solution of NH_3 in H_2O is basic. In this solution NH_3 and H_2O act as Lowry-Bronsted acid and base respectively.

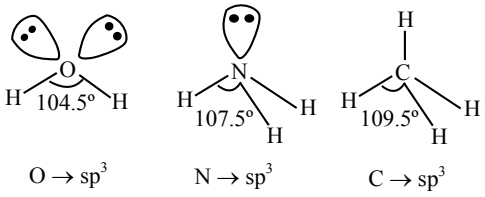
Choose the correct answer from the options given below :

(1) A, B and C only (2) C, D and E only

(3) A, D and E only (4) A, B, C and E only

Ans. **(1)**

Sol.



$O \rightarrow sp^3$ $N \rightarrow sp^3$ $C \rightarrow sp^3$

Dipole moment $H_2O > NH_3 > CH_4$

H_2O & NH_3 are Lewis Bases

NH_3 act as Lowry- Bronsted base

Hence, A, B & C are correct

69. Given below are two statements :

Statement-I : The conversion proceeds well in the less polar medium.

$CH_3–CH_2–CH_2–CH_2–Cl \xrightarrow{HO^-} CH_3–CH_2–CH_2–CH_2–OH + Cl^-$

Statement-II : The conversion proceeds well in the more polar medium.

$CH_3–CH_2–CH_2–CH_2–Cl \xrightarrow{R_3\ddot{N}} CH_3–CH_2–CH_2–CH_2–\overset{R}{\underset{R}{\overset{|}{\underset{|}{N^{(+)}}}}}–R\ Cl^{(-)}$

In the light of the above statements, choose the *correct* answer from the options given below.

(1) Both statement I and statement II are true

(2) Both statement I and statement II are false

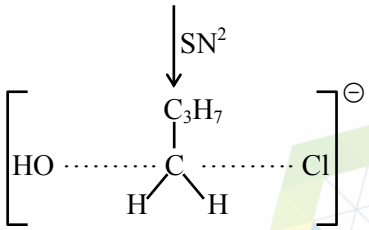
(3) Statement I is false but statement II is true

(4) Statement I is true but statement II is false

Ans. (1)

Sol. $CH_3 – CH_2 – CH_2 – CH_2 – Cl + \overset{\ominus}{O}H$

Reactant (higher charge density)

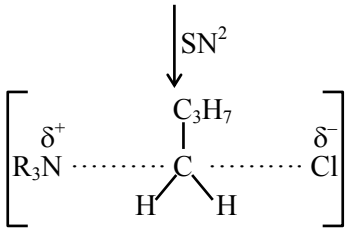


Transition state (less charge density)

$\Rightarrow$ This reaction will proceed faster in less polar medium which will not increase the activation energy value.

$CH_3 – CH_2 – CH_2 – CH_2 – Cl + R_3N$

Reactant (low charge density)



Transition state (Higher charge density)

$\Rightarrow$ This reaction will proceed faster in more polar medium which will decrease the activation energy value.

70. The product (A) formed in the following reaction sequence is :

$CH_3–C\equiv CH \xrightarrow[(iii)H_2/Ni]{(i)Hg^{2+},\ H_2SO_4\ (ii)HCN}$ (A) Product

(1) $CH_3–\overset{NH_2}{\underset{CH_3}{\overset{|}{\underset{|}{C}}}}–CH_2–OH$

(2) $CH_3–\overset{OH}{\underset{CH_3}{\overset{|}{\underset{|}{C}}}}–CH_2–NH_2$

(3) $CH_3–CH_2–\overset{NH_2}{\overset{|}{CH}}–CH_2–OH$

(4) $CH_3–CH_2–\overset{OH}{\overset{|}{CH}}–CH_2–NH_2$

Ans. (2)

Sol. $CH_3 – C \equiv CH \xrightarrow{Hg^{2+},\ H_2SO_4} CH_3 – \overset{O}{\overset{\|}{C}} – CH_3$

$CH_3 – \overset{O}{\overset{\|}{C}} – CH_3 \xrightarrow{HCN} CH_3 – \underset{CH_2–NH_2}{\overset{OH}{\overset{|}{\underset{|}{C}}}} – CH_3 \xleftarrow{H_2/Ni} CH_3 – \underset{CN}{\overset{OH}{\overset{|}{\underset{|}{C}}}} – CH_3$

SECTION-B

71. 37.8 g N_2O_5 was taken in a 1 L reaction vessel and allowed to undergo the following reaction at 500 K

$2N_2O_{5(g)} \rightarrow 2N_2O_{4(g)} + O_{2(g)}$

The total pressure at equilibrium was found to be 18.65 bar.

Then, Kp = _____ $\times 10^{-2}$ [nearest integer]

Assume N_2O_5 to behave ideally under these conditions

Given : R = 0.082 bar L mol^{-1} K^{-1}

Ans. (962)

Sol. Initial pressure of N_2O_5

$$= \frac{\frac{37.8}{108} \times 0.082 \times 500}{1} = 14.35\,\text{bar}$$

$$2N_2O_5 \rightleftharpoons 2N_2O_4 + O_2$$

t = 0	14.35		
t = eq	14.35 –2P	2P	P

P_{Total} at eqb = 14.35 + P = 18.65

P = 4.3

$P_{N_2O_5} = 5.75\,\text{bar}$

$P_{N_2O_4} = 8.6\,\text{bar}$

$P_{O_2} = 4.3\,\text{bar}$

$$k_p = \frac{(8.6)^2 \times (4.3)}{(5.75)^2} = 9.619 = x \times 10^{-2}$$

$x = 961.9 \approx 962$

Ans. 962

72. Standard entropies of X_2, Y_2 and XY_5 are 70, 50 and 110 J K^{-1} mol^{-1} respectively. The temperature in Kelvin at which the reaction

$$\frac{1}{2}X_2 + \frac{5}{2}Y_2 \rightarrow XY_5 \quad \Delta H^- = -35\ \text{kJ mol}^{-1}$$

Will be at equilibrium is ____ (Nearest integer)

Ans. (700)

Sol. $\frac{1}{2}X_2 + \frac{5}{2}Y_2 \rightleftharpoons XY_5$

$$\Delta S^0_{R\,xn} = 110 - \left[\left(\frac{1}{2} \times 70\right) + \left(\frac{5}{2} \times 50\right)\right]$$

= 110 – 160 = – 50 JK^{-1} mol^{-1}

$\Delta G^0 = 0$ at eqb

$\Delta G^0 = \Delta H^0 - T\Delta S^0$

0 = –35000 – T(–50)

T = 700 Kelvin

Ans. 700

73. Xg of benzoic acid on reaction with aq. $NaHCO_3$ release CO_2 that occupied 11.2 L volume at STP. X is _____ g.

Ans. (61)

Sol. $C_6H_5COOH + NaHCO_3 \rightarrow C_6H_5COO^-Na^+ + H_2O + CO_2$

x gm 11.2 L

mole of C_6H_5COOH = mole of $CO_2 = \frac{11.2}{22.4} = 0.5$

mass of C_6H_5COOH = x = 0.5 × 122 = 61 gm

Ans. 61

74. Among the following cations, the number of cations which will give characteristic precipitate in their identification tests with $K_4[Fe(CN)_6]$ is :

Cu^{2+}, Fe^{3+}, Ba^{2+}, Ca^{2+}, NH_4^+, Mg^{2+}, Zn^{2+}

ALELN Ans. (4)

NTA Ans. (3)

Sol. Only Cu^{2+}, Fe^{3+}, Ca^{2+} & Zn^{2+} form precipitate with $K_4[Fe(CN)_6]$

75. Consider the following reaction occurring in the blast furnace.

$Fe_3O_{4(s)} + 4CO_{(g)} \rightarrow 3Fe_{(l)} + 4CO_{2(g)}$

'*x*' kg of iron is produced when 2.32 × 10^3 kg Fe_3O_4 and 2.8 × 10^2 kg CO are brought together in the furnace. The value of 'x' is ____. (nearest integer)

{Given :

Molar mass of Fe_3O_4 = 232 g mol^{-1}

Molar mass of CO = 28 g mol^{-1}

Molar mass of Fe = 56 g mol^{-1}}

Ans. (420)

Sol. moles of $Fe_3O_4 = \frac{2.32 \times 10^3 \times 10^3}{232} = 10000\,\text{mol}$

$$\text{moles of CO} = \frac{2.8 \times 10^2 \times 10^3}{28} = 10000\,\text{mol}$$

$$\underset{10^4\,\text{mol}}{Fe_3O_4} + \underset{10^4\,\text{mol}}{4CO} \longrightarrow 3Fe + 4CO_2$$

CO is L.R.

$$\text{mole of Fe} = \frac{3}{4} \times 10^4$$

$$\text{mass of Fe} = \frac{3}{4} \times \frac{10^4 \times 56}{1000}\,\text{kg} = 420\,\text{kg}$$

Ans. 420