Paper-1

JEE Advanced, 2016

Part II: Chemistry

Read the instructions carefully:

General:

1. This sealed booklet is your Question Paper. Do not break the seal till you are instructed to do so.
2. The question paper CODE is printed on the left hand top corner of this sheet and the right hand top corner of the back cover of this booklet.
3. Use the Optical Response Sheet (ORS) provided separately for answering the questions.
4. The paper CODE is printed on its left part as well as the right part of the ORS. Ensure that both these codes are identical and same as that on the question paper booklet. If not, contact the invigilator.
5. Blank spaces are provided within this booklet for rough work.
6. Write your name and roll number in the space provided on the back cover of this booklet.
7. After breaking the seal of the booklet at 9:00 am, verify that the booklet contains 36 pages and that all the 54 questions along with the options are legible. If not, contact the invigilator for replacement of the booklet.
8. You are allowed to take away the Question Paper at the end of the examination.

Optical Response Sheet

9. The ORS (top sheet) will be provided with an attached Candidate's Sheet (bottom sheet). The Candidate's Sheet is a carbon – less copy of the ORS.
10. Darken the appropriate bubbles on the ORS by applying sufficient pressure. This will leave an impression at the corresponding place on the Candidate's Sheet.
11. The ORS will be collected by the invigilator at the end of the examination.
12. You will be allowed to take away the Candidate's Sheet at the end of the examination.
13. Do not tamper with of mutilate the ORS. Do not use the ORS for rough work.

14. Write your name, roll number and code of the examination center, and sign with pen in the space provided for this purpose on the ORS. Do not write any of these details anywhere else on the ORS. Darken the appropriate bubble under each digit of your roll number.

Darken the Bubbles on the ORS

15. Use a Black Ball Point Pen to darken the bubbles on the ORS.

16. Darken the bubble  completely.

17. The correct way of darkening a bubble is as: 

18. The ORS is machine – gradable. Ensure that the bubbles are darkened in the correct way.

19. Darken the bubbles only if you are sure of the answer. There is no way to erase or "un–darken" a darkened bubble.

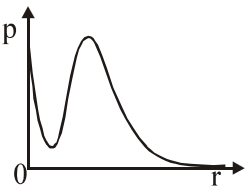
PART-II : CHEMISTRY

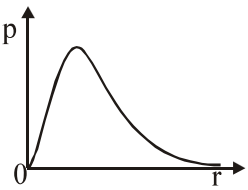
SECTION–1 : (Maximum Marks : 15)

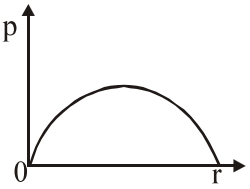
- This section contains **Five** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct
- For each question, darken the bubble corresponding to the correct option in the ORS
- For each question, marks will be awarded in one of the following categories :

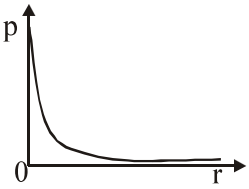
Full Marks : +3 If only the bubble corresponding to the correct option is darkened.
Zero Marks : 0 If none of the bubbles is darkened.
Negative Marks : –1 In all other cases

19. P is the probability of finding the 1s electron of hydrogen atom in a spherical shell of infinitesimal thickness, dr, at a distance r from the nucleus. The volume of this shell is $4\pi r^2 dr$. The qualitative sketch of the dependence of P on r is -

(A) 

(B) 

(C) 

(D) 

Ans. (B)

Sol. For 1s, radial part of wave function is

$$\psi_{(r)} = 2\left(\frac{1}{a_0}\right)^{\frac{3}{2}} e^{-\frac{r}{a_0}}$$

probability of finding an e^- in a spherical shell of thickness, 'dr' at distance 'r' from nucleus,

$P = \psi^2_{(r)} \cdot 4\pi r^2 dr$

$$= 16\pi r^2 \left(\frac{1}{a_0}\right)^3 e^{\frac{-2r}{a_0}} dr$$

So P is zero at r = 0 and r = ∞.

20. One mole of an ideal gas at 300 K in thermal contact with surroundings expands isothermally from 1.0 L to 2.0 L against a constant pressure of 3.0 atm. In this process, the change in entropy of surroundings (ΔS_{surr}) in J K^{-1} is -

(1 L atm = 101.3 J)

(A) 5.763 (B) 1.013 (C) –1.013 (D) –5.763

Ans. (C)

Sol. From 1st law of thermodynamics

$q_{sys} = \Delta U - w = 0 - [-P_{ext}.\Delta V]$

$= 3.0 \text{ atm} \times (2.0 \text{ L} - 1.0 \text{ L}) = 3.0 \text{ L-atm}$

$$\therefore \Delta S_{surr} = \frac{(q_{rev})_{surr}}{T} = -\frac{q_{sys}}{T}$$

$$= -\frac{3.0 \times 101.3 \text{J}}{300 \text{K}}$$

$$= -1.013 \text{ J/K}$$

21. The increasing order of atomic radii of the following group 13 elements is

(A) Al < Ga < In < Tl (B) Ga < Al < In < Tl

(C) Al < In < Ga < Tl (D) Al < Ga < Tl < In

Ans. (B)

Sol. The order of radius of 13th group elements is Ga < Al < In < Tl.

Reason ⇒ Due to poor shielding effect of d-orbital, radius of Ga is smallar than Al.

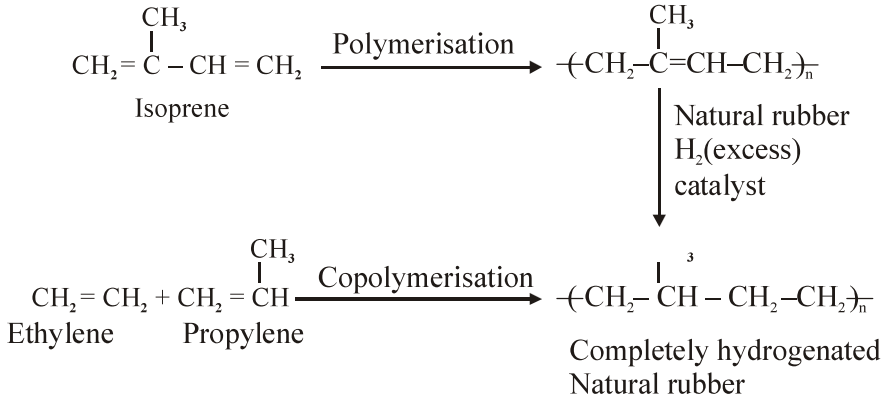
22. On complete hydrogenation, natural rubber produces

(A) ethylene-propylene copolymer (B) vulcanised rubber

(C) polypropylene (D) polybutylene

Ans. (A)

Sol.



23. Among $[Ni(CO)_4]$, $[NiCl_4]^{2-}$, $[Co(NH_3)_4Cl_2]Cl$, $Na_3[CoF_6]$, Na_2O_2 and CsO_2, the total number of paramagnetic compounds is -

(A) 2 (B) 3 (C) 4 (D) 5

Ans. (B)

Sol.

	Compound/Ion	**Magnetic nature of compound**
1.	$[Ni(CO)_4]$	Diamagnetic
2.	$[NiCl_4]^{2-}$	Paramagnetic
3.	$[Co(NH_3)_4Cl_2]Cl$	Diamagnetic
4.	$Na_3[CoF_6]$	Paramagnetic
5.	Na_2O_2	Diamagnetic
6.	CsO_2	Paramagnetic

So total number of paramagnetic compounds is 3.

SECTION–2 : (Maximum Marks : 32)

- This section contains **EIGHT** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct.
- For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS
- For each question, marks will be awarded in one of the following categories :

Full Marks : +4 If only the bubble(s) corresponding to the correct option(s) is (are) darkened.

Partial Marks : +1 For darkening a bubble corresponding **to each correct option**, Provided NO incorrect option is darkened.

Zero Marks : 0 If none of the bubbles is darkened.

Negative Marks : –2 In all other cases.

- for example, if (A), (C) and (D) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (A) and (D) will result in +2 marks; and darkening (A) and (B) will result in –2 marks, as a wrong option is also darkened

24. A plot of the number of neutrons (N) against the number of protons (P) of stable nuclei exhibits upwards deviation from linearity for atomic number, $Z > 20$. For an unstable nucleus having N/P ratio less than 1, the possible mode(s) of decay is(are) -

(A) β^- decay (β emission) (B) orbital or K-electron capture

(C) Neutron emission (D) β^+ decay (positron emission)

Ans. (B, D)

Sol. As $\frac{N}{P}$ ratio is less than 1, for possible decay mode , $\frac{N}{P}$ ratio should increase. The possible modes are α-decay, K-capture and β^+-decay. Hence, correct option are (B), (D).

(In β^--decay or neutron decay , $\frac{N}{P}$ ratio will decrease further)

25. The correct statements(s) about of the following reaction sequence is(are)

$$\text{Cumene}(C_9H_{12}) \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } O_2} \mathbf{P} \xrightarrow{CHCl_3/NaOH} \mathbf{Q}\text{ (major)} + \mathbf{R}\text{ (minor)}$$

$$\mathbf{Q} \xrightarrow[PhCH_2Br]{NaOH} \mathbf{S}$$

(A) **R** is steam volatile

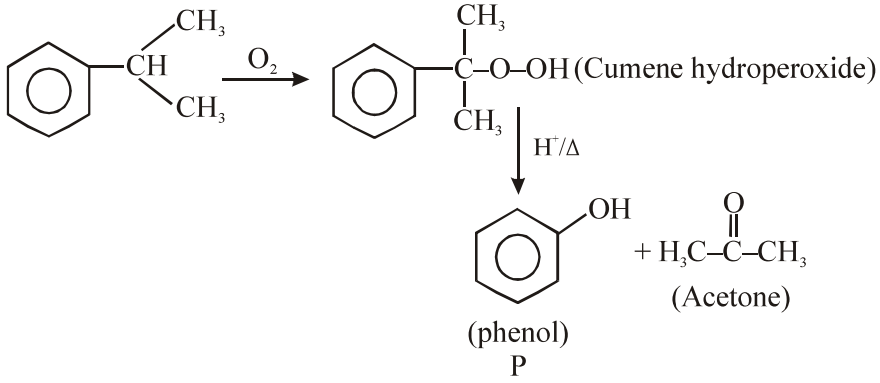
(B) **Q** gives dark violet coloration with 1% aqueous $FeCl_3$ solution

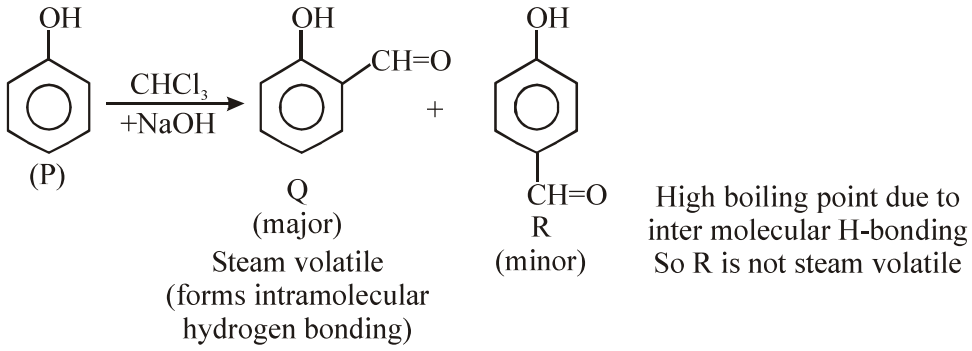
(C) **S** gives yellow precipitate with 2, 4,-dinitrophenylhydrazine

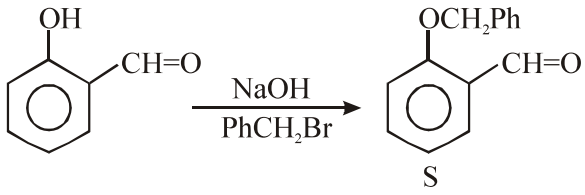
(D) **S** gives dark violet coloration with 1% aqueous $FeCl_3$ solution

Ans. (B, C)

Sol.



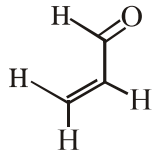


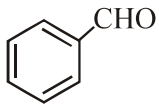


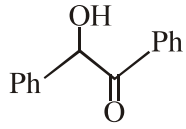
(does not give dark violet
coloration with 1% $FeCl_3$ solution)

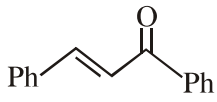
Q gives dark violet coloration with 1% aqueous $FeCl_3$ solution because it has phenolic (–OH) group.

26. Positive Tollen's test is observed for

(A) 

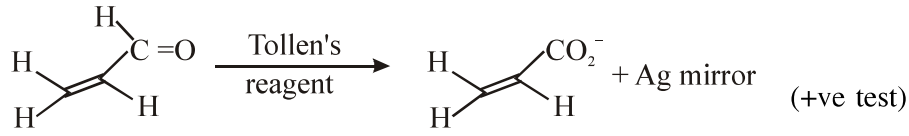
(B) 

(C) 

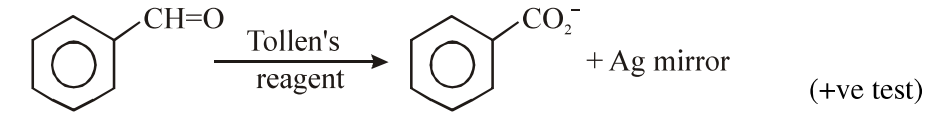
(D) 

Ans. (A,B,C)

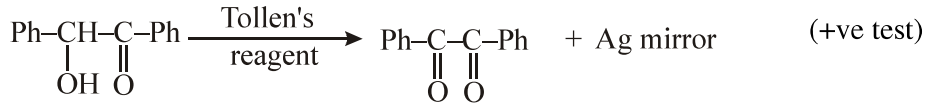
Sol. Tollens's test is given by compounds having aldehyde group. Also α-hydroxy carbonyl gives positive tollen's test.

(A) 

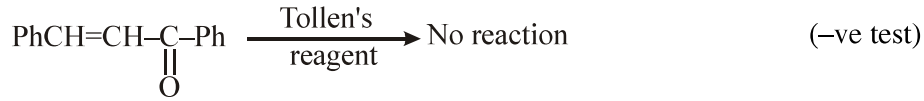
Acraldehyde

(B) 

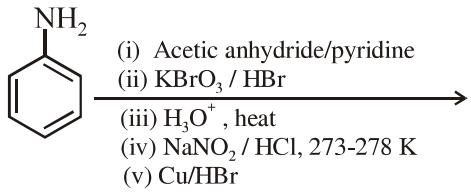
Benzaldehyde

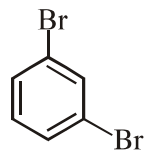
(C) 

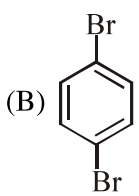
Benzoin

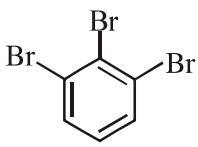
(D) 

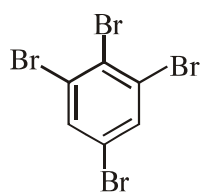
27. The product(s) of the following reaction sequence is(are)



(A) 

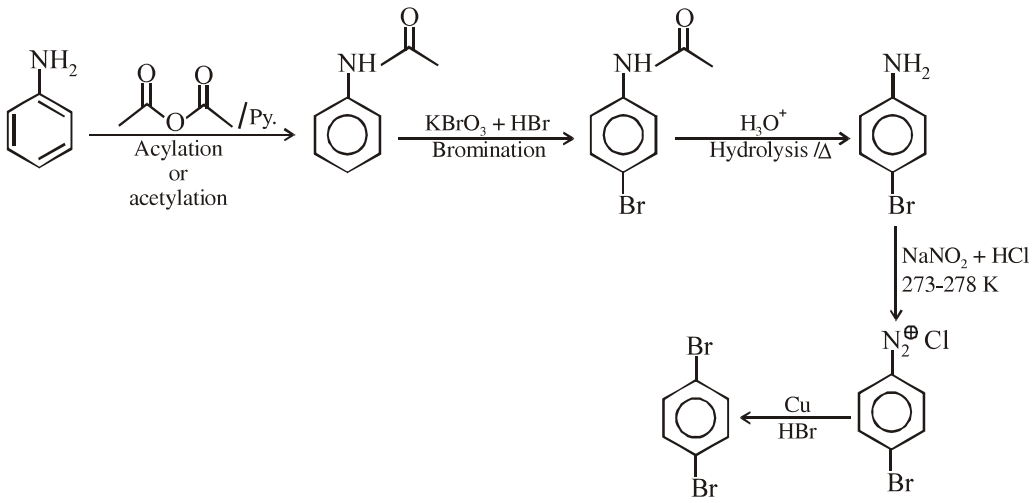
(B) 

(C) 

(D) 

Ans. (B)

Sol.

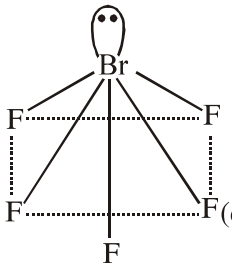


28. The compound(s) with TWO lone pairs of electrons on the central atom is(are)

(A) BrF_5 (B) ClF_3 (C) XeF_4 (D) SF_4

Ans. (B,C)

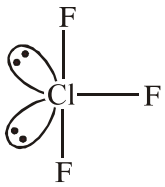
Sol. (A)



sp^3d^2 hybridisation
square pyramidal
(distorted octadehdral)

Number of lone pair on centre atom = 1

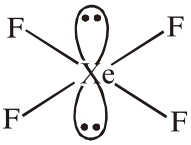
(B)



sp^3d hybridisation
T-shape

Number of lone pair on centre atom = 2

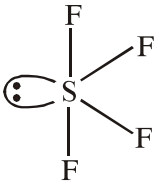
(C)



sp^3d^2 hybridisation
square planar

Number of lone pair on centre atom = 2

(D)



sp^3d hybridisation
see-saw

Number of lone pair on centre atom = 1

Hence **Ans. (B,C)**

29. The crystalline form of borax has

(A) Tetranuclear $[B_4O_5(OH)_4]^{2-}$ unit

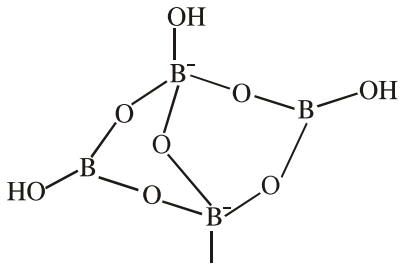
(B) All boron atoms in the same plane

(C) Equal number of sp^2 and sp^3 hybridized boron atoms

(D) One terminal hydroxide per boron atom

Ans. (A,C,D)

Sol.



(A) Having $[B_4O_5(OH)_4]^{2-}$ tetranuclear (boron) unit

(B) All boron atoms not in same plane

(C) Two boron are sp^2 hybridised and two boron are sp^3 hybridised

(D) One terminal hydroxide per boron atom is present.

30. The reagent(s) that can selectively precipiate S^{2-} from a mixture of S^{2-} and SO_4^{2-} in aqueous soltuion is(are) :

(A) $CuCl_2$ (B) $BaCl_2$ (C) $Pb(OOCCH_3)_2$ (D) $Na_2[Fe(CN)_5NO]$

Ans. (A OR A, C)

(A) $\underset{(Sol^n)}{CuCl_2} + \underset{(Sol^n)}{S^{2-}} \longrightarrow \underset{(Black\ ppt.)}{CuS\downarrow} + \underset{(Sol^n)}{2Cl^-}$

$\underset{(Sol^n)}{CuCl_2} + \underset{(Sol^n)}{SO_4^{2-}} \longrightarrow$ No ppt.

(B) $\underset{(Sol^n)}{BaCl_2} + \underset{(Sol^n)}{S^{2-}} \longrightarrow \underset{(No\ ppt.)}{BaS} + \underset{(Sol^n)}{2Cl^-}$

$\underset{(Sol^n)}{BaCl_2} + \underset{(Sol^n)}{SO_4^{2-}} \longrightarrow \underset{(White\ ppt.)}{BaSO_4\downarrow} + \underset{(Sol^n)}{2Cl^-}$

(C) $\underset{(Sol^n)}{Pb(OOCCH_3)_2} + \underset{(Sol^n)}{S^{2-}} \longrightarrow \underset{(Black\ ppt.)}{PbS\downarrow} + \underset{(Sol^n)}{2CH_3COO^-}$

$\underset{(Sol^n)}{Pb(OOCCH_3)_2} + \underset{(Sol^n)}{SO_4^{2-}} \longrightarrow \underset{(White\ ppt.)}{PbSO_4\downarrow} + \underset{(Sol^n)}{2CH_3COO^-}$

(D) $\underset{(Sol^n)}{Na_2[Fe(CN)_5NO]} + \underset{(Sol^n)}{S^{2-}} \longrightarrow \underset{(Purple\ colour\ solution)}{Na_4[Fe(CN)_5NOS]}$

$\underset{(Sol^n)}{Na_2[Fe(CN)_5NO]} + \underset{(Sol^n)}{SO_4^{2-}} \longrightarrow$ No ppt.

Note : $PbSO_4$ Ksp = 2.5×10^{-8}
PbS Ksp = 3×10^{-28} } Which are not given in question

As in question selective precipitation is asked PbS will be precipitate much easier than $PbSO_4$ though both are insoluble. Hence answer should be (C) also alongwith (A)

31. According to the Arrhenius equation,

(A) A high activation energy usually implies a fast reaction

(B) Rate constant increase with increase in temperature. This is due to a greater number of collisions whose energy exceeds the activation energy

(C) Higher the magnitude of activation energy, stronger is the temperature dependence of the rate constant

(D) The pre-exponential factor is a measure of the rate at which collisions occur, irrespective of their energy.

Ans. (B,C,D)

Sol. (A) $k = Ae^{-E_a/RT}$

High E_a means less k, hence slower rate.

(B) $e^{-Ea/RT}$ = fraction of molecules having kinetic energy greater than activation energy which increase as temperature increases.

(C) $\ln\frac{k_2}{k_1} = \frac{E_a}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$ i.e., $\ln\frac{k_2}{k_1} \propto E_a$

(D) Rate of reaction $\propto$ Total number of collisions × Fraction of collisions which can form product

Rate of reaction $\propto Z_{AB} \times (P \times e^{-E_a/RT})$

$\propto A\, e^{-E_a/RT}$

SECTION–3 : (Maximum Marks : 15)

- This section contains **FIVE** questions.
- The answer to each question is a **SINGLE DIGIT INTEGER** ranging from 0 to 9, both inclusive
- For each question, darken the bubble corresponding to the correct integer in the ORS.
- For each question, marks will be awarded in one of the following categories :

Full Marks : +3 If only the bubble corresponding to the correct answer is darkened.

Zero Marks : 0 In all other cases.

32. The mole fraction of a solute in a solution is 0.1. At 298 K, molarity of this solution is the same as its molality. Density of this solution at 298 K is 2.0 g cm^{-3}. The ratio of the molecular weights of the solute and solvent, $\left(\frac{MW_{solute}}{MW_{solvent}}\right)$, is

Ans. (9)

Sol. 1 mole solution has 0.1 mole solute and 0.9 mole solvent

Let M_1 = Molar mass solute

M_2 = Molar mass solvent

Molality, $m = \frac{0.1}{0.9M_2} \times 1000$ ....(1)

Molarity, $M = \frac{0.1}{0.1M_1 + 0.9M_2} \times 2 \times 1000$ .....(2)

$\because \quad m = M$

$\Rightarrow \quad \frac{0.1 \times 1000}{0.9M_2} = \frac{200}{0.1M_1 + 0.9M_2}$

$\Rightarrow \quad \frac{M_1}{M_2} = 9$

Alternate solution :

$\because \quad M = m$

$\Rightarrow$ volume of solution = mass of solvent

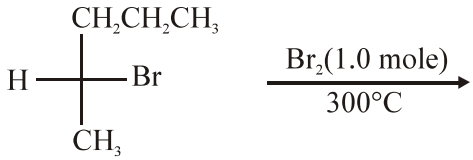
$\Rightarrow \quad \frac{W_{solute} + W_{solvent}}{2} = W_{solvent}$

$W_{solute} = W_{solvent}$

$0.1 \times M_{solute} = 0.9 \times M_{solvent}$

$\frac{M_{solute}}{M_{solvent}} = 9$

33. In the following monobromination reaction, the number of possible chiral products is

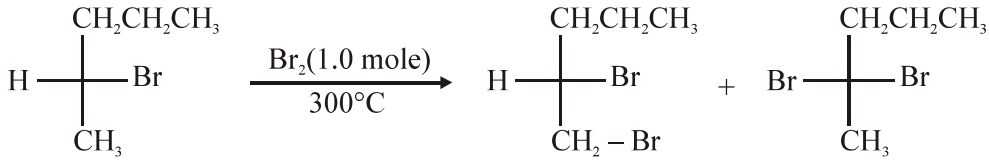


(1.0 mole)

(enantiomerically pure)

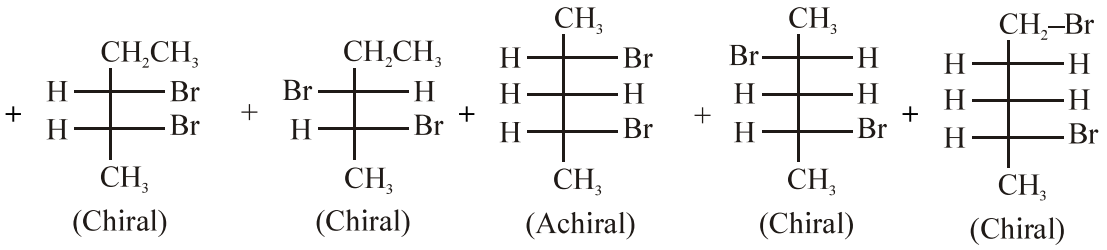
Ans. (5)

Sol.



(1.0 mole) (Chiral) (Achiral)

(enantiomerically pure)



34. The diffusion coefficient of an ideal gas is proportional to its mean free path and mean speed. The absolute temperature of an ideal gas is increased 4 times and its pressure is increased 2 times. As a result, the diffusion coefficient of this gas increases x times. The value of x is

Ans. (4)

Sol. Rate of diffusion $\propto \lambda \times U_{Avg}$

$$\propto \frac{1}{\sqrt{2}\pi\sigma^2 N^*} \times U_{Avg}$$

$$\propto \frac{U_{Avg}}{\sqrt{2}\pi\sigma^2 N^*}$$

$$\propto \frac{U_{Avg}\,(kT)}{\sqrt{2}\pi\sigma^2 P}$$

$$\text{Rate of diffusion} \propto \frac{T^{\frac{3}{2}}}{P}$$

$$\frac{r_{final}}{r_{initial}} = \frac{(4)^{\frac{3}{2}}}{2}$$

$$\frac{r_{final}}{r_{inital}} = 4$$

35. The number of geometric isomers possible for the complex $[CoL_2Cl_2]^-$ ($L = H_2NCH_2CH_2O^-$) is

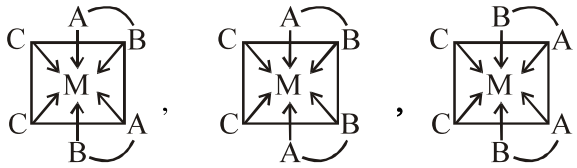
Ans. (5)

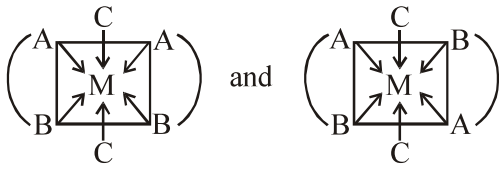
Sol. $[CoL_2Cl_2]^-$ $(L = H_2NCH_2CH_2O^-)$

$[Co(H_2NCH_2CH_2O)_2\ Cl_2]^{\ominus}$

$\downarrow$

It is $[M(AB)_2C_2]$ type of complex





Total geometrical isomers = 5

36. In neutral or faintly alkaline solution, 8 moles permanganate anion quantitatively oxidize thiosulphate anions to produce X moles of a sulphur containing product. the magnitude of X is

Ans. (6)

Sol. $\overset{+7}{MnO_4^-} + \overset{+2}{S_2O_3^{2-}} \longrightarrow \overset{+4}{MnO_2} + \underset{X}{\overset{+6}{SO_4^{2-}}}$

Equivalents of MnO_4^- = equivalents of SO_4^{2-}

Moles of MnO_4^- × n-factor = moles of SO_4^{2-} × n-factor

$8 \times 3 = X \times 4$

$X = 6$