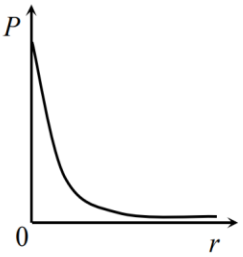
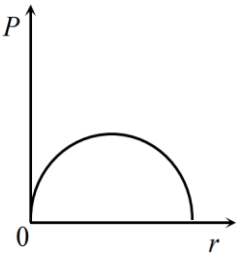
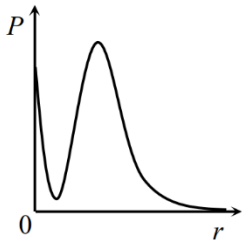
PART II: CHEMISTRY

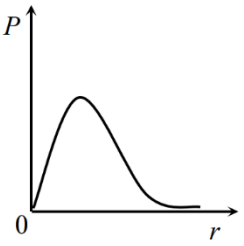
*19. P is the probability of finding the 1s electron of hydrogen atom in a spherical shell of infinitesimal thickness, dr, at a distance r from the nucleus. The volume of this shell is $4\pi r^2 dr$. The qualitative sketch of the dependence of P on r is

(A) 

(B) 

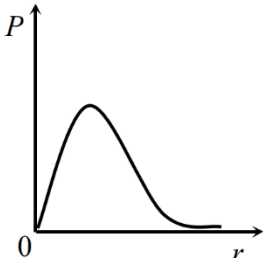
Kns

(C) 

(D) 

Sol. **(D)**

The probability distribution curve for 1s electron of hydrogen atom.



*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 surrounding (ΔS_{surr})in JK^{-1} is (1L atm = 101.3 J)

(A) 5.763 (B) 1.013

(C) – 1.013 (D) – 5.763

Sol. **(C)**

Isothermal process, $\Delta U = 0$

$dq = -dW = P_{ext}(V_2 - V_1) = 3\ L - atm = 3 \times 101.3$ Joule

$\Delta S_{surrounding} = -\frac{3\times101.3}{300}$ Joule K^{-1} $= -1.013$ Joule K^{-1}

$\therefore \Delta S_{surr} = -1.013$ Joule K^{-1}

*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 < T1 < In

Sol. **(B)**

Increasing order of atomic radius of group 13 elements Ga < Al < In < Tl.

Due to poor shielding of d-electrons in Ga, its radius decreases below Al.

22. 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

Sol. **(B)**

Number of paramagnetic compounds are 3.

Following compounds are paramagnetic.

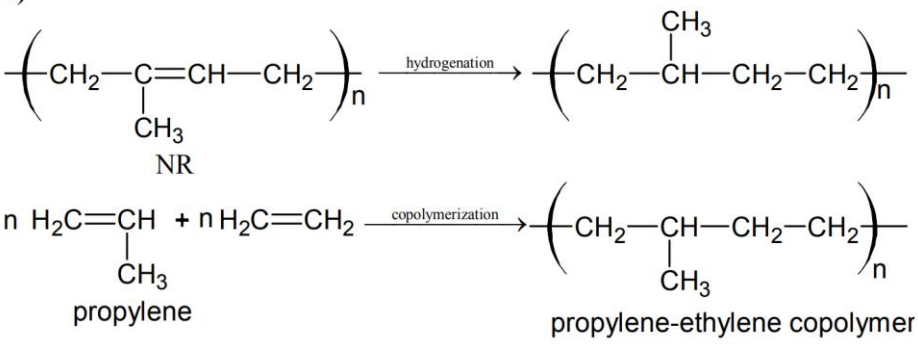
$[NiCl_4]^{2-}$, $Na_3[CoF_6]$, CsO_2

23. On complete hydrogenation, natural rubber produces

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

(C) polypropylene (D) polybutylene

Sol. **(A)**



24. According to the Arrhenius equation,
(A) a high activation energy usually implies a fast reaction.
(B) rate constant increases 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.

Sol. **(B, C, D)**

25. A plot of the number of neutrons (N) against the number of protons (P) of stable nuclei exhibits upward 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)

Sol. **(B, D)**

$\frac{n}{p} < 1$

Positron, emission

$${}_{a}X^{b} \longrightarrow {}_{+1}^{0}e + {}_{a-1}Y^{b}$$

$\Rightarrow$ K - electron capture

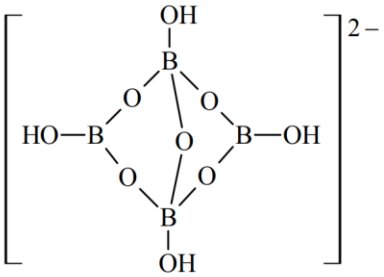
$${}_{a}X^{b} + {}_{-1}e^{0} \longrightarrow {}_{a-1}Y^{b}$$

Both process cause an increase in n/p ratio towards 1 thus stabilising the nucleus.

*26. 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

Sol. **(A, C, D)**

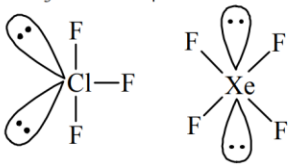
The structure of anion of borax is



*27. 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

Sol. **(B, C)**

ClF_3 and XeF_4 contain two lone pair of electrons on the central atom.



28. The reagent(s) that can selectively precipitate S^{2-} from a mixture of S^{2-} and SO_4^{2-} in aqueous solution is(are)

(A) $CuCl_2$ (B) $BaCl_2$

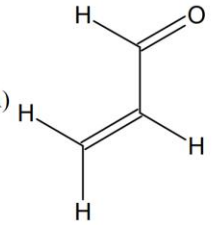
(C) $Pb(OOCCH_3)_2$ (D) $Na_2[Fe(CN)_5NO]$

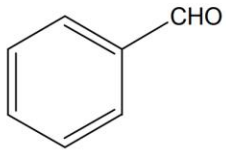
Sol. **(A)**

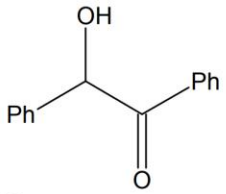
The reagent that can selectively precipitate S^{2-} and SO_4^{2-} in aqueous solution is $CuCl_2$.

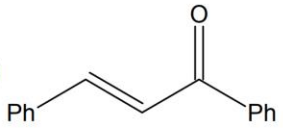
$$S^{2-} + CuCl_2 \longrightarrow CuS\downarrow + 2Cl^-$$

29. Positive Tollen's test is observed for

(A) 

(B) 

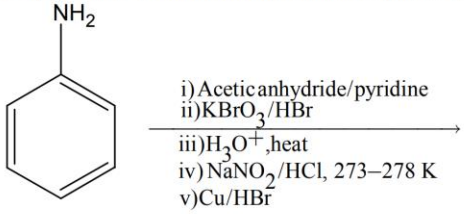
(C) 

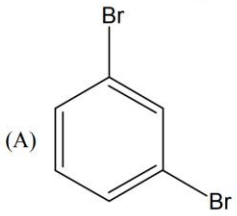
(D) 

Sol. **(A, B)**

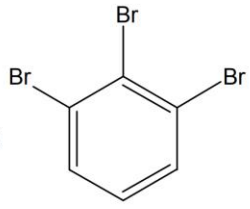
Beside aldehyde α-hydroxy ketones can also show Tollen's test due to rearrangement in aldehyde via ene diol intermediate. (however this needs a terminal α-carbon)

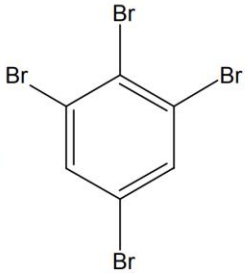
*30. The product(s) of the following reaction sequence is (are)



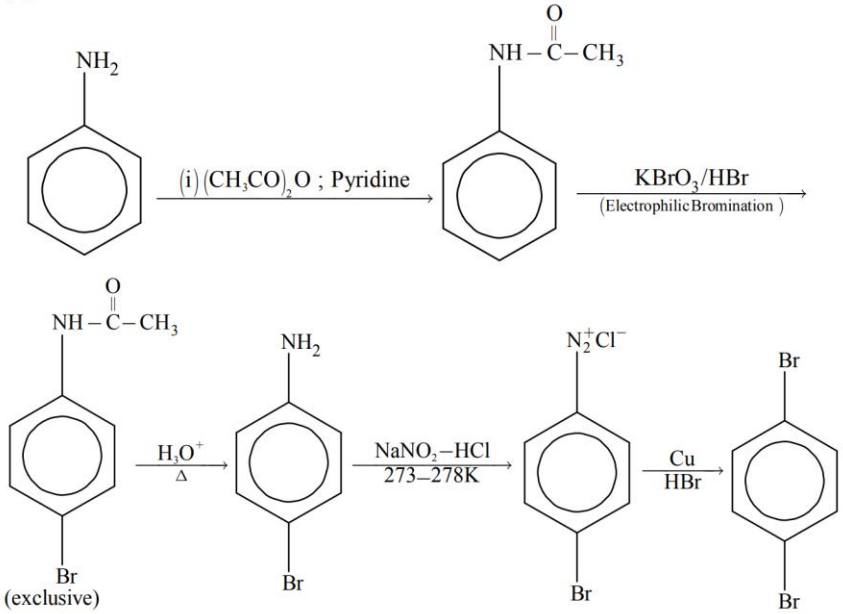
(A) 

(B) 

(C) 

(D) 

Sol. **(B)**



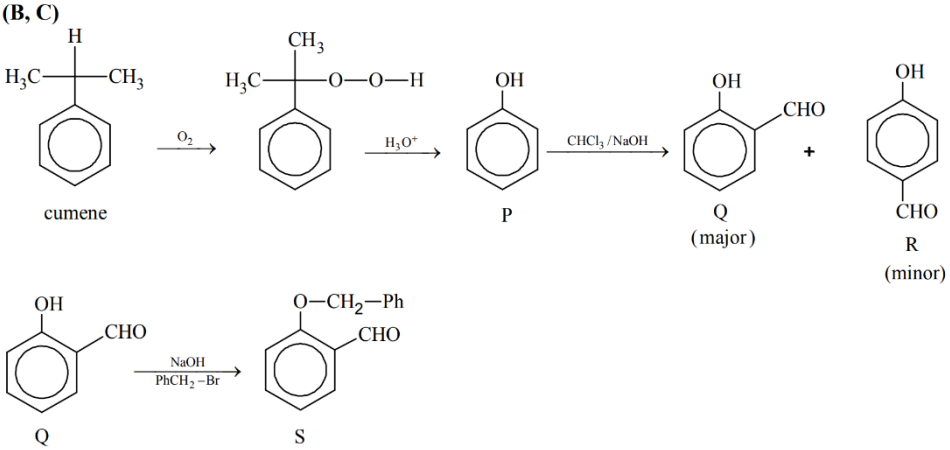
31. The correct statement(s) about the following reaction sequence is(are)

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

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

(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

Sol. **(B, C)**



Q (not R) is steam volatile due to intramolecular hydrogen bonding.
Q gives violet colouration due to phenolic functional group.
S gives yellow precipitate due to aldehydic group with 2, 4 –DNP.
S does not have free phenolic group to respond to $FeCl_3$ test.

*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

Sol. **(9)**

$$m = \frac{X_A \times 1000}{X_B \times M_A}$$

$$m = \frac{1000}{9M_A} \quad \ldots (i)$$

$$M = \frac{n_B \times 1000 \times d}{n_A \times M_A + n_B \times M_B} = \frac{X_B \times 1000 \times d}{X_A \times M_A + X_B \times M_B}$$

$$= \frac{200}{0.9M_A + 0.1M_B}$$

$$= \frac{2000}{9M_A + M_B} \quad \ldots (ii)$$

As $m = M$

$$\frac{1000}{9M_A} = \frac{2000}{9M_A + M_B}$$

$$9M_A + M_B = 18M_A$$

$$\therefore \quad 9M_A = M_B$$

$$\therefore \quad \frac{M_B}{M_A} = 9$$

*33. 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

Sol. **(4)**

Mean free path $(\ell) \propto \frac{T}{P}$

Mean speed $(C_{av}) \propto \sqrt{T}$

Diffusion coefficient (D) is proportional to both mean free path (ℓ) and mean speed.

$$\therefore D \propto \frac{T^{3/2}}{P}$$

At temperature T_1 and P_1

$$D_1 = \frac{KT_1^{3/2}}{P_1} \quad \ldots(1)$$

If T_1 is increased 4 times and P_1 is increased 2 times.

$$D_2 = \frac{K(4T_1)^{3/2}}{2P_1} \quad \ldots(2)$$

$$\frac{D_2}{D_1} = \frac{(4)^{3/2}}{2} = \frac{2^3}{2} = 4$$

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

Sol. **(6)**

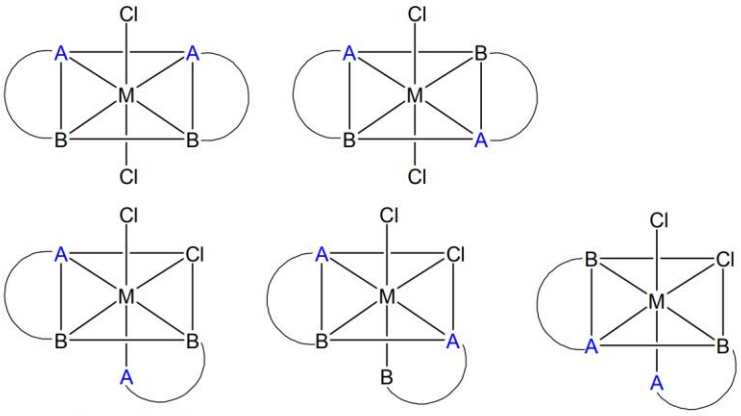
$$8MnO_4^- + 3S_2O_3^{2-} + H_2O \xrightarrow{\text{faintly alkaline}} 8MnO_2 + 6SO_4^{2-} + 2OH^-$$

$\therefore$ 8 moles MnO_4^- produce 6 moles SO_4^{2-}.

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

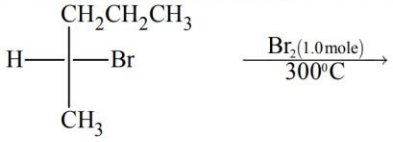
Sol. **(5)**

Number of geometrical isomers = 5.



AB = $H_2NCH_2CH_2O^-$
A site is N
B site is O

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



(1.0 mole)

(enantiomerically pure)

Sol. **(5)**