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OAVS PGT Chemistry Previous Year Question

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10 Toughest Subject Content Questions (2019 – 2024) with Full Solutions



SUBJECT CONTENT – 10 TOUGHEST PYQ

Hand-picked from 4 OAVS PGT Chemistry papers (2019, 2021, 2023 and 2024) – Physical, Inorganic & Organic Chemistry – with the same step-by-step solutions you get in the full pack.

Q-1 A dichloro derivative (P) on treating with KCN followed by acid hydrolysis and heating gives a monobasic acid (Q) along with liberation of CO_2 . (Q) on heating with liquid ammonia followed by treating with Br_2/KOH gives (R), which on treating with NaNO_2 and HCl at low temperature followed by oxidation gives a monobasic acid (S) having molecular mass 74. The (R) involved in this process is _____.

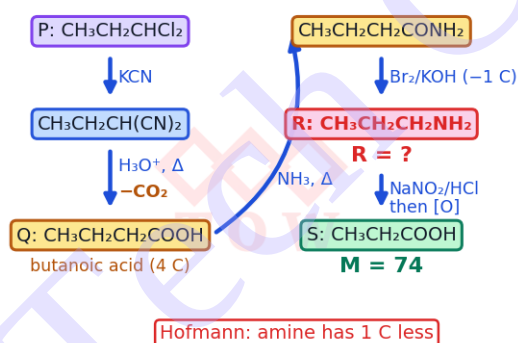
[OAVS PGT CHEMISTRY 2019]

- (A) Tert-butylamine
- (B) Cyclopentylamine
- (C) Propylamine
- (D) Ethylamine

ANS- (C) Propylamine

Given:

→ P (dichloride) → KCN, H_3O^+ , heat → Q (monobasic acid) + CO_2
→ Q → NH_3 , then Br_2/KOH → R → NaNO_2/HCl , then [O] → S (monobasic acid, M = 74)



Concept:

→ Work backwards: Hofmann bromamide removes one carbon ($\text{RCONH}_2 \rightarrow \text{RNH}_2$); HNO_2 turns RCH_2NH_2 into RCH_2OH , which oxidises to RCOOH with the same carbon count

Solution:

- S: $\text{C}_n\text{H}_{2n+1}\text{COOH} = 74$
⇒ $n = 2$
⇒ S = $\text{CH}_3\text{CH}_2\text{COOH}$ (propanoic acid)
- R → $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{COOH}$
⇒ R = $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$ (propylamine)
- R comes from $\text{CH}_3\text{CH}_2\text{CH}_2\text{CONH}_2$
⇒ Q = $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ (butanoic acid)



► $P = \text{CH}_3\text{CH}_2\text{CHCl}_2 \rightarrow \text{CH}_3\text{CH}_2\text{CH}(\text{CN})_2 \rightarrow \text{CH}_3\text{CH}_2\text{CH}(\text{COOH})_2 \rightarrow Q + \text{CO}_2$

► Ans: (C) Propylamine

Hint:

→ Hofmann bromamide: the amine has one carbon fewer than the amide

→ Malonic-type acids (two $-\text{COOH}$ on one carbon) lose CO_2 on heating

Q-2 Elements X and Y form two different binary compounds XY_2 and XY_4 . When dissolved in 20 g of CS_2 solvent, 1 g of XY_2 lowers the freezing point by 2.5°C , whereas 1 g of XY_4 lowers the freezing point by 1.5°C . The molal depression constant for CS_2 is 5. The atomic mass of element Y will be:

[OAVS PGT CHEMISTRY 2019]

(A) 42.64

(B) 33.34

(C) 12.80

(D) 64.42

ANS- (B) 33.34

Given:

→ Solvent $\text{CS}_2 = 20$ g, molal depression constant = 5 K kg/mol; 1 g $\text{XY}_2 \rightarrow \Delta T = 2.5^\circ\text{C}$; 1 g $\text{XY}_4 \rightarrow \Delta T = 1.5^\circ\text{C}$

Concept:

$$\rightarrow M = \frac{K_f \times w \times 1000}{\Delta T_f \times W}$$

Solution:

$$\text{► } M(\text{XY}_2) = \frac{5 \times 1 \times 1000}{2.5 \times 20} = 100$$

$$\text{► } M(\text{XY}_4) = \frac{5 \times 1 \times 1000}{1.5 \times 20} = 166.67$$

$$\text{► } (X + 4Y) - (X + 2Y) = 2Y = 66.67$$

$$\Rightarrow Y = 33.34$$

► Ans: (B) 33.34

Hint:

→ Subtracting the two molar masses cancels X and leaves only $2Y$

Q-3 The wavelength of H_γ line of Balmer series is $4340 \text{ \AA}$. Then the wavelength of H_β line of Balmer series is:

[OAVS PGT CHEMISTRY 2019]

(A) $6563 \text{ \AA}$

(B) $4340 \text{ \AA}$

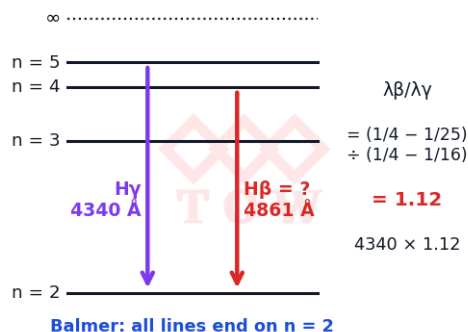


- (C) 4861 Å
(D) 4102 Å

ANS- (C) 4861 Å

Given:

→ $\lambda(H\gamma) = 4340 \text{ Å}$ ($n = 5 \rightarrow 2$); $H\beta$ is $n = 4 \rightarrow 2$



Concept:

$$\rightarrow \frac{1}{\lambda} = R \left(\frac{1}{2^2} - \frac{1}{n^2} \right)$$

Solution:

$$\rightarrow \frac{\lambda_\beta}{\lambda_\gamma} = \frac{\frac{1}{4} - \frac{1}{25}}{\frac{1}{4} - \frac{1}{16}} = \frac{\frac{21}{100}}{\frac{3}{16}} = 1.12$$

$$\rightarrow \lambda(H\beta) = 4340 \times 1.12 \approx 4861 \text{ Å}$$

➤ Ans: (C) 4861 Å

Hint:

→ Balmer lines end at $n = 2$: $H\alpha$ from $n = 3$, $H\beta$ from $n = 4$, $H\gamma$ from $n = 5$

Q-4 The equilibrium constant of the reaction $2 SO_2(g) + O_2(g) \rightleftharpoons 2 SO_3(g)$ is 4.0×10^{24} at 300 K, 2.5×10^{10} at 500 K, and 3.0×10^4 at 700 K. Calculate the reaction enthalpy at 500 K.

[OAVS PGT CHEMISTRY 2021]

- (A) -80 kJ mol^{-1}
(B) $+200 \text{ kJ mol}^{-1}$
(C) $+80 \text{ kJ mol}^{-1}$
(D) -200 kJ mol^{-1}

ANS- (D) -200 kJ mol⁻¹

Given:

→ $K = 4.0 \times 10^{24}$ (300 K), 2.5×10^{10} (500 K), 3.0×10^4 (700 K)

Concept:

→ van't Hoff equation:



$$\rightarrow \ln \frac{K_2}{K_1} = \frac{\Delta H^\circ}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

Solution:

► Take 300 K and 700 K, which lie symmetrically about 500 K.

$$\rightarrow \ln \frac{3.0 \times 10^4}{4.0 \times 10^{24}} = -46.34$$

$$\rightarrow \frac{1}{300} - \frac{1}{700} = 1.905 \times 10^{-3} \text{ K}^{-1}$$

$$\rightarrow \Delta H^\circ = \frac{(-46.34)(8.314)}{1.905 \times 10^{-3}}$$

$$\Rightarrow \Delta H^\circ = -2.02 \times 10^5 \text{ J mol}^{-1} \approx -200 \text{ kJ mol}^{-1}$$

► Ans: (D) -200 kJ mol^{-1}

Hint:

→ K falls as temperature rises ⇒ the reaction is exothermic, so only a negative ΔH can be correct.

Q-5 Calculate the density of silver in g/cm^3 if the Ag atoms crystallise in a face-centered cubic and have a metallic radius of 144 pm.

[OAVS PGT CHEMISTRY 2021]

(A) 1.06 g/cm^3

(B) 8.17 g/cm^3

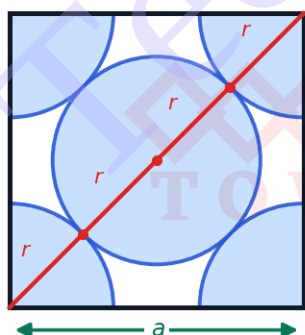
(C) 7.16 g/cm^3

(D) 10.6 g/cm^3

ANS- (D) 10.6 g/cm^3

Given:

→ fcc lattice: $Z = 4$, $r = 144 \text{ pm}$, $M(\text{Ag}) = 107.9 \text{ g mol}^{-1}$



fcc: atoms touch along face diagonal

$$4r = \sqrt{2} a$$

$$a = 2\sqrt{2} r$$

$$= 407.3 \text{ pm}$$

$$Z = 4$$

$$\rho = 10.6 \text{ g cm}^{-3}$$

Concept:

→ In fcc, atoms touch along the face diagonal: $4r = \sqrt{2} a$

$$\rightarrow a = 2\sqrt{2} r, \quad \rho = \frac{ZM}{N_A a^3}$$

Solution:



Concept:

→ The bulky $\text{N}^+(\text{CH}_3)_3$ leaving group gives the Hofmann product (less substituted alkene).

→ Br with a small base ($\text{C}_2\text{H}_5\text{O}^-$) gives the Zaitsev product (more substituted alkene).

Solution:

➤ $\text{CH}_3\text{CH}_2\text{CH}(\text{N}^+(\text{CH}_3)_3)\text{CH}_3 \xrightarrow{\text{OH}^-, \Delta} \text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$ (y)

➤ $\text{CH}_3\text{CH}_2\text{CHBrCH}_3 \xrightarrow{\text{C}_2\text{H}_5\text{ONa}, \Delta} \text{CH}_3\text{CH}=\text{CHCH}_3$ (x)

➤ Ans: (C) 1y, 2x

Why not others:

→ (A) 1x, 2x — reaction 1 is a Hofmann elimination, so but-2-ene is not major.

→ (B) 1y, 2y — ethoxide with 2-bromobutane follows Zaitsev, giving but-2-ene.

→ (D) 1x, 2y — both rules are reversed.

Hint:

→ Quaternary ammonium hydroxide + heat always gives the least substituted (Hofmann) alkene.

Q-7 What will be the predicted molecular shape of the molecule for which steric number is 5 and number of lone pairs is 2?

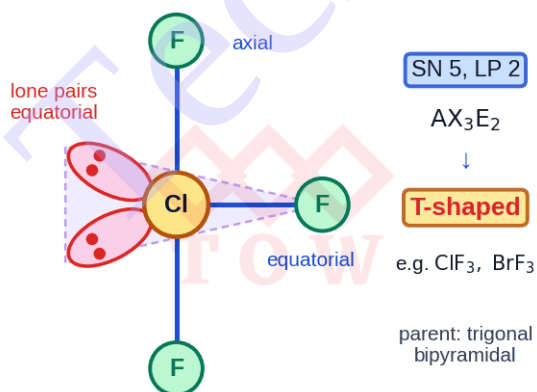
[OAVS PGT CHEMISTRY 2023]

- (A) Linear
- (B) Trigonal bipyramidal
- (C) T-shaped
- (D) Sawhorse

Ans- (C) T-shaped

Given:

→ Steric number = 5, lone pairs = 2



Concept:

→ VSEPR: 5 electron domains → trigonal bipyramidal parent geometry; lone pairs prefer the roomier equatorial positions.

Solution:

➤ AX_3E_2 type (e.g. ClF_3 , BrF_3): 2 lone pairs equatorial



⇒ The three bonded atoms left form a T

► Ans: (C) T-shaped

Hint:

→ Steric 5 series: AX_5 trigonal bipyramidal → AX_4E see-saw (sawhorse) → AX_3E_2 T-shaped → AX_2E_3 linear.

Q-8 Consider the electrochemical cell, Fe, Fe^{2+} (0.1 M) / Cd^{2+} (0.001 M), Cd. Calculate the EMF of the cell. ($E_{Fe^{2+}/Fe} = -0.44$ and $E_{Cd^{2+}/Cd} = -0.40$)

[OAVS PGT CHEMISTRY 2024]

(A) +0.1085 V

(B) +0.0846 V

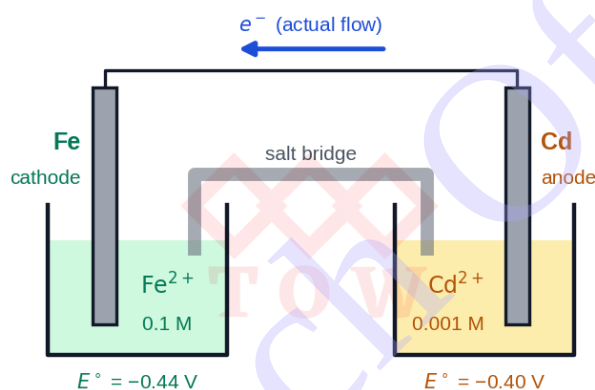
(C) +0.0191 V

(D) +0.0486 V

ANS- (C) +0.0191 V

Given:

→ $Fe | Fe^{2+} (0.1 M) || Cd^{2+} (0.001 M) | Cd$; $E^\circ(Fe^{2+}/Fe) = -0.44 V$, $E^\circ(Cd^{2+}/Cd) = -0.40 V$



as written: $0.04 - 0.0591 = -0.0191 V$

reversed: EMF = +0.0191 V

Concept:

$$\rightarrow E_{cell} = E^\circ_{cell} - \frac{0.0591}{n} \log \frac{[Fe^{2+}]}{[Cd^{2+}]}$$

Solution:

► $E^\circ_{cell} = -0.40 - (-0.44) = 0.04 V$, $n = 2$

$$\Rightarrow E_{cell} = 0.04 - \frac{0.0591}{2} \log \frac{0.1}{0.001}$$

$$\Rightarrow E_{cell} = 0.04 - 0.02955 \times 2$$

$$\Rightarrow E_{cell} = 0.04 - 0.0591 = -0.0191 V$$

⇒ The negative sign means the cell as written is non-spontaneous; reversed (Cd anode), EMF = +0.0191 V

► Ans: (C) +0.0191 V

Hint:



$$\rightarrow \log (0.1/0.001) = \log 100 = 2.$$

Q-9 Calculate how long a hydrogen atom will remain on the surface of a solid at 298 K if its desorption activation energy is 15 kJ mol^{-1} .

Assume that $\tau_0 = 10^{-13} \text{ s}$.

[OAVS PGT CHEMISTRY 2024]

- (A) $4.2 \times 10^{-11} \text{ s}$
(B) $2.8 \times 10^{-11} \text{ s}$
(C) $6.8 \times 10^{-11} \text{ s}$
(D) $9.2 \times 10^{-11} \text{ s}$

ANS- (A) $4.2 \times 10^{-11} \text{ s}$

Given:

$\rightarrow E_a(\text{desorption}) = 15 \text{ kJ mol}^{-1} = 15000 \text{ J mol}^{-1}$, $T = 298 \text{ K}$, $\tau_0 = 10^{-13} \text{ s}$

Concept:

$\rightarrow$ Residence time (Frenkel equation): $\tau = \tau_0 e^{E_a/RT}$

Solution:

$$\rightarrow \frac{E_a}{RT} = \frac{15000}{8.314 \times 298} = 6.054$$

$$\Rightarrow \tau = 10^{-13} \times e^{6.054}$$

$$\Rightarrow \tau = 10^{-13} \times 426$$

$$\Rightarrow \tau \approx 4.2 \times 10^{-11} \text{ s}$$

$\rightarrow$ Ans: (A) $4.2 \times 10^{-11} \text{ s}$

Hint:

$\rightarrow e^6 \approx 403$ — a quick estimate gives about $4 \times 10^{-11} \text{ s}$.

Q-10 What are the bond orders of O_2^- , O_2 and O_2^{2-} respectively?

[OAVS PGT CHEMISTRY 2024]

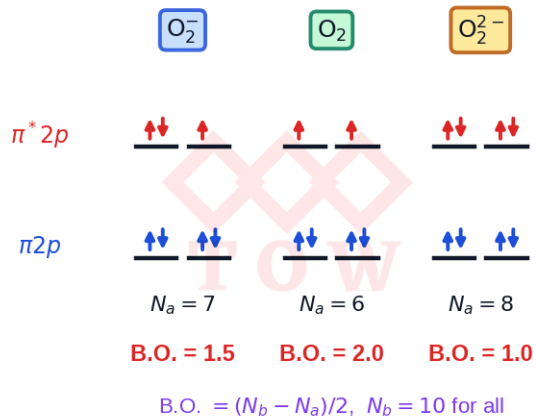
- (A) 2.5, 2.0 and 3.0
(B) 2.0, 1.5 and 1.0
(C) 2.5, 2.0 and 1.5
(D) 1.5, 2.0 and 1.0

ANS- (D) 1.5, 2.0 and 1.0

Given:

$\rightarrow \text{O}_2^-, \text{O}_2, \text{O}_2^{2-}$ (16 e^- in O_2)





Concept:

→ Bond order = $\frac{N_b - N_a}{2}$ (MO theory)

Solution:

► O_2 : $N_b = 10, N_a = 6 \rightarrow \frac{10-6}{2} = 2.0$

⇒ O_2^- : $N_a = 7 \rightarrow \frac{10-7}{2} = 1.5$

⇒ O_2^{2-} : $N_a = 8 \rightarrow \frac{10-8}{2} = 1.0$

► Ans: (D) 1.5, 2.0 and 1.0

Hint:

→ Each electron added to π^* lowers the bond order by 0.5.





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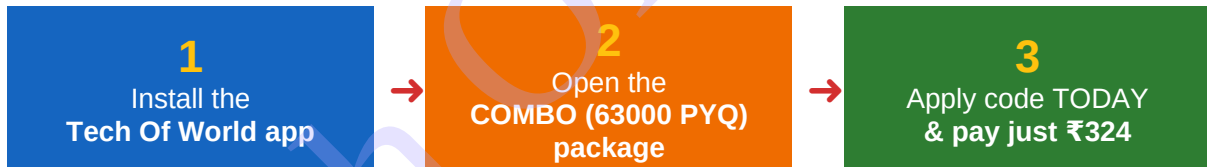
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