PART (B) : CHEMISTRY

SOLUTION

21. (B)

22. (B)
No of molecules is too less to predict $\alpha$.

23. (C)
$\text{NO}_2^+$ has no lone pair.
$\text{NO}_2$ has lone electron.
$\text{NO}_2^-$ has lone pair electron.
Bond angle decreases with lone pairs.
Due to high electronegativity of F, bond pair of $e^-$ is pulled away from O. So, the bond angle is less.

24. (C)
For K, 2$^{\text{nd}}$ I.E. should be considerably higher than 1$^{\text{st}}$ I.E.
For Mg, 3$^{\text{rd}}$ I.E. should be considerably higher than 2$^{\text{nd}}$ I.E.

25. (B)
No of moles of $\text{SO}_2 \neq$ no. of moles of $\text{O}_2$

26. (D)
No. of radial nodes $= n - \ell - 1$
No. of planar nodes $= \ell$
$S_1 = 3s$ (spherically symmetrical so $\ell = 0, n = 3$)
For $S_2$, $E = E_{\text{He}} \times \frac{25}{100} = E_{\text{He}} \times \frac{1}{4}$
$E_{\text{He}} = E_{\text{He}} \times \frac{Z^2}{n^2} = E_{\text{He}} \times \frac{4}{n^2} (Z = 2 \text{ for } \text{He}^+)$
$\Rightarrow n = 4$
Since no. of radial nodes $= 2$
$= n - \ell - 1$
$\Rightarrow \ell = 1 = \text{No. of angular nodes.}$
Degenerally of 51 = $n^2 = 3^2 = 9$

27. (D)
Since ideal gas has no molecular forces of attraction, it can not be liquefied.

28. (A, B, C, D)
(A) Bond order = 0
(B) Maximum oxidation state can not be achieved with H
(C) d-orbitals unavailable.
(D) Br is too bid for coordination no. = 6 around P.
29. (B)
Size of oxygen is too small, so, it repels the incoming electron.

30. (A, B, D)
Higher Z implies lesser compressibility.

31. (A, B, D)

32. (A, B, C, D)
(A) Check bond order hybridized
(B) electronegativity of sp $\pi$ carbon is highest.
(C) heavier isotope lowers zero point energy.
(D) Bond length of C==O is smallest.

33. (B, D)
At Boyle temperature,
$$\left\{ \frac{\partial (PV)}{\partial P} \right\}_T = 0$$

34. (A, B, D)

35. (29.80)

IE$_{i}$ = $\frac{13.6 \times Z^2}{n^2}$ eV for H0like (He$^+$)

E$_2$ = $\frac{13.6 \times 4}{1}$ eV = 54.4 eV

Given: IE$_{i}$ + IE$_{2}$ = 79

$\Rightarrow$ 54.4 + E$_i$ = 79 $\Rightarrow$ E$_i$ = 24.6

E$_2$ − E$_i$ = 54.4 − 24.6 = 29.8 eV

36. (8.50)
Bond order in O$_2$, O$_3$, O$_2^-$, O$_2^{2-}$, O$_2^+$ are 2, 1.5, 1.5, 1, 2.5
37. \( (91.10) \)

Case 1:
\[ (P_{\text{air}})_1 + P_{\text{water}} + 74 = 76 \]
\[ \Rightarrow (P_{\text{air}})_1 = 1 \text{ cm of Hg} \]

Use \( P_{\text{water}} = 1 \text{ cm of Hg} \) (Given)

Case 2:
\[ (P_{\text{air}})_2 + P_{\text{water}} + 72.1 = 76 \]
\[ \Rightarrow (P_{\text{air}})_2 = 0.9 \]

\[ (P_{\text{air}})_1 \propto \frac{1}{L - 74} \]  \hspace{1cm} \text{Case 1} \]

\[ (P_{\text{air}})_2 \propto \frac{1}{L - 72.1} \]  \hspace{1cm} \text{Case 2} \]

\[ \frac{(P_{\text{air}})_1}{(P_{\text{air}})_2} = \frac{L - 72.1}{L - 74} = \frac{1}{0.9} \]
\[ \Rightarrow L = 91.1 \text{ cm} \]
38.  

\[ \text{Dipole moment of } \quad \begin{array}{c} \text{Cl} \\ \text{Cl} \end{array} = 0 \]

\[ \text{So, } \quad \text{Dipole moment of } \quad \begin{array}{c} \text{Cl} \\ \text{Cl} \end{array} = D \]

\[ \text{Similarly, } \quad \text{Dipole moments of } \quad \begin{array}{c} \text{Cl} \\ \text{Cl} \end{array} = D \]

\[ \begin{array}{c} \text{Cl} \\ \text{Cl} \end{array} = D \]

\[ \text{Total Dipole Moment } = (2 + 2\sqrt{3}) D = 5.46 \text{ D} \]

39.  

\[ m_x = \frac{20}{100} \times 12 = 2.4 \text{ g} \]

\[ m_y = 9.6 \text{ g} \]

Their moles are in the ratio of 2 : 5

\[ \frac{n_x}{n_y} = \frac{2}{5} \Rightarrow \frac{2.4}{M_x} = \frac{2}{9.6} \]

\[ \frac{m_x}{m_y} = \frac{2}{5} \Rightarrow \text{Their moles are in the ratio of } 2 : 5 \]
\[ \Rightarrow M_y = 64 \quad \text{(Use } M_x = 40) \]

40. (4.00)
\[
T = \frac{2\pi r_n}{V_n}
\]

Since, \( mV_n = \frac{nh}{2\pi} \)
\[
V_n = \frac{nh}{2\pi m r_n}
\]

Now, \( T = \frac{2\pi r_n}{nh} \times 2\pi m r_n \)
\[
= \frac{4\pi^2 r^3 m}{nh}
\]
So, \( a = 4 \)
PART (B) : CHEMISTRY

SOLUTION

21. (B, D)
Let y mL C<sub>3</sub>H<sub>8</sub> is present in the mixture.

\[ C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O \]

Volumes

\[ y \quad 5y \quad 3y \]

\[ C_{xH_{2x}} + \frac{3x}{2}O_2 \rightarrow xCO_2 + xH_2O \]

Volumes

\[ (72 - y) \quad \frac{3x}{2}(72 - y) \quad (72 - y)x \]

Volume of O<sub>2</sub> = 342 = 5y + (72 - y) \( \frac{3x}{2} \)

Volume of CO<sub>2</sub> = 216 = 3y + (72 - y)x

Solving for x & y.

x = 3
y = 36

(B) Volume of C<sub>3</sub>H<sub>8</sub> = 36 mL
C<sub>3</sub>H<sub>6</sub> = 36 mL

(D) Molecular mass of mixture before mixing (X = mole fraction)

\[ = M_1X_1 + M_2X_2 \]

\[ = 44 \times \frac{1}{2} + 42 \times \frac{1}{2} = 43 \]

22. (C, D)

KE = \( \frac{3}{2}RT \times n \)

(C) both 1 mole
(D) Both 2 mole

23. (A, B)
Everything else same, bond angle decreases with decrease in electronegativity

24. (B, D)
PH<sub>3</sub> and SF<sub>4</sub> are pyramidal and see-saw shaped respectively and are not planar.

25. (B, C, D)

(B) size decreases with increases in oxidation state
(C) size decreases with increase in atomic no. for isoelectronic species.
(D) Anion is larger than cation

26. (C, D)

HIO<sub>4</sub> + 2H<sub>2</sub>O \( \rightarrow \) H<sub>2</sub>IO<sub>6</sub>
Since only 9 g weight has increased, only 0.5 moles of H<sub>2</sub>O has been absorbed.
Hence, only 0.25 moles of HIO₄ has been converted to 0.25 moles of H₃SP₆.
(C) Only half of HIO₄ (initial moles = 0.5) has converted to H₃IO₆.
(D) % HIO₄ (by mass) \( = \frac{48}{105} \times 100 = 45.7\% \neq 50\%

27. (B, C)
H bonding is formed between H & F, H & O, H & N

28. (A, C, D)
(B) Correct order is CH₃Cl > CH₃F > CH₃Br > CH₃I

29. (D)
According to Graham’s law of Diffusion & Effusion,
\[ \frac{r_2}{r_1} = \sqrt{\frac{M_1}{M_2} \times \frac{P_2}{P_1}} \]
\[ r_{He} = \frac{\Delta P}{t} = \frac{250}{25} = 10 \text{ torr/min} \]
\[ \frac{r_X}{r_{He}} = \sqrt{\frac{M_{He}}{M_X} \times \frac{P_X}{P_{He}}} \]
\[ \frac{r_{D_2}}{r_{He}} = \frac{P_{D_2}}{P_{He}} = \frac{2000}{1000} = 2 \]
\[ \Rightarrow P_{D_2} = 2 \times 10 \text{ torr/min.} \]
\[ \Rightarrow \frac{\Delta P}{50} = 20 \Rightarrow \Delta P = 1000 \text{ for D}_2 \]
After 50 min,
\[ P_{D_2} = \text{Initial partial pressure} - \Delta P \]
\[ = 2000 - 1000 = 1000 \text{ torr} \]
Since, residual mixture contains D₂ & X in the ratio of 10 : 9
The pressure of X after 50 min = \( \frac{9}{10} \times 1000 = 900 \text{ torr} \)

30. (A)
\[ \frac{r_X}{r_{He}} = \sqrt{\frac{M_{He}}{M_X} \times \frac{P_X}{P_{He}}} \]
\[ \Rightarrow m_X = 100 \]
Also, KE / mole = 8000 J / mole = \( \frac{3}{2}RT \)
\[ u_{ms} = \sqrt{\frac{3RT}{M}} \text{ using above values,} \]
\[ = 400 \text{ m/s} \]

31. (C)
A = XeF₄
B = NF₃
C = SO₃
D = NH₃

(C) NCl₃ is sp³ hybridised but its bond angle is larger due to larger size of Cl.

32. (B)
XeF₄ = square planar
NF₃ = planar triangular

33. (D)
According to the equations,
\[ \frac{n_{\text{HNO}_3}}{n_{\text{NH}_3}} = \frac{2}{3} \]
\[ \Rightarrow n\text{NH}_3 = \frac{3}{2} \times n_{\text{HNO}_3} = \frac{3}{2} \times \frac{1575}{63} \]
\[ \Rightarrow \frac{V}{22.4} = \frac{3}{2} \times \frac{1575}{63} \Rightarrow V = 840 \text{ L} \]

34. (A)
\[ \frac{n_{\text{HNO}_3}}{n_{\text{NH}_3}} = \frac{2}{3} \times 0.8 \times 0.6 \times 0.5 \]
\[ \Rightarrow \frac{V}{22.4} = \frac{3}{2} \times \frac{1575 \div 63}{0.8 \times 0.6 \times 0.5} = 3500 \text{ L} \]

35. (5.00)
36. (8.00)
37. (5.00)
At high P,
\[ P(V - b) = RT \]
On rearranging,
\[ Z = \frac{PV}{RT} = 1 + \frac{Pb}{RT} \]
So, Z vs P will be a straight line with slope \( \frac{b}{RT} \)
\[ \Rightarrow \frac{b}{RT} = \frac{\pi}{492} \]
Replace \( b = \frac{4}{3} \pi r^3 \times N_A \times 4 \)
On solving, \( 2r = 5Å \)
38. (4.00)
Applying POAC for Fe,
\[ 2 \times n_{\text{Fe}^3} = 5 \times n_{[\text{Fe(CN)}_6]^2} \]
\[ \frac{2 \times 1600}{5 \times 160} = n_{\text{Fe}[\text{Fe(CN)}_6]^2} = 4 \]

39. (8.00)
\[ \text{BH}_4^-, \text{NH}_2^+, \text{NH}_3^+, \text{NH}_4^+, \text{H}_2\text{O}, \text{I}_3^-, \text{NO}_2^-, \text{SO}_2 \]

40. (5.00)
\[ E_n = -\frac{R_H}{n^2} \]
So, \( n_1 = 2, n_2 = 3 \)
Degeneracy = \( n^2 \)
\( X = 4 \)
\( Y = 9 \)
So, \( Y - X = 5 \)