Atomic Structure & Mole Concept Solution

1. (b)

Since, $n = 1, 2, 3$ and 4

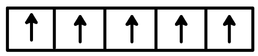
$\frac{1s}{2}, \frac{2s\,2p}{8}, \frac{3s\,3p\,3d}{18}, \frac{4s\,4p\,4d\,4f}{32}$

Thus total number of existent elements is $2 + 8 + 18 + 32 = 60$

2. (b)

$M^{x+}(Z = 25)$: electronic configuration is

$$1s^2 2s^2 2p^6 3d^5 4s^2 3s^2 3p^6$$

or $d^5 = 5$ 

Magnetic moment $= \sqrt{n(n+2)}$BM

$= \sqrt{5(5+2)}\text{BM} = \sqrt{35}\text{BM}$

But given magnetic moment is $\sqrt{15}$BM or $\sqrt{3(3+2)}$BM

Hence, unpaired electrons $= 3$

Therefore, the oxidation number is 4.

3. (a)

For d electron, $l = 2$,

orbital angular momentum

$= \sqrt{l(l+1)}\hbar = \sqrt{2(2+1)}\hbar = \sqrt{6}\hbar$

4. (d)

Configuration of C^6 should be $2p_x^1 2p_y^1$ instead of $2p_x^2$

Configuration of O^8 should be $2p_x^2 2p_y^1 2p_z^1$ instead of $2p_x^2 2p_y^2$

Configuration of N^7 should be $2p_x^1 2p_y^1 2p_z^1$ instead of $2p_x^2 2p_y^1$.

Configuration of F^9, $2p_x^2 2p_y^2 2p_z^1$, is correct because two out of the three degenerate p orbitals are fully filled, one is half-filled, and there is no unfilled p orbital.

5. (b)

Spherically symmetrical state (i.e., s orbitals) with one radial node $= 2s = s_1$

$(n - l - 1)$

$n = 2 \longrightarrow s_2$ (one radial node)

$\equiv n_2$

And $(E_n)_{Li^{2+}} = (E)_{1H}$

$\Rightarrow \quad -13.6 \times \frac{3^2}{n_2^2} = -13.6 \times \frac{1^2}{1^2}$

$\Rightarrow \quad n_2 = 3$

$\Rightarrow \quad s_2 = 3p$

$$\Rightarrow \qquad \frac{E_{s_1}}{(E_H)_{n=1}} = \frac{-13.6\times\frac{3^2}{2^2}}{-13.6\times\frac{1^2}{1^2}} = 2.25$$

6. (b)

Mw_2 of $CaCO_3 = 40+12=100$

Moles of $CaCO_3$ in 10 g $= \frac{10}{100}$

$= 0.1 mol = 0.1 g$ atom

7. (c)

$4B \quad + \quad A \longrightarrow X$

$4\times35 \qquad 12$

Weight of $X = 4\times35.5+12=154$

8. (a)

$N_1V_1 + N_2V_2 + N_3V_3 = N_4V_4$

$(V_4 = V_1 + V_2 + V_3 + V_4)$ or

$V_4 =$ Final volume $= 1L \equiv 1000mL$

$\therefore N_4 = \frac{N}{40}$

9. (a)

$3BaCl_2 + 2Na_3PO_4 \longrightarrow 6NaCl + Ba_3(PO_4)_2$

[3mol 2mol 6mol 1mol]

Given $\Rightarrow 0.5$ mol $BaCl_2$ and 0.2mol of Na_3PO_4

To the find limiting reagent:

2 mol of $Na_3PO_4 \Rightarrow 3$mol of $BaCl_2$

0.2mol of $Na_3PO_4 \Rightarrow 0.3$ mol of $BaCl_2$

$\therefore$ Na_3PO_4 is the limiting reagent

$\therefore$ 2mol of $Na_3PO_4 \Rightarrow 1$ mol of $Ba_3(PO_4)_2$

0.2 mol of $Na_3PO_4 \Rightarrow 0.1$mol of $Ba_3(PO_4)_2$

10. (b)

Since no water added, so volume of solution cannot exceed 2 L. so, less concentrated solution should be taken in its total volume.

Only the small portion of more concentrated solution is to be mixed, so that the total concentrated is less than $(0.3M\,HCl)$.

Let x L of 0.3 M solution is mixed.

Total volume $= (x+1)L$

$M_1V_1 + M_2V_2 = M_3V_3 \qquad [V_3 = (1+x)L$

Final molarity $= 0.2M$

$0.3x + 0.15 = 0.2(1 + x)$

$x = 0.5L$

11. (a, d)

In singly filled orbital electrons must align in one direction of they all must be spin-up $(\uparrow)$ or spin-down $(\downarrow)$.

12. (a)

Excited state is given as $= \frac{-13.6\,eV}{n^2}$

e.g., $n = 2, E = \frac{-13.6}{4} = --3.4\,eV$

13. (a,b)

Angular momentum $\sqrt{l(l+1)} = \frac{h}{2\pi}$

For d electron, $l = 2$

$\therefore$ Angular momentum $= \sqrt{2(2+1)}\frac{h}{2\pi} = \sqrt{6}.\frac{h}{2\pi}$

or $\hbar = \frac{h}{2\pi}$

$\therefore$ Angular momentum $= \sqrt{6}.\hbar$

14. (a)

15. (a)

Moles of $O_2 = \frac{4.8}{32} = 0.15\,mol\ O_2$

Moles of Fe required $= \frac{4 mol\,Fe}{3\,mol\,O_2} \times 0.15 = 0.2\,mol$

a. Given mol of Fe $= 0.15$. Hence Fe is the limiting reagent and no Fe will remain after the reaction.

b. Weight of O_2 required $= (0.15\,mol\,Fe)$

$$\left(\frac{3\,mol\,O_2}{4\,mol\,Fe}\right)\left(\frac{32g\,O_2}{mol\,O_2}\right)$$

$$= \frac{0.15 \times 3 \times 32}{4}$$

$$= 3.6g\,O_2\text{ required}$$

Weight of O_{2s} in excess $= (4.8g\,O_2\text{ present}) - (3.6g\,O_2\text{ required})$

$$= 1.2g\,O_2\text{ in excess}$$

c. Weight of Fe_2O_3 produced $= (0.15\,mol\,Fe)$

$$\left(\frac{2\,mol\,Fe_2O_3}{4\,mol\,Fe}\right)\left(\frac{160g\,Fe_2O_3}{mol\,Fe_2O_3}\right)$$

$$= \frac{0.15 \times 2 \times 160}{4}$$

$$= 12.0\text{g } Fe_2O_3 \text{ produced}$$

16. (a, b, c)

($\text{Mw of } CS_2 = 76, \text{Mw of } Cl_2 = 71, \text{Mw of } CCl_4 = 154\text{g mol}^{-1}$)

Weight of Cl_2 needed

$$= (1.0\text{g } CS_2)\left(\frac{1\text{mol } CS_2}{76\text{g } CS_2}\right)\left(\frac{3\text{mol } CS_2}{\text{mol } CS_2}\right)\left(\frac{71\text{g } Cl_2}{\text{mol } Cl_2}\right)$$

$$= \frac{1 \times 3 \times 71}{76} = 2.8\text{g } Cl_2 \text{ needed}$$

Since there is 2.0g Cl_2 present, Cl_2 is the limiting quantity

a. Weight of CS_2 used

$$= (2.0\text{g } Cl_2)\left(\frac{1\text{mol } Cl_2}{71\text{g } Cl_2}\right)\left(\frac{1\text{mol } CS_2}{3\text{mol } Cl_2}\right)\left(\frac{76\text{g } CS_2}{\text{mol } CS_2}\right)$$

$$= \frac{2 \times 1 \times 1 \times 76}{71 \times 3} = 0.714\text{g } CS_2 \text{ used}$$

b. Weight of CS_2 excess or formed

$$= (1.0\text{g } CS_2 \text{present}) - (0.74\text{g used})$$

$$= 0.286\text{g } CS_2 \text{ formed}$$

c. Weight of CCl_4 formed

$$= (2.0\text{g } Cl_2)\left(\frac{1\text{mol } Cl_2}{71\text{g } Cl_2}\right)\left(\frac{1\text{mol } CCl_4}{3\text{mol } Cl_2}\right)\left(\frac{154\text{g } CCl_4}{\text{mol } CCl_4}\right)$$

$$= \frac{2 \times 1 \times 154}{71 \times 3} = 1.45\text{g } CCl_4$$

17. (a, b, c, d)

mmoles of $HCl \Rightarrow 20 \times 6 = 120 \Rightarrow 120\text{mmol } H^{\oplus} + 120\text{mmol } Cl^{\odot}$

mmoles of $Ba(OH)_2 \Rightarrow 50 \times 2 = 100 \Rightarrow 100\text{mmol}$

$$Ba^{2+} + 200\,\text{mmol}\,\overset{\odot}{O}H$$

$$H^{\oplus} + \overset{\odot}{O}H \longrightarrow H_2O$$

Total volume $= 20 + 50 + 30 = 100\text{mL}$

a. $\therefore \left[\overset{\odot}{O}H\right] = \frac{(200 - 120)}{100\text{mL}} = 0.8\text{M}$

b. $\left[Cl^{\odot}\right] = \frac{120\text{ mmol}}{100\text{mL}} = 1.2\text{M}$

c. $\left[Ba^{2+}\right] = \frac{100\text{ mmol}}{100\text{mL}} = 1.0\text{M}$

d. mmoles of $\overset{\odot}{O}$ left $= 200 - 120 = 80$ mmol

18. (d) $Z = 3$

19. (c)
Visible

20. (3)
$$\Delta E = 13.6 \times I^2 \left[\frac{1}{2^2} - \frac{1}{33^2} \right] = 12.09 eV$$
This will be only absorbed, rest is useless (unabsorbed) so, from $n_2 = 3$ to $n_1 = 1$, we have λ corresponding to $3 \to 2$; $2 \to 1$, and $3 \to 1$. So, total true spectral line.

21. (5)
$$\text{Total mEq of acid} = 50 \times 1 \times + 100 \times 0.5 + x \times 52 \,(\text{n factor})$$
$$= (100 + 10x)\,\text{mEq}$$
$$= \frac{(100 + 10x)}{100\text{mL}} N$$
$$N_1V_1(\text{Acid}) = N_1V_1\left[Al_2\left(CO_3^{2-} \right)_3 \right](\text{Total charge} = 6)(n = 6)$$
$$\therefore \frac{(100 + 10x)}{100\text{mL}} N \times 100\text{mL} = 10\text{mL} \times \frac{1}{3} \times 6 \;\; (100 + 10x) = 200$$
$$\therefore x = 10\text{mL}$$