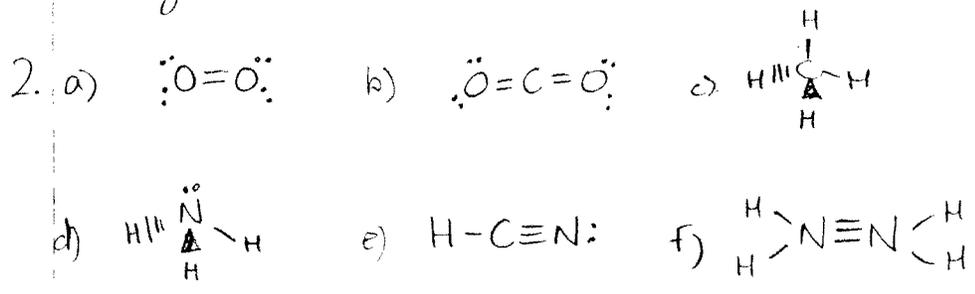


UNIT 1 - MATTER & BONDING

1. Ionic bond → e⁻ are gained or lost to become stable
covalent bond → e⁻ are shared to become stable

- a) Cl-Cl pure covalent
- b) K-I ionic
- c) C-O polar covalent
- d) Mg-F ionic



3. a) C-H $\Delta\text{EN} = 2.5 - 2.2 = 0.3$
O-H $\Delta\text{EN} = 3.5 - 2.2 = 1.3$ ∴ more polar
- b) C-O $\Delta\text{EN} = 3.5 - 2.5 = 1.0$ ∴ more polar
N-O $\Delta\text{EN} = 3.5 - 3.0 = 0.5$
- c) C-C $\Delta\text{EN} = 2.5 - 2.5 = 0$
C-H $\Delta\text{EN} = 2.5 - 2.2 = 0.3$ ∴ more polar
- d) S-H $\Delta\text{EN} = 2.5 - 2.2 = 0.3$
O-H $\Delta\text{EN} = 3.5 - 2.5 = 1.0$ ∴ more polar
- e) H-Cl $\Delta\text{EN} = 3.0 - 2.2 = 0.8$ ∴ more polar
H-I $\Delta\text{EN} = 2.5 - 2.2 = 0.3$

4. a) AlCl_3 g) NH_4NO_3
 b) CuSO_4 h) Na_3PO_4
 c) Ca(OH)_2 i) SnBr_4
 d) $\text{Pb(NO}_3)_2$ j) $\text{Fe}_2(\text{CO}_3)_3$
 e) $\text{H}_2\text{SO}_4(\text{aq})$ k) K_2O
 f) FeI_2 l) $\text{CO}_2(\text{SO}_4)_3$

5. a) single displacement
 b) combustion
 c) decomposition
 d) complete combustion
 e) decomposition
 f) synthesis
 g) double displacement

6. a) $\text{Cu(s)} + 2\text{HCl(aq)} \rightarrow \text{CuCl}_2(\text{aq}) + \text{H}_2(\text{g})$
 b) $\text{Au(s)} + \text{ZnSO}_4(\text{aq}) \rightarrow \text{NR}$
 c) $\text{Pb(s)} + \text{CuSO}_4(\text{aq}) \rightarrow \text{PbSO}_4(\text{aq}) + \text{Cu(s)}$
 d) $\text{Cl}_2(\text{g}) + 2\text{NaBr(aq)} \rightarrow 2\text{NaCl(aq)} + \text{Br}_2(\text{l})$
 e) $\text{Fe(s)} + 3\text{AgNO}_3(\text{aq}) \rightarrow \text{Fe(NO}_3)_3(\text{aq}) + 3\text{Ag(s)}$

7. a) $\text{CuCl}_2(\text{aq}) + \text{Mg(NO}_3)_2(\text{aq}) \rightarrow \text{NR}$
 b) $(\text{NH}_4)_2\text{SO}_4(\text{aq}) + 2\text{AgNO}_3(\text{aq}) \rightarrow \text{Ag}_2\text{SO}_4(\text{s}) + 2\text{NH}_4\text{NO}_3(\text{aq})$
 c) $\text{Ba(OH)}_2(\text{aq}) + \text{K}_2\text{SO}_4(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2\text{KOH(aq)}$
 d) $\text{Na}_3\text{PO}_4(\text{aq}) + \text{CuSO}_4(\text{aq}) \rightarrow$

8. Reactivity: Metals are more reactive $\bar{\omega}$ a \downarrow EN
 Non-metals " " \uparrow EN

- a) F e) F
 b) Ca
 c) Na
 d) Cl

1. a) atomic radius trend:

down a group = A.R. \uparrow b/c valence e^- are located in larger energy levels/shells
across a period = A.R. \downarrow b/c valence e^- are pulled in stronger by an increasingly positive nucleus ($\uparrow Z_{\text{eff}}$)

b) first ionization energy:

down a group = I.E. \downarrow b/c valence e^- are further from the positive nucleus and \therefore require less energy to be removed.
across a period = I.E. \uparrow b/c valence e^- are held more tightly by an increasingly positive nucleus ($\uparrow Z_{\text{eff}}$)

10. a) mass number represents the # of p^+ in an atom's nucleus. Each p^+ has a relative mass of 1. Atomic mass represents a weighted average of an atom's # of p^+ (mass number) plus number of neutrons.

b) An isotope is an atom with the same number of protons but different number of n^0 .
A radioisotope is an isotope where the amount of neutrons inside the nucleus change due to radioactive decay.

	i) <u>ionic properties</u>	vs.	<u>covalent properties</u>
state @ room temp	solid		solid, liquid, gas
melting pt	high		low
conduct electricity	aqueous - yes solid - no		no, rarely
solubility	usually high		low

Quantities in Chemical Reactions

2. a) Assume a 100 g sample

$$m_N = 36.8 \text{ g} \quad m_O = 100 - 36.8 \\ = 63.2 \text{ g}$$

$$n_N = \frac{m}{M}$$

$$n_O = \frac{m}{M}$$

$$= \frac{36.8 \text{ g}}{14.0 \text{ g/mol}}$$

$$= \frac{63.2 \text{ g}}{16.0 \text{ g/mol}}$$

$$= 2.629 \text{ mol}$$

$$= 3.95 \text{ mol}$$

$$\therefore \frac{2.629 \text{ mol}}{2.629 \text{ mol}}$$

$$\frac{3.95 \text{ mol}}{2.629 \text{ mol}}$$

$$\therefore 1 : 1.5$$

(2)

$$2 : 3$$

\therefore EF is N_2O_3

b) $m_{MF} = 76.02 \text{ g/mol}$

$$m_{EF} = 2(14.0) + 3(16.0)$$

$$= 76 \text{ g/mol}$$

$$\text{multiple} = \frac{m_{MF}}{m_{EF}}$$

$$= \frac{76.02}{76}$$

$$= 1$$

$$\therefore 1$$

\therefore the MF is N_2O_3 .

(3)

$$\begin{aligned} 3. \quad n_H &= \frac{m}{M} & n_C &= \frac{m}{M} \\ &= \frac{16.0g}{1.01g/mol} & &= \frac{96.0g}{12.01g/mol} \\ &= 15.84 \text{ mol H} & &= 8.0 \text{ mol C} \end{aligned}$$

$$\frac{15.84 \text{ mol H}}{8.0 \text{ mol}} = \frac{8.0 \text{ mol C}}{8.0 \text{ mol}}$$

$$2 : 1$$

∴ the EF is CH_2

$$M_{\text{MF}} = 28.06g/mol$$

$$m_{\text{EF}} = 1(12.01) + 2(1.01)$$

$$= 14.03g$$

$$\text{multiple} = \frac{M_{\text{MF}}}{m_{\text{EF}}}$$

$$= \frac{28.06}{14.03}$$

$$= 2$$

∴ the MF is C_2H_4

4a) assume 1 mol of PbI_2

$$\begin{aligned} \% \text{Pb} &= \frac{m_{\text{Pb}}}{m_{\text{PbI}_2}} \times 100 \\ &= \frac{207.2}{461} \times 100 \end{aligned}$$

$$= 44.95\%$$

$$\begin{aligned} \% \text{I} &= \frac{m_{\text{I}}}{m_{\text{PbI}_2}} \times 100 \\ &= \frac{2(126.9)}{461} \times 100 \end{aligned}$$

$$= 55.05\%$$

∴ the % comp of PbI_2 is 44.95% Pb & 55.05% I

b) assume 1 mol of NH_4NO_3

$$\begin{aligned} \% \text{N} &= \frac{m_{\text{N}}}{m_{\text{NH}_4\text{NO}_3}} \times 100 \\ &= \frac{2(14.0)}{80.04} \times 100 \end{aligned}$$

$$= 34.98\%$$

$$\begin{aligned} \% \text{H} &= \frac{m_{\text{H}}}{m_{\text{NH}_4\text{NO}_3}} \times 100 \\ &= \frac{4(1.01)}{80.04} \times 100 \end{aligned}$$

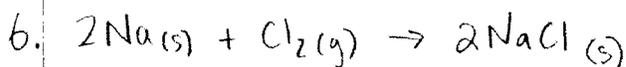
$$= 5.05\%$$

$$\begin{aligned} \% \text{O} &= \frac{m_{\text{O}}}{m_{\text{NH}_4\text{NO}_3}} \times 100 \\ &= \frac{3(16)}{80.04} \times 100 \end{aligned}$$

$$= 59.97\%$$

∴ NH_4NO_3 is 34.98% N, 5.05% H, 59.97% O.

5. a) $4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{l})$
 b) $3\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{HNO}_3(\text{aq}) + \text{NO}(\text{g})$
 c) $\text{C}_{12}\text{H}_{22}\text{O}_{11}(\text{s}) + 12\text{O}_2(\text{g}) \rightarrow 12\text{CO}_2(\text{g}) + 11\text{H}_2\text{O}(\text{g})$
 d) $2\text{KClO}_3(\text{s}) \rightarrow 2\text{KCl}(\text{s}) + 3\text{O}_2(\text{g})$
 e) $\text{MnO}_2(\text{s}) + 4\text{HCl}(\text{aq}) \rightarrow \text{MnCl}_2(\text{aq}) + \text{Cl}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
 f) $2\text{Al}_2\text{O}_3(\text{s}) \rightarrow 4\text{Al}(\text{s}) + 3\text{O}_2(\text{g})$
 g) $3\text{KOH}(\text{aq}) + \text{H}_3\text{PO}_4(\text{aq}) \rightarrow \text{K}_3\text{PO}_4(\text{aq}) + 3\text{H}_2\text{O}(\text{l})$



a) $m = ?$ $m = 15.0\text{g}$

$$n_{\text{Cl}_2} = \frac{m}{M}$$

$$= \frac{15.0\text{g}}{70.9\text{g/mol}}$$

$$\approx 0.2116 \text{ mol Cl}_2$$

$$\frac{1 \text{ mol Cl}_2 = 2 \text{ mol Na}}{0.2116 \text{ mol} \quad x}$$

$$x = 0.4231 \text{ mol Na}$$

$$m_{\text{Na}} = nM$$

$$= (0.4231 \text{ mol})(22.99 \text{ g/mol})$$

$$\approx 9.73 \text{ g}$$

∴ 9.73g of Na is needed.

b) $m_{\text{NaCl}} = 8.00\text{g}$, $m_{\text{Na}} = ?$

$$n_{\text{NaCl}} = \frac{m}{M}$$

$$= \frac{8.00\text{g}}{58.44\text{g/mol}}$$

$$\approx 0.1369 \text{ mol MgCl}_2$$

$$\frac{2 \text{ mol NaCl} = 2 \text{ mol Na}}{0.1369 \text{ mol} \quad x}$$

$$x = 0.1369 \text{ mol Na}$$

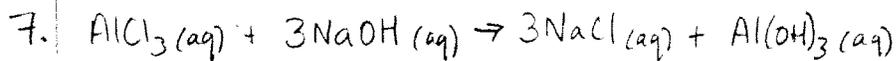
$$m_{\text{Na}} = nM$$

$$= (0.1369 \text{ mol})(22.99 \text{ g/mol})$$

$$\approx 3.15 \text{ g of Na}$$

∴ 3.15g of Na is required

(4)



$$a) m = 15.0\text{g}$$

$$m = 15.0\text{g}$$

$$n_{\text{AlCl}_3} = \frac{m}{M}$$

$$= \frac{15.0\text{g}}{133.33\text{g/mol}}$$

$$= 0.1125\text{mol AlCl}_3$$

$$n_{\text{NaOH}} = \frac{m}{M}$$

$$= \frac{15.0\text{g}}{40.0\text{g/mol}}$$

$$= 0.375\text{mol NaOH}$$

$$\frac{1\text{ mol AlCl}_3}{0.1125\text{ mol}} = \frac{1\text{ mol Al}(\text{OH})_3}{x}$$

$$\frac{3\text{ mol NaOH}}{0.375\text{ mol}} = \frac{1\text{ mol Al}(\text{OH})_3}{x}$$

$$\text{L.R. } x = 0.1125\text{ mol Al}(\text{OH})_3$$

$$x = 0.125\text{ mol Al}(\text{OH})_3$$

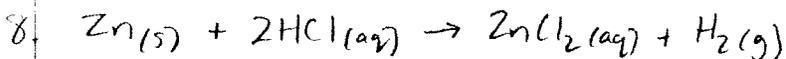
b)

$$m_{\text{Al}(\text{OH})_3} = nM$$

$$= (0.1125)(78.01)$$

$$= 8.78\text{g}$$

$\therefore 8.78\text{g}$ of $\text{Al}(\text{OH})_3$ is produced.



$$a) m = 8.40\text{g}$$

$$m = 11.6\text{g}$$

$$n_{\text{Zn}} = \frac{m}{M}$$

$$= \frac{8.40\text{g}}{65.39\text{g/mol}}$$

$$= 0.1285\text{ mol Zn}$$

$$n_{\text{HCl}} = \frac{m}{M}$$

$$= \frac{11.6\text{g}}{36.46\text{g/mol}}$$

$$= 0.3182\text{ mol HCl}$$

$$\frac{1\text{ mol Zn}}{0.1285\text{ mol}} = \frac{1\text{ mol H}_2}{x}$$

$$\frac{2\text{ mol HCl}}{0.3182\text{ mol}} = \frac{1\text{ mol H}_2}{x}$$

$$\text{L.R. } x = 0.1285\text{ mol H}_2$$

$$x = 0.159\text{ mol H}_2$$

$$m_{\text{H}_2} = nM$$

$$= (0.1285)(2.02)$$

$$= 0.26\text{g}$$

$$\% \text{ Yield} = \frac{\text{AY}}{\text{TY}} \times 100$$

$$= \frac{0.19\text{g}}{0.26\text{g}} \times 100$$

$$= 73.1\%$$

\therefore % yield is 73.1%

Solutions : Solubility

1. a) water is able to dissolve many numerous solutes due to its properties.
b) Water is V-shaped and is a polar molecule capable of making H-bonds

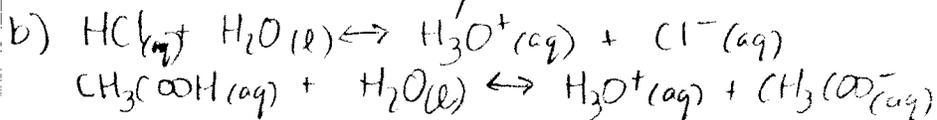


- c) due to its polarity, water is able to dissolve ionic solutes (ion-dipole forces) and polar solutes (dipole-dipole forces) according to the "like-dissolves like" rule as oppositely charged or partially charged entities are attracted to the corresponding opposite partially-charged δ^+ H or δ^- O of water.

- d) Water is unable to dissolve oil b/c oil is non-polar and \therefore will not have charges which will attract water. Oil is not like water and \therefore does not follow the "like dissolves like rule"

2. a) solubility \uparrow for solids ;
b) " \uparrow liquids
c) " \downarrow for gases

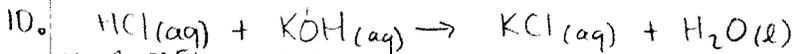
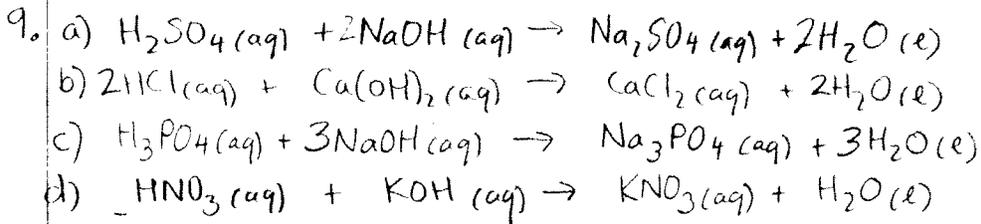
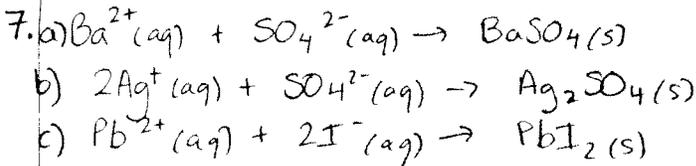
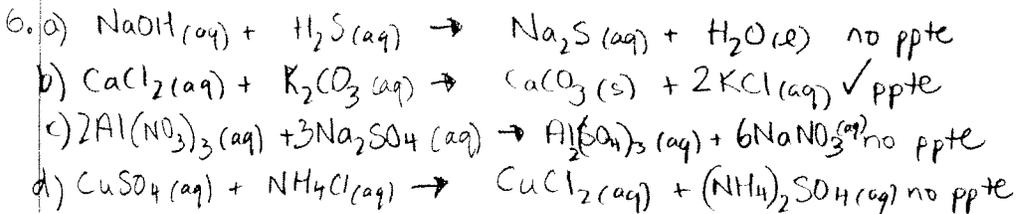
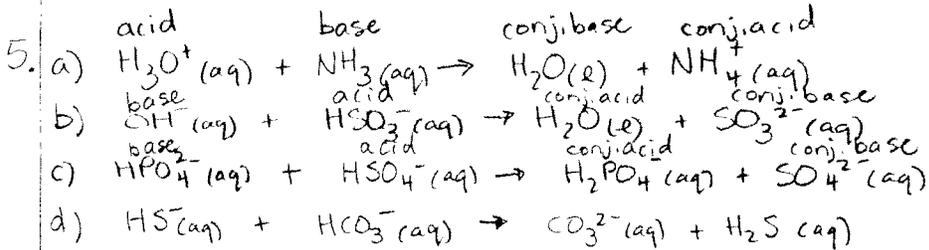
3. a) A strong acid ionizes fully whereas a weak acid ionizes very little.



(5)

4. a) Arrhenius: acids dissociate in water to release $H^+(aq)$
bases " " $OH^-(aq)$

b) Brønsted-Lowry: acids are proton donors
bases are proton acceptors



$V = 0.025L$ $V = 0.0214L$
 $C = 0.125M$ $C = ?$

$n_{HCl} = CV$
 $= (0.125M)(0.025L)$
 $= 3.125 \times 10^{-3} \text{ mol HCl}$

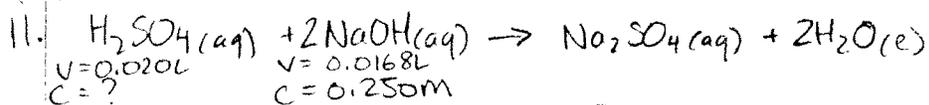
$\frac{1 \text{ mol HCl} = 1 \text{ mol KOH}}{3.125 \times 10^{-3} \quad \quad \quad x}$

$x = 3.125 \times 10^{-3} \text{ mol KOH}$

$C = \frac{n}{V}$
 $= \frac{3.125 \times 10^{-3} \text{ mol}}{0.0214L}$

$= 0.146 M$

∴ the $[KOH]$ is $0.146 M$



$V = 0.020\text{L}$
 $C = ?$

$V = 0.0168\text{L}$
 $C = 0.250\text{M}$

$n_{\text{NaOH}} = CV$

$= (0.250\text{M})(0.0168\text{L})$

$= 4.2 \times 10^{-3} \text{ mol NaOH}$

$C = \frac{n}{V}$

$= \frac{(2.1 \times 10^{-3})}{(0.020\text{L})}$

$= 0.105\text{M}$



$4.2 \times 10^{-3} \text{ mol} \quad \times$

$x = 2.1 \times 10^{-3} \text{ mol H}_2\text{SO}_4$

$\therefore [\text{H}_2\text{SO}_4]$ is 0.105M .

12. a) $C = \frac{n}{V}$

$= \frac{(0.174 \text{ mol})}{(0.250\text{L})}$

$= 0.696\text{M}$

\therefore the concentration is 0.696M

b) $n_{\text{NaOH}} = \frac{m}{M}$

$= \frac{60.0\text{g}}{40.0\text{g/mol}}$

$= 1.5 \text{ mol NaOH}$

$C = \frac{n}{V}$

$= \frac{1.5 \text{ mol}}{0.750\text{L}}$

$= 2.0\text{M}$

\therefore the $[\text{NaOH}]$ is 2.0M

13. $n_{\text{Na}_2\text{CO}_3} = CV$

$= (0.12\text{M})(0.500\text{L})$

$= 0.06 \text{ mol Na}_2\text{CO}_3$

$m = nM$

$= (0.06 \text{ mol})(105.99\text{g/mol})$

$= 6.36\text{g}$

\therefore the mass of Na_2CO_3 is 6.36g .

14. $n_{\text{NaOH}} = CV$

$= (0.200\text{M})(0.0249\text{L})$

$= 4.98 \times 10^{-3} \text{ mol NaOH}$

$M = nM$

$= (4.98 \times 10^{-3})(40)$

$= 0.20\text{g}$

\therefore the mass of NaOH is 0.20g .

(6)

15. $C_1V_1 = C_2V_2$
 $V_1 = \frac{C_2V_2}{C_1}$
 $= \frac{(0.215M)(2.0L)}{(17.8M)}$
 $= 0.0242 L$

$\therefore 0.0242 L$ of stock solution is required

16. $C_1V_1 = C_2V_2$
 $C_2 = \frac{C_1V_1}{V_2}$
 $= \frac{(11.6M)(0.015L)}{(0.500L)}$
 $= 0.348 M$

$\therefore [HCl]$ is $0.348 M$

Gases & Atmospheres

$$\begin{aligned}
 6. \quad P_1 V_1 &= P_2 V_2 \\
 V_2 &= \frac{P_1 V_1}{P_2} \\
 &= \frac{(98.0 \text{ kPa})(2.00 \text{ L})}{(82.0 \text{ kPa})} \\
 &= 2.39 \text{ L}
 \end{aligned}$$

∴ the new volume of the balloon is 2.39 L

$$\begin{aligned}
 7. \quad \frac{P_1}{T_1} &= \frac{P_2}{T_2} & T_1 &= 298 \text{ K} \\
 & & T_2 &= 398 \text{ K}
 \end{aligned}$$

$$\begin{aligned}
 P_2 &= \frac{P_1 T_2}{T_1} \\
 &= \frac{(135 \text{ kPa})(398 \text{ K})}{(298 \text{ K})} \\
 &= 180.3 \text{ kPa}
 \end{aligned}$$

∴ the final pressure is 180.3 kPa

$$\begin{aligned}
 8. \quad \frac{P_1 V_1}{T_1} &= \frac{P_2 V_2}{T_2} & T_1 &= 295 \text{ K} \\
 & & T_2 &= 273 \text{ K} \\
 V_2 &= \frac{P_1 V_1 T_2}{P_2 T_1} & P_2 &= 101.3 \text{ kPa}
 \end{aligned}$$

$$\begin{aligned}
 &= \frac{(700 \text{ kPa})(1.00 \text{ L})(273 \text{ K})}{(101.3 \text{ kPa})(295 \text{ K})} \\
 &= 6.39 \text{ L}
 \end{aligned}$$

∴ the new volume is 6.39 L

$$\begin{aligned}
 9. \quad PV &= nRT & T &= 233 \text{ K} \\
 V &= \frac{nRT}{P}
 \end{aligned}$$

$$\begin{aligned}
 &= \frac{(2.50 \text{ mol})(8.314)(233 \text{ K})}{(58.6 \text{ kPa})} \\
 &= 82.6 \text{ L}
 \end{aligned}$$

∴ the volume occupied is 82.6 L

(7)

10. $PV = nRT$

$$n = \frac{PV}{RT}$$

$$= \frac{(450 \text{ kPa})(0.500 \text{ L})}{(8.314)(293 \text{ K})}$$

$$= 0.0924 \text{ mol Cl}_2(\text{g})$$

$$T = 293 \text{ K}$$

$$M = nM$$

$$= (0.0924 \text{ mol})(70.9 \text{ g/mol})$$

$$= 6.55 \text{ g}$$

∴ the mass is 6.55g.

11. $PV = nRT$

$$n = \frac{PV}{RT}$$

$$= \frac{(101.3 \text{ kPa})(1.00 \text{ L})}{(8.314)(273 \text{ K})}$$

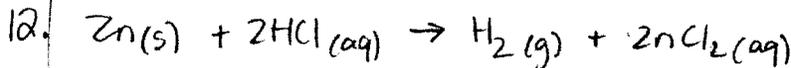
$$= 0.04463 \text{ mol}$$

$$M = \frac{m}{n}$$

$$= \frac{1.25 \text{ g}}{0.04463 \text{ mol}}$$

$$= 28.01 \text{ g/mol}$$

∴ the molar mass is 28.01g/mol



$$V = 0.250 \text{ L}$$

$$n_{\text{H}_2} = \frac{PV}{RT}$$

$$= \frac{(101.3 \text{ kPa})(0.250 \text{ L})}{(8.314)(273 \text{ K})}$$

$$= 0.01116 \text{ mol H}_2$$

$$\frac{1 \text{ mol H}_2}{0.01116 \text{ mol}} = \frac{1 \text{ mol Zn}}{x}$$

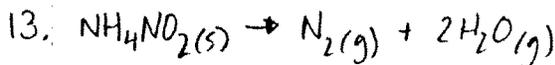
$$x = 0.01116 \text{ mol Zn}$$

$$M = nM$$

$$= (0.01116)(65.39)$$

$$= 0.73 \text{ g of Zn}$$

∴ 0.73g of Zn is required.



$$m = 128 \text{ g}$$

$$n_{\text{NH}_4\text{NO}_2} = \frac{m}{M}$$

$$= \frac{128 \text{ g}}{80.06 \text{ g/mol}}$$

$$= 1.60 \text{ mol NH}_4\text{NO}_2$$

$$\frac{1 \text{ mol NH}_4\text{NO}_2}{1.60 \text{ mol}} = \frac{2 \text{ mol H}_2\text{O}}{x}$$

$$x = 3.20 \text{ mol H}_2\text{O}(\text{g})$$

$$V = \frac{nRT}{P}$$

$$= \frac{(3.20 \text{ mol})(8.314)(819 \text{ K})}{(101.3 \text{ kPa})}$$

$$= 215.1 \text{ L}$$

∴ the volume is 215 L

14. @ STP, $P = 101.3 \text{ kPa}$, $T = 273 \text{ K}$

$$P_{\text{TOT}} = P_{\text{N}_2} + P_{\text{O}_2}$$

$$P_{\text{TOT}} = 101.3 \text{ kPa}$$

$$P_{\text{N}_2} = 0.8 \times P_{\text{TOT}} \\ = 0.8(101.3 \text{ kPa}) \\ = 81.04 \text{ kPa}$$

$$P_{\text{O}_2} = 0.2 \times P_{\text{TOT}} \\ = 0.2(101.3 \text{ kPa}) \\ = 20.26 \text{ kPa}$$

\therefore the partial pressures of N_2 & O_2 are 81.04 kPa & 20.26 kPa

15. $P_{\text{TOT}} = P_{\text{O}_2} + P_{\text{He}} + P_{\text{CO}_2}$, 9 TOTAL MOLES

$$P_{\text{TOT}} = 810 \text{ kPa}$$

$$P_{\text{O}_2} = \frac{3}{9} \times P_{\text{TOT}} \quad P_{\text{He}} = \frac{2}{9} \times P_{\text{TOT}} \quad P_{\text{CO}_2} = \frac{4}{9} \times P_{\text{TOT}} \\ = 0.33(810 \text{ kPa}) \quad = 0.22(810 \text{ kPa}) \quad = 0.44(810 \text{ kPa}) \\ = 270 \text{ kPa} \quad = 180 \text{ kPa} \quad = 360 \text{ kPa}$$

\therefore the partial pressure of He is 180 kPa

16. $P_{\text{TOT}} = P_{\text{H}_2} + P_{\text{H}_2\text{O}}$

$$P_{\text{H}_2} = P_{\text{TOT}} - P_{\text{H}_2\text{O}} \\ = (98.2 \text{ kPa}) - (2.64 \text{ kPa}) \\ = 95.56 \text{ kPa}$$

\therefore the P_{H_2} is 95.56 kPa