CALCULATION (WORKED EXAMPLES)

QUESTION 1:

What mass of hydrochloric acid (HCl) is required to completely react with 196.2 grams of zinc (Zn)?

$$\overset{\checkmark}{Zn_{(s)}} + \overset{?}{2HCl_{(aq)}} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

*(Zn)

65.38	**x 1**
65.38	**g/ mol**

$$n(Zn) = \frac{m}{*M}$$

$$= \frac{196.2}{65.38}$$

$$\therefore \quad \underline{\underline{n(Zn) = 3.00 \text{ mol}}}$$

$$n(HCl) = 2 \times n(Zn)$$

$$= 2 \times 3.00$$

$$\underline{\underline{n(HCl) = 6.00 \text{ mol}}}$$

*(HCl)

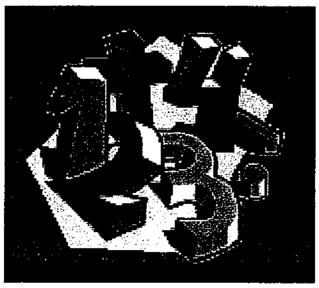
1.008	**x 1**
35.45	**x 1**
36.458	**g/ mol**

$$m(HCl) = n \times *M$$

$$= 6.00 \times 36.458$$

$$\therefore \underline{\underline{m(HCl) = 218.7g}} \text{ or}$$

$$= \underline{\underline{219 \text{ g}}} \text{ (3S.F.)}$$



QUESTION 2:

What mass of $ZnCl_2$ will be produced when 146 grams of HCl is reacted with EXCESS (more than enough!) zinc metal?

$$\overset{}{Zn_{(s)}} + \overset{\surd}{2HCl_{(aq)}} \rightarrow \overset{?}{ZnCl_{2(aq)}} + H_{2(g)}$$

*(HCl)

1.008	**x 1**
35.45	**x 1**
36.458	**g/ mol**

$$n(HCl) = \frac{m}{*M} = \frac{146}{36.458}$$

$$\therefore \underline{\underline{n(HCl) = 4.00\ mol}}$$

$$n(ZnCl_2) = \tfrac{1}{2} \times n(HCl) = \tfrac{1}{2} \times 4.00$$

$$\therefore \underline{\underline{n(ZnCl_2) = 2.00\ mol}}$$

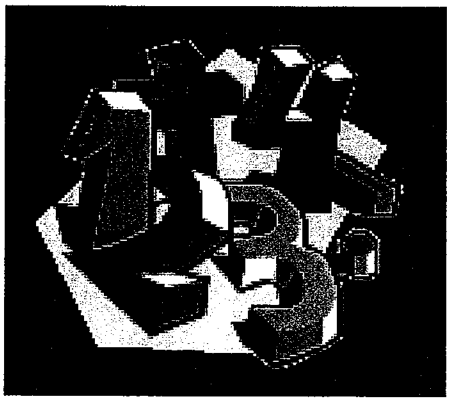
*($ZnCl_2$)

65.38	**x 1**
35.45	**x 2**
136.28	**g/ mol**

$$m(ZnCl_2) = n \times *M = 2.00 \times 136.28$$

$$\therefore \underline{\underline{m(ZnCl_2) = 272.56g}}$$

$$\underline{\underline{= 273g}} \text{ (3 S.F.)}$$



QUESTION 3:

Iron Oxide (Fe_2O_3) can be reduced in a blast furnace by carbon monoxide to produce liquid iron according to the following equation:

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$$

How many grams of iron can be produced if 45 kg of iron oxide are consumed in the process?

$$\overset{\surd}{Fe_2O_3(s)} + 3CO(g) \rightarrow \overset{?}{2Fe(l)} + 3CO_2(g)$$

*(Fe_2O_3)

55.85 x 2

16.00 x 3

159.70 g/ mol

$$n(Fe_2O_3) = \frac{m}{*M}$$

$$= \frac{45{,}000}{159.70} \quad (45kg)$$

$$\therefore \underline{\underline{n(Fe_2O_3) = 281.8 \text{ mol}}}$$

$$n(Fe) = 2 \times n(Fe_2O_3)$$

$$= 2 \times 281.8$$

$$\therefore \underline{\underline{n(Fe) = 563.6 \text{ mol}}}$$

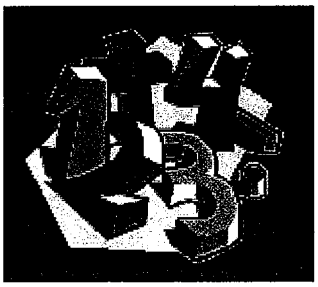
*(Fe)

55.85 x 1

55.85 g/ mol

$$m(Fe) = n \times *M$$

$$= 563.6 \times 55.85$$



$$\therefore \underline{\underline{m(Fe) = 31{,}477 \text{ g or}}}$$

$$= \underline{\underline{31{,}500 \text{ g}}} \quad (3\text{ S.F.})$$

QUESTION 4:

When salt solution is added to lead nitrate solution a white precipitate of lead chloride is formed according to the following molecular equation:

$$2NaCl(aq) + Pb(NO_3)_2(aq) \rightarrow 2NaNO_3(aq) + PbCl_2(s)$$

If a solution containing 225 grams of NaCl is added to an EXCESS of $Pb(NO_3)_2$ then what mass of lead chloride crystals could be filtered from the solution?

√ ?

$$2NaCl(aq + Pb(NO_3)_2(aq) \rightarrow 2NaNO_3(aq) + PbCl_2(s)$$

*(NaCl)

22.99	**x 1**
35.45	**x 1**
58.44	**g/ mol**

$$n(NaCl) = \frac{m}{*M}$$

$$= \frac{225}{58.44}$$

$$\therefore \underline{\underline{n(NaCl) = 3.85\ mol}}$$

$$n(PbCl_2) = \tfrac{1}{2} \times n(NaCl)$$

$$= \tfrac{1}{2} \times 3.85$$

$$\therefore \underline{\underline{n(PbCl_2) = 1.925\ mol}}$$

*($PbCl_2$)

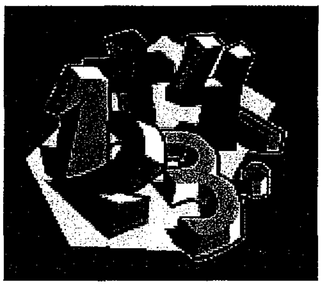
207.20	**x 1**
35.45	**x 2**
278.10	**g/ mol**

$$m(PbCl_2) = n \times *M$$

$$= 1.925 \times 278.10$$

$$\therefore \underline{\underline{m(?) = 535.3\ g}}$$

$$= \underline{\underline{535g}}\ (3\ S.F)$$



QUESTION 5:

How many grams of potassium sulphide (K_2S) can be produced if 205.27 grams of potassium metal are heated with 112.35 grams of sulphur according to the following equation?

$$2K(s) + S(s) \rightarrow K_2S(s)$$

$$\underset{2K(s)}{\surd} + \underset{S(s)}{\surd} \rightarrow \underset{K_2S(s)}{?}$$

*K

39.10	x 1	
39.10	g/ mol	

$$n(K) = \frac{m}{*M} = \frac{205.27}{39.10}$$

$\therefore$ $\underline{\underline{n(K) = 5.25 \text{ mol}}}$

*S

32.06	x 1	
32.06	g/ mol	

$$n(S) = \frac{m}{*M} = \frac{112.35}{32.06}$$

$\therefore$ $\underline{\underline{n(S) = 3.50 \text{ mol}}}$

IF ALL (K) IS CONSUMED :

- $n(S) = \frac{1}{2} \times n(K)$

$= \frac{1}{2} \times 5.25$

$\therefore$ $\underline{\underline{n(S) = 2.625 \text{ mol}}}$

We have more than enough Sulphur(S)!

$\therefore$ **Potassium (K) IS LIMITING!!**

$$n(K_2S) = \frac{1}{2} \times n(K)$$

$= \frac{1}{2} \times 5.25$

$\therefore$ $\underline{\underline{n(K_2S) = 2.625 \text{ mol}}}$

$*K_2S$

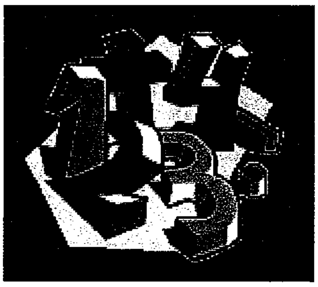
39.10	x 2	
32.06	x 1	
110.26	g/ mol	

$$m(K_2S) = n \times *M$$

$= 2.625 \times 110.26$

$\therefore$ $\underline{\underline{m(K_2S) = 289.4 \text{ g}}}$

$\underline{\underline{= 289\text{g}}}$ (3S.F.)



QUESTION 6:

Hydrochloric acid can be oxidised to chlorine (Cl_2) by oxidising agents such as manganese (IV) oxide:

$$MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$$

If 183g of HCl is reacted with 58g of MnO_2, what mass of Cl_2 will be produced?

$$\overset{\checkmark}{MnO_2(s)} + \overset{\checkmark}{4HCl(aq)} \rightarrow MnCl_2(aq) + 2H_2O(l) + \overset{?}{Cl_2(g)}$$

*MnO_2

54.94	**x 1**
16.00	**x 2**
86.94	***g/ mol***

$$n(MnO_2) = \frac{m}{{}^*M} = \frac{58}{86.94}$$

$$\therefore \underline{\underline{n(MnO_2) = 0.667 \text{ mol}}}$$

*HCl

1.008	**x 1**
35.45	**x 1**
36.458	***g/ mol***

$$n(HCl) = \frac{m}{{}^*M} = \frac{183}{36.458}$$

$$\therefore \underline{\underline{n(HCl) = 5.019 \text{ mol}}}$$

IF ALL (MnO_2) IS CONSUMED :

$$\blacklozenge\ n(HCl) = 4 \times n(MnO_2)$$
$$= 4 \times 0.667$$
$$\therefore \underline{\underline{n(HCl) = 2.668 \text{ mol}}}$$

We have more than enough HCl

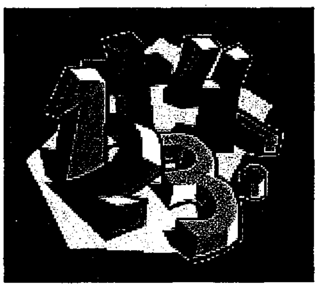
$\therefore$ **MnO_2 IS LIMITING**

$$n(Cl_2) = n(MnO_2)$$
$$= 0.667$$
$$\therefore \underline{\underline{n(Cl_2) = 0.667 \text{ mol}}}$$

*Cl_2

35.45	**x 2**
70.90	***g/ mol***

$$m(Cl_2) = n \times {}^*M$$
$$= 0.667 \times 70.90$$
$$\therefore \underline{\underline{m(Cl_2) = 47.29 \text{ g}}}$$
$$\underline{\underline{= 47.3 \text{ g}}} \quad (3\text{ S.F.})$$



QUESTION 7:

Calculate the mass of Nitric acid that can be manufactured from

20 tonnes of ammonia in the following synthesis:

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

$$3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$$

√

$$\mathbf{4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)}$$

$\boxed{1}$ $\qquad\qquad$ **1**

$$\mathbf{2NO(g) + O_2(g) \rightarrow 2NO_2(g)}$$

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1 $\qquad\qquad$ **1** **?**

$$\mathbf{3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)}$$

1 $\qquad\qquad$ $\boxed{\frac{2}{3}}$

*NH_3

14.01 x 1
1.008 x 3

17.034 g/ mol

$$n(NH_3) = \frac{m}{*M}$$

$$= \frac{20{,}000{,}000}{17.034}$$

$\therefore$ $\underline{\underline{n(NH_3) = 1{,}174{,}122 \text{ mol}}}$

$$n(HNO_3) = 2/3 \times n(NH_3)$$

$$= 2/3 \times 1{,}174{,}122$$

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$\therefore$ $\underline{\underline{n(HNO_3) = 781{,}965 \text{ mol}}}$

*HNO_3

1.008 x 1
14.01 x 1
16.00 x 3

63.018 g/ mol

$$m(HNO_3) = n \times *M$$

$$= 781{,}965 \times 63.018$$

$\therefore$ $\underline{m(HNO_3)}$ = 49,277,900g

$\underline{\underline{= 49{,}300{,}000g}}$ (3 S.F.)

$\underline{\underline{= 49.3 \text{ t}}}$