1 Memorandum: Mole calculations

1.1	$n = \frac{m}{M}$ $= \frac{8{,}8}{44}$ $m = 0{,}20\ mol$ $n = \frac{N}{N_A}$ $0{,}20 = \frac{N}{6{,}02 \times 20^{23}}$ $N = 1{,}20 \times 10^{23}\ CO_2\ molecules$
1.2	$c = \frac{m}{MV}$ $0{,}3 = \frac{22{,}5}{90 \times V}$ $V = 0{,}83\ dm^3$
1.3	2Na $+2H_2O$ $\rightarrow$ 2NaOH + H_2(g) n ← n ↓ ↑ N = ? V = 33,6 dm^3 $n = \frac{V}{V_M}$ $= \frac{33{,}6}{22{,}4}$ $= 1{,}50\ mol\ H_2$ $Na : H_2$ $2 : 1$ $x : 1{,}50$ $x = 3{,}00\ mol\ Na$ $n = \frac{N}{N_A}$ $3 = \frac{N}{6{,}02 \times 10^{23}}$ $N = 1{,}81 \times 10^{24}\ Na\ atoms$
1.4	$2KClO_3$ $\rightarrow$ 2KCl + $3O_2$(g) n ← n ↓ ↑ m = ? V = 3,36 dm^3 $n = \frac{V}{V_M}$ $= \frac{3{,}36}{22{,}4}$ $= 0{,}15\ mol\ O_2$ $KClO_3 : O_2$ $2 : 3$ $x : 0{,}15$ $x = 0{,}10\ mol\ KClO_3$ $n = \frac{m}{M}$ $0{,}10 = \frac{m}{122{,}5}$ $m = 12{,}25\ g$
1.5	$N_2O_5 : NO_2$ $2 : 4$ $x : 9{,}64$ $x = 4{,}82\ dm^3\ N_2O_5$ Do NOT USE 22,4 dm.mol^{-1}. It is NOT STP.

1.6

a.

$$c = \frac{m}{M \times V} = \frac{5{,}3}{106 \times 0{,}25} = 0{,}20\ mol.dm^{-3}$$

b. $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2(g)$

c.

$$\frac{n_a}{n_b} = \frac{C_aV_a}{c_bV_b}$$

$$\frac{2}{1} = \frac{C_a(10)}{0{,}20(25)}$$

$$c_b = 1{,}00\ mol.dm^{-3}$$

1.7

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

n → n

↑ ↓

m = 0,28 g   V = 20 cm^3

c = ?

$$n = \frac{m}{M} = \frac{0{,}28}{56} = 0{,}005\ mol\ KOH$$

$KOH : H_2SO_4$

2 : 1

0,005 : x

0,0025 $mol\ H_2SO_4$

$$c = \frac{n}{V} = \frac{0{,}0025}{0{,}020} = 0{,}125\ mol \cdot dm^{-3}$$

2.1

$4Na + O_2 \rightarrow 2Na_2O$

n   n → n

↑   ↑   ↓

m = 483 g   n = 5,8 mol   m = ?

a.

$$n = \frac{m}{M} = \frac{483}{23} = 21{,}00\ \ mol\ Na$$

available

$Na : O_2$

4 : 1

21 : x

$5{,}25\ mol\ O_2\ required$

$O_2\ available > O_2\ required$

$\therefore O_2\ is\ in\ excess$

$Na\ is\ limiting\ agent$

b.

Work with limiting agent

$Na : Na_2O$

4 : 2

21,00 : x

$x = 10{,}50\ mol\ Na_2O$

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

$$10{,}50 = \frac{m}{62}$$

$$m = 651{,}00\ g\ Na_2O$$

2.2	

$H_2SO_4 \quad + \quad 2KOH \rightarrow K_2SO_4 \quad + 2H_2O(g)$

H_2SO_4: n ↑ v = 0,2 dm^3, c = 0,2 mol.dm^{-3}

KOH: n ↑ v = 0,1 dm^{-3}, c = 0,3 mol.dm^{-3}

$$c = \frac{n}{V} \qquad c = \frac{n}{V}$$
$$0{,}2 = \frac{n}{0{,}2} \qquad 0{,}3 = \frac{n}{0{,}1}$$
$$n = 0{,}04 \ \ mol \qquad n = 0{,}03 \ \ mol$$
$$H_2SO_4 \quad available \qquad KOH \quad available$$

$$\begin{array}{rcl} H_2SO_4 & : & KOH \\ 1 & : & 2 \\ x & : & 0{,}03 \\ 0{,}015\ mol & H_2SO_4 & required \\ H_2SO_4\ available & > & H_2SO_4\ required \\ \therefore H_2SO_4 & is & in\ excess \end{array}$$

H_2SO_4 that remain: n = 0,04 - 0,015 = 0,025 mol

$$c = \frac{n}{V}$$
$$= \frac{0{,}025}{0{,}2 + 0{,}1}$$
$$= 8{,}33 \times 10^{-2}\ mol.dm^{-3}$$

H_2SO_4 is a strong base and dissociates completely
$H_2SO_4(l) + 2H_2O(l) \longrightarrow SO_4^{-2}(aq) + 2H_3O^+(aq)$

$$H_2SO_4 \ : \ H_3O^+$$
$$1 \ : \ 2$$
$$[H_3O^+] = 2(8{,}33 \ \times 10^{-2}) = 0{,}167 mol.dm^{-3}$$

$$pH = -log[H_3O^+]$$
$$= -log(0{,}167)$$
$$= 0{,}77$$

3.1

$4Al + 3O_2 (g) \rightarrow 2Al_2O_3$

n → n

↑ ↓

m = 97,2 g   m = ?

$$n = \frac{m}{M} = \frac{97{,}2}{27} = 3{,}60 \; mol \; O_2$$

$$Al : Al_2O_3$$
$$4 : 2$$
$$3{,}60 : x$$
$$x = 1{,}80 \; mol \; Al_2O_3$$

$$n = \frac{m}{M}$$
$$1{,}80 = \frac{m}{102}$$
$$m = 183{,}60 g \; Al_2O_3 \; possible$$

$$\% \; yield = \frac{actual \; yield}{possible \; yield} \times 100 = \frac{150}{183{,}60} \times 100 = 81{,}70\%$$

3.2

$2 Al + 3 H_2SO_4 \rightarrow Al_{(}SO_4)_3 + 3 H_2 + 4H_2O$

n ← n

↓ ↑

m = ?   V = 2,24 dm^3

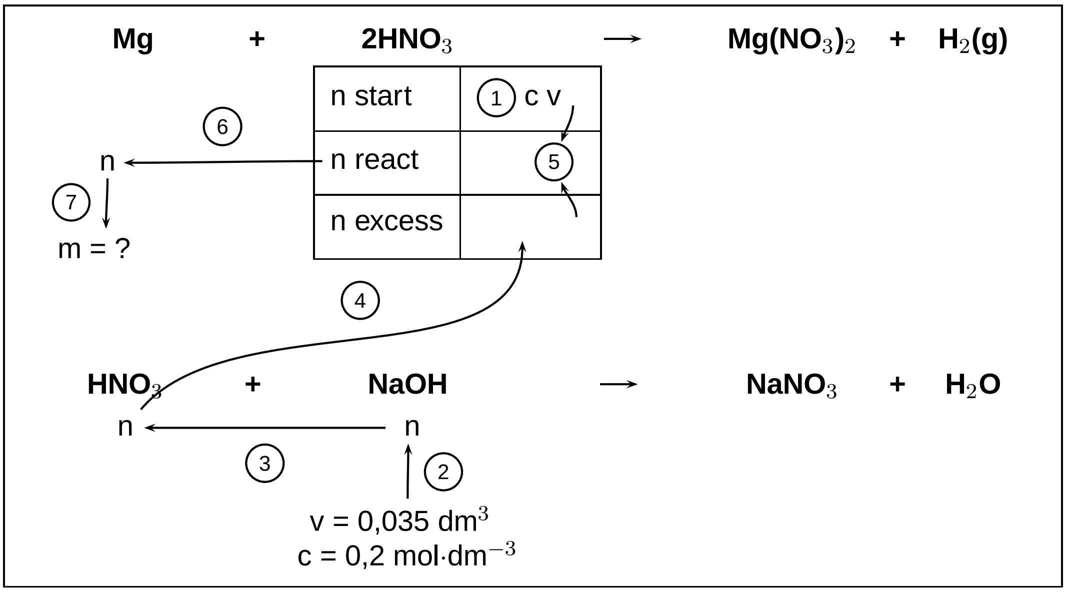
$$n = \frac{V}{V_m} = \frac{6{,}72}{22{,}4} = 0{,}30 \; mol \; NO_2$$

$$Al : H_2$$
$$2 : 3$$
$$x : 0{,}30$$
$$x = 0{,}20 \; mol \; Al$$

$$n = \frac{m}{M}$$
$$0{,}20 = \frac{m}{27}$$
$$m = 5{,}40 \; g \; Al$$

$$\% \; purity = \frac{mass \; Al)}{mass \; sample} \times 100 = \frac{5{,}40}{8} \times 100 = 67{,}50\%$$

3.3



① $HC\ell$ added:

$$c = \frac{n}{V}$$
$$0{,}2 = \frac{m}{0{,}2}$$
$$n = 0{,}04 \text{ mol}$$

② NaOH react:

$$c = \frac{n}{V}$$
$$0{,}2 = \frac{m}{0{,}035}$$
$$n = 0{,}007 \text{ mol}$$

③ HNO_3 : NaOH

1 : 1

0,007 mol $HC\ell$ reacts in 2nd reaction

④ 0,007 mol $HC\ell$ excess in 1st reaction

⑤ $n_{HC\ell}$ react = $n_{HC\ell}$ added - $n_{HC\ell}$ excess
= 0,04 - 0,007
= 0,033 mol

⑥ Mg : HNO_3

1 : 2

x : 0,033

0,0165 mol Mg

⑦
$$n = \frac{m}{M}$$
$$0{,}0165 = \frac{m}{24}$$
$$m = 0{,}396 \text{ g}$$

$$\% \, purity = \frac{mass \; Mg}{mass \; sample} \times 100$$
$$= \frac{0{,}396}{0{,}45} \times 100$$
$$= 88{,}00\%$$