⊗ Give answers to 3 s.f.

Key **Stoichiometry: Mass-Mass, Volume-Volume, Mass-Volume Problems**

→ **Mass-Mass Problems**

① moles $KClO_3$ → g $KClO_3$

$$4.00 \text{ mol } KClO_3 \times \frac{122.6 \text{ g}}{1 \text{ mol}} = 490.4 \text{ g}$$

gfm $KClO_3$ = 122.6 g/mol

3 sf = **490. g**

② $2\ KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

mol $KClO_3$ → mol O_2

$$4.00 \text{ mol } KClO_3 \times \frac{3 \text{ mol } O_2}{2 \text{ mol } KClO_3} = 6.00 \text{ mol } O_2$$

mole ratio from balanced equation

③ from problem 2, 6.00 mol O_2 formed

mol O_2 → g O_2

gfm O_2 = 32.0 g/mol

$$6.00 \text{ mol } O_2 \times \frac{32.0 \text{ g}}{1 \text{ mol}} = 192 \text{ g } O_2$$

④ $2\ KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

g $KClO_3$ → mol $KClO_3$ → mol O_2 → g O_2

gfm $KClO_3$ = 122.6 g/mol

$$61.5 \text{ g } KClO_3 \times \frac{1 \text{ mol } KClO_3}{122.6 \text{ g } KClO_3} \times \frac{3 \text{ mol } O_2}{2 \text{ mol } KClO_3} \times \frac{32.0 \text{ g } O_2}{1 \text{ mol } O_2} = 24.1 \text{ g } O_2$$

mole ratio from balanced eq.

(5) $1\,H_2SO_4(aq) + 2\,NaOH(aq) \rightarrow Na_2SO_4(aq) + 2\,H_2O(l)$

gfm NaOH = 40.0 g/mol

gfm H_2SO_4 = 98.1 g/mol

g NaOH → mol NaOH → mol H_2SO_4 → g H_2SO_4

$$120.\text{g NaOH} \times \frac{1\text{ mol NaOH}}{40.0\text{ g NaOH}} \times \frac{1\text{ mol } H_2SO_4}{2\text{ mol NaOH}} \times \frac{98.1\text{ g } H_2SO_4}{1\text{ mol } H_2SO_4} = 147\text{ g}$$

mole ratio from balanced equation

(6) $2\,HNO_3 + 1\,CaCO_3 \rightarrow 1\,Ca(NO_3)_2 + H_2O + CO_2$

gfm $CaCO_3$ = 100.1 g/mol

gfm $Ca(NO_3)_2$ = 164.1 g/mol

g $CaCO_3$ → mol $CaCO_3$ → mol $Ca(NO_3)_2$ → g $Ca(NO_3)_2$

$$20.0\text{g } CaCO_3 \times \frac{1\text{ mol } CaCO_3}{100.1\text{ g } CaCO_3} \times \frac{1\text{ mol } Ca(NO_3)_2}{1\text{ mol } CaCO_3} \times \frac{164.1\text{ g } Ca(NO_3)_2}{1\text{ mol } Ca(NO_3)_2}$$

mole ratio from balanced eq.

$$= 32.8\text{ g } Ca(NO_3)_2$$

(7) $1\,N_2 + 3\,H_2 \rightarrow 2\,NH_3$

gfm NH_3 = 17.0 g/mol

gfm N_2 = 28.0 g/mol

g NH_3 → mol NH_3 → mol N_2 → g N_2

$$3.40\text{g } NH_3 \times \frac{1\text{ mol } NH_3}{17.0\text{ g } NH_3} \times \frac{1\text{ mol } N_2}{2\text{ mol } NH_3} \times \frac{28.0\text{ g } N_2}{1\text{ mol } N_2}$$

mole ratio from balanced eq.

$$= 2.8\text{ g } N_2$$

gfm $Ca(OH)_2$ = 74.1 g/mol

gfm $Al_2(SO_4)_3$ = 342.3 g/mol

(8) $1Al_2(SO_4)_3 + 3Ca(OH)_2 \rightarrow 2Al(OH)_3 + 3CaSO_4$

g $Ca(OH)_2$ → mol $Ca(OH)_2$ → mol $Al_2(SO_4)_3$ → g $Al_2(SO_4)_3$

$$148\,g\,Ca(OH)_2 \times \frac{1\,mol\,Ca(OH)_2}{74.1\,g\,Ca(OH)_2} \times \underbrace{\frac{1\,mol\,Al_2(SO_4)_3}{3\,mol\,Ca(OH)_2}}_{\text{mole ratio}} \times \frac{342.3\,g\,Al_2(SO_4)_3}{1\,mol\,Al_2(SO_4)_3} = \boxed{228\,g\,Al_2(SO_4)_3}$$

→ Volume - Volume Problems

(9) $1CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

1 mol = 22.4 L of any gas

L CH_4 → mol CH_4 → mol O_2 → L O_2

$$44.8\,L\,CH_4 \times \frac{1\,mol\,CH_4}{22.4\,L\,CH_4} \times \underbrace{\frac{2\,mol\,O_2}{1\,mol\,CH_4}}_{\text{mole ratio}} \times \frac{22.4\,L\,O_2}{1\,mol\,O_2} = \boxed{89.6\,L\,O_2}$$

(10) $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$

L O_2 → mol O_2 → mol CO_2 → L CO_2

$$5.00\,L\,O_2 \times \frac{1\,mol\,O_2}{22.4\,L\,O_2} \times \frac{16\,mol\,CO_2}{25\,mol\,O_2} \times \frac{22.4\,L\,CO_2}{1\,mol\,CO_2} = \boxed{3.2\,L\,CO_2}$$

(11) $N_2 + 3H_2 \rightarrow 2NH_3$

L NH_3 → mol NH_3 → mol H_2 → L H_2

$$100.\,L\,NH_3 \times \frac{1\,mol\,NH_3}{22.4\,L\,NH_3} \times \frac{3\,mol\,H_2}{2\,mol\,NH_3} \times \frac{22.4\,L\,H_2}{1\,mol\,H_2} = \boxed{150.\,L\,H_2}$$

(12) $CS_2 + 3O_2 \rightarrow CO_2 + 2SO_2$

L SO_2 → mol SO_2 → mol O_2 → L O_2

$$10.0\,L\,SO_2 \times \frac{1\,mol\,SO_2}{22.4\,L\,SO_2} \times \frac{3\,mol\,O_2}{2\,mol\,SO_2} \times \frac{22.4\,L\,O_2}{1\,mol\,O_2} = \boxed{15.0\,L\,O_2}$$

(13) $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

- w/ 8.00 L NH_3:

L NH_3 → mol NH_3 → mol NO → L NO

$$8.00\,L\,NH_3 \times \frac{1\,mol\,NH_3}{22.4\,L\,NH_3} \times \frac{4\,mol\,NO}{4\,mol\,NH_3} \times \frac{22.4\,L\,NO}{1\,mol\,NO} = \underline{8.00\,L\,NO}$$

- w/ 2.00 L O_2:

L O_2 → mol O_2 → mol NO → L NO

$$2.00\,L\,O_2 \times \frac{1\,mol\,O_2}{22.4\,L\,O_2} \times \frac{4\,mol\,NO}{5\,mol\,O_2} \times \frac{22.4\,L\,NO}{1\,mol\,NO} = \underline{1.60\,L\,NO}$$

Max. Amount of NO that can be produced is 1.60 L.

* O_2 is the limiting reactant.

→ Mass-Volume Problems

(14) $2H_2O \rightarrow 2H_2 + 1O_2$

$g\ H_2O \rightarrow mol\ H_2O \rightarrow mol\ O_2 \rightarrow L\ O_2$

$$180\,g\ H_2O \times \frac{1\ mol\ H_2O}{18.0\,g\ H_2O} \times \frac{1\ mol\ O_2}{2\ mol\ H_2O} \times \frac{22.4\,L\ O_2}{1\ mol\ O_2} = \boxed{112\,L\ O_2}$$

gfm H_2O = 18.0 g/mol

(15) $2HCl + 1Zn \rightarrow 1H_2 + ZnCl_2$

$L\ H_2 \rightarrow mol\ H_2 \rightarrow mol\ Zn \rightarrow g\ Zn$

$$11.2\,L\ H_2 \times \frac{1\ mol\ H_2}{22.4\,L\ H_2} \times \frac{1\ mol\ Zn}{1\ mol\ H_2} \times \frac{65.4\,g\ Zn}{1\ mol\ Zn} = \boxed{32.7\,g\ Zn}$$

gfm Zn = 65.4 g/mol

(16) $3O_2 + 4Al \rightarrow 2Al_2O_3$

$g\ Al_2O_3 \rightarrow mol\ Al_2O_3 \rightarrow mol\ O_2 \rightarrow L\ O_2$

$$408\,g\ Al_2O_3 \times \frac{1\ mol\ Al_2O_3}{102.0\,g\ Al_2O_3} \times \frac{3\ mol\ O_2}{2\ mol\ Al_2O_3} \times \frac{22.4\,L\ O_2}{1\ mol\ O_2} = \boxed{134\,L\ O_2}$$

gfm Al_2O_3 = 102.0 g/mol

(17) $1Cl_2 + CaI_2 \rightarrow 1CaCl_2 + I_2$

$g\ CaCl_2 \rightarrow mol\ CaCl_2 \rightarrow mol\ Cl_2 \rightarrow L\ Cl_2$

$$222\,g\ CaCl_2 \times \frac{1\ mol\ CaCl_2}{111.1\,g\ CaCl_2} \times \frac{1\ mol\ Cl_2}{1\ mol\ CaCl_2} \times \frac{22.4\,L\ Cl_2}{1\ mol\ Cl_2} = \boxed{44.8\,L}$$

gfm $CaCl_2$ = 111.1 g/mol