2.9 THE MOLE AND CHEMICAL EQUATIONS: STOICHIOMETRY

PRACTICE

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Understanding Concepts

1.

Balanced equation	$2\ Al_2O_{3(s)}$ →	$4\ Al_{(s)}$ +	$3\ O_{2(g)}$
Given mass (g)	125 g		
Molar mass (g/mol)	101.96 g/mol	26.98 g/mol	32.00 g/mol

$$n_{Al_2O_3} = 125\ \cancel{g\,Al_2O_3} \times \frac{1\ mol\,Al_2O_3}{101.96\ \cancel{g\,Al_2O_3}}$$

$$n_{Al_2O_3} = 1.226\ mol\,Al_2O_3$$

$$n_{Al} = 1.226\ \cancel{mol\,Al_2O_3} \times \frac{4\ mol\,Al}{2\ \cancel{mol\,Al_2O_3}}$$

$$n_{Al} = 2.452\ mol\,Al$$

$$m_{Al} = 2.452\ \cancel{mol\,Al} \times \frac{26.98\ g\,Al}{1\ \cancel{mol\,Al}}$$

$$m_{Al} = 66.2\ g\,Al$$

Therefore, 66.2 g of aluminum is produced from 125 g of aluminum oxide.

The combined calculation is as follows:

$$m_{Al} = 125\ \cancel{g\,Al_2O_3} \times \frac{1\ \cancel{mol\,Al_2O_3}}{101.96\ \cancel{g\,Al_2O_3}} \times \frac{4\ \cancel{mol\,Al}}{2\ \cancel{mol\,Al_2O_3}} \times \frac{26.98\ g\,Al}{1\ \cancel{mol\,Al}}$$

$$m_{Al} = 66.2\ g\,Al$$

Therefore, 66.2 g of aluminum is produced from 125 g of aluminum oxide.

2.

Balanced equation	$2\ K_{(s)}$ +	$2\ HCl_{(aq)}$ →	$2\ KCl_{(aq)}$ +	$H_{2(g)}$
Given mass (g)				5.00 g
Molar mass (g/mol)	39.16 g/mol			1.01 g/mol (2.02 g/mol)

$$n_{H_2} = 5.00\ \cancel{g\ H_2} \times \frac{1\ \text{mol}\ H_2}{2.02\ \cancel{g\ H_2}}$$

$$n_{H_2} = 2.48\ \text{mol}\ H_2$$

$$n_K = 2.48\ \cancel{\text{mol}\ H_2} \times \frac{2\ \text{mol K}}{1\ \cancel{\text{mol}\ H_2}}$$

$$n_K = 4.96\ \text{mol K}$$

$$m_K = 4.96\ \cancel{\text{mol K}} \times \frac{39.10\ \text{g K}}{1\ \cancel{\text{mol K}}}$$

$$m_K = 194\ \text{g K}$$

Therefore, 194 g of potassium is required to produce 5.00 g of hydrogen gas.

The combined calculation is as follows:

$$m_K = 5.00\ \cancel{gH_2} \times \frac{1\ \cancel{\text{mol}H_2}}{2.02\ \cancel{gH_2}} \times \frac{2\ \cancel{\text{mol}K}}{1\ \cancel{\text{mol}H_2}} \times \frac{39.10\ \text{gK}}{1\ \cancel{\text{mol}K}}$$

$$m_K = 194\ \text{gK}$$

Therefore, 194 g of potassium is required to produce 5.00 g of hydrogen gas.

3.

Balanced equation	$2\ KClO_{3(s)}$ →	$2\ KCl_{(s)}$ +	$2\ O_{2(g)}$
Given mass (g)			0.96 g

1 mol $KClO_3$ = 6.02×10^{23} formula units $KClO_3$

$$n_{O_2} = 0.96\ \cancel{g\ O_2} \times \frac{1\ \text{mol}\ O_2}{32.00\ \cancel{g\ O_2}}$$

$$n_{O_2} = 0.030\ \text{mol}\ O_2$$

$$n_{KClO_3} = 0.030\ \cancel{\text{mol}\ O_2} \times \frac{2\ \text{mol}\ KClO_3}{3\ \cancel{\text{mol}\ O_2}}$$

$$n_{KClO_3} = 0.020\ \text{mol}\ KClO_3$$

$$N_{KClO_3} = 0.020\ \cancel{\text{mol}\ KClO_3} \times \frac{6.02{\times}10^{23}\ \text{formula units}\ KClO_3}{1\ \cancel{\text{mol}\ KClO_3}}$$

$$N_{KClO_3} = 1.2 \times 10^{22}\ \text{formula units}\ KClO_3$$

Therefore, 1.2×10^{22} formula units of potassium chlorate must decompose.

The combined calculation is as follows:

$$N_{KClO_3} = 0.96\ \cancel{g\ O_2} \times \frac{1\ \cancel{\text{mol}\ O_2}}{32.00\ \cancel{g\ O_2}} \times \frac{2\ \cancel{\text{mol}\ KClO_3}}{3\ \cancel{\text{mol}\ O_2}} \times \frac{6.02 \times 10^{23}\ \text{formula units}\ KClO_3}{1\ \cancel{\text{mol}\ KClO_3}}$$

$$N_{KClO_3} = 1.2 \times 10^{22}\ \text{formula units}\ KClO_3$$

Therefore, 1.2×10^{22} formula units of potassium chlorate must decompose.

SECTION 2.9 QUESTIONS

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Understanding Concepts

1. A mole ratio is the ratio of moles of two or more entities in a balanced chemical equation.
2. Yes, the total amount (in moles) of atoms in the reactants equals the total amount (in moles) of atoms in the products because one mole of any type of atom is 6.02×10^{23} atoms.
3. $3\ NO_{2(g)} + H_2O_{(l)} \rightarrow 2\ HNO_{3(aq)} + NO_{(g)}$
   The mole ratio of the reactants is 3:1. The mole ratio of the products is 2:1.
4. Stoichiometry is the procedure for calculating quantities of reactants or products in a chemical reaction. In stoichiometry, mole ratios in balanced equations are used to calculate quantities of reactants of products produced.
5.

Balanced equation	$2\ H_2O_{(l)}$ →	$2\ H_{2(g)}$ +	$O_{2(g)}$
Given mass (g)	12.0 g		

$1\ \text{mol}\ H_2 = 6.02 \times 10^{23}$ molecules H_2

$$n_{H_2O} = 12.0\ \cancel{\text{g}\ H_2O} \times \frac{1\ \text{mol}\ H_2O}{18.02\ \cancel{\text{g}\ H_2O}}$$

$$n_{H_2O} = 0.666\ \text{mol}\ H_2O$$

$$n_{H_2} = 0.666\ \cancel{\text{mol}\ H_2O} \times \frac{2\ \text{mol}\ H_2}{2\ \cancel{\text{mol}\ H_2O}}$$

$$n_{H_2} = 0.666\ \text{mol}\ H_2$$

$$N_{H_2} = 0.666\ \cancel{\text{mol}\ H_2} \times \frac{6.02 \times 10^{23}\ \text{molecules}\ H_2}{1\ \cancel{\text{mol}\ H_2}}$$

$$N_{H_2} = 4.01 \times 10^{23}\ \text{molecules}\ H_2$$

Therefore, 4.01×10^{23} molecules of hydrogen gas are produced from the decomposition of 12.0 g of water.

The combined calculation is as follows:

$$N_{H_2} = 12.0\ \cancel{\text{g}\ H_2O} \times \frac{1\ \cancel{\text{mol}\ H_2O}}{18.02\ \cancel{\text{g}\ H_2O}} \times \frac{2\ \cancel{\text{mol}\ H_2}}{2\ \cancel{\text{mol}\ H_2O}} \times \frac{6.02 \times 10^{23}\ \text{molecules}\ H_2}{1\ \cancel{\text{mol}\ H_2}}$$

$$N_{H_2} = 4.01 \times 10^{23}\ \text{molecules}\ H_2$$

Therefore, 4.01×10^{23} molecules of hydrogen gas are produced from the decomposition of 12.0 g of water.