Activity 3D: The mole and chemical equations

Ans p. 8

1. A student weighed out 2.40 g of magnesium and burned it in air. Magnesium burns in air to form magnesium oxide. The equation for the reaction is:

$$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$$

Calculate the mass of magnesium oxide produced in the reaction.

2. The reaction between magnesium carbonate and dilute hydrochloric acid is represented by the equation:

$$MgCO_3(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2O(\ell) + CO_2(g)$$

$M(MgCO_3) = 84.3$ g mol^{-1}, $M(MgO) = 40.3$ g mol^{-1}, $M(CO_2) = 44.0$ g mol^{-1}

Calculate the mass of magnesium carbonate that will be needed to produce 8.80 g of CO_2.

3. The reaction for the decomposition of calcium carbonate is:

$$CaCO_3 \longrightarrow CaO + CO_2$$

If 100 kg of calcium carbonate is heated, what mass of calcium oxide will form?

4. When sulfur trioxide dissolves in water, the reaction occurring is:

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

Find the mass of H_2SO_4 formed when 8.0 tonnes of sulfur trioxide dissolves in water.

5. $CH_4(g) + 2O_2(g) \longrightarrow 2H_2O(g) + CO_2(g)$

How many moles of water vapour form when 32 g of methane burns?

6. Calculate the mass of water that will react completely with 4.00 g of pure calcium metal according to the following equation:

$$Ca(s) + 2H_2O(\ell) \longrightarrow Ca(OH)_2(s) + H_2(g)$$

7. Calculate the mass of ammonia that is required to produce 182 kg of urea, $CO(NH_2)_2$, according to the following equation:

$$CO_2(g) + 2NH_3(g) \longrightarrow CO(NH_2)_2(s) + H_2O(\ell)$$

8. Calculate the mass of CO_2 produced in the complete combustion of 21.2 g of butene, C_4H_8, according to the following equation:

$$C_4H_8 + 6O_2 \longrightarrow 4CO_2 + 4H_2O$$

9. Calculate the mass of sulfur trioxide, SO_3, produced from 100 kg of sulfur dioxide, SO_2, according to the following equation:

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

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Activity 3D: The mole and chemical equations (page 7)

1. $n(\text{Mg}) = \frac{m}{M} = \frac{2.40\text{ g}}{24.3\text{ g mol}^{-1}} = 9.88 \times 10^{-2}\text{ mol}$

$n(\text{Mg}) = n(\text{MgO}) = 9.88 \times 10^{-2}\text{ mol}$

$m(\text{MgO}) = n \times M = 9.88 \times 10^{-2}\text{ mol} \times 40.3\text{ g mol}^{-1}$

$= 3.98\text{ g}$

2. $n(\text{CO}_2) = \frac{m}{M} = \frac{8.80\text{ g}}{44.0\text{ g mol}^{-1}} = 0.200\text{ mol}$

$n(\text{MgCO}_3) = n(\text{CO}_2) = 0.200\text{ mol}$

$m(\text{MgCO}_3) = n \times M = 0.200 \times 84.3\text{ g}$

$= 16.9\text{ g}$

3. $M(\text{CaCO}_3) = 100.0\text{ g mol}^{-1}$

$n(\text{CaCO}_3) = \frac{m}{M} = \frac{100\,000}{100.1} = 999\text{ mol}$

$n(\text{CaO}) = n(\text{CaCO}_3) = 999\text{ mol}$

$m(\text{CaO}) = n \times M = 999\text{ mol} \times 56.1\text{ g mol}^{-1}$

$= 56\text{ kg}$

4. $n(\text{SO}_3) = \frac{m}{M} = \frac{8.0 \times 10^6\text{ g}}{80.1\text{ g mol}^{-1}} = 1 \times 10^5\text{ mol}$

$n(\text{H}_2\text{SO}_4) = n(\text{SO}_3) = 1 \times 10^5\text{ mol}$

$m(\text{H}_2\text{SO}_4) = n \times M = 1 \times 10^5\text{ mol} \times 98.1\text{ g mol}^{-1}$

$= 9.8\text{ tonnes}$

5. $n(\text{CH}_4) = \frac{m}{M} = \frac{32\text{ g}}{16.0\text{ g mol}^{-1}} = 2\text{ mol}$

$n(\text{H}_2\text{O}) = 2n(\text{CH}_4) = 2 \times 2 = 4\text{ mol}$

6. $n(\text{Ca}) = \frac{m}{M} = \frac{4.00\text{ g}}{40.1\text{ g mol}^{-1}} = 0.0998\text{ mol}$

$n(\text{H}_2\text{O}) = 2n(\text{Ca}) = 0.198\text{ mol}$

$m(\text{H}_2\text{O}) = 0.198\text{ mol} \times 18.0\text{ g mol}^{-1}$

$= 35.6\text{ g}$

7. $n(\text{CO(NH}_2)_2) = \frac{m}{M} = \frac{182\,000\text{ g}}{60.0\text{ g mol}^{-1}} = 3\,033\text{ mol}$

$n(\text{NH}_3) = 2n(\text{CO(NH}_2)_2) = 2 \times 3\,033\text{ mol}$

$= 6\,066\text{ mol}$

$n(\text{NH}_3) = n \times M = 6\,066\text{ mol} \times 17.0\text{ g mol}^{-1}$

$= 103\text{ kg}$

8. $n(\text{C}_4\text{H}_8) = \frac{m}{M} = \frac{21.2\text{ g}}{56.0\text{ g mol}^{-1}} = 0.379\text{ mol}$

$n(\text{CO}_2) = 4n(\text{C}_4\text{H}_8) = 4 \times 0.379\text{ mol} = 1.52\text{ mol}$

$m(\text{CO}_2) = n \times M = 1.52\text{ mol} \times 44.0\text{ g mol}^{-1}$

$= 66.9\text{ g}$

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9. $n(SO_2) = \frac{m}{M} = \frac{100\,000\text{ g}}{64.1\text{ g mol}^{-1}} = 1\,560\text{ mol}$

$n(SO_2) = n(SO_3) = 1\,560\text{ mol}$

$m(SO_3) = n \times M = 1\,560\text{ mol} \times 80.1\text{ g mol}^{-1} = 125\text{ kg}$

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