Quiz (Calculation involving Chemical Equation)

1. Magnesium reacts with copper(II) oxide according to the following equation:

   $Mg(s) + CuO(s) \longrightarrow MgO(s) + Cu(s)$

   Calculate the mass of magnesium required to react completely with 7.95 g of copper(II) oxide.
   (Relative atomic masses: O = 16.0, Mg = 24.3, Cu = 63.5)

2. Magnesium reacts with lead(II) oxide according to the following equation:

   $Mg(s) + PbO(s) \longrightarrow MgO(s) + Pb(s)$

   Calculate the mass of magnesium required to react completely with 10.55 g of lead(II) oxide.
   (Relative atomic masses: O = 16.0, Mg = 24.3, Pb = 207.2)

3. Lead(II) oxide reacts with carbon powder to give lead and carbon dioxide.

   $2PbO(s) + C(s) \longrightarrow 2Pb(s) + CO_2(g)$

   Calculate the mass of lead formed when 44.6 g of lead(II) oxide has completely reacted.
   (Relative atomic masses: C = 12.0, O = 16.0, Pb = 207.2)

4. Sodium reacts with water to give sodium hydroxide and hydrogen according to the following equation:

   $2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$

   Calculate the mass of hydrogen formed when 8.51 g of sodium reacts completely with water.
   (Relative atomic masses: H = 1.0, O = 16.0, Na = 23.0)

5. Calculate the mass of zinc formed when 8.14 g of zinc oxide are heated with 2.20 g of carbon powder.
   (Relative atomic masses: C = 12.0, O = 16.0, Zn = 65.4)

6. Calculate the mass of nitrogen dioxide formed when 26.58 g of nitrogen monoxide reacts with 8.06 g of oxygen according to the following equation:

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

   (Relative atomic masses: N = 14.0, O = 16.0)

7. In an experiment, 15.9 g of copper(II) oxide was heated with 0.60 g of hydrogen according to the following reaction:

   $CuO(s) + H_2(g) \longrightarrow Cu(s) + H_2O(l)$

   (a) Calculate the theoretical yield of copper.

   (b) Given the percentage yield of copper is 82%. Calculate the actual yield of copper.

   (Relative atomic masses: H = 1.0, O = 16.0, Cu = 63.5)

8. Methanol (CH_3OH) can be produced from carbon monoxide and hydrogen according to the following equation:

$$CO(g) + 2H_2(g) \longrightarrow CH_3OH(g)$$

(a) Calculate the theoretical yield of methanol when 430 g hydrogen reacts with excess carbon monoxide.

(b) Given the percentage yield of methanol is 45%, calculate the actual yield of methanol.

(Relative atomic masses: H = 1.0, C = 12.0, O = 16.0)

9. Upon strong heating, silver oxide decomposes to silver and oxygen. Calculate the mass of silver obtained when 6.96 g of silver oxide is strongly heated in air.
(Relative atomic masses: O = 16.0, Ag = 107.9)

10. Titanium can be prepared by the reaction of titanium(IV) chloride with molten magnesium.

$$TiCl_4(g) + 2Mg(l) \longrightarrow Ti(s) + 2MgCl_2(l)$$

Calculate the mass of titanium obtained when 5.42×10^6 g of magnesium were allowed to react with 1.77×10^7 g of titanium(IV) chloride.
(Relative atomic masses: Mg = 24.3, Cl = 35.5, Ti = 47.9)

11. A student performed the following experiment to prepare calcium hydroxide. 1.50 g of calcium granules was dissolved in a large amount of water. The calcium hydroxide precipitate was then filtered off, washed and dried.

(a) Write an equation for the reaction of calcium with water.

(b) Calculate the theoretical mass of calcium hydroxide obtained.

(c) The mass of calcium hydroxide obtained from the experiment was much less than the theoretical value. Explain why there was such a difference.

(Relative atomic masses: H = 1.0, O = 16.0, Ca = 40.1)

Suggested Answer

1. $Mg(s) + CuO(s) \longrightarrow MgO(s) + Cu(s)$

   Molar mass of CuO = 63.5 + 16.0 = 79.5 g mol^{-1}

   Number of moles of CuO = 7.95 / 79.5 = 0.100 mol

   From the equation, mole ratio of Mg : CuO = 1 : 1.

   ∴ number of moles of Mg = 0.100 mol

   Mass of Mg required = 0.100 × 24.3 = 2.43 g

2. Molar mass of PbO = 207.2 + 16.0 = 223.2 g mol^{-1}

   Number of moles of PbO = 10.55 / 223.2 = 0.0473 mol

   From the equation, mole ratio of Mg to PbO is 1 : 1.

   ∴ number of moles of Mg required = 0.0473 mol

   Mass of Mg required = 0.0473 × 24.3 = 1.15 g

3. $2PbO(s) + C(s) \longrightarrow 2Pb(s) + CO_2(g)$

   Molar mass of PbO = 207.2 + 16.0 = 223.2 g mol^{-1}

   Number of moles of PbO reacted = 44.6 / 223.2 = 0.200 mol

   From the equation, mole ratio of PbO : Pb = 2 : 2 = 1 : 1.

   ∴ number of moles of Pb = 0.200 mol

   Mass of Pb formed = 0.200 × 207.2 = 41.4 g

4. Number of moles of Na reacted = 8.51 / 23.0 = 0.37 mol

   From the equation, mole ratio of Na to H_2 is 2 : 1.

   ∴ number of moles of H_2 formed = 0.37 / 2 = 0.185 mol

   Mass of H_2 produced = 0.185 × 1.0 × 2 = 0.37 g

5. $2ZnO(s) + C(s) \longrightarrow 2Zn(s) + CO_2(g)$

Molar mass of ZnO = 65.4 + 16.0 = 81.4 g mol^{-1}

Number of moles of ZnO = 8.14 / 81.4 = 0.100 mol

Number of moles of C = 2.20 / 12.0 = 0.183 mol

From the equation, mole ratio of ZnO : C = 2 : 1.

$\therefore$ 0.100 mol of ZnO would react with 0.100 / 2 = 0.0500 mol of C

Since 0.183 mol of C is heated, C is in excess.

ZnO is the limiting reactant in this case, as it is all used up.

From the equation, mole ratio of ZnO : Zn = 2 : 2 = 1 : 1.

$\therefore$ number of moles of Zn formed = 0.100 mol

$\therefore$ Mass of Zn formed = 0.100 × 65.4 = 6.54 g

6. Molar mass of NO = 14.0 + 16.0 = 30.0 g mol^{-1}

Number of moles of NO = 26.58 / 30.0 = 0.886 mol

Molar mass of O_2 = 16.0 × 2 = 32.0 g mol^{-1}

Number of moles of O_2 = 8.06 / 32.0 = 0.252 mol

From the equation, mole ratio of NO to O_2 = 2 : 1.

$\therefore$ O_2 is the limiting reactant.

Molar mass of NO_2 = 14.0 + 16.0 × 2 = 46.0 g mol^{-1}

From the equation, mole ratio of O_2 to NO_2 = 1 : 2.

$\therefore$ Number of moles of NO_2 formed = 0.252 × 2 = 0.504 mol

Mass of NO_2 formed = 0.504 × 46.0 = 23.2 g

7. (a) $CuO(s) + H_2(g) \longrightarrow Cu(s) + H_2O(l)$

Molar mass of CuO = 63.5 + 16.0 = 79.5 g mol^{-1}

Number of moles of CuO = 15.9 / 79.5 = 0.20 mol

Molar mass of H_2 = 1.0 × 2 = 2.0 g mol^{-1}

Number of moles of H_2 = 0.60 / 2.0 = 0.30 mol

From the equation, mole ratio of CuO : H_2 = 1 : 1.

∴ 0.20 mol of CuO would react with 0.20 mol of H_2.

Since 0.30 mol of H_2 is heated, H_2 is in excess.

CuO is the limiting reactant in this case, as it is all used up.

From the equation, mole ratio of CuO : Cu = 1 : 1.

∴ number of moles of Cu formed = 0.20 mol

∴ theoretical yield of Cu = 0.20 × 63.5 = 12.7 g

(b) Actual yield of Cu = theoretical yield × percentage yield
= 12.7 g × 82%
= 10.4 g

8. (a) Number of moles of H_2 = 430 / (1.0 × 2) = 215 mol

Molar mass of CH_3OH = 12.0 + 1.0 × 4 + 16.0 = 32.0 g mol^{-1}

From the equation, mole ratio of H_2 to CH_3OH = 2 : 1.

∴ number of moles of CH_3OH produced = 215 / 2 = 107.5 mol

Theoretical yield of CH_3OH = 107.5 × 32.0 = 3440 g

(b) Actual yield of CH_3OH = 3440 × 45% = 1548 g

9. $2Ag_2O(s) \longrightarrow 4Ag(s) + O_2(g)$

Number of moles of Ag_2O used = 6.96 / (107.9 × 2 + 16.0) = 0.0300 mol

From the equation, mole ratio of Ag_2O to Ag is 1 : 2.

∴ number of moles of Ag produced = 0.0300 × 2 = 0.0600 mol

Mass of Ag produced = 0.0600 × 107.9 = 6.47 g

10. Number of moles of Mg used = $5.42 \times 10^6 / 24.3$ = 223 045 mol

Number of moles of $TiCl_4$ used = $1.77 \times 10^7 / (47.9 + 35.5 \times 4)$ = 93 207 mol

From the equation, mole ratio of $TiCl_4$ to Mg is 1 : 2.

∴ $TiCl_4$ is the limiting reactant.

From the equation, mole ratio of $TiCl_4$ to Ti is 1 : 1.

number of moles of Ti formed = 93 207 mol

Mass of Ti formed = 93 207 × 47.9 = 4 464 615 g

11. (a) $Ca(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(s) + H_2(g)$

(b) Number of moles of Ca used = 1.50 / 40.1 = 0.0374 mol

From the equation, mole ratio of Ca to $Ca(OH)_2$ = 1 : 1.

∴ number of moles of $Ca(OH)_2$ formed = 0.0374 mol

Theoretical mass of $Ca(OH)_2$ formed
= 0.0374 × [40.1 + (16.0 + 1.0) × 2] = 2.77 g

(c) Possible reasons:

i) The calcium used was impure (Covered by a layer of calcium oxide).

ii) Some calcium hydroxide was lost during filtration (Calcium hydroxide is slightly soluble in water).