

Quiz (Calculation involving Chemical Equation)

1. Magnesium reacts with copper(II) oxide according to the following equation:
$$\text{Mg(s)} + \text{CuO(s)} \longrightarrow \text{MgO(s)} + \text{Cu(s)}$$

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:
$$\text{Mg(s)} + \text{PbO(s)} \longrightarrow \text{MgO(s)} + \text{Pb(s)}$$

Calculate the mass of magnesium required to react completely with 10.55 g of lead(II) oxide.

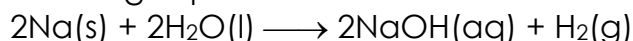
(Relative atomic masses: O = 16.0, Mg = 24.3, Pb = 207.2)

3. Lead(II) oxide reacts with carbon powder to give lead and carbon dioxide.
$$2\text{PbO(s)} + \text{C(s)} \longrightarrow 2\text{Pb(s)} + \text{CO}_2(\text{g})$$

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:



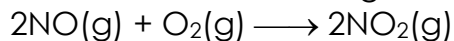
Calculate the mass of hydrogen formed when 8.51 g of sodium reacts completely with water.

(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.

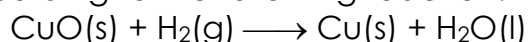
(Relative atomic masses: C = 12.0, O = 16.0, Zn = 65.4)

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:



(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:

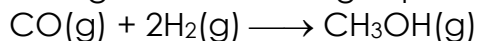


(a) Calculate the theoretical yield of copper.

(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 (CH₃OH) can be produced from carbon monoxide and hydrogen according to the following equation:



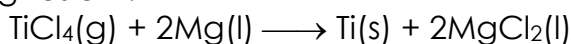
- (a) Calculate the theoretical yield of methanol when 430 g hydrogen reacts with excess carbon monoxide.
- (b) Given the percentage yield of methanol is 45%, calculate the actual yield of methanol.

(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.



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.

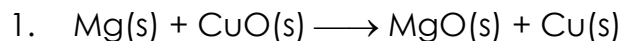
(a) Write an equation for the reaction of calcium with water.

(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



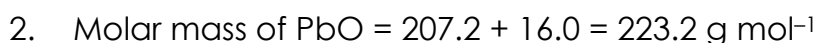
$$\text{Molar mass of CuO} = 63.5 + 16.0 = 79.5 \text{ g mol}^{-1}$$

$$\text{Number of moles of CuO} = 7.95 / 79.5 = 0.100 \text{ mol}$$

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

$$\therefore \text{ number of moles of Mg} = 0.100 \text{ mol}$$

$$\text{Mass of Mg required} = 0.100 \times 24.3 = 2.43 \text{ g}$$

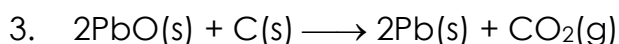


$$\text{Number of moles of PbO} = 10.55 / 223.2 = 0.0473 \text{ mol}$$

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

$$\therefore \text{ number of moles of Mg required} = 0.0473 \text{ mol}$$

$$\text{Mass of Mg required} = 0.0473 \times 24.3 = 1.15 \text{ g}$$



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

$$\text{Number of moles of PbO reacted} = 44.6 / 223.2 = 0.200 \text{ mol}$$

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

$$\therefore \text{ number of moles of Pb} = 0.200 \text{ mol}$$

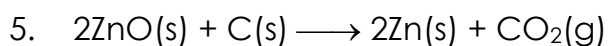
$$\text{Mass of Pb formed} = 0.200 \times 207.2 = 41.4 \text{ g}$$



From the equation, mole ratio of Na to H₂ is 2 : 1.

$$\therefore \text{ number of moles of H}_2 \text{ formed} = 0.37 / 2 = 0.185 \text{ mol}$$

$$\text{Mass of H}_2 \text{ produced} = 0.185 \times 1.0 \times 2 = 0.37 \text{ g}$$



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

Number of moles of ZnO = $8.14 / 81.4 = 0.100 \text{ mol}$

Number of moles of C = $2.20 / 12.0 = 0.183 \text{ mol}$

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

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

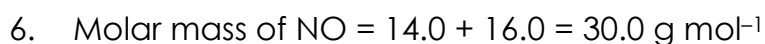
Since 0.183 mol of C is heated, C is in excess.

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 = $0.100 \times 65.4 = 6.54 \text{ g}$



Number of moles of NO = $26.58 / 30.0 = 0.886 \text{ mol}$

Molar mass of O₂ = $16.0 \times 2 = 32.0 \text{ g mol}^{-1}$

Number of moles of O₂ = $8.06 / 32.0 = 0.252 \text{ mol}$

From the equation, mole ratio of NO to O₂ = 2 : 1.

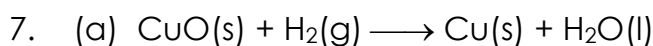
\therefore O₂ is the limiting reactant.

Molar mass of NO₂ = $14.0 + 16.0 \times 2 = 46.0 \text{ g mol}^{-1}$

From the equation, mole ratio of O₂ to NO₂ = 1 : 2.

\therefore Number of moles of NO₂ formed = $0.252 \times 2 = 0.504 \text{ mol}$

Mass of NO₂ formed = $0.504 \times 46.0 = 23.2 \text{ g}$



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

$$\text{Number of moles of CuO} = 15.9 / 79.5 = 0.20 \text{ mol}$$

$$\text{Molar mass of H}_2 = 1.0 \times 2 = 2.0 \text{ g mol}^{-1}$$

$$\text{Number of moles of H}_2 = 0.60 / 2.0 = 0.30 \text{ mol}$$

From the equation, mole ratio of CuO : H₂ = 1 : 1.

∴ 0.20 mol of CuO would react with 0.20 mol of H₂.

Since 0.30 mol of H₂ is heated, H₂ 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

$$\begin{aligned} \text{(b) Actual yield of Cu} &= \text{theoretical yield} \times \text{percentage yield} \\ &= 12.7 \text{ g} \times 82\% \\ &= 10.4 \text{ g} \end{aligned}$$



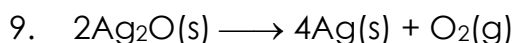
$$\text{Molar mass of CH}_3\text{OH} = 12.0 + 1.0 \times 4 + 16.0 = 32.0 \text{ g mol}^{-1}$$

From the equation, mole ratio of H₂ to CH₃OH = 2 : 1.

∴ number of moles of CH₃OH produced = 215 / 2 = 107.5 mol

$$\text{Theoretical yield of CH}_3\text{OH} = 107.5 \times 32.0 = 3440 \text{ g}$$

$$\text{(b) Actual yield of CH}_3\text{OH} = 3440 \times 45\% = 1548 \text{ g}$$



$$\text{Number of moles of Ag}_2\text{O used} = 6.96 / (107.9 \times 2 + 16.0) = 0.0300 \text{ mol}$$

From the equation, mole ratio of Ag₂O to Ag is 1 : 2.

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

$$\text{Mass of Ag produced} = 0.0600 \times 107.9 = 6.47 \text{ g}$$

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.

\therefore 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 = $93\,207 \times 47.9 = 4\,464\,615$ g

11. (a) $\text{Ca(s)} + 2\text{H}_2\text{O(l)} \longrightarrow \text{Ca(OH)}_2\text{(s)} + \text{H}_2\text{(g)}$

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

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

\therefore number of moles of Ca(OH)_2 formed = 0.0374 mol

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