PΣΛK
PHYSICS & CHEMISTRY

SCIENCE Years 7 – 10
Hieu Le
www.peaktuition.com.au
Mobile: 0404 754 848
Office: 0497 952 888
Level 1, 223 Canley Vale Rd, Canley Heights

PHYSICS & CHEMISTRY Years 11 – 12
Duyen Nguyen
www.peakhsc.com.au
Mobile: 0432 637 032
Office: 0452 558 316
Level 1, 262 Canley Vale Rd, Canley Heights

Solutions

Foundation

1. Consider the following reaction:

$$2A + 3B \rightarrow 2C + 4D$$

How many moles of B is required to completely react with 2.50 moles of A?

(a) 2.50 mol
(b) 3.00 mol
(c) 3.75 mol
(d) 7.50 mol

2. For the same reaction in Question 1, if 5.00 moles of A is mixed with 6.00 moles of B, how many moles of C is produced?

(a) 4.00 mol
(b) 5.00 mol
(c) 6.00 mol
(d) 12.0 mol

3. Butanol burns in oxygen according to the following equation:

$$C_4H_9OH_{(l)} + 6\,O_{2(g)} \rightarrow 4\,CO_{2(g)} + 5\,H_2O_{(g)}$$

How many moles of carbon dioxide would form if exactly 12 moles of oxygen was consumed in this reaction?

(a) 2 mol
(b) 4 mol
(c) 8 mol
(d) 10 mol

4. Carbon monoxide can be oxidised according to the following equation:

$$2\,CO_{(g)} + O_{2(g)} \rightarrow 2\,CO_{2(g)}$$

How many moles of oxygen is required to combust 28 g of carbon monoxide?

(a) 0.40 mol
(b) 0.50 mol
(c) 0.60 mol
(d) 0.70 mol

5. Consider the following reaction:

$$2\,BiCl_{3(aq)} + 3\,H_2S_{(g)} \rightarrow Bi_2S_{3(s)} + 6\,HCl_{(aq)}$$

What volume of hydrogen sulfide gas at 25°C and 100 kPa is required to convert 0.600 moles of bismuth chloride into bismuth sulfide?

(a) 7.40 L
(b) 14.7 L
(c) 20.2 L
(d) 22.3 L

6. Aluminum can be extracted from aluminum oxide through the following electrolytic process:

$$2\,Al_2O_{3(s)} \rightarrow 4\,Al_{(s)} + 3\,O_{2(g)}$$

What mass of aluminum oxide needs to be electrolysed to produce 500.0 L of oxygen at 0°C and 100 kPa?

(a) 1020 g
(b) 1327 g
(c) 1497 g
(d) 2275 g

7. What volume of carbon dioxide gas is produced at 25°C and 100 kPa when 200.0 g of calcium carbonate is thermally decomposed?

(a) 22.20 L
(b) 24.50 L
(c) 44.42 L
(d) 49.54 L

8. What is the mass of calcium oxide produced when 25 g of calcium carbonate is thermally decomposed?

(a) 10 g
(b) 14 g
(c) 16 g
(d) 25 g

9. (a) Write a chemical equation for the reaction between magnesium and hydrochloric acid. **1**

$Mg_{(s)} + 2\,HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$

1 mark – Writes the correct chemical equation with states of matter

(b) Calculate the mass of hydrochloric acid that is required to completely dissolve 6.00 g of magnesium. **2**

$$\begin{aligned} n(\text{Mg}) &= \frac{6.00\text{ g}}{24.31\text{ g mol}^{-1}} \\ &= 0.247\text{ mol} \\ n(\text{HCl}) &= 2 \times 0.247\text{ mol} \\ &= 0.494\text{ mol} \\ m(\text{HCl}) &= 0.494\text{ mol} \times (1.008 + 35.45)\text{ g mol}^{-1} \\ &= 18.0\text{ g} \end{aligned}$$

2 marks – Calculates the correct moles of Mg and mass of HCl (1 mark each)

10. (a) Write a chemical equation for the complete combustion of methane (CH_4) gas. **1**

$CH_{4(g)} + 2\,O_{2(g)} \rightarrow CO_{2(g)} + 2\,H_2O_{(g)}$

1 mark – Writes the correct chemical equation with states of matter (liquid water is also an acceptable product)

(b) Calculate the mass AND volume of oxygen gas at 0°C and 100 kPa required to completely combust 10.0 g of methane. **3**

$$\begin{aligned} n(\text{CH}_4) &= \frac{10.0\text{ g}}{(12.01 + 4(1.008))\text{ g mol}^{-1}} \\ &= 0.623\text{ mol} \\ n(\text{O}_2) &= 2 \times 0.623\text{ mol} \\ &= 1.25\text{ mol} \\ m(\text{O}_2) &= 1.25\text{ mol} \times 2(16.00)\text{ g mol}^{-1} \\ &= 39.9\text{ g} \\ V(\text{O}_2) &= 1.25\text{ mol} \times 22.71\text{ L mol}^{-1} \\ &= 28.3\text{ L} \end{aligned}$$

3 marks – Calculates the correct moles of CH_4, mass of O_2 and volume of O_2 (1 mark each)

11. (a) Write a chemical equation for the reaction between aluminum and oxygen gas. **1**

$4\,Al_{(s)} + 3\,O_{2(g)} \rightarrow 2\,Al_2O_{3(s)}$

1 mark – Writes the correct chemical equation with states of matter

(b) Calculate the mass of the salt produced when 0.89 g of aluminum is reacted with excess oxygen gas. **2**

$$\begin{aligned} n(\text{Al}) &= \frac{0.89\text{ g}}{26.98\text{ g mol}^{-1}} \\ &= 0.032\text{ mol} \\ n(\text{Al}_2\text{O}_3) &= \frac{2}{4} \times 0.032\text{ mol} \\ &= 0.016\text{ mol} \\ m(\text{Al}_2\text{O}_3) &= 0.016\text{ mol} \times (2(26.98) + 3(16.00))\text{ g mol}^{-1} \\ &= 1.7\text{ g} \end{aligned}$$

2 marks – Calculates the correct moles of Al and mass of Al_2O_3 (1 mark each)

12. During a class demonstration, Mr Geerling mixed 1.50 g of sodium with excess sulfuric acid.

(a) Write a chemical equation for the reaction between sodium and sulfuric acid. **1**

$2\,Na_{(s)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + H_{2(g)}$

1 mark – Writes the correct chemical equation with states of matter

(b) Calculate the mass of the salt produced from this reaction. **2**

$$\begin{aligned} n(\text{Na}) &= \frac{1.50\text{ g}}{22.99\text{ g mol}^{-1}} \\ &= 0.0652\text{ mol} \\ n(\text{Na}_2\text{SO}_4) &= \frac{1}{2} \times 0.0652\text{ mol} \\ &= 0.0326\text{ mol} \\ m(\text{Na}_2\text{SO}_4) &= 0.0326\text{ mol} \times (2(22.99) + 32.07 + 4(16.00))\text{ g mol}^{-1} \\ &= 4.63\text{ g} \end{aligned}$$

2 marks – Calculates the correct moles of Na and mass of Na_2SO_4 (1 mark each)

(c) Calculate the volume of the gas produced from this reaction at 25°C and 100 kPa. **1**

$$\begin{aligned} n(\text{H}_2) &= \frac{1}{2} \times 0.0652 \text{ mol} \\ &= 0.0326 \text{ mol} \\ V(\text{H}_2) &= 0.0326 \text{ mol} \times 24.79 \text{ L mol}^{-1} \\ &= 0.809 \text{ L} \end{aligned}$$

1 mark – Calculates the correct volume of H_2

13. (a) Write a chemical equation for the reaction between nitric acid and barium hydroxide. **1**

$2\,\text{HNO}_{3(\text{aq})} + \text{Ba(OH)}_{2(\text{aq})} \rightarrow \text{Ba(NO}_3)_{2(\text{aq})} + 2\,\text{H}_2\text{O}_{(\text{l})}$

1 mark – Writes the correct chemical equation with states of matter

(b) Calculate the mass of the salt produced when 1.60 g of nitric acid is mixed with excess barium hydroxide. **2**

$$\begin{aligned} n(\text{HNO}_3) &= \frac{1.60 \text{ g}}{(1.008 + 14.01 + 3(16.00)) \text{ g mol}^{-1}} \\ &= 0.0254 \text{ mol} \\ n(\text{Ba(NO}_3)_2) &= \frac{1}{2} \times 0.0254 \text{ mol} \\ &= 0.0127 \text{ mol} \\ m(\text{Ba(NO}_3)_2) &= 0.0127 \text{ mol} \times (137.3 + 2(14.01 + 3(16.00))) \text{ g mol}^{-1} \\ &= 3.32 \text{ g} \end{aligned}$$

2 marks – Calculates the moles of HNO_3 and mass of $\text{Ba(NO}_3)_2$ (1 mark each)

14. Calcium hypochlorite ($Ca(OCl)_2$) is often used to disinfect swimming pools. It can be prepared from calcium carbonate with the following series of reactions: **3**

$$\begin{aligned} CaCO_{3(s)} &\rightarrow CaO_{(s)} + CO_{2(g)} \\ CaO_{(s)} + H_2O_{(l)} &\rightarrow Ca(OH)_{2(aq)} \\ 2\,Ca(OH)_{2(aq)} + 2\,Cl_{2(g)} &\rightarrow Ca(OCl)_{2(aq)} + CaCl_{2(aq)} + 2\,H_2O_{(l)} \end{aligned}$$

Calculate the mass of calcium hypochlorite that can be produced from 2.50 kg of calcium carbonate.

$$\begin{aligned} m(CaCO_3) &= 2.50\text{ kg} \times \frac{1000\text{ g}}{1\text{ kg}} \\ &= 2500\text{ g} \\ n(CaCO_3) &= \frac{2500\text{ g}}{(40.08 + 12.01 + 3(16.00))\text{ g mol}^{-1}} \\ &= 25.0\text{ mol} \\ n(CaO) &= 25.0\text{ mol} \\ n(Ca(OH)_2) &= 25.0\text{ mol} \\ n(Ca(OCl)_2) &= \frac{1}{2} \times 25.0\text{ mol} \\ &= 12.5\text{ mol} \\ m(Ca(OCl)_2)) &= 12.5\text{ mol} \times (40.08 + 2(16.00 + 35.45))\text{ g mol}^{-1} \\ &= 1790\text{ g} \end{aligned}$$

3 marks – Calculates the correct moles of $CaCO_3$, moles of $Ca(OCl)_2$ and mass of $Ca(OCl)_2$ (1 mark each)

15. (a) Write a chemical equation for the reaction between zinc and sulfuric acid. **1**

$Zn_{(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + H_{2(g)}$

1 mark – Writes the correct chemical equation with states of matter

(b) Calculate the volume of the gas produced at 25°C and 100 kPa when 1.50 g of zinc is reacted with 1.70 g of sulfuric acid. **3**

$$\begin{aligned} n(\text{Zn}) &= \frac{1.50 \text{ g}}{65.38 \text{ g mol}^{-1}} \\ &= 0.0229 \text{ mol} \\ n(\text{H}_2\text{SO}_4) &= \frac{1.70 \text{ g}}{(2(1.008) + 32.07 + 4(16.00)) \text{ g mol}^{-1}} \\ &= 0.0173 \text{ mol} \end{aligned}$$

H_2SO_4 is the limiting reagent while Zn is in excess.

$$\begin{aligned} n(\text{H}_2) &= 0.0173 \text{ mol} \\ V(\text{H}_2) &= 0.0173 \text{ mol} \times 24.79 \text{ L mol}^{-1} \\ &= 0.430 \text{ L} \end{aligned}$$

3 marks – Calculates the correct moles of HNO_3, moles of H_2SO_4 and volume of H_2 (1 mark each)

16. (a) Write a chemical equation for the reaction between potassium and oxygen. **1**

$4\,K_{(s)} + O_{2(g)} \rightarrow 2\,K_2O_{(s)}$

1 mark – Writes the correct chemical equation with states of matter

(b) Calculate the mass of the salt produced when 5.00 g of potassium is reacted with 0.70 L of oxygen gas at 0°C and 100 kPa. **3**

$$\begin{aligned} n(\mathrm{K}) &= \frac{5.00\ \mathrm{g}}{39.10\ \mathrm{g\,mol^{-1}}} \\ &= 0.128\ \mathrm{mol} \\ n(\mathrm{O_2}) &= \frac{0.70\ \mathrm{L}}{22.71\ \mathrm{L\,mol^{-1}}} \\ &= 0.031\ \mathrm{mol} \end{aligned}$$

O_2 is the limiting reagent while K is in excess.

$$\begin{aligned} n(\mathrm{K_2O}) &= 2 \times 0.031\ \mathrm{mol} \\ &= 0.062\ \mathrm{mol} \\ m(\mathrm{K_2O}) &= 0.062\ \mathrm{mol} \times (2(39.10) + 16.00)\ \mathrm{g\,mol^{-1}} \\ &= 5.8\ \mathrm{g} \end{aligned}$$

3 marks – Calculates the correct moles of K, moles of O_2 and mass of K_2O (1 mark each)

17. Sodium carbonate can be used to neutralise acid spills. In a particular incident, a university student added 9.00 g of solid sodium carbonate to a spill containing 8.50 g of hydrochloric acid.

(a) Write a chemical equation for the reaction that occurs. **1**

$2\,HCl_{(aq)} + Na_2CO_{3(s)} \rightarrow 2\,NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

1 mark – Writes the correct chemical equation with states of matter

(b) Calculate the mass of the salt produced from this reaction. **3**

$$\begin{aligned} n(HCl) &= \frac{8.50\text{ g}}{(1.008 + 35.45)\text{ g mol}^{-1}} \\ &= 0.233\text{ mol} \\ n(Na_2CO_3) &= \frac{9.00\text{ g}}{(2(22.99) + 12.01 + 3(16.00))\text{ g mol}^{-1}} \\ &= 0.0849\text{ mol} \end{aligned}$$

Na_2CO_3 is the limiting reagent while HCl is in excess.

$$\begin{aligned} n(NaCl) &= 2 \times 0.0849\text{ mol} \\ &= 0.170\text{ mol} \\ m(NaCl) &= 0.170\text{ mol} \times (22.99 + 35.45)\text{ g mol}^{-1} \\ &= 9.92\text{ g} \end{aligned}$$

3 marks – Calculates the correct moles of HCl, moles of Na_2CO_3 and mass of NaCl (1 mark each)

(c) Calculate the volume of the gas produced from this reaction at 25°C and 100 kPa. **1**

$$\begin{aligned} n(CO_2) &= 0.0849\text{ mol} \\ V(CO_2) &= 0.0849\text{ mol} \times 24.79\text{ L mol}^{-1} \\ &= 2.11\text{ L} \end{aligned}$$

1 mark – Calculates the correct volume of H_2

(d) Calculate the mass of the leftover reactant at the end of the reaction. **1**

$$\begin{aligned} n(HCl)_{\text{leftover}} &= 0.233\text{ mol} - 2 \times 0.0849\text{ mol} \\ &= 0.0633\text{ mol} \\ m(HCl)_{\text{leftover}} &= 0.0633\text{ mol} \times (1.008 + 35.45)\text{ g mol}^{-1} \\ &= 2.31\text{ g} \end{aligned}$$

1 mark – Calculates the correct mass of HCl leftover