Unit 07 Stoichiometry I: Mole-Mole Problems, Answers

1. For the reaction: $\mathbf{Cu_{(s)} + 2\ AgNO_{3\ (aq)} \longrightarrow Cu(NO_3)_{2\ (aq)} + 2\ Ag_{(s)}}$

a) How many moles of silver are formed when 1 mole of copper is reacted?

$$1 \text{ mol Cu} \times \frac{2 \text{ mol Ag}}{1 \text{ mol Cu}} = 2 \text{ mol Ag are formed}$$

b) How many moles of copper (II) nitrate are formed if 4 moles of $AgNO_3$ are reacted?

$$4 \text{ mol } AgNO_3 \times \frac{1 \text{ mol } Cu(NO_3)_2}{2 \text{ mol } AgNO_3} = 2 \text{ mol } Cu(NO_3)_2 \text{ are formed}$$

c) How many moles of copper are reacted when 10 moles of silver are formed?

$$10 \text{ mol Ag} \times \frac{1 \text{ mol Cu}}{2 \text{ mol Ag}} = 5 \text{ mol Cu are reacted}$$

2. For the reaction: $\mathbf{4\ Fe_{(s)} + 3\ O_{2\ (g)} \longrightarrow 2\ Fe_2O_{3\ (s)}}$

a) How many moles of Fe are required to produce 6.0 moles of Fe_2O_3?

$$6.0 \text{ mol } Fe_2O_3 \times \frac{4 \text{ mol Fe}}{2 \text{ mol } Fe_2O_3} = 12 \text{ mol Fe are required}$$

b) How many moles of O_2 are used up when 1.0 mole of Fe_2O_3 is produced?

$$1.0 \text{ mol } Fe_2O_3 \times \frac{3 \text{ mol } O_2}{2 \text{ mol } Fe_2O_3} = 1.5 \text{ mol } O_2 \text{ are used up}$$

c) How many moles of O_2 are needed to react with 3.00 moles of Fe?

$$3.00 \text{ mol Fe} \times \frac{3 \text{ mol } O_2}{4 \text{ mol Fe}} = 2.25 \text{ mol } O_2 \text{ are needed}$$

d) How many moles of Fe_2O_3 will form if 0.80 mole of iron are reacted?

$$0.80 \text{ mol Fe} \times \frac{2 \text{ mol } Fe_2O_3}{4 \text{ mol Fe}} = 0.40 \text{ mol } Fe_2O_3 \text{ will form}$$

3. For the reaction: $\mathbf{3\ Cu_{(s)} + 8\ HNO_{3\ (aq)} \longrightarrow 3\ Cu(NO_3)_{2\ (aq)} + 2\ NO_{(g)} + 4\ H_2O_{(v)}}$

a) How many moles of NO are produced from 4.00 moles of copper metal reacting?

$$4.00 \text{ mol Cu} \times \frac{2 \text{ mol NO}}{3 \text{ mol Cu}} = 2.67 \text{ mol NO will be produced}$$

b) How many moles of nitric acid are required to react completely with 2.00 moles of copper metal?

$$2.00 \text{ mol Cu} \times \frac{8 \text{ mol } HNO_3}{3 \text{ mol Cu}} = 5.33 \text{ mol } HNO_3 \text{ are required}$$

3. For the reaction: $\mathbf{3\ Cu_{(s)} + 8\ HNO_{3\,(aq)} \longrightarrow 3\ Cu(NO_3)_{2\,(aq)} + 2\ NO_{(g)} + 4\ H_2O_{(v)}}$

c) How many moles of nitric acid are required to react if 2 moles of water are formed?

$$2 \text{ mol } H_2O \times \frac{8 \text{ mol } HNO_3}{4 \text{ mol } H_2O} = 4 \text{ mol } HNO_3 \text{ are required}$$

4. For the reaction: $\mathbf{C_3H_{8\,(l)} + 5\ O_{2\,(g)} \longrightarrow 3\ CO_{2\,(g)} + 4\ H_2O_{(v)}}$

a) How many moles of oxygen gas are required to react with 3.55 moles of C_3H_8 (l)?

$$3.55 \text{ mol } C_3H_8 \times \frac{5 \text{ mol } O_2}{1 \text{ mol } C_3H_8} = 17.75 \text{ mol } O_2 \text{ are required (rounds to 17.8 mol } O_2)$$

b) If 1.78 moles of CO_2 are formed, how many moles of C_3H_8 (l) were burned?

$$1.78 \text{ mol } CO_2 \times \frac{1 \text{ mol } C_3H_8}{3 \text{ mol } CO_2} = 0.593 \text{ mol } C_3H_8 \text{ were burned}$$

c) How many moles of water are formed when 14.22 moles of oxygen gas react with C_3H_8 (l)?

$$14.22 \text{ mol } O_2 \times \frac{4 \text{ mol } H_2O}{5 \text{ mol } O_2} = 11.38 \text{ mol } H_2O \text{ are formed}$$

d) If 0.0034 moles of carbon dioxide are formed, how many moles of water vapour are also produced?

$$0.0034 \text{ mol } CO_2 \times \frac{4 \text{ mol } H_2O}{3 \text{ mol } CO_2} = 0.0045 \text{ mol } H_2O \text{ are also produced (or } 4.5 \times 10^{-2} \text{ mol)}$$

Stoichiometry II: Mass Problems, Answers

1. How many grams of carbon dioxide are produced when 48.0 grams of carbon are burned?

$$\mathbf{C\ (s) + O_2\ (g) \longrightarrow CO_2\ (g)}$$

Molar masses: 12.01 g/mol 44.01 g/mol

$$48.0\text{ g C} \times \frac{1\text{ mol}}{12.01\text{ g}} \times \frac{1\text{ mol } CO_2}{1\text{ mol C}} \times \frac{44.01\text{ g}}{1\text{ mol } CO_2} = 176\text{ g of } CO_2 \text{ are produced}$$

2. For the reaction $\mathbf{2\ KClO_3\ (s) \longrightarrow 2\ KCl\ (s) + 3\ O_2\ (g)}$

Molar masses: 122.55 g/mol 74.55 g/mol 32.00 g/mol

a) What mass of oxygen is formed by the reaction of 102 grams of $KC\ell O_3$?

$$102\text{ g } KC\ell O_3 \times \frac{1\text{ mol}}{122.55\text{ g}} \times \frac{3\text{ mol } O_2}{2\text{ mol } KC\ell O_3} \times \frac{32.00\text{ g}}{1\text{ mol } O_2} = 39.95\text{ g of } O_2 \text{ is formed (rounds to 40.0 g } O_2)$$

b) How many grams of $KC\ell O_3$ must be used in order to produce 25 grams of $KC\ell$?

$$25\text{ g } KC\ell \times \frac{1\text{ mol}}{74.55\text{ g}} \times \frac{2\text{ mol } KC\ell O_3}{2\text{ mol } KC\ell} \times \frac{122.55\text{ g}}{1\text{ mol } KC\ell O_3} = 41\text{ g of } KC\ell O_3 \text{ needed}$$

3. $\mathbf{6\ CO_2\ (g) + 6\ H_2O\ (v) \longrightarrow C_6H_{12}O_6\ (s) + 6\ O_2\ (g)}$

MM: 44.01 g/mol 18.02 g/mol 180.18 g/mol 32.00 g/mol

a) What mass of water is needed to produce 50.0 g of $C_6H_{12}O_6$?

$$50.0\text{ g } C_6H_{12}O_6 \times \frac{1\text{ mol}}{180.18\text{ g}} \times \frac{6\text{ mol } H_2O}{1\text{ mol } C_6H_{12}O_6} \times \frac{18.02\text{ g}}{1\text{ mol } H_2O} = 30.0\text{ g of } H_2O$$

b) How many grams of carbon dioxide are needed to react with 18.0 g of water?

$$18.0\text{ g } H_2O \times \frac{1\text{ mol}}{18.02\text{ g}} \times \frac{6\text{ mol } CO_2}{6\text{ mol } H_2O} \times \frac{44.01\text{ g}}{1\text{ mol } CO_2} = 43.96\text{ g of } CO_2 \text{ (rounds to 44.0 g)}$$

Stoichiometry II: Mass Problems, Answers (cont.)

4. For the reaction: **Cu (s) + 2 $AgNO_3$ (aq) ⟶ $Cu(NO_3)_2$ (aq) + 2 Ag (s)**

Molar masses: 63.55 g/mol 169.88 g/mol 187.57 g/mol 107.87 g/mol

a) How many grams of copper can react with 10.0 g of silver nitrate?

$$10.0\text{ g } AgNO_3 \times \frac{1\text{ mol}}{169.88\text{ g}} \times \frac{1\text{ mol Cu}}{2\text{ mol } AgNO_3} \times \frac{63.55\text{ g}}{1\text{ mol Cu}} = 1.87\text{ g of Cu can react}$$

b) What mass of silver is formed when 5.0 g of copper react with silver nitrate?

$$5.0\text{ g Cu} \times \frac{1\text{ mol}}{63.55\text{ g}} \times \frac{2\text{ mol Ag}}{1\text{ mol Cu}} \times \frac{107.87\text{ g}}{1\text{ mol Ag}} = 17\text{ g of Ag formed}$$

c) Calculate the mass of copper (II) nitrate produced by the reaction of 1.0 g of silver nitrate with copper.

$$1.0\text{ g } AgNO_3 \times \frac{1\text{ mol}}{169.88\text{ g}} \times \frac{1\text{ mol } Cu(NO_3)_2}{2\text{ mol } AgNO_3} \times \frac{187.57\text{ g}}{1\text{ mol } Cu(NO_3)_2} = 0.55\text{ g of } Cu(NO_3)_2 \text{ produced}$$

5. For the reaction: **Zn (s) + 2 HCl (aq) ⟶ H_2 (g) + $ZnCl_2$ (aq)**

Molar masses: 65.41 g/mol 136.31 g/mol

What mass of zinc chloride is produced by the reaction of 2.3 g of zinc?

$$2.3\text{ g Zn} \times \frac{1\text{ mol}}{65.41\text{ g}} \times \frac{1\text{ mol } ZnC\ell_2}{1\text{ mol Zn}} \times \frac{136.31\text{ g}}{1\text{ mol } ZnC\ell_2} = 4.8\text{ g of } ZnC\ell_2 \text{ produced}$$

6. For the reaction **Pb (s) + S (s) ⟶ PbS (s)**

Molar masses: 207.2 g/mol 32.07 g/mol

a) How much sulfur can react with 1.0 g of lead?

$$1.0\text{ g Pb} \times \frac{1\text{ mol}}{207.2\text{ g}} \times \frac{1\text{ mol S}}{1\text{ mol Pb}} \times \frac{32.07\text{ g}}{1\text{ mol S}} = 0.15\text{ g of S can react}$$

b) If 1.00 g of lead and 3.00 g of sulfur are mixed and reacted, how much of the sulfur will not react? (Use your answer from part "a" to help determine your answer.)

If you have 3.00 grams of sulfur, but only 0.15 g react (Part a), then there will be (3.00 g - 0.15 g) = 2.85 g of sulfur still remaining.

Answers:

1. 176 g of CO_2
2a) 39.9510 g = 40.0 g of O_2
2b) 41 g of $KClO_3$
3a) 30.0 g of water
3b) 44.0 g of carbon dioxide
4a) 1.87 g of copper
4b) 17 g of silver
4c) 0.55 g of copper (II) nitrate
5. 4.8 g of zinc chloride
6a) 0.15 g of sulfur
6b) 2.85 g of sulfur will not react

Stoichiometry III: Volume of Gas Problems, Answers

1. For the reaction: **$2\ NH_3\ (g) \longrightarrow 3\ H_2\ (g) + N_2\ (g)$**

What volume of nitrogen gas will be produced when 48.4 L of ammonia (NH_3) are broken down? (all gases are at STP)

$$48.4\text{ L } NH_3 \times \frac{1\text{ mol}}{22.4\text{ L}} \times \frac{1\text{ mol } N_2}{2\text{ mol } NH_3} \times \frac{22.4\text{ L}}{1\text{ mol } N_2} = 24.2\text{ L of } N_2 \text{ gas produced}$$

2. For the reaction:

$3\ Cu\ (s) + 8\ HNO_3\ (aq) \longrightarrow 3\ Cu(NO_3)_2\ (aq) + 2\ NO\ (g) + 4\ H_2O\ (l)$

How many litres of NO gas at STP will be produced when 12.0 g of copper react with excess HNO_3?

$$12.0\text{ g Cu} \times \frac{1\text{ mol}}{63.55\text{ g}} \times \frac{2\text{ mol NO}}{3\text{ mol Cu}} \times \frac{22.4\text{ L}}{1\text{ mol NO}} = 2.82\text{ L NO gas produced}$$

3. For the reaction: **$C_3H_8\ (g) + 5\ O_2\ (g) \longrightarrow 4\ H_2O\ (v) + 3\ CO_2\ (g)$**

Molar masses: 18.02 g/mol 44.01 g/mol

a) What mass of water is produced if 60.0 L of propane gas (C_3H_8) at STP are reacted with excess oxygen?

$$60.0\text{ L } C_3H_8 \times \frac{1\text{ mol}}{22.4\text{ L}} \times \frac{4\text{ mol } H_2O}{1\text{ mol } C_3H_8} \times \frac{18.02\text{ g}}{1\text{ mol } H_2O} = 193\text{ g of } H_2O \text{ produced}$$

b) What volume of O_2 gas, at STP, is required to produce 250.0 g of CO_2?

$$250.0\text{ g } CO_2 \times \frac{1\text{ mol}}{44.01\text{ g}} \times \frac{5\text{ mol } O_2}{3\text{ mol } CO_2} \times \frac{22.4\text{ L}}{1\text{ mol } O_2} = 212\text{ L } O_2 \text{ gas required}$$

4. For the reaction: **$Mg\ (s) + 2\ HCl\ (aq) \longrightarrow H_2\ (g) + MgCl_2\ (aq)$**

What volume of H_2 gas will be produced when 200.0 g of Mg react with excess HCl?

$$200.0\text{ g Mg} \times \frac{1\text{ mol}}{24.31\text{ g}} \times \frac{1\text{ mol } H_2}{1\text{ mol Mg}} \times \frac{22.4\text{ L}}{1\text{ mol } H_2} = 184\text{ L } H_2 \text{ gas produced}$$

5. For the reaction: **$2\ C_8H_{18}\ (l) + 25\ O_2\ (g) \longrightarrow 18\ H_2O\ (v) + 16\ CO_2\ (g)$**

Molar masses: 114.26 g/mol

What volume of O_2 gas must be present at STP in order for 120.0 g of octane (C_8H_{18}) to react?

$$120.0\text{ g } C_8H_{18} \times \frac{1\text{ mol}}{114.26\text{ g}} \times \frac{25\text{ mol } O_2}{2\text{ mol } C_8H_{18}} \times \frac{22.4\text{ L}}{1\text{ mol } O_2} = 294\text{ L } O_2 \text{ gas required}$$

Stoichiometry III: Volume of Gas Problems, Answers (cont.)

6. For the reaction: **XeF_6 (s) + 3 H_2O (l) ⟶ XeO_3 (g) + 6 HF (g)**

Molar masses: 245.29 g/mol

a) How many moles of water are needed to produce 20.0 L of XeO_3 at STP?

$$20.0\text{ L } XeO_3 \times \frac{1\text{ mol}}{22.4\text{ L}} \times \frac{3\text{ mol } H_2O}{1\text{ mol } XeO_3} = 2.68\text{ moles } H_2O \text{ required (**asked for } \textbf{\textit{moles}})$$

b) How many litres of HF gas are formed by the reaction of 20.0 g XeF_6 with excess H_2O?

$$20.0\text{ g } XeF_6 \times \frac{1\text{ mol}}{245.29\text{ g}} \times \frac{6\text{ mol HF}}{1\text{ mol } XeF_6} \times \frac{22.4\text{ L}}{1\text{ mol}} = 10.958\text{ L HF formed (rounds to 11.0 L HF)}$$

7. For the reaction:

3 Ag (s) + 4 HNO_3 (aq) ⟶ 3 $AgNO_3$ (aq) + NO (g) + 2 H_2O (l)

What is the volume at STP of the NO (gas) produced when 5.0 g of silver are reacted?

$$5.0\text{ g Ag} \times \frac{1\text{ mol}}{107.87\text{ g}} \times \frac{1\text{ mol NO}}{3\text{ mol Ag}} \times \frac{22.4\text{ L}}{1\text{ mol}} = 0.35\text{ L NO formed}$$

Answers:

1. 24.2 L of N_2 produced
2. 2.82 L of NO produced
3a) 193 g of water produced
3b) 212 L of O_2 required
4. 184 L of H_2 produced
5. 294 L of O_2 required
6a) 2.68 moles of H_2O required
6b) 11.0 L of HF produced (3 sig digs, round up from 10.96 L)
7. 0.35 L of NO produced