

ANSWER KEY

EXTRA PRACTICE: Gas Stoichiometry Practice #2

Name: _____

INSTRUCTIONS: Answer the following questions using proper units and showing all work. Please note that these problems require a balanced chemical equation.

1.

non-STP

- a. How many Liters of hydrogen gas will be produced in a single replacement reaction at 7.00°C and 96.0 kPa if 40.0 grams of solid sodium react with liquid water? 280 K

$$2\text{Na} + 2\text{H}_2\text{O} \rightarrow \text{H}_2 + 2\text{NaOH}$$

$$\textcircled{1} \frac{40.0 \text{ g Na}}{1} \times \frac{1 \text{ mol Na}}{22.99 \text{ g Na}} \times \frac{1 \text{ mol H}_2}{2 \text{ mol Na}} = 0.870 \text{ mol H}_2$$

$$\textcircled{2} V = \frac{nRT}{P} \rightarrow V = \frac{(0.870 \text{ mol})(8.314)(280 \text{ K})}{(96.0 \text{ kPa})} \rightarrow \boxed{V = 6790 \text{ L H}_2}$$

non-STP

- b. How many grams of sodium are needed to produce 2.24 Liters of hydrogen gas, collected at 23.0°C and 92.5 kPa? 296 K

$$\textcircled{1} \frac{2.24 \text{ L H}_2}{1} \times \frac{2 \text{ L Na}}{1 \text{ L H}_2} = 4.48 \text{ L Na}$$

$$\textcircled{2} n = \frac{PV}{RT} \rightarrow n_{\text{Na}} = \frac{(92.5 \text{ kPa})(4.48 \text{ L Na})}{(8.314)(296 \text{ K})} \rightarrow n_{\text{Na}} = \frac{0.168 \text{ mol Na}}{1} \times \frac{22.99 \text{ g Na}}{1 \text{ mol Na}} \rightarrow \boxed{3.87 \text{ g Na}}$$

STP

- c. How many Liters of hydrogen gas at STP can be produced by the reaction of 4.60 grams of solid sodium and excess water?

$$\frac{4.60 \text{ g Na}}{1} \times \frac{1 \text{ mol Na}}{22.99 \text{ g Na}} \times \frac{1 \text{ mol H}_2}{2 \text{ mol Na}} \times \frac{22.4 \text{ L H}_2}{1 \text{ mol H}_2} = \boxed{2.24 \text{ L H}_2}$$

non-STP

2. What volume of oxygen (in Liters), collected at 25.0°C and 101 kPa, can be prepared by the decomposition reaction of 37.9 grams of aqueous potassium chlorate? 298 K

$$2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$$

$$\textcircled{1} \frac{37.9 \text{ g KClO}_3}{1} \times \frac{1 \text{ mol KClO}_3}{122.55 \text{ g KClO}_3} \times \frac{3 \text{ mol O}_2}{2 \text{ mol KClO}_3} = 0.464 \text{ mol O}_2$$

$$\textcircled{2} V = \frac{nRT}{P} \rightarrow V = \frac{(0.464 \text{ mol})(8.314)(298 \text{ K})}{(101 \text{ kPa})} \rightarrow \boxed{V = 11.4 \text{ L O}_2}$$

non-STP

3. Hydrogen and oxygen gases are burned in a rocket in this synthesis reaction. What volume (in Liters) of water vapor, at 555°C and 573 mmHg, can be produced from 4.67 kg of hydrogen gas? 828 K

$$2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O(g)}$$

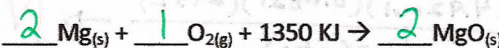
$$\textcircled{1} \frac{4.67 \text{ kg H}_2}{1} \times \frac{1000 \text{ g H}_2}{1 \text{ kg H}_2} \times \frac{1 \text{ mol H}_2}{2.016 \text{ g H}_2} \times \frac{2 \text{ mol H}_2\text{O}}{2 \text{ mol H}_2} = 2316 \text{ mol H}_2\text{O}$$

$$\textcircled{2} V = \frac{nRT}{P} \rightarrow V = \frac{(2316 \text{ mol})(62.4)(828 \text{ K})}{(573 \text{ mmHg})} \rightarrow \boxed{V = 2.09 \text{ E}5 \text{ L H}_2\text{O}}$$

4.

non-STP

- a. Given the following chemical reaction, what mass of magnesium will react with 500 mL of oxygen gas at 150. °C and 0.900 atm? 423 K



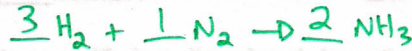
$$\textcircled{1} n = \frac{PV}{RT} \rightarrow n = \frac{(0.900 \text{ atm})(0.500 \text{ L O}_2)}{(0.0821)(423 \text{ K})} \rightarrow n_{\text{O}_2} = 0.0130 \text{ mol O}_2$$

$$\textcircled{2} \frac{0.0130 \text{ mol O}_2}{1} \times \frac{2 \text{ mol Mg}}{1 \text{ mol O}_2} \times \frac{24.31 \text{ g Mg}}{1 \text{ mol Mg}} = \boxed{0.630 \text{ g Mg}}$$

- b. How much energy would be needed to produce 5.30 E -19 f.m.u of magnesium oxide?
(Hint: 1 mol = 1350 kilojoules (KJ) of energy)

$$\frac{5.30 \text{ E}^{-19} \text{ fmu}}{1} \times \frac{1 \text{ mol MgO}}{6.02 \text{ E}23 \text{ fmu MgO}} \times \frac{1350 \text{ kJ}}{1 \text{ mol MgO}} = \boxed{1.19 \text{ E}^{-39} \text{ kJ}}$$

5. What volume of ammonia gas can be produced from a synthesis reaction of 22.5 Liters of hydrogen gas reacting with nitrogen gas?



$$\frac{22.5 \text{ L H}_2}{1} \times \frac{2 \text{ L NH}_3}{3 \text{ L H}_2} = 15.0 \text{ L NH}_3$$

6.

non-STP

- a. What volume of chlorine gas at 311 K and 1.63 atm is needed to react completely with 10.4 grams of solid sodium to produce solid sodium chloride?



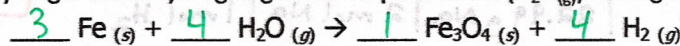
$$\frac{10.4 \text{ g Na}}{1} \times \frac{1 \text{ mol Na}}{22.99 \text{ g Na}} \times \frac{1 \text{ mol Cl}_2}{2 \text{ mol Na}} = 0.226 \text{ mol Cl}_2$$

$$V = \frac{nRT}{P} \rightarrow V = \frac{(0.226 \text{ mol Cl}_2)(0.0821)(311 \text{ K})}{(1.63 \text{ atm})} \rightarrow V_{\text{Cl}_2} = 3.54 \text{ L}$$

- b. How many molecules of chlorine gas are needed to completely react with the solid sodium in 6a?

$$\frac{10.4 \text{ g Na}}{1} \times \frac{1 \text{ mol Na}}{22.99 \text{ g Na}} \times \frac{1 \text{ mol Cl}_2}{2 \text{ mol Na}} \times \frac{6.02 \times 10^{23} \text{ molecule Cl}_2}{1 \text{ mol Cl}_2} = 1.36 \times 10^{23} \text{ molecule Cl}_2$$

7. One method used in the 18th Century to generate hydrogen gas was to pass steam ($\text{H}_2\text{O}_{(g)}$) through red-hot steel tubes. The following reaction takes place:



- a. What volume of hydrogen gas at STP can be produced by the reaction of 6.28 grams of iron?

STP

Gas stoich

$$\frac{6.28 \text{ g Fe}}{1} \times \frac{1 \text{ mol Fe}}{55.85 \text{ g Fe}} \times \frac{4 \text{ mol H}_2}{3 \text{ mol Fe}} \times \frac{22.4 \text{ L H}_2}{1 \text{ mol H}_2} = 3.36 \text{ L H}_2$$

non-STP

- b. What mass of iron will react with $500. \text{ Liters}$ of steam at $250. \text{ }^\circ\text{C}$ and 1.00 atm of pressure?

$$n_{\text{H}_2\text{O}} = \frac{PV}{RT} \rightarrow n_{\text{H}_2\text{O}} = \frac{(1.00 \text{ atm})(500 \text{ L H}_2\text{O})}{(0.0821)(523 \text{ K})} \rightarrow n_{\text{H}_2\text{O}} = 11.6 \text{ mol H}_2\text{O}_{(g)}$$

$$\frac{11.6 \text{ mol H}_2\text{O}}{1} \times \frac{3 \text{ mol Fe}}{4 \text{ mol H}_2\text{O}} \times \frac{55.85 \text{ g Fe}}{1 \text{ mol Fe}} = 488 \text{ g Fe}$$

non-STP

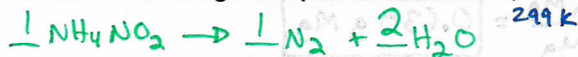
- c. If 285 grams of Fe_3O_4 are formed, what volume of hydrogen gas, measured at 20.0°C and 1.06 atm , is produced?

$$\frac{285 \text{ g Fe}_3\text{O}_4}{1} \times \frac{1 \text{ mol Fe}_3\text{O}_4}{231.55 \text{ g Fe}_3\text{O}_4} \times \frac{4 \text{ mol H}_2}{1 \text{ mol Fe}_3\text{O}_4} = 4.92 \text{ mol H}_2$$

$$V = \frac{nRT}{P} \rightarrow V = \frac{(4.92 \text{ mol})(0.0821)(293 \text{ K})}{(1.06 \text{ atm})} \rightarrow V = 112 \text{ L H}_2$$

non-STP

8. A 2.55 grams sample of ammonium nitrite (NH_4NO_2) is heated in a test tube. The ammonium nitrite is expected to undergo a decomposition reaction to produce nitrogen gas and water. If it does decompose in this way, what volume of nitrogen gas will be collected? The water and gas temperature are 26.0°C , and the barometric pressure is 0.980 atm .



$$\frac{2.55 \text{ g NH}_4\text{NO}_2}{1} \times \frac{1 \text{ mol NH}_4\text{NO}_2}{64.052 \text{ g NH}_4\text{NO}_2} \times \frac{1 \text{ mol N}_2}{1 \text{ mol NH}_4\text{NO}_2} = 0.0398 \text{ mol N}_2$$

$$V = \frac{nRT}{P} \rightarrow V_{\text{N}_2} = \frac{(0.0398 \text{ mol})(0.0821)(299 \text{ K})}{(0.980 \text{ atm})} \rightarrow V_{\text{N}_2} = 0.997 \text{ L N}_2$$