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.

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? (non-STP) (280 K)

$2\,Na + 2\,H_2O \rightarrow 1\,H_2 + 2\,NaOH$

① $40.0\text{ g Na} \times \frac{1\text{ mol Na}}{22.99\text{ g Na}} \times \frac{1\text{ mol } H_2}{2\text{ mol Na}} = 0.870\text{ mol } H_2$

② $V = \frac{nRT}{P} \rightarrow V = \frac{(0.870\text{ mol})(8.314)(280\text{ K})}{(96.0\text{ kPa})} \rightarrow \boxed{V = 6790\text{ L } H_2}$

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? (non-STP) (296 K)

① $2.24\text{ L } H_2 \times \frac{2\text{ L Na}}{1\text{ L } H_2} = 4.48\text{ L Na}$

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

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? (STP)

$4.60\text{ g Na} \times \frac{1\text{ mol Na}}{22.99\text{ g Na}} \times \frac{1\text{ mol } H_2}{2\text{ mol Na}} \times \frac{22.4\text{ L } H_2}{1\text{ mol } H_2} = \boxed{2.24\text{ L } H_2}$

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? (non-STP) (298 K)

$2\,KClO_3 \rightarrow 2\,KCl + 3\,O_2$

① $37.9\text{ g } KClO_3 \times \frac{1\text{ mol } KClO_3}{122.55\text{ g } KClO_3} \times \frac{3\text{ mol } O_2}{2\text{ mol } KClO_3} = 0.464\text{ mol } O_2$

② $V = \frac{nRT}{P} \rightarrow V = \frac{(0.464\text{ mol})(8.314)(298\text{ K})}{(101\text{ kPa})} \rightarrow \boxed{V = 11.4\text{ L } O_2}$

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? (non-STP)

$2\,H_2 + 1\,O_2 \rightarrow 2\,H_2O_{(g)}$

① $4.67\text{ kg } H_2 \times \frac{1000\text{ g } H_2}{1\text{ kg } H_2} \times \frac{1\text{ mol } H_2}{2.016\text{ g } H_2} \times \frac{2\text{ mol } H_2O}{2\text{ mol } H_2} = 2316\text{ mol } H_2O$

② $V = \frac{nRT}{P} \rightarrow V = \frac{(2316\text{ mol})(62.4)(828\text{ K})}{(573\text{ mmHg})} \rightarrow \boxed{V = 2.09\text{ E5 L } H_2O}$

4.

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? (non-STP) (0.500 L $O_2$) (423 K)

$2\,Mg_{(s)} + 1\,O_{2(g)} + 1350\text{ KJ} \rightarrow 2\,MgO_{(s)}$

① $n = \frac{PV}{RT} \rightarrow n = \frac{(0.900\text{ atm})(0.500\text{ L } O_2)}{(0.0821)(423\text{ K})} \rightarrow n_{O_2} = 0.0130\text{ mol } O_2$

② $0.0130\text{ mol } O_2 \times \frac{2\text{ mol Mg}}{1\text{ mol } O_2} \times \frac{24.31\text{ g Mg}}{1\text{ mol Mg}} = \boxed{0.630\text{ g Mg}}$

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)**

$5.30\text{ E-19 fmu} \times \frac{1\text{ mol MgO}}{6.02\text{ E23 fmu MgO}} \times \frac{1350\text{ kJ}}{1\text{ mol MgO}} = \boxed{1.19\text{ E-39 kJ}}$

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

$$3\ H_2 + 1\ N_2 \rightarrow 2\ NH_3$$

$$\frac{22.5\ L\ H_2}{1}\left|\frac{2\ L\ NH_3}{3\ L\ H_2}\right. = \boxed{15.0\ L\ NH_3}$$

6.

a. What volume of chlorine gas at 311 K (38.0°C) and 1.63 atm is needed to react completely with 10.4 grams of solid sodium to produce solid sodium chloride? (non-STP)

$$2\ Na + 1\ Cl_2 \rightarrow 2\ NaCl$$

① $\frac{10.4\ g\ Na}{1}\left|\frac{1\ mol\ Na}{22.99\ g\ Na}\right|\frac{1\ mol\ Cl_2}{2\ mol\ Na} = 0.226\ mol\ Cl_2$

② $V = \frac{nRT}{P} \rightarrow V = \frac{(0.226\ mol\ Cl_2)(0.0821)(311\ K)}{(1.63\ atm)} \rightarrow \boxed{V_{Cl_2} = 3.54\ L}$

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

$$\frac{10.4\ g\ Na}{1}\left|\frac{1\ mol\ Na}{22.99\ g\ Na}\right|\frac{1\ mol\ Cl_2}{2\ mol\ Na}\left|\frac{6.02\ E23\ molecule\ Cl_2}{1\ mol\ Cl_2}\right. = \boxed{1.36\ E23\ molecule\ Cl_2}$$

7. One method used in the 18th Century to generate hydrogen gas was to pass steam ($H_2O_{(g)}$) through red-hot steel tubes. The following reaction takes place:

$$3\ Fe_{(s)} + 4\ H_2O_{(g)} \rightarrow 1\ Fe_3O_{4\ (s)} + 4\ H_{2\ (g)}$$

a. What volume of hydrogen gas at STP can be produced by the reaction of 6.28 grams of iron? (STP, gas stoich)

$$\frac{6.28\ g\ Fe}{1}\left|\frac{1\ mol\ Fe}{55.85\ g\ Fe}\right|\frac{4\ mol\ H_2}{3\ mol\ Fe}\left|\frac{22.4\ L\ H_2}{1\ mol\ H_2}\right. = \boxed{3.36\ L\ H_2}$$

b. What mass of iron will react with 500. Liters of steam at 523 K (250. °C) and 1.00 atm of pressure? (non-STP)

① $n_{H_2O} = \frac{PV}{RT} \rightarrow n_{H_2O} = \frac{(1.00\ atm)(500\ L\ H_2O)}{(0.0821)(523\ K)} \rightarrow n_{H_2O} = 11.6\ mol\ H_2O_{(g)}$

② $\frac{11.6\ mol\ H_2O}{1}\left|\frac{3\ mol\ Fe}{4\ mol\ H_2O}\right|\frac{55.85\ g\ Fe}{1\ mol\ Fe} = \boxed{488\ g\ Fe}$

c. If 285 grams of $Fe_3O_4$ are formed, what volume of hydrogen gas, measured at 293 K (20.0°C) and 1.06 atm, is produced? (non-STP)

① $\frac{285\ g\ Fe_3O_4}{1}\left|\frac{1\ mol\ Fe_3O_4}{231.55\ g\ Fe_3O_4}\right|\frac{4\ mol\ H_2}{1\ mol\ Fe_3O_4} = 4.92\ mol\ H_2$

② $V = \frac{nRT}{P} \rightarrow V = \frac{(4.92\ mol)(0.0821)(293\ K)}{(1.06\ atm)} \rightarrow \boxed{V = 112\ L\ H_2}$

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. ($P_{atm}$) (non-STP)

$$1\ NH_4NO_2 \rightarrow 1\ N_2 + 2\ H_2O \quad (299\ K)$$

① $\frac{2.55\ g\ NH_4NO_2}{1}\left|\frac{1\ mol\ NH_4NO_2}{64.052\ g\ NH_4NO_2}\right|\frac{1\ mol\ N_2}{1\ mol\ NH_4NO_2} = 0.0398\ mol\ N_2$

② $V = \frac{nRT}{P} \rightarrow V_{N_2} = \frac{(0.0398\ mol)(0.0821)(299\ K)}{(0.980\ atm)} \rightarrow \boxed{V_{N_2} = 0.997\ L\ N_2}$