**P.S 11.1 Kinetic Molecular Theory, Pressures & Temperatures**

**Common Conversions**

1. Convert the following pressures into atmospheres

a. 105.2 kPa b. 752 mm

Hg

c. 767 torr

2. Convert the following pressures into units of mmHg:

a. 0.9975 atm

b. 99.7 kPa c. 1.078 atm

3. Convert the following pressures into kPa.

a. 774 torr b. 112,500

Pa

c. 801 mmHg

4. Convert each of the following Celsius temperatures to Kelvin temperatures.

a. 0°C

b. 27°C

c. –50°C

d. –273°C

5. Convert each of the following Kelvin temperatures to Celsius temperatures.

a. 273 K

b. 350 K

c. 100 K

d. 20 K

6.Explain why a straw can only be a certain length. Hint: Use your book to help you.

7. What assumptions does the kinetic molecular theory make?

8.How do gases differ from liquids and solids?

9.What is pressure?

**P.S. 11.2 Kinetic Molecular Theory, Pressure & Temperature**

1. Convert the following pressures into torr

a. 125.2 kPa b. 792 mm

Hg

c. 2 atm

2. Convert the following pressures into units of kPa:

a. 0.8975 atm

b. 990 mmHg

c. 2.078 atm

3. Convert the following pressures into kPa.

a. 680 mmHg

b. 132,500

Pa

c. 820 torr

4. Convert each of the following Celsius temperatures to Kelvin temperatures.

a. 5°C

b. 52°C

c. –33°C

d. –253°C

5. Convert each of the following Kelvin temperatures to Celsius temperatures.

a. 0 K

b. 250 K

c. 150 K

d. 50 K

**PS 11.3 The Gas Laws**

1. If the pressure exerted on the gas in a weather balloon decreases from 1.01 atm to 0.562 atm as it rises, by what factor will the volume of the gas in the balloon increase as it rises?

2. What pressure (in atmospheres) is required to compress 1.00 L of gas at 760 mm

Hg pressure to a volume of 50.0 ml? (**20 atm**)

3. If a 45.0 ml sample of gas at 26.5°C is heated to 55.2°C, what is the new volume of the gas sample (at constant pressure)? (**49.3 mL**)

4. The pressure exerted on a 240 mL sample of hydrogen gas at constant temperature is increased from 0.428 atm to 0.724 atm. What will the final volume of the sample be? (**142 mL**)

5. At STP, the volume of a gas is 325 cm3. What volume does it occupy at 20.0°c and 93.3 kPa? (**379 cm3**)

6. If a helium filled balloon has a volume of 3.40 dm3 at 25.0 °c and 120 kPa, what is its volume at STP? (**3.69 dm3**)

**P.S. 11.4 More Gas Laws**

1. Maintaining constant pressure, the volume of a gas is increased from 15.0 L to 30.0 L by heating it. If the original temperature was 20.0°C, what is the new temperature? **(586 K)**

2. A cylinder contains 4.3 L of a gas at a pressure of 105.0 kPa. Keeping the temperature constant, a piston is moved in the cylinder until the volume of the cylinder is 2.8L. What is the pressure at this volume? **(161.4 kPa)**

3. To what volume would you have to change 85.0 L of gas at 104.4 kPa in order to decrease its pressure to 20.0 kPa? Assume no temperature change occurs. **(443.7 L)**

4. Find the volume of a gas at STP if it measures 806 ml at 26°C and 103.0 kPa. **(748 ml)**

5. A flask containing 155 cm3 of hydrogen was collected under a pressure of 22.5 kPa.

What pressure would have been required for the volume of the gas to have been 90.0 cm3, assuming the same temperature? **(38.8 kPa)**

6. A sample of air has a volume of 140.0 ml at 67°C. At what temperature will its volume be 50.0 mL at constant pressure? **(121 K)**

7. A gas has a volume of 3.04  10-3 m3 at 12°C and a pressure of 99.7 kPa. What pressure will cause the gas to have a volume of 3.25  10-3 m3 at 25°C? **(97.5 kPa)**

8. A gas has a volume of 450.0 mL. If the temperature is held constant, what volume would the gas occupy if the pressure were doubled? **(225.0 ml)**

9. At standard temperature, a gas has a volume of 275 mL. The temperature is then increased to 130°C and the pressure is held constant. What is the new volume? **(406 ml)**

**P.S. 11.5 Even More Gas Laws**

1. A sample of gas at 47°C and 10.3 atm occupies a volume of 2.20 L. What volume would this gas occupy at 107°C and 0.789 atm? **(34.1 L)**

2. A 350 ml air sample collected at 35°C has a pressure of 550 torr. What pressure will the air exert if it is allowed to expand to 425 ml at 57°C? **(485 Torr)**

3. A gas has a volume of 1.75 L at –23°C and 150 kPa. At what temperature would the gas occupy 1.30 L at 210 kPa? **(260 K)**

4. A sample of oxygen at 40°C occupies 820 ml. If this sample later occupies 1250 ml at 60°C and 1.40 atm, what was its original pressure? **(2.01 atm)**

5. A gas at 7.75  104 Pa and 17°C occupies a volume of 850 ml. At what temperature in degrees Celsius would the gas occupy 720 ml at 8.10  104 Pa? **(-16 0C)**

6. If 5.0 L of an ideal gas is cooled from 24°C to –272 °C, what will the volume of the gas become? (assume constant pressure) **(0.02 L)**

7. A sample of neon gas occupies 266 ml at 25.2°C. At what temperature would the volume of this sample of neon be reduced to half its initial size (at constant pressure)? At what temperature would the volume of this sample of neon be doubled (at constant pressure)? **(149 K, 596 K)**

8. A meteorological balloon contains 250 L of He at 22°C and 740 mmHg. If the volume of the balloon can vary according to external conditions, what volume would it occupy at an altitude at which the temperature is –52 °C and the pressure is 0.750 atm? **(243 L)**

9. The normal respiratory rate for a human being is 15.0 breaths per minute. The average volume of air for each breath is 505 cm3 at 20.0°C and 9.95  104 Pa. What is the volume of air at STP that an individual breathes in one day? **(1.0 X 107 cm3/day)**

10. The label on an aerosol spray can contains a warning that the can should not be heated to over 130°F because of the danger of explosion due to the pressure increase as it is heated. Calculate the potential volume of the gas contained in a

500. ml aerosol can when it is heated from 25°C to 54°C (approximately 130°F),

assuming a constant pressure. **(549 mL)**

**P.S. 11.6 Avogadro’s Law, Ideal Gas Law and Molar Volume**

1. If 0.214 moles of argon gas occupy a volume of 652 ml at a particular temperature and pressure, what volume would 0.375 moles of argon occupy under the same conditions? **(1143 ml)**

2. If 46.2 grams of oxygen gas occupies a volume of 100.0 L at a particular temperature and pressure, what volume will 5.00 grams of oxygen gas occupy under the same conditions? (hint: change grams to moles first!) **(10.8 L)**

3. 0.75 moles of helium occupy a volume of 692 ml. Assuming constant temperature and pressure, calculate the volume if I change the number of moles to 1.75 moles. **(1615 ml)**

4. Calculate the pressure in atmospheres, exerted by 2.50 L of HF containing 1.35 mol at 320.0K. **(14.2 atm)**

5. Calculate the pressure, in atmospheres, exerted by 4.75 L of NO2 containing 0.86 mol at 300 K. **(4.5 atm)**

6. Calculate the volume, in liters, occupied by 2.00 mol of H2 at 300 K and 1.25 atm. **(39.4 L)**

7. What is the molecular mass of a gas if 150.0 ml have a mass of 0.922 grams at

99°C and 107.0 kPa? **(184.4 g/mol)**

8. What is the molecular mass of a gas if 3.59 grams of it occupy 4.34 L at 99.2 kPa and 31°C? **(21.1 g/mol)**

**P.S. 11.7 More Avogadro, Ideal Gas law and Molar Volume**

1. At what temperature is a gas if 0.0851 moles of it is contained in a 604 ml vessel at 100.4 kPa? **(85.7 K)**

2. What pressure is exerted by 0.00306 moles of gas in a 25.9 ml container at 9°C? **(277 kPa)**

3. What pressure is exerted by 0.622 moles of gas contained in a 9.22 L vessel at

16°C? **(162.1 kPa)**

4. How many moles of gas occupy a 486 ml flask at 11°c and 66.7 kPa pressure? **(.0137 mol)**

5. Determine the number of moles of gas contained in each of the following:

a. 1.25 L at 250 K and 1.05 atm  
**(.064 mole)**  
b. 0.80 L at 27°C and 0.925 atm  
**(.030 mol)**

c. 7.50  102 ml at –50°C and 0.921 atm  
**(.038 mol)**

6. What is the molecular mass of a gas if 0.858 grams of it occupies 150 ml at 106.3 kPa and 2°C? **(122.6 g/mol)**

7. Find the molar mass of each gas measured at the specified conditions. a. 0.650 grams occupying 1.12 L at 280K and 1.14 atm **(11.69 g/mol)**

b. 1.05 g occupying 2.35 L at 37°C and 0.840 atm **(13.51 g/mol)**

c. 0.432 g occupying 7.5  102 ml at –23°C and 0.13 atm **(90 g/mol)**

8. If the density of an unknown gas is 3.2 g/L at –18°C and 2.17 atm, what is the molar mass of this gas? **(30.8 g/mol)**

9. Given each of the following sets of values for an ideal gas, calculate the unknown quantity.

a. P = 782 mmHg; V = **?**/ n = 0.210 mol; T = 27°C **(5.0 L)**

b. P = **?** mmHg; V = 644 ml; n = 0.0921 mol, T = 303 K **(2700 mm Hg)**

c. P = 745 mmHg; V = 11.2 L; n = 0.401 mol; T = **?** K **(334 K)**

10. What volume does 4.24 grams of nitrogen gas occupy at 58.2°C and 2.04 atm? **(2.01 L)**

11. At what temperature does 16.3 grams of nitrogen gas have a pressure of 1.25 atm in a 25.0 L tank? **(655 K)**

12. What is the volume, in liters, of each of the following at STP?

a. 1.00 mol O2 **(22.4 L)**

b. 3.50 mol F2 **(78.4 L)**

c. 95 grams of CO2 **(48.4 L)**

d. 56 grams He **(313.4 L)**

**P.S. 11.8 Law of Partial Pressure, Dry Gases**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Vapor Pressure of Water** | | | | | | | |
| **Temperature**  **oC** | **Pressure kPa** |  | **Temperature**  **oC** | **Pressure kPa** |  | **Temperature**  **oC** | **Pressure kPa** |
| 0 | 0.6 | 20 | 2.3 | 30 | 4.2 |
| 3 | 0.8 | 21 | 2.5 | 32 | 4.8 |
| 5 | 0.9 | 22 | 2.6 | 35 | 5.6 |
| 8 | 1.1 | 23 | 2.8 | 40 | 7.4 |
| 10 | 1.2 | 24 | 3.0 | 50 | 12.3 |
| 12 | 1.4 | 25 | 3.2 | 60 | 19.9 |
| 14 | 1.6 | 26 | 3.4 | 70 | 31.2 |
| 16 | 1.8 | 27 | 3.6 | 80 | 47.3 |
| 18 | 2.1 | 28 | 3.8 | 90 | 70.1 |
| 19 | 2.2 | 29 | 4.0 | 100 |  |

1. A sample of oxygen gas is saturated with water vapor at 27°C. The total pressure of the mixture is 772 torr, and the vapor pressure of water is 26.7 torr at 27°C. What is the partial pressure of the oxygen gas? **(745.3 torr)**

2. Determine the partial pressure of oxygen collected by water displacement if the water temperature is 20.0°C and the total pressure of the gases in the collection bottle is 730.0 torr. **(95.0 kPa)**

3. A chemist collects 8.00 cm3 of gas over water at 23°C and a pressure of 98.5 kPa.

What volume would the dry gas occupy at STP? **(6.97 cm3)**

4. A volume of 50.0 ml of gas is collected over water at 17°C and 740 mmHg. What volume will the dry gas occupy at STP? **(44.9 ml)**

5. Water displacement is used to collect 40.0 ml of gas at an atmospheric pressure of 734.8 mmHg and 22°C. Determine the volume of dry gas at STP? **(34.8 ml)**

6. 93.0 mL of O2 gas is collected over water at 0.930 atm and 10.0 °C. What would be the volume of this dry gas at standard conditions? **(82.4 ml)**

7. 6.12 L of wet xenon gas is collected at 2.00 x 105 Pa and 80.0 °C. What would be the volume of this dry gas at standard conditions? **(7.13 L)**

8. 1.000 L of hydrogen gas is collected over water at 30.0 °C at a pressure of 831.8 mm Hg. Find the volume of dry hydrogen collected at STP. **(.949 L)**

9. 50.6 mL of a gas is collected over water at 18.0 °C and 755.5 mm Hg pressure.

What is the volume of dry gas at STP? **(46.2 ml)**

**P.S. 11.9 More Partial Pressure and Dry Gas Problems**

1. A sample of gas is collected over water at a temperature of 35.0°C when the barometric pressure is 742.0 torr. What is the partial pressure of the dry gas? **(93.3 kPa)**

2. A tank contains a mixture of 3.0 mol N2, 2.0 mol O2 and 1.0 mol CO2 at 25°C, and a total pressure of 10.0 atm. Calculate the partial pressure (in torr) of each gas

in the mixture. **(3800 torr, 2533.3 torr, 1266.7 torr)**

3. If 4.0 grams of O2 (g) and 4.0 g of He(g) are placed in a 5.0 L vessel at 65°C, what will be the partial pressure of each gas and the total pressure in the vessel? **(.70 atm, 5.6 atm)**

4. 690.0 mL of oxygen are collected over water at 26.0 °C and a total pressure of

725.0 mm of mercury. What is the volume of dry oxygen at 52.0 °C and 800.0 mm pressure? **(655.8 ml)**

5. 400.0 mL of hydrogen are collected over water at 18.0 °C and a total pressure of

740.0 mm of mercury.

a. What is the partial pressure of H2? **(96.6 kPa)**

b. What is the partial pressure of H2O? **(2.1 kPa)**

c. What is the volume of DRY hydrogen at STP? **(357.6 ml)**

6. 45.0 mL of wet argon gas is collected at 729.3 mm Hg and 25.0 °C. What would be the volume of this dry gas at standard conditions? **(38.3 ml)**

7. 19.1 L of He gas is collected over water at 681.3 mm Hg and 18.5 °C. What would be the volume of this dry gas at standard conditions? **(15.6 L)**

8. 407 mL of H2 gas is collected over water at 785.3 mm Hg and 23.5 °C. What would be the volume of this dry gas at standard conditions? **(376.5 ml)**

9. A sample of oxygen collected over water when the atmospheric pressure was

1.002 atm and the room temperature, 25.5 °C occupied 105.8 mL. What would be the volume of this dry gas at standard conditions? **(93.8 ml)**

**P.S. 11.10 Gas Stoichiometry**

1. When calcium carbonate is heated strongly, carbon dioxide gas is released

\_CaCO3 (s) CaO (s) + \_ CO2 (g)

What volume of CO2(g), measured at STP, is produce if 15.2 grams of

CaCO3 is heated? **(3.40 L)**

2. Consider the following unbalanced chemical equation for the combustion of propane.

C3H8 (g) + \_O2 (g)   \_CO2 (g) + \_H2O (g) What volume of oxygen gas at 25°C and 1.04 atm is needed for the complete

combustion of 5.53 grams of propane? **(15 L)**

3. At STP, carbon monoxide reacts with oxygen to produce carbon dioxide. If 1.0 L

of carbon monoxide reacts with oxygen:

a. How many liters of oxygen are required? **(0.50 L)**

b. How many liters of carbon dioxide are produced? **(1.0 L)**

4. Acetylene gas, C2H2, undergoes combustion to produce carbon dioxide and water vapor. Assuming STP, if 75.0 L of CO2 are produced,

a. How many liters of C2H2 are required? **(35.5 L)**

b. What volume of H2O vapor is produced? **(37.5 L)**

c. What volume of O2 is required? **(93.8 L)**

5. If liquid carbon disulfide reacts with 4.5  102 ml of oxygen to produce the gases carbon dioxide and sulfur dioxide, at STP what volume of each product is produced? **(CO2: 150 ml, SO2: 300 ml)**

6. Assuming that 5.60 L of H2 at STP react with CuO according to the following balanced equation:

CuO (s) + H2(g)  Cu (s) + \_H2O (g)

a. How many moles of H2 react? **(0.250 mol)**

b. How many moles of Cu are produced? **(0.250 mol)**

c. How many grams of Cu are produced? **(15.9 g)**

7. Ammonia and gaseous hydrogen chloride combine to form ammonium chloride.

NH3 (g) + HCl (g)  NH4Cl (s)

If 4.21 L of NH3(g) at 27°C and 10.2 atm is combined with 5.35 L of HCl (g) at 26°C and 0.998 atm, what mass of NH4Cl (s) will be produced? Which gas is the limiting reactant? **(12 g, limiting reactant is HCL)**

8. If water is added to magnesium nitride, ammonia gas is produced when the mixture is heated.

Mg3N2 (s) + 3H2O (l)  3MgO (s) + 2NH3 (g)

If 10.3 grams of magnesium nitride is treated with water, what volume of ammonia gas would be collected at 24°C and 752 mmHg? **(5.0 L)**

**P.S. 11.11 Gas Stoichiometry**

1. Given the following unbalanced chemical equation for the combination reaction of sodium metal and chlorine gas

Na(s) + Cl2 (g)  NaCl (s)

What volume of chlorine gas, measured at STP, is necessary for the complete reaction of 4.81 grams of sodium metal? **(2.34 L)**

2. If air is 20.9% oxygen by volume, how many liters of air are needed for complete combustion of 25.0 L of octane vapor at STP? **(1.5 x 103 L)**

3. In the following equation:

ZnS (s) + O2 (g)  ZnO (s) + SO2 (g)

a. What mass of ZnO could be produced from 0.53 L of oxygen at STP? **(1.1 g)**

b. What volume, at STP, of SO2 would be produced from 4.66 grams of ZnS? **(1.07 L)**

4. What volume of chlorine gas at 24°C and 99.2 kPa is required to react with 2.51 grams of silver in the following equation? **(0.29 L)**

2 Ag (s) + Cl2(g)  2Ag Cl (s)

5. What volume of oxygen at 26°C and 102.5 kPa is required to burn 684 L of methane at 101°C and 107.5 kPa? **(1.1 x 103 L)**