Pressure Conversion Problems

1. 1.08 atm
2. 471 mm Hg
3. 813 torr
4. 0.9983 atm
5. 101,498 Pa
6. 1,678 Pa
7. 2.94 atm
8. 240. kPa

Name:____Date:_____________________Period:____________

Gas Laws Worksheet

atm = 760.0 mm Hg = 101.3 kPa= 760 .0 torr

Boyle's Law Problems: $P_1V_1 = P_2V_2$

1. If 22.5 L of nitrogen at 748 mm Hg are compressed to 725 mm Hg at constant temperature. What is the new volume?

$$(748\,mmHg)(22.5\,L) = (725\,mmHg)\,V_2$$

$$V_2 = \frac{(748\,\cancel{mmHg})(22.5\,L)}{(725\,\cancel{mmHg})}$$

$$\boxed{V_2 = 23.2\,L}$$

2. A gas with a volume of 4.0L at a pressure of 205kPa is allowed to expand to a volume of 12.0L. What is the pressure in the container if the temperature remains constant?

$$(4.0\,L)(205\,kPa) = (12.0\,L)\,P_2$$

$$P_2 = \frac{(4.0\,\cancel{L})(205\,kPa)}{12.0\,\cancel{L}}$$

$$\boxed{P_2 = 68.3\,kPa}$$

3. What pressure is required to compress 196.0 liters of air at 1.00 atmosphere into a cylinder whose volume is 26.0 liters?

$$(196.0\,L)(1.00\,atm) = (26.0\,L)\,P_2$$

$$P_2 = \frac{(196.0\,\cancel{L})(1.00\,atm)}{26.0\,\cancel{L}}$$

$$\boxed{P_2 = 7.54\,atm}$$

4. A 40.0 L tank of ammonia has a pressure of 12.7 kPa. Calculate the volume of the ammonia if its pressure is changed to 8.4 kPa while its temperature remains constant.

$$(40.0\,L)(12.7\,kPa) = (8.4\,kPa)\,V_2$$

$$V_2 = \frac{(40.0\,L)(12.7\,\cancel{kPa})}{8.4\,\cancel{kPa}}$$

$$\boxed{V_2 = 60.5\,L}$$

Name:____Date:_____________________Period:____________

Charles' Law Problems: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

1. Calculate the decrease in temperature when 6.00 L at 20.0 °C is compressed to 4.00 L.

$$\frac{6.00L}{293K} = \frac{4.00L}{T_2}$$

$$T_2 = 4.00\cancel{L}\left(\frac{293K}{6.00\cancel{L}}\right)$$

$$\boxed{T_2 = 195.3\ K}$$

2. A container containing 5.00 L of a gas is collected at 100 K and then allowed to expand to 20.0 L. What must the new temperature be in order to maintain the same pressure (as required by Charles' Law)?

$$\frac{5.00L}{100K} = \frac{20.0L}{T_2}$$

$$T_2 = 20.0\cancel{L}\left(\frac{100K}{5.00\cancel{L}}\right)$$

$$\boxed{T_2 = 400K}$$

3. A gas occupies 900.0 mL at a temperature of 27.0 °C. What is the volume at 132.0 °C?

$$\frac{900.0mL}{300K} = \frac{V_2}{405K}$$

$$V_2 = \left(\frac{900.0mL}{300\cancel{K}}\right) 405\cancel{K}$$

$$\boxed{V_2 = 1215mL}$$

4. If 15.0 liters of neon at 25.0 °C is allowed to expand to 45.0 liters, what must the new temperature be to maintain constant pressure?

$$\frac{15L}{298K} = \frac{45.0L}{T_2}$$

$$T_2 = 45.0\cancel{L}\left(\frac{298K}{15.0\cancel{L}}\right)$$

$$\boxed{T_2 = 894\ K}$$

Name:____Date:____________________Period:____________

Guy-Lussac's Law $\frac{P_1}{T_1} = \frac{P_2}{V_2}$

The gases in a hair spray can are at a temperature of 27°C and a pressure of 30 lbs/in^2. If the gases in the can reach a pressure of 90 lbs/in^2, the can will explode. To what temperature must the gases be raised in order for the can to explode? Assume constant volume. (630 °C)

$$\frac{30\ lb/in^2}{300\ K} = \frac{90\ lb/in^2}{T_2}$$

$$T_2 = 90\ \cancel{lb/in^2}\left(\frac{300\ K}{30\ \cancel{lb/in^2}}\right)$$

$$\boxed{T_2 = 900\ K}$$

2. Maybelline Cousteau's backup oxygen tank reads 900 mmHg while on her boat, where the temperature is 27°C. When she dives down to the bottom of an unexplored methane lake on a recently-discovered moon of Neptune, the temperature will drop down to –183°C. What will the pressure in her backup tank be at that temperature? (270 mmHg)

$$\frac{900\ mmHg}{300\ K} = \frac{P_2}{90\ K}$$

$$P_2 = 90\ \cancel{K}\left(\frac{900\ mmHg}{300\ \cancel{K}}\right)$$

$$\boxed{P_2 = 270\ mmHg}$$

Avogadros Law and Molar Volume at STP

(1 mole of any gas = 22.4 L at STP)

1. 50 g of nitrogen (N_2) has a volume of ___ liters at STP. (40 L)

$$50\ \cancel{g} \times \frac{1\ \cancel{mol}}{28.14\ \cancel{g}} \times \frac{22.4\ L}{1\ \cancel{mol}} = 39.8\ L = \boxed{40\ L}$$

2. 100 g of oxygen(O_2) is added to the gas in Question 16. What is the volume of the combined gases at STP. (110 L)

$$100\ \cancel{g} \times \frac{1\ \cancel{mol}}{32.00\ \cancel{g}} \times \frac{22.4\ L}{1\ \cancel{mol}} = 70\ L \text{ of } O_2$$

$$70\ L + 40\ L = \boxed{110\ L}$$

3. What is the density of carbon dioxide at STP? (2.0 g/L)

$$\frac{44.01\ g}{1\ \cancel{mol}} \times \frac{1\ \cancel{mol}}{22.4\ L} = 1.96\ g/L = \boxed{2.0\ g/L}$$

Name:______________________________________Date:____________________Period:___________

Combined Gas Law Problems: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

1. A gas balloon has a volume of 106.0 liters when the temperature is 45.0 °C and the pressure is 740.0 mm of mercury. What will its volume be at 20.0 °C and 780 .0 mm of mercury pressure?

$$\frac{(106.0\,L)(740.0\,mm\,Hg)}{315\,K} = \frac{V_2(780.0\,mm\,Hg)}{293\,K}$$

$$V_2 = \left(\frac{293\,K}{780.0\,mm\,Hg}\right)\left(\frac{106.0\,L \cdot 740.0\,mm\,Hg}{315\,K}\right) \quad \boxed{V_2 = 93.5\,L}$$

2. If 10.0 liters of oxygen at STP are heated to 512 °C, what will be the new volume of gas if the pressure is also increased to 1520.0 mm of mercury?

$$\frac{(10.0\,L)(760\,mm\,Hg)}{298\,K} = \frac{V_2(1520.0\,mm\,Hg)}{785\,K}$$

$$V_2 = \left(\frac{785\,K}{1520.0\,mm\,Hg}\right)\left(\frac{10.0\,L \cdot 760\,mm\,Hg}{298\,K}\right)$$

$$\boxed{V_2 = 13.2\,L}$$

3. A gas is heated from 263.0 K to 298.0 K and the volume is increased from 24.0 liters to 35.0 liters by moving a large piston within a cylinder. If the original pressure was 1.00 atm, what would the final pressure be?

$$\frac{(24.0\,L)(1\,atm)}{263.0\,K} = \frac{P_2(35.0\,L)}{298\,K}$$

$$P_2 = \left(\frac{298\,K}{35.0\,L}\right)\left(\frac{24.0\,L \cdot 1\,atm}{263.0\,K}\right)$$

$$\boxed{P_2 = 0.777\,atm}$$

4. The pressure of a gas is reduced from 1200.0 mm Hg to 850.0 mm Hg as the volume of its container is increased by moving a piston from 85.0 mL to 350.0 mL. What would the final temperature be if the original temperature was 90.0 °C?

$$\frac{(1200.0\,mm\,Hg)(85.0\,mL)}{363\,K} = \left(\frac{(850\,mm\,Hg)(350.0\,mL)}{T_2}\right)$$

$$T_2 = (850\,mm\,Hg \cdot 350.0\,mL)\left(\frac{363\,K}{1200.0\,mm\,Hg \cdot 85.0\,mL}\right)$$

$$\boxed{T_2 = 1058.75\,K}$$

Mixed Gas Laws Worksheet - Solutions

1) How many moles of gas occupy 98 L at a pressure of 2.8 atmospheres and a temperature of 292 K?

$$n = \frac{PV}{RT} = \frac{(2.8\text{ atm})(98\text{ L})}{(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(292\text{ K})} = 11 \text{ moles of gas}$$

2) If 5.0 moles of O_2 and 3.0 moles of N_2 are placed in a 30.0 L tank at a temperature of 25^0 C, what will the pressure of the resulting mixture of gases be? **25^0 C = 298 K**

$$O_2: P = \frac{nRT}{V} = \frac{(5.0\text{ mol})(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(298\text{ K})}{(30.0\text{ L})} = 4.1\text{ atm}$$

$$N_2: P = \frac{nRT}{V} = \frac{(3.0\text{ mol})(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(298\text{ K})}{(30.0\text{ L})} = 2.4\text{ atm}$$

$$P_{Tot} = P_{O2} + P_{N2} = 4.1\text{ atm} + 2.4\text{ atm} = 6.5\text{ atm}$$

3) A balloon is filled with 35.0 L of helium in the morning when the temperature is 20.0^0 C. By noon the temperature has risen to 45.0^0 C. What is the new volume of the balloon?

$T_1 = 20.0^0$ C = 293 K, V_1 = 35.0 L, $T_2 = 45.0^0$ C = 318 K, V_2 = ?

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(35.0\text{ L})(318\text{ K})}{(293\text{ K})} = 38.0\text{ L}$$

4) A 35 L tank of oxygen is at 315 K with an internal pressure of 190 atmospheres. How many moles of gas does the tank contain?

$$n = \frac{PV}{RT} = \frac{(190\text{ atm})(35\text{ L})}{(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(315\text{ K})} = 260 \text{ moles of gas}$$

5) A balloon that can hold 85 L of air is inflated with 3.5 moles of gas at a pressure of 1.0 atmosphere. What is the temperature in ^{0}C of the balloon?

$$T = \frac{PV}{nR} = \frac{(1\text{ atm})(85\text{ L})}{(3.5\text{ mol})(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})} = 296\text{ K} = 23^0\text{ C}$$

6) $CaCO_3$ decomposes at 1200^0 C to form CO_2 gas and CaO. If 25 L of CO_2 are collected at 1200^0 C, what will the volume of this gas be after it cools to 25^0 C?

$T_1 = 1200^0$ C = 1473 K, V_1 = 25 L, $T_2 = 25^0$ C = 298 K, V_2 = ?

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(25\text{ L})(298\text{ K})}{(1473\text{ K})} = 5.1\text{ L}$$

7) A helium balloon with an internal pressure of 1.00 atm and a volume of 4.50 L at 20.0^0 C is released. What volume will the balloon occupy at an altitude where the pressure is 0.600 atm and the temperature is -20.0^0 C?

P_1 = 1.00 atm, V_1 = 4.50 L, $T_1 = 20.0^0$ C = 293 K, P_2 = 0.600 atm, V_2 = ?,
$T_2 = -20.0^0$ C = 253 K

$$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{(1.00\text{ atm})(4.50\text{ L})(253\text{ K})}{(293\text{ K})(0.600\text{ atm})} = 6.48\text{ L}$$

8) There are 135 L of gas in a container at a temperature of 260^0 C. If the gas was cooled until the volume decreased to 75 L, what would the temperature of the gas be?

$T_1 = 260^0$ C = 533 K, V_1 = 135 L, T_2 = ?, V_2 = 75 L

$$T_2 = \frac{V_2 T_1}{V_1} = \frac{(75\text{ L})(533\text{ K})}{(135\text{ L})} = 296\text{ K} = 23^0\text{ C}$$

9) A 75 L container holds 62 moles of gas at a temperature of 215^0 C. What is the pressure in atmospheres inside the container? **215^0 C = 488 K**

$$P = \frac{nRT}{V} = \frac{(62\ mol)(0.0821\ L\cdot atm/mol\cdot K)(488\ K)}{(75\ L)} = 33\ atm$$

10) 6.0 L of gas in a piston at a pressure of 1.0 atm are compressed until the volume is 3.5 L. What is the new pressure inside the piston?

$P_1 = 1.0$ atm, $V_1 = 6.0$ L, $P_2 = ?$, $V_2 = 3.5$ L

$$P_2 = \frac{P_1 V_1}{V_2} = \frac{(1.0\ atm)(6.0\ L)}{(3.5\ L)} = 1.7\ atm$$

11) A gas canister can tolerate internal pressures up to 210 atmospheres. If a 2.0 L canister holding 3.5 moles of gas is heated to 1350^0 C, will the canister explode? **1350^0 C = 1623 K**

$$P = \frac{nRT}{V} = \frac{(3.5\ mol)(0.0821\ L\cdot atm/mol\cdot K)(1623\ K)}{(2.0\ L)} = 230\ atm$$

Yes, the canister will explode.

12) The initial volume of a gas at a pressure of 3.2 atm is 2.9 L. What will the volume be if the pressure is increased to 4.0 atm?

$P_1 = 3.2$ atm, $V_1 = 2.9$ L, $P_2 = 4.0$ atm, $V_2 = ?$

$$V_2 = \frac{P_1 V_1}{P_2} = \frac{(3.2\ atm)(2.9\ L)}{(4.0\ atm)} = 2.3\ L$$

13) An airtight container with a volume of 4.25×10^4 L, an internal pressure of 1.00 atm, and an internal temperature of 15.0^0 C is washed off the deck of a ship and sinks to a depth where the pressure is 175 atm and the temperature is 3.00^0 C. What will the volume of the gas inside be when the container breaks under the pressure at this depth?
**$P_1 = 1.00$ atm, $V_1 = 4.25 \times 10^4$ L, $T_1 = 15.0^0$ C = 288 K, $P_2 = 175$ atm, $V_2 = ?$,
$T_2 = 3.00^0$ C = 276 K**

$$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2} = \frac{(1.00\ atm)(4.25 \times 10^4\ L)(276\ K)}{(288\ K)(175\ atm)} = 233\ L$$

14) Two flasks are connected with a stopcock. Flask #1 has a volume of 2.5 L and contains oxygen gas at a pressure of 0.70 atm. Flask #2 has a volume of 3.8 L and contains hydrogen gas at a pressure of 1.25 atm. When the stopcock between the two flasks is opened and the gases are allowed to mix, what will the resulting pressure of the gas mixture be? (**P' & V' are initial conditions before mixing)**
$P'_{O2} = 0.70$ atm, $P'_{H2} = 1.25$ atm, $V'_{O2} = 2.5$ L, $V'_{H2} = 3.8$ L, $V = 6.3$ L

O_2: $$P_2 = \frac{P'_{O2} V'_{O2}}{V} = \frac{(0.70\ atm)(2.5\ L)}{(6.3\ L)} = 0.28\ atm$$

H_2: $$P_2 = \frac{P'_{H2} V'_{H2}}{V} = \frac{(1.25\ atm)(3.8\ L)}{(6.3\ L)} = 0.75\ atm$$

$P_{Tot} = P_{O2} + P_{H2} = 0.28\ atm + 0.75\ atm = 1.0\ atm$

15) A weather balloon has a volume of 35 L at sea level (1.0 atm). After the balloon is released it rises to where the air pressure is 0.75 atm. What will the new volume of the weather balloon be?
$P_1 = 1.0$ atm, $V_1 = 35$ L, $P_2 = 0.75$ atm, $V_2 = ?$

$$V_2 = \frac{P_1 V_1}{P_2} = \frac{(1.0\ atm)(35\ L)}{(0.75\ atm)} = 47\ L$$

Solutions

1. How many moles of gas (air) are in the lungs of an adult with a lung capacity of 3.9 L? Assume that the lungs are at 1.00 atm pressure and at a body temperature of 40 °C. (Hint: V, P, and T are given. Use the equation PV = nRT where R = 0.082058 $\frac{L \cdot atm}{K \cdot mol}$)
   K = 40 °C + 273.15 = 313.15 K

   $$n = \frac{PV}{RT} = \frac{(1.00\ atm)(3.9\ L)}{(0.082058\ \frac{L \cdot atm}{K \cdot mol})(313.15\ K)} = 0.15 \text{ mol}$$

2. Calculate the volume occupied by 0.921 moles of nitrogen gas (N_2) at a pressure of 1.38 atm and a temperature of 316 K.

   $$V = \frac{nRT}{P} = \frac{(0.921\ mol)(0.082058\ \frac{L \cdot atm}{K \cdot mol})(316\ K)}{(1.38\ atm)} = 17.3 \text{ L}$$

3. A sample of gas has a mass of 0.312 g. Its volume is 0.255 L at a temperature of 55 °C and a pressure of 888 mmHg. Find its molar mass $\frac{Mass\ (m)}{Moles\ (n)}$

   K = 55 °C + 273.15 = 328.15 K

   P = 888 mmHg × $\frac{1\ atm}{760\ mmHg}$ = 1.1684 atm

   $$n = \frac{PV}{RT} = \frac{(1.1684\ atm)(0.255\ L)}{(0.082058\ \frac{L \cdot atm}{K \cdot mol})(328.15\ K)} = 0.01106 \text{ mol}$$

   molar mass = $\frac{Mass\ (m)}{Moles\ (n)} = \frac{0.312\ g}{0.01106\ mol}$ = 28.2 g/mol is the molar mass of this gas.

4. A piece of dry ice (solid carbon dioxide) with a mass of 30.0 g sublimes (solid to gas) into a large balloon. Assuming that all of the carbon dioxide ends up in the balloon, what is the volume of the balloon at a temperature of 22 °C and a pressure of 745 mmHg?

   30.0 g CO_2 × $\frac{1\ mol\ CO2}{44.01\ g\ CO2}$ = 0.68166 mol CO_2 ; K = 22 °C + 273.15 = 295.15 K

   745 mmHg × $\frac{1\ atm}{760\ mmHg}$ = 0.980 atm

   $$PV = nRT \rightarrow V = \frac{nRT}{P} = \frac{(0.68166\ mol\ CO2)(0.082058\ \frac{L \cdot atm}{K \cdot mol})(295.15\ K)}{(0.980\ atm)} = 16.8 \text{ L}$$

5. What is the volume occupied by 0.212 mol of helium gas at a pressure of 0.95 atm and a temperature of 325 K?

PV = nRT → $V = \frac{nRT}{P} = \frac{(0.212\ mol)(0.082058\frac{L\cdot atm}{K\cdot mol})(325\ K)}{(0.95\ atm)} = 6.0\ \text{L}$

6. A cylinder contains 32.4 L of oxygen gas at a pressure of 2.3 atm and a temperature of 298 K. How much gas (in moles) is in the cylinder?

PV = nRT → $n = \frac{PV}{RT} = \frac{(2.3\ atm)(32.4\ L)}{(0.082058\frac{L\cdot atm}{K\cdot mol})(298\ K)} = 3.0\ \text{mol}$

7. A sample of gas has a mass of 0.501 g. Its volume is 0.425 L at a temperature of 110 °C and a pressure of 1120 mmHg. Find its molar mass.

K = 110 °C + 273.15 = 383 K

P = 1120 mmHg × $\frac{1\ atm}{760\ mmHg}$ = 1.47 atm

n = $\frac{PV}{RT} = \frac{(1.47\ atm)(0.425\ L)}{(0.082058\frac{L\cdot atm}{K\cdot mol})(383\ K)} = 0.0198786\ \text{mol}$

molar mass = $\frac{Mass\ (m)}{Moles\ (n)} = \frac{0.501\ g}{0.0198786\ mol}$ = 25.2 g/mol is the molar mass of this gas.

Name: KEY   Period:

Gas Stoichiometry Worksheet

Directions: Use the gas laws we have learned to solve each of the following problems. ***Each of the chemical equations must first be balanced***. Show all your work for credit.

1. When calcium carbonate is heated strongly, carbon dioxide gas is released according to the following equation:

$$100.1\,g/mol \quad 1\,CaCO_3(s) \rightarrow 1\,CaO(s) + 1\,CO_2(g) \quad 44.0\,g/mol$$

What volume of $CO_2(g)$, measured at STP, is produced if 15.2 grams of $CaCO_3(s)$ is heated?

$$\frac{15.2\,g\,CaCO_3}{} \cdot \frac{1\,mol\,CaCO_3}{100.1\,g} \cdot \frac{1\,mol\,CO_2}{1\,mol\,CaCO_3} \cdot \frac{22.4\,L\,CO_2}{1\,mol\,CO_2} = 3.40\,L\,CO_2$$

2. The synthesis of sodium chloride occurs according to the reaction:

$$2\,Na(s) + Cl_2(g) \rightarrow 2\,NaCl(s)$$

What volume of chlorine at STP is necessary for the complete reaction of 4.81 grams of sodium metal?

$$\frac{4.81\,g\,Na}{} \cdot \frac{1\,mol\,Na}{23.0\,g} \cdot \frac{1\,mol\,Cl_2}{2\,mol\,Na} \cdot \frac{22.4\,L\,Cl_2}{1\,mol\,Cl_2} = 2.34\,L\,Cl_2$$

3. Potassium permanganate is produced commercially by the this reaction:

$$2\,K_2MnO_4(aq) + 1\,Cl_2(g) \rightarrow 2\,KMnO_4(s) + 2\,KCl(aq)$$

What volume of chlorine gas at STP would be required to produce 10.0 grams of $KMnO_4$?

$$\frac{10.0\,g}{} \cdot \frac{1\,mol\,MnO_4}{158\,g\,MnO_4} \cdot \frac{1\,mol\,Cl_2}{2\,mol\,MnO_4} \cdot \frac{22.4\,L}{1\,mol} = .709\,Liters$$

4. Consider the following *unbalanced* chemical equation for the combustion of propane:

$$C_3H_8(g) \quad + \quad 5\ O_2(g) \quad \rightarrow \quad 3\ CO_2(g) \quad + \quad 4\ H_2O(g)$$

What volume of oxygen at 25°C and 1.04 atm is needed for the complete combustion of 5.53 grams of propane?

$P = 1.04\text{ atm} \quad T = 25°C = 298K \quad R = 0.0821 \frac{L\cdot atm}{K\cdot mol}$

$$\frac{5.53g\ C_3H_8}{} \left| \frac{1mol\ C_3H_8}{44g} \right| \frac{5mol\ O_2}{1mol\ C_3H_8} = .628mol\ O_2$$

$$PV = nRT \rightarrow V = \frac{nRT}{P} = \frac{(.628mol)(.0821)(298K)}{(1.04atm)} = 14.8L\ O_2$$

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

$$1\ Mg_3N_2(s) \quad + \quad 3\ H_2O(l) \quad \rightarrow \quad 3\ MgO(s) \quad + \quad 2\ NH_3(g)$$

When excess water is added to 10.3 grams of magnesium nitride, what volume of ammonia gas would be collected at 24°C and 752 mmHg? $T = 24°C + 273 = 297K \quad P = \frac{752mmHg}{} \left| \frac{1atm}{760mmHg} \right. = .989atm$

$$\frac{10.3g\ Mg_3N_2}{} \left| \frac{1mol\ Mg_3N_2}{100.9g\ Mg_3N_2} \right| \frac{2mol\ NH_3}{1mol\ Mg_3N_2} = .204mol\ NH_3$$

$$PV = nRT \rightarrow V = \frac{nRT}{P} = \frac{(.204mol)(0.0821)(297K)}{(.989atm)} = 5.03L\ NH_3$$

6. Ammonia and gaseous hydrogen chloride combine to form ammonium chloride according to this equation:

$$1\ NH_3(g) \quad + \quad 1\ HCl(g) \quad \rightarrow \quad 1\ NH_4Cl(s)$$

If 4.21 L of $NH_3(g)$ at 27°C and 1.02 atm is combined with 5.35 L of $HCl(g)$ at 26°C and 0.998 atm, what mass of $NH_4Cl(s)$ will be produced? Which gas is the limiting reactant? Which gas is the excess reactant?

NH_3 HCl

$NH_3 \begin{cases} V = 4.21L\ NH_3 \\ T = 27 + 273 = 300K \\ P = 1.02\text{ atm} \\ R = 0.0821 \frac{L\cdot atm}{K\cdot mol} \end{cases}$

$HCl \begin{cases} V = 5.35L \\ T = 26°C + 273 = 299K \\ P = .998atm \\ R = 0.0821 \frac{L\cdot atm}{K\cdot mol} \end{cases}$

$$PV = nRT \rightarrow n = \frac{PV}{RT} = \frac{(1.02atm)(4.21L)}{(0.0821)(300K)} = .174mol$$

less moles, must be LR

$$n = \frac{PV}{RT} = \frac{(.998atm)(5.35L)}{(0.0821)(299K)} = .218mol$$

excess

$$\frac{.17mol\ NH_3}{} \left| \frac{1mol\ NH_4Cl}{1mol\ NH_3} \right| \frac{53.5g}{1mol\ NH_4Cl} = 9.1g\ NH_4Cl$$

ANSWERS TO PROBLEMS

Problem 1:
a. 0.5 L O_2
b. 1.0 L CO_2

Problem 2:
a. 37.5 L C_2H_2
b. 37.5 L H_2O
c. 93.75 L O_2

Problem 3:
CO_2 = 150 mL, SO_2 = 300 mL

Problem 4:
a. 0.25 mol H_2
b. 0.25 mol Cu
c. 15.88 Cu

Problem 5:
a. 0.38 mol I_2
b. 0.76 mol KI
c. 126.2 g KI

Problem 6:
a. 2.35 g $Fe(OH)_3$
b. 1.76 Fe_2O_3

Problem 7: 4.40 g $FeSO_4$

Problem 8:
a. 0.5 mol Al
b. 0.75 mol H_2
c. 16.8 L H_2

Problem 9:
a. 1495.2 L air
b. CO_2 = 200 L, H_2O = 225 L

Problem 10: 2945 L NH_3

Problem 11:
CO_2 = 79.2 grams, H_2O = 64.8 grams

Problem 12:
a. $3\,H_2 + N_2 \rightarrow 2\,NH_3$
b. 193 liters NH_3

Problem 13: 1250 mL C_2H_2

Chemistry 1

Volume 5

Worksheet 19

Dalton's Law of Partial Pressures – Part 2

Answer Key

1. A mixture of 4.5% H_2, 76% O_2, and 19.5% N_2 has a total pressure of 2.3 atm. What is the partial pressure of each of the gases?

    P_{H_2} = (0.045)(2.3 atm) = 0.10 atm
    P_{O_2} = (0.76)(2.3 atm) = 1.75 atm
    P_{N_2} = (0.195)(2.3 atm) = 0.45 atm

    Check your answer by adding the individual gases:
    0.10 atm + 1.75 atm + 0.45 atm = 2.30 atm.

    Since the answer matches original total pressure of 2.3 atm, the answer is correct.

    Correct answer: P_{H_2} = 0.10 atm; P_{O_2} = 1.75 atm; P_{N_2} = 0.45 atm

2. A 2.5 L sample at 273 K contains 0.006 mol H_2, 0.0024 mol O_2, and 0.0002 mol CH_4. What is the partial pressure of O_2?

    Each of the gases in a mixture obeys the Ideal Gas law individually.

    Thus:

    $P_{O_2}V = n_{O_2}RT$

    P_{O_2}(2.5L) = (0.0024 mol)(0.08206 L atm/mol K)(273 K)
    P_{O_2} = 0.022 atm

    Correct answer: 0.022 atm

3. A 1.5 L sample at 298 K contains 0.030 mol N_2 and 0.0020 mol O_2. If the total pressure of the system is 0.52 atm, what is the partial pressure of the two gases?

There are two methods to solve this problem.

Method 1: Use mole fractions

Step 1:

Calculate the mol fraction of each of the gases.

$$x_{N_2} = \frac{n_{N_2}}{(n_{N_2} + n_{O_2})}$$

$$x_{N_2} = \frac{0.030\ mol}{(0.030\ mol + 0.0020\ mol)}$$

$x_{N_2} = 0.94$

$x_{O_2} = 1.00 - 0.94 = 0.06$

Step 2:

Multiply the mole fraction by the total pressure.

$P_{N_2} = (0.94)(0.52\text{ atm}) = 0.49\text{ atm}$

$P_{O_2} = (0.06)(0.52\text{ atm}) = 0.03\text{ atm}$

Method 2: Use the Ideal Gas Law

$P_{N_2}(1.5\text{ L}) = (0.030\text{ mol})(0.08206\text{ L atm/mol K})(298\text{ K})$

$P_{N_2} = 0.49\text{ atm}$

$P_{O_2}(1.5\text{ L}) = (0.0020\text{ mol})(0.08206\text{ L atm/mol K})(298\text{ K})$

$P_{O_2} = 0.03\text{ atm}$

Each method gives the same answer!

Correct answer: P_{N_2} = 0.49 atm; P_{O_2} = 0.03 atm

4. A 500.0 mL sample of gases is at 307 K and contains N_2 at a pressure of 1.4 atm and O_2 at a pressure of 0.24 atm. What is the mole fraction of each of the two gases?

Step 1:
Calculate the number of moles of each of the two gases using the Ideal Gas Law.

Moles N_2:
$P_{N_2}V = n_{N_2}RT$

$(1.4\ \text{atm})(0.5000\ \text{L}) = n_{N_2}(0.08206\ \text{L atm/mol K})(307\ \text{K})$

$n_{N_2} = 0.028$ mol

Moles O_2:
$P_{O_2}V = n_{O_2}RT$

$(0.24\ \text{atm})(0.5000\ \text{L}) = n_{O_2}(0.08206\ \text{L atm/mol K})(307\ \text{K})$

$n_{O_2} = 0.0048$ mol

Step 2:
Calculate the mol fraction of each gas using.

$x_{N_2} = \frac{0.028\ mol}{(0.028\ mol + 0.0048\ mol)} = 0.85 \times 100\% = 85\ \%$

$x_{O_2} = \frac{0.0048\ mol}{(0.028\ mol + 0.0048\ mol)} = 0.15 \times 100\% = 15\%$

Check your answer by making sure the percentages add up to 100%:
85% + 15% = 100%

Correct answer: x_{N_2} = 85 %; x_{O_2} = 15%

5. If a mixture of Ne and Ar has a total pressure of 1.5 atm at 296 K in a 0.5 L container, what is the partial pressure of Ne if Ar is present in a mole fraction of 0.34?

Step 1:
Calculate the mole fraction of Ne:

$x_{Ne} = 1 - x_{Ar}$

$x_{Ne} = 1 – 0.34$

$x_{Ne} = 0.66$

Step 2:
Use Dalton's Law of Partial Pressures to calculate the partial pressure of Ne.

$P_{Ne} = (P_{Tot})(x_{Ne})$

$P_{Ne} = (1.5 \text{ atm})(0.66)$

$P_{Ne} = 0.99 \text{ atm}$

Correct answer: 0.99 atm

6. A mixture of H_2 and NH_3 has a total pressure of 1.02 atm at 273 K in a 0.75 L container. If H_2 is present in a mole fraction of 0.21, how many moles of NH_3 are present?

Step 1:
Calculate the mole fraction of NH_3.

$x_{NH_3} = 1 - x_{H_2}$

$x_{NH_3} = 1 - 0.21$

$x_{NH_3} = 0.79$

Step 2:
Calculate the partial pressure of NH_3.

$\mathrm{P_{NH_3}} = (P_{Tot})(\mathrm{x_{NH_3}})$

$\mathrm{P_{NH_3}} = (1.02\text{ atm})(0.79)$

$\mathrm{P_{NH_3}} = 0.81\text{ atm}$

Step 3:
Use the Ideal Gas Law to calculate the number of moles NH_3.

$\mathrm{P_{NH_3}}V = \mathrm{n_{NH_3}}RT$

$(0.81\text{ atm})(0.75\text{ L}) = \mathrm{n_{NH_3}}(0.08206\text{ L atm/mol K})(273\text{ K})$

$\mathrm{n_{NH_3}} = 0.027\text{ mol } NH_3$

Correct answer: 0.027 mol NH_3

7. A mixture of unknown gases, A and B have partial pressure of P_A = 0.35 atm and P_B = 0.45 atm. If the gas mixture is at 256 K in a 1.1 L container how many moles of gas are present?

   Step 1:
   Determine the total pressure of the mixture by adding the partial pressures.

   $P_{Tot} = P_A + P_B$

   P_{Tot} = 0.35 atm + 0.45 atm

   P_{Tot} = 0.80 atm

   Step 2:
   Use the Ideal Gas Law to calculate the number of moles present.

   $PV=nRT$

   (0.80 atm)(1.1 L) = n(0.08206 L atm/mol K)(256 K)

   n = 0.042 mol

   Correct answer: 0.042 mol of total gas

8. At 304 K, a 5.6 L container with H_2 and N_2 has a total pressure of 1.55 atm. If there are 0.034 moles of H_2, what is the partial pressure of N_2?

   Step 1:
   Calculate the partial pressure of H_2.

   $P_{H_2}V = n_{H_2}RT$

   $P_{H_2}(5.6\ L) = (0.034\ mol)(0.08206\ L\ atm/mol\ K)(304\ K)$

   $P_{H_2} = 0.15\ atm$

   Step 2:
   Calculate the partial pressure of N_2.

   $P_{N_2} = P_{Tot} - P_{H_2}$

   $P_{N_2} = 1.55\ atm - 0.15\ atm$

   $P_{N_2} = 1.4\ atm$

   Correct answer: 1.4 atm