Name Key Period

Introduction to Gases – Guided Reading Sections 13.1 and 14.1:

Use textbook pages 420-424 and 450-454 to complete the following questions and calculations.

1. There are 5 statements/assumptions that describe the Kinetic Theory of gases. Please write them below:
   a. gas particles are small, hard spheres w/ an insignificant volume
   b. motion of gases is rapid, constant, and random
   c. all collisions between particles are perfectly elastic
   d. gas pressure is the result of billions of rapidly moving particles simultaneously colliding w/ an object
   e. the Kelvin temperature of a substance is directly proportional to the average kinetic energy of the particles of the substance
2. What would you expect gas molecules to do if a gas is transferred from a small container into a larger container?
   Gas particles would spread to the full size of the larger container.
3. What does it mean for a collision to be "perfectly elastic"?
   No energy is lost when particles collide.
4. Why don't the particles in a gas eventually slow down and stop?
   They move constantly and rapidly
5. What causes gas "pressure" within a container, such as a balloon?
   billions of simultaneous collisions w/ an object
6. What is "atmospheric pressure"? collisions of gas particles in the air

   What is a barometer used for? device used to measure atmospheric pressure
7. Standard Pressure is defined to be...

   1.000 atm = 760.0 mm Hg = 760.0 torr = 101.3 kPa

   When studying gases, it is important to be able to relate measured values to these standards for unit conversions. Apply you knowledge of dimensional analysis to perform the following pressure unit conversions.

   a. A pressure gauge records a pressure of 450.0 kPa. Convert this measurement to:
      i. Atmospheres = $\frac{450.0\text{ kPa} \mid 1.000\text{ atm}}{\mid 101.3\text{ kPa}} = \boxed{4.442\text{ atm}}$
      ii. Millimeters of mercury = $\frac{450.0\text{ kPa} \mid 760.0\text{ mmHg}}{\mid 101.3\text{ kPa}} = \boxed{3376\text{ mmHg}}$

b. The pressure at the top of Mount Everest is 0.333 atm. How would this measurement be expressed in:

i. Kilopascals = $\frac{0.333\,atm \mid 101.3\,kPa}{\mid 1.000\,atm} = \boxed{33.7\,kPa}$

ii. Torr = $\frac{0.333\,atm \mid 760.0\,Torr}{\mid 1.000\,atm} = \boxed{253\,Torr}$

8. How does an increase in temperature affect the kinetic energy of the gas molecules?

Increase in temp will increase the kinetic energy

Would you describe this relationship as DIRECT or INVERSE?

9. What is "compressibility"?

ability to be reduced to a smaller volume

Why are gases easier to compress than solids?

gases are expanded to fill the entire container it's in so it's easier to compress because it is already expanded and there is lots of space between gas particles

10. What are the four variables used to describe a gas?

pressure, volume, temperature, and amount of particles

Out of these four variables, which are factors that affect the gas pressure?

V, T, + mol

11. How would you describe the relationship between the amount of gas and the pressure of the gas – DIRECT or INVERSE?

How do you predict the pressure would change if the amount of gas in a rigid container is tripled?

The pressure would triple as well

12. How would you describe the relationship between the pressure of a gas and its volume – DIRECT or INVERSE?

How do you predict the pressure would change if the volume available for the gas is doubled?

pressure will reduce by half

13. How would you describe the relationship between the pressure of a gas and the temperature of the gas – DIRECT or INVERSE?

How do you predict the pressure would change if the temperature of the system is decreased by half?

pressure would decrease as well

14. REVIEW: How are the Celsius temperature and the Kelvin temperature related? What is the mathematical formula relating these two temperature units?

$K = °C + 273$

Use this formula to convert the following temperatures:

a. 100.0°C = 373 K

b. 25.0°C = 298 K

c. 312 K = 39 °C

d. 398 K = 125 °C

Pressure Conversions

Conversions:

1.00 atm = 101.325 kPa = 760 Torr = 760 mmHg = 14.7 psi

Solve each problem using the conversion factors above. Remember sig figs and units. These will be one-step dimensional analysis problems (field goal posts.)

1. Convert 92 kPa to Torr

$$\frac{92\text{ kPa}}{} \left| \frac{760\text{ Torr}}{101.325\text{ kPa}} \right. = \boxed{690\text{ Torr}}$$

2. Convert 850 kPa to mmHg

$$\frac{850\text{ kPa}}{} \left| \frac{760\text{ mmHg}}{101.325\text{ kPa}} \right. = \boxed{6400\text{ mmHg}}$$

3. Convert 980 Torr to kPa

$$\frac{980\text{ Torr}}{} \left| \frac{101.325\text{ kPa}}{760\text{ Torr}} \right. = \boxed{130\text{ kPa}}$$

4. Convert 980 Torr to atmospheres (atm)

$$\frac{980\text{ Torr}}{} \left| \frac{1.00\text{ atm}}{760\text{ Torr}} \right. = \boxed{1.3\text{ atm}}$$

5. Convert 3.0 atm to kPa

$$\frac{3.0\text{ atm}}{} \left| \frac{101.325\text{ kPa}}{1.00\text{ atm}} \right. = \boxed{3.0 \times 10^2\text{ kPa}}$$

6. Convert 1.5 atm to Torr

$$\frac{1.5\text{ atm}}{} \left| \frac{760\text{ Torr}}{1.00\text{ atm}} \right. = \boxed{1100\text{ Torr}}$$

7. If a car tire holds 32 psi, what will be its pressure in kPa?

$$\frac{32\text{ psi}}{} \left| \frac{101.325\text{ kPa}}{14.7\text{ psi}} \right. = \boxed{220\text{ kPa}}$$

8. Add 1.25 atm + 150 kPa + 800 Torr and give the final pressure in atmospheres.

$$\frac{150\text{ kPa}}{} \left| \frac{1.00\text{ atm}}{101.325\text{ kPa}} \right. = 1.5\text{ atm} \qquad \frac{800\text{ Torr}}{} \left| \frac{1.00\text{ atm}}{760\text{ Torr}} \right. = 1\text{ atm}$$

$$1.25\text{ atm} + 1.5\text{ atm} + 1\text{ atm} = \boxed{4\text{ atm}}$$

$P_1V_1 = P_2V_2$

Boyles' Law

1) 1.00 L of a gas at standard temperature and pressure is compressed to 473 mL. What is the new pressure of the gas?

273K 1.00 atm

$= 0.473L$

$$\frac{1.00L \cdot 1.00atm}{0.473L} = \boxed{2.11\ atm}$$

2) In a thermonuclear device, the pressure of 0.050 liters of gas within the bomb casing reaches 4.0 x 10^6 atm. When the bomb casing is destroyed by the explosion, the gas is released into the atmosphere where it reaches a pressure of 1.00 atm. What is the volume of the gas after the explosion?

$$\frac{4.0\times10^6 atm \cdot 0.050L}{1.00atm} = \boxed{2.0\times10^5 L}$$

3) Synthetic diamonds can be manufactured at pressures of 6.00 x 10^4 atm. If we took 2.00 liters of gas at 1.00 atm and compressed it to a pressure of 6.00 x 10^4 atm, what would the volume of that gas be?

$$\frac{1.00atm \cdot 2.00L}{6.00\times10^4 atm} = \boxed{3.33\times10^{-5}\ L}$$

4) The highest pressure ever produced in a laboratory setting was about 2.0 x 10^6 atm. If we have a 1.0 x 10^{-5} liter sample of a gas at that pressure, then release the pressure until it is equal to 0.275 atm, what would the new volume of that gas be?

$$\frac{2.0\times10^6 atm \cdot 1.0\times10^{-5}L}{0.275atm} = \boxed{73L}$$

5) Atmospheric pressure on the peak of Mt. Everest can be as low as 150. mm Hg, which is why climbers need to bring oxygen tanks for the last part of the climb. If the climbers carry 10.0 liter tanks with an internal gas pressure of 3.04×10^4 mm Hg, what will be the volume of the gas when it is released from the tanks?

$$\frac{10.0\,L \cdot 3.04 \times 10^4\,mmHg}{150.\,mmHg} = \boxed{2030\,L}$$

6) Part of the reason that conventional explosives cause so much damage is that their detonation produces a strong shock wave that can knock things down. While using explosives to knock down a building, the shock wave can be so strong that 12 liters of gas will reach a pressure of 3.8×10^4 mm Hg. When the shock wave passes and the gas returns to a pressure of 760 mm Hg, what will the volume of that gas be?

$$\frac{12\,L \cdot 3.8 \times 10^4\,mmHg}{760\,mmHg} = \boxed{6.0 \times 10^2\,L}$$

7) Submarines need to be extremely strong to withstand the extremely high pressure of water pushing down on them. An experimental research submarine with a volume of 15,000 liters has an internal pressure of 1.2 atm. If the pressure of the ocean breaks the submarine forming a bubble with a pressure of 250 atm pushing on it, how big will that bubble be?

$$\frac{15000\,L \cdot 1.2\,atm}{250\,atm} = \boxed{72\,L}$$

8) Divers get "the bends" if they come up too fast because gas in their blood expands, forming bubbles in their blood. If a diver has 0.050 L of gas in his blood under a pressure of 250 atm, then rises instantaneously to a depth where his blood has a pressure of 50.0 atm, what will the volume of gas in his blood be? Do you think this will harm the diver?

0.050 L ·

$$\frac{0.050\,L \cdot 250\,atm}{50.0\,atm} = \boxed{0.25\,L}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Charles' Law

Always use Kelvin

1) The temperature inside my refrigerator is about 4.00^0 Celsius. If I place a balloon in my fridge that initially has a temperature of 22.0^0 C and a volume of 0.500 liters, what will be the volume of the balloon when it is fully cooled by my refrigerator?

$$\frac{0.500L \cdot 277K}{295K} = \boxed{0.469L}$$

2) A man heats a balloon in the oven. If the balloon initially has a volume of 0.400 liters and a temperature of 20 ^{0}C, what will the volume of the balloon be after he heats it to a temperature of 250 ^{0}C?

$$\frac{0.400L \cdot 523K}{293K} = \boxed{0.714L}$$

3) On hot days, you may have noticed that potato chip bags seem to "inflate", even though they have not been opened. If I have a 250 mL bag at a temperature of 19 ^{0}C, and I leave it in my car which has a temperature of 60^0 C, what will the new volume of the bag be?

$$\frac{250mL \cdot 333K}{292K} = \boxed{290 mL}$$

4) A soda bottle is flexible enough that the volume of the bottle can change even without opening it. If you have an empty soda bottle (volume of 2.23 L) at room temperature (25.0 ^{0}C), what will the new volume be if you put it in your freezer (-4.00 ^{0}C)?

$$\frac{2.23L \cdot 269K}{298K} = \boxed{2.01L}$$

5) Some students believe that teachers are full of hot air. If I inhale 2.2 liters of gas at a temperature of 18^0 C and it heats to a temperature of 38^0 C in my lungs, what is the new volume of the gas?

$$\frac{2.2L \cdot 311K}{291K} = \boxed{2.4L}$$

6) How hot will a 2.3 L balloon have to get to expand to a volume of 5.0 L? Assume that the initial temperature of the balloon is 25 ^{0}C.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad T_2 = \frac{V_2 T_1}{V_1} = \frac{5.0L \cdot 298K}{2.3L} = \boxed{650K}$$

7) I have made a thermometer which measures temperature by the compressing and expanding of gas in a piston. I have measured that at 100^0 C the volume of the piston is 20. L. What is the temperature outside if the piston has a volume of 15 L? What would be appropriate clothing for the weather?

Bring a sweater!

$$T_2 = \frac{V_2 T_1}{V_1} = \frac{15L \cdot 373K}{20.L} = \boxed{280K = 7.8C = 45°F}$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Combined Gas Law Problems

1) If I initially have a gas at a pressure of 12 atm, a volume of 23 liters, and a temperature of 200. K, and then I raise the pressure to 14 atm and increase the temperature to 300. K, what is the new volume of the gas?

$$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{12\,\text{atm} \cdot 23\,\text{L} \cdot 300.\text{K}}{200.\text{K} \cdot 14\,\text{atm}} = \boxed{30.\text{L}}$$

2) A gas takes up a volume of 17 liters, has a pressure of 2.3 atm, and a temperature of 299 K. If I raise the temperature to 350 K and lower the pressure to 1.5 atm, what is the new volume of the gas?

$$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{2.3\,\text{atm} \cdot 17\,\text{L} \cdot 350\,\text{K}}{299\,\text{K} \cdot 1.5\,\text{atm}} = \boxed{31\,\text{L}}$$

3) A gas that has a volume of 28 liters, a temperature of 45 ^{0}C, and an unknown pressure has its volume increased to 34 liters and its temperature decreased to 35 ^{0}C. If I measure the pressure after the change to be 2.0 atm, what was the original pressure of the gas?

$$P_1 = \frac{P_2V_2T_1}{T_2V_1} = \frac{2.0\,\text{atm} \cdot 34\,\text{L} \cdot 318\,\text{K}}{308\,\text{K} \cdot 28\,\text{L}} = \boxed{2.5\,\text{atm}}$$

4) A gas has a temperature of 14 ^{0}C, and a volume of 4.5 liters. If the temperature is raised to 29 ^{0}C and the pressure is not changed, what is the new volume of the gas?

$V_2 = \frac{P_1V_1T_2}{T_1P_2} =$ pressure is the same so... $= V_2 = \frac{V_1T_2}{T_1} = \frac{4.5\,\text{L} \cdot 302\,\text{K}}{287\,\text{K}} = \boxed{4.7\,\text{L}}$

5) If I have 17 liters of gas at a temperature of 67 ^{0}C and a pressure of 88.89 atm, what will be the pressure of the gas if I raise the temperature to 94 ^{0}C and decrease the volume to 12 liters?

$$P_2 = \frac{P_1V_1T_2}{T_1V_2} = \frac{88.89\,\text{atm} \cdot 17\,\text{L} \cdot 367\,\text{K}}{340.\text{K} \cdot 12\,\text{L}} = \boxed{140\,\text{atm}}$$

$PV = nRT$ * Use Kelvin * $R = 0.0821 \frac{L \cdot atm}{mol \cdot K}$

Ideal Gas Law Problems

1) If I have 4.00 moles of a gas at a pressure of 5.60 atm and a volume of 12.0 liters, what is the temperature?

$$T = \frac{PV}{nR} = \frac{5.60\,atm \cdot 12.0\,L}{4.00\,mol \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K}} = \boxed{205\,K}$$

2) If I have an unknown quantity of gas at a pressure of 1.2 atm, a volume of 31 liters, and a temperature of 87 ^{0}C, how many moles of gas do I have?

$$n = \frac{PV}{RT} = \frac{1.2\,atm \cdot 31\,L}{360.\,K \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K}} = \boxed{1.3\,mol}$$

3) If I contain 3.0 moles of gas in a container with a volume of 60.0 liters and at a temperature of 395 K, what is the pressure inside the container?

$$P = \frac{nRT}{V} = \frac{3.0\,mol \cdot 395\,K \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K}}{60.0\,L} = \boxed{1.6\,atm}$$

4) If I have 7.7 moles of gas at a pressure of 0.090 atm and at a temperature of 56 ^{0}C, what is the volume of the container that the gas is in?

$$V = \frac{nRT}{P} = \frac{7.7\,mol \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K} \cdot 329\,K}{0.090\,atm} = \boxed{2300\,L}$$

5) If I have 17 moles of gas at a temperature of 67 ^{0}C, and a volume of 88.89 liters, what is the pressure of the gas?

$$P = \frac{nRT}{V} = \frac{17\,mol \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K} \cdot 340\,K}{88.89\,L} = \boxed{5.3\,atm}$$

6) If I have an unknown quantity of gas at a pressure of 0.5 atm, a volume of 25 liters, and a temperature of 305 K, how many moles of gas do I have?

$$n = \frac{PV}{RT} = \frac{0.5\,atm \cdot 25\,L}{0.0821 \frac{L \cdot atm}{mol \cdot K} \cdot 305\,K} = \boxed{0.5\,mol}$$

Dalton's Law of Partial Pressures #1

1) A metal tank contains three gases: oxygen, helium, and nitrogen. If the partial pressures of the three gases in the tank are 35 atm of O_2, 5 atm of N_2, and 25 atm of He, what is the total pressure inside of the tank?

35 atm O_2
5 atm N_2
25 atm He

$\boxed{\text{65 atm total}}$

2) Blast furnaces give off many unpleasant and unhealthy gases. If the total air pressure is 0.99 atm, the partial pressure of carbon dioxide is 0.05 atm, and the partial pressure of hydrogen sulfide is 0.02 atm, what is the partial pressure of the remaining air?

0.99 atm
− 0.05 atm CO_2
− 0.02 atm H_2S

$\boxed{\text{0.92 atm}}$

3) 790 torr of gas is collected over water at 25 degrees Celsius. (Vapor pressure of water is 23.12 torr at 25 degrees Celsius). What is the partial pressure of the gas collected?

790 torr
− 23.12 torr H_2O

$\boxed{\text{767 torr dry gas}}$

4) A sample of O_2 is collected over H_2O at 25°C and 760.0 mm Hg pressure. What is the pressure of the dry gas alone? (Vapor pressure of water at 25°C = 23.8 mm Hg)

760.0 mm Hg
− 23.8 mm Hg H_2O

$\boxed{\text{736 mm Hg } O_2}$

Dalton's Law #2

1. If I place 3.00 moles of N_2 and 4.00 moles of O_2 in a 35 L container at a temperature of 25°C, what will the pressure of the resulting mixture of gases be? 298K

$PV = nRT$

N_2: $P = \frac{nRT}{V} = \frac{3.00 \text{ mol } N_2 \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K} \cdot 298K}{35L} = 2.1 \text{ atm}$

O_2 $P = \frac{nRT}{V} = \frac{4.00 \text{ mol } O_2 \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K} \cdot 298K}{35L} = 2.8 \text{ atm}$

2.1 atm
+ 2.8 atm

$\boxed{4.9 \text{ atm}}$

2. If 4.0 g of O_2 and 4.0 g of He 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?

$4.0 g O_2 \left| \frac{1 \text{ mol } O_2}{32.00 g O_2} \right. = 0.13 \text{ mol } O_2$ $P = \frac{0.13 \text{ mol } O_2 \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K} \cdot 338K}{5.0L} = \boxed{0.72 \text{ atm} : O_2}$

$4.0 g He \left| \frac{1 \text{ mol } He}{4.00 g He} \right. = 1.0 \text{ mol } He$ $P = \frac{1.0 \text{ mol } He \cdot 0.0821 \frac{L \cdot atm}{mol \cdot K} \cdot 338K}{5.0L} = \boxed{5.5 \text{ atm} : He}$

$0.72 \text{ atm} + 5.5 \text{ atm} = \boxed{6.2 \text{ atm total}}$

3. A tank contains a mixture of 3.00 mol N_2, 2.00 mol O_2, and 1.00 mol CO_2 at 25 °C and a total pressure of 10.0 atm. Calculate the partial pressure of each gas in the mixture.

total mol gas = 6.00 mol

N_2: 3.00 mol / 6.00 mol · 10.0 atm = 5.00 atm

O_2: 2.00 mol / 6.00 mol · 10.0 atm = 3.33 atm

CO_2: 1.00 mol / 6.00 mol · 10.0 atm = 1.67 atm

10.00 atm total

@ STP $\frac{22.4L}{1\,mol}$ of gas

Gas Stoichiometry #1

1) How many liters of water can be made from 55 grams of oxygen gas and an excess of hydrogen at STP?

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

$$\frac{55g\,O_2}{} \left| \frac{1\,mol\,O_2}{32.00g\,O_2} \right| \frac{2\,mol\,H_2O}{1\,mol\,O_2} \left| \frac{22.4L\,H_2O}{1\,mol\,H_2O} \right. = \boxed{77\,L\,H_2O}$$

2) How many liters of water can be made from 55 grams of oxygen gas and an excess of hydrogen at a pressure of 12.4 atm and a temperature of 85^0 C? (Use reaction from #1)

358K

$$\frac{55g\,O_2}{} \left| \frac{1\,mol\,O_2}{32.00g\,O_2} \right| \frac{2\,mol\,H_2O}{1\,mol\,O_2} = 3.4\,mol\,H_2O$$

$$PV = nRT \qquad V = \frac{nRT}{P} = \frac{3.4\,mol\,H_2O \cdot 0.0821\frac{L\cdot atm}{mol\cdot K} \cdot 358K}{12.4\,atm} = \boxed{8.1\,L\,H_2O}$$

3) How many liters of water can be made from 34 grams of oxygen gas and 6.0 grams of hydrogen gas at STP? What is the limiting reactant for this reaction? (Use reaction from #1) LR problem

$$\frac{34g\,O_2}{} \left| \frac{1\,mol\,O_2}{32.00g\,O_2} \right| \frac{2\,mol\,H_2O}{1\,mol\,O_2} \left| \frac{22.4L\,H_2O}{1\,mol\,H_2O} \right. = \boxed{48L\,H_2O}$$

O_2 is the LR

$$\frac{6.0g\,H_2}{} \left| \frac{1\,mol\,H_2}{2.02g\,H_2} \right| \frac{2\,mol\,H_2O}{2\,mol\,H_2} \left| \frac{22.4\,L\,H_2O}{1\,mol\,H_2O} \right. = 67L\,H_2O$$

4) Ethylene burns in oxygen to form carbon dioxide and water vapor:

$$C_2H_{4(g)} + 3\,O_{2(g)} \rightarrow 2\,CO_{2(g)} + 2\,H_2O_{(g)}$$

How many liters of water can be formed if 1.25 liters of ethylene are consumed in this reaction? Assume that the reaction is being performed at a pressure of 1.0 atm and a temperature of 298 K.

$$n = \frac{PV}{RT} = \frac{1.0atm \cdot 1.25L\,C_2H_4}{0.0821\frac{L\cdot atm}{mol\cdot K} \cdot 298K} = 0.051\,mol\,C_2H_4$$

$$\frac{0.051\,mol\,C_2H_4}{} \left| \frac{2\,mol\,H_2O}{1\,mol\,C_2H_4} \right. = 0.10\,mol\,H_2O$$

$$V = \frac{nRT}{P} = \frac{0.10\,mol\,H_2O \cdot 0.0821\frac{L\cdot atm}{mol\cdot K} \cdot 298K}{1.0\,atm} = \boxed{2.4L\,H_2O}$$

Gas Stoichiometry #2

1. Calculate the volume of oxygen gas produced at 1.00 atm and 25°C by the complete decomposition of 10.5 g of potassium chlorate. $2KClO_3\,(s) \rightarrow 2KCl(s) + 3O_2\,(g)$

298K

$$\frac{10.5\text{ g } KClO_3}{} \left| \frac{1\text{ mol } KClO_3}{\cancel{74.55}\ 122.55\text{ g } KClO_3} \right| \frac{3\text{ mol } O_2}{2\text{ mol } KClO_3} = 0.129\text{ mol } O_2$$

$$V = \frac{nRT}{P} = \frac{0.129\text{ mol } O_2 \cdot 0.0821\frac{L\cdot atm}{mol\cdot K} \cdot 298K}{1.00\text{ atm}} = \boxed{3.16\text{ L } O_2}$$

2. Calculate the volume of hydrogen produced at 1.50 atm and 19°C by the reaction of 26.5 g of zinc with excess hydrochloric acid. $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2\,(aq) + H_2\,(g)$

$$\frac{26.5\text{ g } Zn}{} \left| \frac{1\text{ mol } Zn}{65.39\text{ g } Zn} \right| \frac{1\text{ mol } H_2}{1\text{ mol } Zn} = 0.405\text{ mol } H_2$$

$$V = \frac{nRT}{P} = \frac{0.405\text{ mol } H_2 \cdot 0.0821\frac{L\cdot atm}{mol\cdot K} \cdot 292K}{1.50\text{ atm}} = \boxed{6.47\text{ L } H_2}$$

3. Water is decomposed to produce hydrogen gas and oxygen gas. What would be the pressure, in atmospheres, of a 4.5 g sample of hydrogen gas with a volume of 1.2 L and a temperature of 22°C?

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

$$\frac{4.5\text{ g } H_2}{} \left| \frac{1\text{ mol } H_2}{2.02\text{ g } H_2} \right. = 2.2\text{ mol } H_2$$

$$P = \frac{nRT}{V} = \frac{2.2\text{ mol } H_2 \cdot 0.0821\frac{L\cdot atm}{mol\,K} \cdot 295K}{1.2L} = \boxed{44\text{ atm}}$$

4. Quicklime, CaO, is produced by heating calcium carbonate, $CaCO_3$. Calculate the volume of CO_2 produced at STP from the decomposition of 152 g of CaCO3 according to the reaction,

$CaCO_3\,(s) \rightarrow CaO(s) + CO_2\,(g)$

$$\frac{152\text{ g } CaCO_3}{} \left| \frac{1\text{ mol } CaCO_3}{100.09\text{ g } CaCO_3} \right| \frac{1\text{ mol } CO_2}{1\text{ mol } CaCO_3} \left| \frac{22.4\text{ L } CO_2}{1\text{ mol } CO_2} \right. = \boxed{34.0\text{ L } CO_2}$$

5. Using the equation in the previous problem, what volume of carbon dioxide gas is produced at 25°C and a pressure of 1.02 atm when 10.0 g of calcium carbonate is decomposed? 298K

$$\frac{10.0\,g\,CaCO_3}{} \left| \frac{1\,mol\,CaCO_3}{100.09\,g\,CaCO_3} \right| \frac{1\,mol\,CO_2}{1\,mol\,CaCO_3} = 0.0999\,mol\,CO_2$$

$$V = \frac{nRT}{P} = \frac{0.0999\,mol\,CO_2 \cdot 0.0821\frac{L\cdot atm}{mol\cdot K} \cdot 298K}{1.02\,atm} = \boxed{2.40\,L\,CO_2}$$

6. What volume of oxygen gas, measured at 31°C (304K) and 745 mmHg is needed to burn 5.00 g of benzene, C_6H_6?

$$2\,C_6H_6(l) + 15\,O_2(g) \rightarrow 12\,CO_2(g) + 6\,H_2O(g)$$

$$\frac{745\,mmHg}{} \left| \frac{1.00\,atm}{760\,mmHg} \right. = 0.980\,atm$$

$$\frac{5.00\,g\,C_6H_6}{} \left| \frac{1\,mol\,C_6H_6}{78.18\,g\,C_6H_6} \right| \frac{15\,mol\,O_2}{2\,mol\,C_6H_6} = 0.480\,mol\,O_2$$

$$V = \frac{nRT}{P} = \frac{0.480\,mol\,O_2 \cdot 0.0821\frac{L\cdot atm}{mol\cdot K} \cdot 304K}{0.980\,atm} = \boxed{12.2\,L\,O_2}$$

7. When 24.0 g of ethanol, C_2H_5OH, is burned with 9.00 g of oxygen, what volume of carbon dioxide gas, measured at 35°C (308K) and 0.95 atm, would be produced?

$$C_2H_5OH(l) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 3\,H_2O(g)$$

$$\frac{24.0\,g\,C_2H_5OH}{} \left| \frac{1\,mol\,C_2H_5OH}{46.08\,g\,C_2H_5OH} \right| \frac{2\,mol\,CO_2}{1\,mol\,C_2H_5OH} = 1.04\,mol\,CO_2$$

$$\frac{9.00\,g\,O_2}{} \left| \frac{1\,mol\,O_2}{32.00\,g\,O_2} \right| \frac{2\,mol\,CO_2}{3\,mol\,O_2} = 0.188\,mol\,CO_2 \text{ LR}$$

$$V = \frac{nRT}{P} = \frac{0.188\,mol\,CO_2 \cdot 0.0821\frac{L\cdot atm}{mol\cdot K} \cdot 308K}{0.95\,atm} = \boxed{5.0\,L\,CO_2}$$