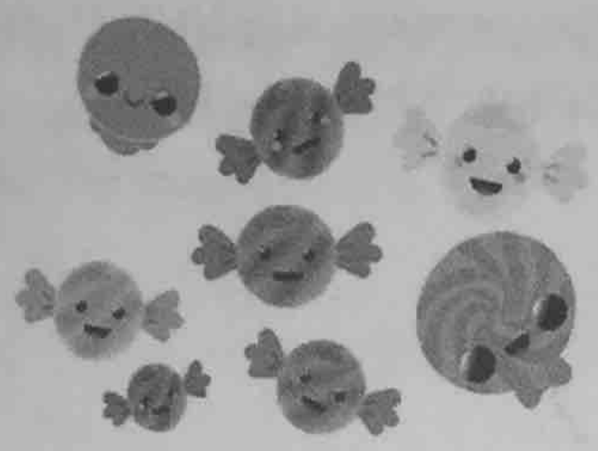
Name Key Date 2019 Period 45 points



Super Chemists' Unit 7 Sweet Sheet: Gases and Gas Laws

Part 1: Vocabulary- You MUST know the definitions/formulas to all of these words.

Pressure, newton, pascal, STP, Kinetic-molecular theory, Boyle's Law (and formula), Charles's Law (and formula), Gay-Lussac's Law (and formula), Avogadro's Law, Idea Gas Law, diffusion, effusion, Graham's Law of Diffusion (and formula), Gay-Lussac's Law of Combining Volumes, Partial pressure, Dalton's Law of Partial Pressure

What is Absolute Zero and what happens at Absolute Zero?

Temperature at which particles stop moving.
0K or -273°C

Part 2: Practice Problems

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

$PV=nRT$ $V=98\,L$ $P=2.8\,atm$ $T=292\,K$ $R=.08206\ \frac{L\cdot atm}{mol\cdot K}$

$(2.8\,atm)(98\,L)=n\left(.08206\ \frac{L\cdot atm}{mol\cdot K}\right)(292\,K)$

$n = 11.5$ 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°C, what will the pressure of the resulting mixture of gases be?

5.0 moles O_2

$PV=nRT$

$P(30.0\,L)=(5.0)\left(8.314\ \frac{L\cdot kPa}{mol\cdot K}\right)(298\,K)$

$\frac{12387.9}{30.0}$

$P_{O_2} = 412.9$ kPa

3.0 moles N_2

$P(30.0\,L)=(3.0)(8.314)(298)$

$P_{N_2} = 247.8$ kPa

$P_{TOTAL} = P_{O_2} + P_{N_2} = 412.9 + 247.8 = 660.7$ kPa

3. A balloon is filled with 35.0 L of Helium in the morning when the temperature is 20.0° C. By noon the temperature has risen to 45.0° C. The pressure is held constant. What is the new volume of the balloon?

$V_2 = ?$

$V_1 = 35.0\,L$ $\quad T_2 = 318\,K$

$T_1 = 293\,K$

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

$\frac{35.0\,L}{293} = \frac{V_2}{318}$

$V_2 = 38\,L$

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

$PV = nRT$ $\quad (190)(35) = n(.08206)(315)$

$V = 35\,L$

$T = 315\,K$

$P = 190\,atm$

$n = ?$

$R = .08206\ \frac{L \cdot atm}{mol\,K}$

$n = 257\,mol\,O_2$

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 °C of the balloon?

$PV = nRT$

$P = 1.0\,atm$

$V = 85\,L$

$n = 3.5\,mol$

$R = .08206\ \frac{L \cdot atm}{mol \cdot K}$

$T = ?$

$(1.0\,atm)(85\,L) = (3.5)(.08206)T$

$T = 296\,K$

$T = 296 - 273 = 23^{\circ}C$

6. Calcium carbonate decomposes at 1200 °C to form Carbon dioxide and Calcium oxide. If 25L of carbon dioxide are measured at 1200° C, what will the volume of this gas be after it cools to 25°C? Pressure is held constant.

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\quad V_1 = 25\,L$ $\quad V_2 =$

$T_1 = 1473\,K$ $\quad T_2 = 298\,K$

$\frac{25\,L}{1473\,K} = \frac{V_2}{298\,K}$

$V_2 = 5.1\,L$

7. A helium balloon with an internal pressure of 1.00 atm and a volume of 4.50 L at 20.0°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°C?

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $P_1 = 1.00\,atm$ $V_1 = 4.50\,L$ $T_1 = 293\,K$ $P_2 = .600\,atm$ $V_2 = ?$ $T_2 = 253\,K$

$\frac{(1.0)(4.50)}{293} = \frac{(.6)(V_2)}{253}$

$V_2 = 6.5\,L$

8. There are 135 L of gas in a container at a temperature of 260°C. If the gas was cooled until the volume decreased to 55 L, what would the temperature of the gas be? Pressure is held constant.

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $V_1 = 135\,L$ $T_1 = 533\,K$ $V_2 = 55\,L$ $T_2 = ?$

$\frac{135}{533} = \frac{55}{T_2}$

$T_2 = 217\,K$ or $-56°C$

9. Under the same conditions of temperature and pressure, how many times faster will hydrogen effuse compared to carbon dioxide?

$\frac{V_{H_2}}{V_{CO_2}} = \sqrt{\frac{M_{CO_2}}{M_{H_2}}} = \sqrt{\frac{44\,g/mol}{2\,g/mol}} = \sqrt{22} \approx 4.69$

about 4.7 times faster

10. What is the relative rate of diffusion of NH_3 compared to He? Does NH_3 effuse faster or slower than He? Why? NH_3 is slower because it is heavier.

$\frac{V_{NH_3}}{V_{He}} = \sqrt{\frac{4\,g/mol}{17\,g/mol}} =$ .485 times as fast

11. Acetylene gas, C_2H_2, undergoes combustion to produce carbon dioxide and water vapor. Assume reactions occur at STP.

a. Write the correct and balanced chemical equation.

$$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$$

b. If 25 grams of C_2H_2 are burned in 52 grams of O_2, which is the limiting reactant?

$$\frac{25\text{ g } C_2H_2}{} \left| \frac{1\text{ mol } C_2H_2}{26\text{ g } C_2H_2} \right| \frac{5\text{ mol } O_2}{2\text{ mol } C_2H_2} \left| \frac{32\text{ g } O_2}{1\text{ mol } O_2} \right| = \boxed{76.9\text{ g } O_2}$$

O_2 is the L.R.

c. How many liters of carbon dioxide can be produced?

$$\frac{52\text{ g } O_2}{} \left| \frac{1\text{ mol } O_2}{32\text{ g } O_2} \right| \frac{4\text{ mol } CO_2}{5\text{ mol } O_2} \left| \frac{22.4\text{ L } CO_2}{1\text{ mol } CO_2} \right| = \boxed{29.1\text{ L of } CO_2}$$

c. How many grams of water can be produced?

$$\frac{52\text{ g } O_2}{} \left| \frac{1\text{ mol } O_2}{32\text{ g } O_2} \right| \frac{2\text{ mol } H_2O}{5\text{ mol } O_2} \left| \frac{18\text{ g } H_2O}{1\text{ mol } H_2O} \right| = \boxed{11.7\text{ g } H_2O}$$

d. If the situation of the reaction changes and instead of being at STP, the temperature is 16°C and the pressure is 104.5 kPa, what volume of oxygen gas is required to burn all of the ~~acetylene~~ oxygen gas (~~25~~ 52 grams)?

$P = 104.5$ kPa

$V = ?$

$n = 1.625$ mol O_2

$R = 8.314 \frac{L \cdot kPa}{mol \cdot K}$

$T = 16 + 273 = 289$ K

$$\frac{52\text{ g } O_2}{} \left| \frac{1\text{ mol } O_2}{32\text{ g } O_2} \right. = 1.625\text{ mol } O_2$$

$(104.5)V = (1.625)(8.314)(289)$

$\boxed{V = 37.4\text{ L of } O_2}$

12. Ethylene, C_2H_4, burns in oxygen to form carbon dioxide and water vapor. Assume STP.

a. Write the correct and balanced chemical equation.

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

b. How many liters of water can be formed if 1.25 liters of ethylene are consumed in this reaction?

$$\frac{1.25\text{ L of } C_2H_4}{} \left| \frac{1\text{ mol } C_2H_4}{22.4\text{ L } C_2H_4} \right| \frac{2\text{ mol } H_2O}{1\text{ mol } C_2H_4} \left| \frac{22.4\text{ L } H_2O}{1\text{ mol } H_2O} \right. = \boxed{2.5\text{ L of } H_2O}$$

c. Using the liters of water formed in part b, how many grams of ~~oxygen~~ water will be formed at 3 atm and 345 K?

$V = 2.5\text{ L}$

$P = 3\text{ atm}$

$T = 345\text{ K}$

$R = .08206\ \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}$

$PV = nRT$

$(3\text{ atm})(2.5\text{ L}) = n(.08206)(345)$

$n = .265\text{ mol } H_2O$

$$.265\text{ mol } H_2O \left| \frac{18\text{ g } H_2O}{1\text{ mol } H_2O} \right. = \boxed{4.8\text{ g } H_2O}$$

13. Use the following gases to answer the following questions.

A. He B. Ne C. Ar D. Kr E. all the same

a. With all gases at the same temperature, the one with the largest kinetic energy. E

b. With all gases at the same temperature, the one with the highest average velocity. A

c. With all gases at the same temperature, the one with the lowest average velocity. D

14. What is the density of argon in a 4.5 L bulb at 0.5 atm and 273 K?

$PV=nRT$

$(.5)(4.5)=n(.08206)(273)$ $n=.100$

$.100\,mol \mid \frac{40\,g\,Ar}{1\,mol} = \frac{4\,g\,Ar}{4.5\,L} = .89\,g/L$

15. The gas with the largest volume at STP is:

a. 14.5 g of Ar $\frac{14.5}{40}=.3265$

B. 14.5 g of He $\frac{14.5}{4}=3.625$ Most moles of gas!

C. 14.5 g of Ne $\frac{14.5}{20}=.725$

D. 14.5 g of Kr $\frac{14.5}{84}=.173$

16. The kinetic molecular theory of ideal gases assumes that: (Circle the one that is true.)

a. the collisions of gas molecules are inelastic

b. all gas molecules travel at the same speed

c. gas molecules exert no pressure on the walls

d. the volume of a gas molecule is negligible

17. If a sample of an ideal gas has its pressure doubled what will its volume will be?

a. 3/2 of its original value

b. ½ of its original value

c. 2/3 of its original value

d. 6 times the original value

$P_1V_1 = P_2V_2$

$\frac{1\cdot 1}{2} = \frac{2\cdot V_2}{2}$

$\frac{1}{2} = V_2$

18. Gas A has a volume of 2L at 250 K and 3 atm. Gas B has a volume of 2L at 500K and 6 atm. The ratio of molecules of A to the number of molecules B is:

a. 1:1 b. 2:1 c. 1:2 d. 1:4

Same volume so

19. Which gas diffuses the most rapidly? And why.

a. Ne $20\,g/mol$

b. O_2 $32\,g/mol$

c. NH_3 $17\,g/mol$ lightest

d. SO_2 $64\,g/mol$

20. Gas A has a diffusion rate of 0.0862 cm/s. Under the same experimental conditions CO_2 has a diffusion rate of 0.1509 cm/s. What is the molecular weight of the unknown gas?

$$\frac{V_{CO_2}}{V_A} = \sqrt{\frac{M_A}{M_{CO_2}}} = \frac{.1509}{.0862} = \sqrt{\frac{M_A}{44\,g/mol}} = M_A = \boxed{134.8\,g/mol \sim 135\,g/mol}$$

Partial Pressure

21. If the pressure of gas A is 3.2 atm, the pressure of gas B is 4.7 atm and the total pressure of gas A, B and C is 12.9 atm, what is the pressure of gas C?

$P_A + P_B + P_C = P_{TOTAL}$

$3.2 + 4.7 + P_C = 12.9$

$\boxed{P_C = 5\,atm}$

22. If the pressure of gas A is 3 atm and the pressure of gas B is 5 atm, what is the total pressure?

$P_A + P_B = P_{TOTAL}$

$3 + 5 = \boxed{8\,atm}$

23. A 320 cm^3 sample of a mixture of oxygen gas saturated with water vapor at 22°C exerts a total pressure of 748 torr. At 22°C the vapor pressure of water is 20 torr. Calculate the number of grams of oxygen in the sample.

$P_{TOTAL} = P_{H_2O} + P_{gas}$

$748 = 20 + P_{gas}$

$P_{gas} = 728\,torr$

$\frac{320\,cm^3}{} \left| \frac{1\,mL}{1\,cm^3} \right| \frac{1\,L}{1000\,mL} = .32\,L$

$728\,torr \left| \frac{1\,atm}{760\,torr} \right. = .958\,atm$

$T = 273 + 22 = 295K$

$PV = nRT$

$(.958\,atm)(.32L) = n(.08206)(295)$

$n = .0127\,mol\,O_2$

$.0127\,mol\,O_2 \left| \frac{32\,g\,O_2}{1\,mol\,O_2} \right. = \boxed{.409\,g\,O_2}$

Part 3: Trends with Gas Laws

Write Boyle's Law: $P_1V_1 = P_2V_2$

If the pressure is increased, what happens to the volume? decreases

If the volume is decreased, what happens to the pressure? increases

If the pressure is decreased, what happens to the volume? increases

If the volume is increased, what happens to the pressure? decreases

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

If the temperature is increased, what happens to the volume? increases

If the temperature is decreased, what happens to the volume? decreases

If the volume is decreased, what happens to the temperature? decreases

If the volume is increased, what happens to the temperature? increases

Write Gay-Lussac's Law: $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

If the temperature increases, what happens to the pressure? increases

If the temperature decreases, what happens to the pressure? decreases

If the pressure is increased, what happens to the temperature? increases

If the pressure is decreased, what happens to the temperature? decreases