11/30/11

Practice Test Chapter 10
Gas Laws

Part I: *Circle the letter of the best annswer(s). No calculators are allowed on this portion of the practice test!*

Target 1: I can describe the general characteristics of gases as compared to the other states of matter, and list the ways in which gases are distinct.

A 1. Circle all of the true statements below.
- a. Gases are more easily compressed than either liquids or solids.
- b. There is more attractive forces between gaseous particles than liquid particles.
- c. Gases tend to be more dense than solids.
- d. Gases have less space between particles than liquids.
- e. The properties of liquids are more affected by pressure than gases.

Target 2: I can define atmosphere, torr, mmHg and pascal, the most common units in which pressure is expressed. I can also describe how a barometer and a manometer work.

B 2. Which of the following is/are TRUE statements?
- a. 1 atm = 1 torr
- b. 1 torr = 1 mmHg
- c. 1 mmHg = 1 mmH_2O
- d. The higher the atmospheric pressure, the lower the column of Hg in a barometer.
- e. Manometers measure gas pressure only whereas barometers measure gas pressure and temperature.

Target 3: I can describe how a gas responds to changes in pressure, volume, temperature, and quantity of gas.

D 3. Consider a sample of gas confined at constant temperature and volume in the closed system. If more of this same gas is added at constant temperature, what effect is observed on pressure and average molecular velocity?
- a. Both pressure and average molecular velocity increase.
- b. Pressure decreases and average molecular velocity remains the same.
- c. Pressure remains the same and average molecular velocity increases.
- d. Pressure increases and average molecular velocity remains the same.
- e. Pressure remains the same and average molecular velocity decreases.

C 4. Which describes a change that occurs when a sample of nitrogen is sealed in a metal tank then heated from 250 K to 300 K?
a. The density of the sample decreases.
b. The volume of the sample increases.
c. The pressure of the sample increases.
d. The mean distance between molecules increases.
e. The number of molecules in the container increases.

B 5. When a sample of oxygen gas in a closed container of constant volume is heated until its absolute temperature is doubled, which of the following is also doubled?
a. The density of the gas.
b. The pressure of the gas.
c. The average velocity of the gas molecules.
d. The number of molecules per cm^3.
e. The potential energy of the molecules.

Target 4: I can use the gas laws, including the combined gas law, to calculate how one variable of a gas (P, V, n, or T) responds to changes in the one or more of the other variables.

E 6. A sample of ideal gas was heated at constant volume from 25°C to a temperature sufficient to exactly double the pressure. What was the volume of the gas sample?
a. 22.4 liters
b. 20.5 liters
c. 24.4 liters
d. 44.8 liters
e. cannot be determined

$P_1V_1 = P_2V_2$

A 7. A gas occupies a 1.5 liter container at 25°C and 2.0 atm. If the gas is transferred to a 3.0 liter container at the same temperature, what will be the new pressure?
a. 1.0 atm
b. 2.0 atm
c. 3.0 atm
d. 4.0 atm
e. 5.0 atm

$P_1V_1 = P_2V_2$

$(2.0atm)(1.5L) = (P_2)(3.0L)$

B 8. Of the following, ______ is a valid statement of Charles' law.
a. P/T = constant
b. V/T = constant
c. PV = constant
d. V = constant • n
e. V = constant • P

$V \propto T$ ↳ "Prince"

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

Target 5: I can use the ideal-gas equation to solve for one variable (P, V, n, or T) given the other three variables or information from which they can be determined.

A 9. A sample of pure gas at 27°C and 380 mm Hg occupied a volume of 492 mL. What is the number of moles of gas in this sample?

a. 0.010 moles
b. 7.6 moles
c. 10 moles
d. 6×10^{21} moles
e. none of these values

$PV = nRT$

$\left(\frac{380 mm}{760 mm}\right)(.492 L) = n\left(.0821 \frac{L\,atm}{mol\,K}\right)(300\,K)$

Target 6: I can calculate the molar mass of a gas, given gas density under specified conditions of temperature and pressure. I can also calculate gas density under stated conditions, knowing molar mass.

B 10. A 22.4 liter sample of gas at STP weighs 16.0 grams. What is the molecular weight of the gas?

a. 22.4 g/mol
b. 16.0 g/mol
c. 29.4 g/mol
d. 12.0 g/mol
e. 32.0 g/mol

MM = g/mol

Since all standard conditions answer is 16.0 g/mol

or $MM = \frac{dRT}{P}$

B 11. Which of the following would express the approximate density of carbon dioxide gas at 0°C and 2.00 atm pressure (in grams per liter)?

a. 2 g/L
b. 4 g/L
c. 6 g/L
d. 8 g/L
e. None of the above

Not correct S.F.

$d = \frac{P\,MM}{RT} = \frac{(2.00\,atm)(44\,g/mol)}{(.0821)(273\,K)}$

C 12. When 2.00 grams of a certain volatile liquid is heated, the volume of the resulting vapor is 821 mL at a temperature of 127°C at standard pressure. The molecular weight of this substance is ________ .

a. 20.0 g/mole
b. 40.0 g/mole
c. 80.0 g/mole
d. 120.0 g/mole
e. 160.0 g/mole

$MM = \frac{dRT}{P} = \frac{\left(\frac{2.00\,g}{.821\,L}\right)(.0821)\,400\,K}{1.00\,atm}$

13. Of the following, _______ correctly relates pressure, volume, temperature, molar mass (M), density (d), and mass (g).

a) $M = \frac{dRT}{PV}$

b) $M = \frac{gRT}{PV}$

c) $M = \frac{PT}{gRV}$

d) $M = \frac{gV}{RT}$

e) $M = \frac{RT}{gV}$

14. Which **one** of the following statements about the density of a gas is correct?

a. It is independent of temperature.
b. It decreases with increasing temperature at constant pressure.
c. It is independent of pressure.
d. It decreases with increasing pressure at constant temperature.
e. It doubles when the volume of a container doubles without a change in pressure or temperature.

15. The density of an unknown gas is found to be 1.65 $g \cdot L^{-1}$. Under the same conditions, the density of oxygen gas is found to be 1.10 $g \cdot L^{-1}$. The molecular mass of the unknown gas is closest to:

a. 14 b. 24 c. 28 d. 32 e. 48

Target 7: I can solve gas stoichiometry problems at standard conditions and at non-standard conditions.

16. The combustion of carbon monoxide yields carbon dioxide. The volume of oxygen gas needed to produce 22 grams of carbon dioxide at STP is:

a. 4.0 liters b. 5.6 liters c. 11 liters d. 22 liters e. 32 liters

17. A 27.0 g sample of an unknown hydrocarbon is burned in excess oxygen to form 88.0 grams of carbon dioxide and 27.0 grams of water. What is a possible molecular formula of the hydrocarbon?
   a. CH_4
   b. C_2H_2
   c. C_4H_3
   d. C_4H_6
   e. C_4H_{10}

18. A sample of 9.00 g of aluminum metal is added to an excess of HCl. The volume of hydrogen gas produced at standard temperature and pressure is:
   a. 22.4 liters
   b. 11.2 liters
   c. 7.46 liters
   d. 5.60 liters
   e. 3.74 liters

19. $$3\ Ag(s) + 4\ HNO_3 \rightarrow 3\ AgNO_3 + NO(g) + 2\ H_2O$$
   The reaction of silver metal and dilute nitric acid proceeds according to the equation above. If 0.10 moles of powdered silver is added to 10.0 mL of 6.0 molar nitric acid, the number of moles of NO gas that can be formed is:
   a. 0.015 mole
   b. 0.020 mole
   c. 0.030 mole
   d. 0.045 mole
   e. 0.090 mole

Target 8: I can calculate the partial pressure of any gas in a mixture, given the composition of that mixture. (Dalton's Law of Partial Pressures)

20. What is the partial pressure of helium when 8.0 grams of helium and 16 grams of oxygen are in a container with a total pressure of 5.00 atm?
   a. 0.25 atm b. 1.00 atm c. 1.50 atm d. 2.00 atm e. 4.00 atm

Target 9: I can calculate the mole fraction of a gas in a mixture, given its partial pressure and the total pressure of the system.

21. One mole of nitrogen, two moles of neon and four moles of argon are sealed in a cylinder. The combined pressure of the gases is 1400 mm Hg. What is the partial pressure of nitrogen in the cylinder?
   a. 100 mm Hg
   b. 200 mm Hg
   c. 400 mm Hg
   d. 500 mm Hg
   e. 1400 mm Hg

Target 10: I can explain the technique of collecting a gas "over water" and make the associated calculations.

C 22. A sample of zinc metal reacts completely with excess hydrochloric acid according to the following equation:

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

8.00 liters of hydrogen gas at 720. mm Hg is collected over water at 40.°C (vapor pressure of water at 40.°C = 55 mm Hg). How much zinc was consumed by the reaction?

a. $\frac{(720/760) \bullet 8.00}{(0.0821) \bullet 313}$

b. $\frac{(760/720) \bullet 313}{(0.0821) \bullet 2}$

(720 - 55)

c. $\frac{(665/760) \bullet 8.00 \bullet (65.39)}{0.0821 \bullet 313}$

d. $\frac{(665/760) \bullet 8.00}{(65.39) \bullet (0.0821) \bullet 313}$

e. $\frac{8.00 \bullet 313 \bullet 65.39}{(665/760) \bullet (0.0821)}$

C 23. When a gas is collected over water, the pressure is corrected by
a. adding the vapor pressure of water.
b. multiplying by the vapor pressure of water.
c. subtracting the vapor pressure of water at that temperature.
d. subtracting the temperature of the water from the vapor.

A 24. If water is the liquid in a barometer instead of mercury, you can change the height difference to an equivalent mercury expression by:
a. dividing by 13.6
b. multiplying by 13.6
c. adding 13.6
d. subtracting 13.6

Target 11: I can use the Kinetic Molecular Theory to explain the behavior of gases.

E 25. 100 grams of $O_2(g)$ (≈ 3 mol) and 100 grams of He(g) (= 25 mol) are in separate containers of equal volume. Both gases are at 100°C. Which **one** of the following statements is true?

PV = nRT

a. Both gases would have the same pressure.
b. The average kinetic energy of the O_2 molecules is greater than that of the He molecules.
c. The average kinetic energy of the He molecules is greater than that of the O_2 molecules.
d. There are equal numbers of He molecules and O_2 molecules.
e. The pressure of the He(g)would be greater than that of the O_2(g).

26. How many of the following statements are FALSE?

Statement 1: STP corresponds to 25°C and 1 atm.

Statement 2: The following relationship is a statement of Boyle's law: $P = c/V$.

Statement 3: The mean free path of O_2 in the atmosphere is expected to decrease with increasing altitude.

a. 0 b. 1 c. 2 d. 3 e. 4

27. Which **2** of the following are **TRUE**?

a. According to Avogadro's hypothesis, when one volume of nitrogen reacts with three volumes of hydrogen to form ammonia, four volumes of ammonia should form.

b. According to Graham's law, you should expect $NH_3(g)$ to effuse faster through a tiny hole than $CO_2(g)$.

c. You would expect a gas at high pressures to behave like an ideal gas.

d. The vapor pressure of ether is greater than the vapor pressure of ethanol. Therefore you should expect more vapor above ether than ethanol in a closed system.

e. When you measure the rate of NH_3 spreading throughout a long tube, you are measuring the rate of effusion of NH_3.

Target 12: I can explain the concepts of effusion and diffusion and make associated calculations using Graham's Law.

28. Graham's Law refers to:

a. boiling points of gases.
b. gaseous diffusion.
c. gas compression problems.
d. volume dependence upon temperature.

29. The diffusion time for carbon dioxide gas was 105 sec. For gas X, 126 sec was required for the same number of moles of gas to diffuse under the same conditions. What is the approximate molecular weight of the unknown gas?

a. 12 g/mol
b. 24 g/mol
c. 37 g/mol
d. 44 g/mol
e. 63 g/mol

30. If the average velocity of a methane molecule, CH_4, is 5.00×10^4 cm/sec at 0°C, what is the average velocity of helium molecules at the same temperature and pressure conditions?

a. 2.50×10^4 cm/sec
b. 5.00×10^4 cm/sec
c. 1.00×10^5 cm/sec
d. 2.00×10^5 cm/sec
e. 5.00×10^5 cm/sec

C 31. According to the kinetic molecular theory, in which of the following gases will the root-mean-square speed of the molecules be the highest at 200°C ?
a. HCl   b. Cl_2 c. H_2O d. SF_6
e. None . . . the rms speeds are the same!

$rms = \sqrt{\frac{3RT}{MM}}$

C 32. Which change increases the mean free path of molecules in a sample of gas?
a. Increase in pressure at constant temperature.
b. Increase in density at constant temperature.
c. Increase in temperature at constant pressure.
d. Increase in temperature at constant volume.
e. Increase in pressure at constant volume.

D 33. Under certain conditions, methane gas, CH_4, diffuses at a rate of 12 cm/s. Under the same conditions, an unknown gas diffuses at a rate of 8.0 cm/s. The molecular mass of the unknown gas is closest to:

a. 6   b. 20   c. 24   d. 36   e. 72

$\frac{r_1}{r_2} = \frac{12 cm/sec}{8.0 cm/sec} = \sqrt{\frac{M?}{16}}$

B 34. When a sample of ideal gas is heated from 20°C to 40°C, the average kinetic energy of the system changes. Which factor describes this change?

a. $\frac{1}{2}$
b. $\frac{313}{293}$
c. $\sqrt{\frac{313}{293}}$
d. $\frac{293}{313}$
e. 2

> Target 13: I can cite the general conditions of T and P under which real gases most closely approximate ideal-gas behavior. Also, I can explain the origin of the correction terms P and V that appear in the van der Waals equation.

A 35. For a substance that remains a gas under the conditions listed, deviation from the ideal gas law would be most pronounced at:

a. -100°C and 5.0 atm
b. -100°C and 1.0 atm
c. 0°C and 1.0 atm
d. 100°C and 1.0 atm
e. 100°C and 5.0 atm

High P + Low T

D 36. A gas is considered "ideal" if ________.

a. it is NOT compressible
b. one mole of it occupies exactly 1 liter at STP
c. it can be shown to occupy zero volume at 0^oC
d. its behavior is described by the ideal gas equation
e. one mole of it in a 1 liter container exerts a pressure of exactly 1 atm at room temperature

A 37. An ideal gas differs from a real gas in that the molecules of an ideal gas . . .

a. have no attraction for one another.
b. have appreciable molecular volumes.
c. have a molecular weight of zero.
d. have no kinetic energy.
e. has an average molecular mass.

D 38. The van der Waals equation adjusts pressure and volume to account for deviations from ideal gas law behavior. In the van der Waals equation, the term that corrects for the finite volume of real molecules is _______.

a) n b) T c) V d) -nb e) $+n^2a / V^2$

MC ave = 80%

AP Chemistry Unit VIII Test - Gas Laws
Part II * 70 points *

Name JOE PERFECT
Date 12/15/00 Period_____

Section I: Solve each of the following problems. Show a set-up for each. Label your final answers with appropriate units and **circle** and of your answers. Each question is worth 7 points.

1. A sample of gas at 15°C and 1 atm has a volume of 2.58 L. What volume (in L) will this gas occupy at 38°C and 1 atm?

$T_1 = 15°C = 288\ K$ $\quad V_1T_2 = T_1V_2$

$V_1 = 2.58\ L$

$T_2 = 38°C = 311\ K$

$V_2 = ?$

$$V_2 = \frac{V_1T_2}{T_1} = \frac{(2.58\ L)(311\ K)}{288\ K} = \boxed{2.79\ L}$$

2. Suppose you have a 12.2 L sample containing 0.50 mol of oxygen gas (O_2) at a pressure of 1 atm and a temperature of 25°C. If all of this O_2 were converted to ozone (O_3) at the same temperature and pressure, what would be the volume, in liters, of the ozone?

$$3\,O_{2\,(g)} \rightarrow 2\,O_{3\,(g)}$$

$$X \text{ mol } O_3 = \frac{0.50 \text{ mol } O_2 \,|\, 2 \text{ mol } O_3}{\,|\, 3 \text{ mol } O_2} = 0.33 \text{ mol } O_2$$

$$\frac{V_1}{n_1} = \frac{V_2}{n_2} \qquad V_2 = \frac{n_2V_1}{n_1} = \frac{(0.33\text{ mol})(12.2\ L)}{0.50\text{ mol}} = \boxed{8.1\text{ Liters}}$$

3. A sample of diborane gas (B_2H_6), a substance that bursts into flame when exposed to air, has a pressure of 345 torr at a temperature of -15°C and a volume of 3.48 L. If the conditions are changed so that the temperature is 36°C and the pressure is 468 torr, what will the volume (in L) of the sample be?

$P_1 = 345$ torr $\quad P_1V_1T_2 = P_2V_2T_1$

$V_1 = 3.48\ L$

$T_1 = -15°C = 258\ K$

$P_2 = 468$ torr

$V_2 = ?$

$T_2 = 36°C = 309\ K$

$$V_2 = \frac{P_1V_1T_2}{P_2T_1} = \frac{(345\text{ torr})(3.48\ L)(309\ K)}{(468\text{ torr})(258\ K)}$$

$$\boxed{V_2 = 3.07\text{ liters}}$$

4. A sample of methane gas, CH_4, having a volume of 2.80 L at 25°C and 1.68 atm was mixed with a sample of oxygen gas having a volume of 35.0 L at 31°C and 1.25 atm. The mixture was then ignited to form carbon dioxide and water. Calculate the volume of CO_2 formed (in L) at a pressure of 2.50 atm and a temperature of 125°C.

$$CH_4\,(g) + 2\,O_2\,(g) \rightarrow CO_2\,(g) + 2\,H_2O\,(g)$$

$$n_{CH_4} = \frac{PV}{RT} = \frac{(1.65\text{ atm})(2.80\ L)}{(0.08206 \frac{L\cdot atm}{mol\cdot K})(298\ K)} = 0.189 \text{ mol } CH_4 \text{ (limiting reagent!)}$$

$$n_{O_2} = \frac{PV}{RT} = \frac{(1.25\text{ atm})(35.0\ L)}{(0.08206 \frac{L\cdot atm}{mol\cdot K})(304\ K)} = 1.75 \text{ mol } O_2$$

$$X \text{ mol } CO_2 = \frac{0.189 \text{ mol } CH_4 \,|\, 1 \text{ mol } CO_2}{\,|\, 1 \text{ mol } CH_4} = 0.189 \text{ mol } CO_2$$

$$V = \frac{nRT}{P} = \frac{(0.189\text{ mol})(0.08206 \frac{L\cdot atm}{mol\cdot K})(398\ K)}{2.50\text{ atm}} = \boxed{2.47\text{ liters}}$$

5. The density of a gas was measured at 1.50 atm and 27°C and found to be 1.95 g/L. Calculate the molar mass of the gas.

$$MM = \frac{dRT}{P} = \frac{(1.95\ g/L)(0.08206 \frac{L\cdot atm}{mol\cdot K})(300\ K)}{1.50\text{ atm}}$$

$$\boxed{32\ g/mol}$$

or $P_1 = 1\text{ atm}$, $V_1 = 46\text{ L}$, $P_2 = ?$, $V_2 = 5\text{ L}$ $P_2 = 9.3\text{ atm}$

6. Mixtures of helium and oxygen are used in scuba diving tanks to help prevent the "bends". For a particular dive, 46.0 L O_2 at 25°C and 1.0 atm and 12.0 L of He at 25°C and 1.0 atm were pumped into a tank with a volume of 5.0 L. Calculate the partial pressure of each gas (in atm) and the total pressure (in atm) in the tank at 25°C.

$n_{O_2} = \frac{PV}{RT} = \frac{(1\text{atm})(46.0\text{L})}{(0.08206)(298\text{K})} = 1.9\text{ mol } O_2$ (2)

$n_{He} = \frac{PV}{RT} = \frac{(1\text{atm})(12.0\text{L})}{(0.08206)(298\text{K})} = 0.49\text{ mol He}$ (2)

$P_{O_2} = \frac{nRT}{V} = \frac{(1.9\text{ mol})(0.08206 \frac{\text{L·atm}}{\text{mol·K}})(298\text{ K})}{5.0\text{L}} = 9.3\text{ atm} = P_{O_2}$ (1)

$P_{He} = \frac{nRT}{V} = \frac{(0.49\text{ mol})(0.08206 \frac{\text{L·atm}}{\text{mol·K}})(298\text{ K})}{5.0\text{L}} = 2.4\text{ atm} = P_{He}$ (1)

$P_{TOTAL} = P_{O_2} + P_{He} = 9.3\text{ atm} + 2.4\text{ atm} = 11.7\text{ atm}$ (1)

7. A sample of solid potassium chlorate ($KClO_3$) was heated in a test tube and decomposed to form solid potassium chloride and oxygen gas. The oxygen was collected by the displacement of water at 22°C at a total pressure of 754 torr. The volume of gas collected was 0.650 L, and the vapor pressure of water at 22°C is 21 torr. Calculate the mass of $KClO_3$ sample, in grams, that was decomposed.

$P_{O_2} = P_{TOTAL} - P_{H_2O} = 754\text{ torr} - 21\text{ torr} = 733\text{ torr } (0.964\text{ atm})$

$n_{O_2} = \frac{P_{O_2} \cdot V}{RT} = \frac{(0.964\text{ atm})(0.650\text{ L})}{(0.08026 \frac{\text{L·atm}}{\text{mol·K}})(295\text{K})} = 2.59 \times 10^{-2}\text{ moles } O_2$

$x\text{ g } KClO_3 = \frac{2.59 \times 10^{-2}\text{ mol } O_2}{} \cdot \frac{2\text{ mol } KClO_3}{3\text{ mol } O_2} \cdot \frac{122.6\text{ g } KClO_3}{1\text{ mol } KClO_3} = 2.12\text{ g } KClO_3$

$2KClO_3 \rightarrow 2KCl + 3O_2$

Section II: Choose 2 of the following 4 questions to answer. If you work on more than two questions, put a big **"X"** through the questions that you do not want corrected. Each question is worth 10 points.

8. A student tries to determine the volume of a glass bulb. These are her results:

mass of bulb filled with dry air	91.6843 g
mass of evacuated bulb	91.4715 g
temperature of air	23°C
pressure of air inside of bulb	744 mmHg

Assume the composition of air is 78% N_2, 21% O_2, and 1.0 % Ar. What is the volume (in mL) of the bulb. (Hint: First calculate the molar mass of air!)

$MM_{Air} = (0.78)(28.0\text{g/mol}) + (0.21)(32.0\text{g/mol}) + (0.01)(39.95\text{g/mol})$
$= 28.96\text{ g/mol}$ 3 pts

$91.6843\text{ g} - 91.4715\text{ g} = 0.2128\text{ g air}$

Moles air $= \frac{\text{mass}}{MM} = \frac{0.2128\text{ g}}{28.96\text{ g/mol}} = 0.00735$ moles air

$V = \frac{nRT}{P} = \frac{(0.00735\text{ mol})(0.08206 \frac{\text{L·atm}}{\text{mol·K}})(296\text{ K})}{0.979\text{ atm}}$

$V = 182\text{ mL}$

Less collisions w/ container Less pressure

(9.) (a.) Ne would behave more ideally Low MM & size less attractive Forces.

(b.) they increase to compensate For deviation because of Larger masses have greater attraction

(c.) A Real gas would have ↓P because attractive Forces

11	I can use the Kinetic Molecular Theory to explain the behavior of gases.	10.7

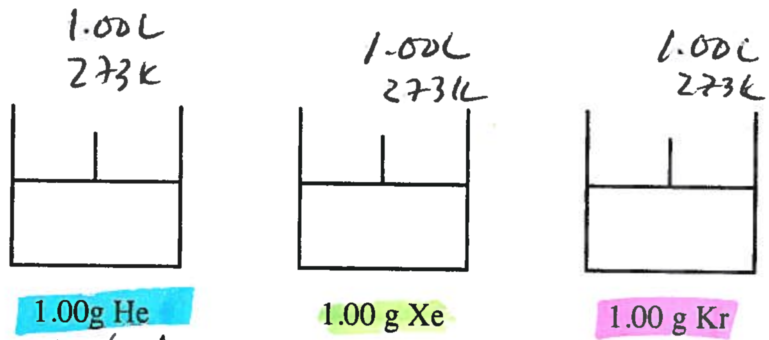
11. What is the major emphasis of the kinetic molecular theory?

- gas molecules are in constant random motion all the time
- the volume of a single gas molecule is negligible compared to the volume of the container
- Collisions are perfectly elastic (No loss of energy or momentum)

12. Consider three pistons each containing 1.00 g of the gas specified in 1.00 liters measures at 273 K. The
pressure is not specified.

$PV = nRT$

$1.00\,g \times \frac{mol}{4\,g}$



most moles least moles

$\rightarrow 1.00\,g\,Xe \times \frac{1\,mole}{131\,g}$

Comment on the following:

A. The pressure of the gases in each piston.

The pressure is greatest in He, least in Xe due to the large MM of Xe

B. The average velocity of the gases in each piston.

He is the Fastest

C. The density of the gases in each piston.

The density is the same!

D. The number of gas molecules in each piston. He has the most molecules (smallest MM)

E. the average K.E. Same 'cause at the same temp.

12	I can explain the concepts of effusion and diffusion and make associated calculations using Graham's Law.	10.8

13. N_2 gas effused through a pinhole in 2.00 seconds. How many seconds will it take an equivalent amount of H_2 to effuse under the same conditions?

28 g, 2 g/mol

$rate = \frac{distance}{time}$

inverse: $\frac{r_1}{r_2} = \sqrt{\frac{MM_2}{MM_1}}$; direct: $\frac{time_1}{time_2} = \sqrt{\frac{MM_1}{MM_2}}$

$\frac{2.00\,sec}{x} = \sqrt{\frac{28\,g\,N_2}{2\,g\,H_2}}$

$x = .53\,sec$

13	I can cite the general conditions of T and P under which real gases most closely approximate ideal-gas behavior. Also, I can explain the origin of the correction terms P and V that appear in the van der Waals equation.	10.9

17. The van der Waals equation $[P + a(n/V)^2] (V - bn) = nRT$
    What do the constants a and b each compensate for?

"a" compensates for the attractive forces between gas molecules

"b" compensates for actual volume occupied by a mole of gas.

18. Which gas deviates the least from ideal gas behavior: H_2 or SO_2 ? (Explain your answer)

As Gases increase in Molar Mass and complexity they deviate more from ideal gas behavior and larger a & b → constant values.

19. Use the following information to answer the questions below. A student measured the mass of a sealed 700. mL glass flask that contained dry air. The student then flushed the flask with the unknown gas, resealed it, and measured the mass again. Both the air and the unknown gas were at 22.0°C and ~~1.00 atm~~ 740.0 mm. The data for the experiment are shown in the table below.

A. Volume of sealed flask: 700.0 mL
B. Mass of sealed flask and dry air: 140.0 G
C. Mass of sealed flask and unknown gas: 150.0 g

A. Volume of sealed flask	700. mL
B. Mass of sealed flask and dry air	140. g
C. Mass of sealed flask and unknown gas	1~~50~~41. g

Find the mass, in grams, of the following:

A. Of the dry air that was in the sealed flask. (The density of dry air is 1.20 g/L at 22.0°C and 1.00 atm.)

mass = d · V ; $mass_{Air} = \frac{1.20 g}{L} \cdot \frac{.700 L}{1}$ = .840 g AIR

B. Of the sealed flask itself with no air in it.

140.0 g (Flask + AIR) − .840 g Air = 139.2 g empty Flask

C. Of the unknown gas that was added to the sealed flask.

141.0 g − 139.2 g = 1.8 g

D. Knowing all the info above find the molar mass of the unknown gas.

$$MM = \frac{dRT}{P} = \frac{\left(\frac{1.8 g}{.7000 L}\right)\left(.0821 \frac{L\,atm}{mol\,K}\right)(295)}{\frac{740.0 mm}{760.0 mm}}$$

(~~1.00 atm~~) → .974 atm

MM = 63.9 g/mol

E. If gas is Cl_2 what is % error :

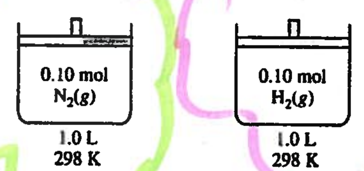
$$\frac{71 g/mol - 63.9 g/mol}{71} \times 100$$

10.0% Error

F. Error: what could raise MM of gas: If temp recorded too High!!

G. decrease! Not substract AIR (part B)

Question 6



Consider two containers of volume 1.0 L at 298 K, as shown above. One container holds 0.10 mol $N_2(g)$ and the other holds 0.10 mol $H_2(g)$. The average kinetic energy of the $N_2(g)$ molecules is 6.2×10^{-21} J. Assume that the $N_2(g)$ and the $H_2(g)$ exhibit ideal behavior.

(a) Is the pressure in the container holding the $H_2(g)$ less than, greater than, or equal to the pressure in the container holding the $N_2(g)$? Justify your answer.

The pressure in the container holding the $H_2(g)$ is equal to the pressure in the container holding the $N_2(g)$ because there is an equal number of moles of both gases at the same temperature and volume ($P = nK$, *where the constant* $K = \frac{RT}{V}$).	One point is earned for the correct choice. One point is earned for the correct explanation.

(b) What is the average kinetic energy of the $H_2(g)$ molecules?

The average kinetic energy of the $H_2(g)$ molecules is 6.2×10^{-21} J because both gases are at the same temperature.	One point is earned for the correct energy.

(c) The molecules of which gas, N_2 or H_2 , have the greater average speed? Justify your answer.

$H_2(g)$ molecules will have the greater average speed. Both gases have the same average kinetic energy, but $H_2(g)$ has the smaller molar mass. Therefore, the $H_2(g)$ molecules will have a greater average speed because, at a given temperature, the average (root-mean-square) speed of gas molecules is inversely proportional to the square root of the molar mass of the gas: $u_{rms} = (\sqrt{3RT})\frac{1}{\sqrt{M}}$	One point is earned for the correct answer with an explanation.

Question 6 (continued)

(d) What change could be made that would decrease the average kinetic energy of the molecules in the container?

The average kinetic energy of a gas particle depends on the temperature of the gas sample. To decrease the average kinetic energy of the gas particles in a gas sample, the temperature of the $N_2(g)$ would have to be lowered.	One point is earned for the correct answer with an explanation.

(e) If the volume of the container holding the $H_2(g)$ was decreased to 0.50 L at 298 K, what would be the change in each of the following variables? In each case, justify your answer.

(i) The pressure within the container

The pressure would be doubled. *PV* is a constant when the temperature and number of moles of gas are held constant. Therefore, if the volume is halved the pressure is doubled. $P_1V_1 = P_2V_2$ If $V_2 = \frac{1}{2}V_1$, then $P_1V_1 = P_2\left(\frac{1}{2}V_1\right) \Rightarrow P_1 = P_2\left(\frac{1}{2}\right) \Rightarrow$ $P_2 = 2P_1$	One point is earned for the correct answer. One point is earned for the correct explanation.

(ii) The average speed of the $H_2(g)$ molecules

The average speed is unchanged when the volume of the gas sample is halved. Average speed depends on changes in temperature, not changes in volume.	One point is earned for the correct answer with an explanation.

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Question 8

Answer the following questions about carbon monoxide, CO(*g*), and carbon dioxide, $CO_2(g)$. Assume that both gases exhibit ideal behavior.

(a) Draw the complete Lewis structure (electron-dot diagram) for the CO molecule and for the CO_2 molecule.

:C≡O: Ö=C=Ö	1 point for each correct, complete Lewis structure

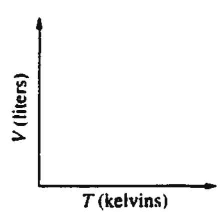
(b) Identify the shape of the CO_2 molecule.

CO_2 has a linear molecular geometry	1 point for correct molecular geometry

(c) One of the two gases dissolves readily in water to form a solution with a pH below 7. Identify the gas and account for this observation by writing a chemical equation.

The gas that produces a pH less than 7 when added to water is CO_2. The reaction that accounts for this is $CO_2(g) + H_2O(l) \rightarrow HCO_3^-(aq) + H^+(aq)$ <u>OR</u>, $CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$	1 point for identifying CO_2 in a correct chemical equation

(d) A 1.0 mole sample of CO(*g*) is heated at constant pressure. On the graph below, sketch the expected plot of volume versus temperature as the gas is heated.



The graph should have a straight line with a positive slope.	1 point for drawing a correct line

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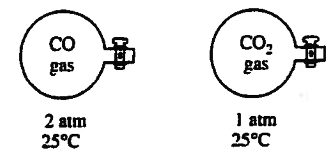
Question 8 (cont'd.)

(e) Samples of CO(*g*) and $CO_2(g)$ are placed in 1 L containers at the conditions indicated in the diagram below.



(i) Indicate whether the average kinetic energy of the $CO_2(g)$ molecules is greater than, equal to, or less than the average kinetic energy of the CO(*g*) molecules. Justify your answer.

The average kinetic energy is the same for both samples because the temperature is the same for both samples. Average kinetic energy is proportional to temperature.	1 point for correct answer and explanation

(ii) Indicate whether the root-mean-square speed of the $CO_2(g)$ molecules is greater than, equal to, or less than the root-mean-square speed of the CO(*g*) molecules. Justify your answer.

The root-mean-square speed for CO_2 is lower than the root-mean-square speed for CO. The molar mass of CO_2 is higher than the molar mass of CO. The root-mean-square speed is inversely proportional to the square root of the molar mass of the gas.	1 point for correct answer and explanation

(iii) Indicate whether the number of $CO_2(g)$ molecules is greater than, equal to, or less than the number of CO(*g*) molecules. Justify your answer.

There are fewer CO_2 molecules than CO molecules. The CO_2 molecules exert half the pressure of the CO molecules (at the same *T* and *V*), so there must be half as many molecules present.	1 point for correct answer and explanation