South Pasadena • AP Chemistry

Name Key
Period ___ Date ___/___/___

12 • The Gas Laws

Review Topic 1: Pressure and Partial Pressure

1 atm = 760 mmHg = 760 torr = 14.7 psi = 101.3 kPa

Make the following conversions: (Show your work)

550 mmHg x $\frac{101.3 \text{ kPa}}{760 \text{ mmHg}}$ = 73.3 kPa

55 psi x $\frac{760 \text{ mmHg}}{14.7 \text{ psi}}$ = 2844 mmHg   2800 mmHg

325 kPa x $\frac{1 \text{ atm}}{101.3 \text{ kPa}}$ = 3.21 atm

2284 torr x $\frac{101.3 \text{ kPa}}{760 \text{ torr}}$ = 304.4 kPa

125.0 g of CH_4 and 15.00 g of He are placed in a rigid container. The total pressure of the gas mixture is 1.45 atm. What is the partial pressure of each gas?

calculate moles

$$125.0\text{ g } CH_4 \times \frac{1 \text{ mol } CH_4}{16.05 \text{ g}} = 7.788 \text{ mol } CH_4$$

$$15.00\text{ g He} \times \frac{1 \text{ mol He}}{4.003 \text{ g}} = 3.747 \text{ mol He}$$

11.535 mol Tot

$$P_{CH_4} = (1.45 \text{ atm})\left(\frac{7.788}{11.535}\right) = \boxed{.979 \text{ atm}}$$

$$P_{He} = (1.45 \text{ atm})\left(\frac{3.747}{11.535}\right) = \boxed{.471 \text{ atm}}$$

12 • The Gas Laws

Review Topic 2: Root Mean Square

Three cars with speeds of 10 mph, 45 mph, and 70 mph are traveling down the highway. What is their root mean square velocity?

$$\sqrt{\frac{10^2 + 45^2 + 70^2}{3}} = \sqrt{\frac{100 + 2025 + 4900}{3}} = 48.39 = \boxed{48 \text{ mph}}$$

Calculate the root mean square velocity of a sample of SF_6 gas at room temperature (~~21.0 °C~~ 294 K).

S 32.07
F_6 114.00
M = 146.07 g/mol

$$U_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{(3)(8.31 \text{ kg}\cdot\text{m}^2\cdot\text{s}^{-2}\cdot\text{mol}^{-1}\cdot\text{K}^{-1})(294 \text{ K})}{146.07 \text{ g}\cdot\text{mol}^{-1} \times \frac{1 \text{ kg}}{1000 \text{ g}}}}$$

$$= \sqrt{\frac{(3)(8.31)(294)}{.14607}\frac{m^2}{s^2}} = \sqrt{50177 \frac{m^2}{s^2}} = \boxed{224 \frac{m}{s}}$$

12 • The Gas Laws

Review Topic 3: Graham's Law

1 mole each of He gas and CO_2 gas are in a rigid container at the same temperature.

The kinetic energy of He is the same as (greater than, less than, the same as) the kinetic energy of CO_2?
The velocity of He is greater than (greater than, less than, the same as) the ~~kinetic energy~~ velocity of CO_2?

Calculate the ratio of the velocities of He/CO_2.

$$\frac{V_{He}}{V_{CO_2}} = \sqrt{\frac{m_{CO_2}}{m_{He}}} = \sqrt{\frac{44.0}{4.0}} = \sqrt{11} = \boxed{3.32 : 1}$$

He is 3.32 x faster than CO2.

When HCl(g) and NH_3(g) come in contact, they form a white solid, NH_4Cl(s).
If samples of the two gases are placed at the ends of a tube, the white solid will appear closest to point b?

HCl | a b c d e | NH_3

36.5 g/mol — 17.0 g/mol FASTER

$$\frac{V_{NH_3}}{V_{HCl}} = \sqrt{\frac{m_{HCl}}{m_{NH_3}}} = \sqrt{\frac{36.5}{17.0}} = \sqrt{2.14} = 1.47 : 1$$

12 • The Gas Laws

Review Topic 4: Real Gases

$$(P + \frac{n^2 a}{V^2})(V - nb) = nRT$$

1.00 mol of ammonia gas, NH_3, fills a 7.00 liter bottle at 350 K. What does the van der Waals equation predict that the pressure will be? For ammonia $a = 4.17\ \frac{\text{atm L}^2}{\text{mol}^2}$ and $b = 0.0371$ L/mol.

$$\left(P + \frac{(1^2)(4.17)}{7^2}\right)(7 - 0.0371) = (1)(.0821)(350)$$

$$(P + .0851)(6.9629) = 28.735$$

$$\boxed{P = 4.04 \text{ atm}}$$

NOTE:
(USING PV=nRT
P = 4.11 atm)

12 • The Gas Laws

Review Topic 5: Gas Law Problems

Solve the following problems:

_________ 1. A balloon at ~~35.0°C~~ 308 K and 0.980 atm has a volume of 12.5 L.
What is its volume at ~~75.0°C~~ 348 K and 150. kPa? $\times \frac{1 \text{ atm}}{101.3 \text{ kPa}} = 1.48$ atm

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad V_2 = \overset{12.5 L}{V_1} \times \frac{348 K}{308 K} \times \frac{.980 \text{ atm}}{1.48 \text{ atm}} = \boxed{9.35 L}$$

_________ 2. A balloon has a volume of 1.00 L at ~~21.0°C~~ 294 and 750. mmHg.
What is the balloon's volume at STP?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \qquad V_2 = 1.00 L \times \frac{273 K}{294 K} \times \frac{750 \text{ mmHg}}{760 \text{ mmHg}} = \boxed{.916 L}$$

12 • The Gas Laws

Review Topic 6: Kinetic Molecular Theory

Explain the following observations in terms of the "kinetic molecular theory" (that is, what do the gas particles look like?)

A balloon of gas is placed in a car on a hot day. The balloon gets larger. Explain.

as the temperature rises, the gas particles speed up causing more and harder collisions with the walls of the balloon. the walls of the balloon are pushed outward.

A syringe is squeezed so the gas sample changes from 10 cc to 5 cc. The pressure doubles. Explain.

the volume is reduced, so the travel time from container wall to container wall is reduced. the particles collide into the container wall more often creating more pressure.

12 • The Gas Laws

Review Topic 7: Ideal Gas Law

A 0.00195 mole sample of CO_2 has what volume (in Liters) measured at ~~27.0°C~~ 300K and 740 mmHg?

P = 740 mmHg V = x n = .00195 mol R = $62.4 \frac{L \cdot mmHg}{mol \cdot K}$ T = 300 K

$$PV = nRT \quad V = \frac{nRT}{P} = \frac{(.00195\ mol)(62.4\ \frac{L \cdot mmHg}{mol \cdot K})(300K)}{740\ mmHg} = \boxed{.0493L}$$

How many moles of CO2 gas will fit into a 2.00 Liter soda bottle at ~~35.0°C~~ and 0.990 atm?

P = .990 atm V = 2.00L n = x R = $0.0821 \frac{L \cdot atm}{mol \cdot K}$ T = 308K

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(.990)(2.00)}{(0.0821)(308)} = \boxed{.0783\ mol}$$

12 • The Gas Laws

Review Topic 8: Molar Mass

Calculate the molar mass of a gas sample if 3.00 grams of the gas in a 2.00 L container at ~~25.0°C~~ 298K has a pressure of 2.294 atm.

$$M = \frac{mRT}{PV} = \frac{(3.00g)(.0821)(298K)}{(2.294\ atm)(2.00L)} = 15.9976 = \boxed{16.0\ g/mol}$$

What mass of chlorine gas, Cl_2, is needed to fill a 10.0 L container at ~~100.°C~~ 373K and 775 torr?

$$M_{Cl_2} = 35.453 \times 2 = 70.906\ g/mol$$

$$M = \frac{mRT}{PV} \quad m = \frac{MPV}{RT} = \frac{(70.906)(775\ torr)(10.0L)}{(62.4\ \frac{L \cdot mmHg}{mol \cdot K})(373K)}$$

$$= \boxed{23.6\ g}$$

Review Topic 9: Molar Volume Lab

Information:

volume of gas at room conditions: 45.0 mL
length of Mg used: 4.65 cm   mass of 1.00 m of Mg: 0.958 g
room temperature: 22.0°C = 295 K   room pressure: 751 mmHg
water vapor pressure at 22.0°C = 19.8 mmHg

$P_{H_2} = 751 - 19.8\ mmHg = 731.2\ mmHg$

How many moles of magnesium were used? Show work.

$4.65\ cm \times \frac{1\ m}{100\ cm} \times \frac{.958\ g}{1\ m} \times \frac{1\ mol\ Mg}{24.3\ g} = .00183\ mol\ Mg$

What is the molar volume of this hydrogen gas sample under room conditions? Show work.

$\frac{45.0\ mL}{.00183\ mol} = \frac{x}{1.00\ mol}$ $x = 24590\ mL = 24.59\ L$

What is the molar volume of this hydrogen gas sample at STP? Identify the variables and show work.

P_{H_2} $P_1=$	731.2 mmHg	$P_2=$	760 mmHg
$V_1=$	24.59 L	$V_2=$	x
$T_1=$	295 K	$T_2=$	273 K

$V_2 = 24.59\ L \times \frac{273\ K}{295\ K} \times \frac{731.2\ mmHg}{760\ mmHg} = \boxed{21.8\ L}$