CHEM Ch. 13 Notes~ GASES

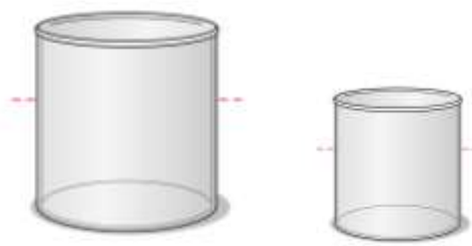
NOTE: Vocabulary terms are in **boldface and underlined**. Supporting details are in *italics*.

STANDARD ATMOSPHERIC PRESSURE:				
1.00 atm	**760. mm Hg**	**760. torr**	**101.3 kPa**	**14.7 psi**

I. Adding or removing a gas
   A. *adding gas*
      1) *increases number of particles*
      2) *increases the pressure (number of collisions)*
   B. *removing gas*
      1) *decreases the number of particles*
      2) *decreases the pressure (number of collisions)*

5 particles 0.5 atm | 10 particles 1 atm | 20 particles 2 atm

II. Changing container size
   A. *increase container size*
      1) *increases the volume*
      2) *decreases the pressure*
      3) gases cool
   B. *decrease container size*
      1) *decreases the volume*
      2) *increases the pressure*
      3) gases heat up



A. B.

III. Heating or cooling a gas
   A. *increase temp.:*
      increases the kinetic energy (K.E.) and pressure
   B. *decrease temp.*
      decreases the K.E. and pressure

NOTE: for the gas laws…	***1** = initial*	***2** = final*		
***P** = pressure*	***V** = volume*	***T** = temperature*	***n** = # of moles*	***R** = a constant*

Tip for math success:
Rearrange the equation in symbols before plugging in the numbers and units.

13.1 notes Gas Laws

IV. Boyle's Law (Robert Boyle, 1627-1691)

A. **Boyle's Law**: *for a gas a constant temperature, pressure and volume are indirectly or inversely proportional.* $P \propto 1/V$

B. equation: $\boxed{P_1V_1 = P_2V_2}$

C. examples

E1) A sample of CO gas is at 0.66 atm in a 3.0 L piston container. If the pressure is increased to 5.0 atm, what is the new volume? (Temperature is constant.)

P_1 = 0.66 atm P_2 = 5.0 atm
V_1 = 3.0 L V_2 = ? L

$P_1V_1 \quad P_2\boxed{V_2}$

$\dfrac{P_1V_1}{P_2} = V_2$

$\dfrac{(0.66\ \text{atm})(3.0\ \text{L})}{(5.0\ \text{atm})} = \boxed{0.40\ \text{L}}$

E2) 14.5 L of gas has a pressure of 850. mm Hg. If the gas is allowed to expand to a volume of 20.0 L, what is the new pressure?

P_1 = 850.mmHg P_2 = ? mmHg
V_1 = 14.5 L V_2 = 20.0 L

$P_1V_1 = \boxed{P_2}V_2$

$\dfrac{P_1V_1}{V_2} = P_2$

$\dfrac{(850.\ \text{mm Hg})(14.5\ \text{L})}{(20.0\ \text{L})} = \boxed{616\ \text{mm Hg}}$

V. Charles' Law (Jacques Charles, 1746-1823)

A. **Charles' Law**: *for a gas a constant pressure, volume and temperature are directly proportional.* $V \propto T$

B. equation:

$\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2}$ **Temps must be in Kelvin.**

C. examples

E3) A piston drum container of He at 25.0 °C has a volume of 10.0 L. If it is heated to 150.0 °C, what is is the new volume?

T_1 = 25.0+273 = 298 K T_2 = 150.0+273 = 423 K
V_1 = 10.0 L V_2 = ? L

$\dfrac{V_1}{T_1} = \dfrac{\boxed{V_2}}{T_2}$

$\dfrac{V_1T_2}{T_1} = \boxed{V_2}$

$\dfrac{(10.0\ \text{L})(423\ \text{K})}{(298\ \text{K})} = \boxed{14.2\ \text{L}}$

E4) A sample of chlorine gas occupies 7.50 L at 62.0 °C. If pressure is held constant, What is the temperature which will allow the gas to occupy 0.250 L?

T_1 = 62.0+273 = 335 K T_2 = ? K
V_1 = 7.50 L V_2 = 0.250 L

$\dfrac{V_1}{T_1} = \dfrac{V_2}{\boxed{T_2}}$

$V_1\boxed{T_2} = V_2T_1$

$\boxed{T_2} = \dfrac{V_2T_1}{V_1}$

$\dfrac{(0.250\ \text{L})(335\ \text{K})}{(7.50\ \text{L})} = \boxed{11.2\ \text{K}}$

VI. Gay-Lussac's Law (Joseph Gay-Lussac, 1778-1850)

A. **Gay-Lussac's Law**: *for a gas a constant volume, pressure and temperature are directly proportional.* $P \alpha T$

B. equation:

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$ **Temps must be in Kelvin.**

C. examples

E5) A sample of O_2 gas has a pressure of 475.0 mm Hg at 38.5 °C. If the temperature is raised to 85.2 °C and the volume is unchanged, what is the new pressure?

P_1 = 475.0 mm Hg P_2 = ? mm Hg

T_1 = 38.5+273 = 312 K T_2 = 85.2+273 = 358 K

$$\frac{P_1}{T_1} = \frac{\boxed{P_2}}{T_2} \qquad P_1T_2 = T_1\boxed{P_2} \qquad \frac{P_1T_2}{T_1} = \boxed{P_2}$$

$$\frac{(475.0 \text{ mm Hg})(358 \text{ K})}{(312 \text{ K})} = \boxed{545 \text{ mm Hg}}$$

E6) A container of methane gas at 511 °C has a pressure of 466.9 kPa. What must the temperature be for the pressure to become 101.3 kPa?

P_1 = 466.9 kPa P_2 = 101.3 kPa

T_1 = 511+273 = 784 K T_2 = ? K

$$\frac{P_1}{T_1} = \frac{P_2}{\boxed{T_2}} \qquad P_1\boxed{T_2} = T_1P_2 \qquad \boxed{T_2} = \frac{T_1P_2}{P_1}$$

$$\frac{(784 \text{ K})(101.3 \text{ kPa})}{(466.9 \text{ kPa})} = \boxed{170. \text{ K}}$$

VII. The **Combined Gas Law**

A. combination of Boyle's, Charles' and Gay-Lussac's Laws.

B. no constants

C. equation and tips:

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

Temps must be in Kelvin.

Combined Gas Law

"Potato Chips are Very Good To Bite." **(from Mr. D. Noyes, CCCHS, 1982)**

Pressure constant – Charles Volume constant – Gay-Lussac

Temperature constant – Boyle

D. examples

E7) 2.00 L of a gas at 30.3 °C has a pressure of 1.77 atm. The gas is heated to 50.9 C, and a 4.01 atm pressure is observed. What is the new volume of the gas?

$P_1 = 1.77$ atm $P_2 = 4.01$ atm $\frac{P_1V_1}{T_1} = \frac{P_2\boxed{V_2}}{T_2}$ $\frac{P_1V_1T_2}{T_1P_2} = \boxed{V_2}$

$V_1 = 2.00$ L $V_2 = ?$ L

$T_1 = 30.3 + 273 = 303$ K $T_2 = 50.9 + 273 = 324$ K

$$\frac{(1.77\ \cancel{atm})(2.00\ L)(324\ \cancel{K})}{(303\ \cancel{K})(4.01\ \cancel{atm})} = \boxed{0.944\ L}$$

E8) A 7.50 L sample of N_2 gas in a piston container is measured at 244.8 kPa and 24.2 °C, If the pressure increases to 300.0 kPa and the volume is increased to 9.00 L, what is the Kelvin temperature of the gas?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{\boxed{T_2}} \qquad P_1V_1\boxed{T_2} = T_1P_2V_2$$

$P_1 = 244.8$ kPa $P_2 = 300.0$ kPa

$V_1 = 7.50$ L $V_2 = 9.00$ L

$T_1 = 24.2+273 = 297$ K $T_2 = ?$ K

$$\boxed{T_2} = \frac{T_1P_2V_2}{P_1V_1} \qquad \boxed{T_2} = \frac{(297\ K)(300.0\ \cancel{kPa})(9.00\ \cancel{L})}{(244.8\ \cancel{kPa})(7.50\ \cancel{L})} = \boxed{437\ K}$$

13.2 notes

VIII. The Ideal Gas Law

A. **Ideal Gas Law**: the number of moles of an "ideal" gas can be found when P, V, and T are known.

B. equation:

PV = nRT

P = pressure	R = ideal gas constant
V = volume	T = Kelvin temperature
n = # of moles	

Values for R, the ideal gas constant: (R varies with the pressure unit)

0.08206	(L atm / mol K)
8.314	(L kPa /mol K)
62.36	(L mm Hg / mol K) or (L torr/ mol K)

C. examples

E9) A container of nitrogen dioxide gas occupies 14.0 L at 22.3 °C. The pressure is 75 atm. How many moles of gas are in the container?

P = 75 atm R = 0.08206 L atm/mol K

V = 14.0 L T = 22.3+273 = 295 K

n = ? moles

$$PV = \boxed{n}RT \qquad \frac{PV}{RT} = \boxed{n}$$

$$n = \frac{(75\ \cancel{atm})(14.0\ \cancel{L})}{\left(0.08206\ \frac{\cancel{L}\ \cancel{atm}}{mol\ \cancel{K}}\right)(295\ \cancel{K})} = \boxed{43\ mol}$$

E10) How many particles of gas are in the container in the previous problem?

$$43\ \cancel{mol\ NO_2} \times \frac{6.02 \times 10^{23}\ molec.\ NO_2}{1\ \cancel{mol\ NO_2}} = 1978 = \boxed{2.6 \times 10^{25}\ molecules\ NO_2}$$

D. Real vs. Ideal Gas

1) **<u>Real Gas</u>**—*any gas found in nature or made synthetically*
2) **<u>Ideal Gas</u>**—*a theoretical gas with particles of negligible mass and no attraction for one another (always follows the gas laws)*
3) at many temp. and pressure conditions, real gases behave like ideal gases

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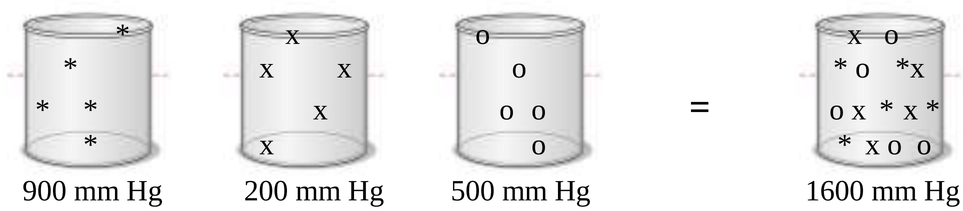
IX. Dalton's Law of Partial Pressures

A. **<u>Dalton's Law of Partial Pressures</u>**: *At constant temperature and volume, the total pressure exerted by a mixture of gases equals the sum of the pressures exerted by each individual gas.*

B. equation

$P_{TOTAL} = P_1 + P_2 + P_3\ldots$
Volume and temp must be constant.



C. examples

E11) Give the total pressure of a mixture of gases if the partial pressures are 1.9 atm and 3.5 atm.

$\boxed{P_{TOTAL}} = P_1 + P_2$ $\quad\quad$ P_{TOTAL} = 1.9 atm + 3.5 atm = $\boxed{5.4 \text{ atm}}$

E12) What is the partial pressure of Xe gas in a 750.0 kPa mixture of He at 200.0 kPa, and Rn at 105.5 kPa, and Xenon?

$P_{TOTAL} = P_{He} + P_{Rn} + \boxed{P_{Xe}}$ $\quad$ 750.0 kPa = 200.0 kPa + 105.5 kPa + P_{Xe} $\quad$ $P_{Xe} = \boxed{444.5 \text{ kPa}}$

X. Avogadro's Principle

A. **<u>Avogadro's Principle</u>**: *equal volumes of gases at the same temperature and pressure contain equal numbers of particles*

B. gases have a very large amount of space between the particles

C. review: at STP (273 K and 1.00 atm), 1 mol of any gases occupies 22.4 L

D. examples

E13) Calculate the volume occupied by 26 g of sulfur dioxide gas at STP.

$$26\ \cancel{g\ SO_2} \times \frac{1\ \cancel{mol\ SO_2}}{64.1\ \cancel{g\ SO_2}} \times \frac{22.4\ L\ SO_2}{1\ \cancel{mol\ SO_2}} = \boxed{9.1\ L\ SO_2}$$

E14) How many particles of argon gas are in 200.7 L argon at STP?

$$200.7\ \cancel{L\ Ar} \times \frac{1\ mol\ Ar}{22.4\ L\ Ar} \times \frac{6.02 \times 10^{23}\ atoms\ Ar}{1\ mol\ Ar} = \boxed{5.39 \times 10^{24}\ atoms\ Ar}$$