Name:______________________ Date:_______

H. Chemistry

Ch. 12.8-12.10 Lecture Guide

- The Kinetic Molecular Theory of Gases
    - model that attempts to explain molecular movement in a gas
  - Postulates of the Kinetic Molecular Theory of Gases
    - gases consist of tiny particles (molecules or atoms)
    - these particles are so small, that the volume is assumed to be zero
    - particles are in constant motion, colliding with the walls of container (P)
    - particles do not attract or repel each other
    - avg. kinetic energy of gas particles is directly proportional to kelvin temp. of the gas
  - Demo Notes
    -
  - Kinetic Energy
    - energy of motion
    - Equation: $KE = \frac{1}{2} MV^2$

      M = mass of particle
      V = velocity of particle
  - Implications
    - The Meaning of Temperature
      - temperature of a gas reflects how rapidly particles are moving

        fast moving particles = HOT
        slow moving particles = COLD
    - The Relationship Between Pressure and Temperature
      - When particles move faster, they collide with the side of a container more often and more forcefully.

        So, P increases, T also increases.

Demo Notes: →

    - The Relationship Between Volume and Temperature
      - Increase in temperature increases space between gas particles.

        So, V increase, T also increases.

Gas Stoichiometry

- If we know that n = PV/RT, then we can perform stoichiometric calculations for reactions involving gases!

- **Calculating Volume**
  - Calculate the volume of oxygen gas produced at 1.00 ~~atom~~ atm and 25°C by the complete decomposition of 10.5 g of potassium chlorate.

$$2KClO_3\ (s) \longrightarrow 2KCl\ (s) + 3\ O_2\ (g)$$

    - Step 1: Convert from grams of $KClO_3$ to moles of O_2 using stoichiometry.
    - Step 2: Use Ideal Gas Law to find volume of O_2.

$$10.5\,g\ KClO_3 \times \frac{1\ mol\ KClO_3}{122.6\,g\ KClO_3} \times \frac{3\ mol\ O_2}{2\ mol\ KClO_3} = 1.28 \times 10^{-1}\ mol\ O_2$$

V = x
P = 1.00 atm
T = 25°C + 273 = 298K
n = 1.28 × 10⁻¹ mol
R = 0.08206 L·atm/K·mol

$$PV = nRT$$

$$V = \frac{nRT}{P} = \frac{(1.28 \times 10^{-1}\ mol)(0.08206\ \frac{L\cdot atm}{K\cdot mol})(298\,K)}{1.00\ atm}$$

V = 3.13 L

  - 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 according to the balanced equation below:

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

$$26.5\,g\ Zn \times \frac{1\ mol\ Zn}{65.38\,g\ Zn} \times \frac{1\ mol\ H_2}{1\ mol\ Zn} = .405\ mol\ H_2$$

V = x
P = 1.50 atm
T = 19°C + 273 = 292K
n = .405 mol H_2
R = 0.08206 L·atm/K·mol

$$PV = nRT$$

$$V = \frac{nRT}{P} = \frac{(.405\ mol)(0.08206\ \frac{L\cdot atm}{K\cdot mol})(292\,K)}{1.50\ atm}$$

V = 6.47 L

STP → standard temperature + pressure

- Sometimes, it is useful to calculate the volume occupied by 1.00 mol of gas under certain conditions.
- Temperature: 0 °C or 273 K
- Pressure: 1.00 atm
- Number of moles: 1.00 mol
- Volume: 22.4 L

$$V = \frac{(1\ mol)(0.08206\ \frac{L\cdot atm}{K\cdot mol})(273K)}{1.00\ atm}$$

$V = 22.4\ L$

- **Calculations Involving Gases at STP**
  - A sample of nitrogen gas has a volume of 1.75 L at STP. How many moles of N_2 are present?

$V = 1.75\ L$
$n = x$
$T = 0°C = 273K$
$P = 1.00\ atm$
$R = 0.08206\ \frac{L\cdot atm}{K\cdot mol}$

$$n = \frac{PV}{RT} = \frac{(1.00\ atm)(1.75\ L)}{(0.08206\ \frac{L\cdot atm}{K\cdot mol})(273K)}$$

$n = .0781\ mol\ N_2$

  - Ammonia is commonly used as fertilizer to provide a source of nitrogen for plants. A sample of NH_3 (g) occupies a volume of 5.00 L at 25°C and 15.0 atm. What volume would this sample occupy at STP?

$V = 5.00\ L$
$T = 298\ K$
$P = 15.0\ atm$
$n = x$
$R = 0.08206\ \frac{L\cdot atm}{K\cdot mol}$

$$n = \frac{(15.0\ atm)(5.00\ L)}{(0.08206\ \frac{L\cdot atm}{K\cdot mol})(298K)} = 3.07\ mol\ NH_3$$

STP:
$V = x$
$T = 273K$
$P = 1.00\ atm$
$n = 3.07\ mol\ NH_3$

$$V = \frac{nRT}{P} = \frac{(3.07\ mol)(0.08206)(273)}{1.00\ atm}$$

$V = 68.8\ L$

  - 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 $CaCO_3$ according to the reaction

$$CaCO_3\ (s) \longrightarrow CaO\ (s) + CO_2\ (g)$$

$V =$
$T = 273K$
$P = 1.00\ atm$
$n = 1.52\ mol$
$R = 0.08206\ \frac{L\cdot atm}{K\cdot mol}$

$$152\ g\ CaCO_3 \times \frac{1\ mol\ CaCO_3}{100.09\ g\ CaCO_3} \times \frac{1\ mol\ CO_2}{1\ mol\ CaCO_3} = 1.52\ mol\ CO_2$$

$$V = \frac{nRT}{P}$$

$$V = \frac{(1.52\ mol)(0.08206)(273K)}{1.00\ atm} = 34.0\ L$$