ChE102 September 22, 2014

Lesson 7: Applying the Ideal Gas Law

Example 1: Gas Densities
Given the temperature and pressure of a gas, derive an expression for the density using the ideal gas law.

Example 2: Monocholoroethylene is used to make polyvinlylchloride (PVC). It has a density of 2.56 g/l at 22.8 °C and 756 mmHg. What is the molar mass of monochloroethylene?

Example 3: A 132.10 ml glass vessel weighs 56.1035 g when evacuated and 56.2445 g when filled with the gaseous hydrocarbon acetylene at 749.3 mmHg and 20.02 °C.

a) What is the molar mass of acetylene?
b) What conclusion can you draw about its molecular formula?

Example 4: A 3.57 g sample of potassium chlorate (KCl-$KClO_3$) mixture is decomposed by heating and produces 119 ml O_2 (g) measured at 22.4 °C and 738 mmHg. What is the mass percent of $KClO_3$ in the mixture?

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

Example 5: When 2.93 g of a compound containing only Hg and Cl is vaporized in a 1.0 l container at 680 K, the pressure is 458 torr. What are the molecular mass and molecular formula of the compound?

Example 6: When 0.21 g of a compound containing only hydrogen and carbon is burned, 0.66 g of CO_2 is recovered.

a) What is the empirical formula of the compound?
b) A determination of the density of this hydrocarbon gives a value of 1.87 g/l at STP (0 °C and 1 atm). What is the molecular formula of the compound?

Example 7: A 0.596 g sample of a gaseous compound containing boron and hydrogen occupies 484 cm^3 at STP. When the compound is ignited in excess of oxygen all its hydrogen is recovered as 1.17 g of H_2O and all the boron is left over as B_2O_3.

a) What are the empirical formula, the molecular formula, and the molar mass of the boron-hydrogen compound?
b) What is the mass of B_2O_3 produced in the reaction?

Suggested Readings:

6.1 Properties of Gases: Gas Pressure
6.2 The Simple Gas Laws
6.3 Combining Gas Laws: The Ideal Gas Equation and the General Gas Equation
6.4 Applications of the Ideal Gas Equation
6.5 Gases in Chemical Reactions

2. $PV = nRT$

$PV = \frac{m}{M} RT$

$M = \frac{m}{V} \frac{RT}{P}$

$T = 22.8°C + 273.15$
$= 295.95\ K$

$P = 756\,mmHg \times \frac{1\,atm}{760\,mmHg}$

M : molar mass

$M = \frac{\rho RT}{P} = \frac{(2.56)(0.08206)(295.95)}{\left(\frac{756}{760}\right)}$

3. a) $M = \frac{mRT}{PV}$

$m_{gas} = 56.2445 - 56.1035$
$= 0.1410\,g$

$T = 20.02°C + 273.15$
$= 293.17\ K$

$P = 749.3\,mmHg \times \frac{1\,atm}{760\,mmHg}$

$V = 132.10\,ml = 0.13210\,l$

useful gas constant

$$M = \frac{(0.1410\,g)\left(0.08206\,\frac{l \cdot atm}{mol \cdot K}\right)(293.17\,K)}{\frac{749.3}{760}\,atm \cdot 0.13210\,l} = 26.05\,g/mol$$

b) $M_C \approx 12\ g/mol$
$M_H \approx 1\ g/mol$

$\left.\begin{array}{l} 2C \approx 24 \\ 2H \approx 2 \end{array}\right\} \approx 26\ g/mol$

$\therefore C_2H_2$

4)

1) moles O_2

2) moles $KClO_3$

3) mass $KClO_3$

4) mass %

$M_{KClO_3} = 122.5495\ g/mol$

$PV = nRT$

$n = \frac{PV}{RT} = \frac{(\frac{738}{760}\ atm)(0.119\ l)}{(0.08206)(22.4 + 273.15)K}$

$= 4.77 \times 10^{-3}$ mol O_2

4.77×10^{-3} mol $O_2 \times \frac{2 \text{ mol } KClO_3}{3 \text{ mol } O_2}$

$= 3.18 \times 10^{-3}$ mol $KClO_3$

$3.18 \times 10^{-3} \cdot 122.5495$

$= 0.39\ g$ $KClO_3$

$\boxed{0.39/3.57 = 10.9\%}$