Chemistry: It’s a Gas

Part III

Ideal Gas Law

Molar Volume at STP

Molar mass, Density of Gases

Dalton’s Law of Partial Pressure

When a 2.0 L weather balloon goes from sea level (1 atm, 23°C) to 10 km the pressure decreases to 0.495 atm and the temperature -18°C. What is the new volume?

Use the combined gas law.

A. 3.48 L
B. 0.85 L
C. 1.15 L
D. -2.81 L
E. None of these

$$\frac{2.0\ \text{L} \times 1\ \text{atm}}{296\text{K}} = \frac{0.495\ \text{atm} \times \text{Volume}}{255\text{K}}$$

$$\frac{255\text{K} \times 2.0\ \text{L} \times 1\ \text{atm}}{296\text{K} \times .495\text{atm}} = \text{Volume}$$

Ideal gas law: PV = nRT

$R = 0.0821 \frac{L\ atm}{mole\ K}$

How many moles of gas are present in a 3.2 L container at 30°C and 750mmHg?

PV = nRT

Divide both sides by RT:

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

A. 1.28 moles. B. 974 moles. C. 0.127 moles D. 0.14 moles E. none of these

Remember to convert mmHg to atm (760 mmHg = 1 atm) and
°C to K ,(273 + °C = K)

Ideal gas law: $PV = nRT$

$R = 0.0821$ (Latm/moleK)

How many liters does 1.00 mole of gas occupy at STP?

A. 1.00 L
B. 22.4 L
C. 5.73 L
D. 0.1744L
E. None of these

STP = 1 atm, 273K

1 atm x V = (1 mole)0.0821(Latm/moleK) (273)

V = 22.4 L

As magnesium reacts with hydrochloric acid, hydrogen gas, magnesium ions and chloride ions are produced. Write the balanced equation:

$$Mg(s) + 2HCl(aq) \rightarrow Mg^{+2}(aq) + 2Cl^{-}(aq) + H_2(g)$$

You weighed 0.221 g of magnesium and it was the limiting reagent. How many moles of hydrogen gas were produced?

$$0.221 \text{ g Mg} \times \frac{1 \text{ mole Mg}}{24.31\text{g}} \times \frac{1 \text{ mole } H_2}{1 \text{ mole Mg}} = 0.00909 \text{ moles } H_2$$

At the end of the reaction, you measured the volume of the water in a graduated cylinder= volume of the gas: 222 mL.
Use Dalton's Law of partial pressures to determine pressure of the hydrogen gas: $P_T = p_{H2O} + p_{H2}$

P_T = room pressure = 768 mmHg
Temperature = 23°C, P_{H2O} at 23°C = 21.1 mmHg
768 mmHg – 21.1 mmHg = 746.9 mmHg/760 = 0.983 atm

Use the combined gas law to determine the volume of hydrogen gas at STP.

V_{STP} = ?	V_{exp} = 0.222 L	$V_{STP} = 0.\frac{222\text{ L x }0.983\text{ atm x }273\text{K}}{1\text{ atm x }296\text{K}}$
P_{STP} = 1 atm	P_{exp} = 0.972atm	V_{STP} =0 .201 L
T_{STP} = 273K	T_{exp} = 296	

To get the molar volume:

Divide the volume by the number of moles produced by the reaction: 0.00909 moles H_2

$$\frac{0.201 \text{ L}}{0.00909 \text{ moles } H_2} = 22.14 \text{ L/mole}$$

$$\% \text{ error} = \frac{(\text{actual} - \text{calculated})(100\%)}{\text{actual}} = \frac{22.4 - 22.14}{22.4} = 1.2\% \text{ error}$$

What percent sodium carbonate is in your unknown?

- The moles of CO_2 = moles of Na_2CO_3
- Use the volume of gas collected, the pressure of CO_2 and the temperature to calculate the moles of CO_2, = moles Na_2CO_3.
- $p_{CO2} = P_{T(room)} – p_{H2O}$
- $PV = nRT$
- Convert the moles of Na_2CO_3 to grams (multiply by molar mass)
- Divide grams of Na_2CO_3 by the total mass of your sample
- Multiply by 100% = %

p_{CO2} = 768-21.1 = 746.9 mmHg x 1 atm/760 mmHg = 0.983 atm

Calculate the Percent of Sodium carbonate in an unknown sample

Data

Mass of unknown	Volume of water	Temperature	Room pressure	Pressure of H_2O
1.090g	250 mL = 0.250L	23°C = 296K	768 mmHg	At 23°C P_{H20} = 21.1 mmHg

1. p_{CO2} = 768-21.1 = 746.9 mmHg x 1 atm/760 mmHg = 0.983 atm
2. $n = \frac{PV}{RT}$ R = 0.0821 (Latm/moleK)

3. convert moles of gas to moles of sodium carbonate, then convert moles to grams (multiply by molar mass of sodium carbonate)
4. Divide your mass of Na_2CO_3 by the total mass of your sample x 100% = % Na_2CO_3

$$n = \frac{0.983 \text{ atm} \times 0.250\text{L}}{0.0821 \text{ (Latm/moleK)} 296\text{K}} = 0.01011 \text{ moles}$$

0.01011 moles x 105.96 g/mole = 1.071 g

100%(1.071/1.090) =98.25%