Gases

Properties of Gases

Occupy the entire volume of their container
Compressible
Flow readily and mix easily
Have low densities, low molecular weight

Elements	Compounds
H_2 (molecular hydrogen)	HF (hydrogen fluoride)
N_2 (molecular nitrogen)	HCl (hydrogen chloride)
O_2 (molecular oxygen)	HBr (hydrogen bromide)
O_3 (ozone)	HI (hydrogen iodide)
F_2 (molecular fluorine)	CO (carbon monoxide)
Cl_2 (molecular chlorine)	CO_2 (carbon dioxide)
He (helium)	NH_3 (ammonia)
Ne (neon)	NO (nitric oxide)
Ar (argon)	NO_2 (nitrogen dioxide)
Kr (krypton)	N_2O (nitrous oxide)
Xe (xenon)	SO_2 (sulfur dioxide)
Rn (radon)	H_2S (hydrogen sulfide)

The Combined Gas Law and the Ideal Gas Constant

Combines all three laws by means of varying the volume

Boyles Law	constant = PV
Charles's Law	constant = V / T
Avogadro's Law	constant = V / n

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

STP: Standard Temperature and Pressure = 1atm 273K

$$\frac{P_1V_1}{n_1T_1} = \frac{1atm x 22.4L}{1mol x 273K} = \frac{0.0821 Latm}{molK} = R$$

Ideal Gas Constant: R= $\frac{0.0821 Latm}{mol\, K}$

Acts as 1 side of combined gas law

Using the Ideal Gas Law

Ideal Gas Law PV = nRT

Must convert units to match R

$$R = \frac{PV}{nT} = \frac{0.0821 Latm}{molK}$$

Identify the noble gas if 23.6 g exerts a pressure of 1293 torr at 37ºC in a 17.5-L container?

Convert T and P: T = 37 ºC = 310.15 K P= $\frac{1293 torr}{1}$x $\frac{1atm}{760torr}$=1.70atm

$$n = \frac{1.70atm}{1} x \frac{17.5L}{1} x \frac{molK}{0.0821Latm} x \frac{1}{310.15K} = 1.17mol$$

Solve for moles

Find molar mass MM=$\frac{23.6g}{1.17mol}$= 20.2g/mol

Identify noble gas Neon: MM20.17g/mol

A 16.4-g sample of a gas at 25.0 lb/in^2 and 25.0ºC is confined in a 17.5 L container. This gas is moved to a 28.5 L container at 100.0ºC and 14.0 lb/in^2.
How much gas was removed or added?

Get equation:

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2} \qquad n_2 = \frac{n_1T_1P_2V_2}{T_2P_1V_1}$$

Use gas masses, not moles	n_1 = 16.4g	n_2 = ?
Convert temp. to Kelvin	T_1 = 298K	T_2 = 373K
Pressure units cancel:	P_1 = 25.0 lb/in^2	P_2 = 14.0 lb/in^2
Volume as written:	V_1 = 17.5L	V_2 = 28.5L

$$n = \frac{16.4g}{1} x \frac{298K}{373K} x \frac{14.0lb/in^2}{25.0lb/in^2} x \frac{28.5L}{17.5L} = 11.9g$$

16.4g of gas at start - 11.9g after moving it = 4.5g removed

Stoichiometry and Gas Laws

What volume in liters of CO (g) at 250ºC and 0.904 atm is produced from 453.6g Fe_2O_3 (s) in the following reaction:

Fe_2O_3 (s) + 3C (s) $\rightarrow$ 2Fe (s) +3 CO (g)

Determine # moles of CO (g) produced to get n

$$?\,mol_{CO} = \frac{453.6g_{Fe_2O_3}}{1} x \frac{1mol_{Fe_2O_3}}{159.6g_{Fe_2O_3}} x \frac{3mol_{CO}}{1mol_{Fe_2O_3}} = 8.52mol_{CO} = n$$

Use the ideal gas law to determine the volume

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

n = 8.52 mol

T = 523.15 K

R = 0.0821 L atm / mol K

P = 0.904 atm

$$V = \frac{8.52mol}{1} x \frac{0.0821Latm}{molK} x \frac{523.15K}{1} x \frac{1}{.904atm} = 405L$$

Dalton’s Law of Partial Pressures

Mixtures of Gases: Dalton's Law of Partial Pressures

The <u>Total Pressure</u> is the sum of the partial pressures.

$$P_{total} = P_1 + P_2 + P_3 + \cdots$$

The <u>Partial Pressure</u> is the pressure exerted by each individual gas in the container.

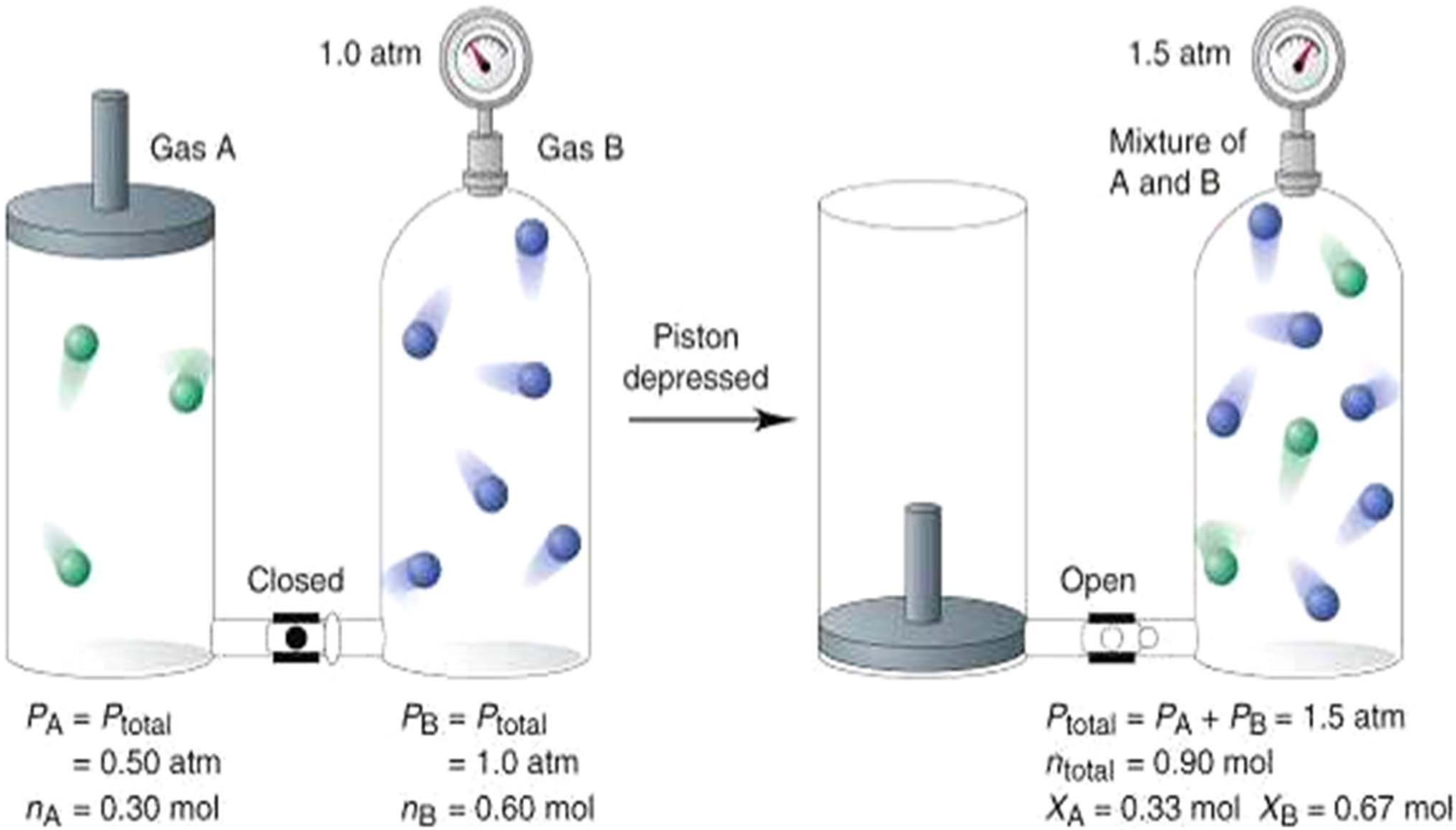
$$P_1 = (n_1RT)/ V; \quad P_2 = (n_2RT)/ V; \text{ and so on}$$

The <u>Mole Fraction</u> is the fraction of all the molecules in a mixture that are of a given type.

$$P_1/P_{total} = n_1/n_{total} = x_1$$
$$P_1 = x_1 \cdot P_{total}$$

Mixtures of Gases
Dalton's Law of Partial Pressures

IN your experiment, you have water vapor mixed into the hydrogen gas



Collection of Gases Over Water

An gas is collected into a container of water

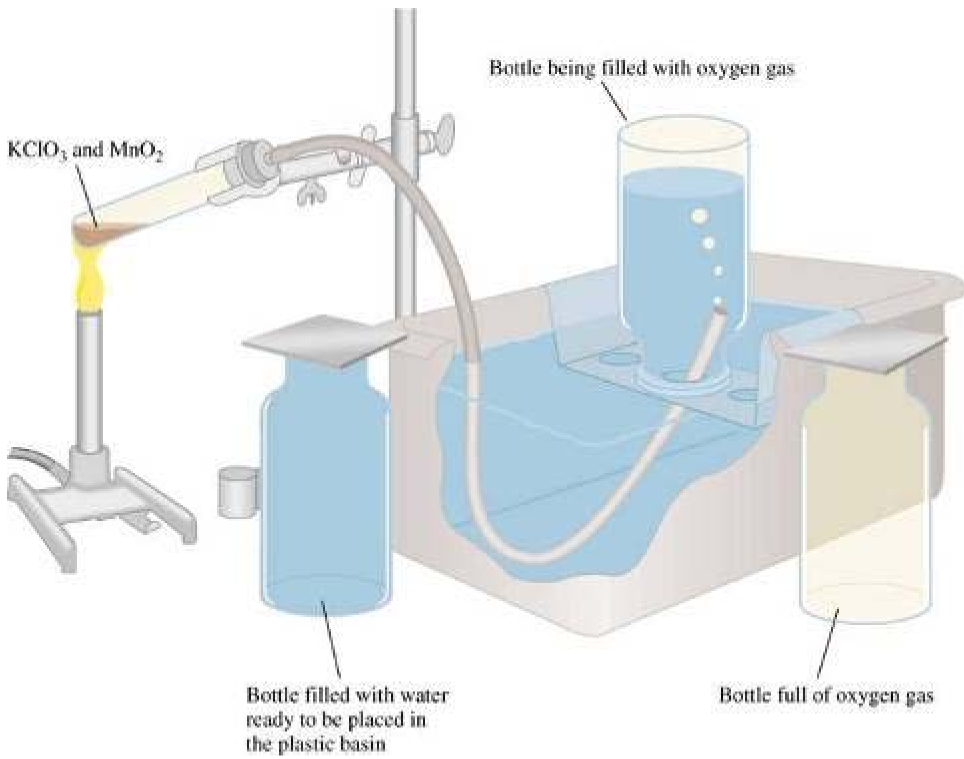
The water saturated gas rises and displaces liquid water

The vapor pressure is the partial pressure of the water vapor

It must be deducted from the measured pressure of the gas

$P_{total}\ P_{atm} = P_{gas} + P_{water(g)}$

$P_{gas} = P_{atm} - P_{water(g)}$



Temperature (°C)	Water Vapor Pressure (mmHg)
0	4.58
5	6.54
10	9.21
15	12.79
20	17.54
25	23.76
30	31.82
35	42.18
40	55.32
45	71.88
50	92.51