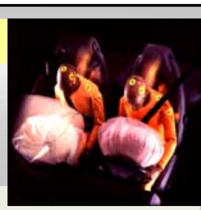
Unit 9

OBJECTIVES

- To learn the characteristics of properties gases.
- To understand the measurements and conversions of pressure, temperature, and volume.
- To learn and calculate with the gas laws the lead to the combined gas law.
- To learn and calculate the ideal gas law.
- To be able to convert between molar mass and volume using the ideal gas law.
- To be able to perform stoichiometric calculations using the gas laws.

Gas Introduction

GAS MOLECULES

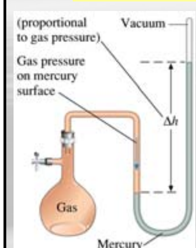


Characteristics of GASES:

1) Gases expand indefinitely and uniformly.
2) Gases have no definite shape or volume.
3) Gases can be highly compressed.
4) Gases of lower densities than liquids and solids.
5) Most non reacting gases mix uniformly.

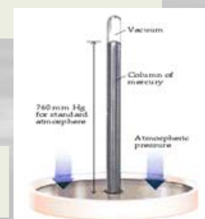
ASSOCIATIONS WITH GASES

PRESSURE (P)



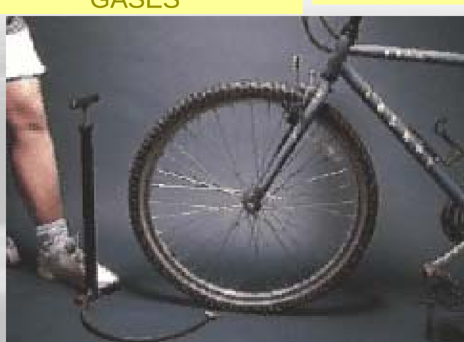
A **MANOMETER** is used to measure the pressure of a gas (or liquid) in a sealed flask.

A **BAROMETER** is used to measure atmospheric pressure.



ASSOCIATIONS WITH GASES

PRESSURE (P)



ASSOCIATIONS WITH GASES

PRESSURE (P)

Units:

1 atm = 760. torr = 760. mmHg = 101.3 kPa = 14.7 psi

Convert the pressure inside a can of pop:
4560 torr to ___ atm to ___ mmHg to ___ kPa to ___ psi

ASSOCIATIONS WITH GASES — VOLUME (V)

VOLUME (V) is the amount of space occupied by a gas.

Units: 1 L = 1000 mL = 1000 cm^3 = 1 dm^3

Convert 455 mL to cm^3 and L

ASSOCIATIONS WITH GASES — TEMPERATURE (T)

TEMPERATURE (T) a measure of the average kinetic energy of the particles in a sample of gas.

Units: $^{O}F = 1.8^{O}C + 32$ $K = 273.15 + {}^{O}C$

Calculate the temperature (in ^{O}C and Kelvin) of oxygen at $55^{O}F$.

ASSOCIATIONS WITH GASES — AMOUNT OF SUBSTANCE (n)

AMOUNT OF SUBSTANCE (n) the amount of gas present.

Units: moles 1 mol == 22.4 L at STP

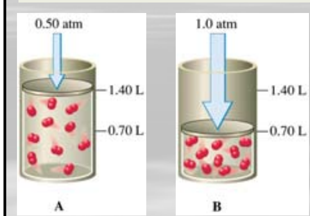
STP = STANDARD TEMPERATURE AT PRESSURE
TEMPERATURE = 0ºC, PRESSURE = 1 atm

Calculate the moles of 45.6 grams nitrogen dioxide at STP.

GAS LAWS — BOYLE'S LAW

At constant temperature, **VOLUME** is inversely proportional to **PRESSURE**

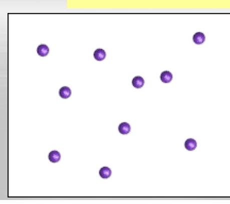
Robert Boyle, (1627-1691)

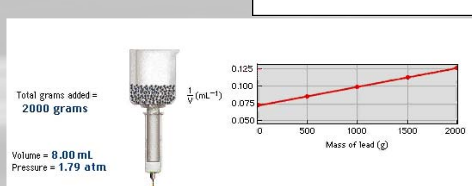


At constant temperature: $P_1V_1 = P_2V_2$

GAS LAWS — BOYLE'S LAW

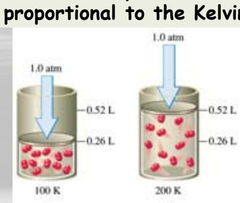
VOLUME
PRESSURE





GAS LAWS — CHARLES' LAW

At constant pressure, **VOLUME** is directly proportional to the Kelvin **TEMPERATURE**



Volume
Temp

Jacques Charles(1746-1823)

At constant pressure:

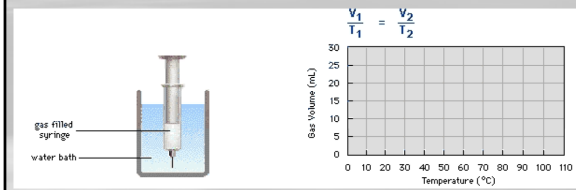
$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

GAS LAWS

CHARLES' LAW

VOLUME
TEMPERATURE

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$



GAS LAWS

GAY-LUSSAC'S LAW

At constant volume, **PRESSURE** is directly proportional to the Kelvin **TEMPERATURE**

Gay-Lussac (1778-1850)

Pressure
Temp

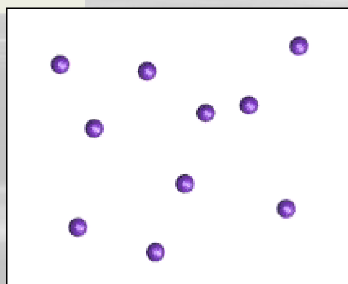
At constant volume

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

GAS LAWS

GAY-LUSSAC'S LAW

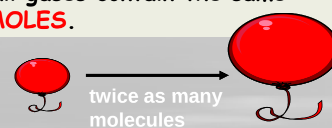
TEMPERATURE
PRESSURE



GAS LAWS

AVOGADRO'S LAW

At constant temperature and pressure equal **VOLUMES** of all gases contain the same **NUMBER OF MOLES**.



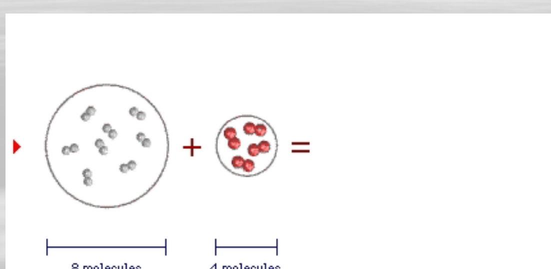
At constant temperature and pressure:

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

GAS LAWS

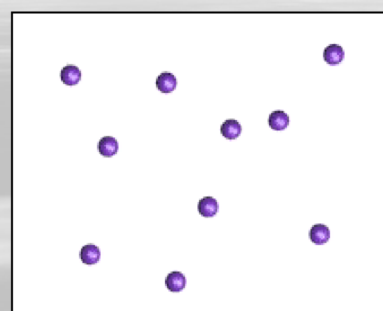
AVOGADRO'S LAW

VOLUME to MOLES



GAS LAWS

PRESSURE to MOLES



COMBINED GAS LAWS

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

More common:

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

Easiest:

$$P_1V_1T_2 = P_2V_2T_1$$

COMBINED GAS LAWS

Anesthetic gas is normally given to a patient when the room temperature is 20.0°C and the patient's temperature is 37°C. What would this temperature change do to 1.60 L of gas if the pressure and the mass stay constant?

COMBINED GAS LAWS

After a sample of xenon with a volume of 0.532 L was heated from 22.0°C to 86.0°C, its volume changed to 587 mL and its pressure became 789 torr. What must have been its initial pressure in atmospheres?

IDEAL GAS LAW

The relationship between PRESSURE, VOLUME, TEMPERATURE, and the number of MOLES of a gas.

PV = nRT (pronounced: puv-nert)

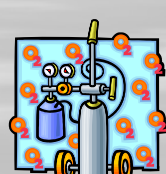
R = THE IDEAL GAS CONSTANT

$$R = 0.0821\frac{atmL}{molK}$$

Inflate a bike tire

IDEAL GAS LAW

A sample of oxygen at 24°C at 745 torr has a volume of 455 mL. How many grams of O_2 were in the sample?

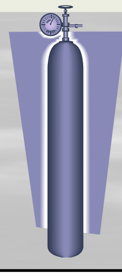


IDEAL GAS LAW
MOLECULAR MASS CALCULATIONS

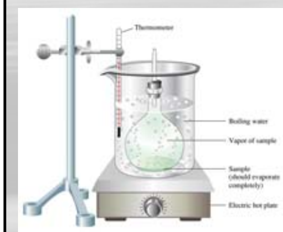
$$M_m = \frac{mRT}{PV}$$

IDEAL GAS LAW
MOLECULAR MASS CALCULATIONS

A sample of gas is collected in a 0.220 L gas bulb until its pressure reached is 0.757 atm at a temperature of 25.0oC. The sample's mass is 0.299 grams. What is the molecular mass of the gas?



IDEAL GAS LAW
DENSITY CALCULATIONS



If density $(d) = \frac{\text{mass } (m)}{\text{volume } (V)}$

$$d = \frac{M_m P}{RT}$$

IDEAL GAS LAW
DENSITY CALCULATIONS

IDEAL GAS LAW
DENSITY CALCULATIONS

What density (in g/L) does oxygen have at 24.0ºC and 742 torr?