Gases:

Units of pressure:

the pascal(Pa)(1 Pa = 1 N/m^2 = 1 $kg \cdot m^{-1} \cdot s^{-2}$)

psi(pounds per square inch)

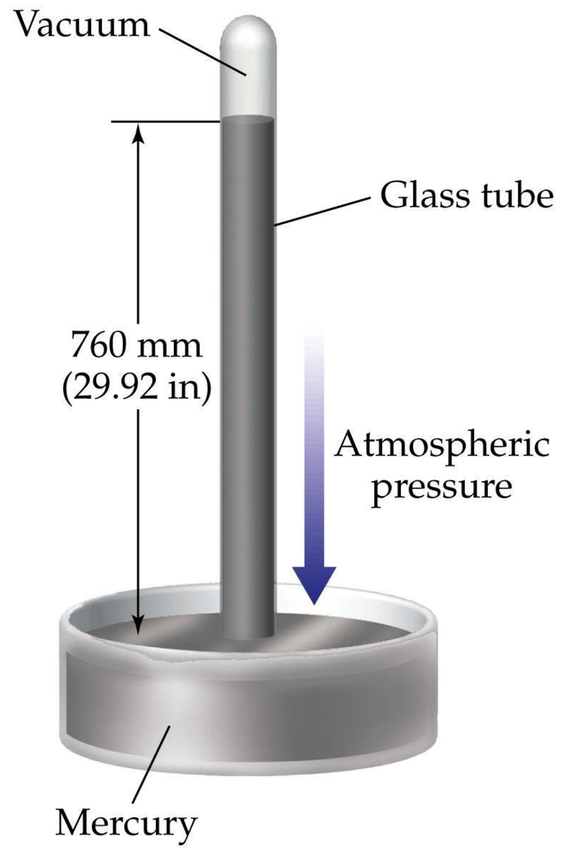
atmosphere(atm)

millimeters of mercury(mm Hg)

torr(1 torr = 1 mm Hg)

kilopascal(kPa)

Mercury Barometer:



Standard Pressure:

1 atm = 760 mm Hg = 760 torr = 101 kPa

Boyle's Law:

$$V \alpha \frac{1}{P} \qquad V = \frac{k_1}{P}$$

V: volume P: pressure

k_1: constant(depends on temperature and amount of gas)

$$\mathbf{P_i V_i = P_f V_f}$$

i: initial f: final

Ex:

If a gas occupies 360. mL under a pressure of 0.750 atm, what volume will the same gas occupy at 1.000 atm, assuming constant temperature.

Charle’s Law:

$$V \alpha T \qquad V = k_2 T$$

V: volume

T: temperature in degrees Kelvin

k_2: constant(depends on pressure and amount of gas)

$$\frac{V_i}{T_i} = \frac{V_f}{T_f}$$

i:initial **f: final**

Ex:

A gas has a volume of 79.5 mL at 45.0 °C. What volume will it have at 0.00 °C, assuming a constant presuure?

Avogadro's Law:

$$V \alpha\, n \qquad\qquad V = k_3 n$$

$$\frac{V_i}{n_i} = \frac{V_f}{n_f}$$

i:initial **f: final**

Ideal Gas Law:

$$PV = nRT$$

P: pressure(in atm)
V:volume(in litres)
T:temperature(in Kelvins)
n: moles of gas
R: Gas Constant(0.082057 $L \cdot atm \cdot K^{-1} \cdot mole^{-1}$)

Ideal Gas - A hypothetical gas that obeys the ideal gas law.

Combined Gas Law

For a fixed amount of gas.

$$\frac{P_i V_i}{T_i} = \frac{P_f V_f}{T_f}$$

Ex:

The volume of a gas is 462 mL at 35.0 °C and 1.15 atm. Calculate the volume of the gas at STP.

Standard Temperature and Pressure(STP):

T = 273 K, P = 1 atm

Can use the ideal gas law and the measured P, V, and T to determine the amount of gas.

Ex: If a 1.00 L vessel contains O_2(g) at a pressure of 12.0 atm and 25.0°C, find the number of moles of O_2(g)?

Ex:2 At what pressure will 7.00 g of N_2(g) occupy 10.0 L at 1.00°C?

Density of a Gas:

$$d = \frac{PM}{RT} \qquad M = \frac{dRT}{P}$$

d: density(g/L)
T: temperature(K)
M: molar mass(g/mole)
P: pressure(atm)
R = 0.0821 $L \cdot atm \cdot K^{-1} \cdot mole^{-1}$

Ex: Find the density of $NH_3(g)$ at 100.°C and 1.15 atm.

Kinetic Theory of Gases:

Postulates:

1. Volume of gas molecules is negligible.

2. No kinetic energy(energy of motion) is lost.

3. At a set temperature, all gas molecules have the same average kinetic energy. Average kinetic energy depends on temperature.

4. Attractive forces between gas molecules is negligible.

Real Gases:

Real gases deviate from ideal behavior at low temperatures and high pressures.

Deviation determined by measuring the ratio for one mole of a gas.

$$\frac{PV}{RT}$$

<u>Factors for Deviation From Ideal Behavior:</u>

Gas behaving ideally. $\frac{PV}{RT} = 1$

$\frac{PV}{RT} < 1$ **Intermolecular forces of attraction.**

$\frac{PV}{RT} > 1$ **Molecular Volume.**

Van der Waals Equation:

$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$$

a and b are determined experimentally.

$\frac{n^2 a}{V^2}$ **Corrects for intermolecular forces.**

nb **Corrects for the intrinsic volume of the gas molecules.**

a: indicates attraction between molecules.

b: related to size.

Speed of Gas Molecules:

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

μ_{rms} = root-mean-square speed
M = molar mass
R = 8.314 $J \cdot K^{-1} \cdot mole^{-1}$ = 8.314 $kg \cdot m^{2} \cdot s^{-2} \cdot K^{-1} \cdot mole^{-1}$

Ex: Calculate the root-mean-square speed of a $H_2(g)$ molecule at 0.00°C.

Dalton's Law of Partial Pressures:

Partial Pressure - The pressure a component of a mixture of gases would exert if alone.

Total pressure exerted by a mixture of gases that do not react is equal to the sum of the partial pressures of all the gases present.

Mole Fraction(X_a):

$$X_a = \frac{n_a}{n_{total}}$$

For a system consisting of two gases A and B.

$$X_a + X_b = 1$$

Partial Pressure:

$$P_a = X_a \cdot P_{total}$$

Ex: A mixture of 40.0 g of oxygen and 40.0 g of helium has a total pressure of 0.900 atm. Calculate the partial pressures of oxygen and helium.

Stoichiometry and Gas Volumes:

reactants → gas

Ex:

A sample of sodium azide, NaN_3(s) is heated to produce nitrogen and deploy a car airbag.

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

If the produced N_2(g) has a required volume of 230. mL at 25.0°C and 0.980 atm, how much sodium azide is required?