Gases

Air: mixture of gases

Gas	Content
Nitrogen	78.0%
Oxygen	20.9%
Argon	0.9%
Other gases i.e. carbon dioxide, neon, helium, etc.	0.2%

Kinetic Molecular Theory
- atoms/molecules are constantly moving
- when the temperature increases, the atoms/molecules move faster
- when the atoms/molecules move faster, they spread out to occupy a larger space
- atoms/molecules of gas exert a pressure on a surface when they collide with it

Pressure: the amount of force exerted on a given area

$$P = \frac{F}{A} \qquad F = PA \qquad A = \frac{F}{P}$$

P= pressure (Pa)
F= force (N)
A = area (m^2)

ex. Calculate the pressure experienced when 150 N of force is applied over 8.0 m^2.

Measuring Pressure

Barometer: used to measure atmospheric pressure

1.00 atm = 760 mm Hg = 101325 Pa

ex. 0.850 atm = _____ mm Hg = _____ Pa g

Gas Laws

(1) Dalton's Law
- the total pressure of a mixture of gases is equal to the sum of the partial pressures of all the gases in the mixture

$$P_{Total} = P_1 + P_2 + P_3 \ldots$$

ex. A mixture contains nitrogen with a partial pressure of 2.5 atm and oxygen with a partial pressure of 1.5 atm, what is the total pressure of the mixture?

ex. A mixture of air and ozone has a total pressure of 1.00×10^5 Pa. If the partial pressure of air is 9.55×10^4 Pa, what is the partial pressure of ozone?

(2) Boyle's Law
- at a constant temperature, Boyle's Law gives the relationship between changing pressure/volume

$$P_1V_1 = P_2V_2$$

P = pressure
V = volume

ex. A sample of argon gas at 0.950 atm of pressure occupies a volume of 1.50 L. What is the volume if the pressure is increased to 1.25 atm if the temperature remains constant?

ex. A sample of air under 1.50×10^5 Pa of pressure has a volume of 175 mL. What is the pressure if the volume is increased 200 mL if the temperature remains constant?

(3) Charles' Law
- at a constant pressure, Charles' Law gives the relationship between changing volume/temperature

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

V = volume
T = temperature (in Kelvin!)

ex. A sample of oxygen gas occupies 750 mL at 300 K. What volume with the gas occupy is the temperature in increased to 400 K if the pressure remains constant?

ex. A sample of chlorine gas occupies 80 mL at 30 °C. At what temperature will the volume be 45 mL, if the pressure remains constant?

(4) Gay-Lussac's Law
- at constant volume, Gay-Lussac's Law gives the relationship between changing pressure/temperature

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

P = pressure
T = temperature (in Kelvin!)

ex. A sample of nitrogen gas at 1.2 atm of pressure and 275 K is heated to 350 K. What is the pressure if the volume remains constant?

ex. A sample of xenon is under 8.9×10^4 Pa of pressure at 50 °C. What is the temperature when the pressure is increased to 1.2×10^5 Pa is the volume remains constant?

(5) Combined Gas Law
- gives the relationship between changing pressure/volume/temperature for a gas

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

P = pressure
V = volume
T = temperature (in Kelvin!)

ex. A balloon filled with helium has a volume of 4.0 L at 20 °C and 1.04 atm. What is the volume at 25 °C and 0.90 atm?

(6) Avagadro's Law
- At STP = Standard Temperature (0 °C or 273 K) and Pressure (1.00 atm or 1.01325×10^5 Pa), 1 mole of ANY gas will occupy 22.4 L

ex. What is the mass of 200 L of Neon at STP?

ex. How many particles of air are in 1.0 mL at STP?

Review: Avagadro's Law
Which of the following has a larger volume at STP?

(a) 20.2 g of carbon dioxide

(b) 2.52×10^{23} molecules of nitrogen dioxide?

(7) Ideal Gas Law
- gives the relationship between pressure/volume/temperature/moles of gas

$$PV = nRT$$

P = pressure (Pa or atm)
V = volume (L)
n = moles (mol)
R = 0.0821 L atm/mol K or 8314 L Pa/mol K (use units of given pressure to decide which value of R to use)
T = temperature (K)

ex. What is the volume of a sample containing 0.550 mol of nitrogen gas at 340 K and 1.05×10^5 Pa?

ex. What is the mass of a 50 L sample of helium at 280 K and 0.85 atm.

The Ideal Gas Law assumes that gases behave "ideally"
- Ideal Behaviour for a gas includes the following:
(1) particles of a gas are far apart relative to their size
(2) particles of a gas are in constant motion
(3) particles are not attracted to or repelled from other particles, but they do randomly collide with them
(4) When particles collide, they do not lose any energy
- Real Behaviour for a gas can deviate from Ideal Behaviour, for example, water vapour molecules can be attracted to one another

Gas Stoichiometry

ex. Nitrogen gas and hydrogen gas combine to form ammonia (NH_3).
What volume and mass of nitrogen gas and hydrogen gas (at STP) form 150 g of ammonia?

ex. Propane (C_3H_8) is combusted with oxygen gas.
(a) If 14.0 L of propane and 130 L of oxygen and are present at 0.955 atm and 15 °C, which reactant is limiting and which is excess?
(b) What would be the volume of each of the products?