

Name _____ Date _____ Period _____

Objectives

- Analyze the changes of a gas while changing pressure, temperature, volume and number of particles
- Measure atmospheric pressure, convert between pressure units and calculate gas laws

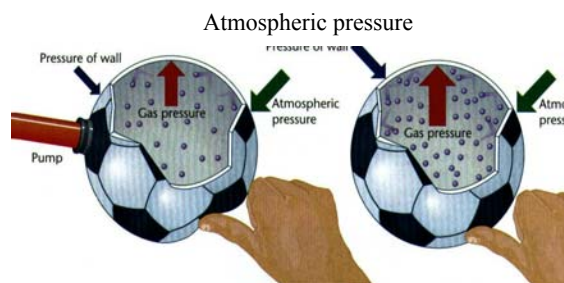
11.1 Gas pressure**Remember? Basic Assumptions of The Kinetic Theory of Gases:**

- Gases are composed of tiny particles (atoms or molecules), with insignificant volume. In-between is empty space without attractive forces between them. This explains the "Compressibility of Gases"
- Gas particles constantly travel fast in a straight line until they collide with one another or with the container wall.
- All collisions are perfectly elastic, which means that the total kinetic energy remains the same.

Gas pressure is a force exerted by a gas per surface area of the container wall.

Gas molecules are in constant motion and exert pressure when they strike the walls of a container, for example inside the ball to the right, which is counter-balanced by the outside atmospheric pressure. Pumping more air into the ball increases the number of molecules inside, which increases the number of collisions with the inner wall. More collisions = more pressure = firmer and bouncier ball.

The ball that contains more air has higher pressure and greater mass. Doubling the number of gas particles in a container doubles the pressure.



Pressure is directly proportional to the number of particles.

Temperature and Pressure At higher temperature the gas particles have higher average kinetic energy, move faster and collide with the walls of the container more often and with greater force; so the pressure rises. The pressure is directly proportional to the Kelvin temperature. Doubling the Kelvin temperature doubles the pressure if the volume and number of particles remain constant.

Atmospheric Pressure results from collisions of air molecules with objects and decreases with elevation (barometric pressure).

Barometers measure atmospheric pressure. The original barometer type contains a column of mercury and measures the height Hg in mm (invented in the 17th century by Toricelli). Newer types of barometers work without mercury.

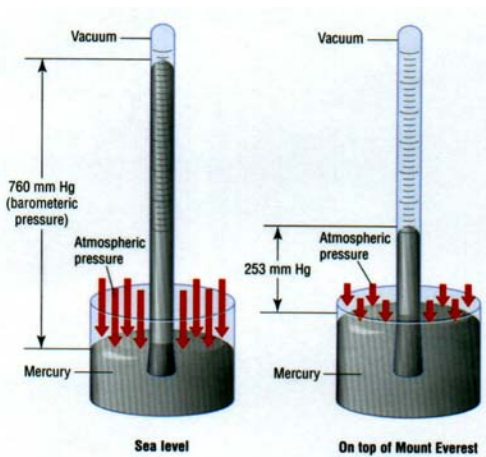
The SI unit for pressure is Pascal (Pa)

Standard Atmospheric Pressure is 101.3 kilopascals (kPa)

Older units for pressure are millimeter of mercury (mm Hg) and atmospheres (atm). The English unit for pressure is pounds per square inch (psi).

101.3 kPa = 760 mm Hg = 1 atm = 14.7 psi

For **unit conversions** see separate worksheet or book p.379.



Standard temperature and pressure (STP) = 0 °C and 1 atm or in SI units: 273 K and 101.3 kPa

A **pressure gauge** measures pressure in closed containers, for example tires. Some pressure gauges are not calibrated to the fact that they also work against the outside atmospheric pressure. To calculate the actual pressure in the tire you may have to add 14.7 psi to the pressure reading (= absolute pressure or psi a)

Example: 44.0 psi + 14.7 psi = 59 psi. (or 59 psi a)

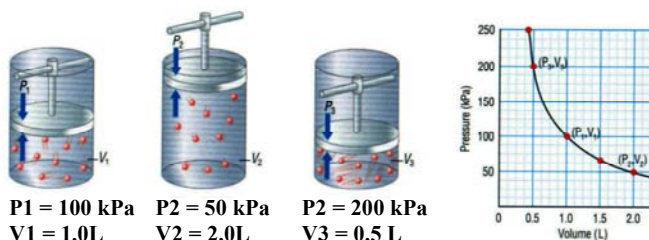
11.2 The Gas Laws

Boyle’s Law: Pressure and Volume

If the volume is decreases by half, the pressure is doubled (pressure and volume are inversely proportional).

For a given mass of gas at constant temperature, the volume of the gas varies inversely with pressure.

$$P_1 \times V_1 = P_2 \times V_2$$



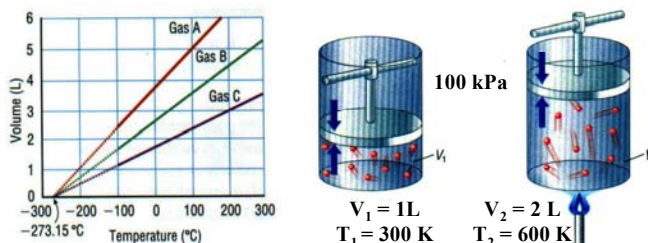
$$P_1 \times V_1 = P_2 \times V_2 = P_3 \times V_3 = 100 \text{ (Lx kPa)}$$

Kinetic explanation: When the volume is reduced, the same number of gas particles have a shortened distance between collisions, thus each hits the container wall more often. In addition, by compressing the gas particles into a smaller space, the frequency of collisions per square unit of the (remaining) container wall increases.

Charles’s Law

The volume of a gas is directly proportional to its Kelvin temperature if pressure and mass are kept constant. Doubling the Kelvin temperature doubles the volume.

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



Kinetic explanation: When an expandable container is heated, the average kinetic energy of the particles increases. More and more powerful collisions force the container to expand (which keeps the pressure constant).

Absolute Zero Jacques Charles (1746 - 1823) observed that at constant pressure the graph of gas volume versus temperature yields a straight line. The lines extended (extrapolated) to zero volume all intersect the temperature axis at the same point, -273.15 °C, identified by Lord Kelvin as absolute zero, the lowest possible temperature at which the average kinetic energy of gas particles would be zero (zero Kelvin, 0 K).

The Combined Gas Law

Boyle’s law can only be used if the temperature is unchanged, Charles’ law only if the pressure is constant. The combined gas law can be used if pressure, temperature and volume all change at the same time.

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

For calculations using Boyle’s, Charles’ or the combined Gas Laws see separate worksheet or textbook 11.2.

Summary of factors affecting gas pressure

Amount of Gas

The pressure increases proportional to the number of particles pumped into a closed rigid container. Twice the number of gas particles doubles the pressure.

Volume

1/2 the volume doubles the pressure and visa versus

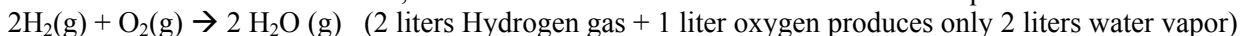
Temperature

Doubling Kelvin temperature (\approx average kinetic energy of gas particles) doubles the pressure.

How does the pressure change when only one variable changes? (+ increase or - decrease)

Variables + or -	Pressure + or -
+ # of particles	
- # of particles	
+ volume	
- volume	
+ temperature	
- temperature	

The law of combining gas volumes states that is chemical reactions involving gases, the ratio of the gas volumes is a small whole number, which reflect the coefficients in the balanced equation.



Avogadro’s Principle

Equal volumes of gases at the same temperature and pressure contain equal numbers of particles.