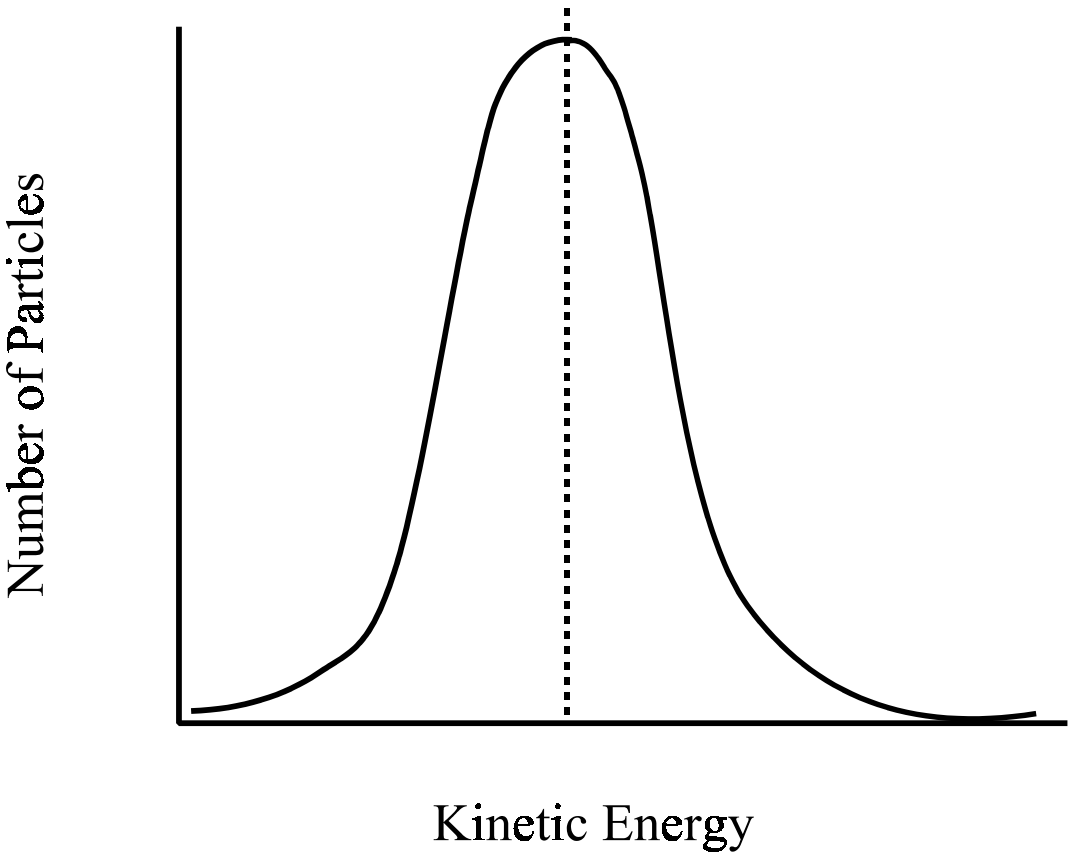
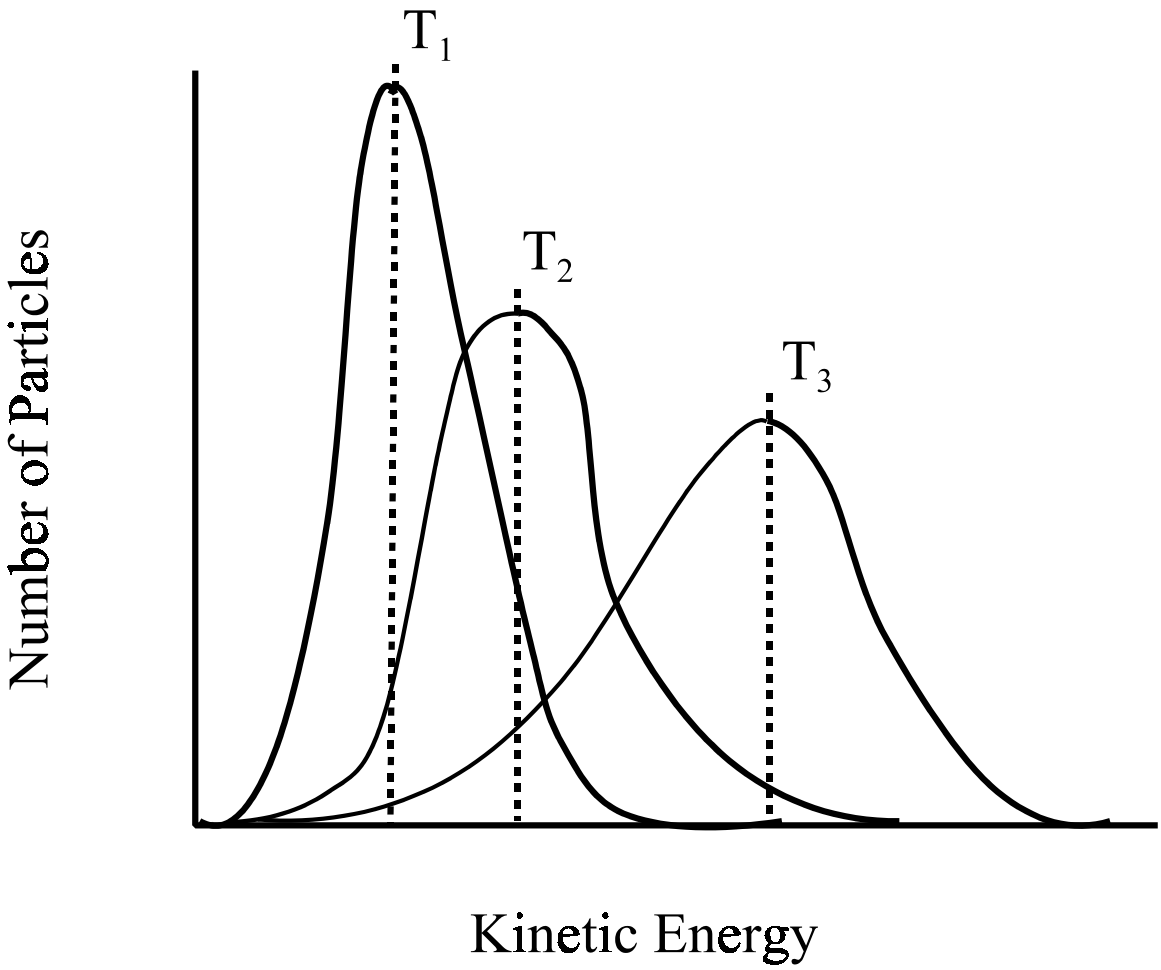
Temperature

The temperature of a system of molecules is a measure of the average kinetic energy of those molecules. Some of the molecules in the system are moving very fast and some are moving slowing or not moving at all, but the temperature measures the average velocity.

$$\text{Temperature} \propto \text{KE} = \frac{1}{2}mv^2$$

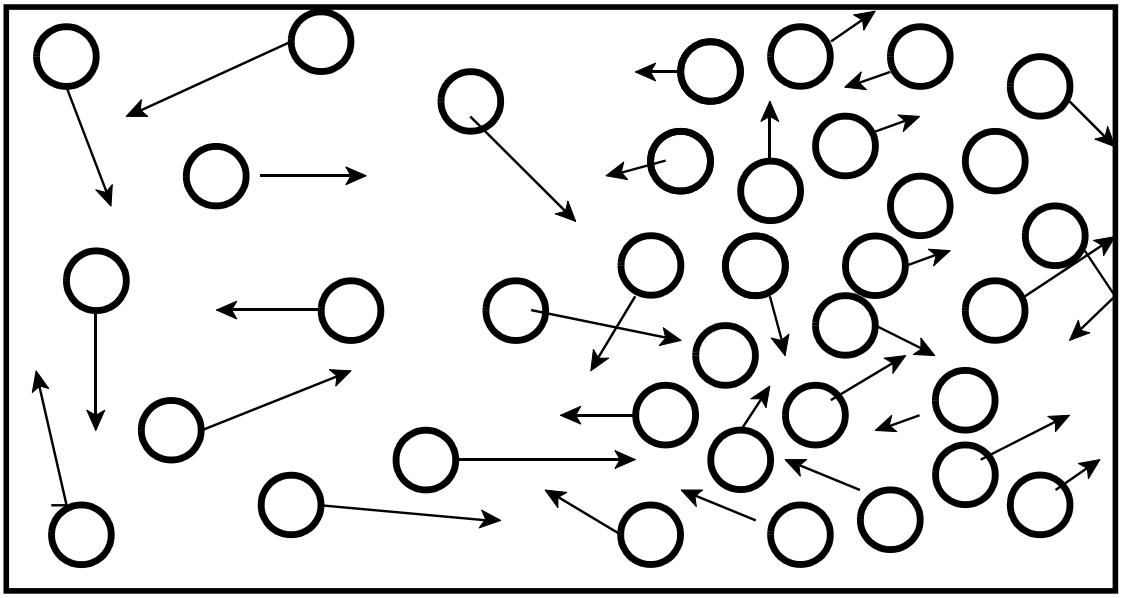


That is, the temperature measures the speed at which the molecules move. As the temperature increases, the average velocity increases. If the temperature drops, the average molecule slows down.



Heat flows spontaneously from a body at a high temperature to a body at a lower temperature.

Heat is transferred when faster moving, high temperature molecules collide with slower moving, lower temperature molecules. As a result of the collision, the slower moving molecules speed up and thus heat up.

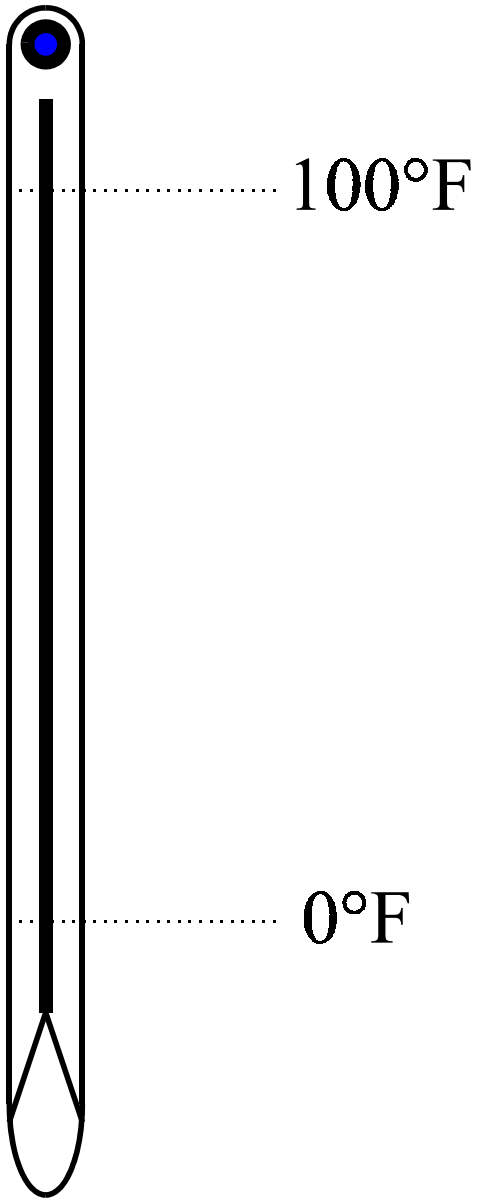


High temperature particles move rapidly and are far apart

Low temperature particles move slowly and are close together

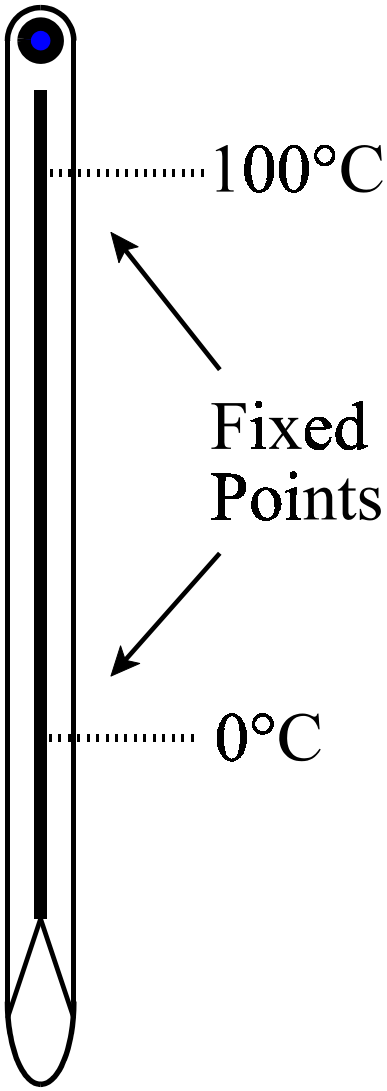
Temperatures are measured by thermometers. The first thermometer was created by Gabriel Fahrenheit (1686-1736). Fahrenheit noticed that the level of some mercury in a tube rose and fell according to how hot or cold it was in his laboratory.

Fahrenheit used his body temperature (100°) and the lowest temperature he could achieve by mixing ice and salt (0°) as the fixed points on his thermometer. The distance between these two points was then divided into 100 equal parts.



Anders Celsius (1701-1744) studied Fahrenheit's work and devised a thermometer using the boiling point and freezing point of water as his fixed points. The freezing point and boiling points of water are more reproducible than Fahrenheit's body temperature and freezing point of an ice salt mixture.

Celsius divided the distance between the 0° mark and the 100° mark into 100 equal divisions. Each division equals 1°C.

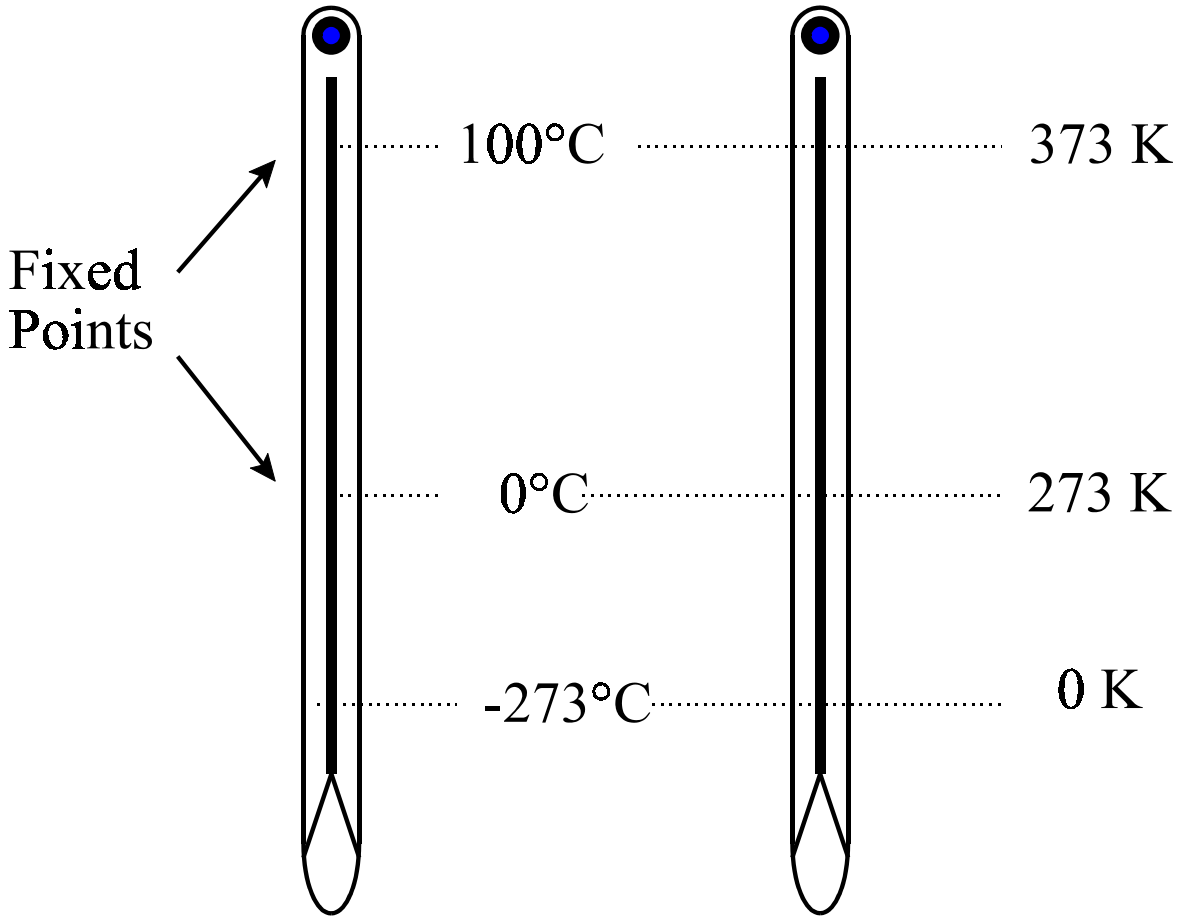


The equation to convert from degrees Celsius to degrees Fahrenheit is

$$°F = (°C \times \frac{9}{5}) + 32$$

William Thomson (1824-1907), known as Lord Kelvin, first suggested a temperature scale which was based on the Celsius scale but does not have negative numbers. He achieved this by setting the lowest possible temperature as “0."

The Kelvin scale uses the same fixed points, the boiling point and freezing point of water, and the same divisions as the Celsius scale.



Absolute Zero

Lord Kelvin's zero point became known as "**Absolute Zero.**" At absolute zero, all molecular motion ceases.

Absolute zero is defined as the lowest possible temperature and is believed to be -273.15°C.

STANDARD TEMPERATURE

Standard temperature is defined as 0°C or 273 K.

0°C is chosen as standard temperature because it is easily obtained and maintained. The sample need only to immersed in a container of melting ice and the temperature is maintained at a constant 0°C.

Converting between °C and °K

The equation used to convert from degrees Celsius to degrees Kelvin is

$$°K = °C + 273.$$

Convert 100°C to degrees Kelvin.

$$°K = 100°C + 273 = 373\ K$$

Convert from 200 K to °C.

$$°C = 200\ K - 273 = -73\ °C$$

Perform the following conversions:

300 K = ? °C

200 °C = ? K

25°C = ? K

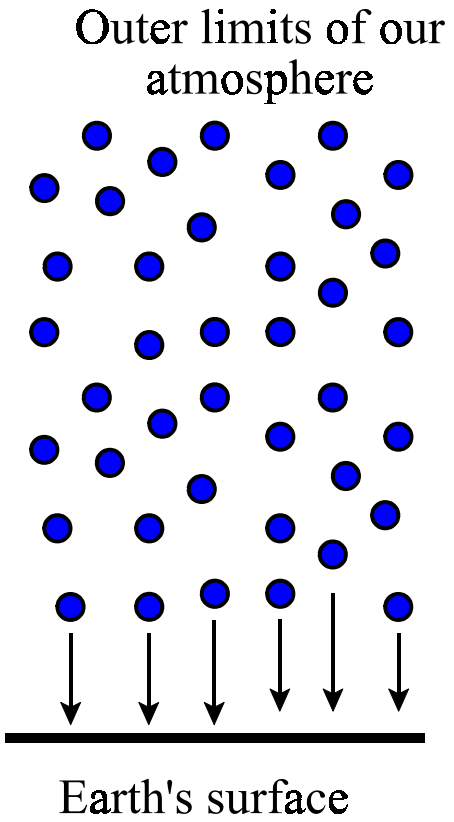
600 K = ? °C

PRESSURE

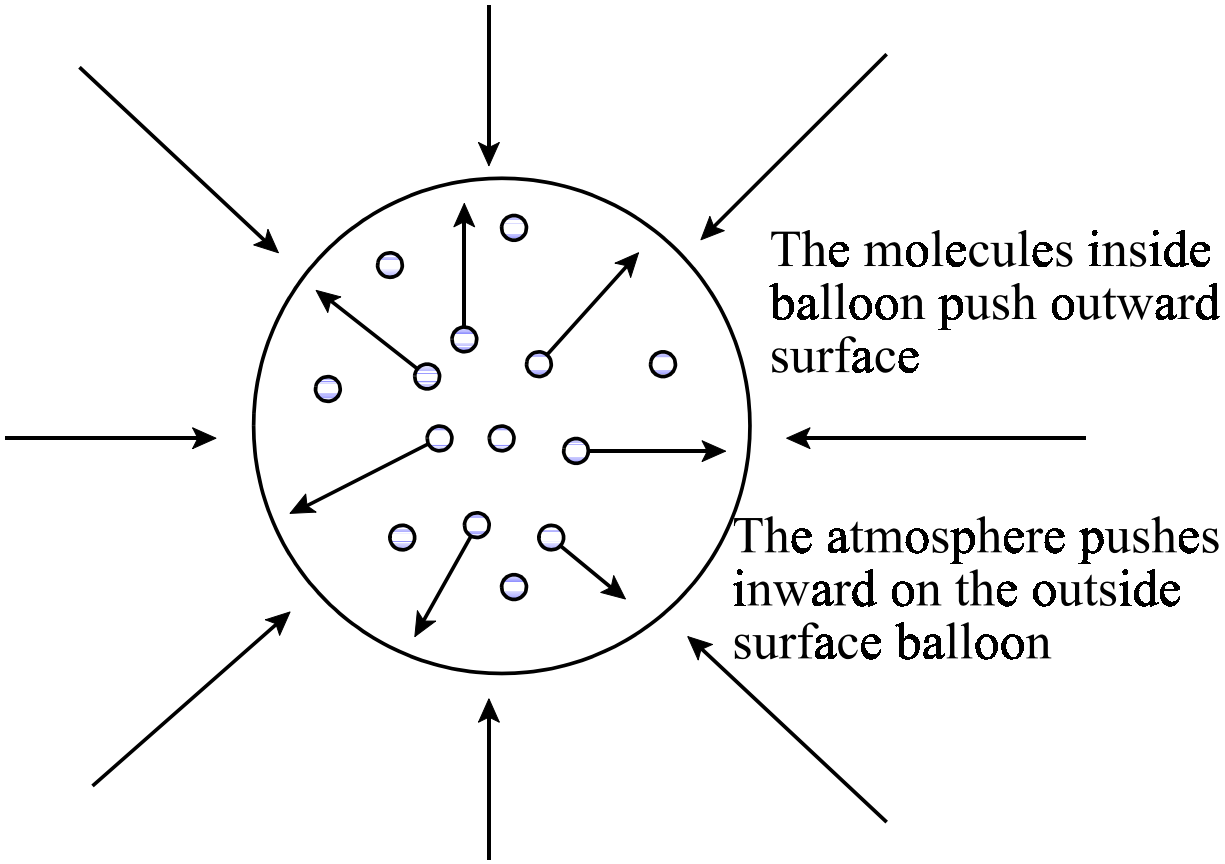
The **Pressure** is the force exerted on a given area of an object.

Gases exert a force on their container by their repeated collision with its sides. This force is dependent upon three factors; the mass of the particles, the number of particles in the container, and their velocity which is related to their temperature.

The most common pressure measured is the **atmospheric pressure.** Atmospheric pressure is created by the weight of a column of air molecules from the outer limits of our atmosphere to the earth's surface being pulled towards the surface of the earth by gravity.

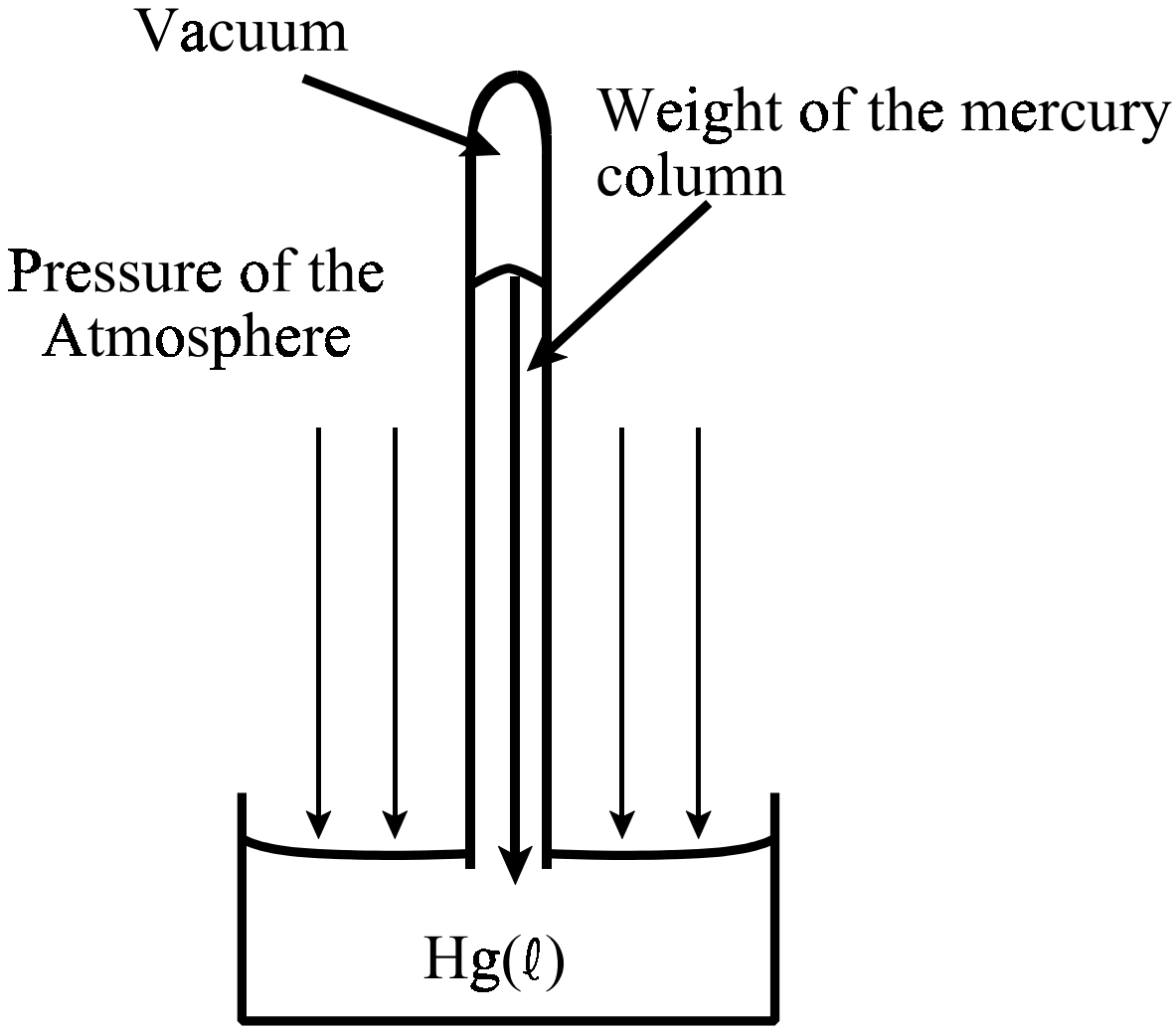


A balloon reaches a certain size because the force of the molecules pushing against the inside the balloon equals the atmospheric pressure pressing on the outside surface of the balloon. If either of these forces change, the size of the balloon changes.

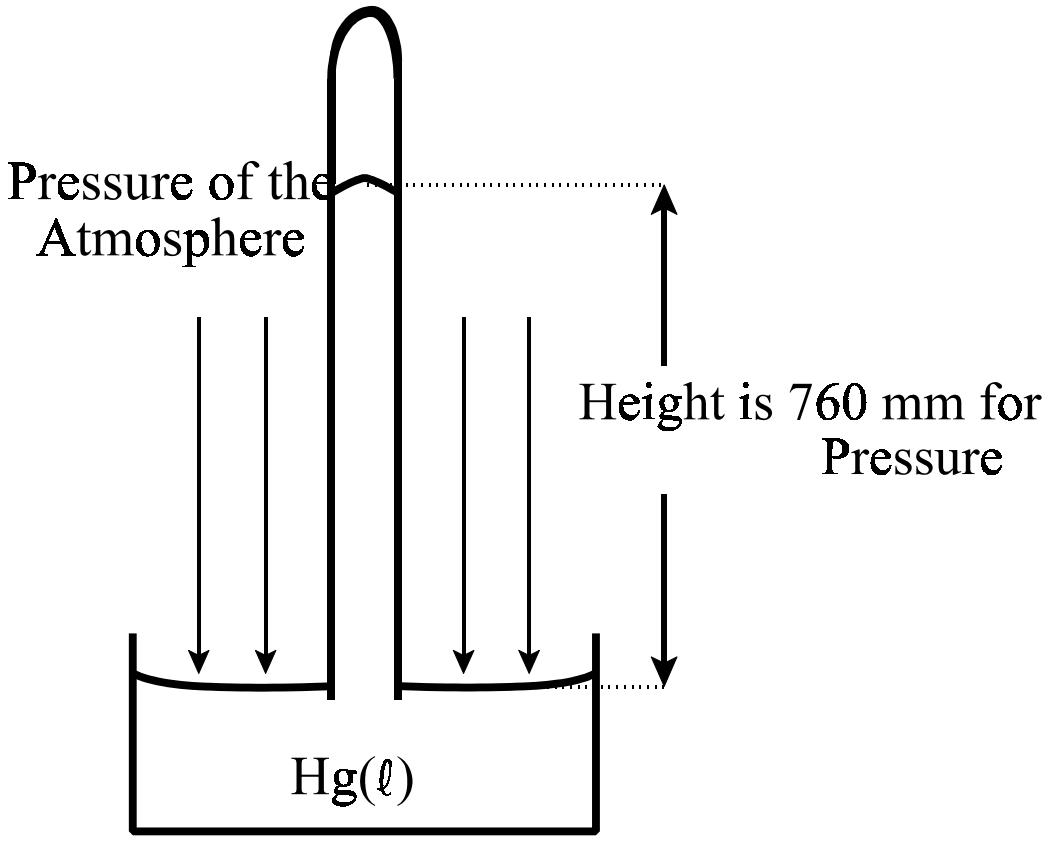


MEASURING THE PRESSURE

Atmospheric pressure is measured by means of a **barometer.** A barometer consists of a sealed glass tube filled with mercury and inverted into a container filled with mercury. The mercury in the tube will fall until the weight of the mercury in the tube equals the atmospheric pressure.



UNITS OF PRESSURE

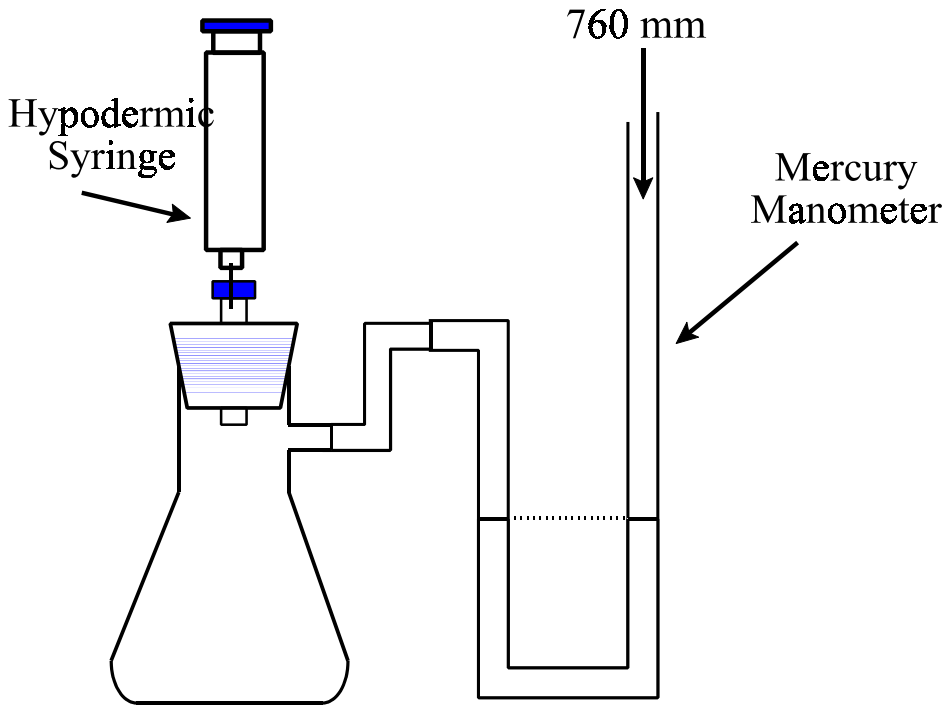


The standard unit of pressure is the **atmosphere, atm**. A standard atmosphere is equivalent to the force exerted by a column of mercury, 760 mm high. Another unit, a mm of Hg, is called "**torr**" after Evangelista Torricelli (1608-1647), the inventor of the mercury barometer.

$$1 \text{ atm} = 760 \text{ mm Hg} = 14.7 \text{ lb/in}^2$$
$$1 \text{ atm} = 760 \text{ torr} = 101.325 \text{ kPa}$$

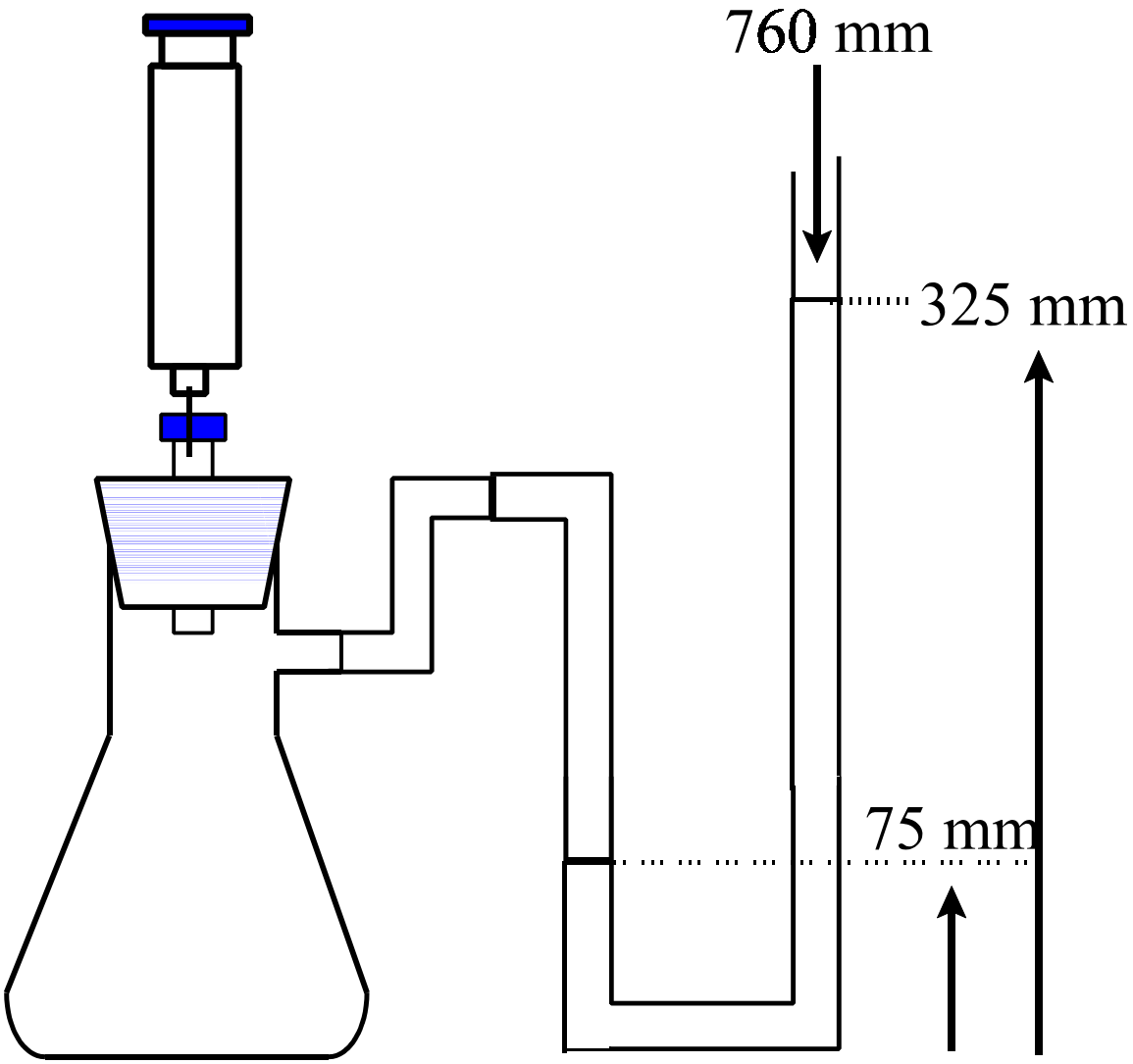
Mercury Manometer

Another method of measuring pressure is with a mercury manometer. Any change of pressure inside the flask changes the level of the mercury in the manometer. Since the liquid inside the manometer is mercury, the change in height measures the change in pressure directly.
What is the pressure inside the flask?



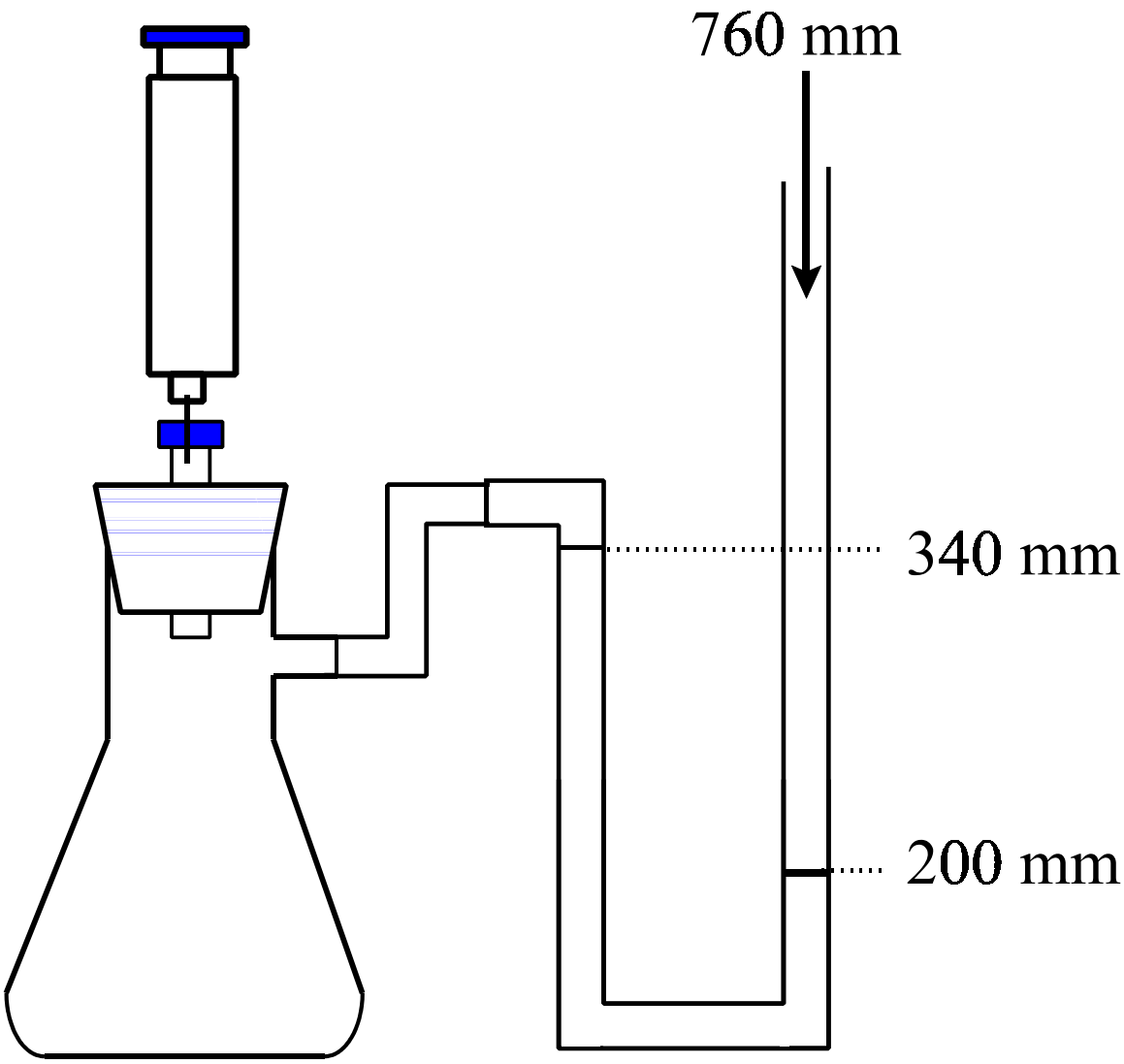
P (inside) = P (outside)
P (inside flask) = P (atm)

What is the pressure inside the flask?



P (inside flask) = P (outside)
P (inside flask) = P (atm) + P (Hg column)
P (inside flask) = 760 mm + (325 mm -75 mm)
P (inside flask) = 1010 mm Hg

What is the pressure inside the flask?



P (inside flask) = P (outside)
P (inside flask) + P (Hg column) = P (atm)
P (inside flask) + (340 mm - 200 mm)= 760 mm
P (inside flask) = 620 mm

STP

Standard Temperature and Pressure abbreviated **"STP"** is defined as a temperature of 273 K (0°C) and one atmosphere (760 torr) pressure.

Where,

Standard temperature = 0°C or 273 K

Standard Pressure = 1 atmosphere or 760 torr