

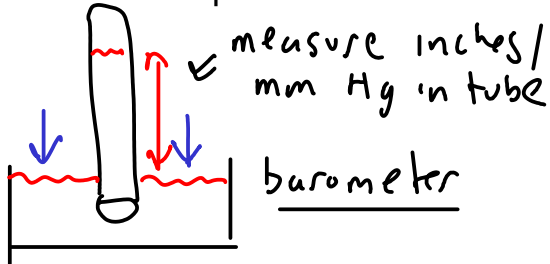
GASES

- Gases differ from the other two phases of matter in many ways:
 - They have very low viscosity (resistance to flow), so they flow from one place to another very easily.
 - They will take the volume of their container. In other words, gas volumes are variable.
 - They are the least dense of all three phases.
 - Most gases are transparent, and many are invisible.
 - Gases show a much larger change of volume on heating or cooling than the other phases.
- ↙ thermal expansion!
- Gases react to changes in temperature and pressure in a very similar way. This reaction often does not depend on what the gas is actually made of.

KINETIC THEORY

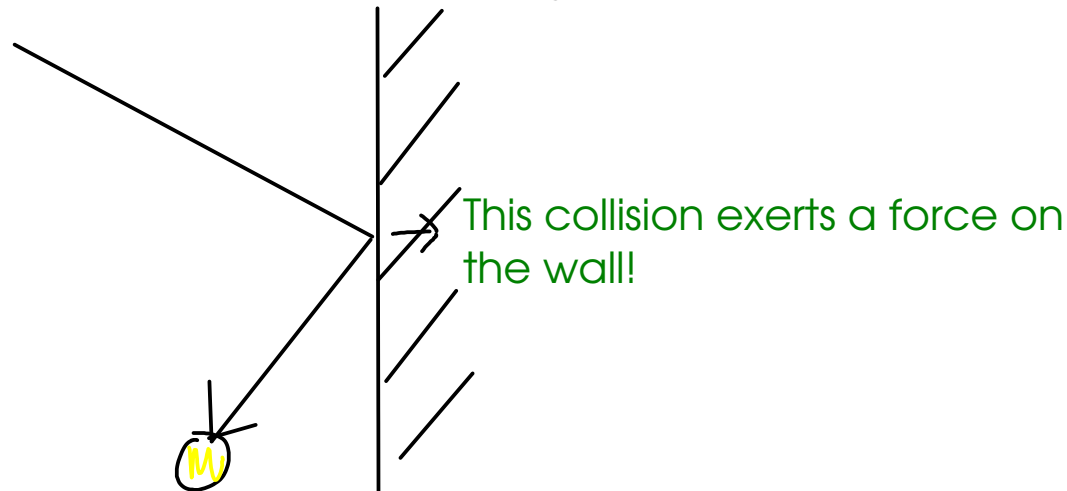
- is a way to explain the behavior of gases.
 - views the properties of gases as arising from them being molecules in motion.
-

- Pressure: force per unit area. Units: Pascal, bar, mm Hg, in Hg, atm, etc.



$$760 \text{ mm Hg} = 1 \text{ atm}$$

- According to kinetic theory, pressure is caused by collisions of gas molecules with each other and the walls of the container the gas is in.



136- Temperature:

- a measure of the average kinetic energy of the molecules of the gas

$$E_k = \frac{1}{2} m v^2$$

velocity
mass

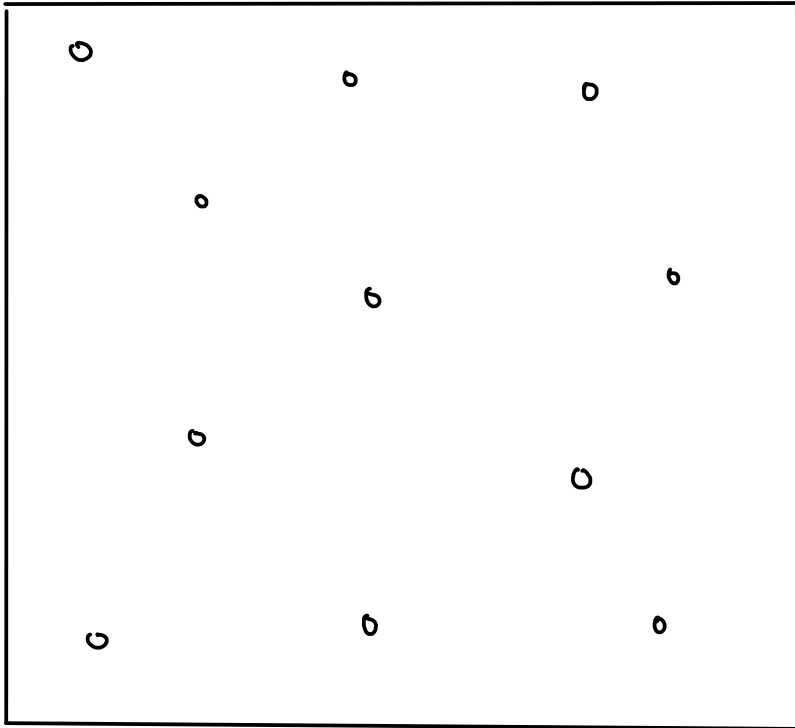
- The faster the gas molecules move, the higher the temperature!
- The temperature scales used when working with gases are ABSOLUTE scales.
 - ABSOLUTE: scales which have no values less than zero.
 - KELVIN: metric absolute temperature scale.

Quick comparison of temperature scales!

$$K = 273.15 + ^\circ C$$

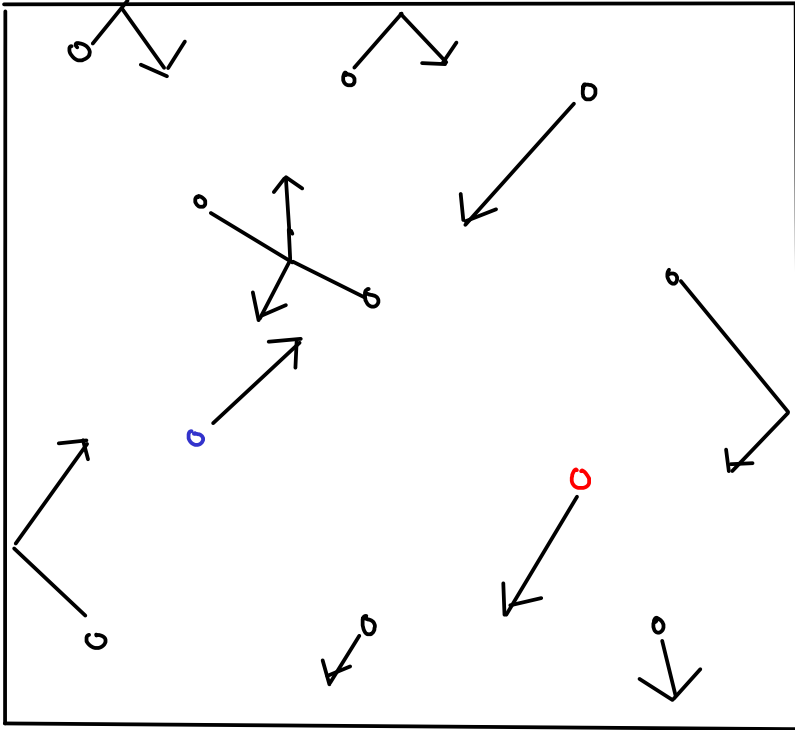
212	100	373	Water boils
77	25	298	Room temperature
32	0	273	Water freezes
-460	-273	0	Absolute zero!
$^{\circ}F$	$^{\circ}C$	K	

THE KINETIC PICTURE OF GASES



LOW DENSITY!

① Gas molecules are small compared to the space between the gas molecules!



- ② Gas molecules are constantly in motion. They move in straight lines in random directions and with various speeds.
- ③ Attractive and repulsive forces between gas molecules are so small that they can be neglected except in a collision.
 - Each gas molecule behaves independently of the others.
- ④ Collisions between gas molecules and each other or the walls are ELASTIC.

⑤ The average kinetic energy of gas molecules is proportional to the absolute temperature.

How does this picture explain the properties of gases?

- Gases expanding to fill their container? Agrees with kinetic picture, since gas molecules are independent
- Thermal expansion of gas at constant pressure? Agrees, because the container has to EXPAND to keep the pressure (from collisions) constant when the gas molecules move faster.
- Pressure increases with temperature at constant volume: Agrees, because the number and force of collisions increases with molecular speed.

GAS LAWS

- were derived by experiment long before kinetic theory, but agree with the kinetic picture!

Boyle's Law: $PV = \text{constant}$] True at constant temperature

$$P_1 V_1 = \text{constant} \qquad P_2 V_2 = \text{constant}$$

$$\downarrow \qquad \downarrow$$

$$\boxed{P_1 V_1 = P_2 V_2} \quad \text{True at constant temperature}$$

Charles's Law:

$$\frac{V}{T} = \text{constant} \quad \text{] True at constant pressure, and using ABSOLUTE temperature}$$

$$\downarrow$$

$$\boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}} \quad \text{True at constant pressure, and using ABSOLUTE temperature}$$

140 Combined gas law:

$$\frac{PV}{T} = \text{constant}$$

Must use ABSOLUTE temperature units!

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

Must use ABSOLUTE temperature units!

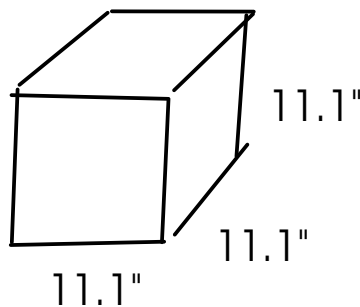
↑ amount (moles) of gas must be constant!

Avogadro's law:

- a mole of any gas at the same conditions has the same volume.

1 mol gas molecules @ 0°C and 1 atm
volume = 22.4 L

"STP"
Standard
Temperature
and
Pressure



= 22.4 L

Ideal gas law:

$$\frac{PV}{T} = \text{constant}$$

... but this constant actually depends on the amount of gas!

$$= n \times "R"$$

The ideal gas constant,

$$0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

... combining these together ...

$$\frac{PV}{T} = nR$$



$$PV = nRT$$

P = pressure atm

V = volume L

T = ABSOLUTE temperature K

R = ideal gas constant

n = number of moles of gas molecules

A balloon is taken from a room where the temperature is 27.0 C to a freezer where the temperature is -5.0 C. If the balloon has a volume of 3.5 L in the 27.0 C room, what is the volume of the balloon in the freezer. Assume pressure is constant.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}; P \text{ constant} \rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$V_1 = 3.5 \text{ L} \quad V_2 = ?$$

$$T_1 = 27.0^\circ\text{C} = 300.2 \text{ K} \quad T_2 = -5.0^\circ\text{C} = 268.2 \text{ K}$$

$$\frac{(3.5 \text{ L})}{(300.2 \text{ K})} = \frac{V_2}{(268.2 \text{ K})}; V_2 = \boxed{3.1 \text{ L}}$$

2.25 L of nitrogen gas is trapped in a piston at 25.0 C and 1.00 atm pressure. If the piston is pushed in so that the gas's volume is 1.00 L while the temperature increases to 31.0 C, what is the pressure of the gas in the piston?

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

$$P_1 = 1.00 \text{ atm}$$

$$P_2 = ?$$

$$V_1 = 2.25 \text{ L}$$

$$V_2 = 1.00 \text{ L}$$

$$T_1 = 25.0^\circ\text{C} = 298.2 \text{ K}$$

$$T_2 = 31.0^\circ\text{C} = 304.2 \text{ K}$$

$$\frac{(1.00 \text{ atm})(2.25 \text{ L})}{(298.2 \text{ K})} = \frac{P_2 (1.00 \text{ L})}{(304.2 \text{ K})}; P_2 = \boxed{2.30 \text{ atm}}$$

Calculate the mass of 22650^{*} L of oxygen gas at 25.0 C and 1.18 atm pressure.



* Volume of a 10'x10'x8' room

- 1 - Use ideal gas equation to find MOLES gas.
- 2 - Convert moles to mass using FORMULA WEIGHT.

$$PV = nRT \quad \left| \quad P = 1.18 \text{ atm} \quad R = 0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}\right.$$

$$n = \frac{PV}{RT} \quad \left| \quad V = 22650 \text{ L}\right.$$

$$\quad \quad \quad \left| \quad T = 25.0^\circ \text{C} = 298.2 \text{ K}\right.$$

$$n = \frac{(1.18 \text{ atm})(22650 \text{ L})}{(0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(298.2 \text{ K})} = 1092.222357 \text{ mol O}_2$$

$$1092.222357 \text{ mol O}_2 \times \frac{32.00 \text{ g O}_2}{\text{mol O}_2} = \boxed{35000 \text{ g O}_2} \quad \begin{matrix} 35.0 \text{ kg} \\ \sim 77 \text{ lb} \end{matrix}$$