

Kinetic Theory of Gases

This assumes that **gases are made up of hard little balls** which are **moving very rapidly** and often **run into each other and the walls of the container**. The **energy** with which they are moving is **directly proportional to the temperature** of the molecule.

Postulates of the Kinetic Theory

1. **Gases consists of particles (atoms or molecules) in continuous, random motion.** These particles frequently with the walls of the container and with each other. The pressure exerted by the gas is do to the forces associated with wall collisions. Pressure is force per unit area.
2. **Collisions between gas particles are elastic.** The collision of two particles conserves energy. The individual energies of colliding particles may change (one may gain energy and the other lose energy), but the overall energy of the two particles before and after the collision is the same. This means that no kinetic energy is converted to hear energy and therefore the temperature of a gas insulated from its surroundings does not change.
3. **The volume occupied by gas molecules is negligibly small** compared to that of the container in which the molecules are confined. This assumption breaks down at high temperature and pressure.
4. **Their are no attractive forces between gas molecules or atoms.** The gaseous particles are do not interact in any way other than through conservative elastic collisions.
5. **The average energy of translational motion of a gas particle is directly proportional to temperature.** At a given temperature, the average energy of all the gas particles is the same. They may have different average velocities due to a difference in mass, but the kinetic energy is the same for all species at the same temperature.

$$\text{Energy} = \frac{1}{2} \mu u^2 = \frac{3}{2} \frac{RT}{N}$$

$$\text{Average speed of a particle: } \bar{u} = \left(\frac{3 RT}{MM} \right)^{\frac{1}{2}}$$

Grahams law of effusion: at a given temperature, the rate of effusion of a gas is inversely proportional to the square root of its molar mass.

$$\frac{\text{rate of effusion of A}}{\text{rate of effusion of B}} = \left(\frac{MM_B}{MM_A} \right)^{\frac{1}{2}}$$

Student Packet: 3.3: Kinetic Theory of Gases: AssessMe questions

- 1) In the kinetic theory of gases, what is the relation between temperature and average molecular velocity (u)?
- A) u is proportional to T
B) u is proportional to $1/T$
C) $\log u$ is proportional to $1/T$
D) u is proportional to $T^{1/2}$
E) I'm clueless
- 2) When a sample of oxygen gas in a closed container of constant volume is heated until its absolute temperature is doubled, which of the following is also doubled?
- A) The density of the gas.
B) The pressure of the gas.
C) The average velocity of the gas molecules.
D) The number of molecules per cm^3 .
E) I'm clueless
- 3) The diffusion time for carbon dioxide gas was 105 sec. For gas X, 126 sec were required for the same number of moles of gas to diffuse under the same conditions. What is the approximate molecular weight of the unknown gas?
- A) 31 g/mol B) 37 g/mol C) 44 g/mol D) 63 g/mol E) I'm clueless
- 4) Graham's Law refers to
- A) the boiling points of gases.
B) gaseous diffusion.
C) gas compression problems.
D) the temperature dependence of volume.
E) I'm clueless
- 5) A gas occupies a 1.5 liter container at 25°C and 2.0 atm. If the gas is transferred to a 3.0 liter container at the same temperature, what will be the new pressure?
- A) 1.0 atm B) 2.0 atm C) 3.0 atm D) 4.0 atm E) I'm clueless
- 6) What is the density of sulfur dioxide gas at STP?
- A) 0.72 g/L B) 1.43 g/L C) 2.86 g/L D) 17.7 g/L E) I'm clueless

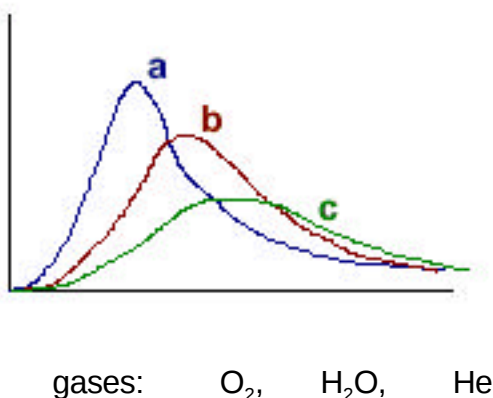
Student Packet: 3.3: Kinetic Theory of Gases: ShowMe questions

- 1) A sample of He gas at STP is transferred from a 4 L container into a 3 L container, also at STP. How does this affect:
 - a) average kinetic energy of each molecule.
 - b) average speed of each molecule.
 - c) total number of collisions within container walls.
 - d) total number of collisions with a unit area of wall.

- 2) Which has more kinetic energy: an atom of He at 500 K or an atom of Ar at 500 K? Which is moving faster?

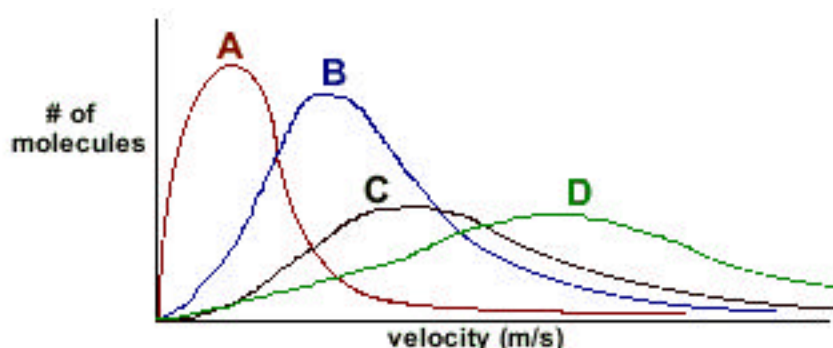
- 3) The average velocity of a N₂ molecule is 5×10^4 cm/s at 30°C. What is the average velocity of He at this same temperature and condition?

- 4) Label the following curves with the gas expected to give that particular distribution of molecular speeds. All gases are at the same temperature.



Student Packet: 3.3: Kinetic Theory of Gases: TestMe questions

- 1) A gas whose molar mass is unknown effuses through an opening at a rate of $1/5$ as fast as the effusion rate of helium. What is the molar mass of the unknown? (Both gases are at the same temperature.)
 A) 4 g/mol B) 100 g/mol C) 5 g/mol D) 20 g/mol E) 600 g/mol
- 2) The distribution of molecular speeds of O_2 is determined for a variety of temperatures. Which curve represents the distribution at the lowest temperature sampled?



- A) Curve A B) Curve B C) Curve C D) Curve D E) None of the above
- 3) What is the root-mean-square speed of an Ar molecule at 20°C ?
 A) 56 m/s B) 124 m/s C) 348 m/s D) 427 m/s E) 569 m/s
 - 4) What is the ratio of average velocities for an Ar molecule and a Cl_2 molecule at 300 K ?
 A) 0.56 B) 0.75 C) 1.33 D) 1.82 E) 2.46
 - 5) Order the following gases in order of increasing average molecular speed at 50°C : Ar, CH_4 , He, N_2 , CO_2 .
 A) CO_2 , Ar, N_2 , CH_4 , He
 B) CO_2 , Ar, CH_4 , N_2 , He
 C) Ar, CO_2 , N_2 , CH_4 , He
 D) He, CH_4 , N_2 , Ar, CO_2
 E) He, CH_4 , N_2 , CO_2 , Ar