**Real vs. Ideal Gases & the Kinetic Molecular Theory**

**Location,**[**Location**](https://www.ck12.org/c/earth-science/location)**, Location**

The behavior of a molecule depends a lot on its structure. We can have two compounds with the same number of atoms and yet they act very differently. Ethanol (C2H5OH) is a clear [liquid](https://www.ck12.org/c/physical-science/liquid) that has a [boiling](https://www.ck12.org/c/chemistry/boiling) point of about 79°C. Dimethylether (CH3OCH3) has the same number of carbons, hydrogens, and oxygens, but boils at a much lower [temperature](https://www.ck12.org/c/earth-science/temperature)(-25°C). The difference lies in the amount of intermolecular interaction – the attraction between molecules (strong H-bonds for ethanol, weak van der Waals force for the ether).

**Real and Ideal Gases**

An ideal [gas](https://www.ck12.org/c/physical-science/gas) is one that follows the gas laws at all conditions of [temperature](https://www.ck12.org/c/earth-science/temperature) and pressure. To do so, the gas would need to completely follow the kinetic-molecular theory.

The Kinetic molecular theory (KMT) for an ideal gas states that all gas particles:

* are in random, constant, straight-line motion
* are separated by great distances relative to their size; the volume of the gas particles is considered negligible
* have no attractive forces between them
* have collisions that may result in a transfer of energy between gas particles, but the total energy of the system remains constant

The gas particles would need to occupy zero volume and they would need to exhibit no attractive forces what so ever toward each other. Since neither of those conditions can be true, there is no such thing as an ideal gas. A **real gas** is a [gas](https://www.ck12.org/c/physical-science/gas) that does not behave according to the assumptions of the kinetic-molecular theory. Fortunately, at the conditions of [temperature](https://www.ck12.org/c/earth-science/temperature) and pressure that are normally encountered in a [laboratory](https://www.ck12.org/c/biology/laboratory), real gases tend to behave very much like ideal gases.

*Under what conditions then, do gases behave least ideally*? When a gas is put under high pressure, its molecules are forced closer together as the empty space between the particles is diminished. A decrease in the empty space means that the assumption that the volume of the particles themselves is negligible is less valid. When a gas is cooled, the decrease in [kinetic energy](https://www.ck12.org/c/chemistry/kinetic-energy) of the particles causes them to slow down. If the particles are moving at slower speeds, the attractive forces between them are stronger. Another way to view it is that continued cooling the gas will eventually turn it into a [liquid](https://www.ck12.org/c/physical-science/liquid) and a liquid is certainly not an ideal gas anymore (see liquid nitrogen in **Figure** [below](https://www.ck12.org/c/chemistry/real-and-ideal-gases/lesson/Real-and-Ideal-Gases-CHEM/?collectionCreatorID=3&conceptCollectionHandle=chemistry-%3A%3A-real-and-ideal-gases&collectionHandle=chemistry#x-ck12-OTgwNDUtMTM2Mzc1NTg3Ni0zNy01Ny0z)). In summary, a real gas deviates most from an ideal gas at low temperatures and high pressures. Gases are most ideal at high temperature and low pressure.

Nitrogen gas that has been cooled to 77 K has turned to a liquid and must be stored in a vacuum insulated container to prevent it from rapidly vaporizing.

The ideality of a gas also depends on the strength and type of intermolecular attractive forces that exist between the particles. Gases whose attractive forces are weak are more ideal than those with strong attractive forces. At the same temperature and pressure, neon is more ideal than [water](https://www.ck12.org/c/biology/water) vapor because neon’s atoms are only attracted by weak dispersion forces, while water vapor’s molecules are attracted by relatively stronger hydrogen bonds. Helium is a more ideal gas than neon because its smaller number of electrons means that helium’s dispersion forces are even weaker than those of neon.

**Question Time**

**Directions:** Answer all questions **ON A SEPARATE SHEET OF PAPER!** All multiple-choice questions must have an explanation as to why you chose the answer. *No explanation, no credit for those questions*.

**Review**

1. What does the KMT state?
2. Why doesn’t an ideal gas actually exist?
3. What becomes more significant as the pressure increases?
4. Do the attractive forces between gas particles become more prominent at higher or lower temperatures?
5. Would HCl gas be more or less ideal than helium?
6. What is an ideal gas?
7. What is a real gas?
8. Under what conditions does a gas behave most like an ideal gas?
9. Under what conditions does a gas behave least like an ideal gas?

**Regents Questions:**

1. Under which conditions of temperature and pressure does carbon dioxide behave most like an ideal gas?
	1. Low temperature and low pressure
	2. Low temperature and high pressure
	3. High temperature and low pressure
	4. High temperature and high pressure
2. Under which conditions of temperature and pressure does a sample of neon behave most like an idea gas?
	1. 100K and 0.25 atm
	2. 100K and 25 atm
	3. 400K and 0.25 atm
	4. 400K and 25 atm
3. A real gas differs form an ideal gas because the molecules of a real gas have
	1. Some volume and no attraction for each other
	2. Some volume and some attraction for each other
	3. No volume and no attraction for each other
	4. No volume and come attraction for each other
4. Under the same conditions of temperature and pressure, which of the following gases would behave most like an ideal gas?
	1. He*(g)*
	2. NH3*(g)*
	3. Cl2*(g)*
	4. CO2*(g)*
5. The kinetic molecular theory states that all particles of an ideal gas are
	1. Colliding without transferring energy
	2. In random, constant, straight-line motion
	3. Arranged in a regular geometric pattern
	4. Separated by small distances relative to their size
6. A sample of chlorine gas is at 300K and 1.00 atmosphere. At which temperature and pressure would the sample behave more like an ideal gas?
	1. 0k and 1.0 atm
	2. 150K and. 0.50 atm
	3. 273K and 1.00 atm
	4. 600K and 0.50 atm