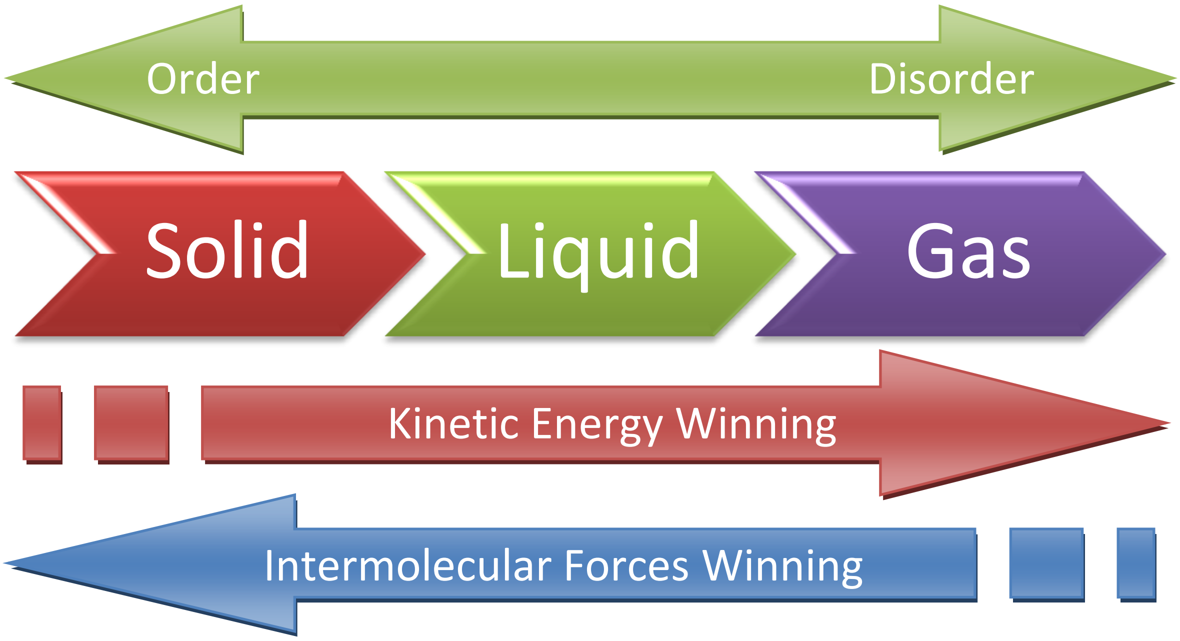
Chapter 4 (AS-Level)

States of Matter

The three states:



Intermolecular forces tend to bring order to molecules, while kinetic energy brings disorder.

Brownian motion occurs in only gases and liquids.

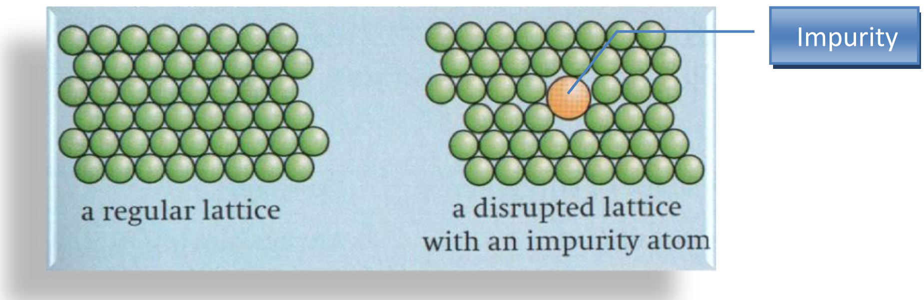
How much order is there in liquid?

There is short-range order and long-range disorder.

Arrangement of Particles in Solids

There are different types of solids:

- Giant Metallic (Metals)
- Giant Ionic (Ionic Compounds)
- Giant Covalent (Graphite, SiO_2 diamond)
- Simple Covalent (I_2)



Difference in properties of solids, liquids, and gases:

They are due to differences in spacing and speed of particles.

Spacing

In gases, particles are much further apart than in liquids and solids. There is little difference between liquids and solids.

- Both (solids and liquids) are hard to compress
- Gases are poor conductors, because of the large distances between particles.
- Liquids and solids are better conductors

For heat to be transferred by particles, movement of energy of particles must be passed from one to another (by collision in gases & liquids and vibration in solids).

Metals are unique in thermal and electrical conduction due to the presence of free electrons.

	Solids	Liquids	Gases
Amount of order of arrangement of particles	Very orderly	Short-range order; longer-range disorder	Almost complete disorder
Shape	Fixed	Takes shape of the container	No Shape
Position of particles	Fixed; no movement; vibration in place	Some movement	Always moving rapidly
Spacing of particles	Close (10^{-10} m)	Close (10^{-10} m)	Far apart (10^{-8} m)
Compressibility	Very low	Very low	High
Conduction of heat	Metals & graphite conduct; others poor	Metals very good; others poor	Very poor

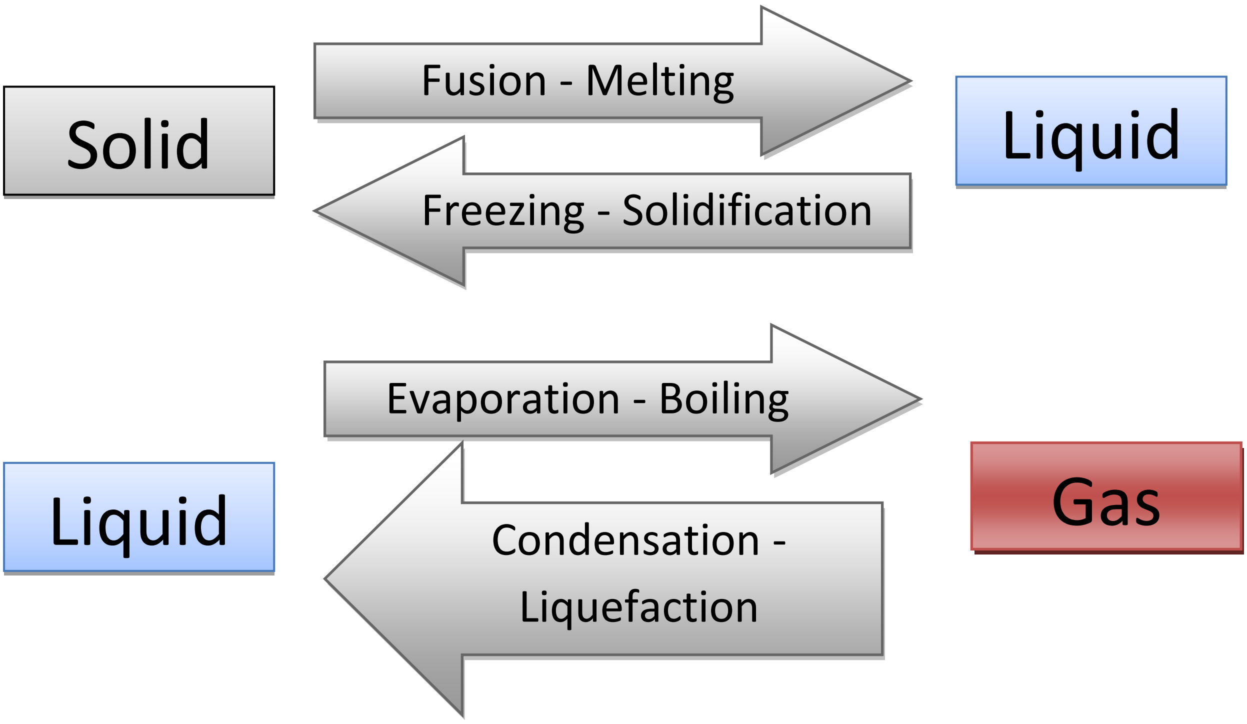
Why gases liquefy and solids melt?

By bringing molecules closer (applying pressure) and slower (reducing their temperature), intermolecular forces become sizable and overcome repulsive forces. Molecules stick together leading to liquid state.

Each gas has its characteristic T at which intermolecular forces are strong enough to win (T_c critical temperature).

For melting, heating is necessary, i.e. thermal energy to increase kinetic energy of molecules must be supplied to overcome intermolecular forces to allow molecules to be free to move.

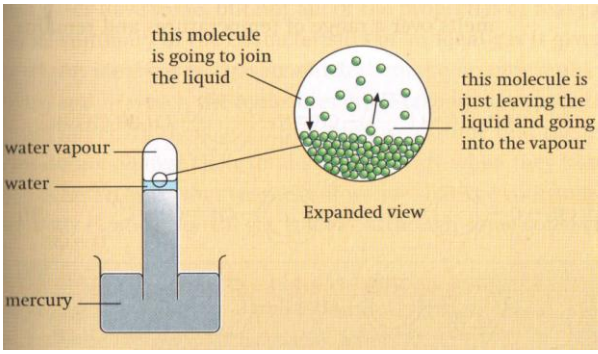
Explaining changes of state



Experiment to measure the vapor pressure of a liquid:

Read page 57. Not required for examination.

At equilibrium, the rate at which molecules leave the liquid equals the rate at which molecules join the liquid.



A liquid boils when its vapor pressure equals atmospheric pressure.

Remarkable Substances:

Liquid Crystals

These are liquids which have sufficient long-range order to behave like solids (at certain range of temperature). Usually molecules are thin, long, and not very symmetrical. Arrangement of molecules can be upset by slight changes in the surroundings.

Glass

It is in a state between solid and liquid, similar to a very viscous liquid which melts and remains viscous over a range of temperatures. The building block is tetrahedron of Silicon attached to 4 Oxygen atoms.

Real and Ideal Gases

Gases have the following properties:

- They fill the space available to them
- Expand when heated
- Exert pressure on the walls of the container
- Pressure Changes with temperature

***Real Gases:* are the gases that exist in reality, O_2, N_2, CO_2, NH_3, and etc.**

***Ideal Gases:* Are theoretical gases which do not exist in reality. Mathematical model where:**

- ***Molecules are regarded as points (do not occupy space)***
- ***Molecules do not attract each other (no intermolecular forces)***
- ***Their collisions are perfectly elastic***

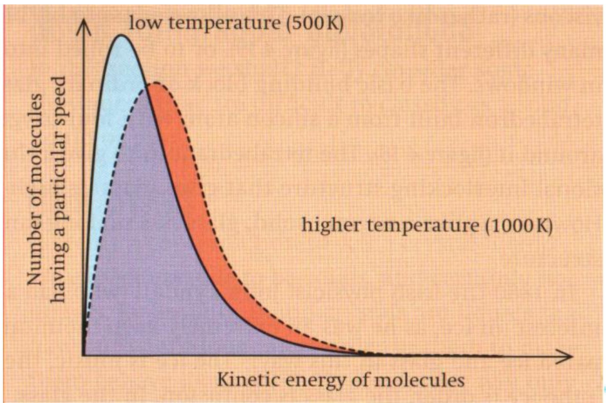
The Kinetic Theory of Gases

Gases consist of molecules (or atoms in noble gases) in a state of constant random motion.

- The pressure they exert is due to collisions with the walls of container.
- The molecules travel in straight lines between collusions with one another and with the walls of container.
- The total kinetic energy of the molecules does not change in collisions i.e. KE is conserved (elastic collisions)

Average Molecular Speed at the room temperature is of the order of 500 m/s. The speed is faster in lighter molecules (e.g. H_2 1500 m/s). The speed is slower in heavier molecules (e.g. CO_2 350 m/s).

How the distribution of the kinetic energy of the molecules in a gas changes with temperature.

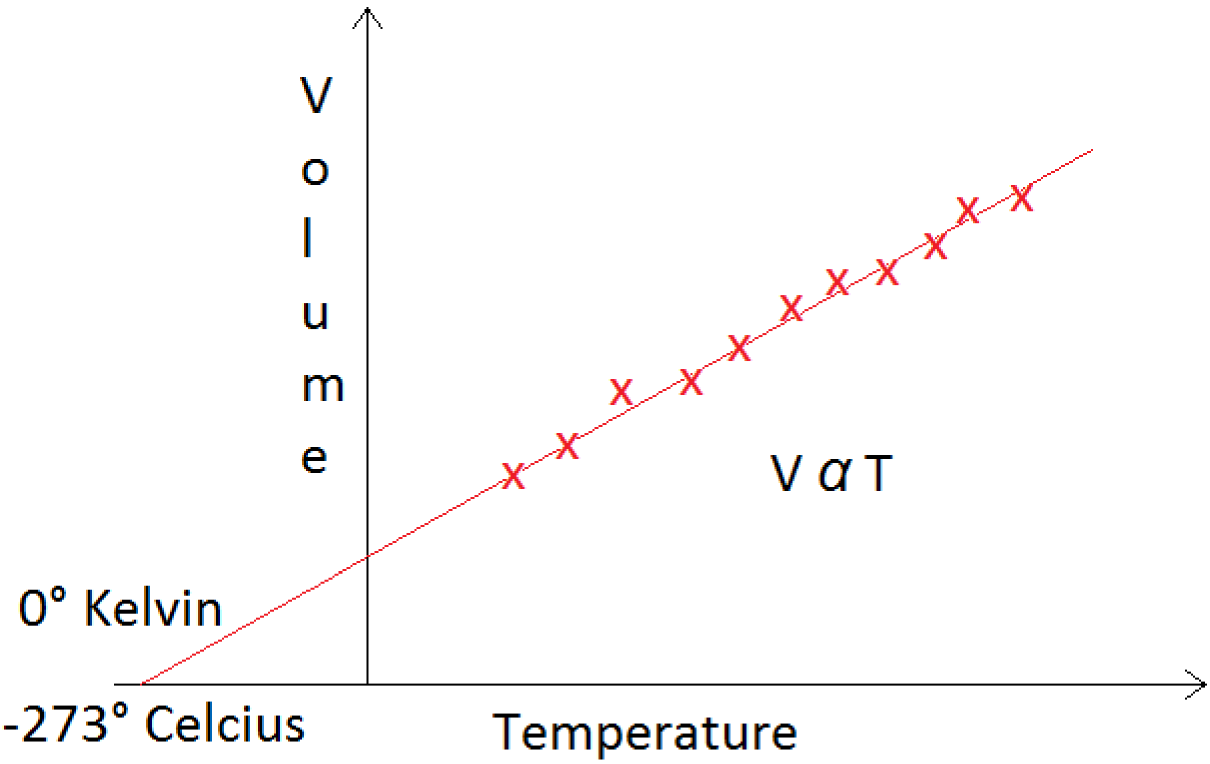


The Pressure & Volume of Ideal Gas

Pressure is due to collisions on the walls of container due to continuous random motion. It depends on three factors.

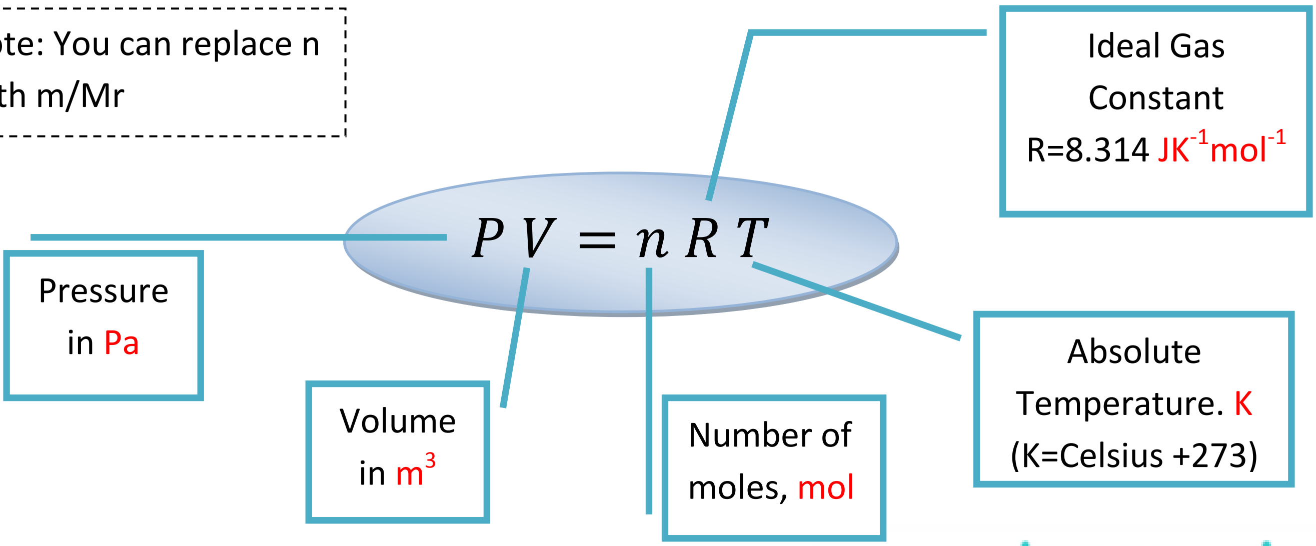
1. The number of molecules per unit volume (i.e. concentration), the higher the number of particles → higher the number of collisions → the more pressure.
2. The mass of molecules
3. The speed of molecules

The volume of a given amount of gas at a fixed pressure increases as temperature increases and decreases as temperature drops. The volume is directly proportional to temperature as in the graph.



The Ideal Gas Law

Note: You can replace n with m/Mr



Behavior of Real Gases

Real Molecules → Occupy Space → Less volume than ideal volume

Real Molecules → Attract each other → Less pressure than ideal value

Real Gas Equation

Real gases approach ideal gas behavior quite away from conditions of their liquefaction.

Opposite of Liquification= Low pressure (small intermolecular forces) and high temperature (large distances between molecules)

END OF LESSON