The Particulate Nature of Matter

Sunday, September 20, 2020 1:52 PM

Matter is defined as any substance in the Universe which takes up space and mass. We are able to further classify matter into 3 states, namely Solid, Liquid and Gas.

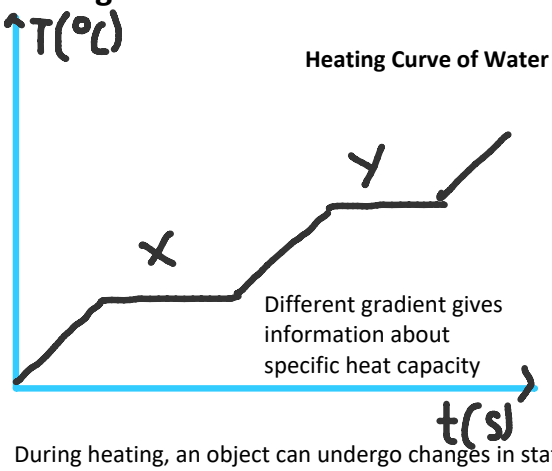
P.S: Classification helps both scientist and people all over the world as it helps develop in depth understanding of each state and help also to identify and differentiate different types of matter.

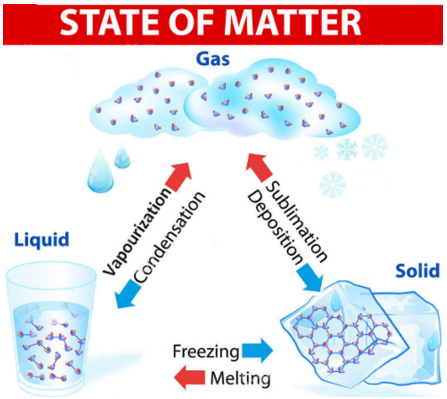
1.1:
3 States of Matter

Solid	Liquid	Gas
Fixed shape	Takes up the shape of the container	Takes up the shape of the container
Fixed volume	Fixed volume (In higher level, liquids can be so slightly compressed)	No fixed volume
Regular arrangement	Irregular arrangement	No fixed shape
Particles vibrate in its **fixed position**	Particles **slide** over one another	Particles move randomly in **zig-zag** motion
Strong forces of attraction	Weak forces of attraction	Negligible force of attraction (Theoretically speaking)



1.2:
Change of State





http://www.angelfire.com/ego/mr.f/SubjectLinks/science/heat/matterstates.html

During heating, an object can undergo changes in state. This is due to their physical properties, namely melting and boiling point.

Key Takeaways:

1) As objects gain heat energy, its particles move in a greater velocity which enables it to break its force of attraction
2) During melting and boiling, as seen from the graph, temperature is constant. This is due to the fact that when boiling or melting occurs, all of the energy absorbed are used to break its forces of attraction and not to raise its temperature.
3) Pure substances will have one boiling and melting point. Impurities may cause substances to boil or melt at a range of temperatures

1.3:
Kinetic Particle Theory

1) All matter consist of small and very many particles in constant motion. The degree of speed of this motion varies with temperature as well as its state.
2) Gasses have the highest amount of energy and solid the least. This is due to the fact gasses have minimal forces of attractions and hence can move in random motion in high speed
3) When particles gain energy, they may be able to change state from solid – liquid –gas. When particles lose energy, vice versa occurs. Hence, we can say that melting and boiling absorb energy whereas freezing and condensation release energy.

Question that appear consistently in the Exams:

1) **Explain, with respect to the Kinetic Particle Theory, what happens when ice, when heated melts to water**

Ice is initially in solid state. As it is being heated, thermal energy is converted to kinetic energy. The kinetic energy enables the particles to vibrate at greater velocity up to melting point where temperature remains constant and all energy being absorbed is used to break the forces of attraction. By the time the movement of particles no longer vibrates it its fixed position but rather slide over one another, the process is complete.

PS: Solid to Gas directly is sublimation and the opposite of this change is called deposition

Evidence for Gas Molecules being present:

1) Diffusion: Gas particle collide with the air particles surrounding it. This is why the smell of perfume can be recognized across the room.
2) Brownian motion:

1.4:
Brownian Motion and Diffusion

Brownian Motion is an experimented conducted in order to be able to provide evidence that our atmosphere consist of tiny gas particles that are always in constant, random motion.

What Is Brownian Motion? | Properties of Matter | Chemistry | FuseSchool
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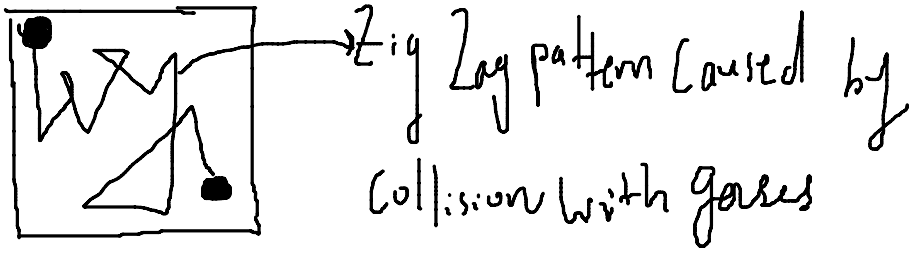
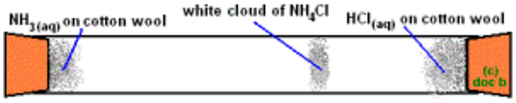
When grain of pollens are suspended under a microscope, these pollen grains demonstrated a very abstract path of motion. They travel in zig-zag lines as if being collided by something. This something is what we know as air and air consist of a mixture of gasses.
From this experiments, we are able to conclude that although we can't see it, gas is present all around us. Not only that, it also travels in constant, random motion at high speed.



Diffusion: It is the process where fluids travel from a region of higher to lower concentration. This occurs due to the random motion of fluids colliding with other particles. Rate of diffusion is affected by several factors including:

1) Temperature : The higher the temperature, the greater Kinetic energy particles possess and hence, able to travel at greater speed.
2) Relative Molecular Mass



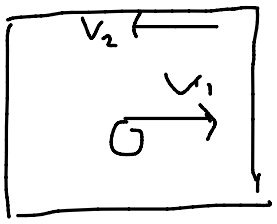
As seen in the picture above, as ammonia has lower molecular mass, the reaction occurs closer to HCl due to ammonia having travelled further.

Analogy: Imagine trying to blow a piece of paper compared with a book. The piece of paper will travel further than the book due to it being lighter.

1.5:
Affect of Temperature and Volume of Gas to its Pressure

Imagine having a syringe against your thumb. Now, with all your strength, compress it. The plunger might tunnel in for a few centimeters and then stop. At this point, you might feel the syringe really pushing you finger back.

With this in mind, what does this tell you about the relationship between volume and pressure of a gas? Logically, as the volume of the container decreases, the pressure increases. This is due to the fact that as the space for the gas molecules to exist decreases, the tendency for the gas molecules to strike at the walls of the container increases. Now, why this exerts pressure will be further studies in Physics but if you are curious, this is why:



1) Gas travels towards the wall at a velocity of V1.
2) It rebounds with a velocity of V2. Assuming an elastic collision, V1 and V2 will have equal magnitude but opposite direction
3) Hence, there will be a change in momentum due to change in velocity(velocity changes if direction changes)
4) When the gas collides, it touches the wall for a short period of time and at a certain area.

$\Delta p = m \times \Delta v$

$\hookrightarrow \Delta p = F \times \Delta t$

$p = \frac{m \times \Delta v}{\Delta t} \times \frac{1}{A}$

$F \times \Delta t = m \times \Delta v$

$= \frac{m \times \Delta v}{\Delta t A}$

$F = \frac{m \times \Delta v}{\Delta t}$

(all conditions met)

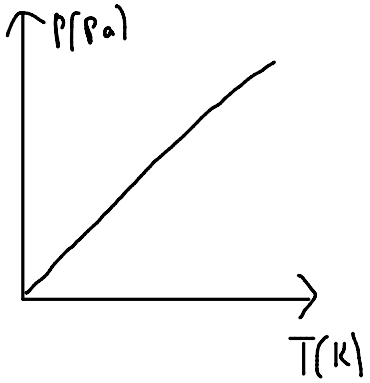
Hence, we can say, pressure is inversely proportional to the volume of the gas(container).

We can then draw a graph to show this relationship

$p = \frac{F}{A}$

$P \propto \frac{1}{V}$

As discussed early on, temperature of a substance will impact the velocity of its particles. Hence, if the temperature of a gas increases, the rate at which it collides with the wall therefore increases, increasing the pressure. At absolute zero, particles will stop moving. Hence, temperature is directly proportional to pressure of the gas.



$P \propto T$