Levelling Up Grades Through Skills

Pure Chemistry

Physical Geography | Section II

Chapter 2.1:
Kinetic Particle Theory

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Learning Outcomes

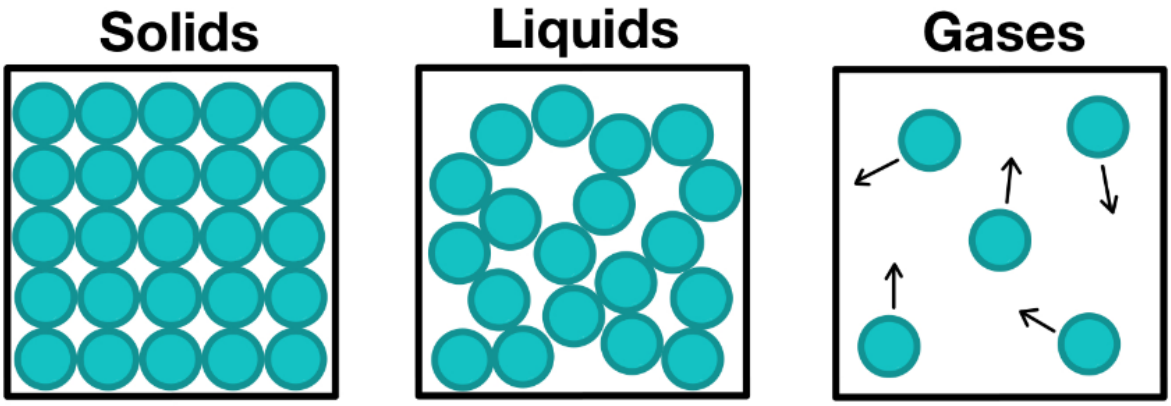
2.1 Kinetic particle theory	Have not Revised yet	Revised but need help	Revised and understood	Revised and able to do questions
(a) describe the particles in solid, liquid, and gaseous states of matter using the kinetic particle theory				
(b)Explain the interconversion between different states of matter using the kinetic particle theory and the energy changes involved				
(c) describe and explain evidence for the movement of particles in liquids and gases				
(d) explain everyday effects of diffusion in terms of particles, e.g. the spread of perfumes and cooking aromas, tea, and coffee grains in water				
(e) state qualitatively the effect of molecular mass on the rate of diffusion and explain the dependence of rate of diffusion on temperature.				

(a) Kinetic Particle Theory

Definition:
The Kinetic Particle Theory states that all matter is made up of tiny particles that are in constant random motion

There are 3 different states of matter: Solid, Liquid and Gas. To describe the 3 states of matter using Kinetic Particle Theory, we shall use the **ADAM** framework.

	Keywords
Attraction between particles	Solids: Strong forces of attraction Liquids: Moderately strong forces of attraction Gas: Weak forces of attraction
Distance between particles	Solids: Closely packed Liquids: Moderately closely packed Gas: Far Apart
Arrangement of particles	Solids: Arranged in orderly manner Liquids: Arranged in disorderly manner Gases: Arranged in disorderly manner
Movement of Particles	Solids: move by Vibrating in fixed positions Liquids: move by Sliding over one another throughout the liquid Gas: Move randomly at high speeds



Question: Describe the Arrangement of particles in a (Solid/Liquid/Gas).

Answer: The Particles in a (Solid/Liquid/Gas) have _____**A**_____ forces of attraction between the particles and are _____**D**_____ in a/an _____**A**_____ manner, and move _____**M**_____.

Properties of Solids Liquids and Gases

Solids and Liquids are incompressible, but Gases are compressible

Solids and liquids have a fixed volume and are incompressible because there is very little space between the particles, hence the volume occupied by the particles cannot be reduced further. (*i.e. the particles cannot be squeezed closer together because they are already so closely packed*)

Meanwhile, since gas particles are so far apart, the particles can be brought closer together to reduce the volume occupied by the gas and reducing the volume of the gas.

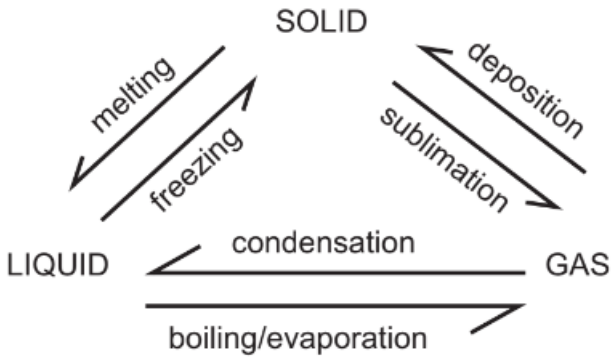
Liquids and Gases have no fixed shape but Solids have a fixed shape

Liquids and Gases have no fixed shape because their particles are not held together in fixed positions. Therefore, the particles are free to move about (either by sliding over one another or at high speeds in random directions), and often take on the shape of the container it is in.

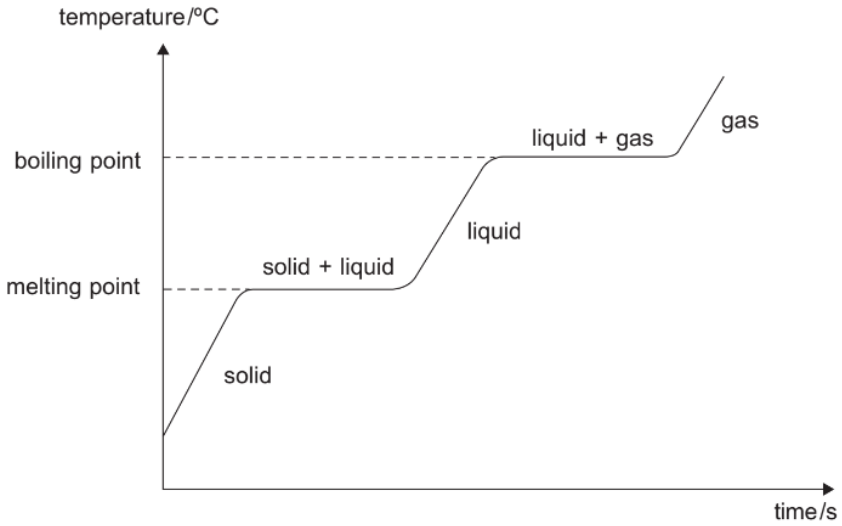
Meanwhile, since solid particles are held in fixed positions by strong forces of attraction, the particles are unable to move about, and so the shape of the solid is fixed.

(b) Changes in State of matter and the Kinetic Particle Theory

Matter can undergo changes in state when heat is applied to or removed from it. The diagram below shows the possible changes in states. (Take note: only a few substances can undergo deposition and sublimation, e.g. Iodine and Carbon Dioxide)



How temperature varies as a substance gains heat and undergoes melting and boiling



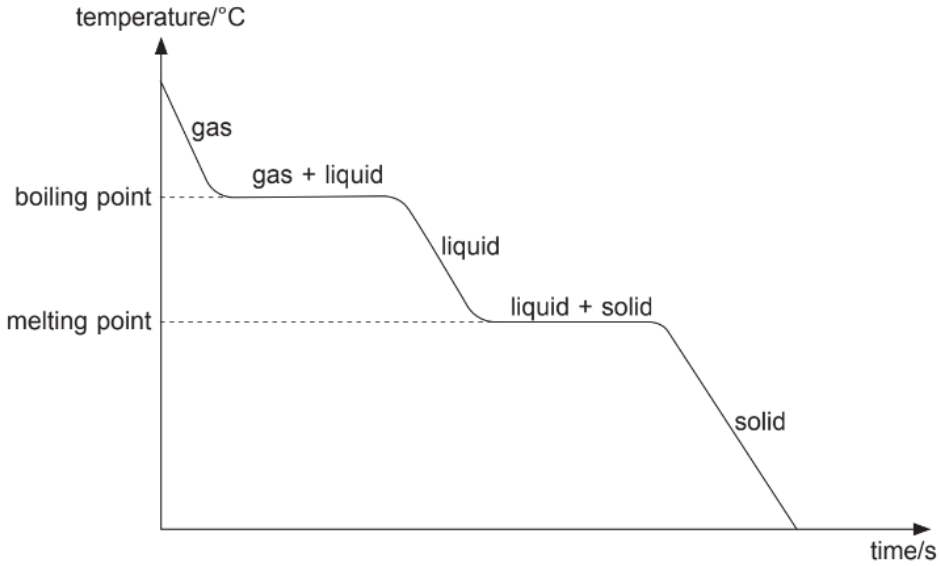
Question: What happens to the particles when heat is applied (without a change in state)?

Answer: As the substance gains heat, **A**ttractive forces become weaker, and **D**istance between particles increases. The **A**rrangement of particles also become more disorderly, as the **M**ovement of particles become more vigorous.

Question: What happens to the temperature of the substance as heat is applied and the substance melts/boils?

Answer: When matter undergoes a change in state, the temperature of the substance will remain constant. This is because *energy supplied is used to overcome the forces of interactions between particles* and bring the particles further apart instead of increasing the temperature of the substance.

<u>How temperature varies as a substance loses heat and undergoes condensation and freezing.</u>



Question: What happens to the particles when heat is applied (without a change in state)?

Answer: As the substance loses heat, **A**ttractive forces become stronger, and **D**istance between particles decreases. The **A**rrangement of particles also become more orderly, as the **M**ovement of particles become less vigorous.

Question: What happens to the temperature of the substance as heat is applied and the substance and the substance freezes/condenses?

Answer: When matter undergoes a change in state, the temperature of the substance will remain constant. This is because energy lost is offset by the energy released when particles come closer together, hence temperature remains constant.

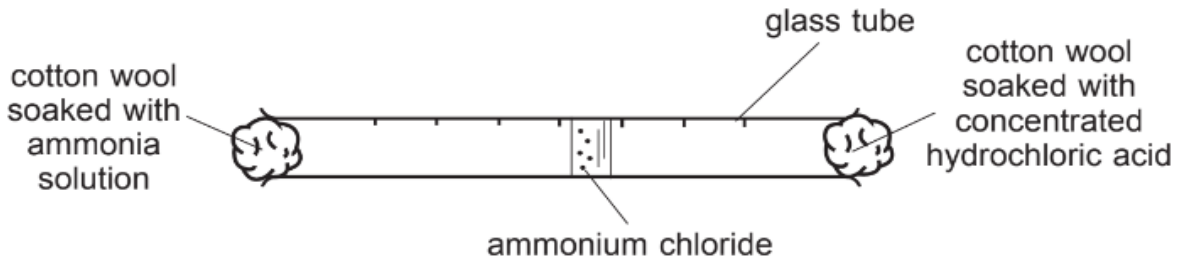
(c) Diffusion

Definition:
Diffusion is the *net movement of particles* from a *region of high concentration to a region of lower concentration* along a *concentration gradient*

(d) Conditions affecting the rate of diffusion:

1. **Temperature**
   At higher temperatures, particles have more kinetic energy and hence move more vigorously/faster.
2. **Particle mass**
   Particles with higher mass move more slowly than particles with lower mass.

Question: In the diagram below, a reaction occurs when ammonia gas (NH_3) comes into contact with hydrochloric acid gas (HCl) , and ammonium chloride would be formed. If both gases moved at the same speed, the ammonium chloride would be formed in the middle. Why then is the ammonium chloride formed closer to the HCl than NH_3?



Answer: Ammonia gas travels a greater distance than the Hydrogen chloride because Ammonia gas diffuses at a higher rate than hydrogen chloride.(Relative Molecular Mass of ammonia = 17, Relative Molecular Mass of hydrogen chloride = 36.5). Therefore, ammonium chloride forms further away from ammonia solution and closer to the Hydrochloric Acid.

In Summary:

Conditions	**Rate of diffusion**	**Reason**
Increase in Temperature	Increase	More kinetic energy of particles allowing particles to move faster
Increase in Particle Mass	Decrease	Particles with higher mass require more kinetic energy to move at the same speed as particles with lower mass

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)