TOPIC 8 Kinetic Model of Matter

Objectives

Candidates should be able to:

(a) compare the properties of solids, liquids and gases
(b) describe qualitatively the molecular structure of solids, liquids and gases, relating their properties to the forces and distances between molecules and to the motion of the molecules
(c) infer from Brownian motion experiment the evidence for the movement of molecules
(d) describe the relationship between the motion of molecules and temperature
(e) explain the pressure of a gas in terms of the motion of its molecules
(f) recall and explain the following relationships using the kinetic model (stating of the corresponding gas laws is not required):
  (i) a change in pressure of a fixed mass of gas at constant volume is caused by a change in temperature of the gas
  (ii) a change in volume occupied by a fixed mass of gas at constant pressure is caused by a change in temperature of the gas
  (iii) a change in pressure of a fixed mass of gas at constant temperature is caused by a change in volume of the gas
(g) use the relationships in (f) in related situations and to solve problems (a qualitative treatment would suffice)

NOTES

8.1 States of Matter

The 3 States of Matter

	Solid	**Liquid**	**Gas**
Volume	Definite	Definite	Indefinite (Takes the shape and size of container)
Shape	Definite	Indefinite (Takes the shape of container)	Indefinite (Takes the shape of container)
Compressibility	Not compressible	Not compressible	Compressible

	Solid	Liquid	Gas
Arrangement of atoms/molecules	1. Closely packed together 2. Orderly arrangement 3. Held together by large forces	1. Closely packed in clusters of atoms or molecules 2. Atoms/ molecules slightly further apart compared to particles 3. Held together by large forces	1. Atoms or molecules are very far apart and occupy any given space 2. Negligible forces of attraction between atoms/ molecules.
Density	High (Usually)	High	Low
Forces between atoms/ molecules	Very strong	Strong	Very Weak
Movement of atoms/ molecules	Can only vibrate about fixed positions	Able to move pass each other and not confined to fixed positions	Move in random manner independent of each other and at high speed.

Common mistakes:

1. Some substances, such as carbon dioxide, are commonly known to be in gaseous state at room temperature. However, this does not mean that the carbon dioxide molecules move in random motion.

   (Check its state (temperature): solid or gas, etc.)

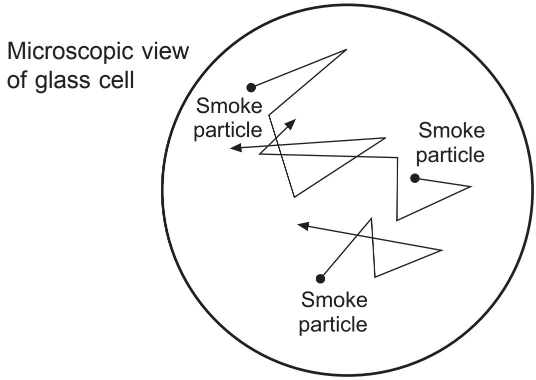
   E.g. Dry ice is a solid which consists of carbon dioxide molecules in an orderly arrangement.

2. ***Not all*** solids have high density, i.e. “ice” is a solid consisting of water molecules arranged orderly in an open hollow structure. Hence, its density is lower than water (liquid) and it can float in water.

8.2 Brownian Motion

The random and irregular motion of gas and liquid molecules.

Experimental observation (using microscope): Smoke particles in a sealed glass cell move about randomly and irregularly, because of bombardment by air molecules in the cell.



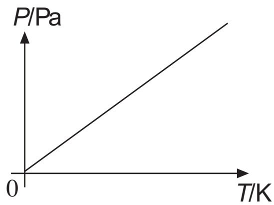
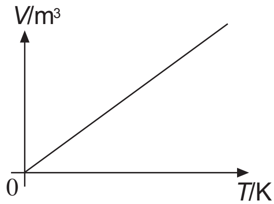
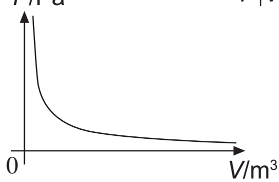
Smoke particles moving randomly

8.3 Pressure of Gas

1. In a sealed container, gas can exert pressure on the walls of the container.
2. The large number of molecules move at high speed, colliding against the container's walls and exerting a force against the wall when they bounce off the walls.
3. The force per unit area exerted by the molecules on the wall is the pressure of the gas on the wall.
4. Gas pressure increases when the
   (a) number of molecules in the container increases,
   (b) speed of molecules increases,
   (c) molecules have larger mass.

8.4 Relationship between Pressure (*P*), Volume (*V*) and Temperature (*T*)

1. For a constant mass of gas:

	P	***V***	***T***	***Relationship***
1.	Increase	Constant	Increase	*P* is directly proportional to *T*.  $\frac{P_1}{T_1} = \frac{P_2}{T_2}$
2.	Constant	Increase	Increase	*V* is directly proportional to *T*.  $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
3.	Increase	Decrease	Constant	*P is* inversely proportional to *V*. $P_1V_1 = P_2V_2$ 

Example 8.1

To get a linear graph that shows *P* is inversely proportional to *V*, rearrange the equation:

$P_1V_1 = P_2V_2 = \text{constant}, k$

$P_1 = \frac{k}{V_1}$

Sketch the graph of *P* against $\frac{1}{V}$:

y-axis (*P*), *x*-axis $\left(\frac{1}{V}\right)$, gradient = *k*