Chapter 7 **Date: _____**

Model of Matter – The Particulate Nature of Matter

1 Physical properties of the three different states of matter

- There are three states of matter: _____, _____ and _____ .

Physical Properties	Solid	Liquid	Gases
Shape	Have _____ shape	_____ the shape of the containers	_____ the shape of the containers
Volume	Have _____ volume	Have _____ volume	_____ on the volume of the container
Density	_____ density	_____ density _____	_____ density
Compressibility	_____ be compressed	_____ be compressed	_____ be compressed

- These properties can be explained using the **<u>Particulate Nature of Matter</u>**.

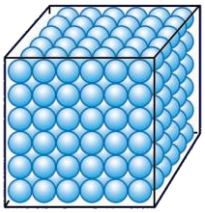
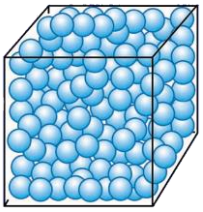
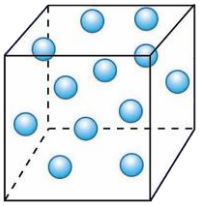
2 Using the Particulate Nature of Matter as a Model

- **Brownian motion** provides evidence for the kinetic molecular model of matter (Kinetic Theory of Matter)

- Matter is made up of _____ (atoms, molecules or ions)

- Scientists found out that the particles:
  - are very _____ and cannot be seen with a microscope.
  - all particles of one pure substance are _____.
  - are in _____.

3 Models of States of Matter (Particulate Model of Matter)

Characteristics	Solids	Liquids	Gases
Model			
Diagram			
Forces between particles	_____ forces of attraction	_____ forces of attraction (weaker as compared to solids)	Very _____ or _____ forces of attraction
Movement/ Motion	_____ about _____ _____	Able to _____ _____	Move _____ in all _____ and at _____
Arrangement	_____ packed and _____ arranged	Not as closely packed as solids and _____ arranged	Very _____ and _____ arranged

- Guidelines of drawing particles:
  1. 2-D side view of the substance
  2. Not necessary to show the vibration of the particles
  3. Size of particles should be roughly the same
  4. Half-drawn particles are not accepted.

- Using the particulate model of matter to ***explain*** the difference in the physical properties of the 3 different states of matter.

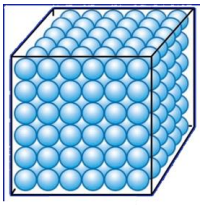
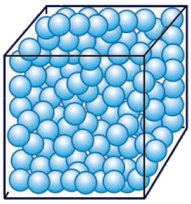
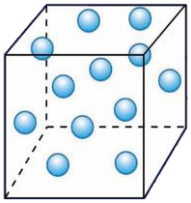
1. Density

Density is defined as the amount of _____ per _____.

Substances in the solid state have a ***higher density*** than the liquid and gaseous state.

Why?

For Example:

	 solid	 liquid	 gas
Mass/g	6	4	2
Volume/cm^3	2	2	2
Density/g/cm^3			

1. Given that the boxes are of the same size. Hence, the three states have the same equal volume.

2. Solid state contains the **most number of particles** (has the highest mass).

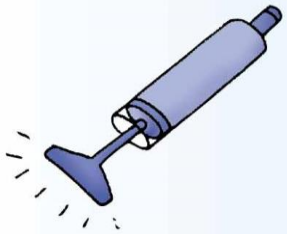
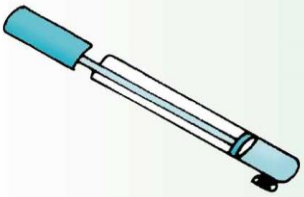
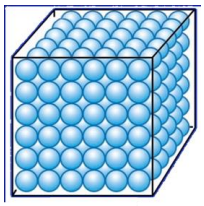
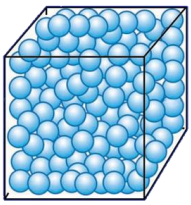
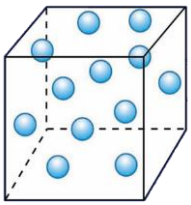
3. Therefore, solids have the _____.

2. Compressibility

Solids and liquids are incompressible unlike gases.

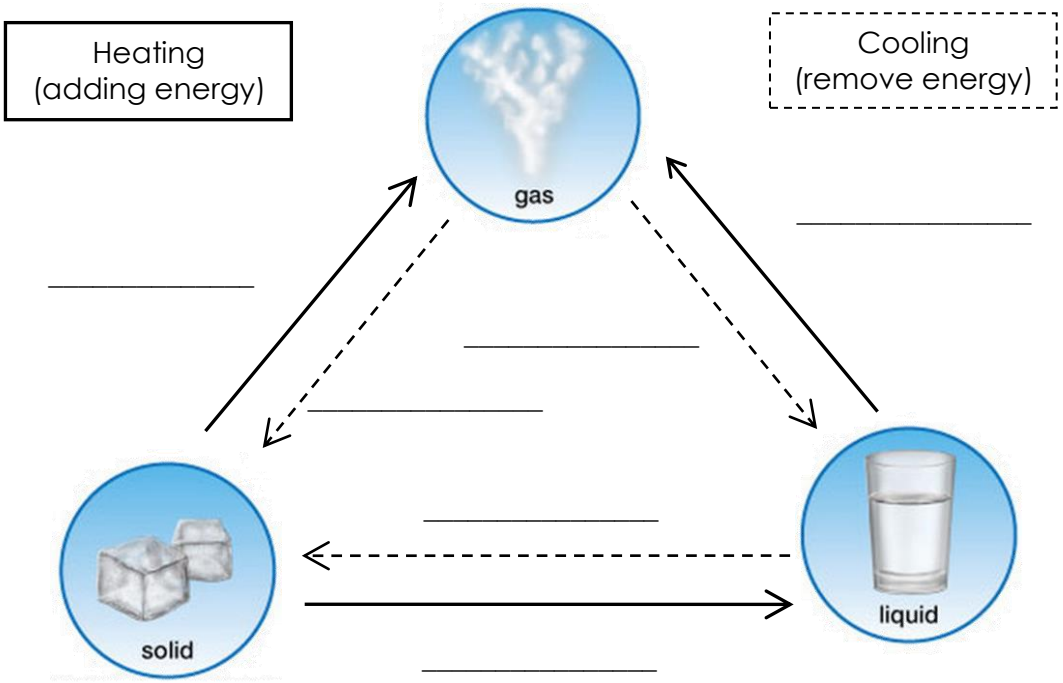
Why?

For example:

 Solids are not compressible	 Liquids are difficult to compress	 Gases are easily compressed
 solid	 liquid	 gas

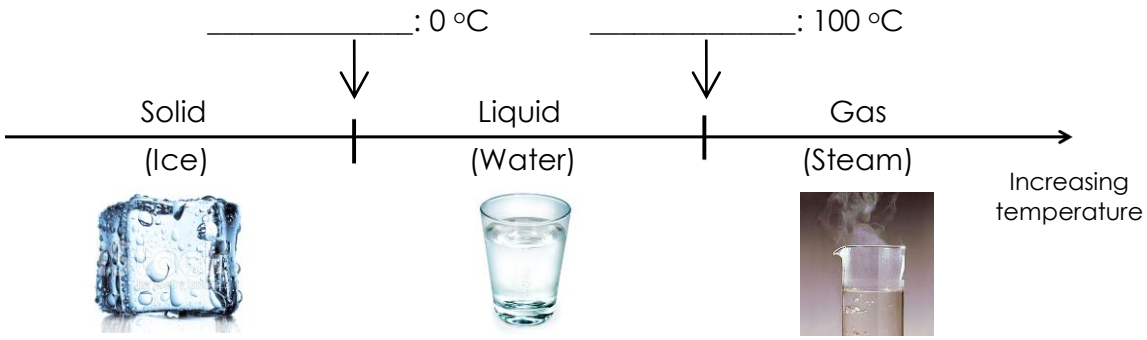
1. Particles in solid and liquid are closely packed.
2. Particles in gas are very far apart from one another.
3. Thus solids and liquids cannot be _____.

4 Changes in states of matter

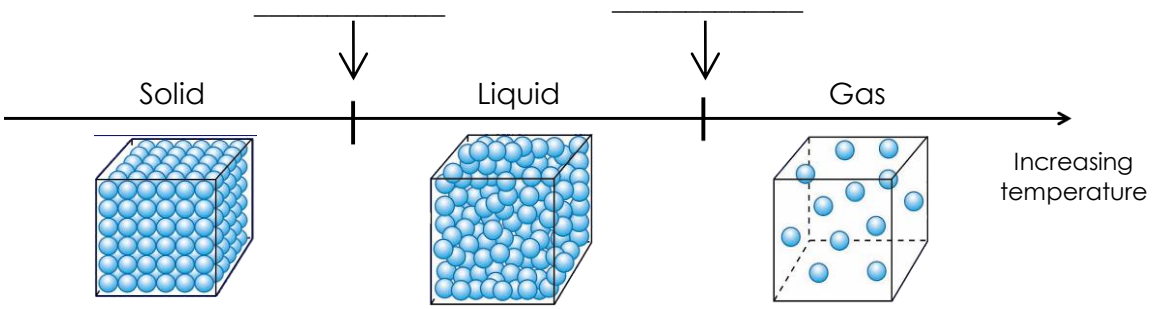


How to predict changes in states of matter?

Example: Temperature line for **H_2O**:



Temperature line (in general):



Worked example

Try-it-out (1)

Given the melting and boiling points of three substances. Complete the table by writing the state of each substance at room temperature and pressure (r.t.p = 25 °C, 101.3 kPa).

Substance	Melting point (^{O}C)	Boiling point (^{O}C)	State at r.t.p
A	−24	10	Gas
B	−120	348	
C	50	121	

Try drawing the temperature line in the space provided.

Try-it-out (2)

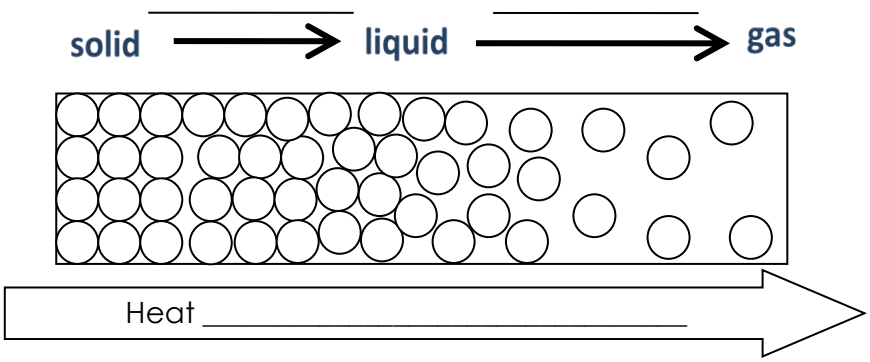
Given are melting and boiling points of three substances. Complete the table by writing the state of each substance at room temperature and pressure (r.t.p = 25 °C, 101.3 kPa).

Substance	Melting point (^{O}C)	Boiling point (^{O}C)	State at r.t.p
D	30	112	
E	−90	2	
F	−8	77	

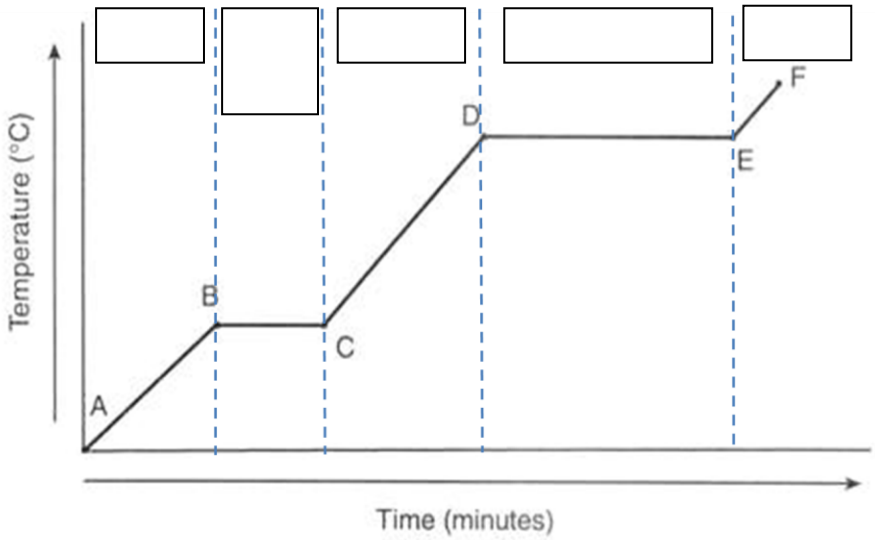
Try drawing the temperature line in the space provided.

5 Using Particulate model of matter to *explain*: Changes in states of matter

a) Heating a solid

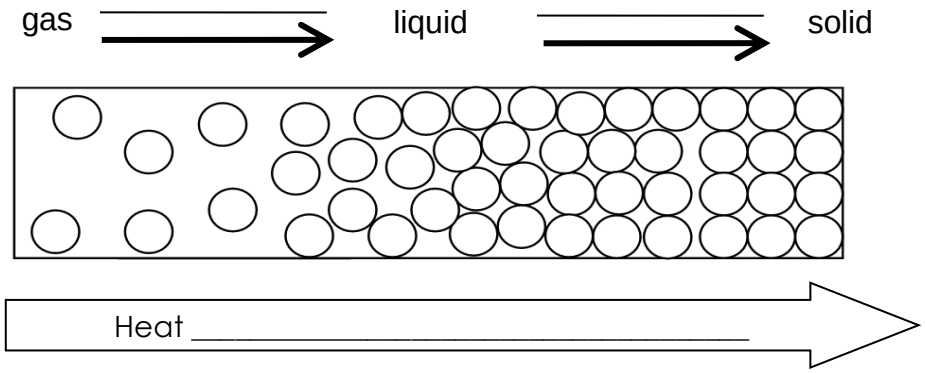


Heating curve

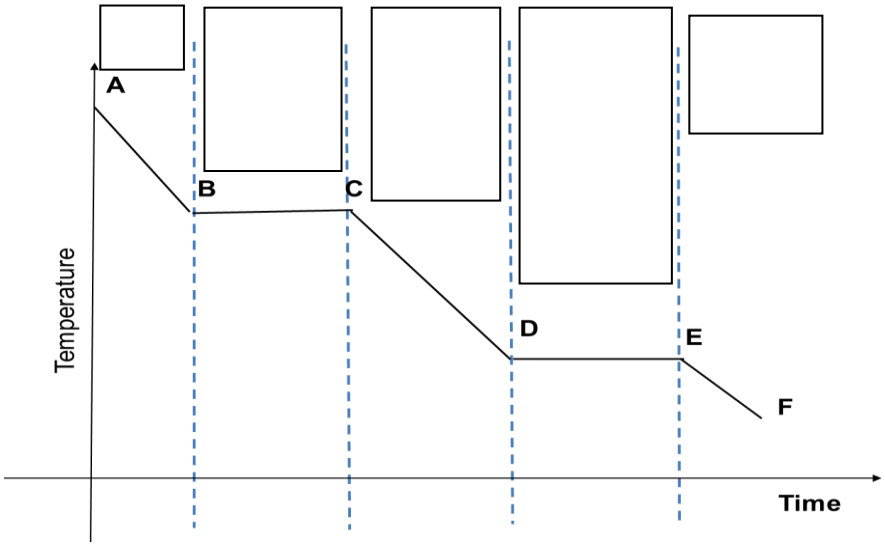


Stage	Description
AB	When solid is ***heated***, particles _____ heat energy and _____ at its _____. Heat absorbed causes _____.
BC	At _____ of solid (change of state), heat energy _____ is used to _____ the strong forces of attraction between the particles. Temperature remains _____ until the solid melts completely into a liquid at point C.
CD	When the liquid is ***heated***, particles _____ heat energy and _____ more vigorously. Heat absorbed causes temperature to rise.
DE	At _____ of liquid (change of state), heat energy _____ is used to _____ the strong forces of attraction between the particles. Temperature remains _____ until the liquid boils completely into gas at point E.
EF	When the gas is further heated, particles gain heat energy and _____.

b) Cooling a gas



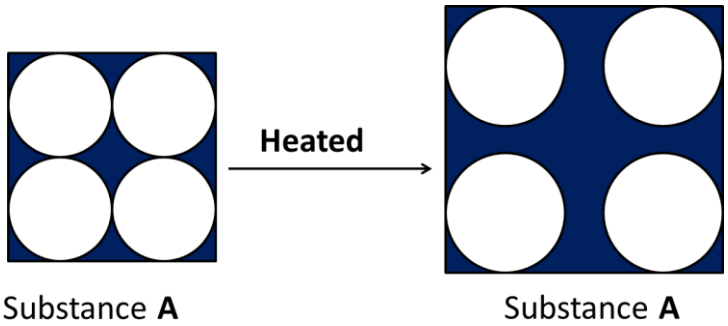
Cooling curve



Stage	Description
AB	When the gas is ***cooled***, particles _____ heat energy and move freely in all directions at _____. Heat energy released causes temperature to fall.
BC	At _____ point (change of state), heat energy _____ is due to _____ stronger forces of attraction between particles. Temperature remains _____ until the gas condenses completely into liquid at point C.
CD	When the liquid is _____, particles _____ heat energy and _____ more slowly. Thermal energy released causes temperature to fall.
DE	At _____ point (change of state), heat energy _____ is due to _____ stronger forces of attraction between the particles. The stronger forces of attraction cause the particles to _____ to their _____ _____. Temperature remains _____ until liquid freezes completely into solid at point E.
EF	When the solid is further cooled, particles _____ heat energy and vibrate _____ about their fixed positions. Thermal every released causes temperature to fall.

6 Using Particulate model of matter to *explain*: Expansion and Contraction

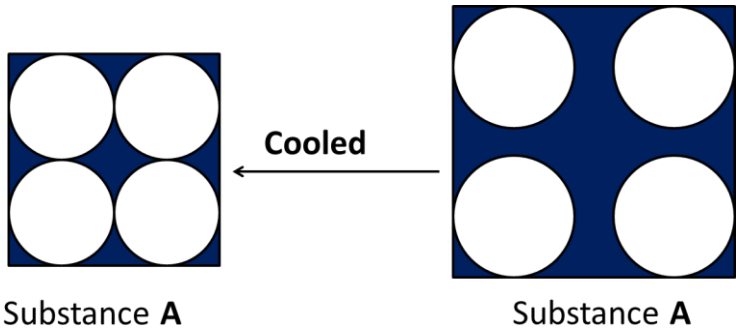
When heated …..



- ✓ Particles start to move faster
- ✓ Particles start to move further apart

- Matter expands when it is _____.
  ⇒ When heated, particles will _____ thermal energy, vibrate _____ vigorously and move _____ apart from one another.

When cooled …..



- ✓ Particles start to move slower
- ✓ Particles start to move closer together

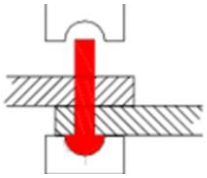
- Matter contracts when it is _____.
  ⇒ When cooled, particles will _____ thermal energy, vibrate _____ vigorously and move _____.

- When heated or cooled, ONLY _____ of matter changes:
  - Only the _____ between particles _____ when heated and decrease when cooled.
  - Mass of matter is _____ as size and number of particles remain the same.

- Examples of expansion and contraction:

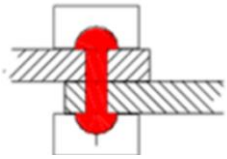
  a) _____ are placed in between slabs of concrete to prevent cracking of concrete.

  b) _____ is a permanent mechanical fastener.

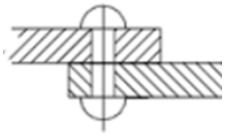


Metal rivet is **heated** and **expands.**

It is **placed through** 2 metal plates.



The other end of the rivet is capped.



When the rivet cools, it **contracts** and **tightens** the two metal plates together.

7 Matter vs Particles

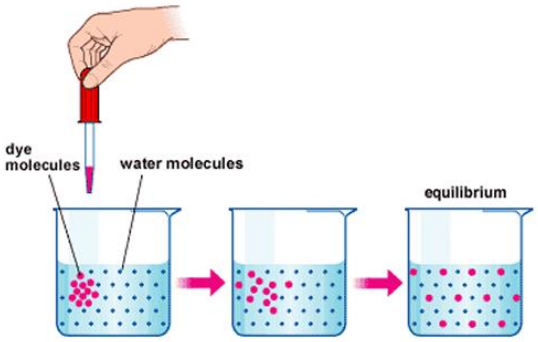
	Matter	**Particles**
Colour	Yes	No
Change in Temperature	Can be felt	No; but is depicted by the _____ _____ of particles.
Change in Size	Can be compressed or expanded	No; but is depicted by the _____ between the particles.

Challenge yourself!

Characteristics of Particles	Solid	Liquid	Gas
Forces of attraction			
Movement			
Distance apart			
Arrangement			

8 Diffusion

A few drops of food dye is added to a beaker of water.

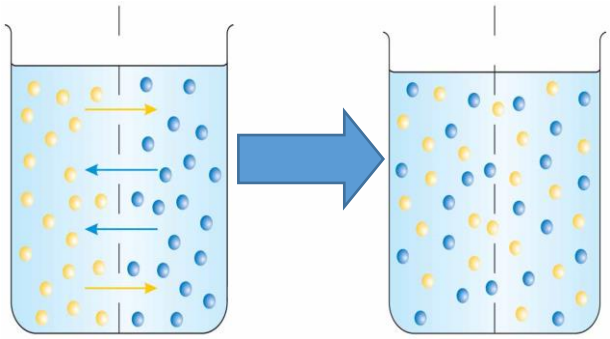


The dye spread throughout the beaker without stirring. Why?

Initially the top of the cup has a _____ concentration of food dye. The food dye then moves downwards, to an area with _____ concentration of food dye.

- Diffusion is the _____ movement of molecules from a region of _____ concentration to a region of _____ concentration, down a concentration _____.

Diffusion can occur between:
a) Solids
b) Liquids
c) Gases



The molecules will continue moving from a higher concentration to a lower concentration till _____ is reached (i.e. molecules are uniformly distributed).

Essential Takeaways

1. The Particulate Model of Matter is a simplified representation of matter composition.
2. Particulate Model of Matter is constructed to explain phenomena e.g. Melting & Boiling.
3. Particulate Model of Matter can be used to make prediction about matter and its behaviour.

Key Terms

Very small discrete particles	Movement / arrangement / distance of particles
Density and compressibility	Forces of attraction
Change of state	Melting point / boiling point
Vibrations about a fixed position	Slide past one another
Diffusion	higher concentration
lower concentration	net movement