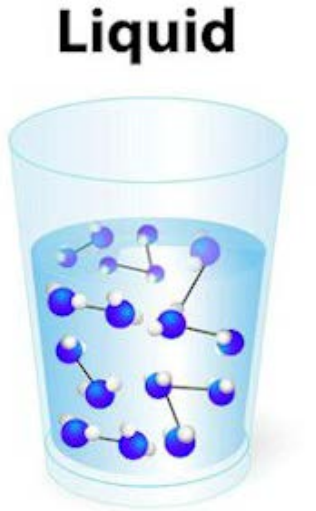
Kinetic Particle Theory

Mr Chen Heping

Furen International School

The three states of matter



Solid	Liquid	Gas
fixed shape	no fixed shape	no fixed shape
fixed volume	fixed volume	no fixed volume
cannot be compressed	cannot be compressed	can be easily compressed

How and Why?

- How matter exists in different states (solid, liquid, and gas) and Why they have such properties?

The kinetic molecular theory of matter states that:

- Matter is made up of particles that are constantly moving.
- There are spaces between particles of matter. The average amount of empty space between molecules gets progressively larger as a sample of matter moves from the solid to the liquid and gas states.
- There are attractive forces between atoms/molecules, and these become stronger as the particles move closer together. These attractive forces are called intermolecular forces.

	Solid	Liquid	Gas
Arrangement	Very closely packed orderly packed in regular pattern	Molecules slightly further apart than solids randomly arranged	Molecules far apart from each other randomly arranged
Movement	Vibrate about fixed positions	Liquid molecules move freely by sliding over each other	Move about randomly at high speeds in all directions
Attractive forces between particles	Very strong attractive forces	Strong attractive forces but weaker than solids	Negligible forces of attraction

	Solid	Liquid	Gas
Fixed Shape	Yes. The particles are held together by very strong forces of attraction and cannot move about freely. They only have enough kinetic energy to vibrate about their fixed positions.	No. The forces of attraction between its particles are weaker than solids. Being arranged in a disorderly manner instead of fixed positions, they can more freely by sliding over each other.	No. The forces of attraction between its particles are very weak. Being arranged randomly instead having fixed positions, they can move about rapidly in all directions.
Fixed volume	Yes. The particles of solids are packed very close together in fixed positions. There is no space between the particles which allow it to be compressed.	Yes. Although the particles of liquids are kept further away than in solids, they are still packed closely together and cannot be compressed.	No. The particles of gases are very far apart. The large space between the particles allows the gas to be easily compressed and hence has no fixed volume.

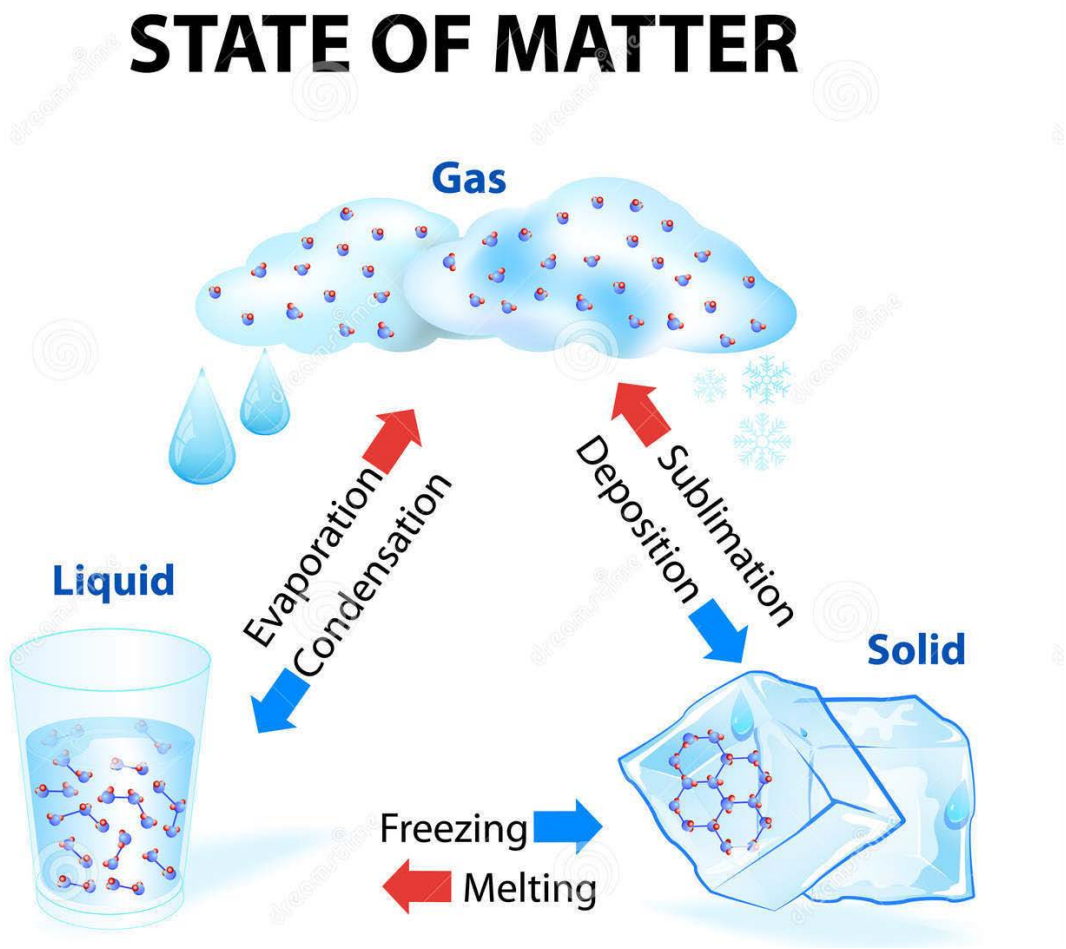
Practice:
Use the kinetic particle theory to explain why solids have higher densities than gases?

- Solids have higher densities than gases as their particles are packed closer together. The number of particles per unit mass in a solid is higher than in gases. Of the same mass, solids have a lower volume hence a higher density; while gases have higher volumes hence a lower density.

The kinetic molecular theory of matter also states that:

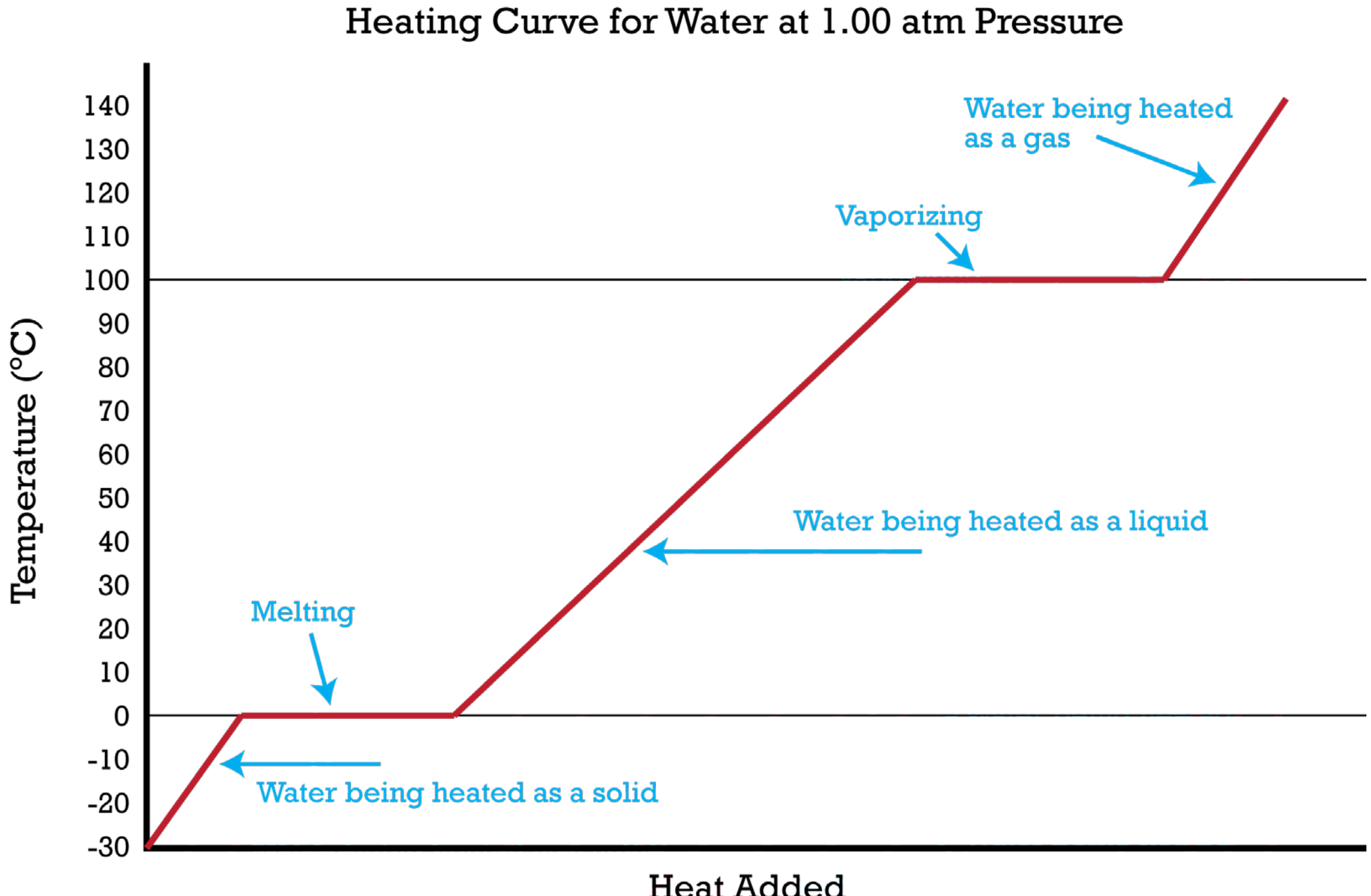
- All particles have energy, but the energy varies depending on the temperature the sample of matter is in. This in turn determines whether the substance exists in the solid, liquid, or gaseous state. Molecules in the solid state have the least amount of energy, while gas particles have the greatest amount of energy.
- The **temperature** of a substance is a measure of the average kinetic energy of the particles.
- A change in state may occur when the energy of the particles is changed.

How matter can change from one state to the next.



State Change Process

(a) Melting	
Stage 1	As a solid is heated, heat energy absorbed by the particles is converted into kinetic energy. The particles vibrate more vigorously in their fixed positions.
Stage 2	When the melting point is reached, heat energy is absorbed by the particles to overcome the forces of attraction holding the particles together. They begin to break away from their fixed positions. During the process, there is no temperature change and a mixture of solid and liquid is present.
Stage 3	Once the melting process has ended, the particles will move out of their fixed positions. The solid has melted to become a liquid.


Heating Curve for Water at 1.00 atm Pressure
Temperature (°C)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
Water being heated as a gas
Vaporizing
Water being heated as a liquid
Melting
Water being heated as a solid
Heat Added

State Change Process

(c) Boiling	
Stage 1	As a liquid is heated, heat energy absorbed by the particles is converted into kinetic energy. The particles move faster as the temperature rises.
Stage 2	When the boiling point is reached, heat energy is absorbed to overcome the attraction forces between liquid particles and to make the particles move faster. During the process, there is no temperature change and a mixture of liquid and gas is present.
Stage 3	The particles are now separated with negligible forces of attraction. The liquid has boiled off to become a gas.

State Change Process

Evaporation

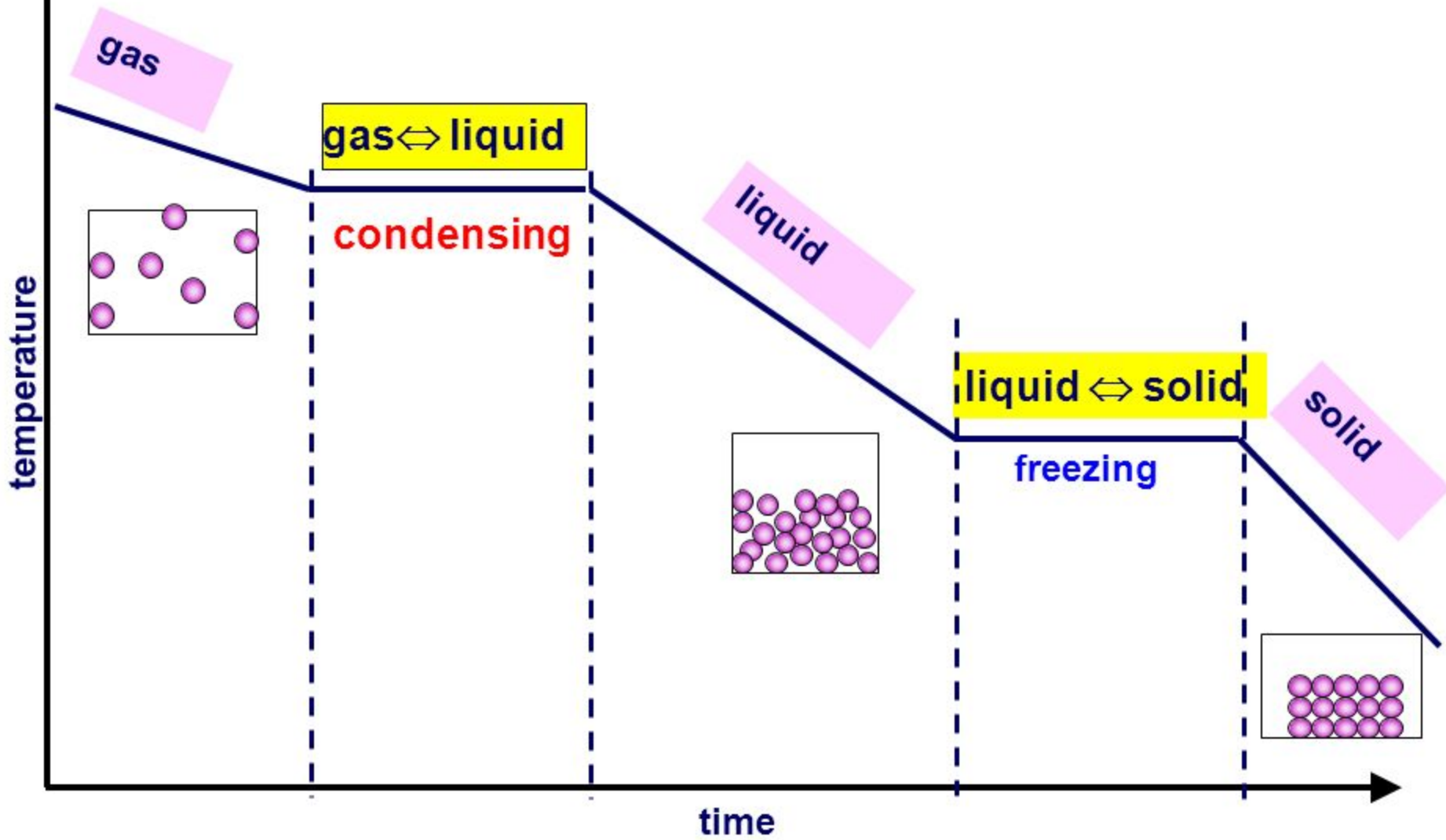
- Evaporation occurs when liquid molecules have enough energy to escape as a gas from the liquid surface.

Differences between Boiling and Evaporation	
Boiling	Evaporation
1) Occurs only at boiling point	1) Occurs at all temperatures
2) Occurs throughout liquid	2) Occurs only at liquid surface
3) Rapid process	3) Slow process

State Change Process

(b) Freezing	
Stage 1	As a liquid is cooled, the particles lose their kinetic energy and slow down.
Stage 2	When the freezing point is reached, heat energy is released as the particles are attracted to each other to form a solid. During the process, there is no temperature change and a mixture of liquid and solid is present.
Stage 3	Once the freezing process has ended, the particles become attracted to each other in fixed positions. The liquid has solidified.

Changes of state – cooling curve

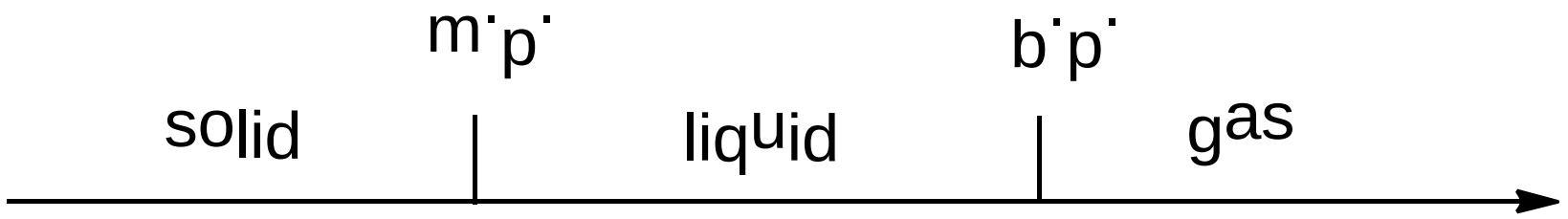


Some other concepts:

- Volatile liquids are liquids that evaporate quickly at room temperature. They have boiling points just above room temperature.

Determining physical state of unknown substance

- Temp below melting point= solid
- Temp above boiling point= gas
- Temp between melting and boiling point= liquid



examples

- Water: