Notes on matter and states of matter

October 24, 2017

What is matter?

Anything that has mass and takes up space

Has both physical and chemical properties

Everyday examples: air, plastic, wood, metal

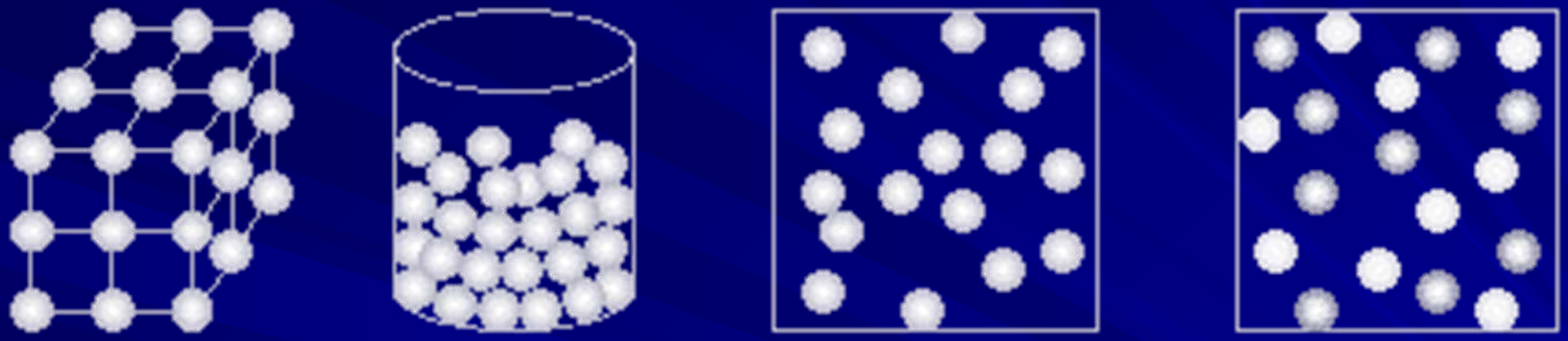
What is meant by “state of matter”?

State of matter describes how a substance holds its volume and shape

Related to how the molecules are moving in relation to one another

Because this can be observed without a chemical reaction, state or phase of matter is a PHYSICAL property!

States of Matter



ADD HEAT

What is a solid?

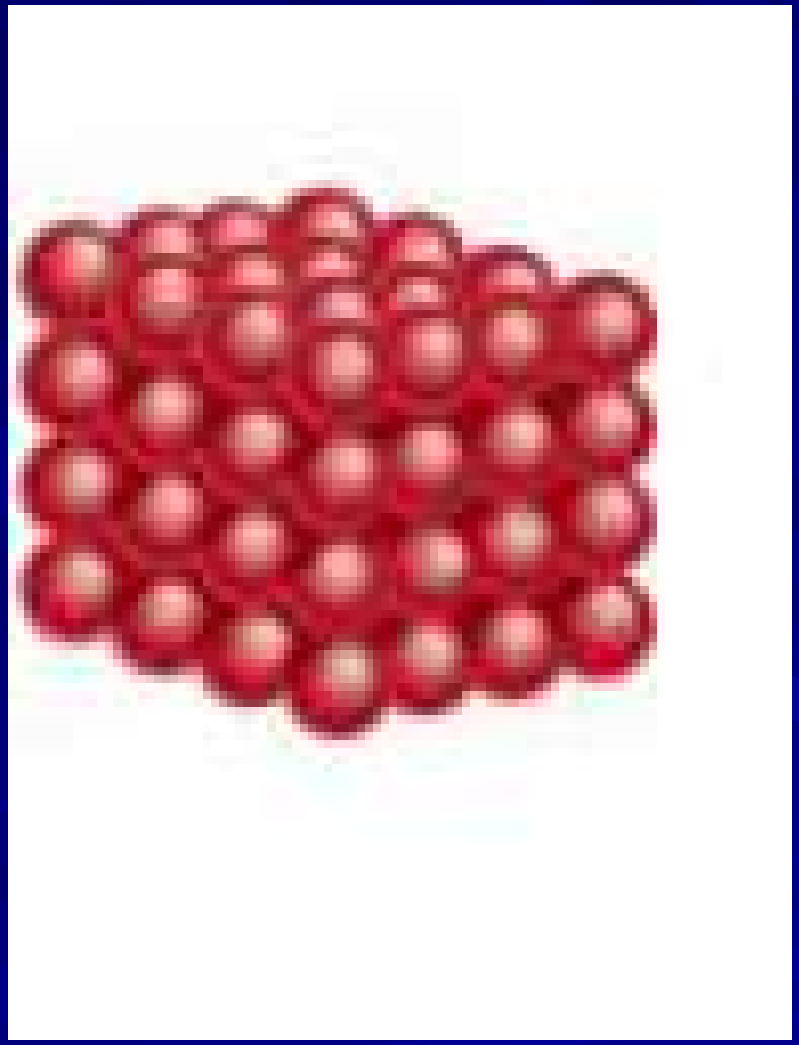
A substance that has a definite shape and a definite volume

Retains its shape no matter what container it is in

Particles in a solid are tightly packed in a fixed position

Molecules vibrate but do not move freely

Molecular Movement of Solid



http://www.iteachbio.com/Chemistry/Matter/Solids-USV.mov

What is a liquid?

- Has a definite volume but NOT a definite shape
- Liquids assume/take on the shape of the container in which they are poured
- Particles are tightly packed but can move freely (this results in changing shape)

Molecular Movement of Liquid

http://www.iteachbio.com/Chemistry/Matter/Liquids-USV.mov

What is a gas?

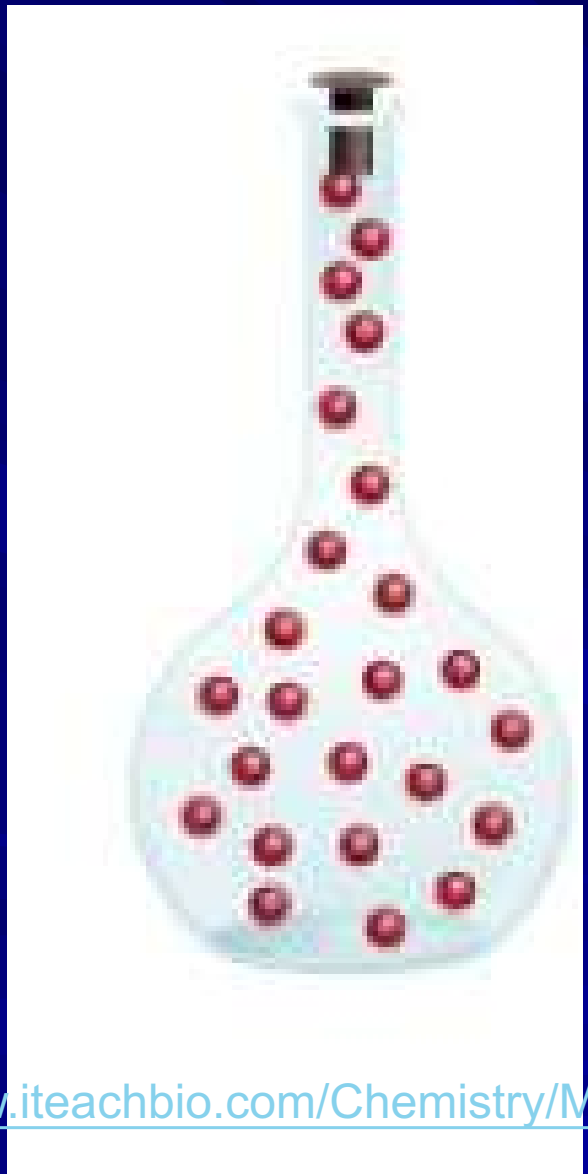
Has neither a definite shape or a volume

Particles move to fill available space

Particles move freely and expand or contract, move at high speeds

Have enough energy to separate completely from one another

Molecular Movement of Gas

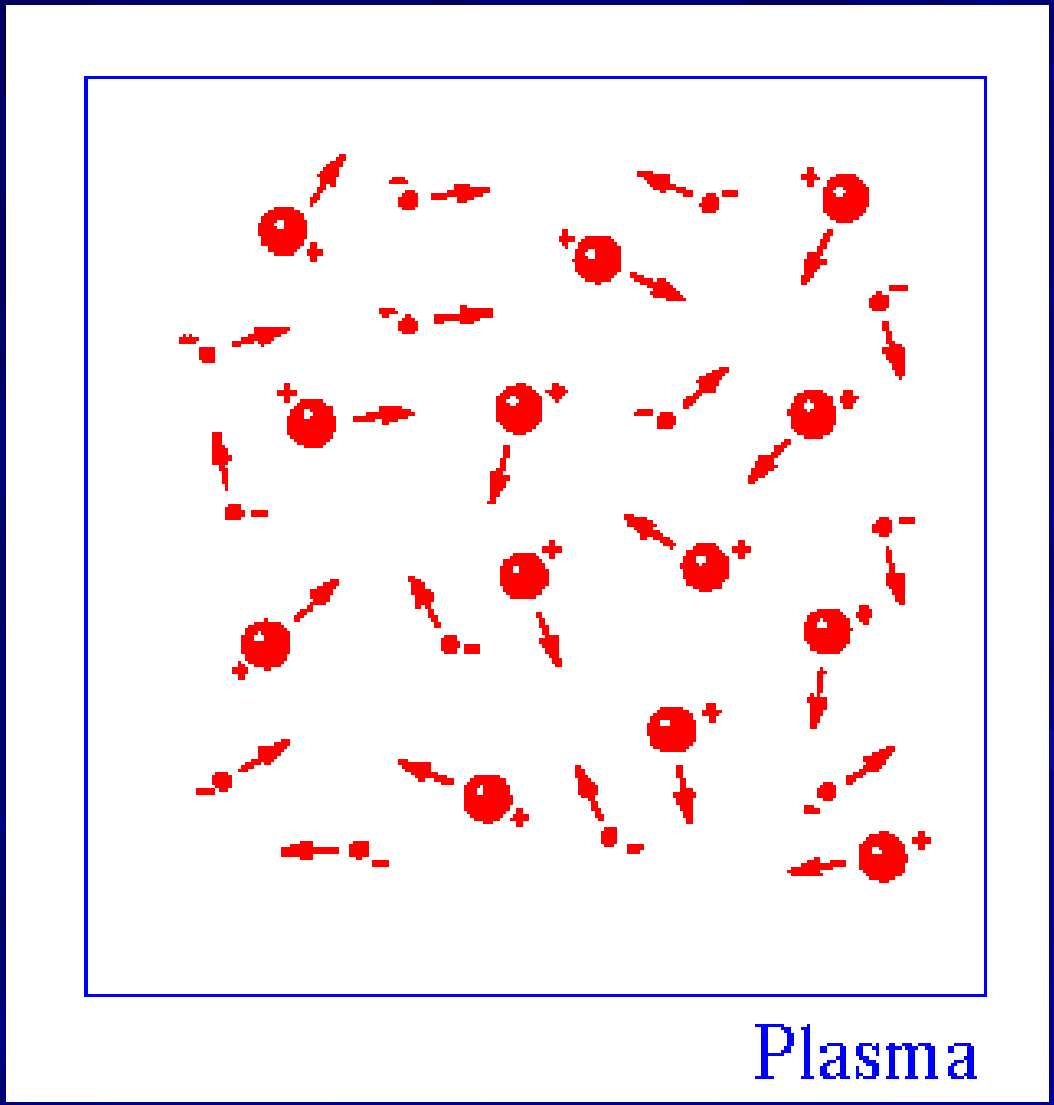


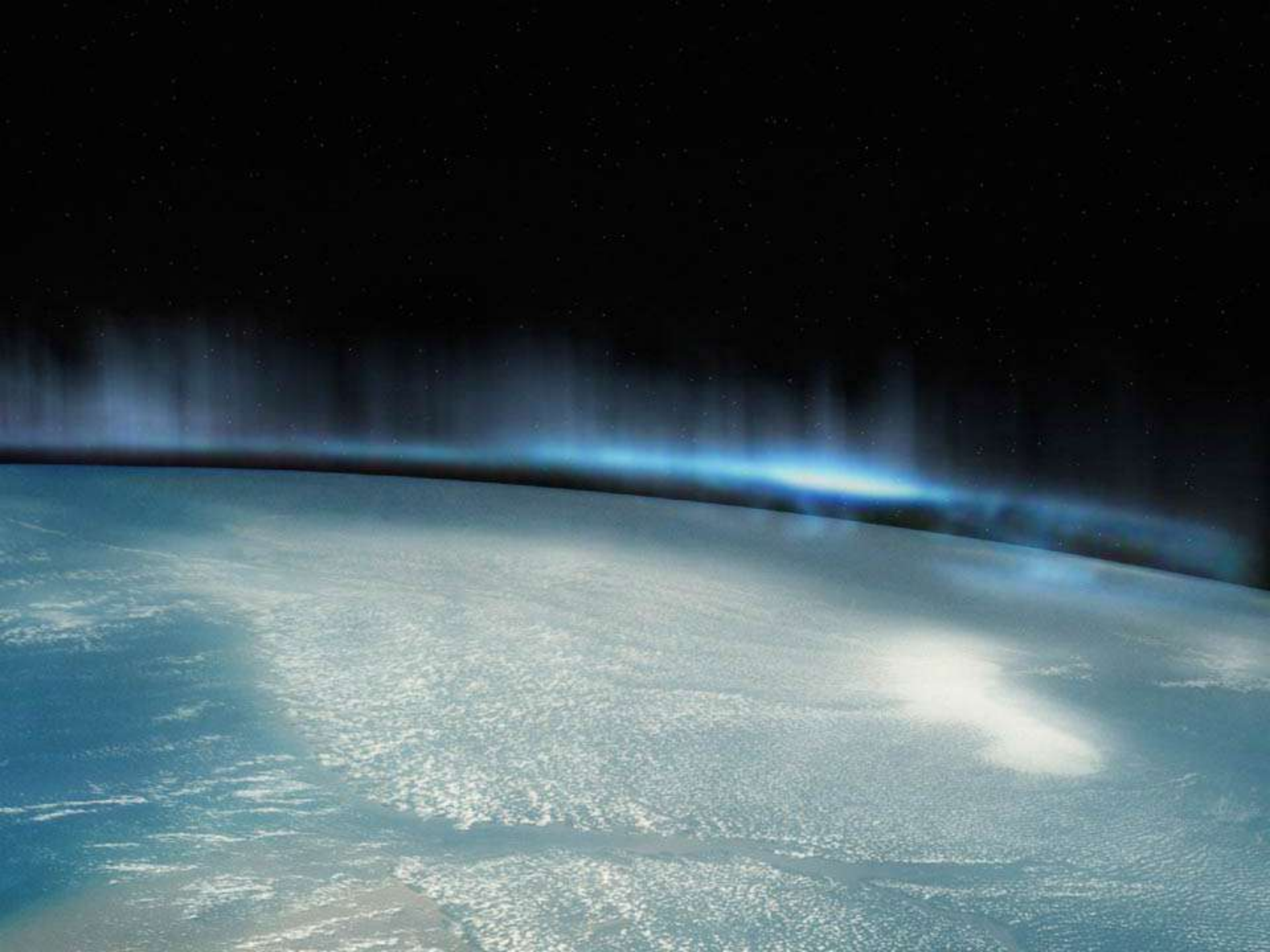
http://www.iteachbio.com/Chemistry/Matter/Gases-USV.mov

What is plasma?

- Gas-like mixture of charged particles
- Affected by a magnetic field
- Most common form of matter in the universe
- Found in lightning, fluorescent bulbs, stars
- Particles move faster as the matter is heated
- Bump or collide into each other at high speeds

Molecular Movement of Plasma





Changes between states/phases

Matter can change from one state to another.

Melting – occurs as a solid changes to a liquid state

Boiling – occurs as a liquid changes to a gas state throughout the material

Sublimation – occurs as a solid goes to a gas state without an obvious liquid state between them (ex: dry ice goes to vapor)

Evaporation – change from liquid to gas state that happens at the SURFACE of the liquid (by contrast boiling happens throughout the liquid)

Condensation – change from a gas (vapor) to a liquid state

Freezing – change from a liquid to solid

Deposition – the change from gas to a solid (example: formation of frost)

Ionization – the change of a gas to a plasma state

Recombination – the change from plasma state to gas

Tracing the changes in water

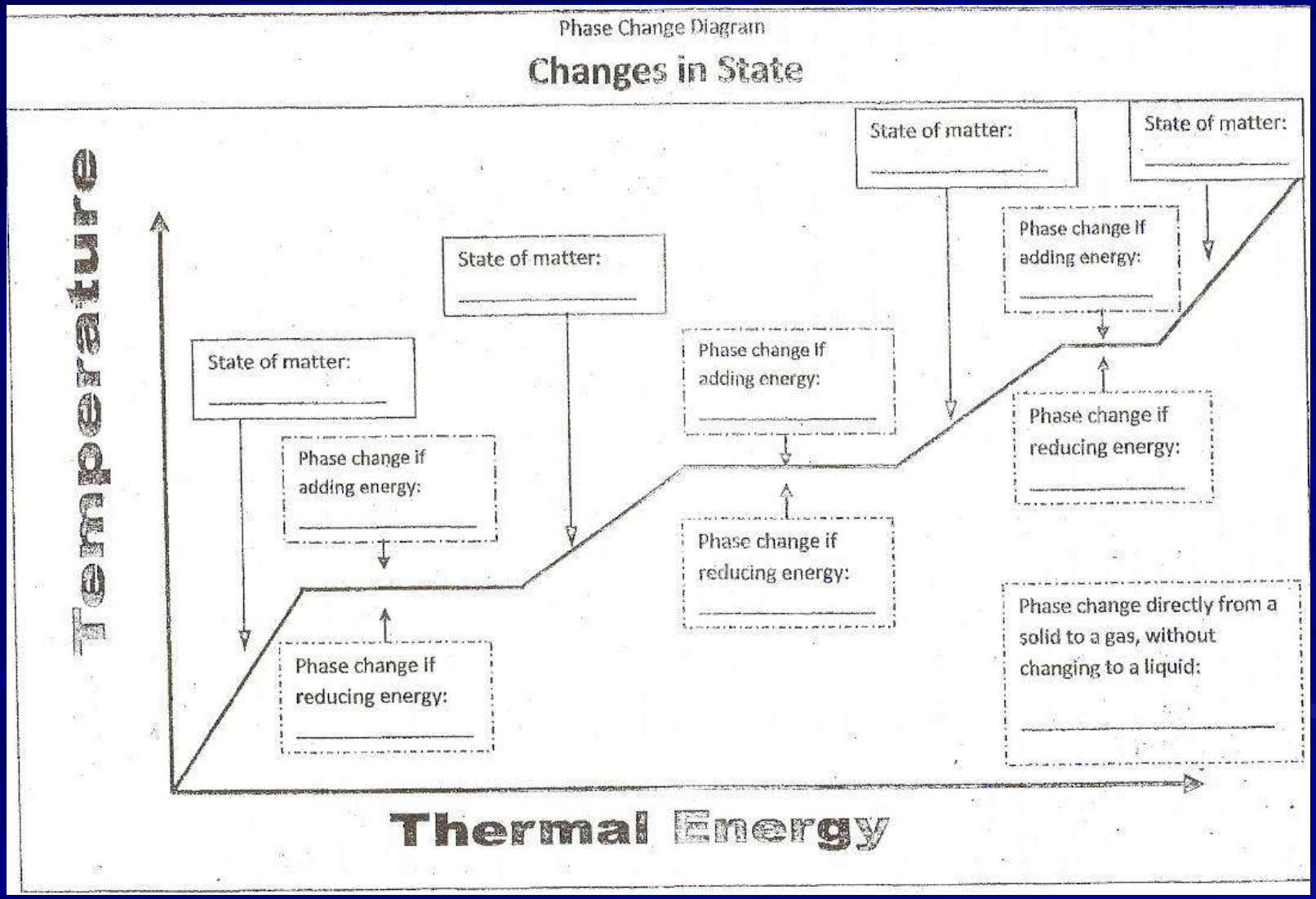
Water at room temperature is in a liquid state.

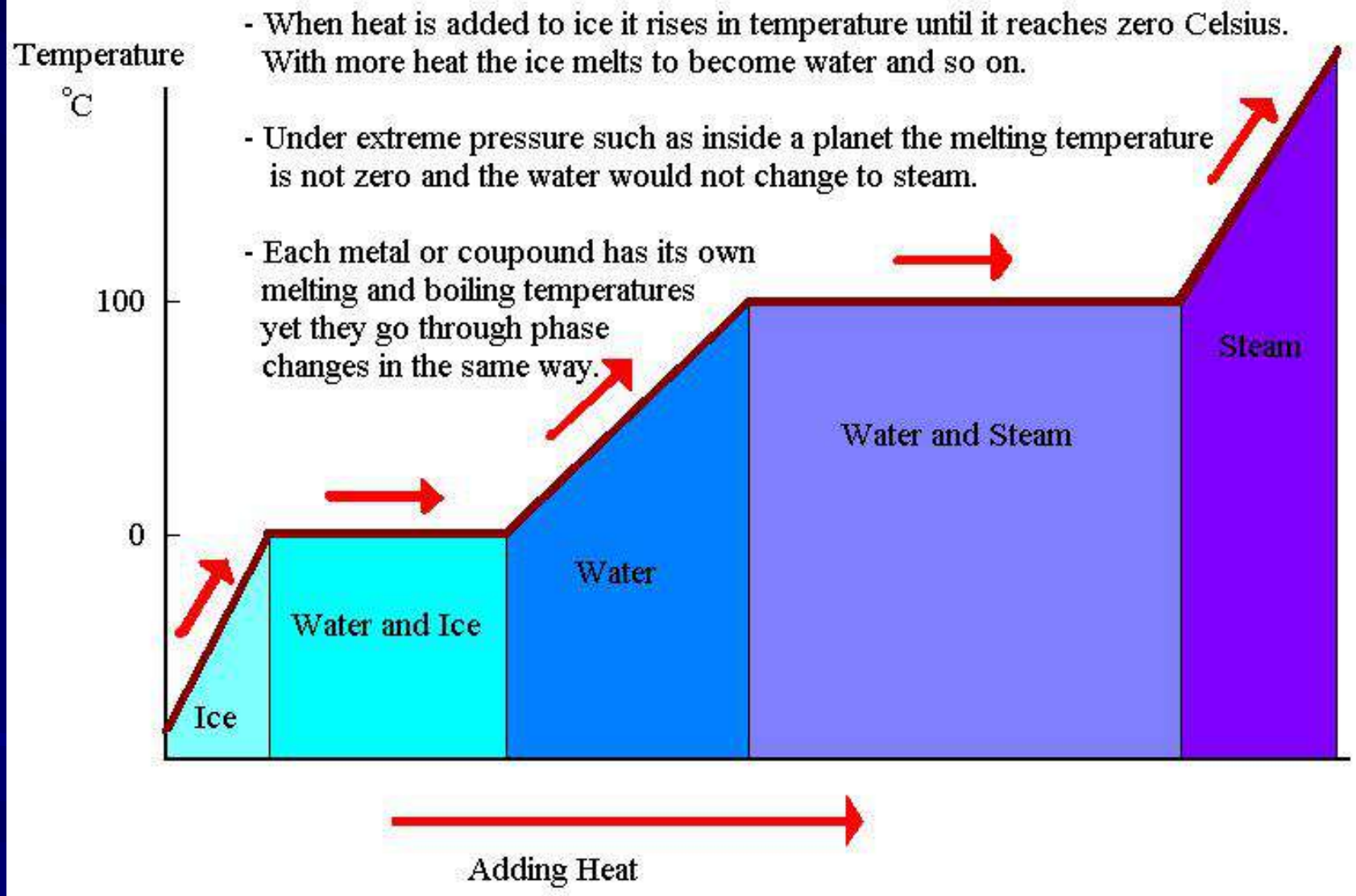
On removing energy (dropping the temperature) below 32F/0C, the liquid water begins to freeze and become solid

If the liquid water is placed in a container and energy (heat) is added, and it reaches 212F/100C, it boils and becomes a gas (water vapor)

If the water vapor cools, it condenses to a liquid.

If the liquid water is left alone, eventually, some particles will evaporate


Phase Change Diagram
Changes in State
Temperature
Thermal Energy
State of matter:
State of matter:
State of matter:
Phase change if adding energy:
Phase change if adding energy:
Phase change if adding energy:
Phase change if reducing energy:
Phase change if reducing energy:
Phase change if reducing energy:
Phase change directly from a solid to a gas, without changing to a liquid:


- When heat is added to ice it rises in temperature until it reaches zero Celsius. With more heat the ice melts to become water and so on.
- Under extreme pressure such as inside a planet the melting temperature is not zero and the water would not change to steam.
- Each metal or coupound has its own melting and boiling temperatures yet they go through phase changes in the same way.
Temperature
°C
100
0
Ice
Water and Ice
Water
Water and Steam
Steam
Adding Heat

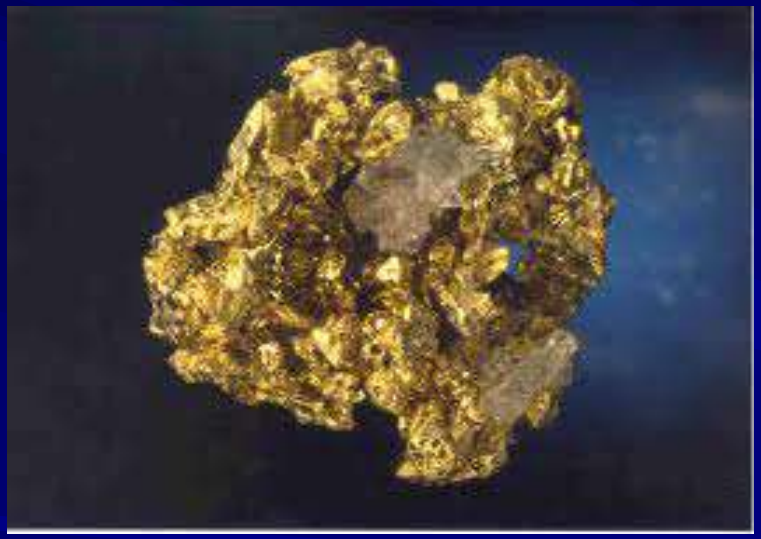
What is a physical property?

A characteristic of a pure substance that can be observed without changing the substance

Examples:

- color
- hardness
- texture
- whether or not a substance dissolves in water
- ability to conduct electricity or heat

Example of physical properties of gold



- Bright yellow metal
- Density: 19.3 g/cm3
- 2.5 hardness on Mohs scale
- Melting point: 1065 C
- Boiling point: 2807 C
- Ductile (can be pulled into wires)
- Malleable (easily formed into sheets and shapes)
- Conducts heat and electricity (conductor)

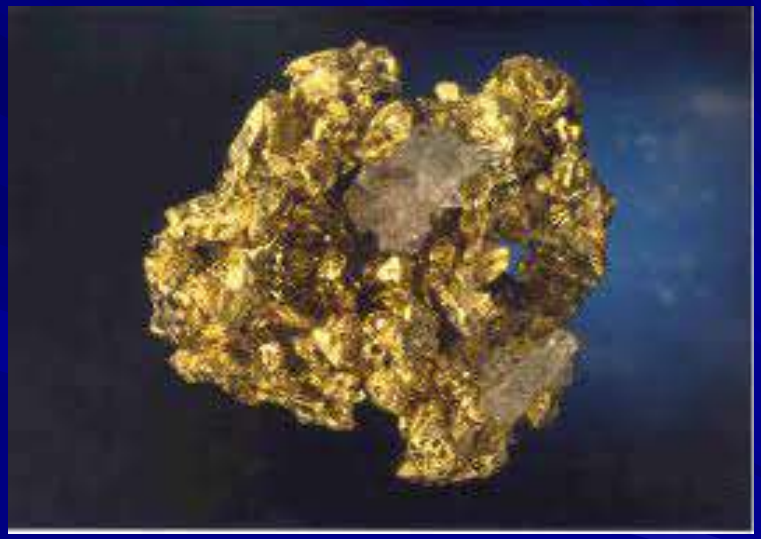
What is a chemical property?

A characteristic of a pure substance that describes its ability to react with other substances

These cannot be determined just by looking at a substance!

Example of chemical properties of gold

- Not very reactive
- Does not combine with oxygen (does not tarnish or rust)
- Does not dissolve or react with most acids
- If swallowed, gold is not known to be a toxin



Intensive vs. extensive

All properties of matter are considered intensive or extensive properties.

Intensive (or characteristic) properties do not depend on the amount of the matter that's present.

Extensive properties do depend on the amount of matter that's present.

Intensive/Characteristic Properties

These physical and chemical properties do not change regardless of how much you have of the substance.

This means that whether you have 1 mL of water or 100 L of water, the characteristic properties do not change.

Characteristic properties can be used to identify an unknown sample of matter.

Intensive/ Characteristic Properties

Some intensive properties include:

- **Color**
- **Odor**
- **Luster.**
- **Malleability**
- **Ductility**
- **Conductivity**
- **Hardness** - How easily a substance can be scratched.
- **Melting/Freezing Point**
- **Boiling Point**
- **Density**
- Flammability

Intensive/ Characteristic Properties

Density is a characteristic property!

Think back to the labs we have done. The density of water stays at 1.0 g/mL regardless of the volume of water you measured.

*The density of water can change though depending on temperature, pressure, and altitude. It just doesn't change relative to the amount you have.

Melting/freezing point is 0 C for water; boiling point is 100 C for water. Both are characteristic properties.

Extensive Properties

These physical properties are dependent on the size of the sample.

This means that they will change if the size of the sample is changed.

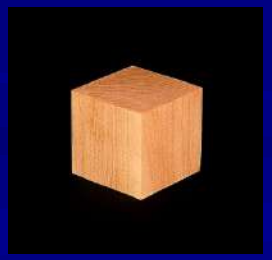
Examples include:

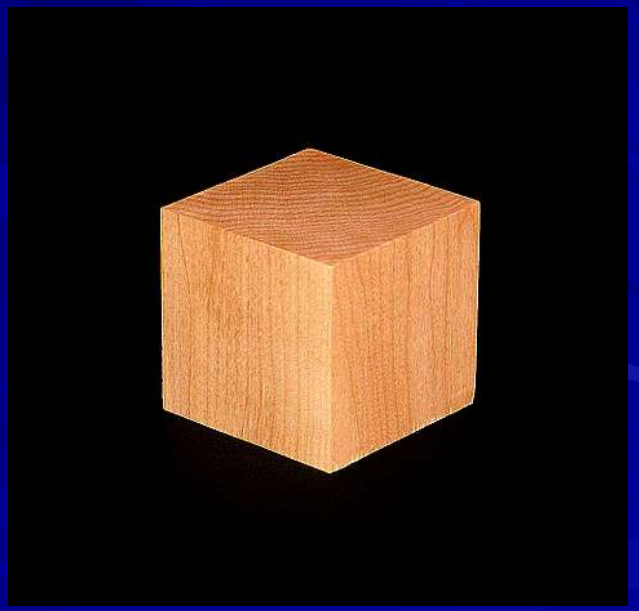
- Mass
- Weight
- Volume

Putting it all together

Look at the two cubes below. Assuming they are made of the same wood, the cube on the right will have a larger mass, volume, and weight.

However, all intensive properties will be the same for both cubes.





Putting it all together

They will have the same:

- Density
- Flammability
- State
- Color
- Texture
- etc.