6^{th} Grade
Introduction to Chemistry

Chapter 2: Solids, Liquids, and Gases

Lesson 1 (States of Matter)

Solid – a state of matter with a definite shape and a definite volume

- The particles in a solid are generally packed close together.
- The particles vibrate slightly about their fixed positions.

Crystalline solid – the particles form a regular, repeating pattern

- melt suddenly when they reach a certain temperature

Examples: salt, sugar, snow, ice

Amorphous solids – the particles are not arranged in a regular pattern

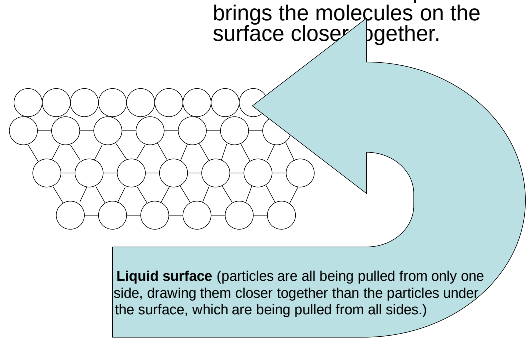
- become softer and softer as they are heated until they are a liquid

Examples: butter, glass, plastic, rubber

Liquid – state of matter with definite volume, but no definite shape

- A liquid takes up the same amount of space (volume) no matter what container it is in.
- The particles are still packed close together, but can move around each other freely. (No shape of its own.)

1. **Surface tension** – an inward force, or pull, among the molecules in a liquid that brings the molecules on the surface closer together.



viscosity – a liquid's resistance to flowing

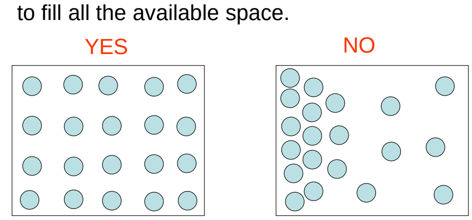
- depends on the size, shape, and the amount of attractive forces holding the particles in place.
- The stronger the attraction between particles, the harder it is for the liquid to flow.
- High viscosity liquids flow slowly. (honey)
- Low viscosity liquids flow easily. (water)

Fluid – a substance that flows, or changes shape easily

- Liquids and gases are fluids.

Gas – a state of matter that has no definite shape and no definite volume

- Particles can move in all directions and spread to fill all the available space.



Three Factors to Consider About Gases:

1. volume
2. Pressure
3. Temperature

Volume – the amount of space matter fills

– The container decides the **volume** and **shape** of a gas as the particles can just move farther apart or closer together.

Pressure – the force of the outward push of gas particles on the walls of the container divided by the area of the walls.

– Gas particles are in constant motion and collide with each other and push on the walls of their container.

$$Pressure = \frac{Force}{Area}$$

Temperature – a measure of the average energy of motion of the particles (a measure of how fast the particles are moving)

– The faster the particles are moving, the greater their energy and the higher the temperature.

– A thermometer is like a speedometer for particles.

Lesson 2 (Changes of State)

A change in state of any substance involves an increase or decrease in thermal energy.

Melting – a change in state from a solid to a liquid as a solid **gains** enough thermal energy

– As thermal energy is absorbed, the particles of a solid move faster, until they vibrate so fast that they break free from their fixed position.

– The particles can now move more freely around each other. (liquid)

Melting point – the specific temperature at which a solid (crystalline) turns to a liquid

– Some solids have lower melting points than others. (They melt easier.)

Freezing – a change in state from a liquid to a solid as a liquid **loses** enough thermal energy.

– As thermal energy is lost, the particles move slower until they are moving so slowly they begin to take on a fixed position. (solid)

– The freezing point of water is the same as its melting point. (0^oC or 32^oF)

Vaporization – a change in state from a liquid to a gas as a liquid **gains** enough thermal energy

Water vapor – water as a gas, rather than a liquid

Types of Vaporization:

1. evaporation
2. boiling

Evaporation – vaporization that takes place **only on the surface** of a liquid

– Thermal energy is gained, or absorbed, by the particles of the liquid.

– Particles move faster until the fastest ones can break free into the air. (They overcome the force of attraction that holds water molecules together.)

Boiling – vaporization that takes place both below and at the surface of a liquid

Boiling point – the specific temperature at which a liquid boils

– Different liquids have different boiling points.

– The air pressure above the liquid affects the boiling point of a liquid.

(Water boils at a lower temperature in the mountains where the air pressure is lower.)

Condensation – a change in state from a gas to a liquid as the gas **loses** enough thermal energy

– When water vapor molecules (gas) touch a cold surface they lose thermal energy.

– This makes them move slower until the force of attraction causes them to regroup into a liquid again.

Examples: water droplets on the outside of a cold drink
clouds forming in the atmosphere
moisture on your bathroom mirror

Sublimation – a change in state from a solid directly to a gas, without passing through the liquid state

Examples: ice cubes "shrinking" in the freezer
snow disappearing when it's too cold to melt

Lesson 3 (Gas Behavior)

Three factors to consider about gases:

1. Volume
2. Pressure
3. Temperature

Pressure and Temperature Relationship:

1. When the temperature of a gas at a constant (unchanged) volume is increased, the pressure of the gas increases.
   – Particles move faster and hit the walls of the **rigid** container more often and with more force.
2. When the temperature of a gas at a constant (unchanged) volume is decreased, the pressure of the gas decreases.
   – Particles move slower and hit the walls of the container less often and with less force.

temperature ↑ (then) pressure ↑
temperature ↓ (then) pressure ↓

Volume and Temperature Relationship:

Charles's Law - When the temperature of a gas is increased at a constant pressure, the volume increases.

– When the temperature of a gas is decreased at a constant pressure, the volume decreases.

– As you heat a gas, the particles move faster, hitting the container with more force that increases the volume of the container. (The opposite happens when you cool a gas.)

– This is the law that says a gas expands when it is heated and contracts (shrinks) when cooled.

temperature ↑ (then) volume ↑
temperature ↓ (then) volume ↓

Pressure and Volume Relationship:

Boyle's Law - When the pressure of a gas at a constant temperature is increased, the volume of the gas decreases.

– When the pressure is decreased, the volume of a gas increases.

– This is the law that says you can squeeze gas particles into a smaller space to increase the pressure they exert (apply).

volume ↓ (then) pressure ↑
volume ↑ (then) pressure ↓

Examples: Putting a lot of air into an air compressor tank.

Inflating a ball or bike tire.

Pushing down on a bicycle pump handle.

T = temperature
P = pressure
V= volume