# **1** States of Matter

There are three states of matter.

Solid:

- Matter that has both a definite shape and definite volume.
- Molecules or atoms are very close together and can only vibrate a little.
- They do not move past each other.

## Liquid:

- Matter that has a distinct volume but no specific shape.
- Molecules or atoms are close together but have the ability to slide across one another very easily.

## Gas:

- Matter that has no fixed volume or shape. It conforms to the volume and shape of its container.
- Its molecules or atoms are very far apart from each other and move very fast.

Compression - forcing a substance into a smaller volume.

- Gases are very compressible because of their empty space.
- Liquids have very little compressibility.
- Solids have almost no compressibility.

### Density Comparison:

- If you consider the solid, liquid, and gas state of one particular substance, this rule holds true in most cases:
- Solid is more dense than liquid and liquid is more dense than gas.

#### Two Types of Solids:

Crystalline Solids

• molecules are packed together in a predictable way. THey are arranged in an orderly, geometric, three dimensional structure. The smallest repeating part of a crystalline structure is called a unit cell.

Atomic Solids

- Unit particles are atoms.
- Noble gases are atomic solids when they are cooled to solid state. Usually very soft because they have weak IMFs.

Molecular Solids

• Units are molecules, held together by weak IMFs. Low melting points.

Covalent Network Solids

• Form a 3-D covalent network, very strong. High melting points.

Ionic Solids

- Crystal lattice is formed from alternating cations and anions.
- High melting point and hardness.

• Always solids at room temperature.

Metallic Solids

- Atoms are surrounded by mobile valence electrons.
- Malleable, ductile, conductors.

### Amorphous Solids:

- particles are not arranged in a regular repeating manner.
- Amorphous means "without shape"

#### Liquids:

- Fluidity liquids have the ability to flow
- Viscosity the measure of the resistance of a liquid to flow.
- Liquids with big, complex molecules tend to be very viscous.
- Viscosity decreases with increasing temperature.

#### Buoyancy:

• The upward force a liquid exerts on an object.

Phase Changes - matter can change from one phase to another by adding or removing energy. There are six phase changes.

Phase Changes That Require Energy

- Melting solid changing to liquid.
- Vaporization liquid to gas, occurs when molecules have enough energy to escape the pull of the other molecules.
- Sublimation solid changing directly into gas

Phase Changes That Release Energy

- Condensation gas to liquid.
- Freezing liquid to solid, achieved by removing heat.
- Deposition gas directly to solid achieved by removing heat.

Boiling is heating a liquid to the temperature at which all molecules have enough energy to escape and vaporize. Evaporation is the vaporization of surface molecules; very slow. This does not occur at high temperatures.

A phase diagram shows what phase a substance will be in at a certain temperature and pressure. Pressure is usually measured in atmospheres.

Triple point - the point on a phase diagram that shows the temperature and pressure combination at which three phases of a substance can coexist.

Critical point - temperature and pressure combination above which a vapor cannot be liquefied under any circumstances.

When energy/heat is added to or removed from a substance, two things could happen: temperature changes or phase change.

How do you know how much energy is needed for a change?

First off.

- Q for heating/adding energy is always positive.
- Q for cooling/releasing energy is always negative.

For a single phase, use the formula  $q = mc\Delta T$ , where q is heat in Joules, m is mass in grams, c is the specific heat, and  $\Delta T$  is the change in temperature.

For a single temperature, use the formula  $g = mol \cdot \Delta H$ .

The heat needed to melt or freeze is the latent heat of fusion and the heat needed to boil/condense is the latent heat of vaporization.

Exercise - How much energy is needed to convert 153 grams of ice at  $-15^\circ$  C to steam at  $125^\circ$  C? The molar mass of water is 18.016 g/mol. (472 kJ)