

# 1 States of Matter

*You has mass, you have volume. You 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  $q = mol \cdot \Delta H$ .

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  $-15^\circ\text{C}$  to steam at  $125^\circ\text{C}$ ? The molar mass of water is 18.016 g/mol.

## Chapter Problems

1. Which liquid is more viscous at room temperature, water or molasses? Explain your reasoning.
2. How is it possible that a pile of snow can slowly shrink even on days when the temperature never rises above the freezing point?
3. How much heat is required to warm 225 g of ice from  $-46.8^\circ\text{C}$  to  $0.0^\circ\text{C}$ , melt the ice, warm the water from  $0.0^\circ\text{C}$  to  $100.0^\circ\text{C}$ , boil the water, and heat the steam to  $173.0^\circ\text{C}$ ?