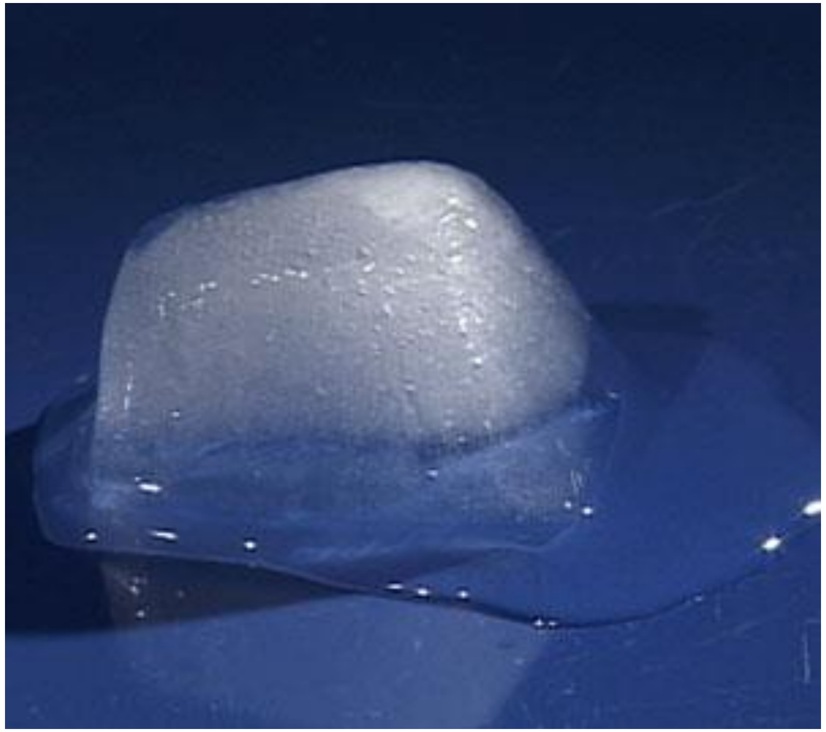
Freezing and Melting



http://www.800mainstreet.com/08/0008-001-state-changes.html

Outcomes:

- Explain the process of freezing/melting, and sublimation/ deposition in terms of KMT. *Include: Freezing point*
- Use KMT to describe the process of evaporation/ condensation. *Include: IMF's, random motion, volatility, dynamic equilibrium.*

Vocabulary:

Endothermic

- **ABSORPTION** of **HEAT** (**ENERGY**) by a substance or reaction.

Exothermic

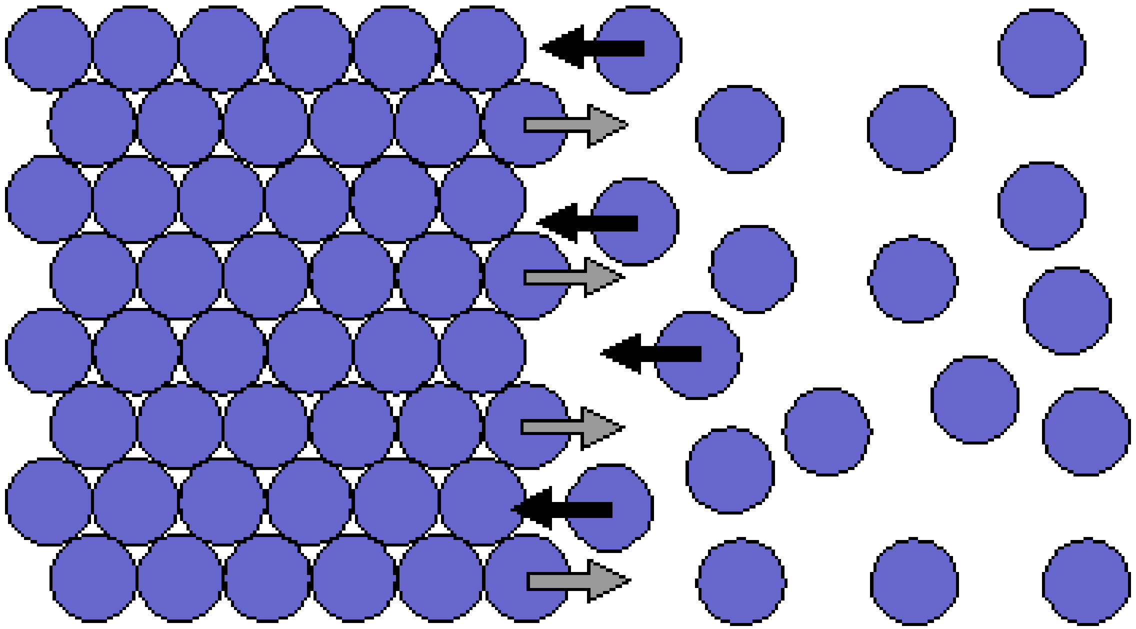
- **RELEASE** of **HEAT** (**ENERGY**) by a substance or reaction

Freezing/Melting Point:

- ***Temperature*** at which **<u>LIQUID</u>** changes to **<u>SOLID</u>**. (water → 0 °C, diamond → 3700 °C)
  - ***Freezing point*** of a ***liquid*** is the ***<u>same</u>*** as the ***melting point*** of a ***solid.***

- At this temperature, liquid and solid are in **<u>EQUILIBRIUM</u>**:

Solid ←→ Liquid



http://antoine.frostburg.edu/chem/senese/101/solutions/faq/why-salt-melts-ice.shtml

Freezing /Melting Point:

- At the melting point, the particles have enough **KINETIC ENERGY** to overcome **INTERACTIONS** that hold them in place as a **SOLID**.

    - **IONIC** solids generally have high **MELTING POINTS** (NaCl → 801°C)
    - **COVALENT** solids are lower (HCl → -112 °C)

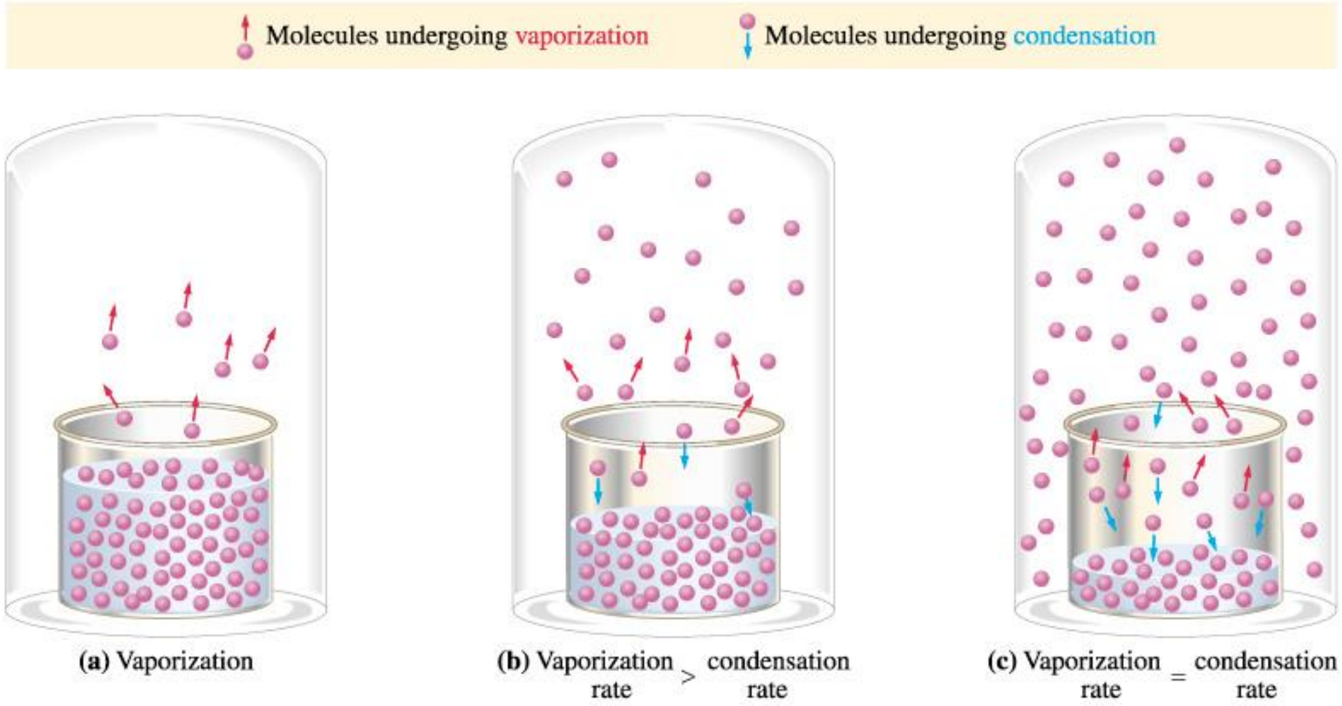
- Not all solids **MELT** (ex. wood)
- Melting/Freezing points are **PHYSICAL** properties of **PURE** substances.

Boiling/Condensation Point:

- The **TEMPERATURE** at which a substance changes between **LIQUID** and **GAS**.
  - ***Boiling and Condensing happen at the same temperature!***

- At this temperature, in a **SEALED CONTAINER**, liquid and gas are in ***dynamic equilibrium***

Liquid ←→ Gas



http://www.sciencesfp.com/unit-2-matter-and-its-properties.html

What is "Normal":

Normal Melting/Freezing Point:

- Temperature at which a solid changes to a liquid (or vice versa) at **STANDARD PRESSURE** → ***1atm (101.3 kPa)***
- ***Ex) the normal melting point of ice is 0˚C, but we can get ice to melt at different temps!***

Normal Boiling Point:

- Temperature at which a liquid changes to a gas at **STANDARD PRESSURE** → ***1atm (101.3 kPa)***
- ***Ex) the normal boiling point of water is 100˚C, but we can get water to boil at different temps!***

Changes of State Review:

Melting - **ENDOTHERMIC**, *solid → liquid*
Freezing - **EXOTHERMIC**, *liquid → Solid*
Condensation - **EXOTHERMIC**, *gas → liquid*
Vaporization - **ENDOTHERMIC**, *Liquid → Gas*

There are two new changes of state:

SUBLIMATION

- **SOLID** changing to a **GAS**.
- **ENDOTHERMIC**

ex) ***dry ice, ice cubes in freezer, moth balls***

Changes of State

DEPOSITION

- **GAS** changing to a **SOLID**
- **EXOTHERMIC**

ex) ***Frost on a car windshield***

More on Changes of State:

- Solids have **VAPOR PRESSURES** just like liquids, only usually much, much **LOWER**.

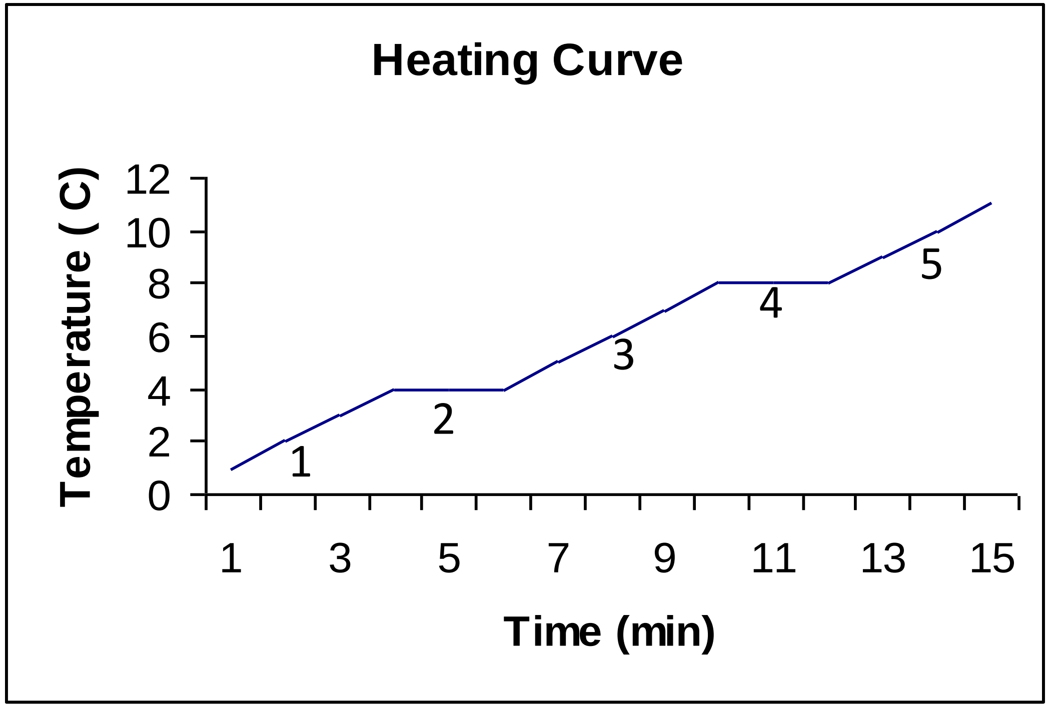
- Solids with **HIGH VAPOUR PRESSURES** have **WEAK INTERMOLECULAR FORCES**, and **SUBLIME** relatively **EASILY**. (*solid air fresheners)*

- We see sublimation and deposition in winter:
  - ***Snow can sublimate even below 0 °C***
  - ***Water vapour undergoes deposition to become snow and frost***

Heating & Cooling Curves:

A ***heating graph*** is a ***Temp vs. Time*** graph that shows a **CHANGE IN STATE** from solid to liquid to gas (or part thereof).

- Flat spots show the ***changes of state.***
- Slopes show a specific ***phase (state)***



Legend:

1. **Solid**
2. **Melting**
3. **Liquid**
4. **Boiling**
5. **Gas**

A ***cooling graph*** is the same as a heating graph, but at time 0 min, you start with a gas, then condense to liquid, then freeze to a solid (the **SLOPE** is **REVERSED**).

Heating & Cooling Curves:

Heating Curves Applet Questions

1. Why are there regions where the temperature does not change with time, despite the fact that heat is being added to the system?

   Changing states → energy is being used to overcome IMF's

2. What is the melting ***point*** of the substance? ≅ 60°C

   =

   ≠

   ≅

3. What is the boiling ***point*** of the substance? ≅ 145°C

4. How does the heating curve for a 400 W heating rate compare with that obtained using a 200 W heating rate? (Be quantitative in your answer.)

   2x faster (same m.p. + B.P.)

5. Do the melting point and boiling ***point*** depend upon the heating rate?

   NO

Heating & Cooling Curves:

Why is the graph level at the melting/boiling points?

→The substance exists in both states so the two states are at equilibrium with each other.

→ The average energy does not change because any added energy is used to overcome IMF's

Ex) When water is boiled:

- ***The molecules gaining the energy escape to the gas phase, leaving the slower molecules behind.***
- ***This keeps the average energy of the remaining molecules constant, as any molecules that gain energy escape.***

Heating & Cooling Curves:

You can imagine changes of state to be on a number line:

Ex) For water at sea level…