Melting Point

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Phase Changes

- Solid → Liquid — Melting
- Liquid → Solid — Freezing
- Liquid → Gas — Vaporization
- Gas → Liquid — Condensation
- Solid → Gas — Sublimation
- Gas → Solid — Deposition

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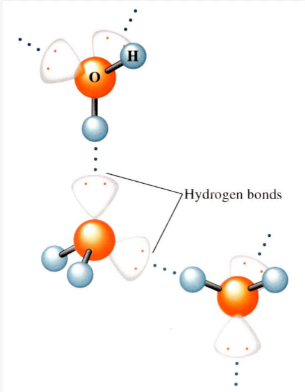
Intermolecular Forces

- Many properties of liquids, solids & gases can be explained on basis of weak attractive forces between molecules: Hydrogen bonds & Dipole-Dipole forces.

- H bonds: attractive force between positive H on N, O, or F & a N, O, F on another molecule. Example: Water



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Intermolecular Forces
van der Waals forces

- Dipole-Dipole Interactions: Weak attractive forces between opposite charged dipoles. Occurs with polar molecules such as H-Cl
- Induced Dipole Interactions: Weaker attractive forces (London Forces) between temporarily induced dipoles. Occurs with non-polar molecules such as Br_2
- Strengths:

Covalent Bond	~	400 kJ/mol
H Bond	~	20 - 60 kJ/mol
van der Waals	<	10 kJ/mol

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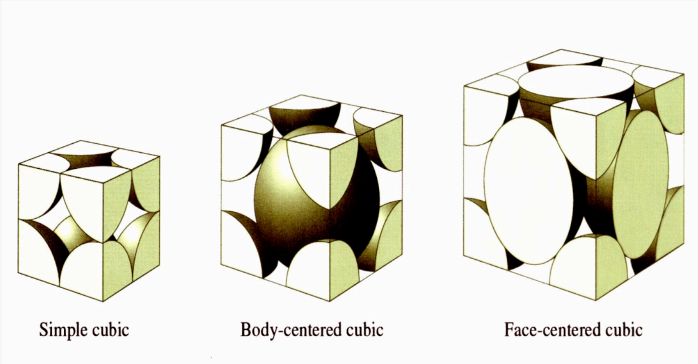
Attractive Forces & Solids

- Solids can be:
  1) Amorphous with no ordered structure (glass)
  2) Crystalline with a well defined 3D structure
- Types of Solids:
  - Molecular – molecules held together by intermolecular forces (Ice).
  - Metallic – metal atoms in sea of electrons (Fe).
  - Ionic – cations & anions held together by opposite charge attractions (NaCl).
  - Covalent – Solids held together by large networks of covalent bonds (graphite).

Attractive Forces & Solids

- Crystalline solids have ordered, repetitive 3d structure that we call the crystal lattice.
- Smallest boxlike unit that makes up the crystal lattice is called the unit cell.
- There are several unit cell shapes: Cubic, Hexagonal, etc.
- Three types of Cubic Unit Cells are:
  - **Simple Cubic Unit Cell**
  - **Body-Centered Cubic Unit Cell**
  - **Face-Centered Cubic Unit Cell**
- Exact crystal structure can be determined by X-Ray Crystallography.

Attractive Forces & Solids
Cubic Unit Cells



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Melting Point

- Temperature at which a transition occurs between solid and liquid phases
- Temperature at which an equilibrium exists between the well-ordered crystalline state and the more random liquid state.

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Melting Point Range

- The first point (lower temperature) is the temperature at which the first drop of liquid forms amongst the crystals.
- The second point (higher temperature) is the temperature at which the entire mass of solid turns to a clear liquid.

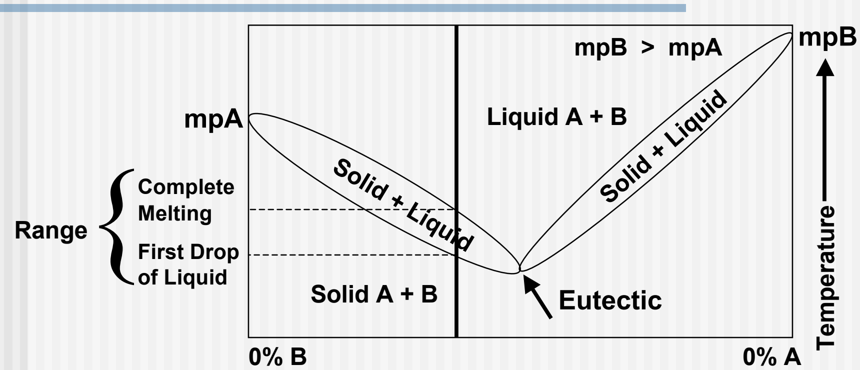
Application of Melting Point

- Identify Compounds
- Establish Purity of Compounds

Melting Point

- **Melting point indicates purity in two ways**
  - The purer the compound, the higher the melting point
  - The purer the compound, the narrower the melting point range
- **Melting point of A decreases as impurity B is added**
- **Eutectic point is the solubility limit of B in A; thus, it is the lowest melting point of an A/B mixture (Note: sharp melting point – no range at eutectic point)**

Phase Diagram of Mixture



Sample Preparation Procedure

- Crush sample
- Loading the capillary tube
- Tap open end of tube into sample (1-2 mm of sample)
- Drop tube (closed end down) down a length of glass tubing letting it bounce on table – sample is transferred to closed end of capillary tube. Repeat, if necessary.

Obtain the "Melting Point Range"

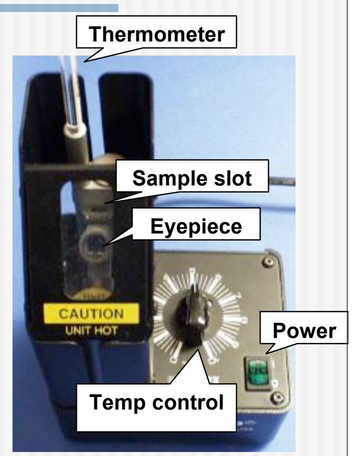
- Place capillary tube with sample at the bottom of the tube in a Mel-Temp apparatus.
- Adjust temperature knob until temperature rises about (2-3°C per minute)
- Determine rough melting point.
- Allow capillary tube to cool until liquid solidifies.
- Reset temperature knob for a slower rate of temperature increase.
- Allow temperature to rise to 10°C below "rough MP"
- Reset temperature knob so that temperature rises no more than 0.5°C/Min.

Experimental Procedure

Turn the Mel-Temp power on and adjust the temp control to the desired rate of heating.

In order to obtain an accurate mp, it is necessary to heat *SLOWLY*, at a rate of 2-3°C/min.

Heating too fast may lead to inaccurate results because of insufficient time for heat transfer.



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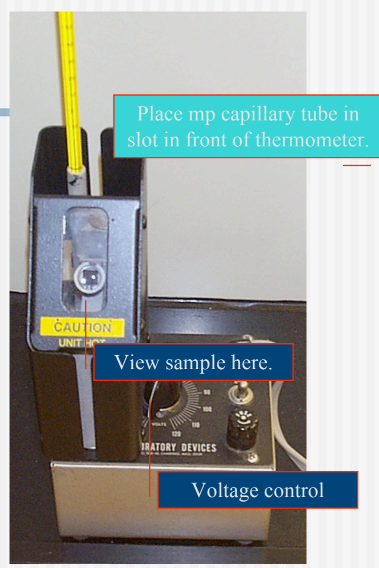

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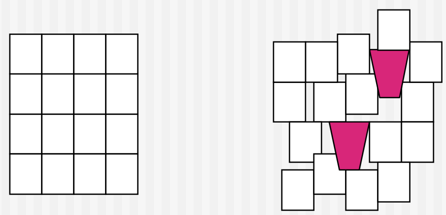
Theory of Melting Point

- **Impurities lower melting point:**
  - takes less energy to disrupt crystal lattice when impurities are present
  - melting point will be lower
  - melting point range will be broader



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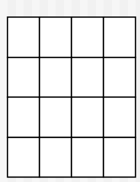
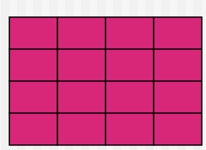
Theory of Melting Point

- **Mixed melting point - used to determine identity of compound:**



Urea
MP 120-121ºC



Cinnamic acid
MP 120-121ºC

Have unknown compound that melts at 120-121. What is the unknown?

How could you tell?

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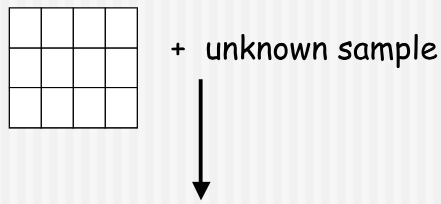
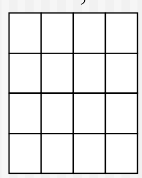
Mixed Melting Point

- Mix unknown compound with a little urea and measure melting point



If melting point is still 120-121ºC, unknown compound was urea.



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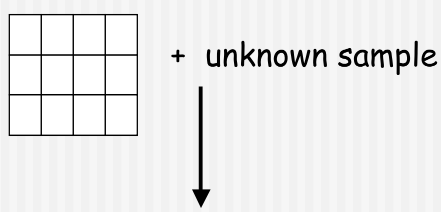
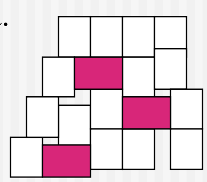
Mixed Melting Point

- Mix unknown compound with a little urea and measure melting point



If melting point is lower and broader, i.e. 110-116ºC, unknown compound was NOT urea.



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