

Objective 14: States of matter - liquids and solids: relate liquid and solid types to chemical forces and properties. Use phase diagrams.

### Quiz Practice problems:

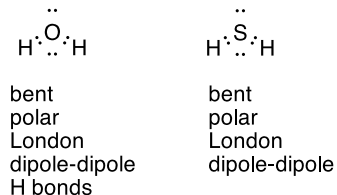
#### Key ideas:

Valence electrons --> Structure --> Shape --> Polarity --> IM forces --> Properties

**Liquids** – intermolecular forces (London, dipole-dipole, and hydrogen bonds) determine the properties (boiling point, viscosity, surface tension) of a liquid.

**Example:** Explain why H<sub>2</sub>O has a higher b.p. than H<sub>2</sub>S.

Answer: draw structure of each molecule, determine shape, polarity, and IM forces.



Water has stronger IM forces than H<sub>2</sub>S so more energy is needed to break the IM forces ==> higher boiling point.

**Solids** types: molecular solids, ionic solids, covalent network solids, and metallic solids.

Different chemical forces exist between each solid type:

Intermolecular forces in molecular solids,

ionic bonds in ionic solids,

covalent bonds in covalent network solids, and

metallic bonds in metallic solids.

The chemical forces determine the properties of each solid type.

**Skills:** Identify the intermolecular forces in a liquid.

Relate intermolecular forces to liquid properties.

Given a solid, identify solid type.

Identify chemical forces in a solid.

Relate chemical forces to solid properties.

1. Viscosity is the internal resistance to flow in a liquid (also called the shear stress).

a. Explain why H<sub>2</sub>O has a higher viscosity than acetone. Look up the structure of acetone.

b. Motor oil consists of large non-polar hydrocarbons (C<sub>19</sub> to C<sub>35</sub>, e.g., C<sub>20</sub>H<sub>42</sub>). Explain why oil has a higher viscosity than water using your knowledge of bonding, structure, and properties. Hint: London forces are proportional to the size of a molecule.

2. a. A bug floats on the surface of water due to surface tension. Add a drop of soap to the water and the bug sinks. Explain why this happens.

b. The tallest living tree today, at 370 feet tall, is the Mendocino Tree, a coast redwood tree near Ukiah, CA. The exact process by which water is taken up by plants against the force of gravity is not fully known (see [http://interactive.usask.ca/ski/forestry/activities/lesson\\_waterworks.html](http://interactive.usask.ca/ski/forestry/activities/lesson_waterworks.html)) One way water gets to the top of trees is by capillary action.

(i) What is capillary action?

(ii) What chemical forces determine capillary action?

(iii) If trees used hexane instead of water, would trees grow as high?

c. You may have mixed, or seen a bartender mix, alcoholic beverages. When a measured volume of ethanol is mixed with a measured volume of water, the sum of the volumes does not equal the actual volume. The actual volume is actually less than the sum of the volumes. Use your knowledge of chemical forces to explain this observation.

### Solids

Solids are classified into 4 types: molecular solids, ionic solids, covalent network solids, and metallic solids.

Each solid type is held together by different chemical forces.

The chemical forces determine the properties (melting point, hardness, conductor or insulator) of a solid.

1. Two common solids are sugar (glucose) and salt.

a. Glucose is C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>. What type of solid is glucose? What intermolecular forces exist between two glucose molecules?

b. Salt is NaCl. What type of solid is salt? What chemical force exists between two salt compounds?

c. Salt has a melting point of 800°C. Glucose has a melting point of 150°C. Explain why salt has a higher melting point than glucose based on chemical forces.

2. a. Your ceramic coffee cup is an ionic solid. Ionic solids are hard but brittle. Explain why ionic solids are hard but brittle.  
b. You measure the properties of a solid. This solid conducts heat, is malleable (can be formed into shapes), and has a relatively high melting point. What type of solid do you have?

3. A Phase diagram of a substance tells you the temperature and pressure conditions for the different states of matter of the substance and the melting points and boiling points at different pressures.

See the phase diagram of water in the textbook.

a. The ice in a typical ice skating rink is cooled to about  $-20^{\circ}\text{C}$ . Ice skaters (figure skaters and hockey players) glide so smoothly across the ice because a layer of liquid water forms between the solid ice and their skate. Explain how this water layer is formed using the phase diagram of water.

b. At high altitudes, e.g., Lake Tahoe, certain foods take longer to cook than at sea level, e.g., Salinas. Explain why.

c. A pressure cooker cooks certain foods much faster. Explain how a pressure cooker works.

4. From *Strange but True*, by Bill Sones and Rich Sones (*The Valley Advisor*, 12/9/01, p. 21). Breathing blanks?

Q. Armchair astronauts, if you removed your helmet in space and tried to breathe, what would happen?

A. Even most astronomers can't answer this but NASA can, reports Cornell's "Ask an Astronomer" Web site. This is because astronauts' helmets occasionally pop off accidentally during training.

Exposed to a vacuum, you would feel the air immediately forced out of your lungs. You could still breathe in, but you'd be drawing airless blacks. There'd be no exploding eyeballs or embolisms, as the movies like to show, but you might suffer a case of the bends. "You'd also feel the spit on your tongue and sweat on your body boil away, described as a fizzy sensation like drinking soda. Otherwise, you wouldn't feel much—until you died of oxygen deprivation." BTW, NASA's helmet poppers have all survived.

a. Using your knowledge of science, why is the air immediately forced out of your lungs when exposed to a vacuum?

b. Using your knowledge of science, why isn't there any exploding eyeballs or embolisms? Why might you suffer a case of the bends?

c. Using your knowledge of science, explain why the spit on your tongue and sweat on your body would boil away.