Chapter 10

Section 10.1 The students need to know that the strengths of intermolecular attractive forces determine whether a compound will be a gas, a liquid, or a solid under normal conditions and that strong attractive ion-ion interactions hold ionic solids together. The strengths of these ion-ion interactions and the magnitude of the resulting **lattice energies** depend on the charges of the cation and anion and the distance between them. High lattice energies correlate with high melting and boiling points and low aqueous solubility's of ionic compounds. The energy change that occurs when one mole of an atom or ion combines with one mole of electrons in the gas phase is called its **electron affinity.** Lattice energies can be calculated with a **Born-Haber cycle**, an application of Hess's law of constant heat summation (Chapter 5).

Section 10.2 You should know that ions interact with water through **ion-dipole** forces and that **Dipole-dipole** forces exist between water and between other polar molecules. However, water's properties indicate the existence of stronger dipole-dipole interactions called **hydrogen bonds** and that these bonds form between other polar molecules containing *O—H*, *N—H*, or *F—H* covalent bonds.

Section 10.3 You should know that **Dispersion (London) forces** are due to the **polarization** of atoms and molecules and the existence of **temporary** (or **induced**) **dipoles** and that these interactions are weak compared with ion-ion and ion-dipole interactions. The strongest dispersion forces exist between the largest atoms, ion, and molecules.

Section 10.4 You should know that the van der Waals equation (Chapter 6) accounts for the behavior of gaseous substances at high pressured and low temperatures. You should also understand that the magnitudes of the parameters *a* and *b* depend on the substance and reflect the strength of intermolecular forces and molecular size, respectively. These parameters are largest for relatively large polar molecules.

Section 10.5 You should know that polar solutes dissolve in polar solvents when the dipole-dipole interactions between solute and solvent molecules off-set the interactions that keep solute or solvent molecules together. It is important to understand that the limited solubility of nonpolar solutes in polar solvents is a result of interactions between dipoles and induced dipoles. **Hydrophilic** substances are more soluble in water than are **hydrophobic** substances which prefer nonpolar solvents. **Henry's law** describes the solubility of sparingly soluble, chemically unreactive gases in liquids. Often more than one type of intermolecular force is responsible for the physical properties of a molecular substance.

Section 10.6 You should know that during **evaporation**, molecules at the surface of a liquid break intermolecular interactions with neighboring molecules and enter the vapor phase and that these vapor-phase molecules are the reason for the liquid's **vapor pressure**, which is an intensive property of a substance. A greater proportion of liquid molecules enter the vapor phase as the temperature increases, leading to higher vapor pressure at higher temperatures. The presence of particles of a nonvolatile solute in a solution decreases the vapor pressure of the solvent. This phenomenon is called a **colligative property** of the solvent. You should understand that **Raoult's law** relates the vapor pressure of a solution to its composition and the vapor pressure of the solvent.

Section 10.7 You should know that the **phase diagram** of a substance indicates whether it exists as a solid, liquid, gas, or **supercritical fluid** at a particular pressure and temperature. Be aware that all three states (solid, liquid, and gas) exist in equilibrium at the **triple point** and that above their critical temperatures and critical pressures, substances exist as **supercritical fluids.**

Section 10.8 You should know that the remarkable behavior of water, including its high melting and boiling points, **surface tension, viscosity,** and its **capillary action** result from the strength of intermolecular hydrogen bonds.

Section 10.9 You should know that solutes in solution *increase* the solvent's **boiling point** and *decrease* its **freezing point** temperature**.** Also, you need to understand that **Osmosis** is a process in which solvent flows through semipermeable membrane from a solution of lower solute concentration into a solution of higher solute concentration. Like freezing point and boiling point, **osmotic pressure** is a colligative property of a solvent. **Reverse osmosis** is used to purify water. The concentration scales used for colligative property measurements include **molarity** (moles solute/liter solution) and **molality**, (moles of solute/kilogram of solvent). The more concentrated a solution is, the higher is its boiling point, the lower its freezing point, and the higher its osmotic pressure. You need to be aware that the **van't Hoff factor** accounts for the colligative properties of electrolytes and the formation of solute **ion pairs** in concentrated solutions.

Section 10.10 You should know that the molar mass (g/mole) of a compound can be determined by measuring the freezing point depression, boiling point elevation, or osmotic pressure of a known mass of compound in a solution of known concentration.