GENERAL CHEMISTRY 2 REVIEWER There are two kinds of forces, or attractions, that operate in a molecule, intramolecular and intermolecular. ● Intramolecular forces - are the attractions that hold atoms together within a molecule (e.g., covalent or ionic bonds). TYPES OF INTRAMOLECULAR FORCES OF ATTRACTION 1. Ionic Bond - The force of attraction between oppositely charged ions. a. Formed by the complete transfer of valence electron/s between atoms b. Is a type of bond that generates two oppositely charged ions. c. Occurs between: Metals and nonmetals. i. Example: Sodium chloride (NaCl) — attraction between Na^+ and Cl^- ions. 2. Covalent Bond - The force of attraction that holds atoms together as they share electrons. a. Occurs between: Nonmetal atoms. i. Example: Water (H_2O) — hydrogen and oxygen share electrons. Types of covalent bonds: ● Single bond (one pair of electrons shared) ● Double bond (two pairs shared) ● Triple bond (three pairs shared) A. Nonpolar Covalent Bond - A bond where electrons are shared equally between atoms. a. Occurs when: The two atoms have the same or very similar electronegativity (ability to attract electrons). b. Result: No charge separation; the molecule is neutral overall. c. Examples: H_2 (Hydrogen gas) O_2 (Oxygen gas) Cl_2 (Chlorine gas) CH_4 (Methane) B. Polar Covalent Bond - A bond where electrons are shared unequally between atoms. a. Occurs when: The atoms have different electronegativities. b. Result: One atom becomes slightly negative (δ–) and the other slightly positive (δ+). c. Examples: H_2O (Water) — oxygen pulls electrons more strongly than hydrogen. HCl (Hydrogen chloride INTERMOLECULAR FORCES OF ATTRACTION ● What Are Intermolecular Forces? Intermolecular forces (IMFs) are the forces of attraction or repulsion between molecules. ○ These forces are weaker than the bonds that hold atoms together in a molecule (such as covalent or ionic bonds) ○ but they play a significant role in determining the physical properties of substances, such as boiling point, melting point, and solubility. Types of Intermolecular Forces 1. London Dispersion Forces (LDFs) - These are the weakest type of intermolecular forces caused by temporary shifts in electron density, creating temporary dipoles. a. Also called induced dipole–induced dipole forces. b. Weakest type of intermolecular force. c. Present in all molecules, but they are the only forces acting in nonpolar molecules. d. Strength increases as the molecule gets bigger or has more electrons. e. Example: F_2, O_2, CH_4 (methane), noble gases. f. Analogy: Like momentary attractions between people brushing shoulders — very temporary. For example, bromine, $Br2$, has more electrons than chlorine , $Cl2$, so bromine will have stronger London dispersion forces than chlorine, resulting in a higher boiling point for bromine,$59oC$, compared to chlorine. $-35oC$ g. Characteristics: i. Present in all molecules, whether polar or nonpolar. ii. More significant in larger, heavier molecules because they have more electrons. h. Example: The attraction between molecules in noble gases like helium or argon 2. Dipole-Dipole Interactions - Forces between the positive end of one polar molecule and the negative end of another polar molecule. a. Occur between polar molecules. b. Positive end of one molecule is attracted to the negative end of another. c. Stronger than London dispersion forces. d. Example: HCl, SO_2. e. Analogy: Like magnets — opposite poles attract. f. Characteristics i. Occur in polar molecules with permanent dipoles. ii. iii. Stronger than London Dispersion Forces. g. Example: Interaction between HCl molecules. 3. Hydrogen Bonding - A special type of dipole-dipole interaction involving hydrogen atoms bonded to highly electronegative atoms (F, O, N) a. A special and strongest type of dipole–dipole attraction. b. Occurs when hydrogen (H) is bonded to very electronegative atoms like nitrogen (N), oxygen (O), or fluorine (F). c. Strongest among common intermolecular forces. d. Example: H_2O (water),

NH_3 (ammonia), HF (hydrogen fluoride). e. Analogy: Like a strong “teamwork handshake” between molecules. a. Characteristics: i. Stronger than regular dipole-dipole forces but weaker than covalent bonds. ii. Responsible for many unique properties of water, such as its high boiling point. b. Example: The attraction between water molecules (H_2O). 4. Ion-Dipole Forces - The attraction between an ion (positive or negative) and the partial charge of a polar molecule. a. Characteristics: i. Strongest of the intermolecular forces. ii. Important in solutions where ionic compounds dissolve in polar solvents (e.g., salt in water). b. Example: Sodium chloride (NaCl) dissolving in water Hydrogen just wanna have FON “Hydrogen Bonding is a relatively strong force of attraction between molecules, and considerable energy is required to break hydrogen bonds” How Intermolecular Forces Affect Properties 1. Surface Tension - is the energy required to increase the surface area of a liquid. a. Effect of IMFs: The stronger the intermolecular forces, the higher the surface tension. b. Molecules at the surface are pulled more tightly toward the liquid, making the surface behave like a stretched film. 2. Viscosity - is the resistance of a liquid to flow. a. Effect of IMFs: Stronger IMFs → higher viscosity because molecules stick together and resist motion. b. Weaker IMFs → lower viscosity, meaning the liquid flows easily. 3. Vapor Pressure - is the pressure exerted by vapor molecules above a liquid at equilibrium. a. Effect of IMFs: Stronger IMFs → lower vapor pressure, because it’s harder for molecules to escape from the liquid to the gas phase. b. Weaker IMFs → higher vapor pressure, since molecules evaporate more easily. 4. Boiling Point - Boiling point is the temperature at which the vapor pressure equals the external pressure. a. Effect of IMFs: Stronger IMFs → higher boiling point, because more energy is needed to break the attractions between molecules. b. Weaker IMFs → lower boiling point. 5. Molar Heat of Vaporization (ΔH_{vap}) - The amount of heat required to vaporize one mole of a liquid at its boiling point. a. Effect of IMFs: Stronger IMFs → higher molar heat of vaporization, since more energy is needed to overcome the forces holding the molecules together. b. Weaker IMFs → lower ΔH_{vap} Key Concepts to Remember ● Intermolecular forces determine how molecules interact with one another. ● The type and strength of these forces depend on molecular structure and polarity. ● Understanding IMFs helps explain everyday phenomena, such as why oil and water don’t mix or why water beads up on waxed surfaces. ● Water is a common substance on earth that we often overlook its unique characteristics. • If water does not have hydrogen bonds, it would be a gas at room temperature. ○ Water is a universal solvent Which statement best describes Why is water an effective solvent? ● Water is an ionic compound that attracts others like molecules. ● Water small sizes allow it to fit between individual atoms, driving them apart ● Waters polarity allows it to dissolve ionic and polar compounds ● Water hydrophobic nature separates polar and nonpolar substances. ● Solvent is a substance that dissolves other substances (solutes) to form a solution. ○ Water is a solvent because it can dissolve many kinds of substances — more than any other liquid. ○ Like dissolves like. Polar to polar, nonpolar to nonpolar ○ Water molecules are also attracted to other polar molecules and to ions. ○ A charged or polar substance that interacts with and dissolves in water is said to be hydrophilic. ○ In contrast, nonpolar molecules like oils and fats do not interact well with water. They separate from it rather than dissolve in it and are called hydrophobic. 1. Cohesion - The attraction between molecules of the same substance. a. Example: Water molecules stick to each other because of hydrogen bonding. b. Effect: Causes surface tension — that’s why water droplets form beads or why some insects can “walk” on water. c. How does a tree get water from the ground all the way to its leaves? - Adhesion - The attraction between molecules of different substances. - Example: Water sticks to glass, leaves, or paper towels. - Effect: Responsible for capillary action, which helps water move upward in plant stems. - Adhesion vs Cohesion - Adhesion - Different molecules attract each other - Cohesion - Like molecules attract each other Tape sticks to paper because of adhesion. - Mercury forms beads on surfaces because of cohesion. 2. Density - is the amount of mass contained in a given volume of a substance. a. It tells us how tightly packed the particles (atoms or molecules) are in a material. Water's lower density in its solid form is due to the way hydrogen bonds are oriented as it freezes. b. Since ice is less dense compared to water, ice floats on the surface of liquid water. 3. Specific Heat Capacity - is the amount of heat energy required to raise the temperature of 1 gram of a substance by 1°C (or 1 K). a. It tells us how easily a substance heats up or cools down — a measure of how much heat energy a material can store. b. Substance: Specific heat Capacity c ($Jkg^{-1} oC^{-1}$) i. Water 4200 ii. Alcohol 2400 iii. Sand 840 iv. Granite 800 v. Ice 2100 vi. Glass 670 vii. Copper 390 viii. Iron 460 c. Water has high specific heat capacity. Water is 5x greater than the sand. i. The land cools faster than the sea once the sun goes down. The slow cooling water can release heat to nearby land during the night 4. Heat of Vaporization - is the amount of heat energy required to convert a liquid into a gas at its boiling point, without changing its temperature. a. It represents the energy needed to break the intermolecular forces holding the liquid molecules together. It also takes an unusual amount of heat to vaporize a given amount of water, because hydrogen bonds must be broken in order for the molecules to fly off as gas. ● POLLUTED WATER (PPM) - PPM (parts per million) ● Saltwater for aquarium - Molality / concentration ● Sports drinks (Gatorade) - Molarity (ions in solution) ● Juice concentrate - Percent by volume ● Sugar in coffee - Percent by mass/volume 1. Concentration - refers to the amount of solute dissolved in a given amount of solvent or solution. It tells us how strong or diluted a solution is a. In Simple Terms Concentration means how much substance is mixed into a liquid. b. More solute = more concentrated c. Less solute = more diluted Ways to Express Concentration of a Solution ● Percent by Mass Percent - When the solute in a solution is a solid, a convenient way to express the concentration is a mass percent (mass/mass), which is the grams of solute per 100g of solution. ○ ● Percent by Volume Percent - Percent by volume is a way of expressing the concentration of a solution when both the solute and the solvent are liquids. It tells how many milliliters (or liters) of the solute are present in every 100 mL of the solution. ○ ● Percent by Mass/Volume ○ ● Molarity / Molar Concentration - Molarity (M) is the number of moles of solute dissolved in 1 liter of solution. Not per liter of solvent. ○ ● Molality - Molality is the number of moles of solute per kilogram of solvent. The unit of molality is mol/kg (sometimes written as m). ○ Molality is different from molarity. Molarity uses total solution volume, while molality uses mass of solvent. ○ Molality is often used in colligative property calculations because it doesn't change with temperature (volume can expand, but mass