ScienceGuyz

BIO 1107
Properties of Water

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When H_2O is solid, below 0°C, it is arranged in a rigid structure due to molecules not having enough kinetic energy to begin to overcome its hydrogen bonds between one another. As H_2O gets more energy (remember: higher temperature means more kinetic energy), the molecules can temporarily overcome their hydrogen bonds. So, above 0°C, water molecules can flow past one another due to the constant breaking and reforming of hydrogen bonds. The molecules slide past each other but maintain contact as hydrogen bonds break and reform. Note that above 100°C, hydrogen bonds are overcome completely, and H_2O enters the gas phase.

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This is the solid phase. We can tell because of the rigid and repeating units of the structure. i.e. the molecules are uniformly arranged. Also, if this were the liquid phase, the molecules would be more disordered. Gas phase H_2O would feature molecules much farther apart, and more randomized in arrangement. Further, there is more space between the molecules than would be the case in the liquid phase (remember that solid H_2O is less dense than liquid, which is unique).

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This solid H_2O structure is arranged and held in place via hydrogen bonds, pictured as dashes representing the attractions between positively charged hydrogen atoms (smaller spheres) and negatively charged oxygen atoms (larger spheres). These opposite charges are the result of the strongly polar bonds between hydrogen and oxygen – due to oxygen being much more electronegative than hydrogen - and the bent molecular geometry that further consolidates the positive and negative charges on opposite sides of each water molecule.

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CH_4	NH_3
This is a nonpolar molecule, so it will not interact well with water. The only IMFs between water molecules and CH_4 will be London dispersion forces, which occur between all molecules. CH_4 is <u>not</u> considered soluble in water because of this weak interaction.	This is a polar molecule, with the positive hydrogen atoms on one end and the negative nitrogen atom and lone pair on the other. This molecule has hydrogen bonding. NH_3 will react strongly with water because it is polar, and more importantly because it has hydrogen bonding, which strongly impacts interactions with water molecules. NH_3 will also have dipole-dipole and London dispersion attractions to H_2O molecules.

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NH_3 will interact much more strongly with water than CH_4, because the IMFs between NH_3 and water are stronger. Remember, the more hydrogen bonding that water can make with a molecule, the better that molecule will interact with water. Also remember that hydrogen bonding is the strongest IMF, and that London dispersion forces are the weakest.

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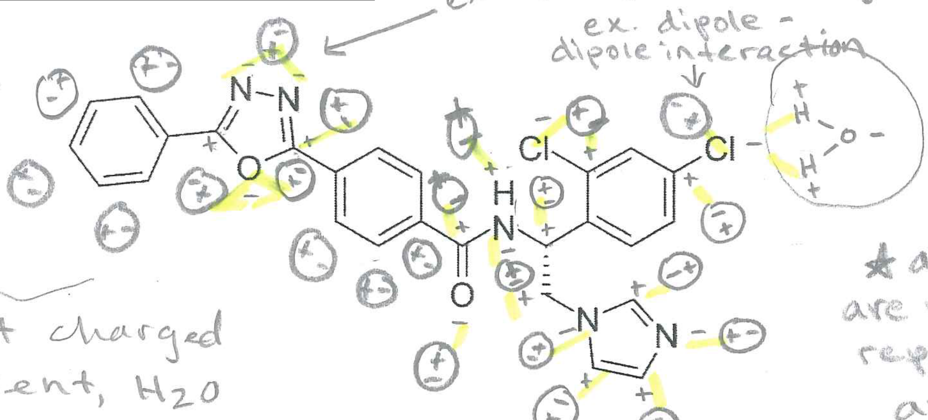

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Formula weight of Nicotine ($C_{10}H_{14}N_2$):
(12.011 X 10) + (1.0079 X 14) + (14.007 X 2) = 162.23 g/mol

$$\frac{500\,\cancel{ml}}{1} \times \frac{1\,\cancel{L}}{1000\,\cancel{ml}} \times \frac{.25\,\cancel{mol}}{1\,\cancel{L}} \times \frac{162.23\,g}{1\,\cancel{mol}} = 20.3\ g\ C_{10}H_{14}N_2$$

Explanation: a .25 molar solution means one that contains .25 moles of the solute, nicotine, per liter of water. We are asked for grams, so we need to know how many grams are in a mole of nicotine (the formula weight). From there, we can convert from volume to number of moles, using the .25 molar concentration given, and then from moles to grams using the formula weight.

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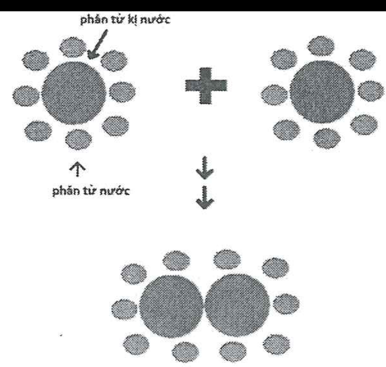

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Importantly, this is due to separate phenomena. Polar substances will interact well with water, because their charged poles will find attractions with the charged poles of polar water molecules. This is especially true if hydrogen bonding occurs between the solute molecules and water. This tends to separate the ions of ionic solutes, and evenly disperse the molecules of polar covalent solutes, dissolving either into solution.

Non-polar solutes tend to aggregate not because they are attracted to one another, but because in doing so they minimize the degree to which they lower the entropy of water. By achieving the smallest possible surface area, aggregated non-polar solutes reduce their disruption of hydrogen bonding between water molecules, allowing the most random and disordered arrangement of water possible. This is what leads to the aggregation of non-polar solutes in solution: the tendency of matter and energy to achieve the highest degree of entropy possible.

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