CH301 Worksheet 9 Anwer Key Intermolecular Forces

1. Rank the following solution properties (from lowest to highest): **C_2H_6, H_2O, CH_4, NH_3**

(a) boiling point

$CH_4 < C_2H_6 < NH_3 < H_2O$

(b) viscosity

$CH_4 < C_2H_6 < NH_3 < H_2O$

(c) evaporation rate

$H_2O < NH_3 < C_2H_6 < CH_4$

(d) capillary action

$CH_4 < C_2H_6 < NH_3 < H_2O$

2. Which of the above molecules are affected by instantaneous dipoles? Explain.

All of them. This is a trick question. It isn't asking which force dominates, only whether a force occurs. And instantaneous dipoles occur in all compounds because of changing electron distributions.

3. Name two solution properties that have a trend that is opposite the trend for surface tension.

Evaporation rate, vapor pressure.

4. Give the approximate strength of

(a) a covalent bond

(b) a hydrogen bond

(c) a dipole-dipole interaction

(a) 400 kJ/mol (b) 20 kJ/mol (c) 5 kJ/mol

5. What is the *dominant* intermolecular force involved in the properties of the following species:

(a) Potassium chloride, KCl

Ionic bonding

(b) Xenon tetrafluoride, XeF_4

Instantaneous dipole

(c) Ethanol, C_2H_5OH

Hydrogen bonding

(d) NO_2^-

Dipole-dipole

5. Provide an explanation for the following physical properties:

(a) Water beads up on your windshield, but acetone doesn't.

Water experiences hydrogen bonding, so it has a higher surface tension than acetone, which only has dipole-dipole interactions.

(b) Butane, C_4H_{10}, is a gas at STP, while pentane, C_5H_{12}, is a liquid.

Because pentane is longer, it has a stronger instantaneous dipole.

(c) Molecular nitrogen boils at 77 K, while nitric oxide boils at 110 K.

NO has a permanent dipole, while N_2 has only instantaneous dipoles.

6. Explain the basic theory behind
   (a) instantaneous dipoles
   Although nonpolar molecules have no dipole on average, at some time they will have a transitory one because the momentary electron distribution is not symmetrical.

   (b) hydrogen bonding.
   Hydrogen *is very small and only has one electron. Thus, when it's bonding, the electron density is pulled away from it and hydrogen is very electropositive.*

7. Why can an ionic bond be considered to be both an intermolecular and intramolecular force?
   In an ionic crystal, there is no clear demarcation between molecules. For example, in a NaCl crystal, each Na^+ has ionic interaction with several Cl^- ions, although a "molecule" consists of only one of each.

8 Dr. Laude has used core concepts associated with kinetic molecular theory, intermolecular forces and charge density to help him explain and rank the various properties of chemical compounds. For each core concept below, list two properties that can be explained by the concept. Then write a one sentence argument you would use to rank a series of compounds and rank the compounds provided for each.

Kinetic molecular theory:
Two properties you can rank: *(speed, diffusion, effusion)*

One sentence argument: Smaller molecules move faster with the same amount of energy as larger molecules, a since $v = (2E/m)^{1/2}$.
Ranking of $H_2 < H_2O < CHCl_3 < CCl_4 < SF_6$

Charge Density:
Two properties you can rank: *lattice energy, solubility in water*

One sentence argument: *Molecules with higher charge density pull more strongly on each other and are more difficult to break apart or solubilize.*

Ranking of $NaI < NaCl < LiF < CaCl_2$

Intermolecular forces:
Two properties you can rank: *viscosity, boiling point*

One sentence argument: *As the stickiness (magnitude) of intermolecular forces increase, and as size increases, the boiling point and viscosity increase.*
Ranking of $H_2 < SF_6 < CCl_4 < CHCl_3 < H_2O$

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