**CHE2060 Lecture 4 HW**

Problems must be solved, or written out, in their entirety with all work shown on engineering graph paper. You must label each set in the upper left hand corner with your name, the date and the chapter. Problems must be identified by number and all work must be shown with answers boxed. Be sure your handwriting is legible.

**4.1: Physical properties of organic molecules**

1. How do physical properties differ from chemical properties?

Molecules can undergo changes in physical properties without changing their identities. But a change in chemical properties requires a change in molecular identity.

Physical properties include: melting point, boiling point, density, color, odor, refractive index, etc.

2. What forces hold molecules together in a solid?

Intermolecular forces (aka intermolecular interactions) like van der Waals bonding, dipolar bonding, H-bonding or salt bridges. These forces are sufficient to hold molecules together without movement as long as energy levels are low.

3. Why are liquid crystals called a ‘mesophase’?

Liquid crystals are more ordered than liquids, but have less molecular density (or abundance) than solids. So liquid crystals exist between liquid and solid phases, hence the term mesophase.

4. Why are molecules with several arenes likely to form liquid crystals?

The arenes line up and lay on top of, or stack onto, one another. Van der Waals interactions between the rings then hold the molecules together.

**4.2: Types of intermolecular interactions**

5. How is melting point affected by chemical purity or mixtures? Why?

When pure, groups of (identical) molecules can stack together tightly because of the uniform 3D structures of all molecules. This tight packing maximizes intermolecular alignment and therefore interaction or bonding. Melting points of pure compounds are high because a significant amount of energy is needed to disrupt (or break up) the intermolecular interactions and melt the solid. Chemical impurities are mixtures of molecules with different 3D structures, polarities, etc. The mixture of molecules is unable to pack as tightly and efficiently. So, intermolecular bonding decreases and less energy is required to disrupt the looser packing. Melting points drop and broaden when impurities are present.

6. What is the relationship between melting point and molecular weight or size?

As molecular weight increases so does melting point.

7. What is unusual about the melting point of spherical molecules? Why?

Spherical molecules have unusually high melting temperatures because they pack together so easily and tightly; symmetry of spheres is extreme.

8. Which member of these pairs has a higher melting point?

a. pentane or cyclopentane

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b. pentane or 2-methylbutane

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c. pentane or 2,2-dimethylpropane

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d. cyclobutane or cyclohexane

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9. For each of the four cases above, why does one molecule have the higher melting point? Give a reason for each pair!

a.

b.

c.

d.

a. Cyclic molecules stack vertically and neighboring stacks bond along their edges.

b. The single branch disrupts stacking but doesn’t produce a spherical shape.

c. 2,2-dimethylpropane is spherical.

d. The MW of cyclohexane is greater than the MW of cyclobutane.

10. Rank the likely boiling points of these compounds from low to high. Of course, you can use the web to discover these bps, so I’d like you to include an explanation of why the boiling points increase as they do.

a. butane vdW only

b. chlorobutane vdW + polarity

c. butanol (CH3CH2CH2CH2OH) vdW + polarity + H-bond

d. butanoic acid (CH3CH2CH2COOH) vdW + more polarity + more H-bond

a < b < c < d

11. Define each of these terms:

a. covalent bond

b. hydrogen bond

c. dipole-dipole bond

d. van der Waals bond

1. A pair of electrons shared between two bonded atoms.
2. A weak bond between a polar hydrogen (bonded to a O, N or F) and a free electron pair on an O, N or F.
3. A weak interaction between the dipolar positive end of one polar molecule and the dipolar negative end of another polar molecule.
4. A very weak and temporary interaction between the electrons of one molecule and the nuclei of another. All molecules experience van der Waals interactions.

12. Is van der Waals attraction an example of an inductive effect or a field effect?

A field effect since the attraction is occurring between two different molecules, normally distant.

13. Do linear or branched molecules of the same carbon number experience greater van der Waals attraction? Why?  
Branching decreases van der Waals forces because the branching prevents molecules from fitting together, overlapping and sharing maximal surface area.

14. What are the essential similarities and differences between dipolar and hydrogen bonding interactions?   
H-bonding is a very particular type of dipolar bonding. Both depend on electrostatic attractions between polar groups.

**4.3: Solubility**

15. Label the most soluble & least soluble in hexane.

1. CH3(CH2)6CH3 most soluble because it is non-polar
2. H2O least soluble because it is the most polar molecule
3. CH3OH

**4.4: Surfactants**

16. List two types of molecules that can act as surfactants? And what essential characteristic(s) of these molecules allow them to be surfactants?

Long carboxylic acids (fatty acids) and some (charged) phospholipids can act as surfactants (aka detergents). All have an amphipathic (or two-faced) nature: a non-polar end and a polar or charged end. The non-polar end bonds to lipids and other non-polar molecules. The polar or charged end interacts with water and other polar solvents. So surfactants serve as bridges (or connectors) between polar and non-polar molecules.

17. Why do fatty acids, surfactants, lipids and other amphipathic molecules form micelles when added to water?  
Amphipathic lipids form micelles, and other 3D structures like bilayers, liposomes and emulsions, in order to protect their hydrophobic fatty acid tails from polar water. All of these 3D structures orient the amphipathic molecule’s polar and hydrophilic head group into the water where multiple intermolecular interactions form between the head groups and solvent, water.