Intermolecular Attractions Review

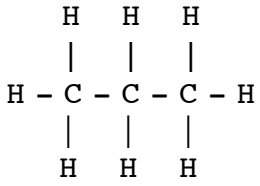
Key ideas

- There are weak attractive forces called van der Waals attractions between molecules.
- Factors such as surface area, shape, and polarity of molecules affect the strength of these attractions.
- One form of chemical potential energy is due to the attractions between molecules. This attraction can be converted into heat (*ie* kinetic energy of atoms and molecules) if molecules which are separated are allowed to come together.
- Latent heat (of vaporization or fusion) represents the heat energy converted from chemical potential energy during an exothermic phase change like condensing or freezing.
- The physical properties of a substance (*ex.* viscosity, boiling point, solubility) are due to the types of strong (covalent and ionic) and weak (dipole-dipole and London dispersion) bonds that make up that substance.
- Breaking attractions or bonds (endothermic) = conversion from heat -> chemical potential energy
- Forming attractions or bonds (exothermic) = conversion from chemical potential energy -> heat
- Boiling point is affected by both the strength of the van der Waals attractions between molecules and the pressure on the liquid.

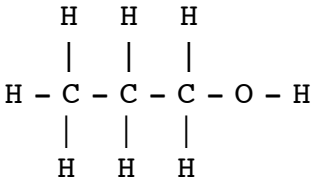
Questions

1. Draw three images representing a solid, liquid, and a gas at the atomic level.
2. What are van der Waals attractions? Describe the different types.
3. Explain how the type of covalent bonds **in** a molecule determine the type of van der Waals attractions that occur **between** molecules.
4. Explain why propane is a gas at room temperature and why propanol is a liquid.

PROPANE



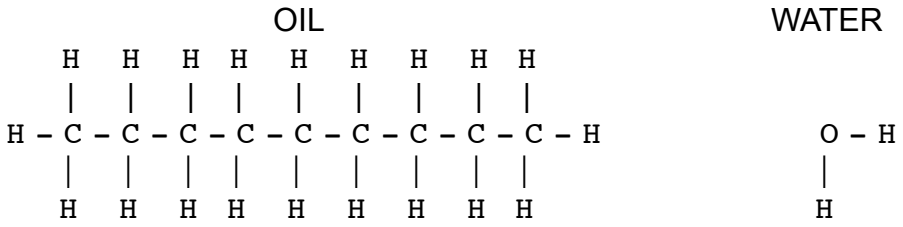
PROPANOL



5. Draw liquid water using solid lines for covalent bonds and dotted lines for van der Waals attractions. Label the type of van der Waals attraction that forms between water.
6. If London Dispersion attraction is generally weaker than dipole-dipole attraction, explain how can a substance with molecules that attract via London dispersion attraction could have a higher melting point than a substance with molecules that attract via dipole-dipole attraction.

7. Which two molecules below could form the strongest London dispersion attraction to each other? Why?

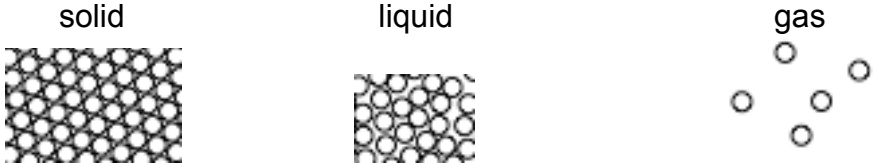
8. List every type of phase change you know and label it as exothermic or endothermic.
9. What kinds of bonds are present in a substance that is a soft solid at room temperature?
10. What kinds of bonds are present in a substance that is extremely hard at room temperature?
11. What kinds of bonds are present in a substance that is a liquid at room temperature?
12. Explain why oil and water don't mix, and how this relate to the phrase "like dissolves like."



13. Draw a potential energy graph representing a substance condensing.
14. Explain why a substance that is in the process of freezing is actually generating heat energy.
15. Assume that your body can't be affected by changes in pressure, and describe a scenario in which you could pour boiling water on your hand and not get burned. Explain why.

Answers

1.

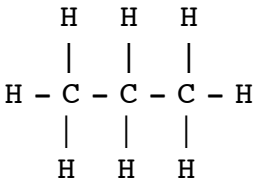


2. Van der Waals attractions are weak attractions between molecules (and atoms). There are two main categories of van der Waals attractions: dipole-dipole and London Dispersion. If a molecules has at least one polar covalent bond then there will be an uneven sharing of electrons and the molecule will have a dipole (a positive and negative part). If two polar molecules attract to each other they

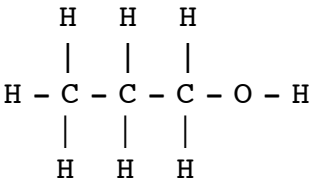
use dipole-dipole attraction. If all of the covalent bonds in a molecule are non-polar, then they can only attract with London Dispersion attraction. This attraction occurs because the evenly shared electrons in the molecule are evenly shared on AVERAGE, but at any moment in time the electrons may be unevenly distributed due to their random motions between atoms as they are shared back and forth. So, on average this is a weak London Dispersion attraction between all atoms in a molecule that can get very close to the atoms of another molecule.

3. Polar covalent bonds in a molecule cause dipole-dipole attractions between molecules. Non-polar covalent bonds in a molecule cause weaker London Dispersion attractions between molecules.
4. Propane is made from all non-polar covalent bonds (C-C and C-H), so the only kinds of attractions that can form between propane molecules are London Dispersion attractions. The C-O bond and the O-H bond in propanol are both polar covalent, so an uneven sharing of electrons occurs causing the propanol molecule to be polar and attract with dipole-dipole attractions. Because the dipole-dipole attraction is stronger than the London Dispersion attraction, there is a stronger attraction between propanol molecules, so you have to heat them up to a higher temperature before their motion can overcome the attractions they have for each other. When molecules completely overcome their van der Waals attractions they separate from each other going from liquid to gas (boiling).

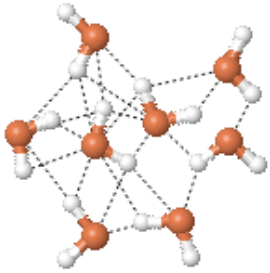
PROPANE



PROPANOL

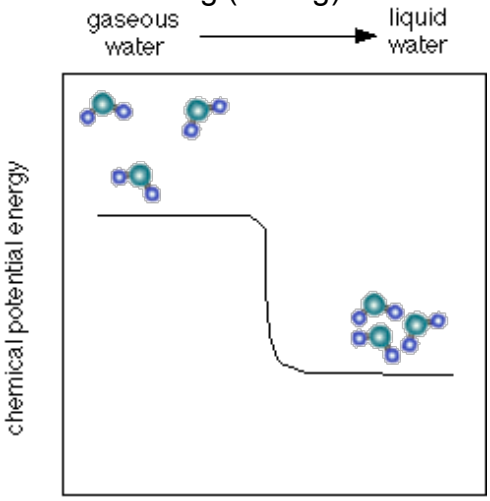


5. The dotted lines are dipole-dipole attractions. In this case, because hydrogen is at one end of the attraction we can call the dotted lines “hydrogen bonds”.



6. If you had a long straight non-polar molecule the surface area is large allowing for many London Dispersion attractions with other similar molecules. Even though the London Dispersion attraction is weaker a really large non-polar molecule might be able to form a stronger London Dispersion attraction than a small polar molecule.
7. This is a somewhat ambiguous question. The best attraction is gong to be between the two molecules who have the largest surfaces that can come in con-

tact with each other. There are several good options, but I think A and B have the most potential for forming the attraction along the greatest surface area.

8. melting --> breaking attractions ---> endothermic
   boiling/evaporating --> breaking attractions ---> endothermic
   sublimation --> breaking attractions ---> endothermic
   condensing --> forming attractions ---> exothermic
   freezing --> forming attractions ---> exothermic
9. If the substance is a soft solid, then it is probably made from large non-polar molecules. So, the molecules are made from non-polar covalent bonds, and they attract to each other with London Dispersion attraction. They must be large non-polar molecules because they attract well enough to form a solid at room temperature with London Dispersion attraction.
10. If it is extremely hard at room temperature, then it could be one giant molecule like a diamond (unlikely), where every atom is bonded to every other atom with covalent bonds. It could be an ionic substance in which every ion is bonded to every other one with ionic bonds. Or, it could be a large very polar molecule with lots of polar covalent bonds, like cellulose, which is what wood is made from. The large number of polar covalent bonds allows for the formation of many dipole-dipole attractions and causes the molecules to stick together very well making the substance hard. That means this substance would probably have non-polar covalent bonds, polar covalent bonds, and dipole-dipole attractions.
11. A liquid at room temp could be made from small polar molecules, medium sized non-polar molecules, or large non-polar molecules that have many bends in them.
12. Oil is non-polar because the oil molecule is made from non-polar covalent bonds, so it attracts to other molecules with London Dispersion attraction. Water is polar so it attracts to other molecules with dipole-dipole attractions. The water's dipole-dipole attraction for itself is stronger than the attraction between the oil and water molecules, so the water sticks to itself better, preventing the oil from dissolving (mixing) with it.
13. 

14. If it is freezing, then it is forming attractions which we know much convert chemical to heat energy.

15. The boiling point of water is determined both by the strength of the attractions between the water molecules AND the external pressure on the molecules. If you were to go into a low pressure room, the water would boil at a lower temperature, because the only thing hold the molecules together would be the van der Waals attractions.