***Chemistry***

**10: Liquids and Solids**

**10.1: Intermolecular Forces**

1. In terms of their bulk properties, how do liquids and solids differ? How are they similar?

Solution

Liquids and solids are similar in that they are matter composed of atoms, ions, or molecules. They are incompressible and have similar densities that are both much larger than those of gases. They are different in that liquids have no fixed shape, and solids are rigid.

3. In terms of the kinetic molecular theory, in what ways are liquids similar to gases? In what ways are liquids different from gases?

Solution

They are similar in that the atoms or molecules are free to move from one position to another. They differ in that the particles of a liquid are confined to the shape of the vessel in which they are placed. In contrast, a gas will expand without limit to fill the space into which it is placed.

5. What is the evidence that all neutral atoms and molecules exert attractive forces on each other?

Solution

All atoms and molecules will condense into a liquid or solid in which the attractive forces exceed the kinetic energy of the molecules, at sufficiently low temperature.

7. Define the following and give an example of each:

(a) dispersion force

(b) dipole‑dipole attraction

(c) hydrogen bond

Solution

(a) Dispersion forces occur as an atom develops a temporary dipole moment when its electrons are distributed asymmetrically about the nucleus. This structure is more prevalent in large atoms such as argon or radon. A second atom can then be distorted by the appearance of the dipole in the first atom. The electrons of the second atom are attracted toward the positive end of the first atom, which sets up a dipole in the second atom. The net result is rapidly fluctuating, temporary dipoles that attract one another (example: Ar).

(b) A dipole-dipole attraction is a force that results from an electrostatic attraction of the positive end of one polar molecule for the negative end of another polar molecule (example: ICI molecules attract one another by dipole-dipole interaction).

(c) Hydrogen bonds form whenever a hydrogen atom is bonded to one of the more electronegative atoms, such as a fluorine, oxygen, nitrogen, or chlorine atom. The electrostatic attraction between the partially positive hydrogen atom in one molecule and the partially negative atom in another molecule gives rise to a strong dipole-dipole interaction called a hydrogen bond (example: .)

9. Why do the boiling points of the noble gases increase in the order He < Ne < Ar < Kr < Xe?

Solution

The London forces typically increase as the number of electrons increase.

11. Arrange each of the following sets of compounds in order of increasing boiling point temperature:

(a) HCl, H2O, SiH4

(b) F2, Cl2, Br2

(c) CH4, C2H6, C3H8

(d) O2, NO, N2

Solution

(a) SiH4 < HCl < H2O; (b) F2 < Cl2 < Br2; (c) CH4 < C2H6 < C3H8; (d) N2 < O2 < NO

13. On the basis of intermolecular attractions, explain the differences in the boiling points of *n*–butane (–1 °C) and chloroethane (12 °C), which have similar molar masses.

Solution

Only rather small dipole-dipole interactions from C-H bonds are available to hold *n*-butane in the liquid state. Chloroethane, however, has rather large dipole interactions because of the Cl-C bond; the interaction is therefore stronger, leading to a higher boiling point.

15. The melting point of H2O(*s*) is 0 °C. Would you expect the melting point of H2S(*s*) to be –85 °C, 0 °C, or 185 °C? Explain your answer.

Solution

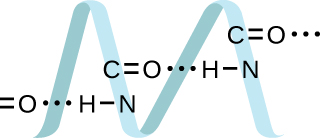
–85 °C. Water has stronger hydrogen bonds so it melts at a higher temperature.

17. Explain why a hydrogen bond between two water molecules is weaker than a hydrogen bond between two hydrogen fluoride molecules.

Solution

The hydrogen bond between two hydrogen fluoride molecules is stronger than that between two water molecules because the electronegativity of F is greater than that of O. Consequently, the partial negative charge on F is greater than that on O. The hydrogen bond between the partially positive H and the larger partially negative F will be stronger than that formed between H and O.

19. Proteins are chains of amino acids that can form in a variety of arrangements, one of which is a helix. What kind of IMF is responsible for holding the protein strand in this shape? On the protein image, show the locations of the IMFs that hold the protein together:



Solution

H-bonding is the principle IMF holding the protein strands together. The H-bonding is between the  and .

21. Identify the intermolecular forces present in the following solids:

(a) CH3CH2OH

(b) CH3CH2CH3

(c) CH3CH2Cl

Solution

(a) hydrogen bonding, dipole-dipole attraction, and dispersion forces; (b) dispersion forces; (c) dipole-dipole attraction and dispersion forces

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