Concept Review

Chapter 8

Summary of Terms

Adhesive Force An attractive force between molecules of two different substances.

Capillary Action The rising of liquid into a small vertical space due to the interplay of cohesive and adhesive forces.

Cohesive Force An attractive force between molecules of the same substance.

Heat of Condensation The energy released by a substance as it transforms from gas to liquid.

Heat of Freezing The heat energy released by a substance as it transforms from liquid to solid.

Heat of Melting The heat energy absorbed by a substance as it transforms from solid to liquid.

Heat of Vaporization The heat energy absorbed by a substance as it transforms from liquid to gas.

Meniscus The curving of the surface of a liquid at the interface between the liquid surface and its container.

Specific Heat The quantity of heat required to change the temperature of 1 gram of a substance by 1 Celsius degree.

Surface Tension The elastic tendency found at the surface of a liquid.

Review Questions

8.1 Open Structured Crystals

1. What accounts for the fact that ice is less dense than water?
2. What is inside one of the open spaces of an ice crystal?
3. What happens to ice when great pressure is applied to it?

8.2 Melting and Freezing

4. What is released when a hydrogen bond forms between two water molecules?
5. When the temperature of 0°C liquid water is increased slightly, does the water undergo a net expansion or a net contraction?
6. At what temperature do the competing effects of contraction and expansion produce the smallest volume for liquid water?

8.3 The Stickiness of Water

7. What is the difference between cohesive forces and adhesive forces?
8. In what direction is a water molecule on the surface pulled?
9. Does liquid water rise higher in a narrow tube or a wide tube?

8.4 Liquid and Gaseous Phases

10. Do all the molecules in a liquid have about the same speed?
11. Why do we feel uncomfortably warm on a hot, humid day?
12. Is it the pressure or the higher temperature that cooks food faster in a pressure cooker?
13. What condition permits liquid water to boil at a temperature below 100°C?

8.5 Water's Specific Heat

14. Is it easy or difficult to change the temperature of a substance that has a low specific heat?
15. Does a substance that heats up quickly have a high or a low specific heat?

16. How does the specific heat of liquid water compare with the specific heats of other common materials?

17. What within liquid water is most responsible for its unusual specific heat?

8.6 Phase Changes and Energy

18. When liquid water freezes, is heat released to the surroundings or absorbed from the surroundings?

19. Why doesn't the temperature of melting ice rise as the ice is heated?

20. How much heat is needed to melt 1 gram of ice? Give your answer in joules.

21. Why does it take so much more energy to boil 10 grams of liquid water than to melt 10 grams of ice?

Quantitative Questions

22. A walnut stuck to a pin is burned beneath a can containing 100.0 grams of water at 21°C. After the walnut has completely burned, the water's final temperature is 28°C. How much heat energy came from the burning walnut?

23. How much heat is required to raise the temperature of 100,000 grams of iron by 30 C°?

24. By how much will the temperature of 5.0 grams of liquid water increase upon the addition of 230 joules of heat?

25. How much heat is required to raise the temperature of 1.00 gram of water from –5.00°C to +5.00°C?

26. How much heat is required to raise the temperature of 1.00 gram of water from absolute zero, -273°C, to 100. °C?

27. How much energy is required to transform 1.00 gram of water from 100°C liquid to 100°C water vapor?

28. Why does transforming water from 100°C liquid to 100°C gas require much more energy than to raise the temperature of the same amount of water from absolute zero all the way to 100°C liquid?

29. To increase the temperature of 575 grams of ocean water by 5.0°C requires 2674 J. Use this information to calculate ocean water's specific heat.

30. Rank the following in order of decreasing melting point. A 0.1 M aqueous solution of

    a) sodium bromide, NaBr.

    b) magnesium chloride, $MgCl_2$.

    c) scandium iodide, ScI_3.

Solutions (Odd-Numbered)

1. Ice is less dense than water because water expands as it freezes. Each water molecule in the solid phase occupies more space than it does in the liquid phase.

3. As great pressure is applied, the open-pockets in the crystalline structure of ice may collapse, which results is a melting of the ice. This occurs primarily where the pressure is being applied, such as at the bottom of a heavy glacier.

5. When the temperature of 0°C liquid water is increased slightly, it undergoes a net contraction. Water at 4°C is more dense (less volume = more contracted) than 0°C.

7. Cohesive forces result from the molecular attractions within a material while adhesive forces result from the molecular attractions occurring between two different materials.

9. Water will rise higher in a narrow tube because there is more surface area of contact between the water and the wall of the tube relative to the weight of the water contained within the tube.

11. Condensation counteracts evaporation on a hot and humid day. The vapor in the air from the humidity condenses on your skin to make you feel uncomfortably warm.

13. Water can boil at temperatures less than 100°C at higher altitudes where the atmospheric pressure is less.

15. A substance that heats up quickly will have a low specific heat.

17. Hydrogen bonds.

19. The temperature of melting ice does not rise as it is heated because the energy being supplied by the added heat is working to break the hydrogen bonds.

21. It takes so much more energy to boil water than to melt it because in a sample of steam, the molecules are relatively free of one another and are not bound together as they are in the liquid phase.

23. From Table 8.1, the specific heat of iron is 0.451 J/g°C. So, the total amount of heat required is:

Heat = 100,000 g × 0.451 J/g°C × 30°C = +1,343,000 joules

which is about 10 million joules less than that required for water.

25. This is a three part calculation. First you need to calculate the amount of heat required to raise the water's temperature from –5.00° to 0.00°C. Then you need to calculate the amount of heat required to transform the 1.00 gram of ice into liquid water. Third, you need to calculate the amount of heat required to raise the water's temperature from 0.00°C to +5.00°C. From Table 8.1 you have that the specific heat of ice is 2.01 J/g°C. Note this calculation provides three significant figures.

1) Heat = (2.01 J/g°C)(1.0 g)(+5.00°C) = 10.1 J

2) Heat = (1.00 g)(+335 J/g) = +335 J

3) Heat = (4.18 J/g°C)(1.00 g)(+5.00°C) = +20.9 J

Total heat = 10.1 J + 335 J + 20.9 J = 366 J

27. Calculate this answer using water's heat of vaporization, which is +2259 J/g

Heat = (1.00 g)(+2259 J/g) = 2260 J (to three sig figs)

29. Heat = (specific heat)(mass)(temperature change)

With a little algebra this transforms into:

Specific heat = Heat/(mass)(temperature change)

Specific heat = (2674 J)/(575 g)(5.0°C)

= 0.93 J/g°C (to two significant figures)

Solutions to Chapter 8
Calculation Corner
How Heat Changes Temperature

1. The temperature change is final temperature minus initial temperature: 55.0°C - 25.0°C = +30.0 C°. Multiply this positive temperature change by the water's specific heat and mass:

   heat = (4.184 J/g °C)(100,000 g)(+30.0 C°)

   = 12,552,000 J

   This large number helps to explain how an electric water heater consumes about 25 percent of all household electricity. With the proper number of significant figures (see Chapter 1), this answer should be expressed as 10,000,000 joules.

2. The temperature change is -30.0°C - (-10.0°C) = -20.0 C°. Multiply this negative temperature change by the ice's specific heat and mass:

   heat = (2.01 J/g °C)(10.0 g)(-20.0 C°) = -402 J

   The next time you're near a refrigerator/freezer, place your hand near its back, and you'll feel the heat that has been extracted from the food inside. Notice that this answer has the opposite sign (-) as the previous answer (+). The reason for this is because the direction of heat flow is reversed. .