EXERCISES

Conceptual Questions

1. State the principle of heat exchange and discuss how it applies to the law of conservation of energy.
2. Liquids are used to transfer heat in car radiators. Why do we mix water and ethylene glycol in the radiator given that water has a higher heat capacity than ethylene glycol?
3. Explain why it is relatively easy to remove baked potatoes from a hot barbecue without a hot pad if they are wrapped in aluminum foil.
4. Two equal mass samples of copper and iron heated with the same amount of heat energy will achieve different temperatures. Which sample will reach the higher temperature and why?
5. To save energy, many home owners have installed temperature set-back thermostats that set the inside house temperature lower at night during the winter. Some critics have suggested that the furnace has to work harder in the morning to warm the house up again. Write a brief paragraph that will explain to any sceptics that the overall heat flow from the inside to the outside of the house is definitely less.
6. Use the kinetic molecular theory to explain the temperature change that occurs when a cold and a hot liquid are mixed.
7. Why is copper used to cover the bottom of many commercial pots and pans for the stove top?
8. You are spending Labour Day Weekend at the beach and it turns out to be a clear, hot day. Using the concept of heat capacity, describe which warms up faster, the water or the sand. Which of the two will cool down faster at night?
9. As you will read in later chapters, water from lakes such as Lake Ontario and Lake Huron is used to cool steam turbines in many of our nuclear power plants. Lake water is also used by fossil-fuel-burning power plants as well as other types of industrial complexes. After use, this warm water is returned to the lakes. Why would industries use water to cool their machinery? Suggest some of the societal and environmental implications of warming our lakes artificially.
10. Should fireplaces be used as part of support walls in houses? Explain.
11. Why does running hot water over a metal lid on a glass jar make it easier to open?
12. What happens to the size of a hole in the centre of a metal ring when the ring is heated? Explain.
13. Why are railway track sections separated by a small air gap? (Hint: They are called expansion slots.)
14. The background universe temperature is constantly cooling. How does this temperature trend help explain the Big Bang Theory?
15. On a cold day, you grab a shiny, metal fence gate with your bare hand. The post feels very cold. The next gate is made of wood and does not feel cold. Both gates are at the same temperature because they are close together outside. Explain why one gate feels colder than the other.
16. Why does the temperature scale have a lower limit but not an upper limit?
17. Where is the energy going in a process where there is a state change yet no temperature change?
18. Describe the heating/cooling system of a car in terms of heat transfer, temperature differences, state changes, heat capacities, and efficiency.

19. Thermograms are pictures which are colour-coded according to the amount of thermal energy radiated from the object. Running from coldest to hottest, the colours are black, blue, pink, red, and white. Describe the colours you would see on a thermogram of a limousine that has been running for a long time. The passenger compartment is separated by a partition and has a curtain on one window. The window on the driver's side is half open.

20. In what other areas of study would thermograms be useful diagnostic tools?

21. How does the greenhouse effect work in terms of types of radiation?

22. Which freezes first, hot water in an ice cube tray or cold water in the same-sized tray?

Problems

8.2 Thermal Energy and Temperature

23. Convert the following:

a) 100°C = _____ K
b) –25°C = _____ K
c) –273°C = _____ K
d) 0°C = _____ K
e) 57 K = _____ °C
f) 300 K = _____ °C

8.4 Specific Heat Capacity

Note: Use the specific heat capacities in Table 8.4 when required.

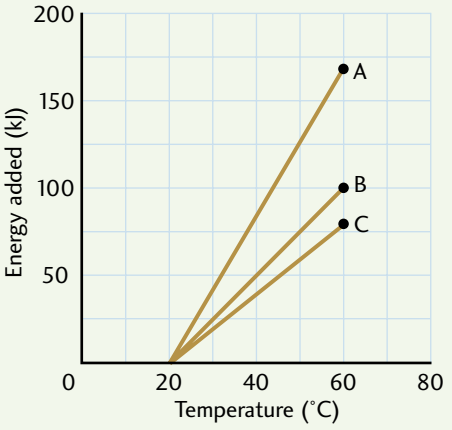
24. How much heat energy is gained per kilogram of water when it is heated from 10.0°C to 90.0°C?

25. A 400.0 g aluminum cooking pot is heated from 25.0°C to 99.0°C. What amount of heat energy does it absorb?

26. What was the initial temperature of a 1.50 kg piece of copper that gains 2.47×10^4 J of energy when it is heated to a final temperature of 150°C?

27. The graph in Fig. 8.25 illustrates the findings of an investigation in which a 1.0 kg mass of three different substances is heated.

Fig.8.25



a) Find the slope (with units) of each of the three lines.
b) Which substance needed the most heat for the same temperature change as the others?
c) Which substance has the highest heat capacity?
d) How is the slope related to heat capacity?

28. What temperature change would occur in each of the following circumstances?

a) 250 g of mercury gains 1.93 kJ of heat energy
b) 5.0 kg of water gains 100 kJ of heat energy

29. A 25.0 g piece of iron, originally at 500°C, has its temperature fall to 100°C when it is placed in a cold water bath. How much energy was lost by the piece of nickel during the cooling process?

8.5 Heat Exchange — The Law of Conservation of Heat Energy

30. A 100.0 g aluminum coffee cup at 15.0°C is filled with 250.0 g of piping hot coffee (about the same heat capacity as water) at 95.0°C. After all the heat transfer between the coffee and the cup is completed, what is the final temperature of the coffee (and the cup)?

31. Native Canadians used to boil water from maple tree sap by heating rocks and placing them into vats of sap sitting in hollowed-out tree logs. For this problem, assume that the syrup and the rocks have the heat capacities of water and sand, respectively. What mass of stone, heated to 1000°C, would be needed to increase 20.0 kg of sap from 60.0°C to 85.0°C?

32. A duck wants to take a bath and fills the tub with 50.0 L of water at a temperature of 38.0°C. After taking a phone call from his friend Bob, a lemming, the bath water had cooled by 10.0°C. How much more hot water at 80.0°C must the duck add to return the bath to the desired temperature?

33. A 200 W heater is used to heat 0.10 kg of a liquid from 20.0°C to 80.0°C, which takes one minute.

a) What is the heat given off by the heater to the liquid?

b) What is the heat capacity of the liquid?

8.6 Changes of State and Latent Heat

34. a) What is the latent heat of fusion of a 1.5 kg substance that requires 3.75×10^4 J to melt it?

b) When the substance is cooled to its freezing point, how much heat energy is given off by 1.0 kg of the substance when it freezes into a solid?

35. What mass of oxygen would freeze by the removal of 7.4×10^4 J of heat energy?

36. How much heat must be removed by a freezer in order to change twenty 60 g sections of water at 0°C to ice at 0°C?

37. Brandy is made by distilling ethyl alcohol, which is done by boiling the alcohol until it turns into a gas. How much heat is required to completely distil 0.750 kg of ethyl alcohol?

38. A 0.200 kg block of ice at −15°C is placed into a pan on a stove, heated to a liquid, and then to vapour with a final temperature of 115°C. Calculate the total amount of heat required for this process.

8.7 Calorimetry — Some Practical Applications

39. The Forensic Sciences Lab in Toronto wants to find out what materials the Romans used in their water pipe systems. A 97.5 g sample of the metal pipe at 20.0°C is placed in a water calorimeter containing 0.10 kg of water at 53.2°C. What is the specific heat capacity of the metal if the calorimeter's final temperature was 52.2°C? Referring to Table 8.4, what are the possibilities for the type of metal used in these Roman pipes? Which do you think was the one that was actually used?

40. What mass of copper at 87.0°C, when added to 300 g of water at 17.0°C in a calorimeter, would yield a final temperature of 26.0°C?