Knowledge

For each question, select the best answer from the four alternatives.

1. Several forces are acting on a wooden block, when you apply an additional force. The work you do on the block will be negative if
   (a) the object does not move
   (b) the force you exert and the displacement have the same direction
   (c) the force you exert and the displacement have opposite directions
   (d) the object speeds up (5.1) K/U
2. The forces acting on a car driven on a hilly road do positive work on the car whenever the car is
   (a) coasting uphill
   (b) slowing down
   (c) speeding up
   (d) changing direction (5.1) K/U
3. Which of these is true about the energy of a hockey puck while sliding on a smooth horizontal surface? (5.2) K/U
   (a) Its kinetic energy is always positive.
   (b) Its potential energy continually decreases.
   (c) Its thermal energy decreases as it moves.
   (d) Its total energy increases.
4. Which of these is a statement of the work–energy principle when a single force acts on an object to change its motion? (5.2) K/U
   (a) The change in kinetic energy of the object is equal to its change in potential energy.
   (b) The work done on the object equals its change in kinetic energy.
   (c) There are no changes in energy.
   (d) The object's gravitational potential energy is zero at the reference level.
5. A grocery store customer accidentally lets go of a shopping cart filled with groceries at the top of a ramp. There is significant friction in the wheel bearings of the cart. Which of these remains constant as the cart rolls down the ramp? (5.3) K/U
   (a) kinetic energy
   (b) gravitational potential energy
   (c) mechanical energy
   (d) mechanical energy plus thermal energy
6. In physics, power directly measures
   (a) the magnitude of an exerted force
   (b) the effect of a force in causing acceleration
   (c) the range over which energy is transmitted
   (d) the rate at which energy is transformed (5.5) K/U
7. Which of the following renewable energy resource technologies produces the most electrical energy worldwide? (5.4) K/U
   (a) hydroelectric power plants
   (b) photovoltaic cells
   (c) wind mills
   (d) tidal turbines
8. The kinetic molecular theory explains
   (a) the behaviour of moving electrons in atoms and molecules
   (b) thermal properties in terms of motions of atoms and molecules
   (c) the kinetic energy of everyday objects
   (d) kinetic and potential energy in falling objects (6.1) K/U
9. The thermal energy of any object is
   (a) the total kinetic energy of its particles
   (b) the total potential energy of its particles
   (c) the total mechanical energy of its particles
   (d) the gravitational and kinetic energy of its particles (6.2) K/U
10. Which of these is greater for a cup of boiling water than for an icy lake? (6.2) K/U
    (a) its thermal energy
    (b) its average kinetic energy per molecule
    (c) its boiling point
    (d) its freezing point
11. The direction in which heat transfers between two objects placed in contact is determined by which one has the greater
    (a) thermal energy
    (b) temperature
    (c) contact area
    (d) chemical energy (6.2) K/U
12. When you stand beside a charcoal grill at a picnic, you may feel its warmth even though heated air from the burning charcoal does not reach you. This is an example of heat transfer by
    (a) radiation
    (b) conduction
    (c) convection
    (d) diffusion (6.2) K/U

13. Placing a pot of water on the heating element of an electric stove results in currents of circulating water that distribute the added thermal energy. What drives the current? (6.2) K/U
    (a) Heat rises.
    (b) The small bubbles from dissolved gases make the water circulate before it boils.
    (c) The thermal energy exerts force on the water.
    (d) The colder water away from the heat source is denser, so it sinks and pushes warmer water up.
14. All isotopes of any one chemical element have the same
    (a) number of neutrons
    (b) number of protons
    (c) atomic mass
    (d) half-life (7.1) K/U
15. Which kind of nuclear decay process emits a positron? (7.2) K/U
    (a) gamma decay
    (b) alpha decay
    (c) beta decay
    (d) electron capture
16. Which kind of nuclear decay process emits the most strongly penetrating form of ionizing radiation? (7.2) K/U
    (a) alpha decay
    (b) beta positive decay
    (c) beta negative decay
    (d) gamma decay
17. Can an atomic nucleus emit an electron? (7.2) K/U
    (a) No. The nucleus contains only protons and neutrons.
    (b) No. Producing negative charge from positive charge violates the laws of physics.
    (c) Yes. A neutron in the nucleus can become a proton plus an electron.
    (d) Yes. A proton in the nucleus can become an electron plus a neutron.
18. Carbon dating is a technique that can be used to determine the age of
    (a) any artifact found
    (b) organisms previously alive
    (c) rocks and soil
    (d) the universe (7.3) K/U

Indicate whether each statement is true or false. If you think the statement is false, rewrite it to make it true.

19. The kinetic energy of a moving object is proportional to the square of its speed. (5.2) K/U
20. According to the work–energy principle, the work done on an object to accelerate it in the absence of friction-like forces equals the change in its potential energy. (5.2) K/U
21. As a roller coaster coasts downhill, its gravitational potential energy is converted into chemical energy and thermal energy. (5.3) K/U
22. The mechanical energy is the sum of the kinetic energy and the electrical energy. (5.3) K/U
23. Hydroelectricity is a renewable energy resource. (5.4) K/U
24. Incandescent light bulbs are less efficient than fluorescent light bulbs because they transform a smaller fraction of electrical energy to thermal energy. (5.4) K/U
25. Thermal energy is a measure of the average kinetic energy of the particles in an object. (6.1) K/U
26. Most substances contract as they freeze. (6.3) K/U
27. Substances absorb energy while boiling. (6.3) K/U
28. The latent heat of fusion of a substance measures the energy it absorbs while freezing. (6.3) K/U
29. The behaviour of water as it is cooled below 4 °C results from the way an oxygen atom in each molecule attaches itself to a hydrogen atom in a neighbouring molecule. (6.3) K/U
30. Alpha decay is a process in which an atomic nucleus emits a helium nucleus. (7.2) K/U
31. The repulsive electrostatic force between protons gets weaker as the protons are brought closer together. (7.2) K/U
32. Gravity is the fundamental force primarily responsible for holding nuclei together despite the electrical repulsion between positively charged protons. (7.2) K/U

Match each type of medium on the left with the most appropriate type of energy on the right.

33. (a) stretched spring — (i) electrical energy
    (b) flashlight battery — (ii) kinetic energy
    (c) visible light — (iii) chemical energy
    (d) moving object — (iv) elastic energy
    (e) electric current — (v) radiant energy (5.3) K/U

Understanding

34. A smooth 0.165 kg hockey puck slides along a smooth floor at an initial speed of 1.0 m/s, and stops in a distance of 2.26 m. (5.1) T/I
    (a) Calculate the work done by the normal force that the floor exerts upward on the puck.
    (b) Calculate the work done by friction.
35. The graph in **Figure 1** shows the force F acting on an object to move it along a straight-line path. (5.1) T/I C

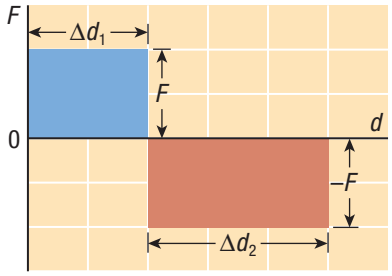

Figure 1

    (a) During which part of the motion are the force and the velocity in the same direction?
    (b) What is the total work done on the object by the force?
36. A 0.145 kg baseball has a kinetic energy of 74 J. Find its speed. (5.2) T/I
37. Explain the role of a reference level in problems involving gravitational potential energy. (5.2) K/U C
38. Suppose a rock is thrown directly upward on the Moon, where air resistance is zero. (5.3) K/U C
    (a) Describe how the work done by the Moon's gravity affects the kinetic energy and velocity of the rock as it moves directly upward.
    (b) How do the potential energy and the mechanical energy of the rock change on its way upward from the Moon's surface?
    (c) How are the kinetic energy and the potential energy each affected by the work that gravity does on the rock as it next falls downward?
39. A student throws a 0.22 kg rock horizontally at 20.0 m/s from 10.0 m above the ground. Ignore air resistance. (5.3) T/I
    (a) Find the initial kinetic energy of the rock.
    (b) Find the kinetic energy of the rock as it strikes the ground.
    (c) Find the speed of the rock as it strikes the ground.
40. A roller coaster starts at rest from a height of 110 m, and accelerates down the track to a height of 10.0 m. Find the speed it can reach, assuming no friction. (5.3) T/I
41. Explain why a device with efficiency greater than 100 % would violate the laws of physics, and why even 100 % efficiency never occurs for any energy-transforming device. (5.4) K/U C
42. A 0.057 kg tennis ball is dropped from 1.22 m onto a hard surface, bouncing up to a height of 0.70 m. (5.4) T/I
    (a) What was the kinetic energy of the ball just before it hit the ground for the first time?
    (b) How much kinetic energy did the ball have just after it hit the ground for the first time?
    (c) What happened to the lost energy?
    (d) What was the percent efficiency of the ball bouncing off the ground?
43. A farmer is considering putting in a wind turbine on his property to produce electricity. After doing some research, he comes up with the following two graphs (**Figure 2** and **Figure 3**): (5.5) K/U C A

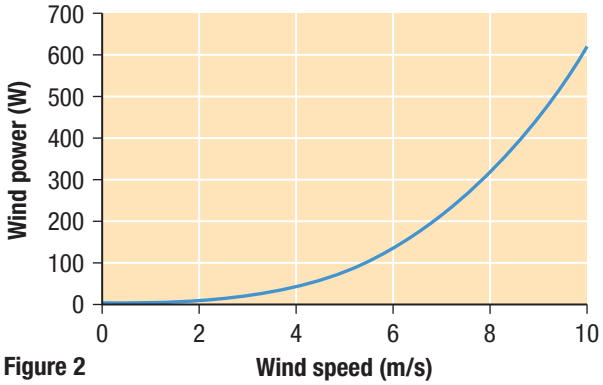

Figure 2

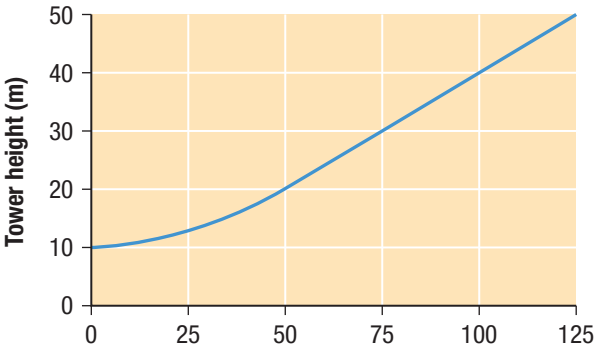

Figure 3

    (a) Describe what happens to wind power as wind speed increases.
    (b) Describe what happens to wind power as the height of the tower for the wind turbine increases. Why do you think this happens?
    (c) If the average wind speed on the farm is not very high, what can the farmer do to increase power generation? How will this affect the construction cost? Explain your reasoning.

44. A 100.0 W incandescent light bulb emits about 1.6 J of energy as useful, visible light each second. What is its efficiency? (5.4) T/I

45. A force of 110 N is applied horizontally to the handles of a lawnmower to move it at a speed of 0.80 m/s across a lawn. Find the power used to mow the lawn. (5.5) T/I

46. A motor that uses electrical energy at a rate of 1.5 kW is connected to a hydraulic lift that is used to lift a 1300 kg car to a height of 1.8 m in 24 s at constant speed. Find the efficiency of the system consisting of the motor and the lift. (5.5) T/I

47. A certain 100 W light bulb has an efficiency of 95 %. How much thermal energy will this light bulb add to the inside of a room in 2.5 h if the bulb is on for the whole time? (5.5) T/I

48. Explain how heat differs from thermal energy. (6.1) K/U

49. (a) Express −20 °C as a temperature on the Kelvin scale.
    (b) Express 68 K as a Celsius temperature. (6.1) K/U

50. Use the temperature difference between the boiling and freezing points of water on each scale to determine how many Fahrenheit degrees of change in temperature are equal to each Celsius degree change in temperature. (6.1) T/I

51. List and describe each of the three main mechanisms for heat transfer. (6.2) K/U C

52. Explain the purpose served by the air space and by the shiny reflecting surfaces in the Thermos bottle shown in **Figure 4**. What kind of heat transfer does each feature reduce? (6.2) C A

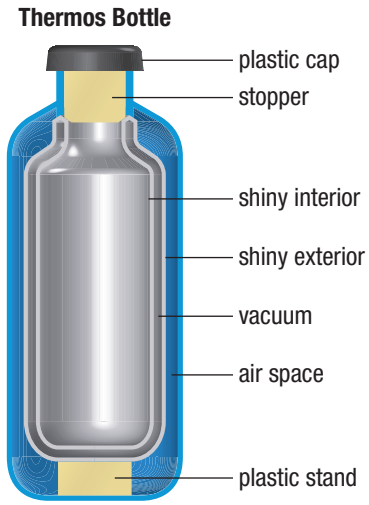

Figure 4

53. When you touch a metal spoon at room temperature it will usually feel colder than when you touch a woollen blanket at the same temperature. Explain what causes this effect. (6.2) K/U C A

54. A 170.0 g sample of a substance is heated to 120.0 °C and then plunged into 200.0 mL of water at 10.0 °C. The resulting mixture has a temperature of 12.6 °C. What is the specific heat capacity of the substance? (6.3) T/I

55. Find how much thermal energy must be added to 200.0 g of iron to increase its temperature by 12 °C. (6.3) T/I

56. A Canadian penny is initially at 100.0 °C. Estimate how much energy it must lose to cool to room temperature at 20.0 °C. The penny consists of 94 % iron with smaller amounts of nickel and copper and has a total mass of 2.35 g. (6.3) K/U T/I

57. Water at 20.0 °C is mixed with 120.0 g of ethyl alcohol at 10.0 °C in a thermally insulated container. If the final mixture has a temperature of 16.0 °C, how much water was added? (6.3) T/I

58. An ice cube is dropped into a large graduated cylinder. From the change in level of the water already in the cylinder the ice cube is found to have a mass of 20.0 g. Find how much energy the ice cube releases merely by melting. (6.4) T/I

59. The graph in **Figure 5** shows how the temperature varies as the thermal energy of a container full of water is increased at a constant rate. Explain what is happening to the sample for part A, part B, and part C of the curve. (6.4) K/U C

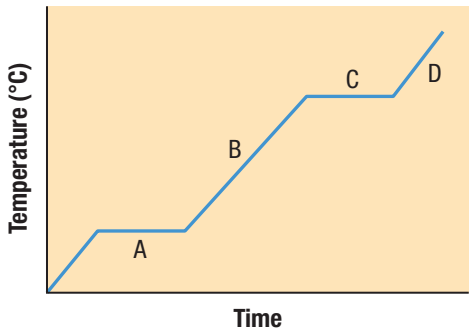

Figure 5

60. Explain what happens to the added thermal energy during a phase transition, when the average kinetic energy of particles in the sample does not increase. (6.4) K/U C

61. Draw the Bohr–Rutherford diagram for sodium-23. (7.1) K/U C

62. Use Bohr–Rutherford models to explain how an excited state differs from the ground state of an atom. (7.1) K/U C

63. What does each of these terms describe in the Bohr–Rutherford atomic model? (7.1) K/U
    (a) atomic mass number
    (b) atomic number
    (c) nucleon

64. Compare the atomic number, atomic mass number, and number of neutrons of $^{99}_{43}\text{Tc}$ and of $^{96}_{43}\text{Tc}$. (7.1) K/U C

65. (a) Which two forces within a nucleus compete to determine how stable a particular nuclear isotope is?
    (b) How can the presence of additional neutrons increase the stability of an isotope in some cases? (7.2) K/U C

66. Calculate the mass defect and binding energy of the iron-56 nucleus with atomic mass 55.934 937 5 u. (7.4) T/I

67. Beryllium-11 has a half-life of 13.81 s. What percent of the initial sample will remain after 30.0 s? (7.3) T/I

68. (a) What is nuclear fission?
    (b) Do nuclei that are fissionable have larger or smaller masses than most nuclei?
    (c) What particle is typically absorbed by the nucleus to induce nuclear fission?
    (d) Why does it require much less energy to induce fission of a fissionable nucleus than to induce nuclear fusion of hydrogen atoms? (7.4) K/U C

69. (a) Explain the role of the control rods in a nuclear reactor, and include an example of a substance used for control rods in CANDU reactors.
    (b) Explain the function of a moderator in a nuclear reactor, and identify a substance used as a moderator in CANDU reactors. (7.4) C A

70. Explain how the binding energy of stable nuclei varies with increasing atomic mass. What does this imply about which isotopes can be combined more readily by fusion and which are more likely to undergo fission? (7.5) K/U C

71. Determine the net energy released in the overall proton-proton chain fusion reaction shown below. Remember to consider the mass defect. (7.5) T/I

$$4\left(^{1}_{1}\text{H}\right) \rightarrow {}^{4}_{2}\text{He} + 2\left(^{0}_{-1}\text{e}\right) + \text{energy}$$

72. (a) Which of the reactions below is a fusion reaction? Explain how you know.
    (i) $^{204}_{82}\text{Pb} \rightarrow {}^{200}_{80}\text{Mg} + {}^{4}_{2}\text{He}$
    (ii) $^{234}_{90}\text{Th} \rightarrow {}^{234}_{92}\text{Pa} + {}^{0}_{-1}\text{e}$
    (iii) $^{2}_{1}\text{H} + {}^{2}_{1}\text{H} \rightarrow {}^{3}_{2}\text{He} + {}^{1}_{0}\text{n}$
    (b) Which of the reactions in (a) is beta decay? Explain how you know. (7.5) T/I

Analysis and Application

73. A 62 kg person is riding on an escalator at constant speed to a height of 4.3 m. The escalator makes an angle of 45° with the horizontal. (5.1) T/I
    (a) Draw a free-body diagram of this situation.
    (b) Calculate the work that the escalator does on the passenger.
    (c) Find the work done by gravity.

74. A child pulls a sled along the ice by exerting a force of 40.0 N on a rope that makes an angle of 30.0° with the horizontal. Find how much work the force has done on the sled when it moves horizontally through a distance of 2.0 m. (5.1) T/I

75. The Canadarm2 shown in **Figure 6** is attached to the International Space Station and used to move heavy objects off rockets and onto the Space Station. It is 17.6 m long and can exert forces up to 1000 N. How much work will the Canadarm2 do on an object if it moves the object through a displacement equal to its length using the maximum force it can apply? Assume that the force acts in the same direction as the object's displacement. (5.1) T/I

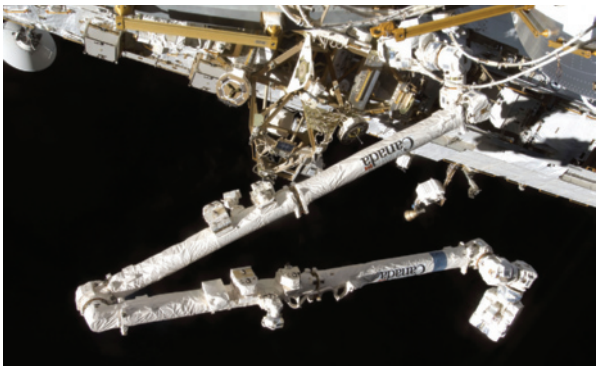

Figure 6

76. Assume a car's brakes when applied produce a constant force to bring the car to a complete stop. Assume the car has mass M. Use energy considerations to find out how the stopping distance depends on the initial velocity v (for example, is it proportional to v, or to v^2, or to $1/v$, and so on). (5.1, 5.2) T/I

77. Suppose you do 200 J of work to compress a spring. (5.2) T/I
    (a) How much work would the spring be able to do when it decompresses, exerting force to move another object?
    (b) How much potential energy is stored in the compressed spring?
    (c) If a 5.0 kg object is placed atop the compressed spring and the spring is released, how high can the spring hurl the object upward?

78. An object hanging from a string like a pendulum is pulled to the side and released, as shown in **Figure 7**. A peg blocks the path of the string. Which letter on the diagram most accurately labels the greatest height that the object could reach during its swing? Justify your answer. (5.3) T/I C

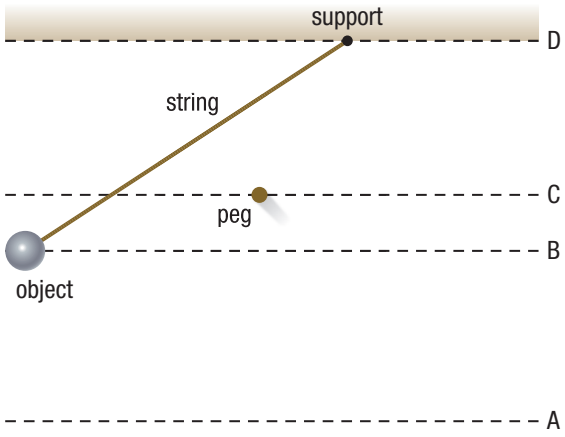

Figure 7

79. Describe which form of energy is transformed into which in a nuclear power plant when
    (a) a nuclear reaction heats water to change it into steam under pressure
    (b) the steam pressure forces a turbine to rotate
    (c) the rotating turbine forces a generator to rotate and produce electricity (5.3) C A

80. Suppose a bicycle and its rider have a mass of 75 kg. The bicyclist does 4700 J of work to travel 210 m along a slightly sloping road that increases the bicyclist's elevation by 5.5 m. Find the efficiency of the bicycle. (5.4) T/I A

81. Find what power is needed to accelerate a 620 kg Formula One car and driver "from zero to sixty" (miles per hour, or mph) in 6.00 s (1 mph = 0.447 m/s). (5.5) T/I

82. On average, 110 000 m^3 of water flow over Niagara Falls each minute and fall through a height of about 52 m. (5.5) T/I
    (a) Calculate the change in gravitational potential energy of the water that flows over Niagara Falls in 1.00 min.
    (b) If all the potential energy lost in going over the falls could be converted to electrical energy, what would the power rating of Niagara Falls be?

83. Two students decide to measure the power rating of a small submersible electric water heater. They place 325 mL of water at 20.0 °C in a thermally insulated container, insert the water heater and a thermometer, and run an electric current through the heater for 60.0 s, stirring the water to keep its temperature uniform. They find that the water reaches 24.9 °C. Calculate the power of the heater in watts. (5.5, 6.3) T/I

84. What are the main ideas in the caloric theory and how did it explain how a hot object would heat a colder object? In what way does Count Rumford's experiment, and simply experiencing what happens when you rub your hands together, show the caloric explanation of warming objects to be inadequate? Explain. (6.1) K/U C

85. The Kelvin temperature scale has a universal meaning related to the thermal energy an object contains. Any object at zero kelvins has the least kinetic energy physically possible for the particles comprising it. Why then would scientists have invented the Celsius scale first, based merely on the boiling and freezing points of one specific substance, water? (6.1) T/I C

86. (a) Explain in terms of what you know about specific heat and about heat transfer by convection why the water in a lake on a warm summer day stays much cooler than the ground. The specific heat of dry soil is about 0.80 kJ/(kg·K).
    (b) On a hot day, near a large body of water, you will likely enjoy a breeze blowing from the water toward and over the ground. The circulating air returns at higher elevation toward the water. Explain the mechanism that produces this circulating current.
    (c) How does the air near a large body of water circulate at night if the water ends up warmer than the land surface? (6.2, 6.3) T/I C A

87. Discuss how the unusual behaviour of water compared to other liquids accounts for the way that lakes freeze first at their surface during winter, and typically remain liquid below. (6.4) C A

88. (a) Describe briefly how the latent heat of condensation and vaporization is used in an air conditioning system.
    (b) Explain what happens to the thermal energy that the refrigerant removes from inside a home, in terms of the law of conservation of energy. (6.4) K/U C A

89. When outside temperatures appear likely to drop just below the freezing point of water, fruit farmers protect their crop by continuously spraying the plants with water. Explain why this would help keep the crop from being damaged. (6.4) T/I C A

90. Calculate how much thermal energy is removed when 50.0 g of ethyl alcohol vaporizes by boiling. (6.4) T/I

91. Different substances expand at different rates with increasing temperature. Explain how this principle is employed in a thermostat that controls the operation of heating and cooling systems. (6.4, 6.5) C A

92. How much thermal energy is required to melt 8.0 g of gold at its melting point? (6.4) T/I

93. Determine whether a kilogram of molten lead can completely boil a kilogram of water by calculating and comparing the heat released by the lead to reach the boiling point of water with the heat absorbed to heat and then boil the water starting at 20.0 °C. The lead starts in liquid form exactly at its melting temperature, 327.5 °C. (6.3, 6.4) T/I

94. (a) How does the source of thermal energy for a geothermal heating system differ from that of a conventional system?
    (b) What advantages does geothermal heating offer? (6.5, 6.6) C A

95. Write a balanced reaction equation for each of the following nuclear decay processes: (7.2) T/I
    (a) Uranium-238 decays by alpha decay.
    (b) Sodium-22 decays by beta positive decay.
    (c) Calcium-41 decays by electron capture.

96. The graph in **Figure 8** shows the decrease in mass of an unknown isotope caused by nuclear decay. (7.3) T/I C
    (a) Determine the half-life of the isotope from the graph.
    (b) Calculate how much of the isotope would remain after 8000 years.

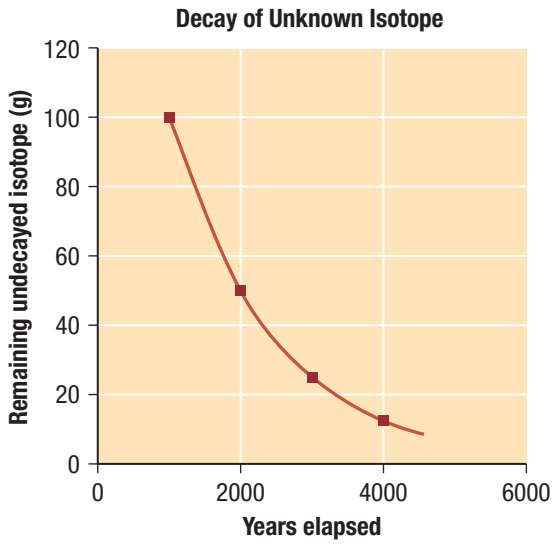

Figure 8

97. A patient comes into the hospital for a bone scan and is injected with a dye containing Tc-99m. The half-life of Tc-99m is 6.03 h. What fraction of the original technetium will remain in the patient 36 h after the procedure if radioactive decay is the only means by which it is removed? (7.3) T/I A

98. When the masses of the correct number of electrons, protons, and neutrons are added together for any particular atomic isotope, the sum never exactly agrees with the measured mass for atoms of the isotope. (7.4) T/I C
    (a) Why is this true?
    (b) How does this difference between the calculated mass and the measured mass of an atomic isotope relate to the interactions between the subatomic particles within the nucleus?

99. Canada's annual consumption of electricity in 2010 has been estimated to be 5.36×10^{11} kWh. If 1.00 kg of matter could be converted completely into electrical energy, how long would it supply Canada's electrical energy needs? (7.4) T/I

Evaluation

100. The Moses-Saunders dam on the St. Lawrence River near Cornwall, Ontario, produces more than 900 000 kW of hydroelectricity. Given what you have learned about the methods of electrical energy production, what advantages does this method have over nuclear and fossil fuel electrical plants? Explain why we cannot use this method exclusively to produce all of Canada's electrical energy. (5.4) T/I C A

101. A group of students are proposing designs for a thermometer to measure only temperatures between 2 °C and 7 °C. One proposal, shown in the diagram in **Figure 9**, would use coloured water instead of coloured alcohol and have a scale from 2 °C to 7 °C. Why is the proposed idea unworkable? (6.3) T/I C A

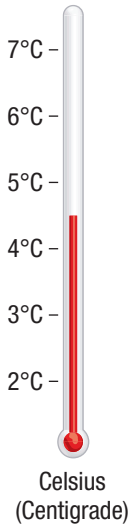

Figure 9

102. An enterprising researcher submits a proposal seeking government funding for a study that would use carbon dating to determine the age of rocks recovered from the moon. Moon rocks generally range in age from 3 billion to 5 billion years old. You are in charge of making decisions about how the government agency's funds are used. (7.3) T/I C A
    (a) Why should you decide not to fund the proposal?
    (b) How might the researcher change the proposal to overcome your objection?

Reflect on Your Learning

103. In your opinion, what is the most important concept you learned in this unit? Why do you feel this is the most important concept? Discuss in a brief paragraph. C

104. The Energy and Society unit covers a broad range of topics. C
    (a) Which topics did you find the most interesting? Explain.
    (b) Which topics did you find easy to understand?
    (c) Which topics did you find the least interesting? Explain.
    (d) Which topics were the most challenging to understand? Explain why and list two things you could do to improve your understanding of these topics.

Research

GO TO NELSON SCIENCE

105. Research the advantages and limitations of passive solar heating. Evaluate whether this would likely provide a cost-effective means of providing the partial or full heating needs of a home in your own location. T/I C A

106. The possibility of laser-induced fusion using "inertial confinement" is a method being explored to create controlled nuclear fusion. Research this method to find out how the process would work, and describe any recent breakthroughs in this field. T/I C A

107. Fuel cells produce electrical energy directly from hydrogen and oxygen. Research the use of hydrogen in energy utilization. Focus on the following issues: T/I C A
    (a) Why is no net energy produced if the hydrogen for the fuel cell is produced by using an electric current to break water apart into hydrogen and oxygen by electrolysis?
    (b) What other means are available to produce hydrogen, and what are their advantages and disadvantages?
    (c) In what ways might hydrogen be useful in energy utilization?

108. Research the average number of kilowatt hours of electricity that a Canadian family uses and estimate, based on your own family's electricity bill and the power rating of electrical lights and electrical devices in your own home, what fraction is for lighting. Use this to estimate how much electrical energy in Canada would be saved each year if all incandescent bulbs were replaced by fluorescent bulbs. T/I C A

109. Deep ocean currents, often referred to as thermohaline currents, take about 1600 years to travel the globe. Research what mechanisms near Earth's poles drive thermohaline currents. Include an explanation of why nearly frozen sea water would sink as it cools, while in freezing lakes the colder water and ice are both at the surface. T/I C A

110. Research radionuclide therapy. How does it work? What are some diseases that can be treated with radionuclide therapy? What are some diseases that cannot be treated using radionuclide therapy at this time? Write a paragraph describing your findings. T/I

111. A number of different isotopes are used in nuclear medicine to image internal organs of the body. Research what properties isotopes must have to be useful for imaging. Consider whether the isotopes should be alpha, beta, or gamma emitters. Consider what the half-lives of the isotopes should be. Discuss why the properties you have identified make these isotopes useful for imaging. T/I C A