# Unit 3 Review, pages 364–371

## Knowledge

**1.** (c)
**2.** (c)
**3.** (a)
**4.** (b)
**5.** (d)
**6.** (d)
**7.** (a)
**8.** (b)
**9.** (c)
**10.** (b)
**11.** (b)
**12.** (a)
**13.** (d)
**14.** (b)
**15.** (c)
**16.** (d)
**17.** (c)
**18.** (b)
**19.** True
**20.** False. 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 *kinetic* energy.
**21.** False. As a roller coaster coasts downhill, its gravitational potential energy is converted into *kinetic* energy and thermal energy.
**22.** False. The mechanical energy is the sum of the kinetic energy and the *potential* energy.
**23.** True
**24.** False. Incandescent light bulbs are less efficient than fluorescent bulbs because they transform a smaller fraction of electrical energy to *radiant* energy.
**25.** False. Thermal energy is a measure of the *total* kinetic energy *and potential energy* of the particles in an object.
**26.** True
**27.** True
**28.** False. The latent heat of fusion of a substance measures the energy it *releases* while freezing.
**29.** True
**30.** True
**31.** False. The repulsive electrostatic force between protons gets *stronger* as the protons are brought closer together.
**32.** False. The strong nuclear force is the fundamental force primarily responsible for holding nuclei together despite the electrical repulsion between positively charged protons.
**33.** (a) (iv)
(b) (iii)
(c) (v)
(d) (ii)
(e) (i)

## Understanding

**34. (a)** Since the puck is not moving up or down, no work is done in those directions. The work done by the normal force is 0 J.
**(b) Given:** $m$ = 0.165 kg; $v_i$ = 1.0 m/s; $\Delta d$ = 2.26 m.
**Required:** $W_f$
**Analysis:**

$$F_f = ma$$

$$v_f^2 = v_i^2 + 2ad$$

$$a = \frac{v_f^2 - v_i^2}{2d}$$

Substitute into the $W_f$ formula:

$$\begin{aligned} W_f &= F_f \Delta d \\ &= ma\Delta d \\ &= m\left(\frac{v_f^2 - v_i^2}{2\cancel{d}}\right)\cancel{\Delta d} \\ W_f &= m\left(\frac{v_f^2 - v_i^2}{2}\right) \end{aligned}$$

**Solution:**

$$\begin{aligned} W_f &= m\left(\frac{v_f^2 - v_i^2}{2}\right) \\ &= (0.165 \text{ kg})\frac{(-1.0 \text{ m/s})^2}{2} \\ &= -0.0825 \text{ J} \\ W_f &= -0.083 \text{ J} \end{aligned}$$

**Statement:** The work done by friction is –0.83 J.
**35. (a)** The force and velocity are in the same direction during the entire motion. The acceleration changes direction after $\Delta d_1$.
**(b)** The general equation for work is $W = F\Delta d$. Therefore, the total work done on the object is given by this equation: $W_T = F\Delta d_1 - F\Delta d_2$.
**36. Given:** $m$ = 0.145 kg; $E_k$ = 74 J
**Required:** $v$
**Analysis:**

$$E_k = \frac{mv^2}{2}$$

$$v = \sqrt{\frac{2E_k}{m}}$$

**Solution:**

$$v = \sqrt{\frac{2Ek}{m}}$$

$$= \sqrt{\frac{2(74\text{ J})}{0.145\text{ kg}}}$$

$$= 31.94\text{ m/s}$$

$$v = 32\text{ m/s}$$

**Statement:** The baseball's speed is 32 m/s.

**37.** The reference level is the height used as the ground level for measuring other heights. We assign it to have a gravitational potential energy of zero.

**38. (a)** Since the force of gravity and the direction of motion are in opposite directions, the Moon's gravity does negative work. This decreases both the kinetic energy and the speed of the rock.

**(b)** The rock's potential energy increases as its height increases, but its mechanical energy stays the same.

**(c)** The kinetic energy increases as the rock speeds up, and the potential energy decreases as its height decreases.

**39. (a) Given:** $m$ = 0.22 kg; $v_i$ = 20 m/s

**Required:** $E_k$

**Analysis:**

$$E_k = \frac{mv^2}{2}$$

**Solution:**

$$E_k = \frac{mv^2}{2}$$

$$= \frac{(0.22\text{ kg})(20.0\text{ m/s})^2}{2}$$

$$E_k = 44\text{ J}$$

**Statement:** The initial kinetic energy of the rock is 44 J.

**(b) Given:** $m$ = 0.22 kg; $h_1$ = 10.0 m; $g$ = 9.8 N

**Required:** $E_k$

**Analysis:**

$$E_g = mgh$$

$$E_{Total} = E_k + E_g$$

$$E_{Total} = E_k + mgh$$

When the rock strikes the ground, $E_g$ = 0, and all of the energy is kinetic.

**Solution:**

$$E_{Total} = E_k + mgh$$

$$= 44\text{ N} + (0.22\text{ kg})(9.8\text{ N})(10.0\text{ m})$$

$$= 65.56\text{ J}$$

$$E_{Total} = 66\text{ J}$$

**Statement:** The rock's kinetic energy when it strikes the ground is 66 J.

**(c) Given:** $m$ = 0.22 kg

**Required:** $v$

**Analysis:**

$$E_k = \frac{mv^2}{2}$$

$$v = \sqrt{\frac{2E_k}{m}}$$

**Solution:**

$$v = \sqrt{\frac{2E_k}{m}}$$

$$= \sqrt{\frac{2(66\text{ J})}{0.22\text{ kg}}}$$

$$= 24.49\text{ m/s}$$

$$v = 24\text{ m/s}$$

**Statement:** The speed of the rock as it strikes the ground is 24 m/s.

**40. Given:** $h_i$ = 110 m; $h_f$ = 10.0 m; $v_i$ = 0 km/h

**Required:** $v_f$

**Analysis:**

$$E_g = mg\Delta d$$

$$E_k = \frac{mv^2}{2}$$

$$E_{k\,i} + E_{g\,i} = E_{k\,f} + E_{g\,f}$$

Let $h_f$ be the reference height. At $h_f$, $E_g$ = 0 J. At $h_i$, $E_k$ = 0 J. By substitution:

$$E_{k\,i} + E_{g\,i} = E_{k\,f} + E_{g\,f}$$

$$0 + \cancel{m}g\Delta d = \frac{\cancel{m}v_f^2}{2} + 0$$

$$v_f = \sqrt{2g\Delta d}$$

**Solution:**

$$v_f = \sqrt{2g\Delta d}$$

$$= \sqrt{2(9.8\text{ N})(100\text{ m})}$$

$$= 44.27\text{ m/s}$$

$$v_f = 44\text{ m/s}$$

**Statement:** The roller coaster can reach a speed of 44 m/s.

**41.** A device with efficiency greater than 100 % would have more output energy than input energy, violating the law of conservation of energy. Because some friction is always present and reduces the output energy, the efficiency is always less than 100%.

**42. (a) Given:** $m$ = 0.057 kg; $h_i$ = 1.22 m; $g$ = 9.8 N
**Required:** kinetic energy just before the ball hit the ground the first time, $E_{\text{k ground 1}}$
**Analysis:** All the potential (gravitational) energy that the ball had at $h_1$ will be converted to kinetic energy just before the ball hits the ground.

$$E_{\text{k ground 1}} = mgh_1$$

**Solution:**

$$\begin{aligned} E_{\text{k ground 1}} &= mgh_1 \\ &= (0.057 \text{ kg})(9.8 \text{ N})(1.22 \text{ m}) \\ &= 0.6814 \text{ J} \\ E_{\text{k ground 1}} &= 0.68 \text{ J} \end{aligned}$$

**Statement:** Just before it hits the ground, the ball will have 0.68 J of kinetic energy.

**(b) Given:** $m$ = 0.057 kg; $h_f$ = 0.70 m; $g$ = 9.8 N
**Required:** kinetic energy just after the ball hit the ground the first time, $E_{\text{k ground 2}}$
**Analysis:** Just after the ball hits the ground, it will have kinetic energy equal to its gravitational energy at the top of its next bounce.

$$E_{\text{k ground 2}} = mgh_2$$

**Solution:**

$$\begin{aligned} E_{\text{k ground 2}} &= mgh_2 \\ &= (0.057 \text{ kg})(9.8 \text{ N})(0.70 \text{ m}) \\ &= 0.3910 \text{ J} \\ E_{\text{k ground 2}} &= 0.39 \text{ J} \end{aligned}$$

**Statement:** Just after it hits the ground, the ball will have kinetic energy of 0.39 J.

**(c)** The energy "lost" during the collision is converted mostly to thermal energy and a small amount of sound energy.

**(d) Given:** $E_{\text{k ground 1}}$ = 0.6814 J; $E_{\text{k ground 2}}$ = 0.3910 J
**Required:** efficiency
**Analysis:**

$$\text{Efficiency} = \frac{E_{\text{out}}}{E_{\text{in}}} \times 100 \ \%$$

**Solution:**

$$\begin{aligned} \text{Efficiency} &= \frac{E_{\text{out}}}{E_{\text{in}}} \times 100 \ \% \\ &= \frac{0.3910 \text{ J}}{0.6814 \text{ J}} \times 100 \ \% \\ &= 57.38 \ \% \\ \text{Efficiency} &= 57 \ \% \end{aligned}$$

**Statement:** The efficiency of the bouncing ball was 57 %.

**43. (a)** As wind speed increases, wind power increases exponentially.

**(b)** As the height of the tower increases, wind power increases. Explanations may vary. Sample explanation: Winds are often stronger higher up because there are fewer obstacles to impede the flow of air.

**(c)** Answers may vary. Sample answer:
If the average wind speed on the farm is not very high, the farmer could build a taller tower. This would provide more wind power, but would increase construction costs because more building materials would be needed.

**44. Given:** power = 100 W = 100 J/s; energy emitted = 1.6 J/s
**Required:** efficiency
**Analysis:**

$$\text{Efficiency} = \frac{E_{\text{out}}}{E_{\text{in}}} \times 100 \ \%$$

**Solution:**

$$\begin{aligned} \text{Efficiency} &= \frac{E_{\text{out}}}{E_{\text{in}}} \times 100 \ \% \\ &= \frac{1.6 \text{ J/s}}{100 \text{ J/s}} \times 100 \ \% \\ \text{Efficiency} &= 1.6 \ \% \end{aligned}$$

**Statement:** The efficiency of the bulb is 1.6 %.

**45. Given:** $F$ = 110 N [horizontal]; $v$ = 0.80 m/s
**Required:** $P$
**Analysis:**

$$W_{\text{net}} = F\Delta d$$

$$P = \frac{W_{\text{net}}}{\Delta t}$$

$$P = \frac{F\Delta d}{\Delta t}$$

**Solution:** Use a time of 1 s to calculate the power.

$$\begin{aligned} P &= \frac{F\Delta d}{\Delta t} \\ &= \frac{(110 \text{ N})(0.80 \text{ m})}{1 \text{ s}} \\ P &= 88 \text{ W} \end{aligned}$$

**Statement:** The power used to mow the lawn is 88 W.

**46. Given:** $E_{\text{out}}$ = 1.5 kW; $m$ = 1300 kg; $h$ = 1.8 m; $t$ = 24 s; speed is constant
**Required:** efficiency of system
**Analysis:**

$$E_{in} = \frac{mv^2}{2}$$

$$\text{Efficiency} = \frac{E_{\text{out}}}{E_{\text{in}}} \times 100 \ \%$$

$$\text{Efficiency} = \frac{2E_{\text{out}}}{mv^2} \times 100 \ \%$$

**Solution:** First, calculate the speed of the lift.

$$v = \frac{1.8 \text{ m}}{24 \text{ s}}$$

$v = 0.075$ m/s

$$\begin{aligned}\text{Efficiency} &= \frac{2E_{\text{out}}}{mv^2} \times 100\ \% \\ &= \frac{2(1.5 \text{ kW})}{(1300 \text{ kg})(0.075 \text{ m/s})^2} \times 100\ \% \\ &= 41.02\ \%\end{aligned}$$

$\text{Efficiency} = 41\ \%$

**Statement:** The efficiency of the system is 41 %.

**47. Given:** efficiency = 95 %; $P = 100$ W; $\Delta t = 2.5$ h = 9000 s

**Analysis:**

$$\text{Efficiency} = \frac{E_{\text{out}}}{E_{\text{in}}} \times 100\ \%$$

$$E_{\text{out}} = \frac{\text{Efficiency} \times E_{\text{in}}}{100\ \%}$$

$$\Delta E = P\Delta t$$

**Solution:** First, find the amount of power wasted.

$$E_{\text{out}} = \frac{\text{Efficiency} \times E_{\text{in}}}{100\ \%}$$

$$E_{\text{out}} = \frac{95\ \cancel{\%} \times 100 \text{ W}}{100\ \cancel{\%}}$$

$$E_{\text{out}} = 95 \text{ W}$$

The energy used for light is 95 W, so the amount of power wasted is
100 W – 95 W = 5 W

Then find how much energy this is.

$$\begin{aligned}\Delta E &= P\Delta t \\ &= (5 \text{ W})(9000 \text{ s}) \\ &= 45\ 000 \text{ W•s}\end{aligned}$$

$\Delta E = 45\ 000$ J

**Statement:** Thermal energy of 45 000 J, or 45 kJ, will be added to the inside of a room in 2.5 h.

**48.** Thermal energy is the kinetic and potential energy in an object. Heat is the transfer of thermal energy from a substance with a higher temperature to a substance with a lower temperature.

**49. (a) Given:** $T_C = –20$ °C

**Required:** $T_K$

**Analysis:** $T_K = T_C + 273$

**Solution:**

$$\begin{aligned}T_K &= T_C + 273 \\ &= –20 + 273\end{aligned}$$

$T_K = 253$ K

**Statement:** The temperature –20 °C can be expressed as 253 K.

**(b) Given:** $T_K = 68$ K

**Required:** $T_C$

**Analysis:** $T_C = T_K – 273$

**Solution:**

$$\begin{aligned}T_C &= T_K – 273 \\ &= 68 – 273\end{aligned}$$

$T_C = –205$ °C

**Statement:** The temperature 68 K can be expressed as –205 °C.

**50. Given:** $B_F = 212$ °F; $F_F = 32$ °F; $B_C = 100$ °C; $F_C = 0$ °C

**Required:** number of Fahrenheit degrees equivalent to each Celsius degree (°F/°C)

**Analysis:**

$$\frac{°\text{F}}{°\text{C}} = \frac{(B_F - F_F)}{(B_C - F_C)}$$

**Solution:**

$$\begin{aligned}\frac{°\text{F}}{°\text{C}} &= \frac{(B_F - F_F)}{(B_C - F_C)} \\ &= \frac{(212\ °\text{F} - 32\ °\text{F})}{(100\ °\text{C} - 0\ °\text{C})} \\ &= \frac{1.8\ °\text{F}}{1\ °\text{C}}\end{aligned}$$

$$\frac{°\text{F}}{°\text{C}} = 1.8\ °\text{F}$$

**Statement:** A 1.8 °F change in temperature is equal to each Celsius degree change in temperature.

**51.** The three main mechanisms for heat transfer are conduction, convection, and radiation.

In conduction, two objects are in physical contact. The fast-moving particles in the warmer object collide with the slower-moving particles in the cooler object and transfer some of their thermal energy to them.

In convection, colder denser material in a fluid falls, causing the warmer, less dense material in the fluid to rise. This cyclical movement of the fluid spreads thermal energy throughout the fluid.

In radiation, thermal energy is transferred from one substance to another by electromagnetic waves, even though they are not in physical contact.

**52.** Air is much less dense than a solid so it does not transfer thermal energy by conduction as well as a solid would. In the Thermos bottle, the air space stops the conduction of thermal energy between the outside and the inside. The shiny surfaces reflect radiation and prevent or reduce the amount of thermal energy that is transferred by radiation.

**53.** The metal spoon is a thermal conductor and allows thermal energy to pass through it easily. This causes the thermal energy in your (warmer) hand to travel quickly into the (cooler) spoon and away from your body. This results in your hand feeling cold where it touches the spoon. A woollen blanket is a thermal insulator, and thermal energy does not travel through it easily. This means the thermal energy from your (warmer) hand does not travel into the blanket, so you do not feel a temperature change in your hand.

**54. Given:** $m_s$ = 170.0 g; $T_{s1}$ = 120.0 °C; $T_{s2}$ = 12.6 °C; $V_w$ = 200.0 mL; $T_{w1}$ = 10.0 °C; $T_{w2}$ = 12.6 °C

**Required:** specific heat capacity of the substance, $c$

**Analysis:**

$$Q_{released} + Q_{absorbed} = 0$$
$$Q = mc\Delta T$$

**Solution:** First calculate the quantity of water in kilograms.

$$m_w = 200.0\ \cancel{mL} \times \frac{1\ \cancel{g}}{1\ \cancel{mL}} \times \frac{1\ kg}{1000\ \cancel{g}}$$
$$mw = 0.2000\ kg$$

Then find the specific heat capacity.

$$Q_{released} + Q_{absorbed} = 0$$
$$m_s c_s \Delta T_s + m_w c_w \Delta T_w = 0$$

$$c_s = \frac{-(m_w c_w \Delta T_w)}{m_s \Delta T_s}$$
$$= \frac{-(0.2000\ \cancel{kg})\left(4.18\times10^3\ \frac{J}{\cancel{kg\bullet °C}}\right)(2.6\ °\cancel{C})}{(0.1700\ kg)(107.4\ °C)}$$
$$= 119.0\ \frac{J}{kg\bullet °C}$$
$$c_s = 1.19\times10^2\ \frac{J}{kg\bullet °C}$$

**Statement:** The specific heat capacity of the substance is 1.19 × $10^2$ J/kg•°C.

**55. Given:** $m$ = 200.0 g = 0.200 kg; $c_{iron}$ = 4.5 × $10^2$ J/(kg•°C); $\Delta T$ = 12 °C

**Required:** $Q$

**Analysis:** $Q = mc\Delta T$

**Solution:**

$$Q = mc\Delta T$$
$$= (0.200\ \cancel{kg})\left(4.5\times10^2\ \frac{J}{\cancel{kg\bullet °C}}\right)(12\ °\cancel{C})$$
$$= 1080\ J$$
$$Q = 1.1\times10^2\ J$$

**Statement:** To increase the temperature of 200.0 g of iron by 12 °C, 1.1 × $10^2$ J of thermal energy must be added.

**56. Given:** Since the penny is 94 % iron, use the specific heat capacity for iron.

$m$ = 2.35 g = 0.002 35 kg; $T_i$ = 100 °C; $T_f$ = 20 °C; $c_{iron}$ = 4.5 × $10^2$ J/(kg•°C)

**Required:** estimate of $Q_{released}$

**Analysis:**

$Q = mc\Delta T$

**Solution:**

$$Q = mc\Delta T$$
$$= (0.002\ 35\ \cancel{kg})\left(4.5\times10^2\ \frac{J}{\cancel{kg\bullet °C}}\right)(-80\ °\cancel{C})$$
$$Q = -84.6\ J$$

**Statement:** The penny will lose approximately 84.6 J as it cools from 100.0 °C to 20.0 °C.

**57. Given**: $T_{w1}$ = 20.0 °C; $T_{w2}$ = 16.0 °C; $T_{a1}$ = 10.0 °C; $T_{a2}$ = 16.0 °C; $m_a$ = 120.0 g = 0.1200 kg; $c_w$ = 4.18 × $10^3$ J/(kg•°C); $c_a$ = 2.46 × $10^3$ J/(kg•°C)

**Required:** $m_w$

**Analysis:**

$$Q_{released} + Q_{absorbed} = 0$$
$$Q = mc\Delta T$$

**Solution:**

$$Q_{released} + Q_{absorbed} = 0$$
$$m_w c_w \Delta T_w + m_a c_a \Delta T_a = 0$$

$$m_w = \frac{-m_a c_a \Delta T_a}{c_w \Delta T_w}$$
$$= \frac{(-0.1200\ kg)\left(2.46\times10^3\ \frac{\cancel{J}}{\cancel{kg\bullet °C}}\right)(6.0\ °\cancel{C})}{\left(4.18\times10^3\ \frac{\cancel{J}}{\cancel{kg\bullet °C}}\right)(4.0\ °\cancel{C})}$$
$$= 0.105\ 93\ kg$$
$$m_w = 106\ g$$

**Statement:** The amount of water added to the ethyl alcohol was 106 g

**58. Given:** $m$ = 20.0 g = 0.0200 kg;
$L_f$ = 3.4 × $10^5$ J/kg

**Required:** $Q$

**Analysis:** $Q = mL_f$

**Solution:**

$$Q = mL_f$$

$$= (0.0200\ \cancel{\text{kg}})\left(3.4 \times 10^5\ \frac{\text{J}}{\cancel{\text{kg}}}\right)$$

$$Q = 6800\ \text{J}$$

**Statement:** The ice cube releases 6800 J of energy by melting.

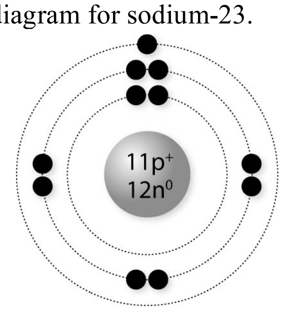
**59. Part A:** The water is melting. Thermal energy is being transferred to the water, but the temperature of the water is not changing. The absorbed energy is potential energy.

**Part B:** Thermal energy is still being transferred to the water and the liquid water is becoming warmer.

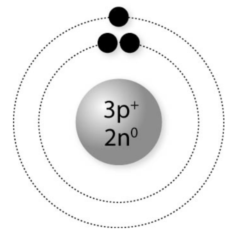
**Part C:** The water is boiling. Thermal energy is being transferred to the water, but the temperature of the water is not changing. The absorbed energy is potential energy.

**60.** During a phase transition, the added thermal energy becomes potential energy that is stored until the substance cools and passes through the phase transition in the opposite direction. Then the potential energy is released.

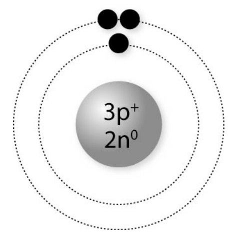
**61.** The mass of this isotope is 23.
Subtract the atomic number from the mass number to find the number of neutrons.
23 – 11 = 12
Sodium has 12 neutrons. This is the Bohr-Rutherford diagram for sodium-23.




**62.** Atoms in their ground state have every electron in its lowest available energy level. Atoms in an excited state have one or more electrons in higher-energy levels when lower levels are available. Models may vary. This Bohr-Rutherford diagram shows lithium in a ground state with two electrons in the first energy level and one electron in the second energy level.




This Bohr-Rutherford diagram shows lithium in an excited state with one electron in the first energy level and two electrons in the second energy level.




**63. (a)** The atomic mass number describes the number of protons and the number of neutrons in the nucleus of the atom.
**(b)** The atomic number describes the number of protons in the nucleus of the atom.
**(c)** The term nucleon describes protons and neutrons, the components of the atom's nucleus.

**64.** Technetium-99 and technetium-96 both have the atomic number 43. The atomic mass number of technetium-99 is 99, three higher than the atomic mass number of technetium-96. Since these isotopes have the same number of protons, technetium-99 has three more neutrons than technetium-96 does.

**65. (a)** Electrostatic forces repelling the protons compete with the strong nuclear force attracting nucleons to one another to determine the stability of a nuclear isotope.
**(b)** The presence of additional neutrons increases the strength of the strong nuclear force. This can help it balance the electrostatic forces of the protons and increase the stability of the isotope.

**66. Given:** $m_{\text{Fe-56}}$ = 55.934 937 5 u;
$m_p$ = 1.007 276 u; $m_n$ = 1.008 665 u;
$m_e$ = 0.000 549 u; $c^2$ = 930 MeV/u

**Required:** $\Delta m$; $E$

**Analysis:** Iron-56 has 26 protons, 26 electrons, and 30 neutrons.

$$\Delta m = m_p + m_n + m_e - m_{\text{Fe-56}}$$

$$E = \Delta mc^2$$

**Solution:**

$$\Delta m = m_p + m_n + m_e - m_{\text{Fe-56}}$$
$$= 26(1.007\ 276\ \text{u}) + 30(1.008\ 665\ \text{u}) + 26(0.000\ 549\ \text{u}) - 55.934\ 937\ 5\ \text{u}$$
$$= 0.5284\ \text{u}$$
$$\Delta m = 0.53\ \text{u}$$

$$E = \Delta mc^2$$
$$= (0.5284\ \cancel{\text{u}})\left(930\ \frac{\text{MeV}}{\cancel{\text{u}}}\right)$$
$$= 491.4\ \text{MeV}$$
$$= 491.4\ \cancel{\text{MeV}} \times 1.602 \times 10^{-13}\ \frac{\text{J}}{\cancel{\text{MeV}}}$$
$$E = 7.9 \times 10^{-11}\ \text{J}$$

**Statement:** The mass defect of iron-56 is 0.53 u and the binding energy is $7.9 \times 10^{-11}$ J.

**67. Given**: $h$ = 13.81 s; $t$ = 30.0 s

**Required:** percent of sample remaining

**Analysis:**

$$A = A_0\left(\frac{1}{2}\right)^{\frac{t}{h}}$$

$$\frac{A}{A_0} \times 100 = \text{percent remaining}$$

**Solution:**

$$\frac{A}{A_0} = \left(\frac{1}{2}\right)^{\frac{t}{h}}$$
$$= \left(\frac{1}{2}\right)^{\frac{30.0\ \cancel{s}}{13.81\ \cancel{s}}}$$
$$\frac{A}{A_0} = 22.185$$
$$\frac{A}{A_0} \times 100 = 22.2\ \%$$

**Statement:** There will be 22.2 % of the original sample of beryllium-11 remaining after 30.0 s.

**68. (a)** Nuclear fission is the breaking apart of nuclei. Some of the binding energy of the nuclei is released during fission.

**(b)** Fissionable nuclei have larger-than-average masses.

**(c)** A neutron is typically absorbed by a nucleus to initiate fission.

**(d)** To initiate nuclear fusion of hydrogen atoms, the fusing nuclei must have enough kinetic energy to overcome the repulsive electrostatic forces between them. These electrostatic forces do not inhibit fission because neutrons have no net electrostatic charge. Therefore, it requires much less energy to induce fission of a fissionable nucleus than to induce nuclear fusion of hydrogen atoms.

**69. (a)** In a nuclear reactor, neutrons promote a chain reaction, causing fission to continue and more energy to be released. Control rods in a nuclear reactor absorb the neutrons that promote this chain reaction. Inserting or removing the control rods adjusts the rate of the reaction. The control rods can also stop the chain reaction in the event of an electrical malfunction. Cadmium is often used in the control rods in CANDU reactors.

**(b)** A moderator, such as heavy water, slows the neutrons to a speed at which they can be absorbed by nuclei. It also absorbs kinetic energy, which is transferred to normal water to produce steam, drive turbines, and generate electricity. Heavy water is used as a moderator in CANDU reactors.

**70.** As atomic mass increases from 0 u to approximately 56 u, binding energy also increases. Nuclei with atomic mass close to 56 u, such as iron-56, have the greatest binding energy and the most stable nuclei. As atomic mass increases past 56 u, binding energy and stability decrease. This means that isotopes with a high mass, such as uranium, are most likely to undergo fission, which will reduce their atomic mass so it is to closer to 56 u. Isotopes with a low mass are most likely to undergo fusion, which will increase their atomic mass so it is closer to 56 u.

**71. Given:** $m_{\text{H}}$ = 1.007 825 u; $m_{\text{He}}$ = 4.002 602 u; $m_e$ = 0.000 549 u; $c^2$ = 930 MeV/u

**Required:** $E$

**Analysis:**

$$\Delta m = 4m_{\text{H}} - \left(m_{\text{He}} + 2m_e\right)$$
$$E = \Delta mc^2$$

**Solution:**

$$\Delta m = 4m_{\text{H}} - \left(m_{\text{He}} + 2m_e\right)$$
$$= 4(1.007.825\ \text{u}) - [4.002\ 602\ \text{u} + 2(0.000\ 549\ \text{u})]$$
$$\Delta m = 0.0276\ \text{u}$$

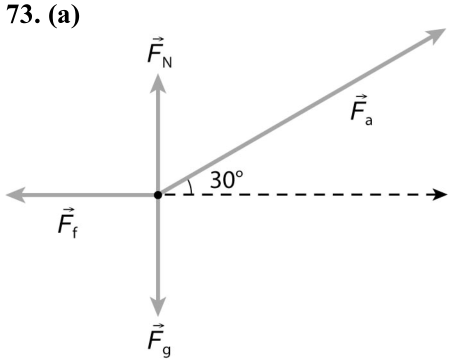
$$E = mc^2$$
$$= (0.276\ \cancel{\text{u}})\left(930\ \frac{\text{MeV}}{\cancel{\text{u}}}\right)$$
$$= 25.668\ \cancel{\text{MeV}} \times 1.602 \times 10^{-13}\ \frac{\text{J}}{\cancel{\text{MeV}}}$$
$$E = 4.1 \times 10^{-12}\ \text{J.}$$

**Statement:** The net energy released in the overall proton-proton chain fusion reaction is $4.1 \times 10^{-12}$ J.

**72. (a)** Reaction (iii) is a fusion reaction. Two hydrogen nuclei fuse to produce a daughter nucleus (helium) with a greater atomic mass than the parent nuclei. This does not occur in the other two reactions.
**(b)** Reaction (ii) is a beta decay reaction. A beta particle (the positron) is produced, and the daughter nuclei have a greater atomic mass than the parent nuclei.

## Analysis and Application

**73. (a)**




**(b) Given:** $m$ = 62 kg; $h$ = 4.3 m; speed is constant; $\theta$ = 45°; $g$ = 9.8 N/kg
**Required:** work done by escalator, $W$
**Analysis:** $W = F\Delta d$
**Solution:**

$$W = F\Delta d$$
$$= mg\Delta d$$
$$= (62\ \text{kg})\left(9.8\ \frac{\text{N}}{\text{kg}}\right)(4.3\ \text{m})$$
$$= 2612.68$$
$$W = 2600\ \text{J}$$

**Statement:** The work done by the escalator on the passenger is –2600 J.
**(c) Given:** $m$ = 62 kg; $h$ = 4.3 m; speed is constant; $g = -9.8\ \text{m/s}^2$
**Required:** work done by gravity, $W$
**Analysis:** $W = F\Delta d$
**Solution:**

$$W = F\Delta d$$
$$= mg\Delta d$$
$$= (62\ \text{kg})(-9.8\ \text{m/s}^2)(4.3\ \text{m})$$
$$= -2612.68\ \frac{\text{kg•m}^2}{\text{s}^2}$$
$$W = -2600\ \text{J}$$

**Statement:** The work done by gravity on the passenger is –2600 J.

**74. Given:** $F_a$ = 40.0 N; $\theta$ = 30°; $\Delta d$ = 2.0 m
**Required:** $W$
**Analysis:** $W = F_a(\cos\theta)\Delta d$
**Solution:**

$$W = F_a(\cos\theta)\Delta d$$
$$= (40.0\ \text{N})(\cos 30°)(2.0\ \text{m})$$
$$= 69.33\ \text{J}$$
$$W = 69\ \text{J}$$

**Statement:** The work done on the sled is 69 J.
**75. Given:** $\Delta d$ = 17.6 m; $F_a$ = 1000 N
**Required:** $W$
**Analysis:** The force and displacement are in the same direction.
$W = F_a\Delta d$
**Solution:**

$$W = F_a\Delta d$$
$$= (1000\ \text{N})(17.6\ \text{m})$$
$$= 17\ 600\ \text{J}$$
$$W = 20\ 000\ \text{J}$$

**Statement:** The Canadarm2 will do 20 000 J of work on the object.
**76.** This equation relates distance to speed, under constant acceleration:

$$v_f^2 = v_i^2 + 2ad$$
$$d = \frac{v_f^2 - v_i^2}{2a}$$

So the stopping distance, $d$, will be proportional to $v^2$.
**77. (a)** Energy is conserved, so the spring will be able to do 200 J of work when it decompresses.
**(b)** There are 200 J of energy stored in the compressed spring.
**(c) Given;** $E_{\text{pot i}}$ = 200 J; $m$ = 5.0 kg
**Required:** $h$
**Analysis:** Energy is conserved, so

$$E_{\text{pot i}} + E_{\text{k i}} = E_{\text{pot f}} + E_{\text{k f}}$$
$$E_{\text{pot f}} = mgh$$

The object is not moving at its highest point, so $E_{\text{k f}} = 0$.
**Solution:**

$$E_{\text{pot i}} + E_{\text{k i}} = E_{\text{pot f}} + E_{\text{k f}}$$
$$200\ \text{J} + 0 = mgh + 0$$
$$h = \frac{200\ \text{J}}{(5.0\ \text{kg})(9.8\ \text{N})}$$
$$= 4.081\ \text{m}$$
$$h = 4.1\ \text{m}$$

**Statement:** The spring can hurl the object upward to a height of 4.1 m.

**78.** The object will reach its greatest height at line B. Energy will be conserved. When the object is released, its potential energy will be converted to kinetic energy. At its lowest point, it will have maximum kinetic energy. This kinetic energy will be converted to potential energy as the object rises to the right. At the top of its path, it will have no kinetic energy, but its potential energy will be almost equal to the potential energy it had at the beginning. So it must be at close to the same height as it was at the beginning. It cannot rise to line C, because it would then have more energy than it started with. If it stopped at line A, it would have much less energy than it started with.

**79. (a)** When the nuclear reactor heats the water, nuclear energy is transformed into thermal energy.
**(b)** When steam pressure turns the turbine, thermal energy is transformed into kinetic or mechanical energy.
**(c)** When the turbine runs the generator, kinetic energy is transformed into electrical energy.

**80. Given:** $m$ = 75 kg; $E_{in}$ = 4700 J; $h$ = 5.5 m; $g$ = 9.8 N
**Required:** efficiency
**Analysis:** Assume a constant speed.

$$E_{out} = E_g$$
$$E_g = mgh$$
$$\text{Efficiency} = \frac{E_{out}}{E_{in}} \times 100\ \%$$
$$\text{Efficiency} = \frac{mgh}{E_{in}} \times 100\ \%$$

**Solution:**

$$\begin{aligned}\text{Efficiency} &= \frac{mgh}{E_{in}} \times 100\ \% \\ &= \frac{(75\text{ kg})(9.8\text{ N})(5.5\text{ m})}{4700\text{ J}} \times 100\ \% \\ &= 86.01\ \%\end{aligned}$$
$$\text{Efficiency} = 86\ \%$$

**Statement:** The bicycle has an efficiency of 86 %.

**81. Given:** $m$ = 620 kg; $t$ = 6.00 s; $v_i$ = 0 m/s; $v_f$ = 60 mi/h = 26.82 m/s
**Required:** $P$
**Analysis:**

$$W_{net} = \frac{mv_f^2}{2} - \frac{mv_i^2}{2}$$
$$v_i = 0$$
$$P = \frac{W_{net}}{t}$$
$$P = \frac{mv_f^2}{2t}$$

**Solution:**

$$\begin{aligned}P &= \frac{mv_f^2}{2t} \\ &= \frac{(620\text{ kg})\left(26.82\ \frac{\text{m}}{\text{s}}\right)^2}{2(6.00\text{ s})} \\ &= 37\ 164\text{ W}\end{aligned}$$
$$P = 37\text{ kW}$$

**Statement:** The power needed to accelerate the car and driver is 37 kW.

**82. (a) Given:** $V$ = 110 000 m$^3$; $h$ = 52 m
**Required:** $\Delta E_g$
**Analysis:** Water with a volume of 110 000 m$^3$ has a mass of 110 000 kg.

$$\Delta E = mgh_i - mgh_f$$

Assume bottom of the waterfall is the reference level, with $E_g$ = 0, so:

$$\Delta E = mgh_i$$

**Solution:**

$$\begin{aligned}\Delta E &= mgh_i \\ &= (110\ 000\text{ kg})(9.8\text{ N})(52\text{ m}) \\ &= 560\ 560\text{ kJ}\end{aligned}$$
$$\Delta E = 5.6 \times 10^8\text{ J}$$

**Statement:** The change in gravitational potential energy is 5.6 $\times 10^8$ J.

**(b) Given:** $\Delta E$ = 5.6 $\times 10^8$ J; $t$ = 1 min = 60 s
**Required:** $P$
**Analysis:**

$$P = \frac{\Delta E}{\Delta t}$$

**Solution:**

$$\begin{aligned}P &= \frac{\Delta E}{\Delta t} \\ &= \frac{5.6 \times 10^8\text{ J}}{60\text{ s}}\end{aligned}$$
$$P = 9.3 \times 10^7\text{ W}$$

**Statement:** The power rating of Niagara Falls would be $9.3 \times 10^7$ W.

**83. Given:** $V$ = 325 mL; $T_i$ = 20.0 °C; $t$ = 60.0 s; $T_f$ = 24.9 °C; $c_w$ = 4.18 x 10$^3$ J/(kg•°C)
**Required:** $P$
**Analysis:** Water with a volume of 1 L has a mass of 1 kg.

$$Q = mc\Delta T$$
$$P = \frac{Q}{t}$$
$$P = \frac{mc\Delta T}{t}$$

**Solution:**

$$P = \frac{mc\Delta T}{t}$$

$$= \frac{(0.325\ \cancel{\text{kg}})\left(4.18\times10^{3}\ \frac{\text{J}}{\cancel{\text{kg}\bullet{}^\circ\text{C}}}\right)(4.9\ \cancel{{}^\circ\text{C}})}{60.0\ \text{s}}$$

$$= 110.94\ \text{W}$$

$$P = 111\ \text{W}$$

**Statement:** The power of the heater is 111 W.

**84.** Answers may vary. Answers should include the following information: The caloric theory included the ideas that a massless fluid called caloric flowed from one object to another, transferring warmth. Scientists believed that there was a fixed amount of this substance in the universe. Count Rumford's experiment showed that in a closed system, that is, one where no elements are introduced from outside, thermal energy could increase. This happens when you rub your hands together. No fluid is flowing from one hand to the other, but increased kinetic energy is causing you to feel warmth.

**85.** Answers may vary. Sample answer:
The Kelvin temperature scale is useful in a science laboratory but in real life nothing is even close to 0 K. The Celsius scale is much more useful for measuring temperatures that we encounter on Earth, since it is based on the common occurrences of water freezing and boiling.

**86. (a)** The specific heat capacity of soil is about 0.80 kJ/(kg•K). The specific heat capacity of water, $4.18 \times 10^3$ kJ/(kg•K), is over four time greater. So it takes over four times as much energy to raise the temperature of water by one degree as it does to raise the temperature of dry soil by one degree.

**(b)** Because the soil warms more quickly than the water, the air over the soil becomes warmer, due to thermal energy transfer by radiation. The cooler air over the water sinks, pushing some air from the water over the soil, and pushing the warmer air over the soil up. Once it rises, this air moves over the water to replace the cool air that sank down.

**(c)** At night, air near a large body of water that is warmer than the soil circulates in the direction opposite to that on a hot day. Cool air over the cooler land sinks, pushing some air over the water, which pushes the warmer air over the water up.

**87.** Answers may vary. Answers should include the following information: Unlike other substances, as water cools lower than 4 °C, it expands. This is because the hydrogen atoms in one molecule are attracted to the oxygen atoms in other molecules and the molecules organize themselves in a way that takes up more space than their disorganized state. One result of this is that ice is less dense than water above 4 °C. As lakes cool, the colder water is at the top, and this water freezes first, resulting in ice on the top of the lake and water under it.

**88.** Answers may vary. Answers should include the following information.

**(a)** As water evaporates, it absorbs thermal energy from the air around it but does not become warmer. In this way, it helps to cool the air. As it condenses, it releases thermal energy to the air around it. In this way, it releases thermal energy from the indoor air to the outside air.

**(b)** The thermal energy the refrigerant removes from inside the home is released outside the home. Thermal energy is not created or destroyed, just transferred.

**89.** As the water sprayed on the fruit begins to freeze, it releases latent heat of fusion, which is absorbed by the fruit and helps keep it from freezing.

**90. Given:** $m$ = 50.0 g = 0.0500 kg;
$L_v = 8.6 \times 10^5$ J/kg

**Required:** $Q$

**Analysis:**

$Q = mL_v$

**Solution:**

$$Q = mL_v$$

$$= (0.0500\ \cancel{\text{kg}})\left(8.6\times10^{5}\ \frac{\text{J}}{\cancel{\text{kg}}}\right)$$

$$= 43\ 000\ \text{J}$$

$$Q = 43\ \text{kJ}$$

**Statement:** Vaporizing 50.0 g of ethyl alcohol by boiling removes 43 kJ of thermal energy,

**91.** Many thermostats are made of coiled strips of metal with one type of metal on one side of the strip and another on the other side. As the metals become warmer (or cooler), they expand (or contract) at different rates. This causes the coil to wind more tightly or to unwind, which tilts a mercury switch at the end of the coil. This mercury switch completes an electric circuit when it is on and opens the circuit when it is off, causing power to flow to the heating or cooling system when needed.

**92. Given:** $m$ = 8.0 g = 0.0080 kg;
$L_f = 1.1 \times 10^6$ J/kg

**Required:** $Q$

**Analysis:**

$Q = mL_v$

**Solution:**

$Q = mL_v$

$= (0.0080\ \cancel{kg})\left(1.1 \times 10^5\ \frac{J}{\cancel{kg}}\right)$

$Q = 8800$ J

**Statement:** It will take 8800 J of thermal energy to melt 8.0 g of gold at its melting point.

**93. Given:** $m_{Pb} = 1$ kg; $m_W = 1$ kg; $T_{iPb} = 327.5$ °C; $T_{fPb} = 100$ °C; $T_{iW} = 20.0$ °C; $T_{fW} = 100$ °C; $L_{vPb} = 2.5 \times 10^5$ J/kg; $L_{vW} = 2.3 \times 10^6$ J/kg; $c_{Pb} = 1.3 \times 10^2$ J/(kg•°C); $c_W = 4.18 \times 10^3$ J/(kg•°C)

**Required:** Does $Q_{released}$ (the thermal energy released by the lead to fuse and cool) equal $Q_{absorbed}$ (the thermal energy absorbed by the water to warm and boil)?

**Analysis:**

$Q_{released} = m_{Pb}L_{fPb} + m_{Pb}c_{Pb}\Delta T_{Pb}$

$Q_{absorbed} = m_W L_{vW} + m_W c_W \Delta T_W$

**Solution:**

$Q_{released} = m_{Pb}L_{fPb} + m_{Pb}c_{Pb}\Delta T_{Pb}$

$= (1\ \cancel{kg})\left(2.5 \times 10^4\ \frac{J}{\cancel{kg}}\right)$

$+(1\ \cancel{kg})\left(1.3 \times 10^2\ \frac{J}{\cancel{kg•°C}}\right)(-227.5\ \cancel{°C})$

$Q_{released} = -5.4575 \times 10^4$ J

$Q_{absorbed} = m_W L_{vW} + m_W c_W \Delta T_W$

$= (1\ \cancel{kg})\left(2.3 \times 10^6\ \frac{J}{\cancel{kg}}\right)$

$+(1\ \cancel{kg})\left(4.18 \times 10^3\ \frac{J}{\cancel{kg•°C}}\right)(80\ \cancel{°C})-$

$Q_{absorbed} = 2.6344 \times 10^6$ J

$5.4575 \times 10^4$ J $< 2.6344 \times 10^6$ J

**Statement:** A kilogram of molten lead will not release enough energy to completely boil a kilogram of water.

**94. (a)** The source of thermal energy for a geothermal heating system is Earth's natural thermal energy. It does not rely on fossil fuels, as conventional heating systems do.

**(b)** Answers may vary. Sample answer: Geothermal heating systems rely on a renewable resource (Earth's thermal heat) and do not create pollution.

**95. (a)** The atomic number of uranium-238, U, is 92.

The new element will have mass number 244 and atomic number 90. From the periodic table, the element with atomic number 90 is thorium, Th. The nuclear reaction equation is

${}^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + {}^{4}_{2}\text{He}$ .

**(b)** The atomic number of sodium, Na, is 11. The new element will have mass number 22 and atomic number 10. From the periodic table, the element with atomic number 10 is neon, Ne. The nuclear reaction equation is

${}^{22}_{11}\text{Na} \rightarrow {}^{22}_{10}\text{Ne} + {}^{0}_{+1}\text{e}$ .

**(c)** The atomic number of calcium, Ca, is 20. The new element will have mass number 41 and atomic number 19. From the periodic table, the element with atomic number 19 is potassium, K. The nuclear reaction equation is

${}^{41}_{20}\text{Ca} + {}^{0}_{-1}\text{e} \rightarrow {}^{41}_{19}\text{K}$ .

**96. (a)** The sample loses 50 % of its original mass between year 1000 and year 2000. The isotope's half-life is 1000 years.

**(b) Given:** $A_0 = 100$ g; $t = 7000$ years; $h = 1000$ years

**Required:** $A$

**Analysis:**

$A = A_0\left(\frac{1}{2}\right)^{\frac{t}{h}}$

**Solution:**

$A = A_0\left(\frac{1}{2}\right)^{\frac{t}{h}}$

$= (100\ \text{g})\left(\frac{1}{2}\right)^{\frac{7000\ \cancel{years}}{1000\ \cancel{years}}}$

$= 0.7812$ g

$A = 0.8$ g

**Statement:** After 8000 years, 0.8 g of the isotope would remain.

**97. Given:** $h = 6.03$ h; $t = 36$ h

**Required:** percent of isotope remaining after 36 h

**Analysis:**

$\frac{A}{A_0} = \left(\frac{1}{2}\right)^{\frac{t}{h}}$; $\frac{A}{A_0} \times 100 =$ percent remaining

**Solution:**

$$\frac{A}{A_0} = \left(\frac{1}{2}\right)^{\frac{t}{h}}$$

$$= \left(\frac{1}{2}\right)^{\frac{36\ \cancel{h}}{6.03\ \cancel{h}}}$$

$$\frac{A}{A_0} = 0.0159$$

$$\frac{A}{A_0} \times 100 = 1.6\ \%$$

**Statement:** After 36 h, 1.6 % of the original technetium-99m will remain in the patient.

**98. (a)** The sum of the masses of an atom's electrons, protons, and neutrons is always a little more than the atomic mass of the isotope because some mass has been converted to binding energy, that is, energy that holds the components of the atom together.

**(b)** If the difference in the masses is great, the binding energy of the atom is also great and it would require a lot of energy to separate the subatomic particles within the nucleus.

**99. Given:** $m = 1.00$ kg; $E_a = 5.36 \times 10^{11}$ kWh; $c = 3.0 \times 10^8$ m/s$^2$

**Required:** $t$

**Analysis:**

$$E = mc^2$$

$$t = \frac{E}{E_a}$$

**Solution:** Calculate $E$.

$$E = mc^2$$

$$= (1.00\ \text{kg})\left(3.0 \times 10^8\ \frac{\text{m}}{\text{s}}\right)^2$$

$$E = 9.0 \times 10^{16}\ \text{kg} \bullet \text{m}^2/\text{s}^2$$

Convert annual energy consumption to joules.

$$E_\text{J} = (E_\text{kWh})(1000)\left(3600\ \frac{\text{s}}{\text{h}}\right)$$

$$= (5.36 \times 10^{11}\ \text{kW}\cancel{\text{h}})(1000)\left(3600\ \frac{\text{s}}{\cancel{\text{h}}}\right)$$

$$E = 1.929 \times 10^{18}\ \text{J}$$

Calculate $t$.

$$t = \frac{E}{E_a}$$

$$= \frac{9.0 \times 10^{16}\ \cancel{\text{J}}}{1.929 \times 10^{18}\ \cancel{\text{J}}}$$

$$= 4.665 \times 10^{-2}\ \text{years}$$

$$t = 17.02\ \text{days}$$

**Statement:** If 1.00 kg of matter could be completely converted to energy, it would supply Canada's electrical energy needs for 17 days.

## Evaluation

**100.** Advantages of hydroelectric power include lower environmental impact and less pollution than fossil fuels. Hydroelectricity is also a renewable resource. Hydroelectric power has several limitations. Projects are very expensive initially, they need a suitable river that is close enough to the area using the power to avoid excessive transmission losses over long distances, and they cause environmental damage and habitat loss by flooding areas around the dam.

**101.** Answers may vary. Sample answer:
When alcohol cools from 7 °C to 2 °C, it contracts linearly. This allows us to use the regular, ordered calibrations on a thermometer to read the temperature. Water does not contract linearly as it cools at these temperatures. It contracts until it reaches approximately 4 °C, then expands. A water thermometer would need to account for the fact that when the water is at 4 °C it has the lowest volume, with water warmer than 4 °C and cooler than 4 °C having higher volumes.

**102.** Answers may vary. Sample answer:

**(a)** Carbon dating is useful for finding the age of things that were once alive. Rocks on the Moon were never alive, so carbon dating could not be used to find their age.

**(b)** Other radioactive isotopes, for example aluminum-26, can be used to determine the age of rocks. The researcher could change the proposal to measure an isotope such as aluminum-26.

## Reflect on Your Learning

**103.** Answers may vary. Students' answers should identify a key concept about kinetic, thermal, and/or nuclear energy and provide evidence related to science, technology, society, or the environment to prove the importance of the concept.

**104.** Answers may vary. Sample answer:

**(a)** The difference between fission and fusion was interesting. I knew they both released energy, but now I have a better understanding of the differences between the amount of energy they can release and the methods used to achieve each one.

**(b)** The transfer of thermal energy was easy to understand. It's something we encounter in our day-to-day lives, and the math was simple.

**(c)** I did not find the section about sources of energy very interesting because we learned about many of the sources in Grade 9.
**(d)** I found the sections about work and power challenging. I am still having trouble understanding the difference, and remembering which equations and units to use to calculate them. To improve my understanding of the topics, I could ask a friend to explain the difference so I can hear a different way of describing it. Or I could make review cards with the equations on them and leave them at home where I am likely to see them to help remember the equations and units.

## Research

**105.** Answers may vary. Answers should include these advantages: lack of pollution and low operating cost since it requires no conventional fuel. Disadvantages should include the need for a large surface area for the equipment and a sunny climate to produce the required amounts of sunlight.
**106.** Answers may vary. Sample answer:
In laser-induced fusion, small pellets containing isotopes of hydrogen are subjected to intense laser pulses from multiple powerful lasers. The pellet surface vaporizes so rapidly that the pellet implodes and pushes its contents together with extreme force. The method has not yet been developed into a means of producing a sustained fusion reaction useful for practical purposes.
**107. (a)** The law of energy conservation assures that no more energy can be released by combining hydrogen with oxygen in a fuel cell than was used to break apart water through electrolysis to produce the hydrogen.
**(b)** Hydrogen can be produced from petroleum. This can result in a net energy gain, but requires fossil fuels and produces waste products.
**(c)** Hydrogen could be useful for storing energy. When the energy in hydrogen is used, it will not produce pollution, since the product of combining hydrogen and oxygen is water.
**108.** Answers may vary. The World Bank estimates the per capita Canadian electrical consumption at 17 319 kW per year.
**109.** Answers may vary. Answers should include the following information: Cool temperatures and increased evaporation near Earth's poles drive thermohaline currents. Unlike fresh water, the salt water near Earth's poles becomes denser as it cools, sinking and pushing other water in the deep ocean away. Water in warmer areas is pushed up and surface water moves toward the poles to complete the cycle.
**110.** Answers may vary. Answers should include information similar to the following: In radionuclide therapy, radioactive isotopes are attached to molecules that bind to particular proteins in the body. This ensures the radioactive isotopes can circulate in the body but are only absorbed by the targeted cells, such as cancer cells. Radionuclide therapy is useful in the treatment of cancers that have spread throughout the body. The alpha particles emitted by radionuclides do not travel far through tissue, so damage to healthy cells is minimal. Thyroid cancer, non-Hodgkins lymphoma, and debilitating pain syndromes can often be treated with radionuclide therapy. Some types of tumours cannot be successfully treated with radionuclides. Diseases that cannot be treated with radionuclide therapy include those that do not progress by cell growth.
**111.** Answers may vary. Sample answer:
Isotopes used in nuclear medicine should have relatively short half-lives of a day or so. This ensures that the radioisotope will not remain in the patient's body for a long time after imaging is finished. The isotopes should be gamma ray emitters. Gamma rays can penetrate through tissue and travel out of the body, where they can be detected by medical imaging machines. Alpha and beta rays are too short to be useful.