Heating Processes

P b e Se 1: Hea , Te e a e a d T e a E e g

1.1 [a] Thermal energy is the total energy (kinetic + potential) of all particles in an object while heat is the thermal energy being transferred between two objects.
[b] Temperature only measures the average kinetic energy of all the particles in a substance while thermal energy measures the total kinetic and potential energy
[c] The average temperature on the Celsius scale has doubled but the thermal energy has not. The difference in thermal energy between 27 ^{o}C and 54 ^{o}C is much less than the total thermal energy of the substance at 27 ^{o}C and so 54 ^{o}C is only 9% hotter rather than twice as hot.

1.2 [a] Potential Energy (nuclear reaction in sun)
[b] Kinetic Energy (moving electrons – electricity)
[c] Kinetic Energy (moving wheel)

1.3 Efficiency = Useful Energy/Input Energy x 100%
Useful Energy = 215 kJ   Input Energy = 985 kJ
Efficiency = 215/985 x 100%   = 21.8%

1.4 The starting temperature of the engine is warmer, so when the thermal energy from the combustion in the engine is added to this greater temperature, the engine is more likely to overheat. This means motoring organisations are required more on these hot days and so they get more calls.

1.5 [a] Efficiency = Useful Energy/Input Energy x 100%
Useful Energy = 18.0 J   Input Energy = 45.0 J
Efficiency = 18.0/45.0 x 100%
Efficiency = 40.0%
Mechanical energy lost = 100% - 40.0%
Mechanical energy lost = 60.0%
[b] Drop the ball from a set height and measure the maximum height of its first bounce. If the height of its first bounce is 40% of the original starting height, you have verified your answer.
[c] Most of this 'lost' energy becomes thermal energy due to friction (air resistance) and an inelastic collision with the wall.

1.6 [a] Most of this kinetic energy is converted into thermal energy though friction.
[b] The resulting thermal energy heats up the brakes of the car.

1.7 The temperature of the room would increase. The thermal energy is pulled out of the freezer and ejected into the room in a process that is less than 100% efficient. When the door is opened, the inside heats up to the room temperature (the thermal energy removed from inside the freezer goes into the room and then back into the freezer) and there is still the energy produced by running it, so the room's temperature would increase.

1.8 The air conditioner is gaining thermal energy from the external environment such as heat trapped in the house and other sources outside the house. When combined with the electrical energy provided to the air conditioner it adds to an efficiency that is greater than 100%. The laws of energy conservation are not broken however as no new energy is created, just gained from other sources.

1.9 [a] Thermal energy is regarded as 'low-grade' energy as it is the result of energy transformations of high-grade energy and is not able to be used readily. It is considered a waste product.
[b] Low-grade energy is different from high-grade energy as it is in a form that is unable to be readily harnessed and used. High-grade energy is energy that can be used and is obtained from a machine.
[c] Potential energy, kinetic energy, electrical energy, light energy.

1.10 [a] The thermal energy can be fed back into the power station and used in the hot water system or used to heat offices and other areas of the power station.
[b] This energy is less useful in the warm Australian climate as we usually require cooling systems rather than heating systems in working environments.

1.11 [a] High temperatures mean that the particles in the system have a greater average kinetic energy which results in more mechanical energy being available to the engine.
[b] In cold weather there is a greater temperature difference between the heat engine and the surrounding environment resulting in easier heat flow.

1.12 Electrical energy produced each day = power x time = 1000 MW x (24 h x 3600 s h^{-1}) = 8.64×10^{13} J

The energy station is 50% efficient meaning that the input energy from the coal it burns is twice the energy produced

Required input energy = 1.728×10^{14} J

Mass of coal required per day = $\frac{energy\ needed\ per\ day}{energy\ provided\ per\ kilogram} = \frac{1.728 \times 10^{14}\ J}{25 \times 10^{6} J\ kg^{-1}}$ = 6.91×10^{6} kg or 6912 tonnes