Answers

Energy

Energy stores and systems

1 First, choose the start and end point; second, find the energy stores at those points; third, show which stores empty and which stores fill up.

2 a Electrical working
b Heating by particles
c Mechanical working
d Heating by particles

3 Example 1: A weightlifter lifting a weight transfers energy via mechanical working;
Example 2: A bonfire transfers energy via heating by radiation.

Changes in energy stores

1 301.6 J

2 1123 J

3 Cyclist A's E_k is 9 times higher than the E_k for cyclist B. This is because their speed is 3 times that of cyclist B, and $3^2 = 9$

Energy changes in systems – specific heat capacity

1 94 500 J

2 The thermal store will increase by 4200 J; as energy is conserved.

3 c

Power

1 (b) 850 W; because it transfers more energy per second to the water.

2 11 J

3 6930 J

Energy transfers in a system

1 Wear streamlined helmet and adjust body position to reduce air resistance; Lubrication between bike's chain and gears to reduce heating effects of friction; High pressure in tyres to reduce surface area of contact between the road and the tyres.

2 The infrared radiation from the heating elements in the toaster warms the surrounding air which rises; so not all the energy is transferred through heating by radiation to the toast.

3 Less fuel consumption; Tyres, brakes and other components do not get worn out as quickly.

Efficiency

1 Because in any change within a system some energy is dissipated to the surroundings.

2 Because the useful energy transferred is the numerator of the fraction and the input energy is the denominator; Since the useful energy transferred can never be greater than the input energy, the fraction can never return a value greater than 1.

3 Being only 25% efficient means that our body needs to transfer 4 times more energy from the chemical store to do the mechanical work needed during exercise, e.g. to lift a weight.

National and global energy resources

1 Renewable energy resources can be replaced (replenished); but non-renewable energy resources cannot be replaced and so will eventually run out if we keep using them.

2 Fossil fuels have high power output and are very reliable.

3 Accept any of the following: Large areas are needed to harness it; It has a low power output; It has a low conversion efficiency; It can only be harnessed during daylight hours.

Review It!

1 Renewable: water waves, biofuel, hydroelectricity, the Sun, geothermal, the tides.

Non-renewable: nuclear fuels, coal, oil, natural gas.

2 a *kinetic energy* = 0.5 × *mass* × *(speed)*^{2}

$$E_k = \frac{1}{2}mv^2 \rightarrow m = 2\frac{E_k}{v^2}$$

b *elastic potential energy* = 0.5 × *spring constant* × *(extension)*^{2}

$$E_e = \frac{1}{2}ke^2 \quad \rightarrow e = \sqrt{2\frac{E_e}{k}}$$

c *g.p.e* = *mass* × *gravitational field strength* × *height*

$$E_p = m\,g\,h \quad \rightarrow h = \frac{E_p}{mg}$$

3 $\Delta\theta$ is a temperature difference, and degrees Celsius and kelvin have the same magnitude; so using degrees Celsius or kelvin will affect the result of the calculation because the taking difference gives the same result; For example, the temperature increase between 2°C and 20°C is $\Delta\theta = 20 - 2 = 18$°C; which expressed in kelvin becomes $\Delta\theta = 293.15 - 275.15 = 18$ K.

4 a Lift B has greater power than lift A; because it can lift the same load the same height in less time; The rate of energy transferred is higher for lift B.

b Energy transferred is

$E_p = mgh$ and $P = \frac{E}{t} = \frac{mgh}{t}$

$$h = \frac{Pt}{mg} = \frac{343 \times 15}{70 \times 9.8} = 7.5\ m$$

So, each floor is $\frac{7.5}{3} = 2.5$ m high.

5 Aluminium has a higher thermal conductivity than plastic; so it will transfer energy by conduction to the ice cube at a higher rate than the plastic block; so the ice cube on the aluminium block will melt faster than the cube on the plastic block.

6 First we need to calculate the energy in the kinetic store when the car is at top speed.

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2}0.520 \times 2.2^2 = 1.26\text{ J}$$

So, at top speed the toy car transfers 1.26 J to the kinetic store each second; This means a useful power output of 1.26 W; So, to find the efficiency of the toy car:

$$Efficiency = \frac{\text{Useful power output}}{\text{Total power input}}$$

$$= \frac{1.26}{1.5} = 0.84$$

We can multiply by 100 to find the percentage efficiency, i.e. 84%.

Electricity

Standard circuit diagram symbols

1 Ammeters have hardly any resistance; but voltmeters have very high resistance.

2 Their I-V characteristics are very similar and they both let current flow only in one direction; However, LEDs emit light, while diodes do not.

3 A diode in series with an LDR.

Electrical charge and current

1 An electrical current is the rate of flow of electrical charge.

2 Free electrons fill all the components of the circuit all the time, even when the circuit is open; So, when the circuit is closed all the free electrons will start drifting