

## Energy

### Energy stores and systems

- 1 A system is an object, or group of objects. The **energy** in a system is a numerical **value** that tells us whether certain **changes** in the system could, or could not, happen. The total **amount** of energy in a system is always the **same** no matter what changes happen in the system, but the energy available can be **redistributed** in different parts of this system.
- 2 3-d; 4-g; 5-e; 6-c; 7-f; 8-a
- 3 1 - Chemical; 2 - Heating; 3 - Heating; 4 - Thermal; 5 - Thermal.

### Changes in energy stores: kinetic energy

- 1 **a** Kinetic energy =  $0.5 \times \text{mass} \times \text{speed}^2$  Or  $\frac{1}{2}mv^2$   
**b** J or joules
- 2 Kinetic energy =  $0.5 \times \text{mass} \times \text{speed}^2$   
Kinetic energy =  $0.5 \times 1000 \times 10^2$   
50 000 J or 50 kJ
- 3 Kinetic energy =  $0.5 \times \text{mass} \times \text{speed}^2$  rearrange to:  
 $\text{mass} = \frac{\text{kinetic energy}}{0.5 \times \text{speed}^2}$   
 $\text{mass} = 800\,000 / 0.5 \times 10^2$   
16 000 kg or 16 tonnes

### Changes in energy stores: elastic potential energy

- 1  $E_e = 0.5 \times \text{spring constant} \times \text{extension}^2$   
or  $E_e = \frac{1}{2}ke^2$ .
- 2  $E_e = 0.5 \times \text{spring constant} \times \text{extension}^2$   
Extension =  $25 - 5 = 20$  cm;  
Extension = 0.2 m  
 $E_e = 0.5 \times 10 \times 0.2^2$   
 $E_e = 0.2$  J
- 3  $F = ke$ ,  $k = \frac{F}{e} = \frac{2.5}{0.1} = 25$  N/m
- 4  $E_e = 0.5 \times \text{spring constant} \times \text{extension}^2$ : rearrange to  
extension =  $\sqrt{\frac{E_e}{0.5 \times \text{spring constant}}}$   
Extension =  $\sqrt{\frac{20\text{ J}}{0.5 \times 10\,000}}$   
Extension = 0.063 m  
convert to cm = 6.3 cm

### Changes in energy stores: gravitational potential energy

- 1  $E_p = mgh$  or gravitational potential energy = mass  $\times$  gravitational field strength  $\times$  height.
- 2  $E_p = mgh$   
 $E_p = 4 \times 10 \times 4$   
 $E_p = 160$  J or joules
- 3  $E_p = mgh$   
 $E_p = 40 \times 10 \times 5$   
 $E_p = 2000$  J or joules
- 4  $E_p = mgh$  rearrange to:  
 $h = \frac{E_p}{m \times g}$ ;  $m = 300$  g = 0.3 kg  
 $h = \frac{90}{0.3 \times 10}$   
 $h = 30$  m

### Energy changes in systems: specific heat capacity

- 1 **a** Specific heat capacity is the amount of energy required to increase the temperature of 1 kg of a substance by 1 °C  
**b** Change in thermal energy = mass  $\times$  specific heat capacity  $\times$  temp change or  
 $\Delta E = m \times c \times \Delta\theta$   
**c** J/kg °C.
- 2 Copper has a lower specific heat capacity than iron; The same amount of energy is delivered to each block; Copper will require less energy to raise its temperature.
- 3  $\Delta E = m \times c \times \Delta\theta$  rearrange to:  
 $m = \frac{\Delta E}{c \times \Delta\theta}$ ; Temp change =  $35 - 25 = 10$  °C  
 $m = \frac{1500}{2400 \times 10}$   
 $m = 0.063$  kg

### Power

- 1 **a** Bill:  $\frac{7500}{60} = 125$  W;  
 $\frac{17800}{60} = 297$  W;  $\frac{7200}{60} = 120$  W  
Ted:  $\frac{6300}{60} = 105$  W;  
 $\frac{20000}{60} = 333$  W;  $\frac{8040}{60} = 134$  W  
**b** Ted; average power =  $\frac{105 + 333 + 134}{3} = 191$  W,  
Bill average power =  $\frac{125 + 297 + 120}{3} = 181$  W  
Therefore Ted is the most powerful.

- 2 Energy = power  $\times$  time  
time =  $7.5 \times 60 \times 60 = 27\,000$  s  
Energy =  $50 \times 27\,000$   
Energy = 1.35 MJ or 1 350 000 J

- 3 Time =  $\frac{\text{energy}}{\text{power}}$   
Time =  $\frac{2\,200\,000}{100\,000}$   
Time = 22 s

### Energy transfers in a system

- 1 Energy stores can neither be created nor destroyed; but can be redistributed to other parts of the system via transfer or dissipation.
- 2 *Any sensible suggestion.* Battery-powered helicopter; MP3 player; electric fire.
- 3 **a** Gravitational potential to kinetic  
**b** Chemical to thermal  
**c** Elastic potential to kinetic (and thermal and vibrational)  
**d** Chemical to thermal and kinetic (and vibrational)

### Efficiency

- 1 **a** Efficiency =  $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$   
**b** Ratio or percentage
- 2 Answers in order: initial; final. Gravitational; kinetic, thermal and vibrational. Chemical; kinetic, gravitational potential, thermal and vibrational. Chemical; Chemical, kinetic and vibrational.
- 3 Efficiency =  $\frac{360}{500} = 0.72$  or 72%
- 4 Efficiency =  $\frac{900}{5000} = 0.18$  or 18%

### National and global energy resources

- 1 **a** Renewable: Wave; Solar; Wind; Hydroelectric [Remove 1 mark per incorrect response]  
**b** Requires burning: Oil and coal (both required)
- 2 Only renewable if extensive replanting takes place.
- 3 **a** 15 m/s  
**b**  $\frac{\text{Total power output}}{\text{Max turbine power output}} = \frac{10\,000\,000}{1\,000\,000} = 10$  turbines  
**c** Wind supply fluctuates, is weather dependent.
- 4 Advantages: wind is renewable, doesn't emit greenhouse gases.