## 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 × mass × speed$^2$ Or $\frac{1}{2}mv^2$

b J or joules

2 Kinetic energy = 0.5 × mass × speed$^2$

Kinetic energy = 0.5 × 1 000 × $10^2$

50 000 J or 50 kJ

3 Kinetic energy = 0.5 × mass × speed$^2$ rearrange to:

mass = $\frac{\text{kinetic energy}}{0.5 \times \text{speed}^2}$

mass = 800 000/0.5 × $10^2$

16 000 kg or 16 tonnes

### Changes in energy stores: elastic potential energy

1 $E_e$ = 0.5 × spring constant × extension$^2$

or $E_e = \frac{1}{2} k e^2$.

2 $E_e$ = 0.5 × spring constant × 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 × spring constant × 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 × gravitational field strength × 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 × specific heat capacity × 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;

$\frac{17\,800}{60}$ = 297 W; $\frac{7200}{60}$ = 120 W

Ted: $\frac{6300}{60}$ = 105 W;

$\frac{20\,000}{60}$ = 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 × time

time = 7.5 × 60 × 60 = 27 000 s

Energy = 50 × 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 = $\frac{900}{5\,000}$ = 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.