Chapter 3: Energy

3.1 Energy can be transferred

Student worksheet answers (pages 40–43)

Energy transfers

1 What is an energy transfer?

When energy is passed from one object to another

2 What is the main source of energy on the Earth?

The Sun

3 In the following diagram you can see the transfer of energy from one object to another. What is the name given to the transfer of energy from

a the Sun to plants?

Photosynthesis

b plants to humans?

Consuming

4 Draw a flowchart, similar to the diagrams on pages 40–43, for the transfer of

a the Sun’s energy to an iPhone

solar → electricity → chemical (battery) → electrical → heat/light/sound

b chemical energy in coal to a toaster

chemical → electricity → heat

c tidal energy (which generates electricity using a turbine) to a television

kinetic (tides) → kinetic (turbine) → electricity → heat/light/sound

d chemical energy (battery) to a car radio

chemical → electricity → sound

e the Sun’s energy to a person bouncing a basketball

solar → chemical (plants) → chemical (humans) → kinetic

Extend your understanding

5 Match each type of energy with its meaning.

|  |  |  |
| --- | --- | --- |
| **Energy** |  | **Meaning** |
| 1 Electrical |  | F Energy of electronic change |
| 2 Chemical |  | D Energy stored in chemical bonds |
| 3 Sound |  | E Caused by the vibration of particles |
| 4 Thermal |  | B Heat energy |
| 5 Potential |  | A Stored energy - any object above the ground has this |
| 6 Kinetic |  | C Energy of movement |

6 There is one key type of energy missing from question 5. What is it?

Light

7 For each of the pictures below, label the type of energy present:

|  |  |  |  |
| --- | --- | --- | --- |
| Thermal | Electrical | Sound | Light |
| Solar | Chemical | Chemical | Kinetic (moving air) |
| Kinetic | Kinetic (moving tyre) | Electrical | Potential |

3.2 Potential energy is stored energy

Student worksheet answers (pages 44–45)

Potential energy is stored energy

1 What is potential energy?

Energy that is stored in objects and available to be used

2 What are the four types of potential energy? Give an example of each.

Examples may vary.

Gravitational – a person sky diving; a person about to ski jump

Chemical – a bomb exploding; a battery

Elastic – a trampoline; a bowstring

Nuclear – atomic bomb

3 In the following table, identify the type of potential energy shown in each picture.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| chemical |  | gravitational |  | elastic |
| gravitational |  | elastic |  | nuclear |
| chemical |  | chemical |  | gravitational |

4 Name two objects that have potential chemical energy transformed into another type of energy. For each object, state the type resulting energy.

*Answers will vary.* Examples include:

• A bomb into heat/light/sound

• A battery into electricity

5 Name two objects that have potential elastic energy transformed into another type of energy. For each object, state the type resulting energy.

*Answers will vary.* Examples include:

• A trampoline into kinetic energy

• A bow and arrow into kinetic energy

6 Name two objects that have potential gravitational energy transformed into another type of energy. For each object, state the type resulting energy.

*Answers will vary.* Examples include:

• A skydiver about to jump out of a place into kinetic energy

• A roller coaster on a downward hill into kinetic energy

Extend your understanding

7 Potential energy is used in children’s playgrounds. Choose five pieces of play equipment shown in the diagram below. For each item selected, name the type of potential energy it uses and explain how this results in motion.

*Answers will vary.* Examples include:

• Springboard – uses elastic potential energy to propel you up to jump into water

• Basketball hoop – uses gravitational potential energy to allow the ball to move down through the basket when shot

• Springy horse ride – uses elastic potential energy to propel you upright if you adjust your weight so gravity pulls you down

• Swing – uses gravitational potential energy to pull you down when you use the chemical potential energy in your body to swing higher

• Slide – uses gravitational potential energy to pull you down after you have climbed up

3.3 Moving objects have kinetic energy

Student worksheet answers (pages 46–47)

Kinetic energy

1 What is kinetic energy?

The energy of motion

2 Which types of objects have the greatest kinetic energy?

Heavy, fast-moving objects

3 Give four examples of kinetic energy.

*Answers will vary.* Examples include a moving rollercoaster, a wheel turning, you (writing the answer to this question ,water flowing down a hill.

4 Which has greater kinetic energy? Explain your answers.

a A jogger or a sprinter?

The sprinter; the sprinter is moving faster

b A car moving at 100 kilometers per hour or a train moving at 100 kilometers per hour?

The train; it is heavier than the car even though they are moving at the same speed

c Electricity or flowing water?

Electricity; although electrons are much smaller than water molecules, they move much faster

d A person on a bicycle moving at 5 kilometers per hour or a person on a motorcycle moving at   
60 kilometers per hour?

The person on the motorcycle; they are heavier and are able to move faster

5 When can our eyes not detect light energy?

We can only see light in the very small visible region of the spectrum; outside of this region our eyes cannot detect light energy

6 What is the function of a solar cell?

To convert light from the Sun into electricity

7 How is thermal energy created?

Through friction, burning chemicals or electrical devices

8 How/where does thermal energy move?

From a place of high temperature to low temperature

9 What is sound made up of?

Vibrations of air particles

Extend your understanding

10 Newton’s second law of motion states that force is equal to the mass of an object multiplied by its acceleration. This means that heavier objects (mass) are harder to push (force), so they cannot move as fast (acceleration). On the other hand, lighter objects are easier to push, so they can move faster.

a An elephant and a mouse are on skateboards. If you were to push both at the same time using the same amount of force, which one would move further? Explain your answer using Newton’s second law of motion.

The mouse would go further. If the force is constant, then the object with a smaller mass will experience a greater acceleration. *F* = *m* × *a*. If F is constant, as *m* decreases, *a* must also increase.

Weight can also be explained using Newton’s second law of motion. Your weight (the force) is equal to your mass multiplied by your acceleration. The unit used for weight is Newtons (N).

b What is the name that is given to your acceleration (9.8 m/s/s) on Earth?

Gravity

c If acceleration is constant, what it the relationship between weight and mass?

As mass increases, weight also increases

d A person has a weight of 50 N on Earth. Calculate their mass in kilograms use the equation   
*F* = *m* × *a*.



e What is the weight in Newtons of the same person on the Moon, if the Moon has th of the Earth’s acceleration?



3.4 Energy can be transformed

Student worksheet answers (pages 48–49)

Energy transformations

1 Name a device that will convert:

Answers will vary.

a chemical to electrical energy: battery

b chemical into heat energy: chemical heat pack; an explosion

c electricity to light: light bulb

d chemical energy into sound: an explosion; fireworks; iPod; phone

e electricity to heat: heater; kettle

f potential to kinetic energy: falling; slide

g chemical energy to light: lighting a match

h kinetic energy to sound: striking a bell

2 Draw a flow diagram that shows all of the energy changes when:

a a light turns on

chemical potential energy (coal) → electrical → light

b a toaster cooks your toast

chemical potential energy (coal)→electrical → heat

c a church bell is struck by a bell-ringer

chemical potential energy (food) → kinetic energy → sound

d a firework explodes

chemical potential energy (explosives) → kinetic energy (through air) → heat/light/sound

e an iPhone is charged using energy from a coal power station

chemical potential energy (coal) → electrical → chemical potential energy (battery) → heat/light/sound

3 Why does a mug of hot chocolate eventually cool down? Where does the heat energy go?

Heat is lost to the surroundings (atmosphere/air)

4 What will happen to a glass of ice-cold water if left at room temperature?

The heat in the atmosphere will transfer to the water in the glass, heating it up

5 Why does the ice-cold water form condensation on the side of the glass?

The ice-cold water cools the glass and air around the glass, condensing water vapour into liquid water

6 Does hot chocolate or cool lemonade have more thermal energy? Explain your answer

The hot chocolate as the more thermal energy an object has, the hotter it is

7 Which of the drinks in question 6 will have more thermal energy if they are left on the same bench overnight? Explain your answer.

They will both reach room temperature overnight and have the same amount of thermal energy

Extend your understanding

In exothermic chemical reactions, reactants have more energy than products. Therefore, when the products form, the extra energy is released to the surroundings as heat.

In endothermic reactions, products have more energy than reactants. Therefore, heat must be absorbed from the surroundings for the reaction to occur.

8 If an exothermic reaction occurred in a beaker, what would the beaker feel like if you picked it up?

Hot/warm

9 If an endothermic reaction occurred in a beaker, what would the beaker feel like if you picked it up?

Cool/cold

10 Show the energy conversion of these two processes by drawing energy chain flow charts:

a Exothermic

chemical potential energy → heat

b Endothermic

heat → chemical potential energy

11 Is the burning of coal an exothermic or an endothermic reaction? Explain your answer.

Exothermic reaction; large quantities of heat energy is produced

3.5 Energy cannot be created or destroyed

Student worksheet answers (pages 50–51)

Energy efficiency

1 What is energy efficiency?

A calculation of the percentage of useful energy transformed

2 Why aren’t any energy conversions 100% efficient?

Energy is transformed into heat and sound energy, as well as the desired form of energy

3 What is the law of conservation of energy?

Energy cannot be created or destroyed

4 Why aren’t light globes 100% energy efficient?

Heat is created in addition to the desired form of energy – light

5 What would a 100% efficient light bulb do?

Convert electricity into light only

6 Complete the table below to compare the efficiency of the three different types of light globes shown:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Incandescent bulb** | **Compact fluorescent light** | **Light-emitting diode** |
| **% Light conversion** | 5 | 10 | 30 |
| **% Heat conversion** | 95 | 90 | 70 |

7 Which of these three bulbs is the most energy efficient? Why?

The light emitting diode as it converts more electricity into light

8 Using the equation for energy efficiency, calculate the efficiency of each of the light bulbs:

Incandescent bulb: 

Compact fluorescent light: 

Light-emitting diode: 

9 Does your answer for question 7 match the calculations you completed in question 8? Why or why not?

Yes, the calculations prove that the light-emitting diode will have a greater percentage of electricity converted into light; therefore it is more energy efficient as less electricity is wasted.

10 Name two energy transformations that result in energy being wasted as heat and/or sound.

*Answers will vary.* Examples include:

• A mobile phone wastes energy as heat, as it gets hotter the more you use it

• A light bulb generates heat as well as light

• A TV generates heat as well as sound and light

Extend your understanding

11 How does the law of conservation of energy relate to energy efficiency and waste energy?

All energy used must be converted to another form of energy, whether it is useful energy or waste

12 If energy cannot be created, state three places that it comes from.

The Sun (the Sun causes wind, so wind is not a suitable answer)

The core of the Earth

Gravity (causes tidal movements)

13 When energy is lost, it is usually lost as heat. What happens to the heat from light bulbs when it has been lost?

It is transferred to the air in the atmosphere and heats the air, which then rises

14 Why is it difficult to get this energy back once it is lost?

Humans have not developed a method for extracting heat from the air to use for power; steam could be a viable option, but not enough heat is created to become steam so it is lost into the atmosphere before it is captured

3.6 Science as a human endeavour: Energy efficiency can reduce energy consumption

Student worksheet answers (pages 52–53)

Minimising energy consumption

1 Explain two reasons why it is beneficial to reduce the amount of energy you use.

*Answers may vary.* Living expenses will be reduced as you use less electricity, and there will be less impact on the environment.

2 How does a hair dryer work?

Electricity makes the fan motor spin (kinetic energy) and the heating element heat up (thermal energy). The air passes over the heating element, making the air hot when it comes out of the appliance.

3 How can you control the amount of heat and air coming out of a hair dryer?

Change the amount of electricity flowing into the hair dryer to vary the amount of heat and kinetic (air) that comes out.

4 Name four devices that heat either your home or your food.

*Answers will vary.* Examples include oven, heater, fireplace, toaster and microwave.

5 On a cold winter night you go to watch TV in your living room and it is very cold. You put on the heater, watch your favourite show in toasty warmth, turn off the heater and then go to bed. When you wake up in the morning the room is freezing cold again. Why is this? Where does the heat go?

In cool environments, the heat inside the house will cool down when in comes into contact with the walls, floor and roof. Therefore, heat is transferred between the inside and outside of the house.

6 Name three ways you can minimise heat loss in your home and explain how each works.

*Answers will vary.* Examples include:

• Insulation in the roof – soft padding in the roof traps heat and acts as a barrier

• Insulation in the walls – soft padding in the wall traps heat and acts as a barrier

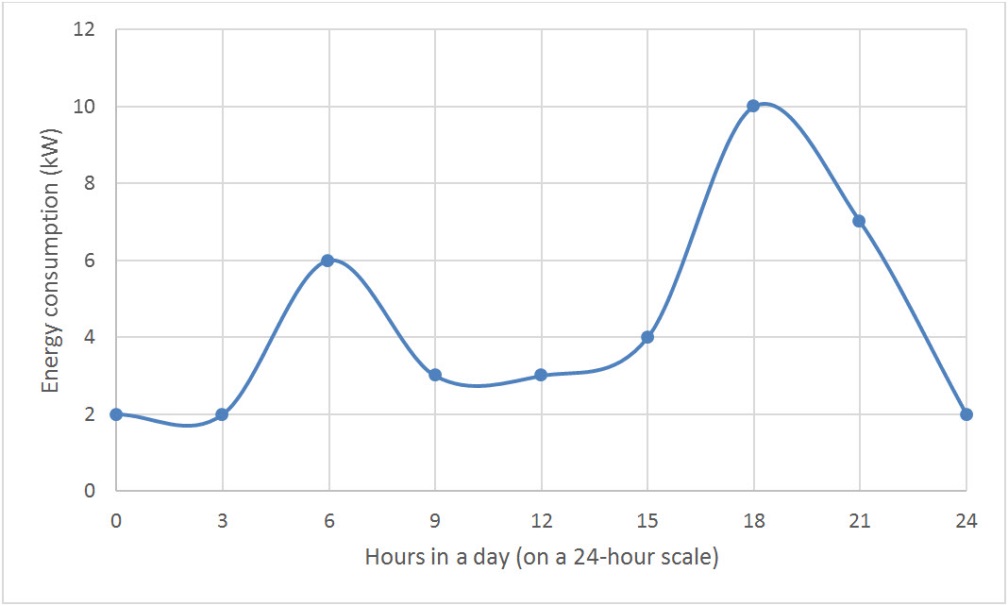
• Double glazing the windows – provides two panels of glass and less chance for heat to escape

7 Draw a flow diagram for the conversion of coal to heat and wind in your hair dryer.

chemical potential energy (coal) → electricity → heat, kinetic energy and sound (waste energy)

Extend your understanding

8 The following graph shows the overall energy consumption used in a typical household over the course of 24 hours, from midnight to midnight, during winter.



a When are there spikes in energy consumption?

6 a.m. and 6 p.m.

b Explain why these spikes occur – what happens at this time of day?

6 a.m. – people wake up, turn on their heater, shower, cook breakfast and get ready for the day

6 p.m. – people come home, turn on their appliances (e.g. heater, TV, computer), cook dinner, turn on the lights (as it is dark at 6 p.m.)

c Suggest a possible reason why one spike is larger than the other.

In winter, it is dark and getting cold by 6 p.m. so more energy is required to heat and light the house than at 6 a.m.

d Suggest two ways that you could minimise the size of these spikes.

Answers will vary.

Avoid using the heater by insulating the house and only turn on appliances when needed.

Using solar panels means that less energy is consumed from the power grid and more is made on site.

3.7 Science as a human endeavour: Solar cells transform the Sun’s light energy into electrical energy

Student worksheet answers (pages 54–55)

Solar energy

1 What is a solar cell?

A device that transforms the Sun’s light energy into electrical energy

2 How is solar energy often measured?

In the number of peak sunlight hours every day, which is averaged over a year

3 The amount of solar energy is different, depending on the Australian state you live in. Which state experiences the highest and lowest solar energy? Why do you think this is?

Queensland, Northern Territory and Western Australia are the highest solar energy states with the average number of peak hours being 6. Tasmania is the lowest with 3. Northern states have longer hours of sunlight, as they are closer to the equator. Tasmania is closer to a pole and therefore it has shorter days.

4 What is the problem with converting light to chemical potential enegy?

People do not use the energy as soon as it is created; they use it at night, when there is no sunlight

5 How is this problem overcome?

By converting the electrical energy into chemical energy in a battery

6 How do solar cells work?

By transforming the Sun’s light energy into electrical energy

7 What is a photovoltaic cell?

A solar cell

8 How does a photovoltaic cell generate electricity?

Light shines on the surface of a photovoltaic cell. This light energy is transformed into electrical energy.

9 How energy efficient are photovoltaic cells?

30% efficient

10 Why can solar cars only carry one person?

The lighter a solar car is, the more energy efficient it is and the further it will travel. More than one person would make the car heavier.

11 Why are solar cars not a practical method of transport?

Solar cells rely on sunlight – during the night or if it becomes cloudy during the day, the solar cells won’t work. A solar car can only carry one person, so it is not suitable as a family car.

Extend your understanding

12 In space, light travels at the speed of light (299 792 458 metres per second). If there is 149 597 870 700 metres between the Earth and the Sun, use the equation  to determine how many seconds it would take for the Sun’s light to reach the Earth.



13 Convert this time into minutes by dividing by 60.

 (which is equal to 8 minutes and 19 seconds)

14 Use the data in the following table to calculate how long it takes the Sun’s light to reach other planets in our solar system. Convert this into minutes and hours where possible.

|  |  |
| --- | --- |
| **Planet** | **Distance from the sun (metres)** |
| Mars | 227 940 000 000 |
| Jupiter | 778 330 000 000 |
| Saturn | 1 424 600 000 000 |
| Neptune | 4 501 000 000,000 |

a Sun to Mars:



b Sun to Jupiter:



c Sun to Saturn:



d Sun to Neptune:



15 Why do astronomers say that looking at stars is like looking hundreds, sometimes thousands or millions, of years into the past?

Some stars are so far away that their light is only reaching us now. If they are a million light years from us, it has taken light a million years to reach us, so we are looking at their sun as it appeared a million years ago.

3.8 Science as a human endeavour: Engineers use their understanding of energy to solve problems

Student worksheet answers (pages 56–57)

Engineering

1 Explain the role of each of the following engineers. Provide examples where possible.

a Chemical engineer

Combine existing materials and develop new materials, e.g. making new plastics or fabrics

b Mechanical engineer

Design and improve things that have moving parts or have physical forces pushing/pulling them, e.g. designing motors, cars, boats

c Electrical engineer

Design and organise electrical equipment, e.g. computers, robotics, satellites

d Civil engineer

Research, plan and design structures, e.g. building bridges

2 For each of the tasks below, state which type of engineer would perform this job.

a Build a bridge: Civil engineer

b Make a new type of biodegradable plastic: Chemical engineer

c Build a sattelite for NASA: Electrical engineer

d Design a different type of paper: Chemical engineer

e Design and build a car to be raced at NASCAR: Mechanical engineer

f Design and test robotics: Electrical engineer

g Build the tallest building in the world: Civil engineer

h Design shatter-proof glass: Chemical engineer

i Organise the electronics of the CERN super-collider: Electrical engineer

j Design new medical equipment: Mechanical engineer

k Dig and reinforce a tunnel between Victoria and Tasmania: Civil engineer

l Build the longest waterslide in the world: Mechanical engineer

m Improve photovoltaic cells to increase energy efficiency: Electrical engineer

3 Match each type of engineering assessment with the question it asks:

|  |  |  |
| --- | --- | --- |
| **Engineering assessment** |  | **Question it asks** |
| 1 Environmental impact |  | C What is the impact on the environment? |
| 2 Geotechnical hazard assessment |  | D What will happen if you dig up the soil? |
| 3 Contamination assessment |  | E Will any chemicals contaminate living things? |
| 4 Strength and facility life assessment |  | F What sort of load (or weight) can the structure withstand? |
| 5 Social impact assessment |  | B Will it have good or bad impact on people’s lives? |
| 6 Risk assessment |  | A What happens if it fails? |

Extend your understanding

Your best friend develops an engineering proposal to place a waterslide in your house so that it will be easier to get drinks and icy poles on hot days, and so that summer will be awesome!

The waterslide is planned to go from the kitchen at the front, through the house, and then out to the backyard.

4 As the engineering expert that you now are, evaluate your friend’s proposal (completely impartially of course) by completing the following assessments:

*Answers will vary.* Hopefully there are some entertaining ones!

a Environmental impact (i.e. the impact on the rest of the house if the waterslide runs through the house)

Floors, carpets and walls may be damaged by water – floors may need to be ripped out or covered up.

b Social impact (i.e. will the family be happy?)

Although your siblings/cousins/friends will love it, your parents will be **very** unhappy that their house is being destroyed.

c Risk assessment

If it fails, there will be a big cost involved in cleaning up not only the waterslide but also the house.

d Contamination assessment

The water will need to be chlorinated; this could kill any creepy crawlies in the house … BONUS!

e Strength and facility assessment

The loads will depend on the people on the waterslide, but it should be able to hold everyone if it is designed correctly and built out of suitable materials.

f Geotechnical hazard assessment (think about the floors)

The floors of the house will need to be dug up to fit the waterslide into the house, which will be a huge problem and very costly.

5 What is your final assessment of the waterslide proposal? Should the project go ahead? Why or why not?

Answers will most certainly vary.

This waterslide proposal should be rejected and the project should not go ahead. It is too expensive and there will be too much destruction. Plus, you should never upset your parents!

vary.