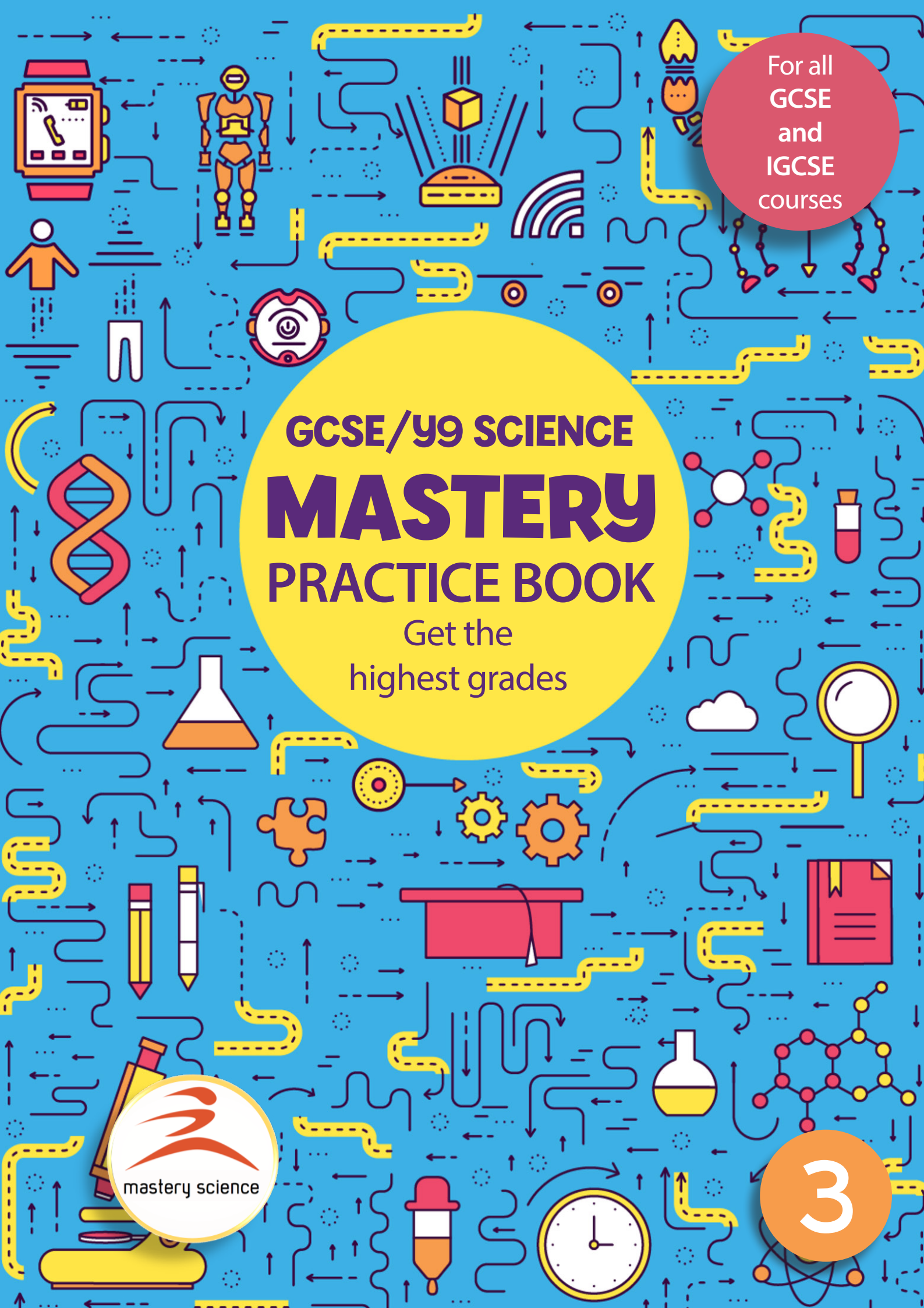
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Contents

How to use the book

Applying what you know is not easy. Keep trying, and learn from your mistakes. With practice you will master the concepts and be confident with whatever examiners ask.

Detect

- Diagram
- Values
- Unknown
- Concept

Recall

Solve

Why is this evidence?

Your turn

1	/3	2	/3	3	/3	4	/3	Total	/12

Hints & Answers

The ***Example*** pages have 3 steps:

1. Detect. Work out what you need to do to answer the question. There are 4 different parts to detect:
- diagram, makes the situation clearer
- values, information that the question provides
- unknown, what you have to find out
- concept, the key idea that the question is applying

2. Recall. Bring to mind what you already know about the concept. Showing it visually helps the thinking process.

3. Solve. Go from what you know to the answer, step-by-step. When Solve involves an explanation, it is set out as a scientific argument:
- claim, the answer that you believe it true
- evidence, information in the question or knowledge
- reasoning, how to get from the evidence to the answer

Do answer the questions in speech bubbles. This will help you follow the example and remember the main points.

The ***Your Turn*** pages have three practice questions. The first is very similar to the example. Look back and copy the steps. The other two questions might look different but they are testing the same thinking process.

Use the scoring box to check how you're doing. Award yourself 3 points if you did Detect, Recall and Solve well. Subtract 1 point for each step you didn't do well.

If you're stuck, go to the ***Hints*** pages at the back. The hint is a clue or question to get you moving.

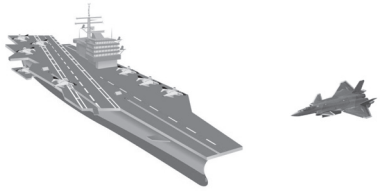
The ***Answers*** are online. Go to masteryscience.com. If you made a mistake, look back at the example to figure out what you did wrong.

Good luck!

Example

1.1 Distance travelled

A jet is travelling at 67 m/s when it lands on an aircraft carrier.

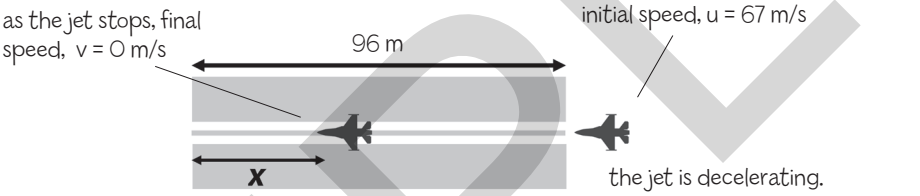


The runway is 96 m and the jet comes to a stop in 2.4 seconds.
How far from the end of the runway does it stop?

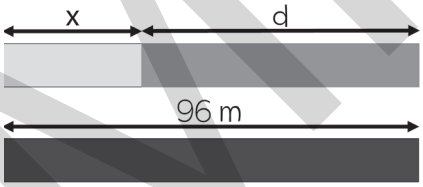
Detect

- ✔ **Concept**
- ✔ **Diagram**
- ✔ **Values**
- ✔ **Unknown**

The description involves changing speed, so the concept is acceleration.



I need to find the distance, **x**, from where the jet stops to the end of the runway.

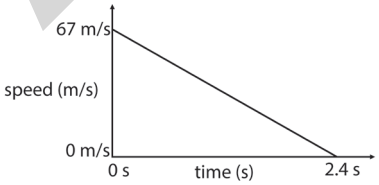


I cannot calculate **x** directly as the distance travelled is d.

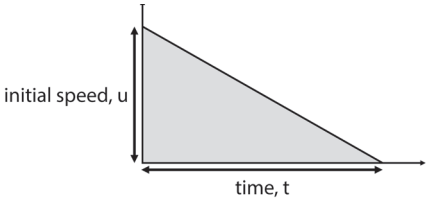
So first I calculate d, using a graph or a formula.
Then I can work out **x**, because **x** = 96-d.

Recall

Method 1. Area under a speed/time graph



Here is the speed / time graph for the jet's motion.



The distance travelled in time t = the area under the graph.
As the area is a triangle,
distance travelled = ½ × base × height
= ½ × initial speed × time
= ½ × u × t

Recall

Method 2. Distance-speed-time formula

Distance travelled is related to speed by this formula:

distance = average speed × time

I can calculate this — I know t = 2.4 s

Why is this the average speed?

$$\text{average speed} = \frac{\text{initial speed} + \text{final speed}}{2}$$

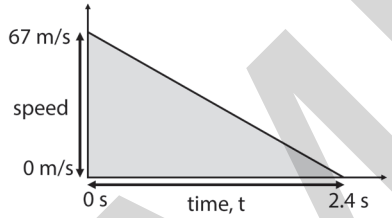
I know u = 67 m/s — I know v = 0

As we know all the quantities, we can calculate distance from the formula.

Solve

Method 1. Area under a speed/time graph

How do you calculate the area under the graph?



Here is a speed-time graph of the jet's motion.

First find d, the distance the jet travels.

d = area of the triangle
= ½ × speed × time
= 0.5 × 67 × 2.4
= 80.4 m

Then find **x**, the distance to the end of the runway.
We know the runway = 96 m.
x = 96 m - d
= 96 – 80.4
= 15.6 m

Method 2. Distance-speed-time formula

First, calculate average speed:

$$\text{average speed} = \frac{\text{initial speed} + \text{final speed}}{2}$$

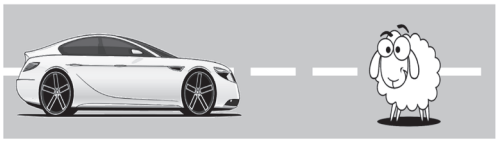
= (67+0)/2
= 33.5 m/s

Then, calculate distance travelled, d:

d = average speed × time
= 33.5 × 2.4
= 80.4 m

We know the runway = 96 m.
The distance, **x**, to the end of the runway = 96 m - d. So **x** = 96 – 80.4 = 15.6 m

1

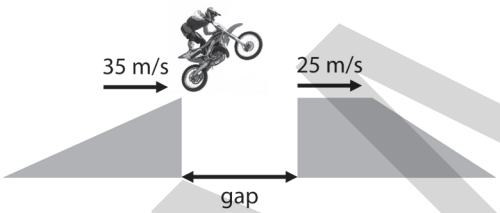


A driver travels at 28 m/s and notices a sheep in the road. The driver brakes when the sheep is 125 m away. The car stops in 8.5 s.
How far from the sheep is the car when it stops?

2

A rocket going to a space station is fired vertically into space. It reaches a speed of 0.75 km/s in 2 minutes.
How far has it travelled in this time?
(Assume its acceleration is constant).

3



A stunt rider goes up a ramp and jumps over a gap. On take-off, her horizontal speed is 35 m/s. On landing, her horizontal speed is 25 m/s. She is in the air for 1.5 seconds.
a) Sketch a speed-time graph of the motion across the gap.
b) Calculate the length of the gap.

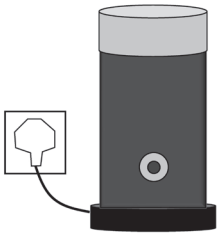
4

A car stopped at the traffic lights. It then accelerated to a top speed of 35 m/s while travelling 350 m.

How long did this take?

Example

2.3 Specific heat capacity

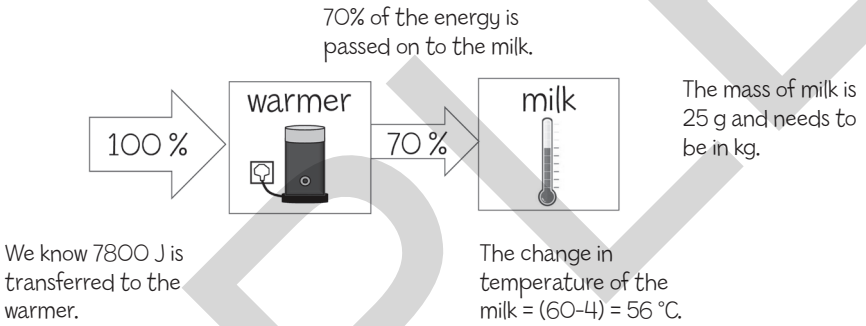


An electric milk warmer heats 25 g milk from 4 °C to 60 °C. It transfers 7.8 kJ of energy from the mains but is only 70 % efficient.

How much energy does it take to heat 1 kg of the milk by 1 °C?

Detect

- Diagram
- Values



- Unknown
- Concept

I need to find the energy to heat 1 kg of a material by 1 °C, its specific heat capacity, c.

The question is about specific heat capacity, I need an equation that links c to energy, mass and temperature.

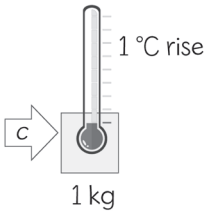
Recall

1. How to find find energy using specific heat capacity.

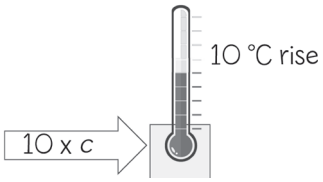
Method 1: Scale the energy for a different mass and temperature.

What mass and temperature change does c give the energy required?

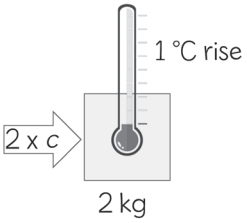
A 1 kg mass takes c Joules of energy for a rise in temperature of 1 °C.



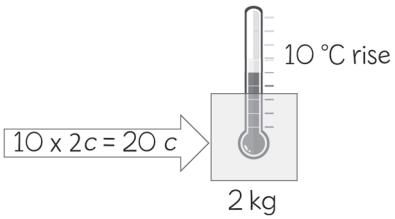
A 10 °C rise in temperature takes 1 × 10 = 10 times as much energy.



A 2 kg mass rise takes 2 × the energy (2 × c Joules) for a rise in temperature of 1 °C.



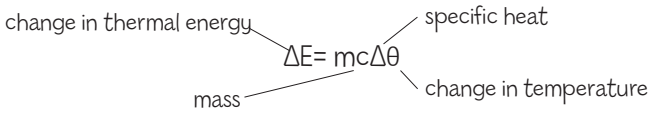
A 10°C rise in temperature takes 2 × 10 = 20 times as much energy for a 2 kg mass.



Recall

Method 2: Use the specific heat capacity equation.

I can find unknown quantities by changing the subject of the equation.



To remove the Δθ, divide both sides by Δθ.

$$\Delta E = mc\Delta\theta \quad (\div \Delta\theta \text{ on both sides}) \rightarrow \frac{\Delta E}{\Delta\theta} = mc$$

To remove the m, divide both sides by m.

$$\frac{\Delta E}{\Delta\theta} = mc \quad (\div m \text{ on both sides}) \rightarrow \frac{\Delta E}{m\Delta\theta} = c$$

2. How to calculate energy using efficiency.

$$\frac{\overset{?}{\Delta E}}{m\Delta\theta} = c \quad (\checkmark\ \checkmark)$$

I need the energy transferred to the milk.
I know the input energy (7.8 kJ) and efficiency (70%).
I can use this equation: Efficiency = (useful output energy) / (input energy)

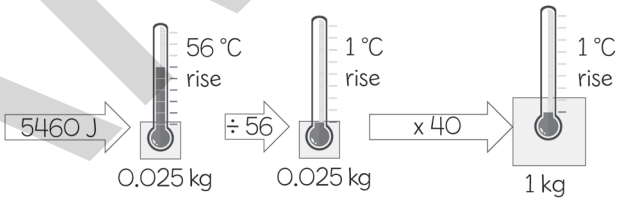
Solve

First I calculate the energy from the equation: Efficiency = (useful output energy) / (input energy)

Efficiency x input energy = useful output energy
70% efficiency is 0.7 as a fraction of 1
0.7 × 7800 J = 5460 J

Then I calculate the specific heat capacity.

Method 1: Scale the energy for a different mass and temperature.



This is the energy to heat the 25 g of milk by 56 °C.

To find the energy for a 1°C rise, I divide by 56.
5460 J ÷ 56 = 97.5 J/ °C

I need the energy for 1 kg which is 40 × 25 g. So I multiply the energy by 40.
97.5 J × 40 = 3900 J/ °C

2. How to calculate energy using efficiency.

Can you identify the steps: rearrange, insert values?

$\Delta E = mc\Delta\theta$

$$\frac{\Delta E}{m\Delta\theta} = c$$

I know:
E= 5460 J
m = 0.025 kg
Δθ = 60-4 = 56 °C

$$\frac{5460}{0.025 \times 56} = c$$

c = 3900 J/(kg °C)

So, the specific heat capacity, c = 3900 J/(kg °C)

Hint p.121

Your turn

1

A glue gun heats 1 g of glue from 20 °C to 120 °C. It draws 200 J from the mains supply but it is only 55 % efficient. Find the specific heat capacity of the glue.

2

A mug containing 250 g water is heated in a 750 W microwave for 1 minute. It absorbs 45 000 J of energy.

What is the temperature increase, Δθ?
(specific heat capacity of water = 4200 J/(kg °C))

3

A 0.3 kg baking potato is put in a BBQ with the lid on. It takes 81 000 J to heat the potato to its cooking temperature from 20 °C.

What is its cooking temperature?
The specific heat capacity of potato is 1700 J/(kg°C).

4

A handwarmer pouch contains gel at 40 °C. When it cools to 15 °C outdoors, it gives off 10.5 kJ of energy.

What is the mass of the gel?
The specific heat capacity of the gel is 3000 J/(kg °C).

1	/3	2	/3	3	/3	4	/3	Total	/12

Example

4.4 Reactions of groups 1 & 7

Element	When melted sodium is added
Bromine	Small orange sparks. A white powder is formed.
Chlorine	Very vigorous reaction, bright orange light. A white powder is formed.

A scientist reacted two different group 7 elements with sodium.

a) Name the product of each reaction.

b) Explain the difference in the reactions of bromine and chlorine with sodium.

Detect

- **Values**
- **Unknown**
- **Concept**

Both chlorine and bromine reacted to form a white powder. But the reaction of chlorine with sodium was more vigorous than the reaction of bromine.

a) I don't know the white powders formed in each reaction:
sodium + bromine → ? sodium + chlorine → ?
b) I don't know why chlorine is more reactive than bromine.
This question is about explaining trends in reactivity of group 1 and 7 elements.

Recall

1. How group 1 elements (alkali metals) react.

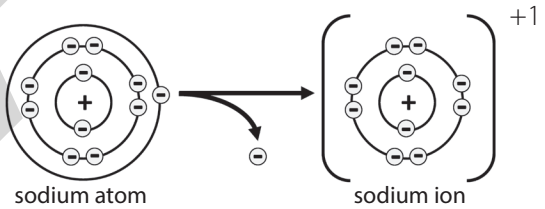
Water:
metal + water → metal hydroxide + hydrogen
$2Na + 2H_2O \rightarrow 2NaOH + H_2$

Oxygen (when heated):
metal + oxygen → metal oxide
$2Na + O_2 \rightarrow 2NaO$

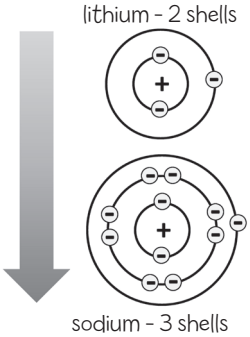
Group 7 elements (halogens):
metal + halogen → metal halide
$2Na + Cl_2 \rightarrow 2NaCl$

2. How group 1 reactivity depends on electron structure.

All group 1 atoms have one electron on their outer shell. When they react, they lose this electron to form a positive ion.



atom loses an electron so ion has a +1 charge



Sodium's outer electron is further from the positively charged nucleus than lithium's.
It feel less attraction, and is lost more easily.
Sodium is more reactive.

The easier it is for the atom to lose electrons from its outer shell, the more reactive it is.

Reactivity increases down group 1.

Recall

3. How group 7 elements (halogens) react.

Group 7 elements take part in displacement reactions.

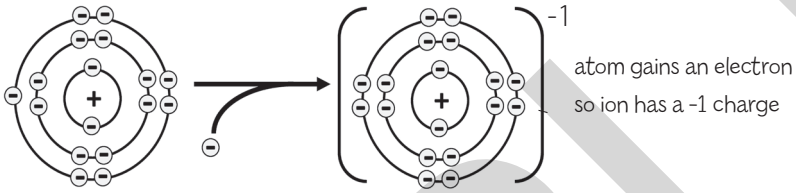
chlorine + sodium bromide → sodium chloride + bromine

Cl_2 + 2NaBr → 2NaCl + Br_2

A more reactive halogen can displace a less reactive halogen from a solution of its salt.

4. How group 7 reactivity depends on electron structure.

All group 7 atoms have seven electrons on their outer shell. When they react with metals they gain an electron to form a negative ion with a charge of -1.



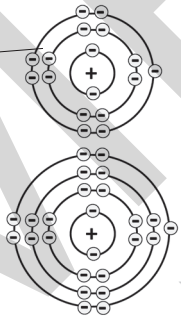
5. How electron structure affects group 7 reactivity

All group 7 atoms have seven electrons on their outer shell. When they react with metals they gain an electron to form a negative ion with a charge of -1.

What is the relationship between size and reactivity for the atoms in each group?

chlorine - 3 shells

An electron added to chlorine's outer shell is closer to the nucleus than bromine's.
It feels more attraction, so it is added more easily.
Chlorine is more reactive.



The easier it is for an atom to gain electrons, the more reactive it is.

Reactivity decreases down group 7.

bromine - 4 shells

Solve

a) Group 1 metals react with group 7 elements like this:
metal + halogen → metal halide
so: sodium + bromine → sodium bromide sodium + chlorine → sodium chloride.

- ✔ **Claim**
- ✔ **Evidence**
- ✔ **Reasoning**

b) Chlorine is a more reactive element than bromine.
When chlorine reacted with sodium a more vigorous reaction was observed.

This is because chlorine atoms gain an electron more easily than bromine atoms.
When group 7 elements react they gain an electron to fill their outer shell. The negative electron is attracted to the positive nucleus.
In chlorine the outer shell is closer to the nucleus so the force of attraction between the electron and the nucleus is greater than in bromine. So, it has a greater tendency to attract an electron.
This explains why chlorine is more reactive than bromine.

1

Alkali metal	Observations during reaction
Lithium	The lithium melted to form a ball. It moved slowly around the surface of the water.
Sodium	The sodium melted to form a ball. It move very quickly around the surface of the water. It had an orange flame.

A teacher added two alkali metals to water. The table shows the observations.

a) Name the products formed in each reaction.
b) Explain the difference in the reaction of the two alkali metals.

2

Reaction	Reactant 1	Reactant 2
X	Sodium	Iodine
Y	Bromine	Lithium
Z	Potassium	Chlorine

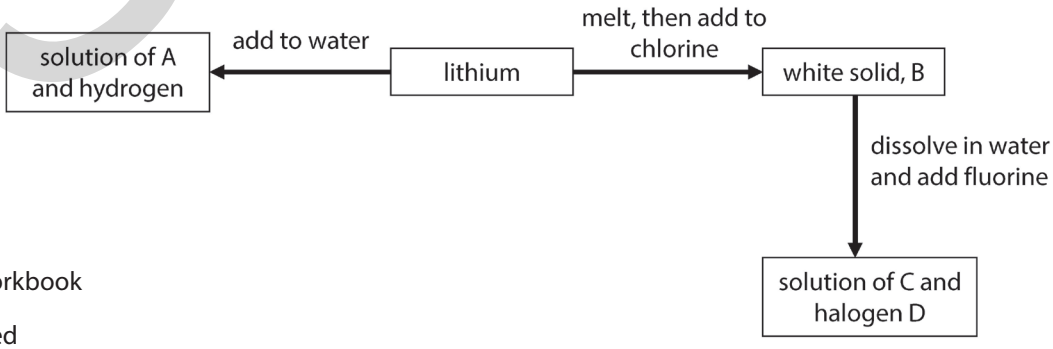
The table shows the reactants in three chemical reactions.

a) Name the products for each reaction.
b) Explain which reaction is likely to be the most violent.

3

A student cut a 2 cm^3 cube of lithium. The surface inside was shiny.
She timed how long it took for the shiny surface to become dull.
a) Explain why the surface went dull.
b) Explain how the time would change if the experiment was repeated using sodium.

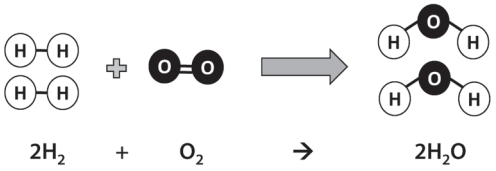
4 The flow chart shows some reactions of lithium. Name the substances A-D.



Example

5.2 Calculate bond energies

A car manufacturer wants to use hydrogen as a car fuel.



The diagram shows how hydrogen reacts with oxygen.

Bond	Bond Energy (kJ/mol)
H-H	436
O=O	498
H-O	463

Use the bond energy data to explain if hydrogen could act as a fuel.

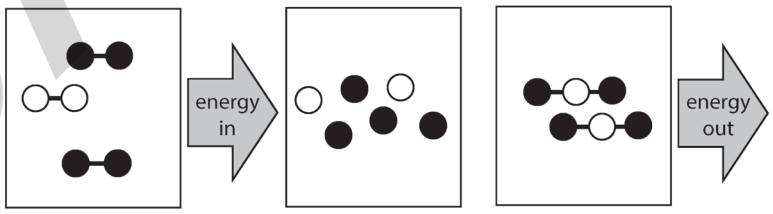
Detect

- **Values** — The symbol equation shows me that two hydrogen molecules react with one oxygen molecule to form two water molecules. The bond energies table tells me the amount of energy to break each chemical bond. For something to act as a fuel it needs to give out energy to its surroundings when it reacts.
- **Unknown** — I need to work out if hydrogen's reaction with oxygen releases energy or not.
- **Concept** — This question is about using bond energies to calculate energy changes in a reaction.

Recall

1. How energy changes during a chemical reaction.

A chemical reaction involves energy changes. There are two stages:

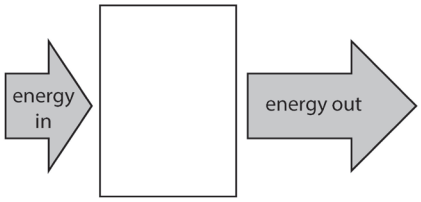


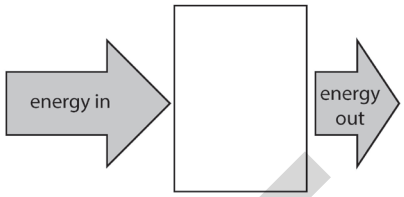
1. Energy is needed to break apart the bonds in the reactants.

2. Energy is released to the surroundings when new bonds form.

Recall

The energy taken and given out can be different.





If the reaction gives out more energy than it takes in, there is a net release of energy.
This warms up the surroundings.
It is an exothermic reaction.

If the reaction takes in more energy than it gives out, the extra energy needed comes from the surroundings. So they cool down.
It is an endothermic reaction.

2. How to decide if a reaction is exothermic or endothermic.

A. Calculate energy in. Add the energies for the bonds that break (reactants on left of equation).

B. Calculate energy out. Add the energies for the bonds that form (products on right of equation).

C. Calculate: energy in - energy out.

D. If the answer is +ve, more energy is taken in by the system. It is endothermic. If the answer is-ve, more energy is given out by the system. It is exothermic.

How do the diagrams explain this?

Solve

A. Calculate energy in.
For the 2 H-H bonds. Breaking each bond takes in 436 kJ/mol.
So 2 x H-H = 2 × 436 = 872 kJ/mol.
For the O=O bond. Breaking each bond takes in 498 kJ/mol
Add the bond energies: 872 + 498 = 1370 kJ/mol

B. Calculate energy out.
For the 4 x O-H bonds. Making each bond gives out 463 kJ/mol.
So 4 × 463 = 1852 kJ/mol

C. Calculate energy in - energy out.
= 1370 - 1852 = - 482 kJ/mol

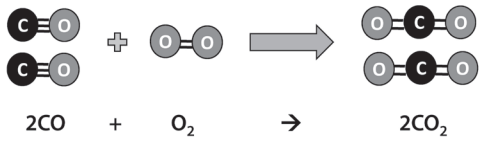
D. Is the energy change +ve or -ve?
The answer is negative. So it is an exothermic reaction.
The reaction of hydrogen with oxygen releases energy. So hydrogen could be used as a fuel in cars.

Why is the sum this way round?

Hint p.122

Your turn

1 Carbon monoxide reacts with oxygen to make carbon dioxide.

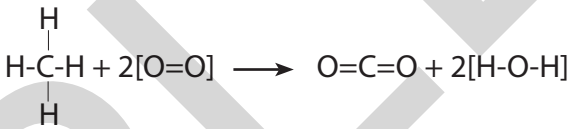


Bond	Bond Energy (kJ/mol)
O=O	498
H-O	463
C-H	413
C=O	799
C≡O	1072

Use the bond energy values to determine whether this reaction releases energy.

2

In a Bunsen burner, methane reacts with oxygen:



Explain why methane is a good choice for a Bunsen burner, using the bond energy data from Q1.

3

In a camping stove, propane reacts with oxygen. Work out the total bond energies of

A) The reactants

B) The products

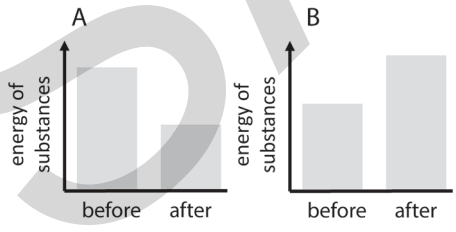
Emma does this homework problem about a camping stove. Her answers are:

A) 5794 kJ/mol B) 4249 kJ/mol.

Emma's sister knew she had made a mistake just by looking at her answers.

Explain how her sister knew without adding bond energies.

4



Hydrogen can be made by reacting methane with water:

$CH_4 + H_2O \longrightarrow 3H_2 + CO$

The energy needed to break the bonds in the reactants is 2578 kJ/mol.

The energy released when new bonds form in the products is 2380 kJ/mol.

a) Which bar chart shows the energy of the substances before and after the reaction? Explain your choice.

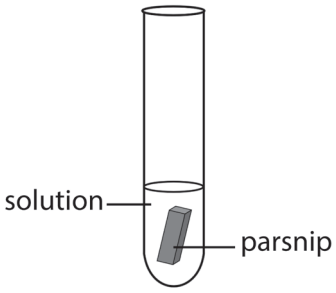
b) Suggest why this reaction has to be constantly heated.

1	/3	2	/3	3	/3	4	/3	Total	/12

Example

7.5 Explain osmosis changes

Ana tested the effect of salt solution on a parsnip. She dissolved different masses of salt into containers of pure water. Then she added pieces of parsnip into tubes of each salt solution. She weighed the parsnips beforehand, left the pieces in the solution for 2 hours, and then dried and reweighed them.



Solution	Mass of salt in 1 dm^3 water in grams	Mass of parsnip at start in grams	Mass of parsnip at end in grams
A	25	4.62	4.84
B	50	4.54	4.70
C	75	4.60	4.64
D	100	4.59	4.44

Explain the pattern in her results.

Detect

- ✓ **Values**
- ✓ **Unknown**
- ✓ **Concept**

The parsnip piece in solution D lost mass but all the other pieces gained mass. I need to explain why.

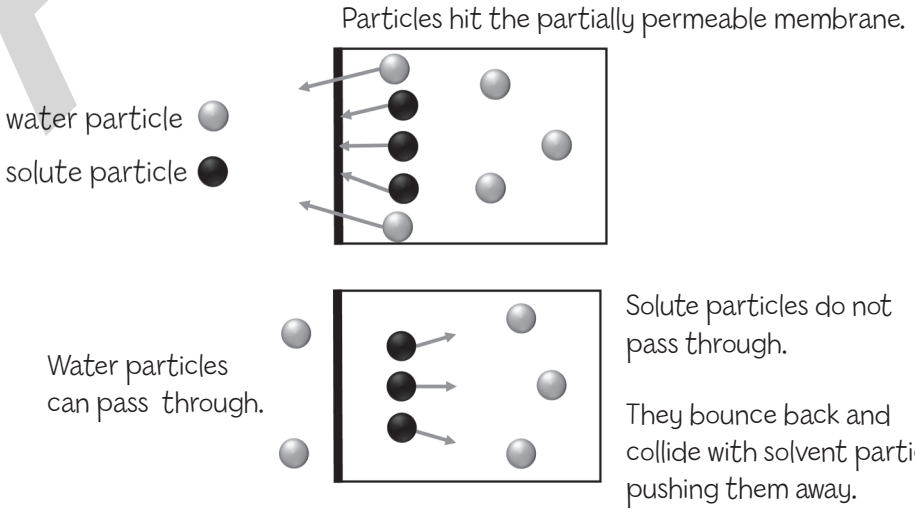
The parsnip pieces were in different concentrations of salt solutions and their mass changed. This question must be about osmosis.

Recall

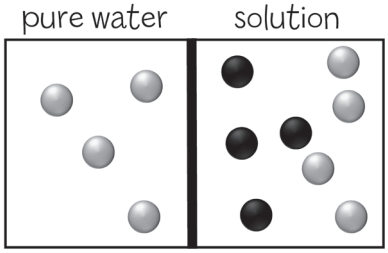
1. How water moves across a membrane by osmosis.

Diagrams can be used to show what happens during osmosis.

What happens during osmosis?



Recall



If water particles are pushed away, there are fewer of them near the membrane.

Overall
When there is a difference in solute concentration, and a partially permeable membrane, there is a net movement of water particles from the less concentrated solution to the more concentrated solution.

there is a larger movement of water across the membrane left → right

and a smaller movement of water right → left

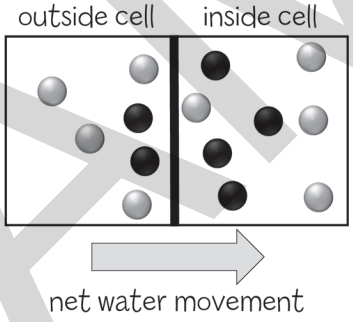
the net movement is left → right

Solve

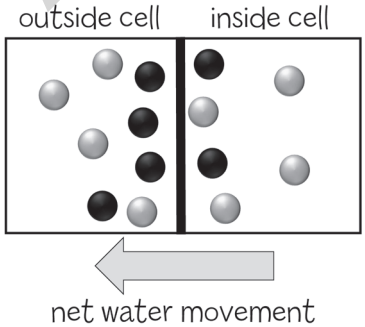
- ✔ **Claim**
- ✔ **Evidence**
- ✔ **Reasoning**
- ✔ **Evidence**
- ✔ **Reasoning**

How can osmosis change the mass?

In solutions A-C, the parsnip's mass increased. But in D, with the biggest salt concentration, the parsnip's mass decreased. Water must have moved out of cell D by osmosis. That means the solute concentration inside the parsnip was been lower than 100 g/dm^3 but higher than 75 g/dm^3.



Solutions A-C: low solute concentration.
When the concentration is 25-75 g/dm^3 the parsnip's mass increases. This happens because the solute concentration inside the parsnip cell is higher than outside, So, there is a net movement of water into the cell by osmosis. This increases the mass of the parsnip.



Solution D: high solute concentration.
When the concentration is 100 g/dm^3, the parsnip's mass decreases. This happens because the solute concentration inside the parsnip cell is lower than outside, There is a net movement of water out of the cell by osmosis which decreases the mass of the parsnip.

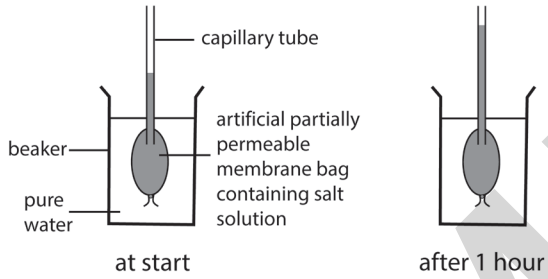
1 Matt investigated the sugar content of a sports drink.

Concentration of sugar solution in mol/dm^3	Change in mass of bag after 20 mins %
0.2	+55
0.4	- 8
0.6	- 22
0.8	- 48

He made four bags from artificial partially permeable membranes. He filled each bag with the drink and put them in different sugar solutions for 20 minutes. He weighed the bags before and after and calculated the percentage change in mass.

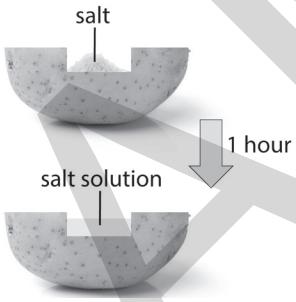
Explain the pattern in the results.

2



Malik sets up the equipment as shown.
Use a labelled diagram to explain the result in terms of particle movement.

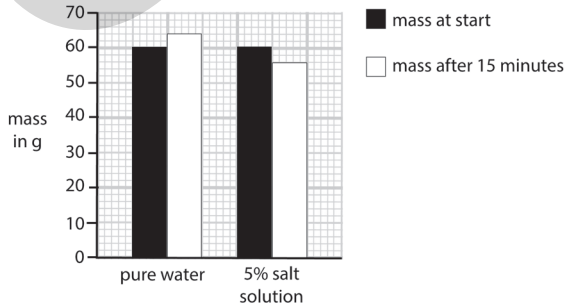
3



The diagram shows an osmosis investigation.
Daisy cuts a potato in half and makes a small well in the centre. She fills it with salt. An hour later, the well is filled with salt solution.

Explain this observation.

4



Ed takes two chicken eggs and dissolves their shells. The egg contents are now covered only by a partially permeable membrane. He places each egg in a different liquid for 15 minutes.
Explain the results shown by the bar chart.

Example

8.1 Gene function

GAA AAC TCT TTA TTG
lactase gene

GAA AAC TCT CTA TTG
Sandra's DNA

Sandra feels ill when she drinks milk. Her body does not produce lactase. Lactase is protein that breaks down lactose, a sugar in milk.
The diagram shows the DNA for part of the lactose gene, and the same part in Sandra's DNA.

Explain why Sandra cannot break down lactose.

Detect

- ✓ Diagram
- ✓ Values
- ✓ Unknown
- ✓ Concept

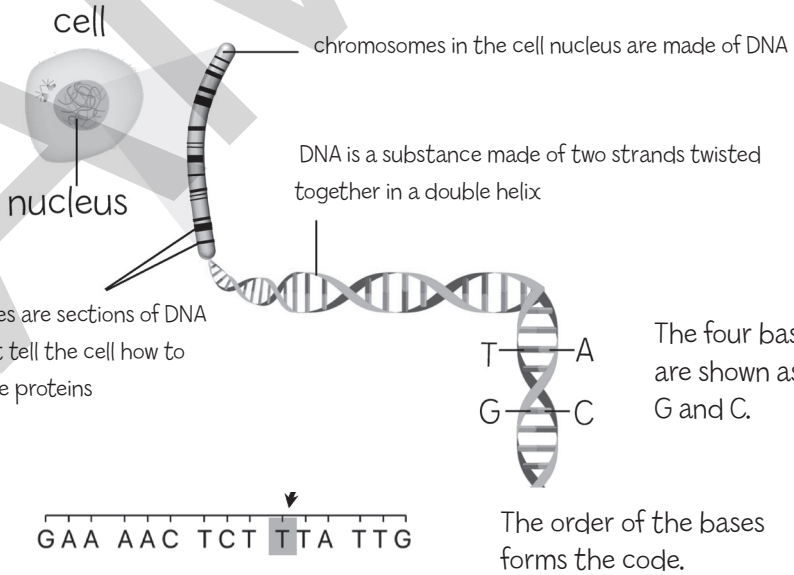
GAA AAC TCT TTA TTG
GAA AAC TCT CTA TTG

There is a difference in the letters in the two strands.

I need to explain how this change results in Sandra not breaking down lactose.
This question is about genes and how they relate to proteins.

Recall

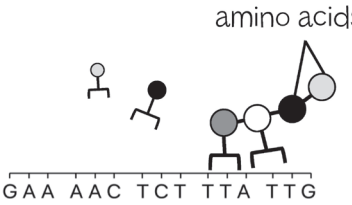
1. How genes are a code, made up of substances called bases.



Sometimes there is a mistake (mutation). One base is added, deleted or substituted for another.

Recall

2. How bases code for amino acids.

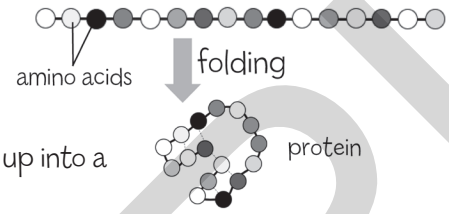


Each group of 3 bases is a code for one amino acid.

Amino acids are brought to the ribosomes in the cell, and join to form a chain.

3. How chains of amino acids make proteins.

Proteins are the molecules that carry out many cell functions. They are made up of chains of amino acids.



The chain folds up into a specific shape.

The order of the amino acids decides the shape the chain folds into. The protein needs to be the right shape to do its job.

Solve

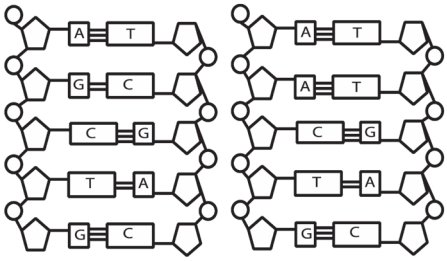
- ✓ **Claim**
- ✓ **Evidence**
- ✓ **Reasoning**

Sandra's DNA has a mutation.
There is a difference in the letters for her gene and the gene for lactase. The base T has been substituted for the base C.
This is a mistake in her DNA, called a mutation.

- ✓ **Claim**
- ✓ **Evidence**
- ✓ **Reasoning**

The protein produced by Sandra's DNA will not do its job of breaking down lactose.
The gene for lactase contains the three bases TTA. Sandra's gene contains CTA.
Each group of three bases is a code for an amino acid.
In Sandra's cells the wrong amino acid will be used in the chain so the order of the amino acids is wrong. The chain will not fold up in the correct way.
The protein made will not have the correct shape so will not be able to do its job, of breaking down lactose, correctly.

1



X Y

Cystic fibrosis is a disease where the body makes sticky mucus.
It is caused by a protein in the cell membrane, called CFTR, which does not work properly.
X shows part of the CFTR gene in a person without cystic fibrosis. Y shows the same part of the gene of a patient with the disease.
Explain why the patient has cystic fibrosis.

2

Melanin produces colour in animal fur.
Tyrosinase is a protein needed to make melanin.

Explain why this deer has white fur.

3

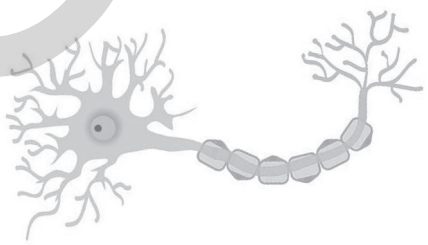
DNA bases	Amino acid
AAT	N
AAC	N
AAA	K
AAG	K
AGT	S
AGC	S
AGA	R
AGG	R

Strand	A	X	Y
	T	T	T
	G	G	G
	A	A	A
	A	A	A
	G	G	G
	C	T	C
	T	T	T
	A	A	A
	A	A	A
	A	A	A
	A	A	A
	T	T	A

There are 20 different amino acids. The table shows how DNA bases code for some of these amino acids. Strand A is normal DNA. Strands X and Y show strands with mutations.

Explain why only the mutation in strand Y affects cell activity.

4



Huntington's disease is a inherited disorder that affects the nervous system. Sufferers cannot make a vital protein for healthy nerve cells.
Now scientists are able to edit genes by changing the order of the DNA bases.
Explain how this could help cure Huntington's disease.

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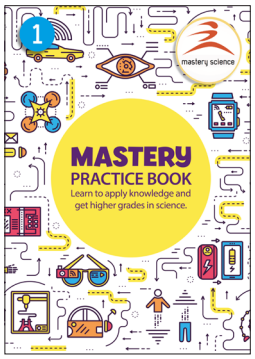
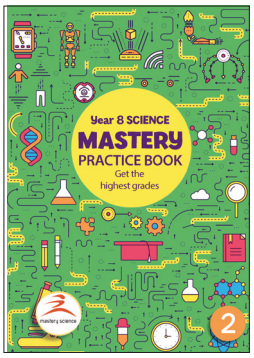


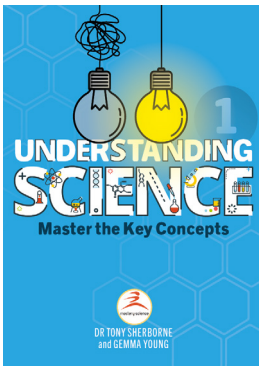
Help students go beyond recalling information and teach them to apply concepts. By starting to practise the strategy of 'Detect, Recall and Solve' from year 7, they will become expert at solving problems by GCSE. This book contains hundreds of questions and covers all the concepts in year 7 of the 5-year plan (Blueprint).

Year 8 Apply Practice Book



Building on 'Detect, Recall, Solve' from year 7, this book teaches the problem-solving process in more detail. It's apply problems, worked examples and 'your turns' cover all the year 8 concepts from the 5-year plan.

Understanding Science 1



Not an ordinary textbook, it's designed using cognitive science to help all abilities grasp the difficult ideas. Understanding Science teaches all the year 7 concepts from the 5-year plan (Blueprint), using visual explanations, thinking and mixed-up questions and full reviews of primary science concepts.

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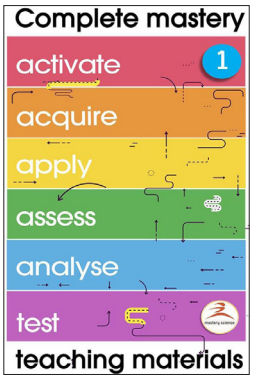

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