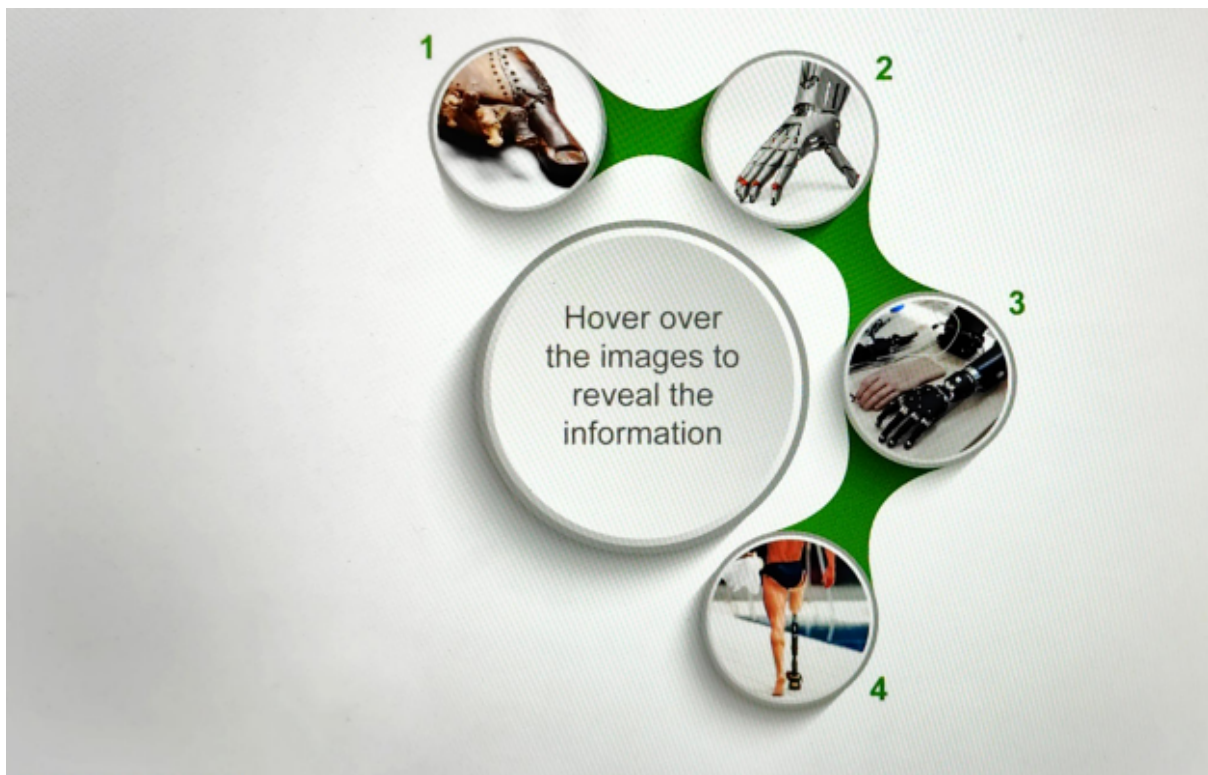


**Question 1 (10 marks)**

Devices have been developed by scientists to replace parts of the human body. These devices are called prosthetics. The earliest known prosthetic was a toe believed to have been used in Egypt around 3000 years ago. Recently, prosthetic hands, arms and legs have become more common and have many different designs, as shown in the images below.

This media is interactive







Question 1a (1 mark)

There is a large demand for prosthetic hands, arms and legs. A child with a prosthetic arm will need to have a new one every one to two years, while adults will only need a replacement if it breaks. **Suggest** a biological reason why children will need regular replacements.

**B** *I* U  $x_2$   $x^2$   $\Omega$   $\Sigma$  Styles

Empty text input area for the answer.





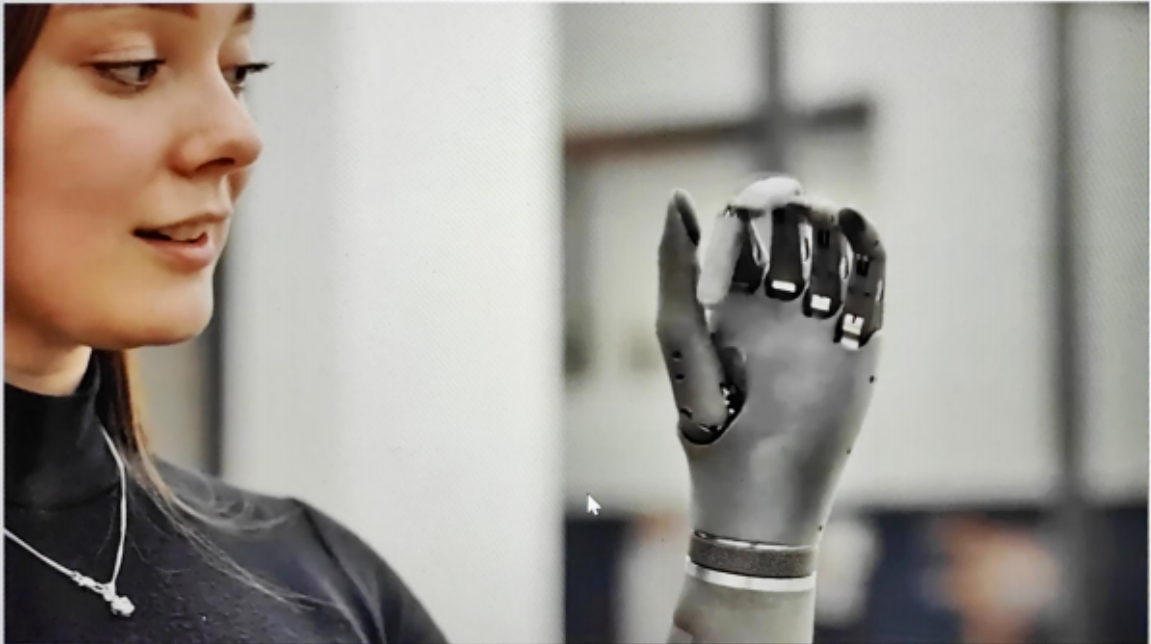
Question 1b (1 mark)

One of the latest developments in prosthetics is the bionic hand. Even when a person does not have a hand, electrical signals to nerves are still being sent from the brain. These electrical signals are picked up by sensors implanted under the skin and are transmitted to the bionic hand. Motors and gears then move the hand in a realistic way.









Select the main energy output of the bionic hand.

- Select
- Select
- Electric
- Gravitational potential
- Kinetic
- Nuclear

Bionic hands help people to carry and grip objects. Different types of bionic hands can carry different masses and have different grip forces. The videos below show a bionic hand gripping and carrying objects.

**Question 1c** (2 marks)

Bionic hands help people to carry and grip objects. Different types of bionic hands can carry different masses and have different grip forces. The videos below show a bionic hand gripping and carrying objects.



This media contains no audio



This media contains no audio



Question 1c (2 marks)

Bionic hands help people to carry and grip objects. Different types of bionic hands can carry different masses and have different grip forces. The videos below show a bionic hand gripping and carrying objects.

This media contains no audio



This media contains no audio



The table below gives some data comparing four types of bionic hand.

	Bionic hands			
	i-Limb	MeHand	Bebionic	ZeusHand
Maximum carrying mass / kg	90	30	45	35
Maximum grip force / N	130	140	140	152

Reset

Using the formula sheet, **calculate** the maximum weight the Bebionic hand can carry. You should assume  $g = 10 \text{ N kg}^{-1}$ .

Rich text editor toolbar with icons for Bold (B), Italic (I), Undo, Redo, Underline (U), Text color, Background color, Bulleted list, Numbered list, Link, Unlink, Styles, and a help icon.



**Question 1d** (2 marks)

Most people do not need to carry more than 20 kg (heavy suitcase) and do not need to have a grip force stronger than 70 N.

Use the data in part (c) to **calculate** how much more mass the i-Limb can carry and how much more grip force the i-Limb gives compared to what a person normally needs.

Mass

**B** *I* ← → U  $\times$   $\times^2$   $\frac{\square}{\square}$   $\frac{\square}{\square}$   $\Omega$   $\Sigma$  Styles -

I

Grip force

Grip force

**B** *I* ← → U  $x_2$   $x^2$   $\int$   $\sum$   $\Omega$   $\Sigma$  Styles





Question 1e (4 marks)

Using the data in part (c), **evaluate** which bionic hand would be the best substitute for a human hand.

**B** *I* | ← → | U  $x_0$   $x^a$  |  $\int$   $\sum$  |  $\Omega$   $\Sigma$  | Styles |

I



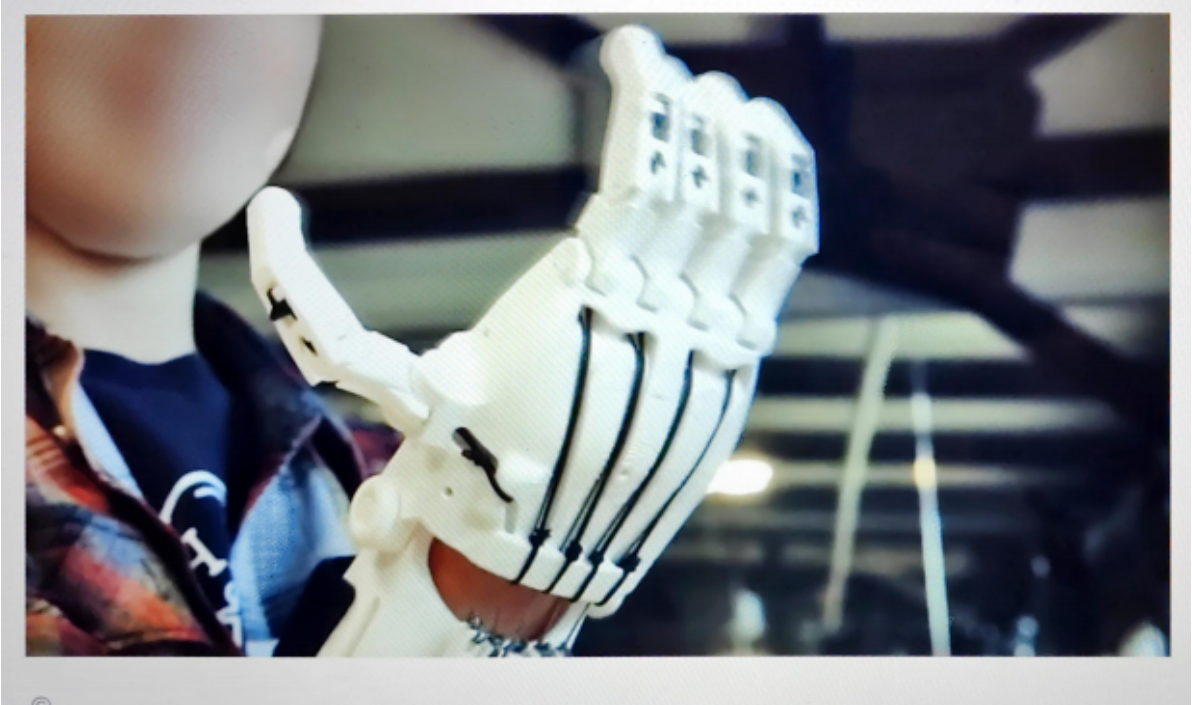
Question 2 (16 marks)



A student has been inspired by studying prosthetics in science class and they want to turn this into a Service Project. The student wants to use a 3D printer to produce prosthetic hands for children in the local community. These hands open and close when the child moves their wrist.



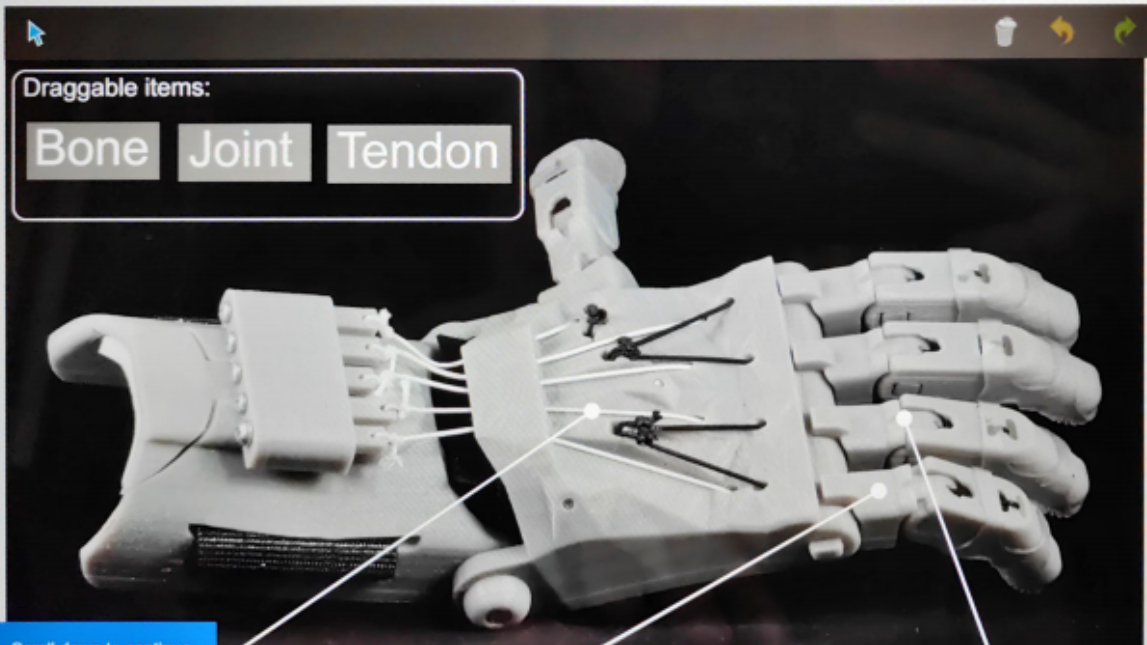
Scroll down to continue





Question 2a (1 mark)

Identify each part of the hand that is being replaced by the prosthetic in the diagram below.

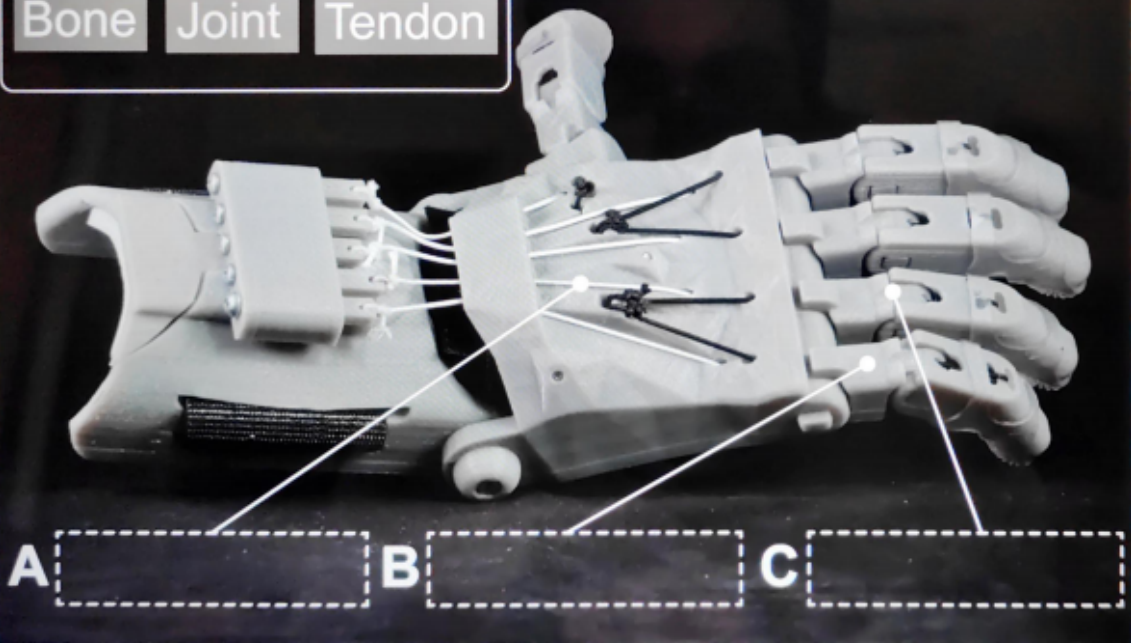


Draggable items:

Bone

Joint

Tendon



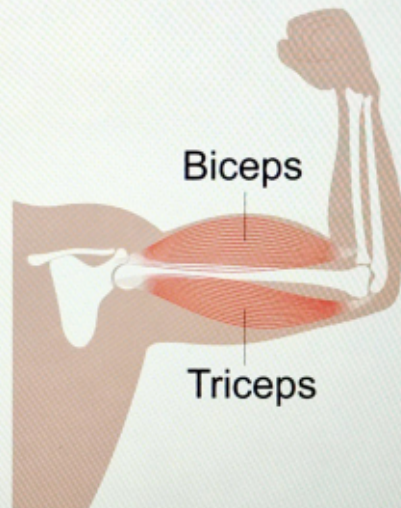


Question 2b (3 marks)

The muscles in the upper arm are called the biceps and the triceps. These are referred to as an antagonistic muscle pair, in which the muscles work to oppose each other. **Outline** how these muscles work to move the lower arm upwards.

**B** *I* ↶ ↷ U  $x_2$   $x^2$   $\int$   $\sum$   $\Omega$   $\Sigma$

Styles -





**Question 2c** (4 marks)


A prosthetic hand does not react to heat in the same way as a human hand. In the human body, the nervous system can react automatically to a stimulus; this is called a reflex. **Explain** what happens at each stage below when your hand touches something hot.




Skin (receptor):

**B** *I* ← → U ×<sub>2</sub> ×<sup>2</sup> ∑ ∑ Ω ∑ Styles -

Sensory neurones:

**B** *I* | ← → | U  $x_0$   $x^2$  |  $\int$   $\sum$  |  $\Omega$   $\Sigma$  | Styles - | 

Motor neurones:

**B** *I* | ← → | U  $x_0$   $x^2$  |  $\int$   $\sum$  |  $\Omega$   $\Sigma$  | Styles - | 

Muscles (effector):

**B** *I* ← → U  $\times_2$   $\times^2$   $\int$   $\sum$   $\Omega$   $\Sigma$  Styles -

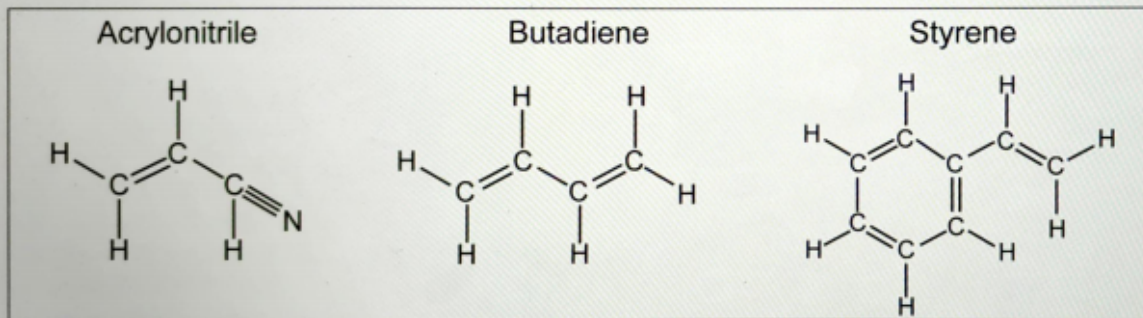




Question 2d (1 mark)

3D-printed hands are often made of ABS (acrylonitrile butadiene styrene). This plastic is resistant to impact and high temperatures.

The structures of the three reactants used to make ABS are shown below.



State the elements in ABS.

Rich text editor toolbar with icons for Bold (B), Italic (I), text color, background color, bulleted list, numbered list, link, unlink, undo, redo, and a Styles dropdown menu.



Question 2e (2 marks)

State the formula for a styrene molecule.

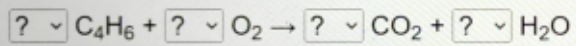
**B** *I* ← → U ×<sub>2</sub> ×<sup>2</sup> ∑ ∏ Ω Σ Styles - ↕





Question 2f (2 marks)

Butadiene (C<sub>4</sub>H<sub>6</sub>) can combust in oxygen (O<sub>2</sub>). **Formulate** a balanced equation for the combustion of butadiene by adding coefficients below.

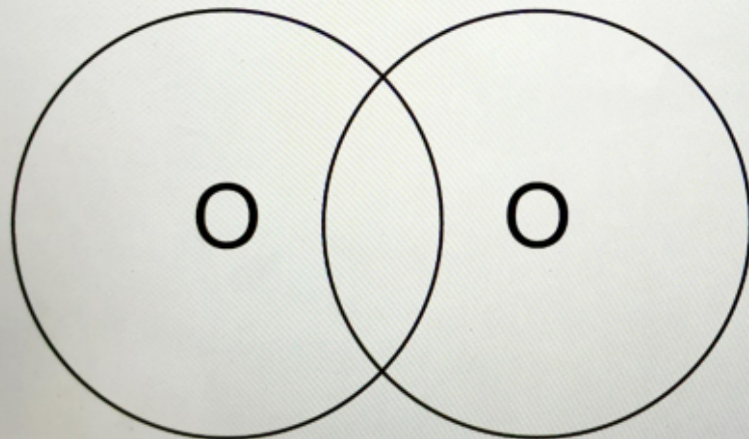
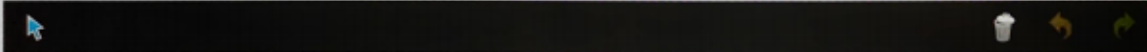


Question 2g (3 marks)



Question 2g (3 marks)

Oxygen molecules are formed by a double covalent bond. Draw a diagram below showing the arrangement of the outer electrons of an oxygen molecule.

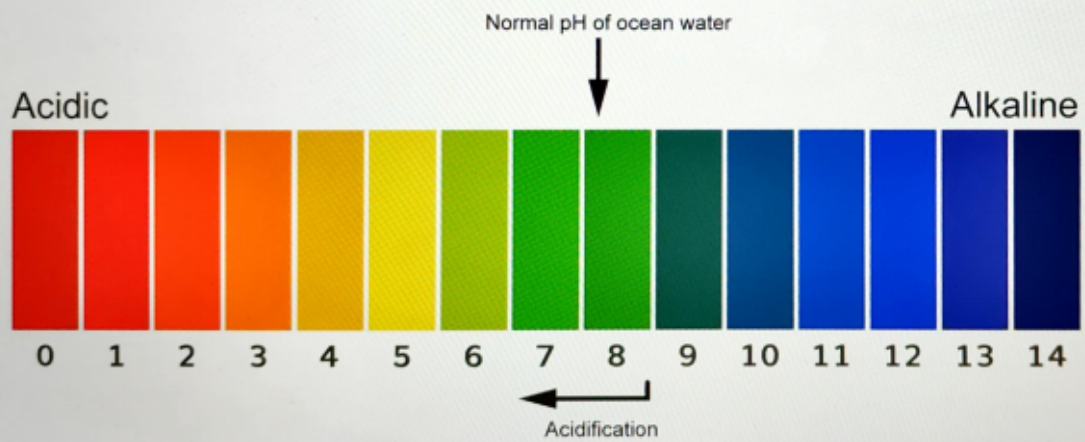


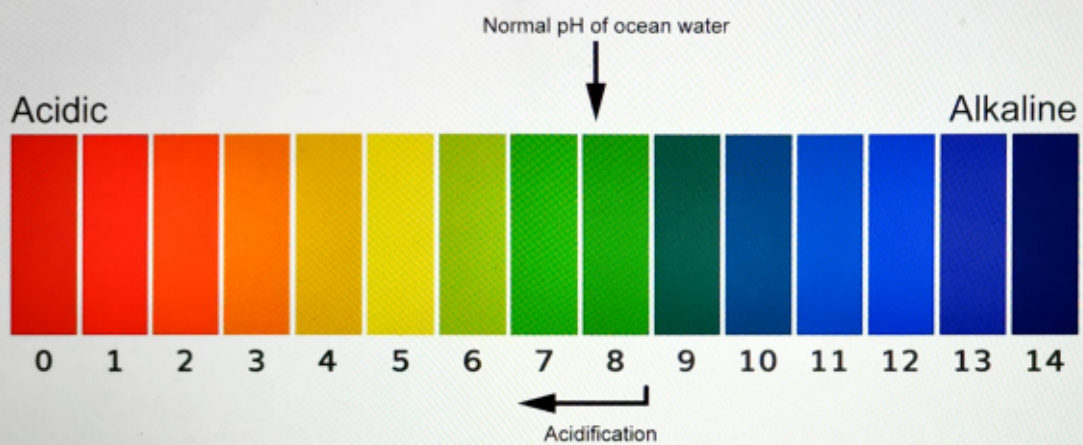
Draggable items



Question 3 (19 marks)

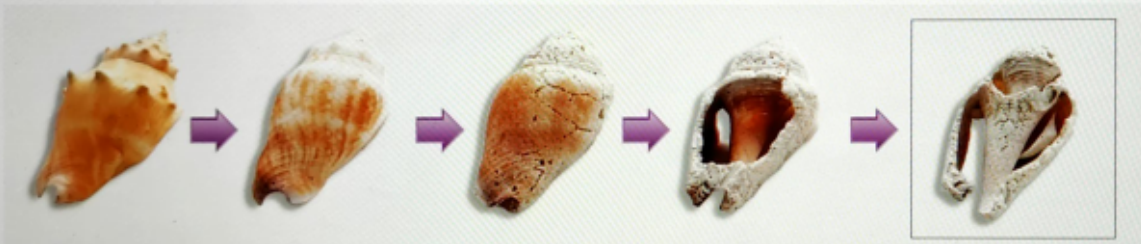
Our climate is changing as more carbon dioxide ( $\text{CO}_2$ ) is being released into the atmosphere. As  $\text{CO}_2$  enters ocean water, it forms carbonic acid. One of the consequences of this process is ocean acidification. Ocean acidification happens when the pH of ocean water drops below its normal value of 8.1.





Ocean acidification will have an impact on biodiversity. Shellfish such as sea snails in the water rely on calcium carbonate ( $\text{CaCO}_3$ ) to build their shells. As the water becomes more acidic, their shells react with the carbonic acid and become thinner and more brittle.

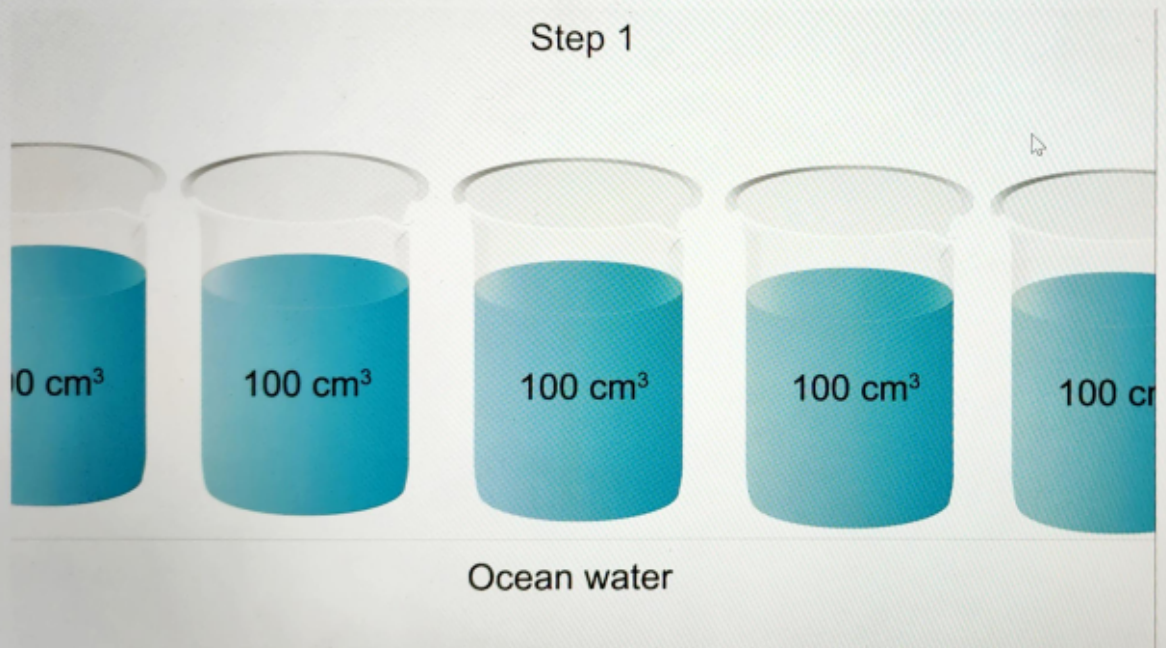
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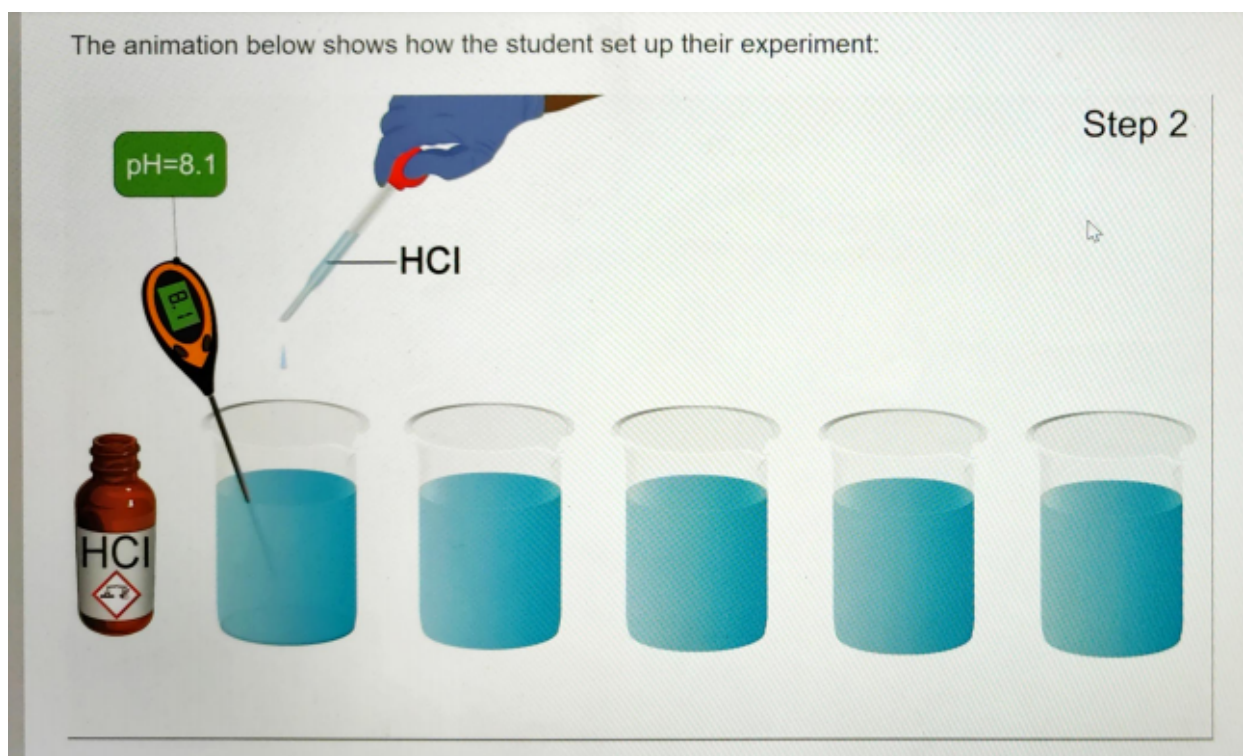
A student planned an experiment to model the effect of increasing acidity of ocean water on shellfish. They used hydrochloric acid ( $\text{HCl}$ ) to increase the acidity of samples of ocean water and studied the change in mass of a shell immersed in the water.

The animation below shows how the student set up their experiment:

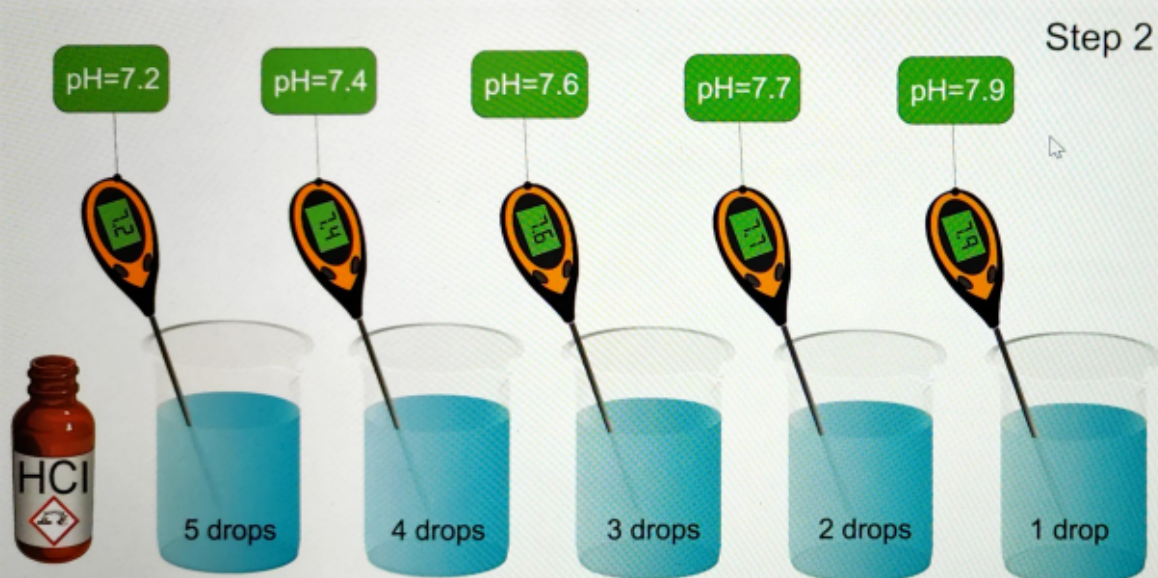
The animation below shows how the student set up their experiment:



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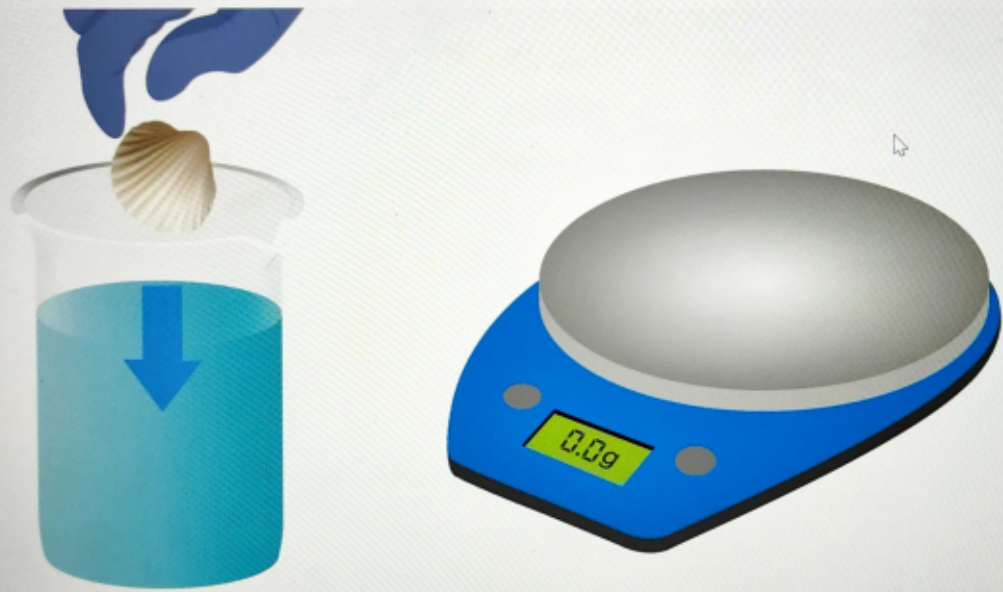
The animation below shows how the student set up their experiment:

Step 3



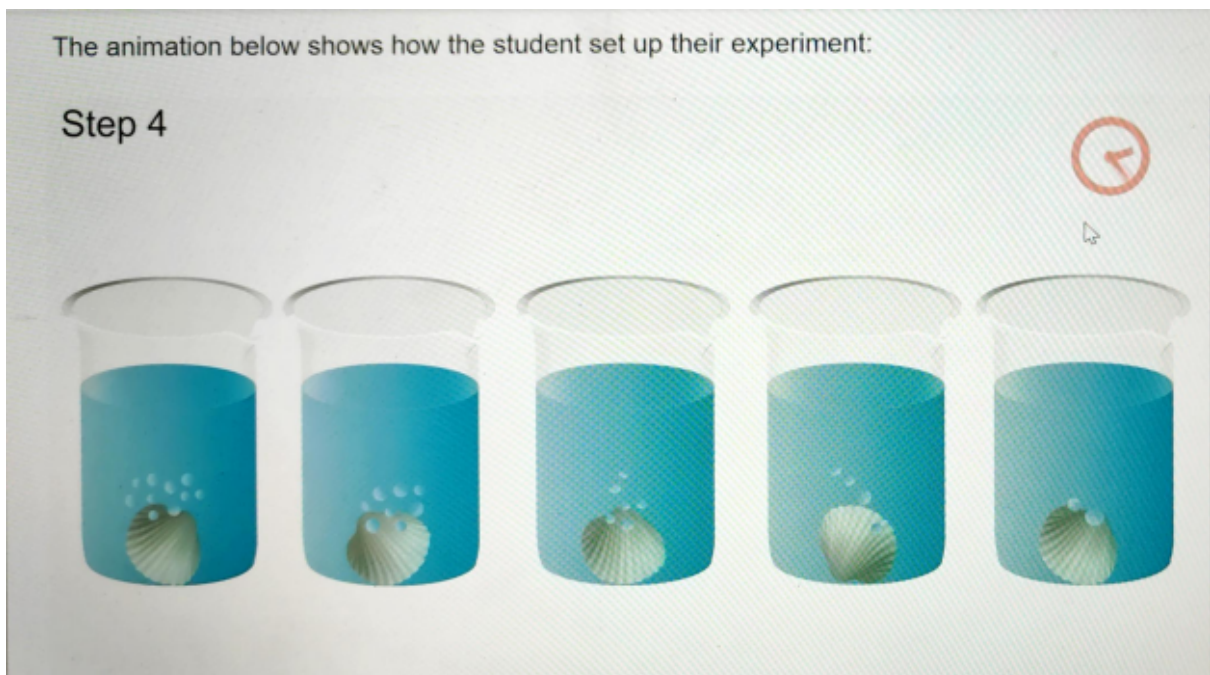
The animation below shows how the student set up their experiment:

Step 4



The animation below shows how the student set up their experiment:

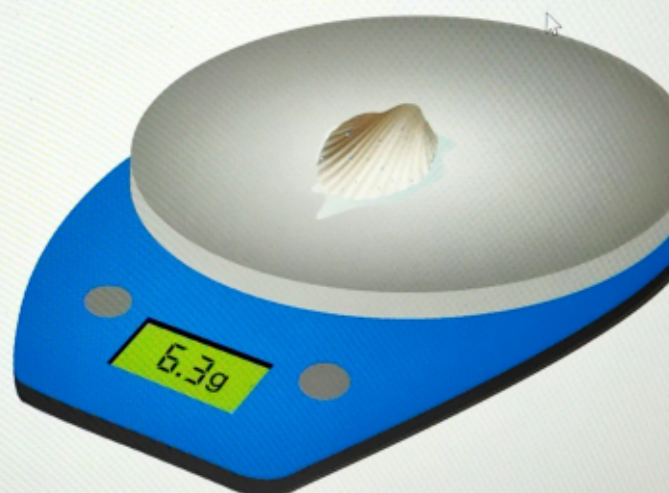
Step 4



The animation below shows how the student set up their experiment:

Step 5

**After 24 hours**





Question 3a (1 mark)

Identify the hazard symbol on the bottle of HCl.



- Select
- Flammable
- Toxic
- Corrosive
- Radioactive
- Select ▾





Question 3b (3 marks)

**Formulate** a testable hypothesis for the student's experiment.

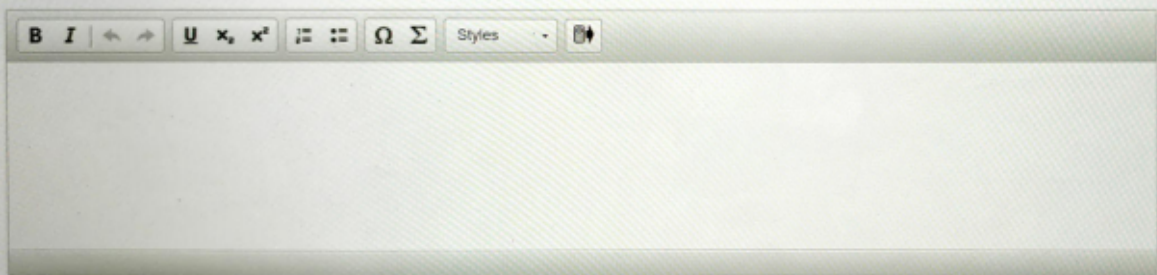
If

**B I**  $\leftarrow$   $\rightarrow$  u  $\times$   $\times^2$   $\dot{=}$   $\ddot{=}$   $\Omega$   $\Sigma$  Styles

Then

**B I**  $\leftarrow$   $\rightarrow$  u  $\times$   $\times^2$   $\dot{=}$   $\ddot{=}$   $\Omega$   $\Sigma$  Styles

Because



A rich text editor toolbar with the following icons from left to right: Bold (B), Italic (I), Undo (left arrow), Redo (right arrow), Underline (U), Subscript (x<sub>2</sub>), Superscript (x<sup>2</sup>), Bulleted List (list with dots), Numbered List (list with numbers), Omega (Ω), Sigma (Σ), a dropdown menu labeled "Styles", and a trash icon.





Question 3c (1 mark)

As well as measuring the change in mass, **suggest** another way the student can tell that a reaction is happening in the animation.

**B** *I* ← → U  $x_0$   $x^e$   $\int$   $\sum$   $\Omega$   $\Sigma$  Styles





Question 3d (4 marks)

**Suggest** two variables the student should control and the equipment they can use to control them.



Variable 1 and equipment

**B I** ← →  x<sub>2</sub> x<sup>2</sup>  := :: Ω Σ

Styles - [icon]

I



Variable 2 and equipment

**B I** ← →  x<sub>2</sub> x<sup>2</sup>  := :: Ω Σ

Styles - [icon]





Question 3e (1 mark)

The results from the student's experiment are shown in the table below:

pH of ocean water	Initial mass of shell / g	Final mass of shell / g	Change in mass / g
7.2	8.2	7.3	0.9
7.4	8.1	7.4	0.7
7.6	8.3	7.8	0.5
7.7	7.6	7.2	0.4
7.9	7.8	7.6	

Reset

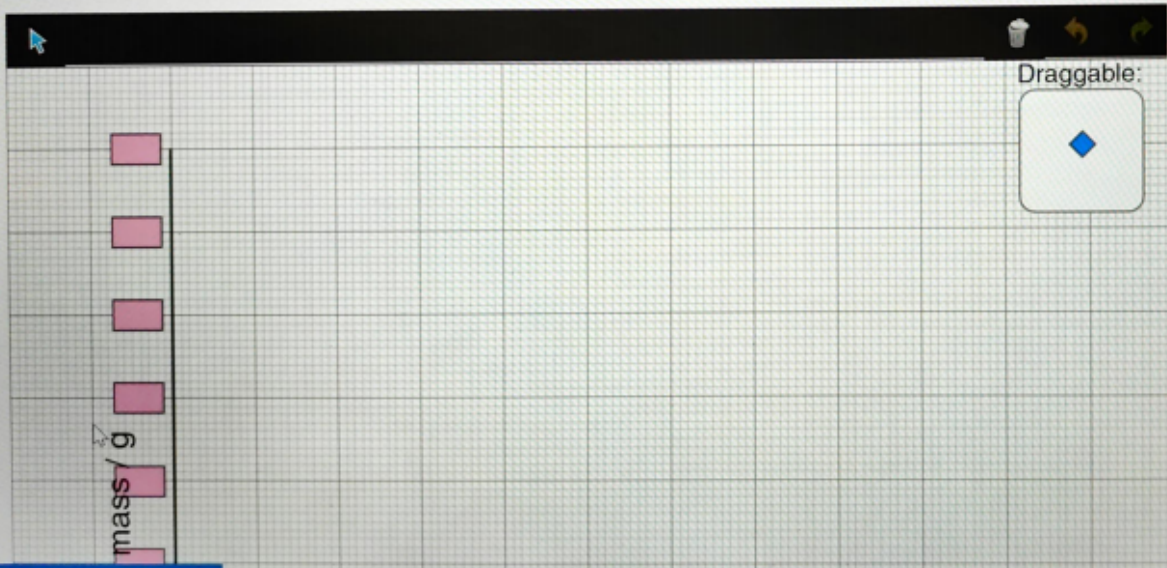
**Calculate** the change in mass for the shell added to the water with pH 7.9.

**B I** | ← → |  x<sub>2</sub> x<sup>2</sup> |  $\int$   $\sum$  |  $\Omega$   $\Sigma$  | Styles - |



Question 3f (5 marks)

Plot the data from the student's experiment on the graph provided. You should also add a title to the graph and scales to the x axis and y axis.







**Question 3g** (3 marks)

**Comment** on the validity of the model to represent the effects of increasing acidity of ocean water on shellfish.

**B I** ← →  x<sub>2</sub> x<sup>2</sup>  := :: Ω Σ

Styles - [icon]

I



**Question 3h** (1 mark)

**Suggest** what additional step the student could have taken before weighing the shells in step 5 that would improve the accuracy of the measurement.

**B I** ← →  x<sub>2</sub> x<sup>2</sup>  := :: Ω Σ

Styles - [icon]



**Question 4** (22 marks)



Ocean acidification affects calcium carbonate ( $\text{CaCO}_3$ ) not only in shells, but also in coral reefs.



**Question 4a** (1 mark)

The Great Barrier Reef is the world's largest coral reef off the coast of Australia. Ocean acidification is impacting the Great Barrier Reef ecosystem.





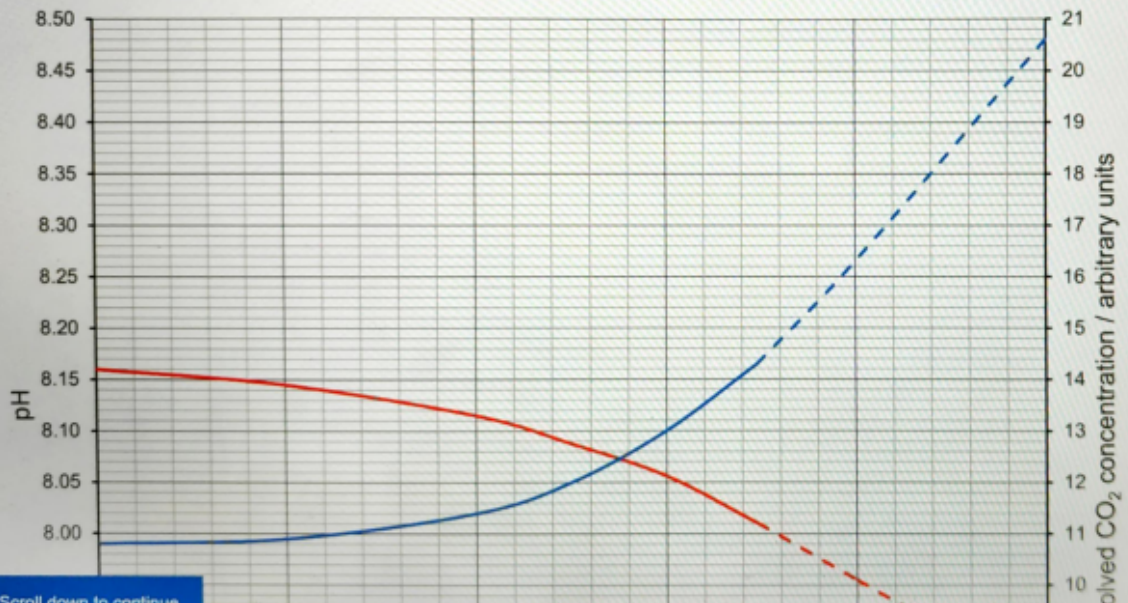
**Question 4a** (1 mark)

The Great Barrier Reef is the world's largest coral reef off the coast of Australia. Ocean acidification is impacting the Great Barrier Reef ecosystem.

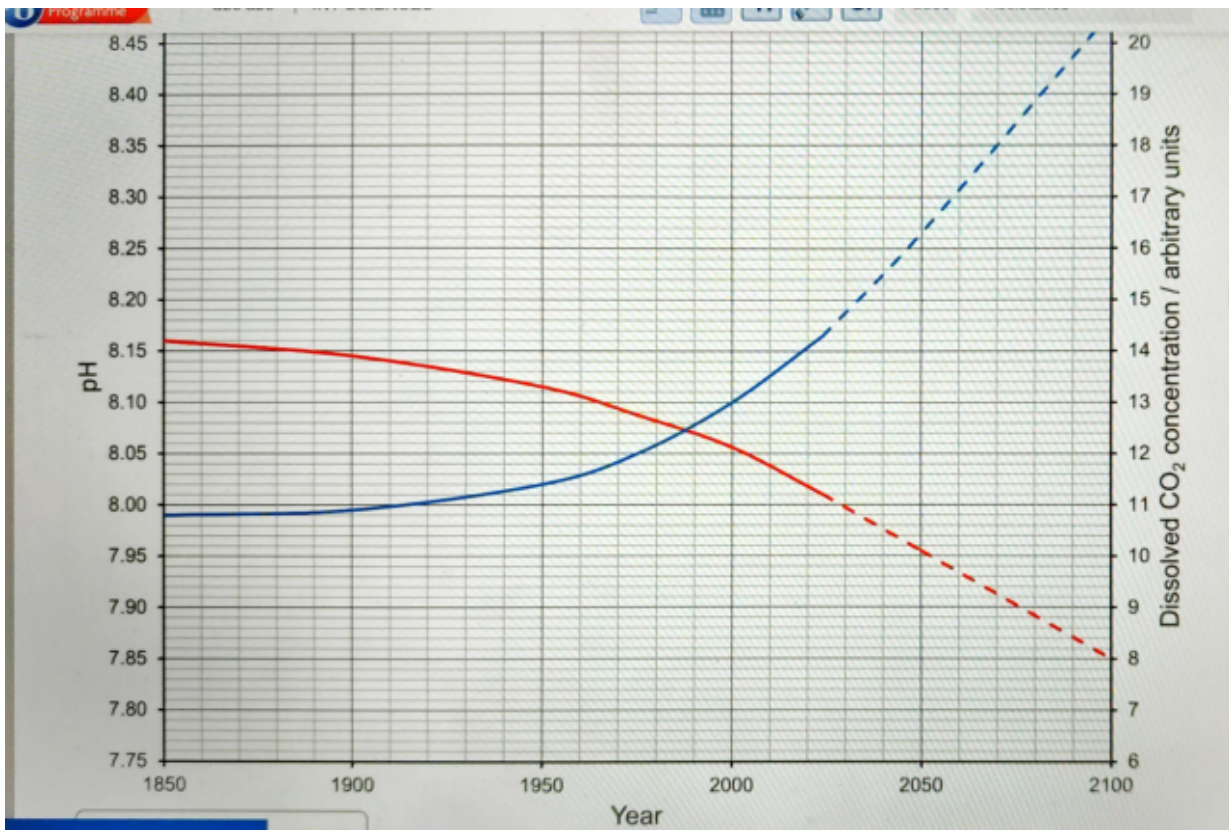


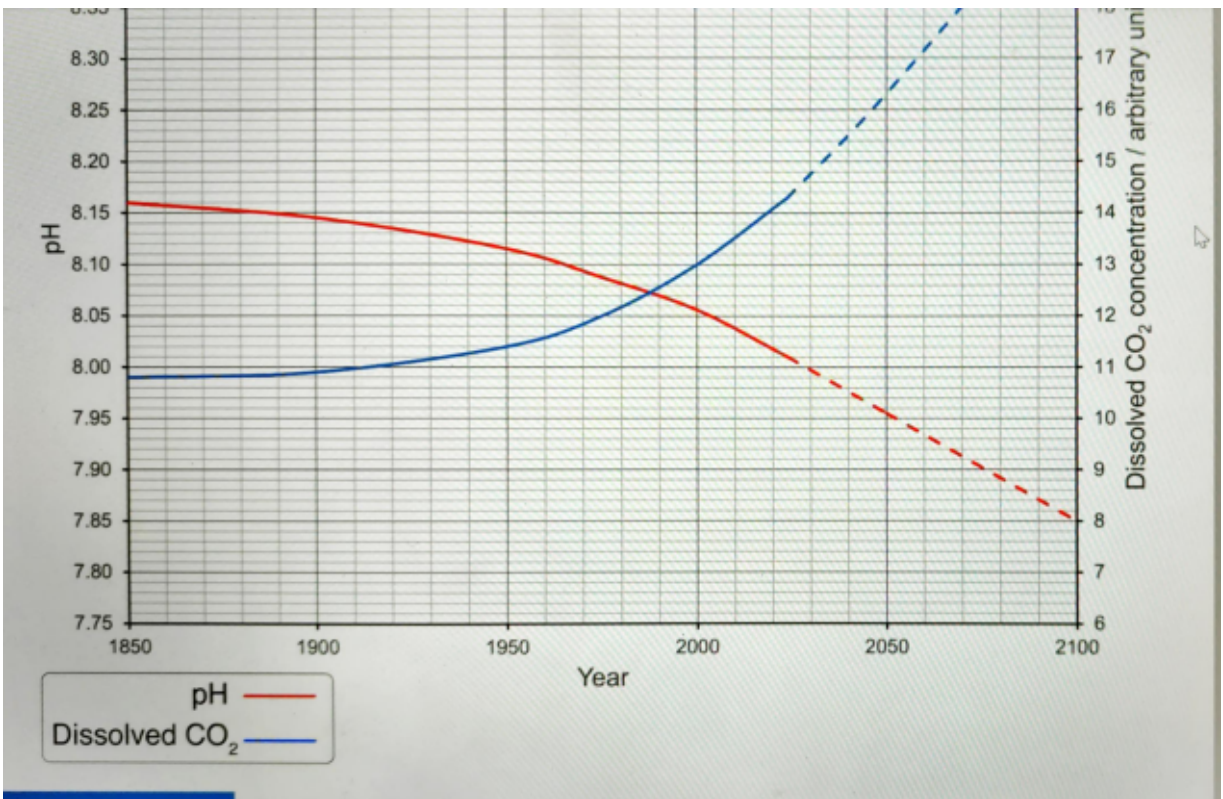
The graph below shows the relationship between dissolved CO<sub>2</sub> concentration and pH values in the Great Barrier Reef area.

### Past and predicted pH and dissolved CO<sub>2</sub>



Scroll down to continue





Arbitrary units

Use the graph to **predict** the pH of the Great Barrer Reef area in the year 2075.

**B** *I* ← → U  $x_0$   $x^2$   $\int$   $\sum$   $\Omega$   $\Sigma$  Styles





Question 4b (3 marks)

**Calculate** the predicted percentage change in dissolved CO<sub>2</sub> concentration between 2000 and 2075. You should give your answer to the nearest whole number. Percentage change can be calculated using the equation:

$$\text{percentage change (\%)} = \frac{\text{final value} - \text{initial value}}{\text{initial value}} \times 100$$

Rich text editor toolbar with icons for Bold (B), Italic (I), Undo, Redo, Underline (U), Bulleted List, Numbered List, Link, Unlink, Styles, and a trash icon. Below the toolbar is a large empty text area for the user's answer.



**Question 4c** (2 marks)

Coral reefs are delicate ecosystems which are highly sensitive to climate change.

A student wishes to model the effect of increased water temperature on the damage to coral reefs. They use a piece of chalk made from  $\text{CaCO}_3$  to represent the coral. They measure the time it takes for the chalk to react completely in acidic ocean water at different temperatures.

**Outline** the student's research question.

**B** *I* ← → U × ×<sup>2</sup> ∑ ∑ Ω Σ Styles -



**Question 4d** (16 marks)

Some of the equipment the student needs to conduct their investigation is shown below:



Acidified ocean water



Chalk



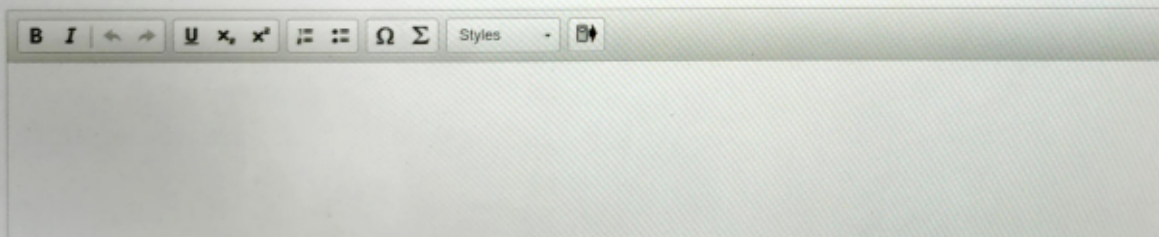
Thermometer

**Design** the student's investigation described in part (c). The student is provided with standard laboratory equipment. In your answer, you should include:

- the independent, dependent and control variables
- any equipment needed

**Design** the student's investigation described in part (c). The student is provided with standard laboratory equipment. In your answer, you should include:

- the independent, dependent and control variables
- any equipment needed
- how the variables will be manipulated to collect sufficient data
- a description of the method used to take measurements
- any safety precautions that should be taken.

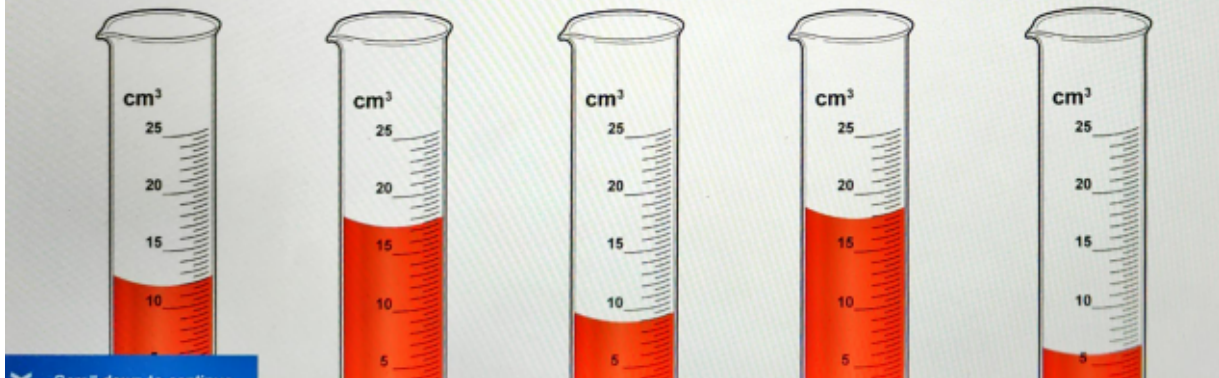


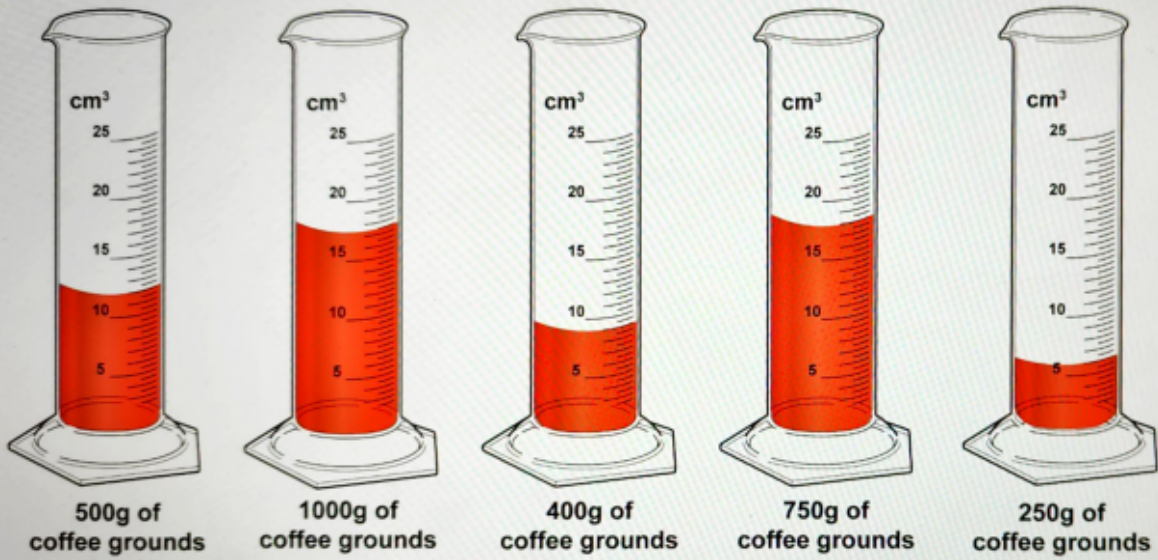


**Question 5a** (3 marks)

The student grew five tomato seeds in different pots. To the first pot of soil, they added 250g of coffee grounds, to the second 400g, to the third 500g, to the fourth 750g and to the fifth 1000g. After three months, the student picked a ripe tomato from each plant and juiced it to measure the volume of juice.

The measurements obtained are shown below:



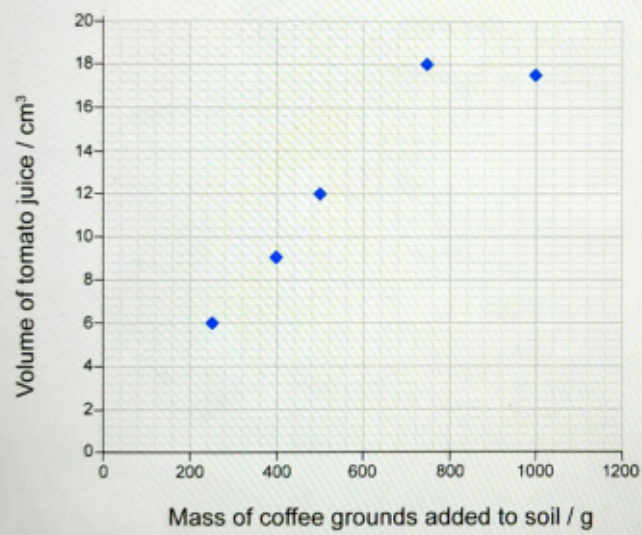


Organize the student's results in a table.



Question 5b (4 marks)

The student presented their data in a graph:



mass of coffee grounds added to soil / g

The student stated:

*The volume of juice obtained from the tomato is directly proportional to the mass of coffee grounds added to the soil for each seed.*

Use the graph to **evaluate** the validity of this statement.

**B I** | ← → |  x<sub>2</sub> x<sup>2</sup> | := :: | Ω Σ | Styles | - | 🗑️



Question 5c (1 mark)

**Suggest** how the reliability of the data in part (a) could be increased.

**B** *I* ← → U  $\times_0$   $\times^2$   $\text{;}$   $\text{:}$   $\text{::}$   $\Omega$   $\Sigma$  Styles



**Question 6** (12 marks)

The video below shows information about the use and applications of the Global Positioning System (GPS) and our reliance on this technology.

Video

Transcript

GPS, or the Global Positioning System, is a network of satellites and GPS-enabled devices used to determine locations on Earth. The use of GPS technology has changed the way we communicate and live.

With a GPS-enabled device, users can quickly determine their precise location, speed and the time.

Initially, the GPS was set up to help the US military to carry out their missions in a secure manner. But now, GPS data has many uses in everyday life too, for example in cell phones, wristwatches, excavators and airplanes. It can be used to help find lost possessions or to tell your friends where you are.

GPS data is used to locate cars or other vehicles and is also used by cell phones to assist

Video

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GPS data is used to locate cars or other vehicles and is also used by cell phones to assist people in mapping and locating unfamiliar places.

Video

Transcript

Initially, the GPS was set up to help the US military to carry out their missions in a secure manner. But now, GPS data has many uses in everyday life too, for example in cell phones, wristwatches, excavators and airplanes. It can be used to help find lost possessions or to tell your friends where you are.

GPS data is used to locate cars or other vehicles and is also used by cell phones to assist people in mapping and locating unfamiliar places.

Use of GPS data increases efficiency in different areas such as agriculture, construction, mining, fishing and package delivery.

GPS can be used to keep track of the elderly, children and pets and also criminals. It can also be used to locate lost or stolen property.



Question 6a (1 mark)

**Suggest** how GPS can be used to increase efficiency when delivering packages.

**B** *I* ↵ ↻ U ×<sub>2</sub> ×<sup>2</sup> ☰ ☷ Ω Σ Styles · 🗑️

I





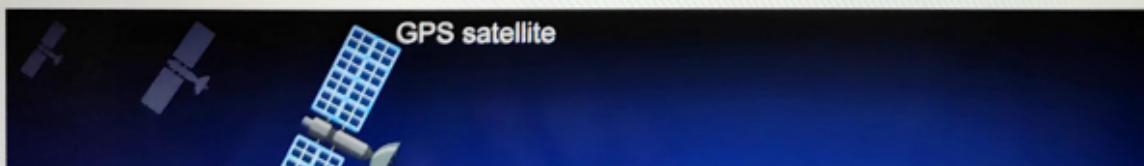
**Question 6b** (2 marks)

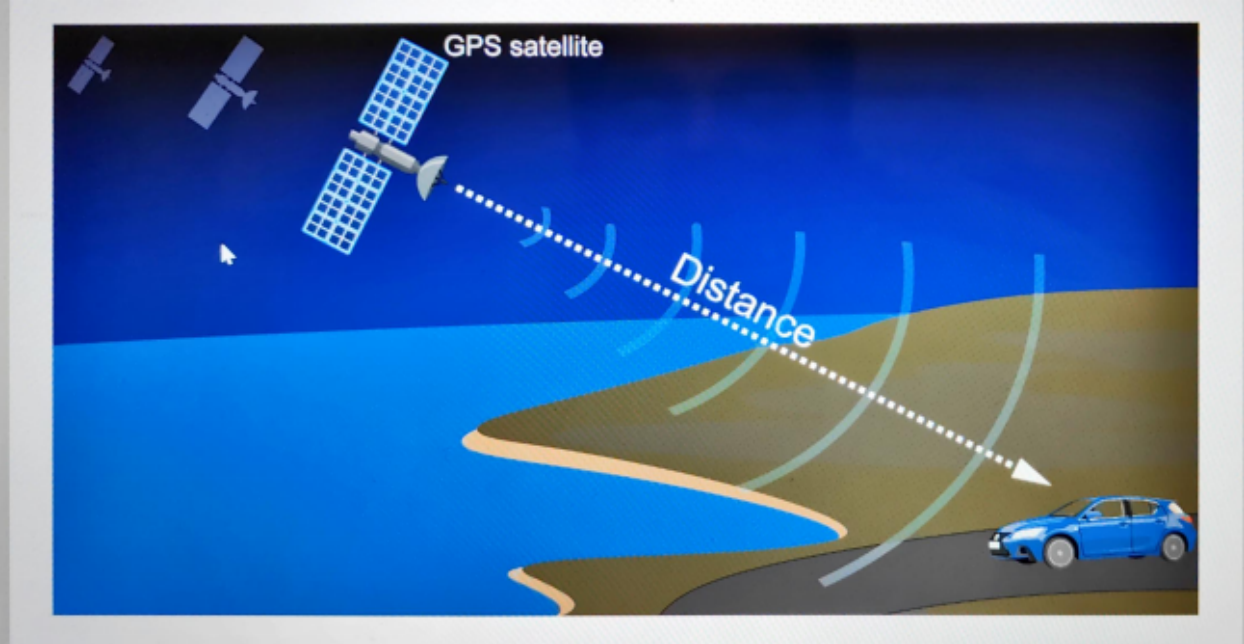
Radio waves are low-energy electromagnetic waves used for long-distance communication. GPS-enabled devices use radio waves to determine location. Signals from multiple satellites are needed to determine an accurate location.

Radio waves travel at the speed of light,  $3 \times 10^8 \text{ m s}^{-1}$ . The distance from the satellites to the GPS-enabled device can be calculated using the speed of the waves and the time the signal takes to reach the device.

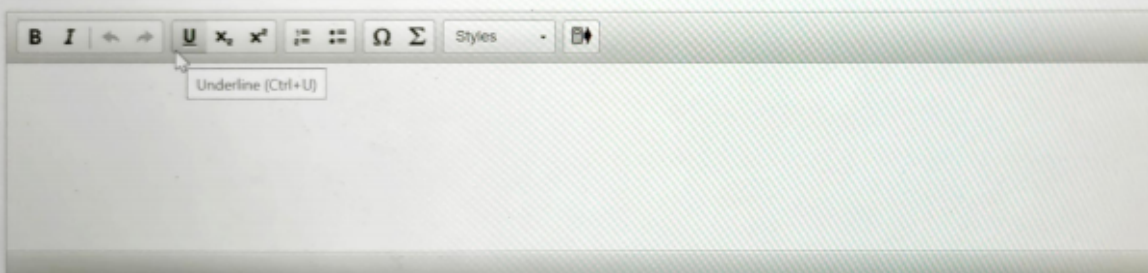
$$\text{distance} = \text{speed} \times \text{time}$$

Diagram not to scale





**Calculate** the distance between the satellite and the GPS-enabled device in the car if the time taken to receive the signal is 0.09 s. You should give your answer in km.



A rich text editor toolbar with various icons for text formatting. The icons include Bold (B), Italic (I), Undo (left arrow), Redo (right arrow), Underline (U), Strikethrough (ABC with slash), Bulleted List (list with dots), Numbered List (list with numbers), Link (Omega symbol), and Unlink (Sigma symbol). There is also a 'Styles' dropdown menu and a 'Send' icon (envelope with arrow). A tooltip is visible over the Underline icon, displaying the text 'Underline (Ctrl+U)'.





Question 6c (4 marks)

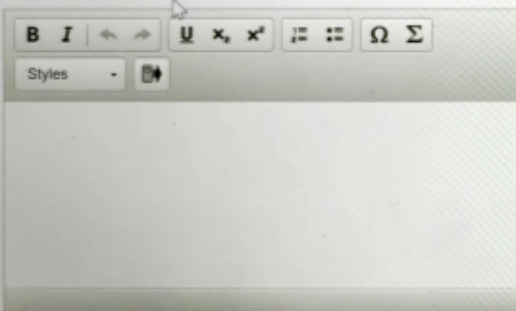
Digital mapping apps such as Google Maps or Waze are used for searching locations and to show distances, routes and arrival times.



**Outline** two advantages and two limitations of the use of digital mapping apps.

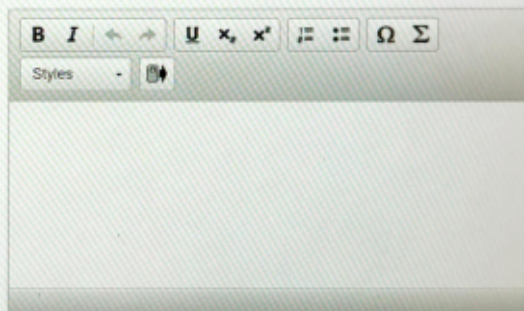


Advantage 1



Limitation 1

Advantage 2



Limitation 2





**Question 6d** (3 marks)

Many people are installing GPS tracking devices in their cars and motorcycles. These tracking devices monitor the vehicle 24 hours a day. Tracking technologies have implications for a user's privacy.



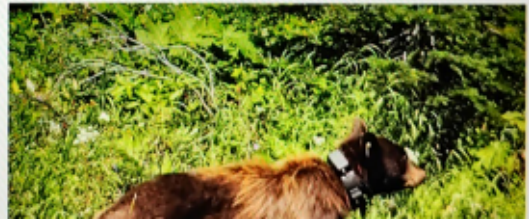


Discuss how this tracking technology could affect a user's privacy.



Question 6e (2 marks)

GPS devices can be also used for animal tracking. Biologists, researchers and wildlife experts use GPS to support conservation efforts. One such GPS-enabled device is the tracking collar shown on the images below. With this tracking collar, movements, behaviours and migratory patterns can be observed.





**Suggest** how this tracking collar could help with the conservation of some species in central Africa.

**B** *I* U Styles

Question 7 (13 marks)

GPS has changed how the world works today. It can be applied in almost all areas of industry, for example by modern fishing companies. Commercial fishing uses GPS data to navigate to fishing locations and data from other devices to map the migration of fish. GPS equipment also captures data about temperature and chlorophyll distribution to help locate fishing zones. However, many local fishermen are still using traditional methods of locating fish.





Using the information provided and knowledge from your MYP studies, **discuss** and **evaluate** the impact of GPS technology on commercial fishing. In your answer, you should include:

- a discussion of the impacts on the ecosystem
- positive economic impacts
- negative economic impacts
- an outline of how GPS technology can be used responsibly.

