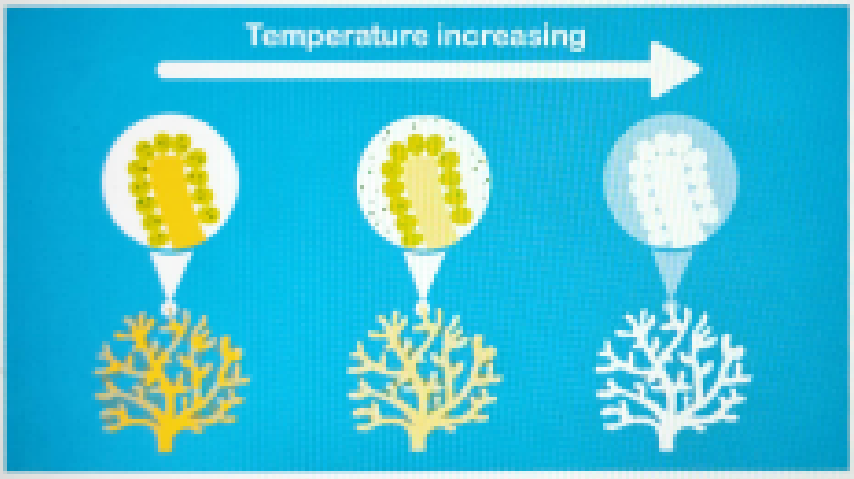
**Question 1** (10 marks)

One reason our planet is so beautiful is due to the range of colours found in nature. Colours in plants and animals are caused by pigments, which can be affected by environmental conditions.

Healthy coral reefs are very colourful. The colour of coral comes from microscopic plant-like organisms called algae that live on the coral.

Increased water temperatures will impact the algae living on coral. As the temperature increases, the algae will leave, resulting in the coral becoming white.



**Question 1a** (2 marks)

Algae carry out photosynthesis to produce glucose, which is used for food by the coral. The word equation for the process of photosynthesis is:

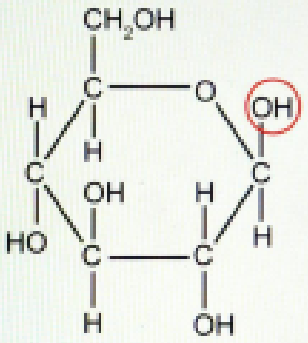
water + carbon dioxide → glucose and oxygen

**Select** the correct coefficients to balance the chemical equation for photosynthesis.

$$\boxed{?}\,H_2O + \boxed{?}\,CO_2 \rightarrow \boxed{?}\,C_6H_{12}O_6 + \boxed{?}\,O_2$$

**Question 1b** (1 mark)

Below is the structure of glucose, $C_6H_{12}O_6$. **Identify** the functional group that is circled.




B I U Ω Σ Styles

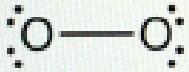
**Question 1c** (1 mark)

Through photosynthesis, the algae also provide the coral with oxygen. **Select** the Lewis (electron dot or dot and cross) structure for $O_2$.

Select

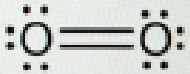
A.

B.



C.

D.



**Question 1d** (1 mark)

Leaves also produce pigments. Each pigment is responsible for a different colour. The hours of sunlight received have an impact on how much of each pigment is being produced by the plant or tree.

Pigment A

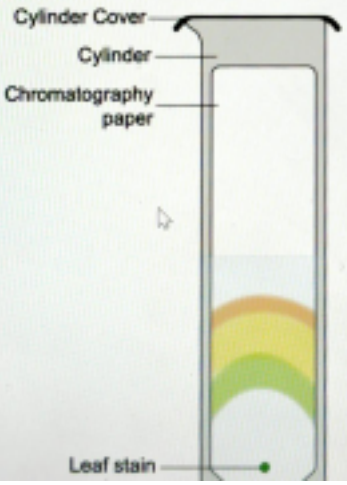
Pigment B

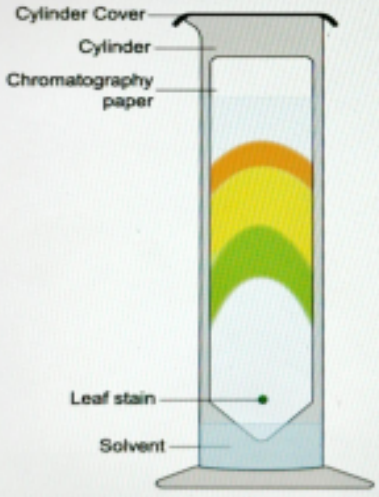
Pigment C

Pigment D

We can use chromatography to find out which colour pigments are in the leaf at different times of the year. The animation below shows how the pigments in a leaf are separated by the process of chromatography.

**This media contains no audio**



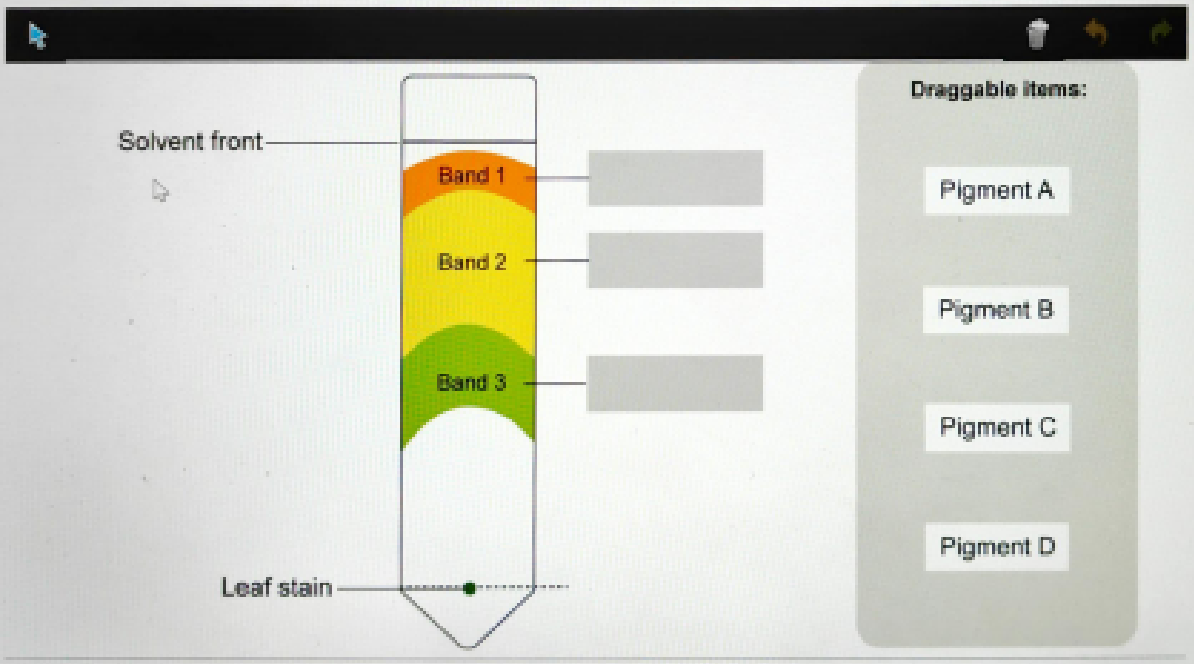

Select the term that best describes the leaf stain used in this animation of chromatography.

**Select** the term that best describes the leaf stain used in this animation of chromatography.

Select
- Select
- An element
- A mixture
- An alloy
- An allotrope

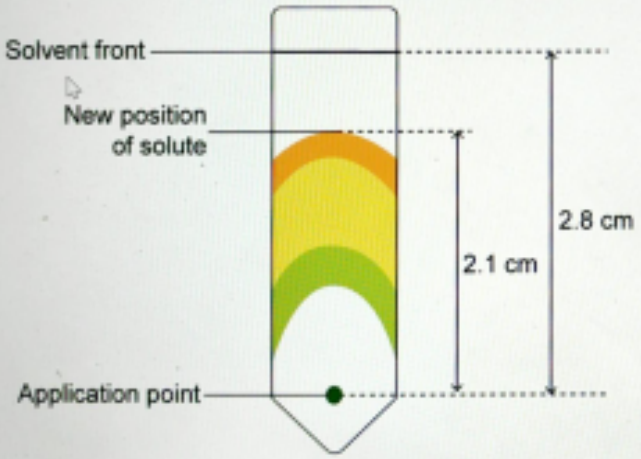
(2 marks)

**Identify** the organic pigments.



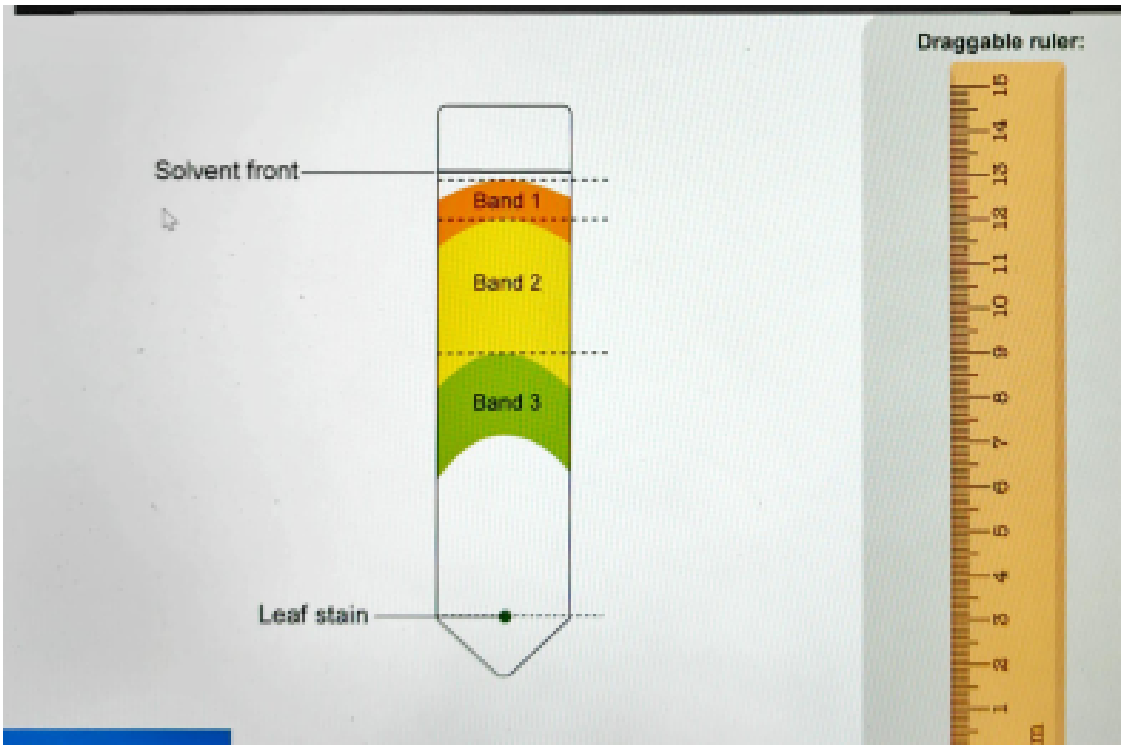
**Question 1f** (3 marks)

The $R_f$ value is the ratio of the solute's distance travelled to the solvent's distance travelled.
The following diagram shows how the $R_f$ value is calculated.




$$R_f = \frac{2.1}{2.8} = 0.75$$

Using the ruler in the diagram below, **calculate** the $R_f$ value for band 1.

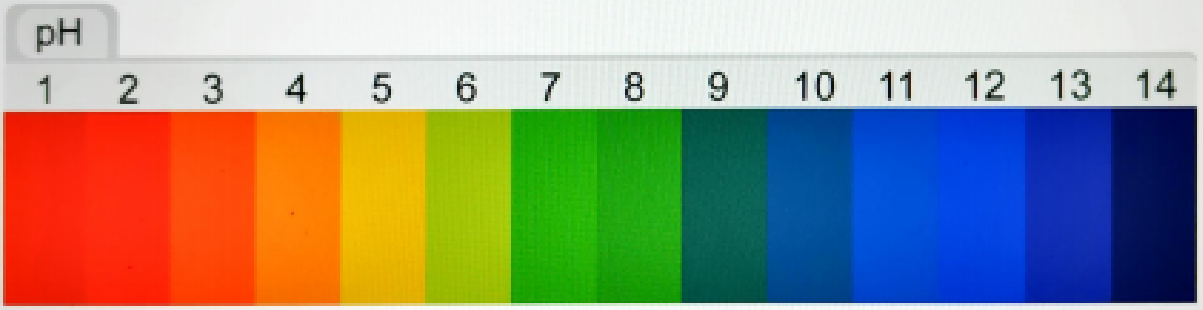


**Question 2** (9 marks)

Hydrangea flowers are known for changing colour in response to changes in soil pH.

**Question 2a** (1 mark)

To measure the soil pH, a pH probe or universal indicator could be used.




| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**Select** the pH of universal indicator when added to pure water.

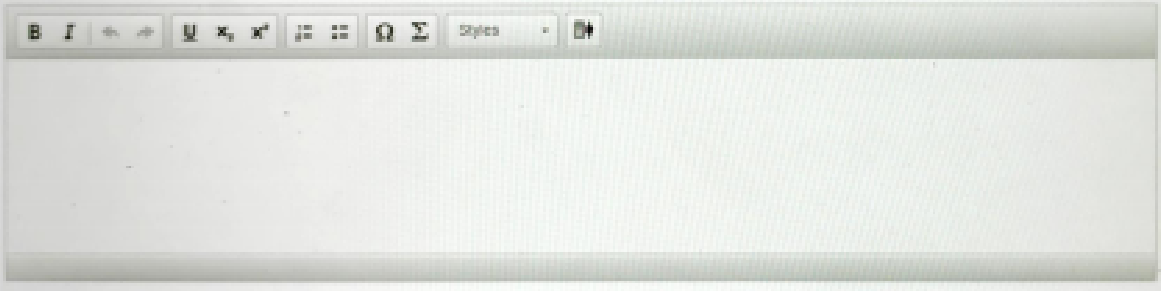
**Question 2b** (2 marks)

Sulfuric acid ($H_2SO_4$) can be used to decrease the pH of the soil, and calcium carbonate ($CaCO_3$) to increase it. Hydrangea flowers are blue in soil with a pH of 5.5 or lower and pink if soil pH is 7 or higher.

**Outline** how you could grow blue flowers if the soil has pH = 6.


**Question 2c** (2 marks)

Calcium carbonate is a metal carbonate. Using the periodic table, **calculate** the molar mass of calcium carbonate.



**Question 2d** (2 marks)

Calcium carbonate can be used to neutralize sulfuric acid, which produces a salt.

**Select** the other two products that are formed when acid is neutralized by a metal carbonate:

sulfuric acid + calcium carbonate → salt + product A + product B

Product A: Select

Product B: Select

**Question 2d** (2 marks)

Calcium carbonate can be used to neutralize sulfuric acid, which produces a salt.

**Select** the other two products that are formed when acid is neutralized by a metal carbonate:

sulfuric acid + calcium carbonate → salt + product A + product B

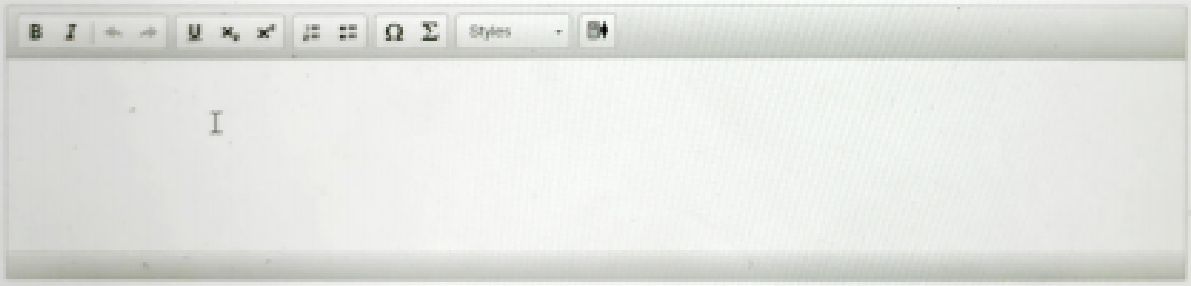
Product A: Select

Product B:

- Select
- CO
- $CO_2$
- $H_2O$

**Question 2e** (1 mark)

**Determine** the formula of the salt that is produced when calcium carbonate neutralizes sulfuric acid.




**Question 2f** (1 mark)

**State** the pH of a solution of the salt produced in part (e).

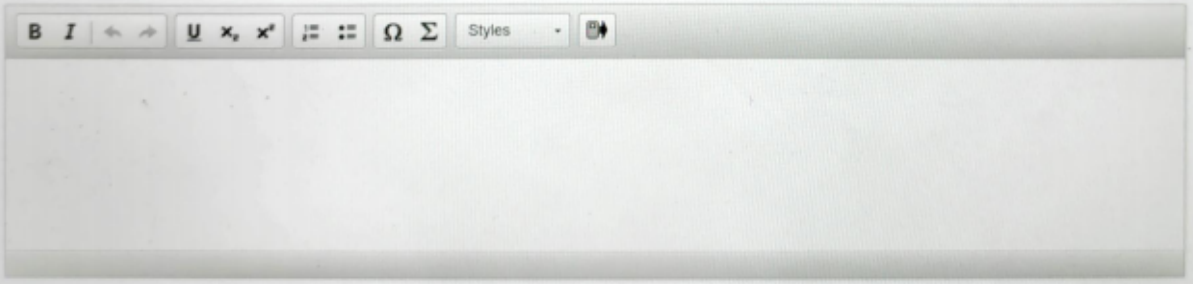
**Question 3** (9 marks)

Some farming techniques can have a significant impact on nature and can change environmental conditions. The image below shows a tractor working on a farm.

The heat generated by the engine in a tractor causes nitrogen and oxygen from the air to react to produce nitrogen monoxide gas as an emission.

**Question 3a** (2 marks)

**Write down** the balanced chemical equation when nitrogen monoxide is formed by the reaction of nitrogen and oxygen.



**Question 3b** (1 mark)

In the box below, **draw** a diagram showing the arrangement of particles in a gas.

Draggable items:

**Question 3c** (2 marks)

**Outline** how particles move in a gas.

**Question 3d** (4 marks)

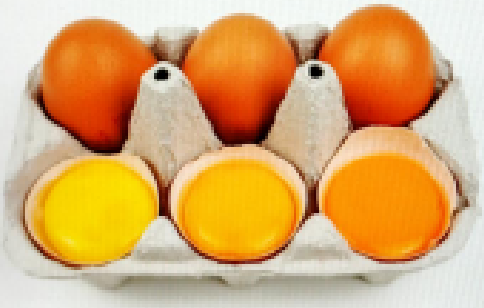
Even though a tractor is slow and does not travel far, the emitted nitrogen monoxide can pollute a large area, even without wind.

**Explain** why the emission can pollute a large area. You should use scientific terminology in your answer.

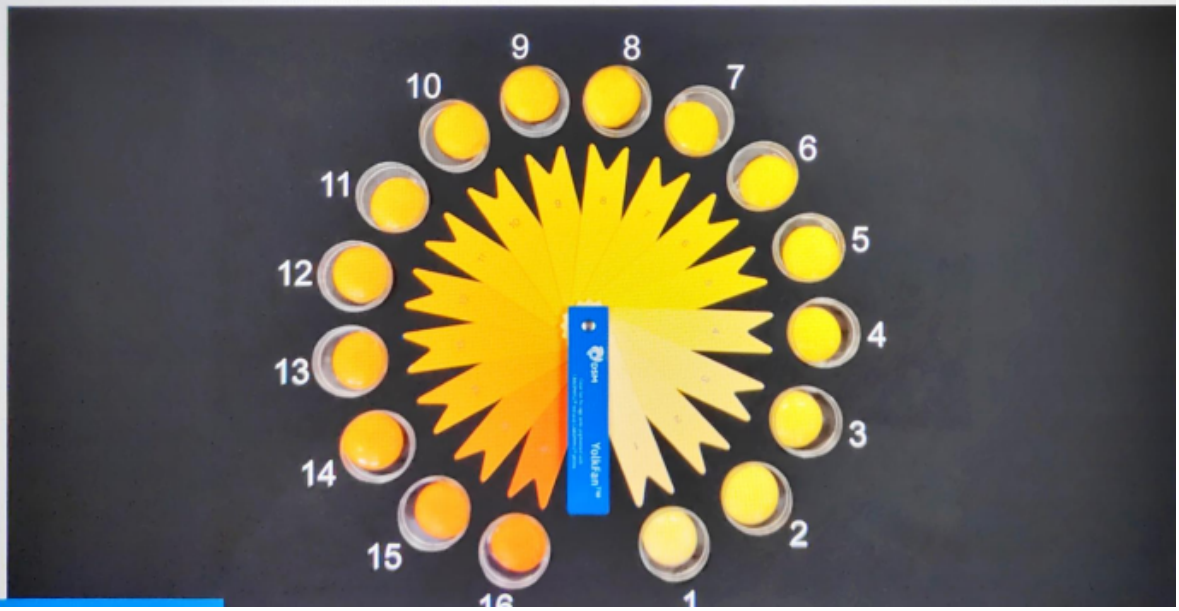
**Question 4** (9 marks)

Chicken eggs are commonly eaten either whole or as an ingredient in a recipe. When we crack open an egg, we are immediately aware of the yolk's colour and make a judgement about whether the egg is safe to eat.

In the picture of the three eggs below, the yolks are different colours.



The difference in colour of the yolks is due to the chicken's diet. Farmers use a qualitative measuring tool called a YolkFan™ to compare the colour of the yolks. Consumers prefer a yolk colour between 7 and 9. The farmer can change the colour of the yolk by adding yellow and red organic pigments as additives to the chicken's diet.




**Question 4a** (1 mark)

Two students are investigating the colour of eggs laid by the same chicken. One student uses a colorimeter, the other uses the YolkFan™ scale.

**Justify** which method gives a better measurement of the colour of the yolk.

B I U $x_2$ $x^2$ Ω Σ Styles

**Question 4b** (3 marks)

The table below shows how additives can change the yolk colour.

| YolkFan™ score | Yellow pigment / *ppm | Red pigment / ppm |
|---|---|---|
| 8 | 7.5 | 0.5 |
| 9 | 7.5 | 1 |
| 10 | 7.5 | 1.5 |
| 11 | 7.5 | 2 |
| 12 | 9 | 3 |
| 13 | 10.5 | 4 |
| 14 | 10.5 | 5 |
| 15 | 10.5 | 5.5 |
| 16 | 12 | 8 |

*ppm - Parts per million, a unit used to measure very low concentrations.

A student wants to determine how the yolk colour changes with additives. Using the information in the table, **formulate** the student's hypothesis.

A student wants to determine how the yolk colour changes with additives. Using the information in the table, **formulate** the student's hypothesis.

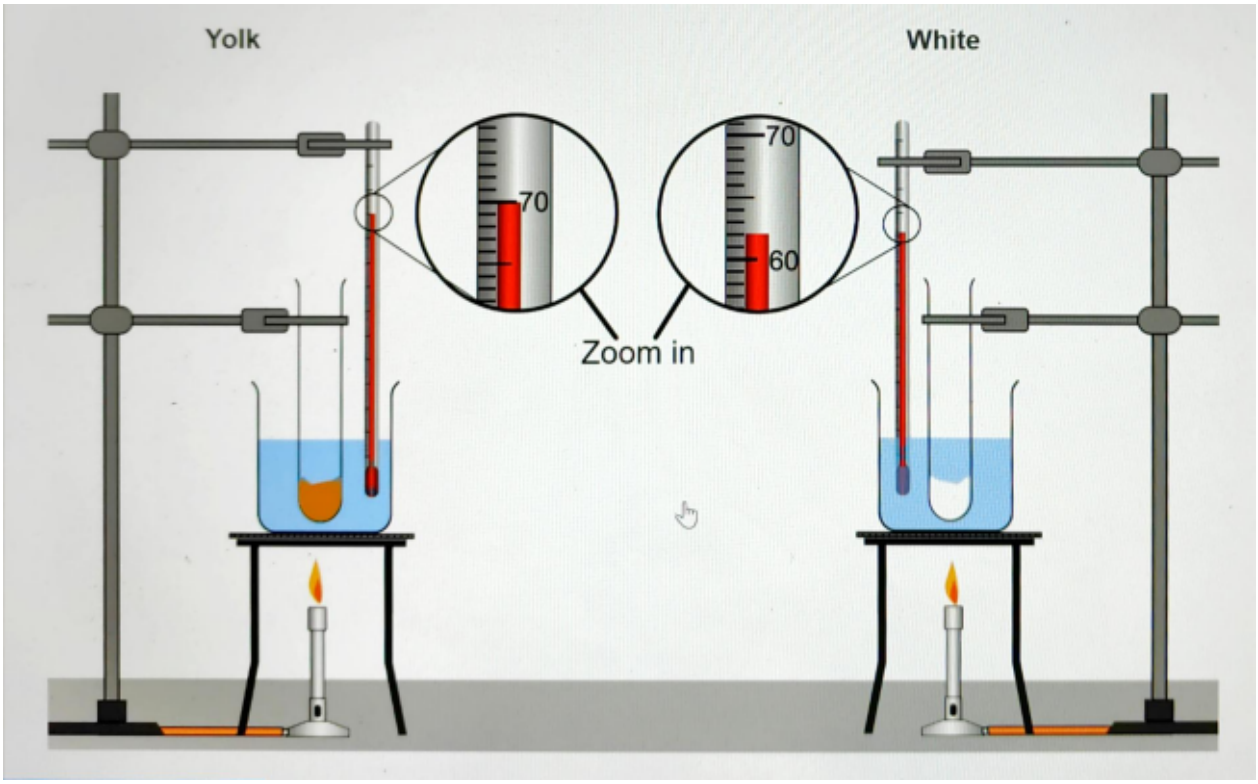
If

Then

**Question 4c** (1 mark)

Eggs are often used in cooking. They can be used whole or separately as the yolk or white. The proteins in the yolk and the white have different chemical and physical properties. When they are heated, these proteins denature and become solid. A student separated an egg into the yolk and white, heated each one and measured the temperature when the proteins became solid. The results are shown below.

**This media is interactive**

**Measure** the temperature at which the egg white becomes denatured. Add your value to the table.

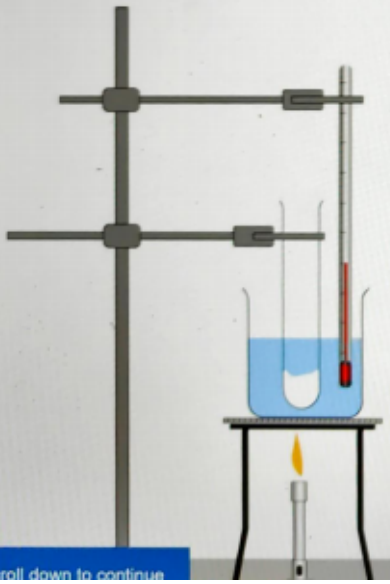
| | Starting temperature / °C | Temperature at which protein is denatured / °C |
|---|---|---|
| Yolk | 20 | 70 |
| White | 20 | |

Reset

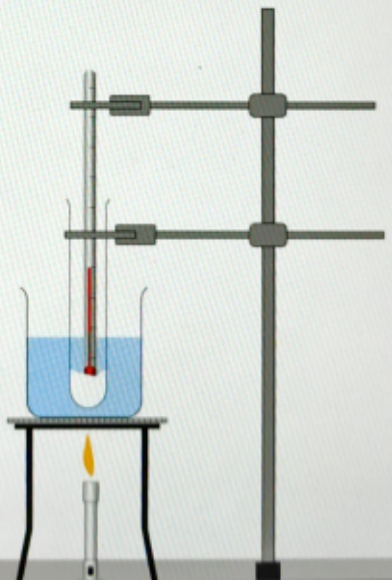
**Question 4d** (1 mark)

The diagram below shows two different methods for measuring temperature.

**Method A**



**Method B**



Scroll down to continue

**Select** which method would produce the most valid measurement of the temperature at which the proteins denature. **Justify** your answer.

Select

Justification:

B I U $x_2$ $x^2$ Ω Σ Styles

**Question 4e** (3 marks)

**Predict** the temperature for a mixture of yolk and white to denature. **Justify** your answer.

B I U $x_2$ $x^2$ Ω Σ Styles

**Question 5** (8 marks)

One method of food preservation is pickling, in which the food is soaked in vinegar. Cooked peeled eggs can be pickled. When pickling, care has to be taken that the white of the eggs stays tender and the yolk keeps its yellow colour.

A student has decided to investigate the effect of vinegars with different pH on pickled eggs. They read a research paper. In this paper, the taste and tenderness scores were given by a trained panel consisting of a group of people who gave a score out of 10, where 10 is the best score. The average of the values for each vinegar was calculated and is shown in the following table.

A student has decided to investigate the effect of vinegars with different pH on pickled eggs. They read a research paper. In this paper, the taste and tenderness scores were given by a trained panel consisting of a group of people who gave a score out of 10, where 10 is the best score. The average of the values for each vinegar was calculated and is shown in the following table.

| Solution | Average starting pH of the solution | Average pH of egg whites after 3 weeks | Average panel score for taste | Average panel score for tenderness |
|---|---|---|---|---|
| Apple cider vinegar, 1.5% salt | 3.3 | 4.0 | 6.3 | 6.3 |
| Red wine vinegar, 1.5% salt | 3.0 | pH meter not working | 5.0 | 7.3 |
| Distilled white vinegar, 1.5% salt | 2.6 | 4.2 | 6.3 | 5.2 |

**Question 5a** (4 marks)

**Identify** the independent variable, dependent variable and two control variables for this investigation.

Independent variable:

B I U $x_2$ $x^2$ Ω Σ Styles

Dependent variable:

**Question 5b** (2 marks)

**Suggest** a suitable research question for this investigation.

B I U $x_2$ $x^2$ Ω Σ Styles

**Question 5c** (1 mark)

The starting pH of the cooked egg white was pH = 7. **State** what happens to the pH of the egg whites after pickling with apple cider vinegar.

B I U $x_2$ $x^2$ Ω Σ Styles

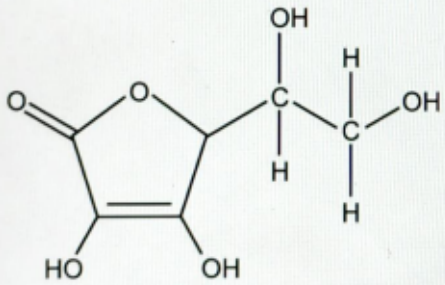
**Question 5d** (1 mark)

The student was surprised that there was no value for the pH of egg white after being pickled for three weeks with red wine vinegar. **Suggest** an improvement to the method to increase the validity of the data.

B I U $x_2$ $x^2$ Ω Σ Styles

**Question 6** (14 marks)

Vitamin C is an essential nutrient without which the body cannot function. The stability of the vitamin C structure is dependent upon environmental conditions such as temperature and oxygen availability. In the presence of oxygen, vitamin C oxidizes, causing it to break down. The structure of vitamin C is shown below.




**Question 6a** (5 marks)

The table below shows the vitamin C concentration of some juices.

| Juice sample | Vitamin C concentration / mg 100cm$^{-3}$ of juice |
|---|---|
| Apple | 20 |
| Pink grapefruit | 82 |
| Beetroot | 68 |
| Red cabbage | 60 |
| Tomato | 23 |

**Present** this data in a graph.

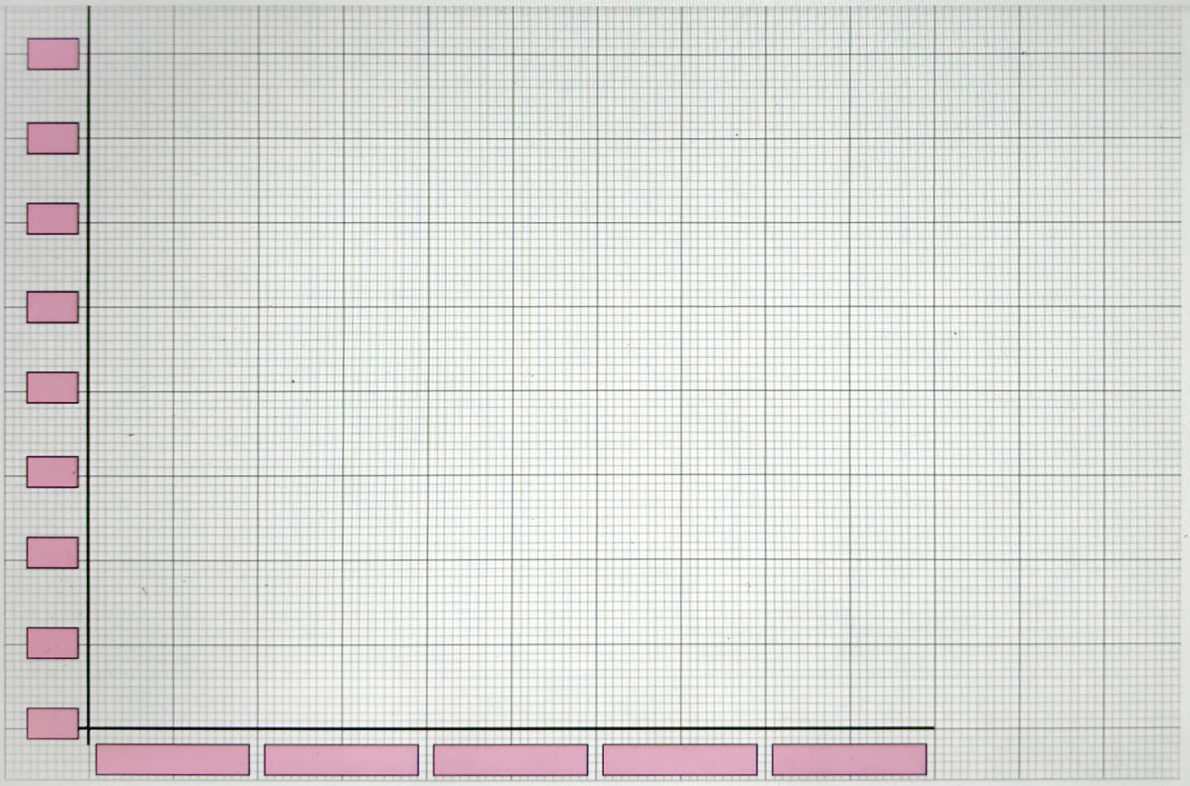
Title:

B I U $x_2$ $x^2$ Ω Σ

Styles

*x* axis

B I U $x_2$ $x^2$ Ω Σ

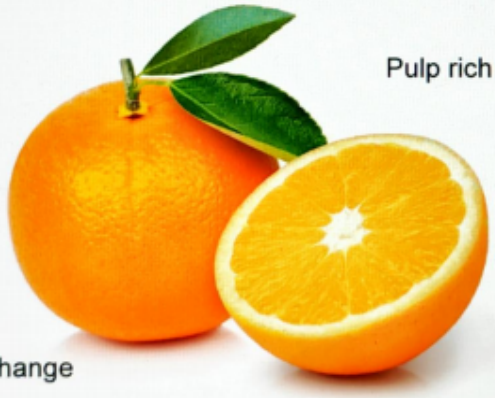




Scroll down to continue

**Question 6b** (3 marks)

Oranges are a good source of vitamin C and are recommended as part of a healthy diet. Orange juice is extracted from the pulp in oranges.

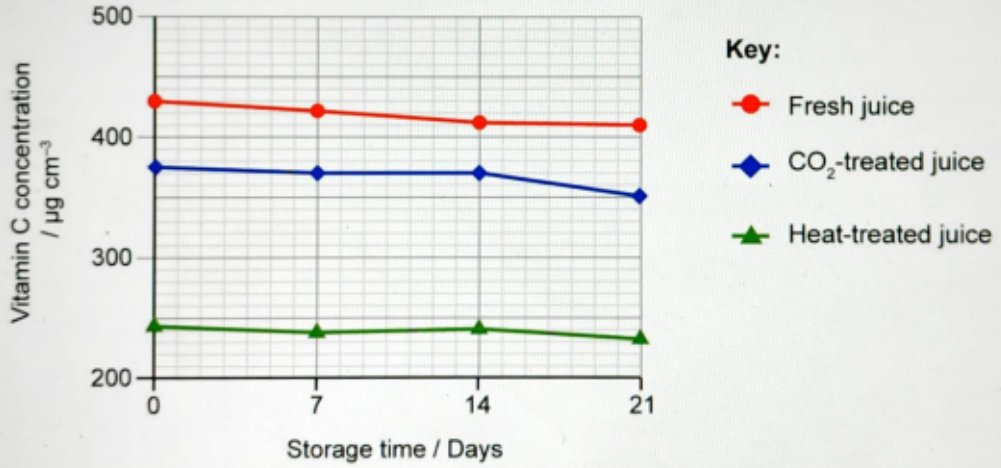



Peel reduces gas exchange

A student was interested in determining if the vitamin C concentration of orange juice changes over time when kept in a fridge at 4°C over a period of 3 weeks. The following three orange juices were tested:

- fresh orange juice
- orange juice that had been heat-treated to 70°C
- orange juice that had been treated with $CO_2$ to remove some of the oxygen present.

Effect of time on the vitamin concentration of fresh orange juice, heat-treated orange juice and orange juice treated with $CO_2$




**Identify** which juice has the lowest vitamin C concentration at the start of the investigation.
**Justify** your answer using scientific reasoning.

**Question 6c** (2 marks)

Using the graph in part (b), **calculate** the rate of change in vitamin C concentration for the $CO_2$-treated orange juice over the 21-day period.

B I U $x_2$ $x^2$ Ω Σ Styles

**Question 6d** (4 marks)

The student made the following hypothesis:

> If a whole orange is left for a number of weeks, the vitamin C concentration will decrease because the vitamin C will be oxidized.

Using the graph in part (b), **evaluate** the validity of this hypothesis.

B I U $x_2$ $x^2$ Ω Σ Styles

**Question 7** (16 marks)

Cans are used to extend the shelf life of the food they contain.

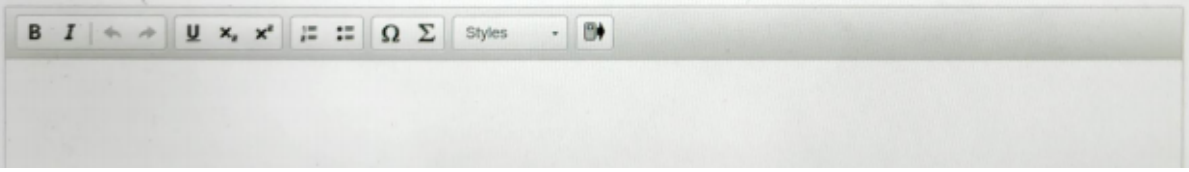
The four main materials currently used in can production are steel, tin-coated steel, chromium-coated steel and aluminium. These materials are known to react with acidic soft drinks. A packaging company has developed a new alloy called can-x aimed at the soft drink market.

**Design** an investigation to determine the best material from steel, tin-coated steel, chromium-coated steel, aluminium and can-x to make the soft drink containers from. You are

The four main materials currently used in can production are steel, tin-coated steel, chromium-coated steel and aluminium. These materials are known to react with acidic soft drinks. A packaging company has developed a new alloy called can-x aimed at the soft drink market.

**Design** an investigation to determine the best material from steel, tin-coated steel, chromium-coated steel, aluminium and can-x to make the soft drink containers from. You are provided with standard laboratory equipment, samples of each material and a sample of the soft drink. In your answer, you should include:

- the independent, dependent and two control variables
- a list of equipment you will use
- details of the method
- details of the data you will collect.



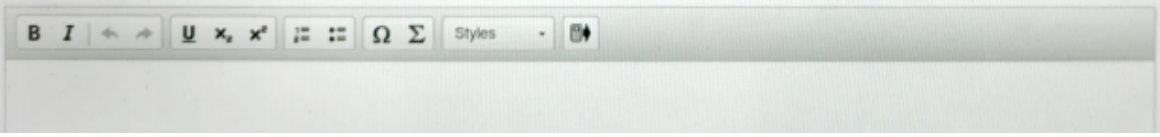

**Question 8** (8 marks)

The global human population has increased from 6 billion to 9 billion in the last 20 years. The availability of land to produce food to sustain this increasing population needs to be addressed before we run out of time. According to a study carried out in 2014, at least 20% of all land used to grow crops is affected by the increased salinity of the water that is used for irrigation.

Salinity in water is caused by dissolved salts such as sodium chloride, and it is determined by measuring the water's electrical conductivity.

**Question 8a** (2 marks)

**Outline** why electrical conductivity can be used to determine the salt content of water.



**Question 8a** (2 marks)

**Outline** why electrical conductivity can be used to determine the salt content of water.

**Question 8b** (2 marks)

The table below contains some information about the salinity of water from four different locations. Electrical conductivity is measured in units of $S\,m^{-1}$ (siemens per metre).

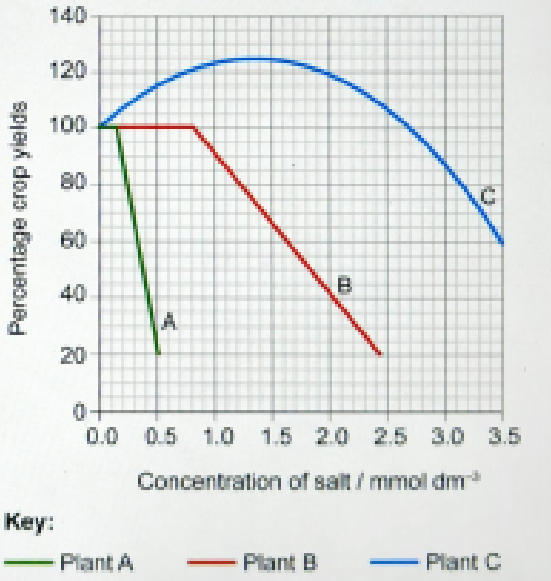
| | Alamo | Colorado | Negev | Pacific |
|---|---|---|---|---|
| Electrical conductivity / $S\,m^{-1}$ | 0.40 | 0.13 | 0.55 | 4.6 |
| Dissolved salts / $\mu g\,dm^{-3}$ | 3000 | 850 | 3750 | 35 000 |

Using the information in the table, **identify** the location of water with the highest salinity. **Justify** your answer.

**Question 8c** (1 mark)

High salinity affects plant growth and crop yield. The high concentration of salts prevents most plants from absorbing water from the soil. Researchers have developed plants and crops that can grow in environments with high salinity.

The graph shows the crop yield of three types of plants grown with different concentrations of salt in water, compared with how the plants would grow with fresh water.




**Determine** the optimum concentration of salt for a maximum crop yield for plant C.

**Question 8d** (3 marks)

**Compare** how salinity affects the percentage crop yield of plant A and plant B. You should include data from the graph in your answer.

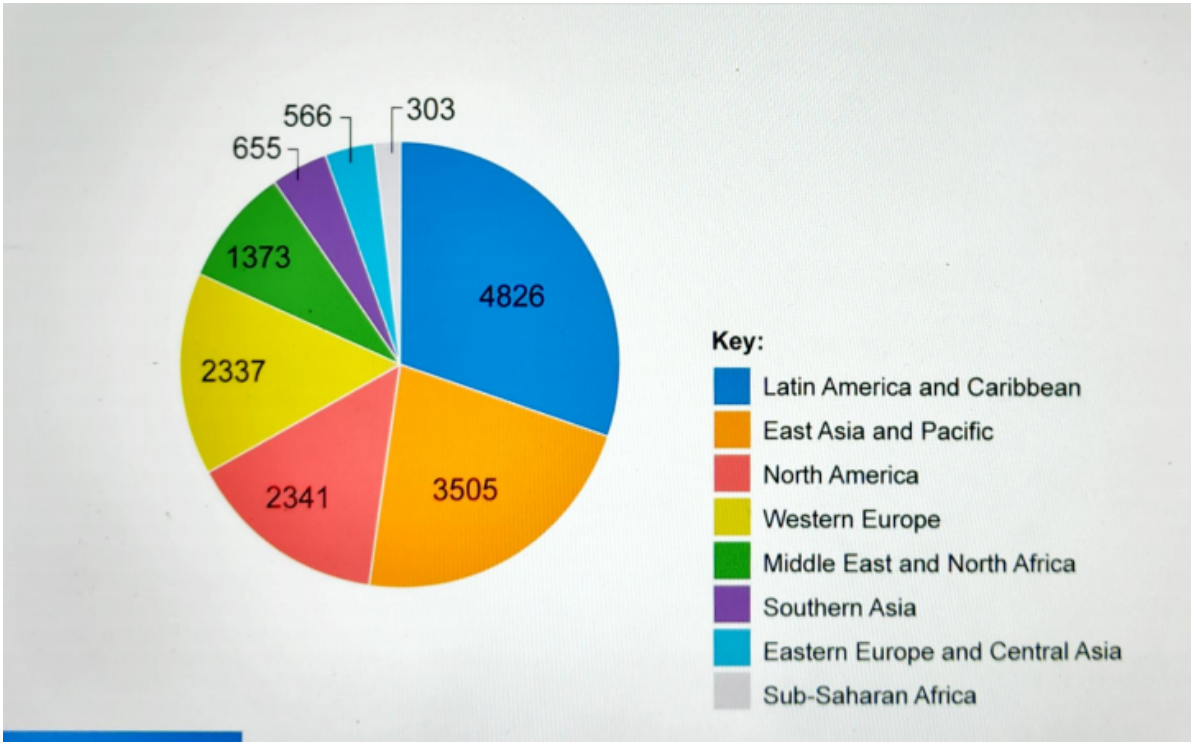
**Question 9** (17 marks)

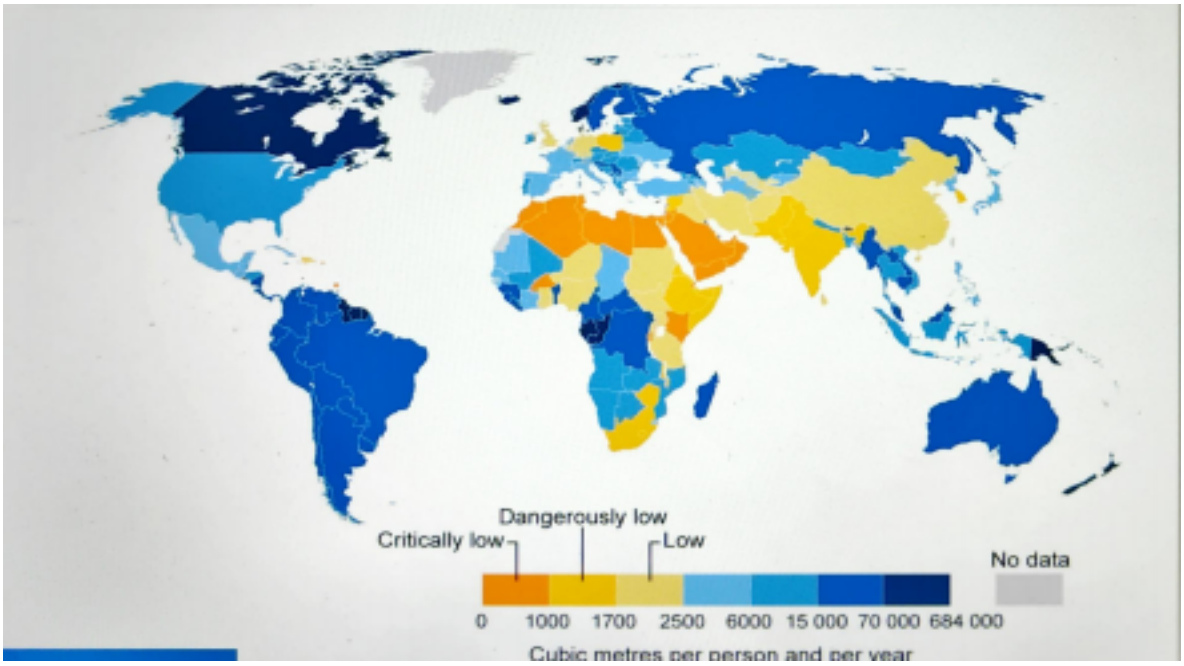
Most of the drinking water consumed in the world comes from either surface water (streams, rivers, lakes, reservoirs) or ground water sources (spaces between rocks). This water has a low concentration of salt and is known as fresh water.

One other source of water is saline water from seas and oceans. Through the process of desalination, saline water is converted into water suitable for human consumption or irrigation of plants and crops.

While desalination is very costly and requires a lot of energy, it is necessary in places where fresh water is not available. How efficient a process is can be determined by how much energy or resources are needed to produce fresh water.

The images in the tabs below show the number of desalination systems per region and a map of the availability of fresh water across the world.


566
303
655
1373
4826
2337
2341
3505
Key:
Latin America and Caribbean
East Asia and Pacific
North America
Western Europe
Middle East and North Africa
Southern Asia
Eastern Europe and Central Asia
Sub-Saharan Africa


Dangerously low
Critically low
Low
No data
0
1000
1700
2500
6000
15 000
70 000
684 000
Cubic metres per person and per year

**Question 9a** (3 marks)

Use the data in both tabs to **identify** the region with the highest number of desalination systems in the world and **justify** why this is the case.

B I U Styles

**Question 9b** (14 marks)

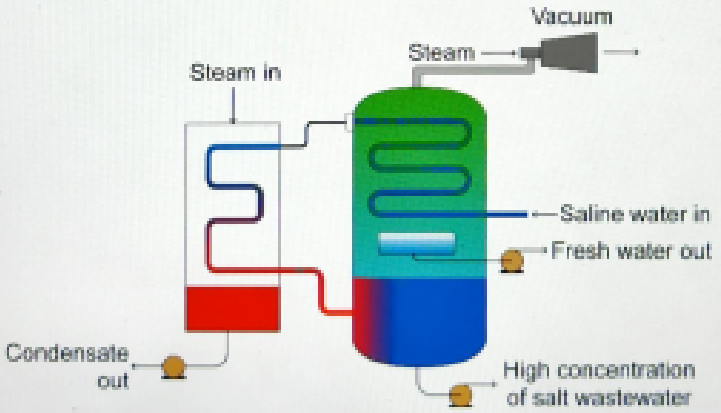
There are various systems used for desalination such as thermal-based, membrane-based and solar-based systems.

**This media is interactive**

**Desalination processes**

- Thermal-based
- Membrane-based
- Solar-based

## Thermal-based



Thermal-based systems use successive evaporations and distillations:

- Simple to build and operate
- No dangerous moving parts
- Treated water contains no dissolved minerals
- Minerals have to be re-added to make the water fit for consumption
- Water is heated to 115°C
- Energy needed for condensation
- High efficiency
- Due to the high operating temperatures, some salts such as calcium sulphate deposit on the tubes, causing clogging
- High-energy process
- Operating $CO_2$ emission = 24 kg $CO_2$ $m^{-3}$
- Suitable for large-scale industrial use

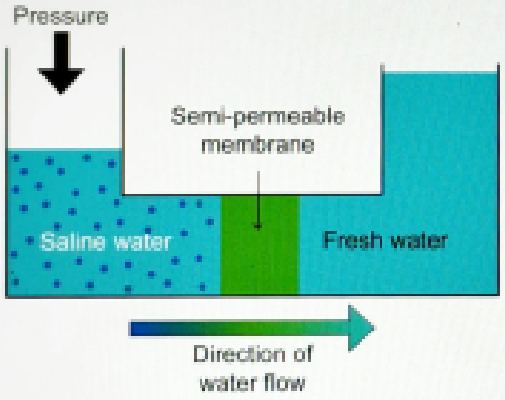
**Desalination processes**

Thermal-based

Membrane-based

Solar-based

## Membrane-based




In membrane-based systems, the saltwater is passed through a membrane that removes chlorine, salts and dirt. Depending on the size of the pores in the membrane, the water might require a pre-treatment to remove the larger impurities.

- Expensive to build
- Clean and safe
- Treated water contains adequate concentration of dissolved minerals
- Water is suitable for human consumption
- Operates at room temperature

Scroll down to continue

In membrane-based systems, the saltwater is passed through a membrane that removes chlorine, salts and dirt. Depending on the size of the pores in the membrane, the water might require a pre-treatment to remove the larger impurities.

- Expensive to build
- Clean and safe
- Treated water contains adequate concentration of dissolved minerals
- Water is suitable for human consumption
- Operates at room temperature
- Condensation is not required
- Low efficiency
- High costs of maintenance due to the membrane change
- Low-energy process
- Operating $CO_2$ emission = 5.3 kg $CO_2$ $m^{-3}$
- Suitable for large-scale industrial use

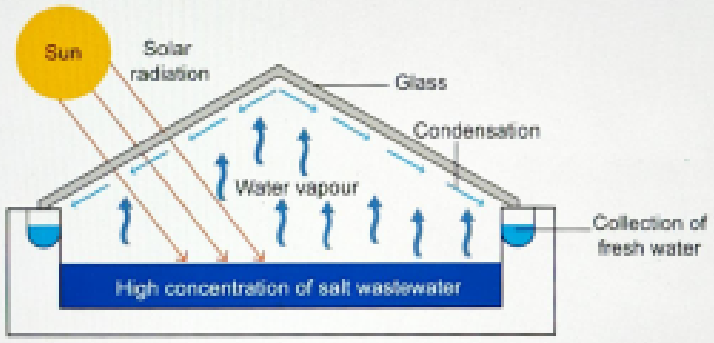
**Desalination processes**

Thermal-based

Membrane-based

Solar-based

## Solar-based




In solar-based systems:

- Simple construction – glasshouse
- Clean and safe
- Treated water contains no dissolved minerals
- Minerals to be re-added to make the water fit for consumption
- Water is heated by solar energy
- No energy needed for condensation
- Medium efficiency

In solar-based systems:

- Simple construction – glasshouse
- Clean and safe
- Treated water contains no dissolved minerals
- Minerals to be re-added to make the water fit for consumption
- Water is heated by solar energy
- No energy needed for condensation
- Medium efficiency
- Low maintenance costs
- System uses renewable energy directly
- Operating $CO_2$ emission = 0 kg $CO_2$ $m^{-3}$
- Suitable for small-scale domestic use

Using the information provided and your wider MYP knowledge, **discuss** and **evaluate** the systems available for water desalination. In your answer, you should include:

- a comparison of the efficiencies of the three systems
- the economic impacts of the three systems
- the environmental impacts of the three systems
- an appraisal of the three systems.