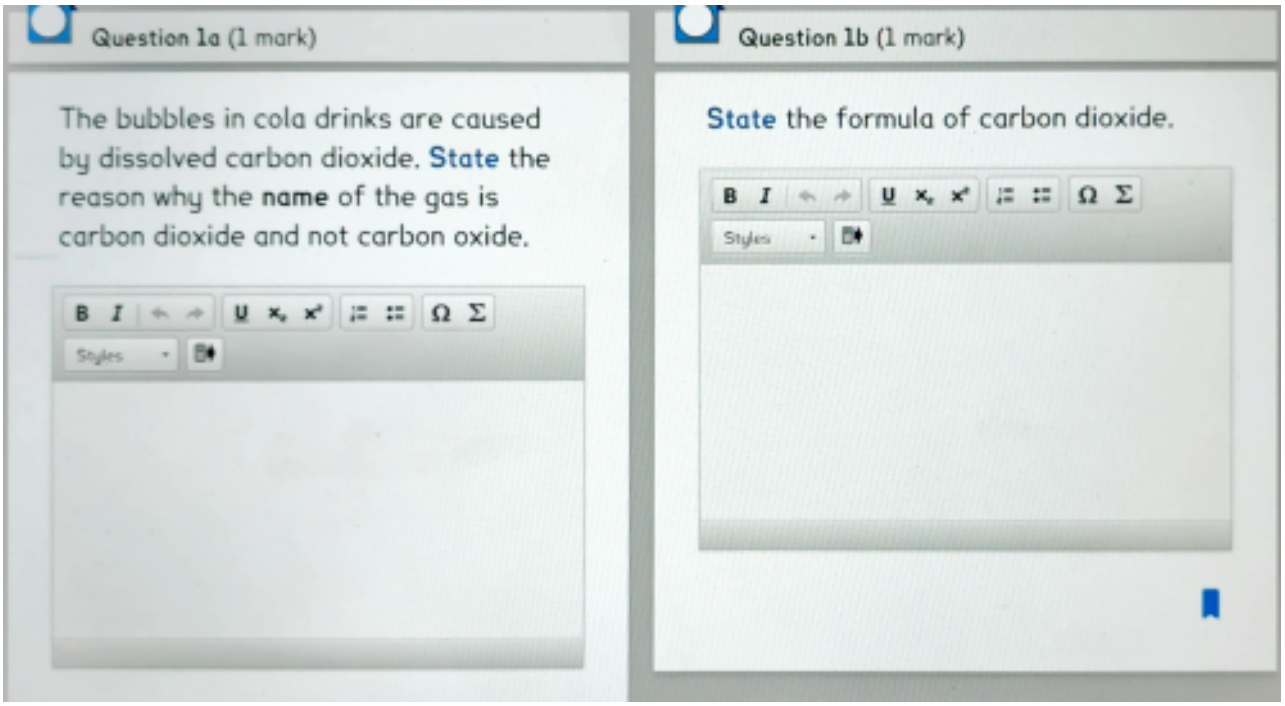
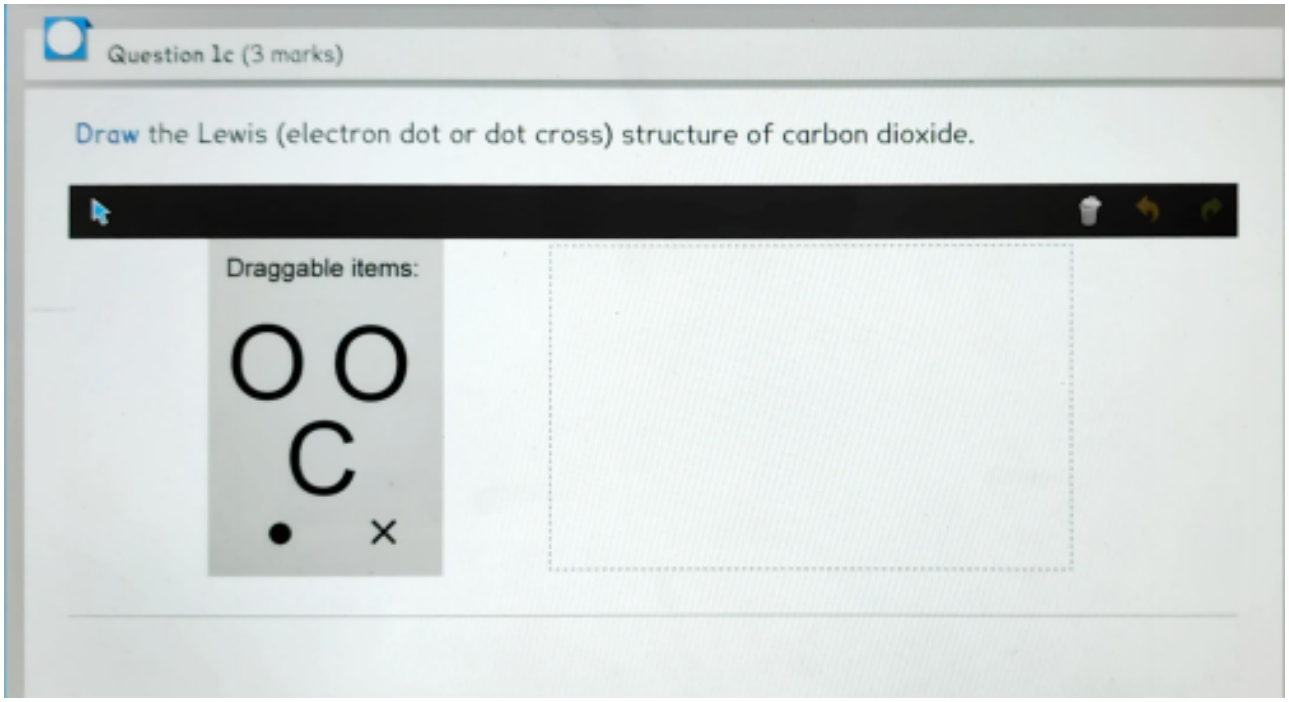
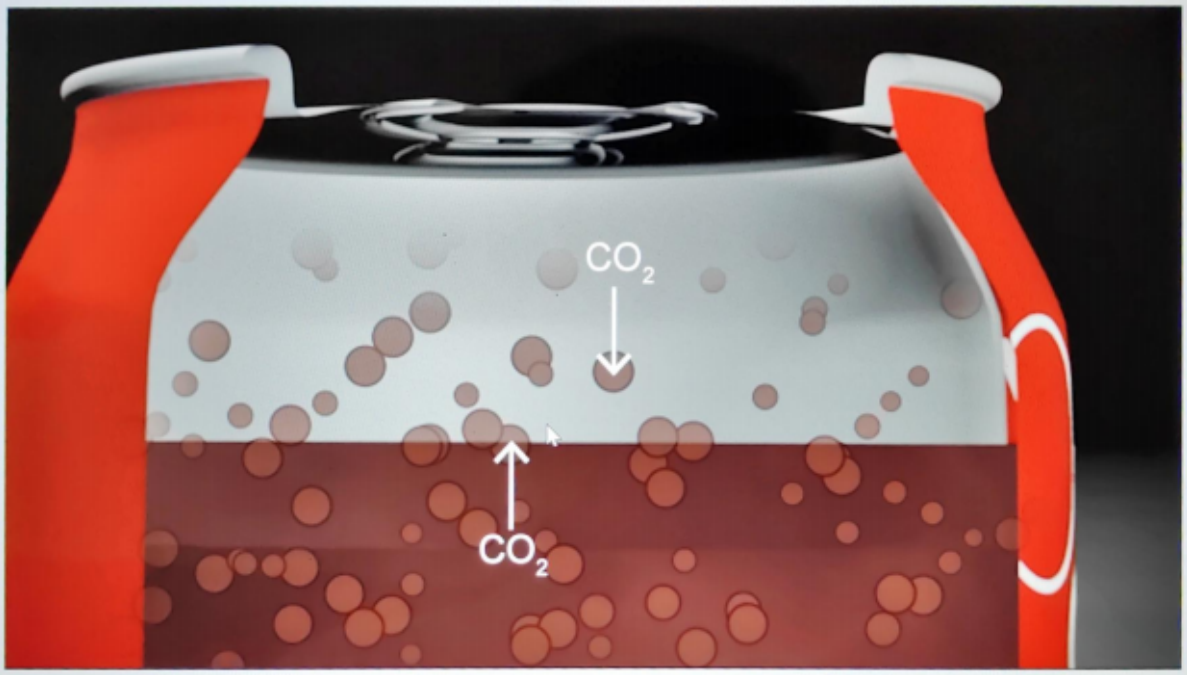

Question 1a (1 mark)
The bubbles in cola drinks are caused by dissolved carbon dioxide. State the reason why the name of the gas is carbon dioxide and not carbon oxide.
Styles
Question 1b (1 mark)
State the formula of carbon dioxide.
Styles


Question 1c (3 marks)
Draw the Lewis (electron dot or dot cross) structure of carbon dioxide.
Draggable items:
O O
C



Select symbols to drag and drop to form an equation showing the equilibrium between the dissolved carbon dioxide and the carbon dioxide in the space above the drink.

Select symbols to drag and drop to form an equation showing the equilibrium between the dissolved carbon dioxide and the carbon dioxide in the space above the drink.

Draggable items: $CO_2(l)$ $CO_2(g)$ $CO_2(aq)$ $CO_2(s)$ $\rightleftharpoons$ $\rightarrow$

Question 1e (3 marks)

A student opens a cold can of cola and takes it outside on a warm day. **Explain** what will happen to the concentration of dissolved carbon dioxide in the drink after 10 minutes.

B I U x_2 x^2 Ω Σ Styles

Question 2 (9 marks)

Phosphoric acid (H_3PO_4) is added to cola to make it sour and balance the sweet taste of sucrose.

Question 2a (2 marks)

The formula for phosphoric acid is H_3PO_4. **Calculate** the molar mass of phosphoric acid and give the unit.

B I U x_2 x^2 Ω Σ Styles

Question 2b (2 marks)

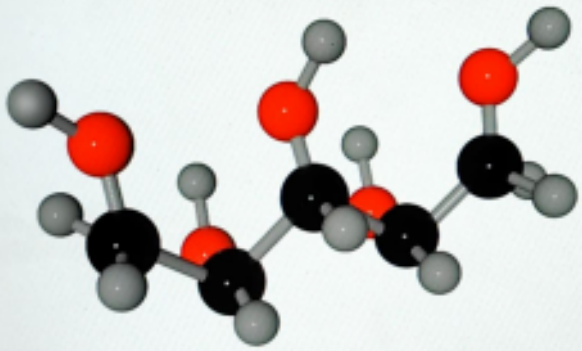
In a can of cola, there is 39 g of sucrose. The molar mass of sucrose is 342.3 g mol^{-1}. **Calculate** the number of moles of sucrose in one can of cola. Give your answer to 3 significant figures.

B I U x_2 x^2 Ω Σ Styles

Question 2c (3 marks)

In some varieties of cola, sugar is replaced with alternative sweeteners. One very common artificial sweetener is xylitol. The structural formula of xylitol is shown below.

Xylitol



Slider control

Key: C O H

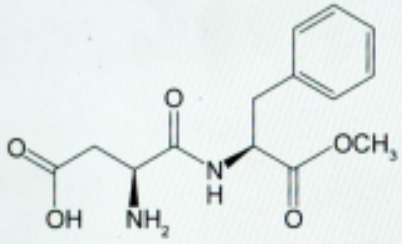
Key: C O H

Determine the molecular formula of xylitol.

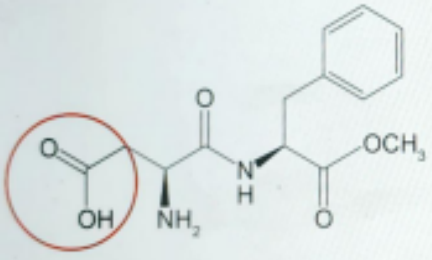
B I U x_2 x^2 Ω Σ Styles

Question 2d (2 marks)

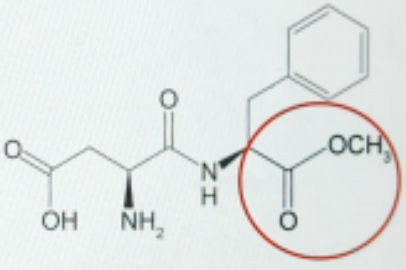
Aspartame is another artificial sweetener. The structure of aspartame is shown below.



Select the name of the highlighted group in each structure.



Select



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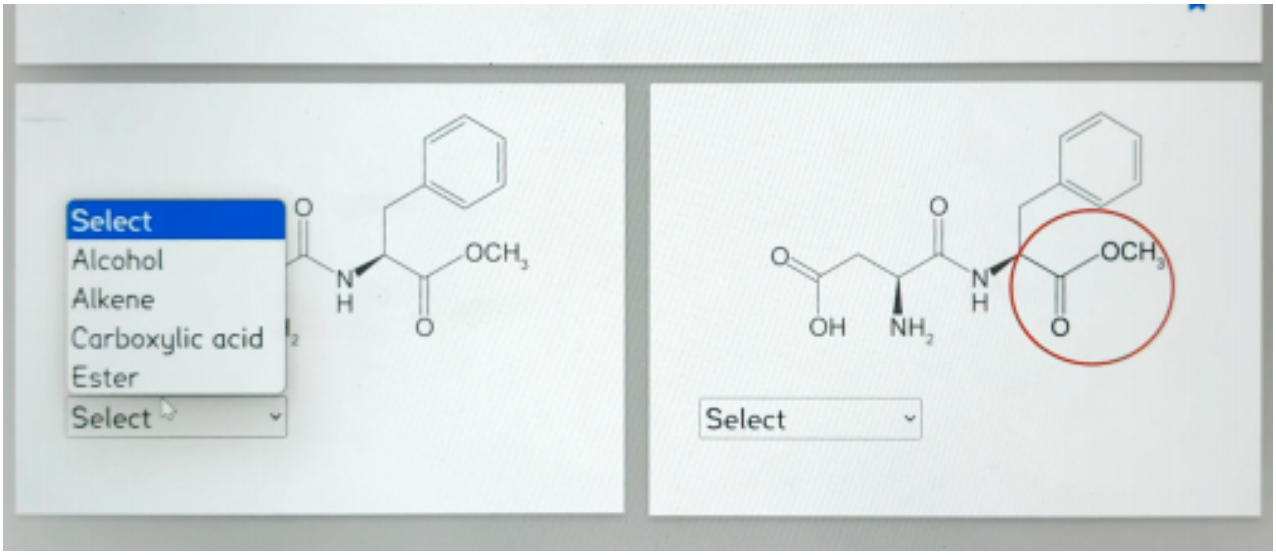


Question 3a (1 mark)

For many years, food and drink have been stored in cans to make them easy to transport and store. Eighty years ago, most cans were made from tin-plated steel. More recently aluminium has been used to make cans. As tin and iron become more difficult to obtain, all cans may be made from aluminium in the future.

Tin-plated steel can

Aluminium can

State the electron configuration of aluminium.

Question 3b (4 marks)

Using the information in the table below and your wider MYP studies, **explain** two advantages of aluminium cans compared to tin-plated steel cans.

Property	Aluminium can	Tin-plated steel can
Density / $g\,cm^{-3}$	2.70	7.30
Melting point / °C	660.32	231.9
Resistant to corrosion caused by:	Water, acid and bases	Water
Malleability relative to iron	Very high	High
Moh's hardness (resistance to scratching)	2.5	1.5

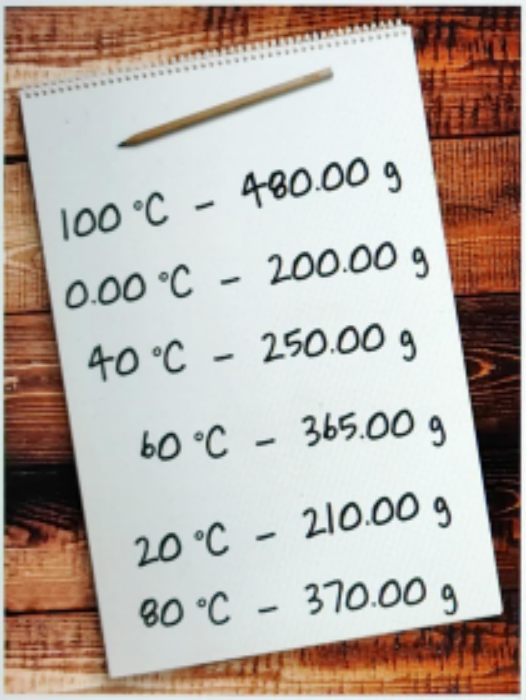
Advantage 1:

Advantage 2:

Question 4 (15 marks)

In cooking, and in particular the manufacture of sweets, the mass of sugar in the starting mixture will determine what type of sweets can be produced. It is important to determine the maximum mass of sugar that can be dissolved in 100 cm^3 of water. A student decided to collect data to find out the maximum mass of sugar that can be dissolved at different temperatures. The student's raw data is shown below.

Question 4a (3 marks)



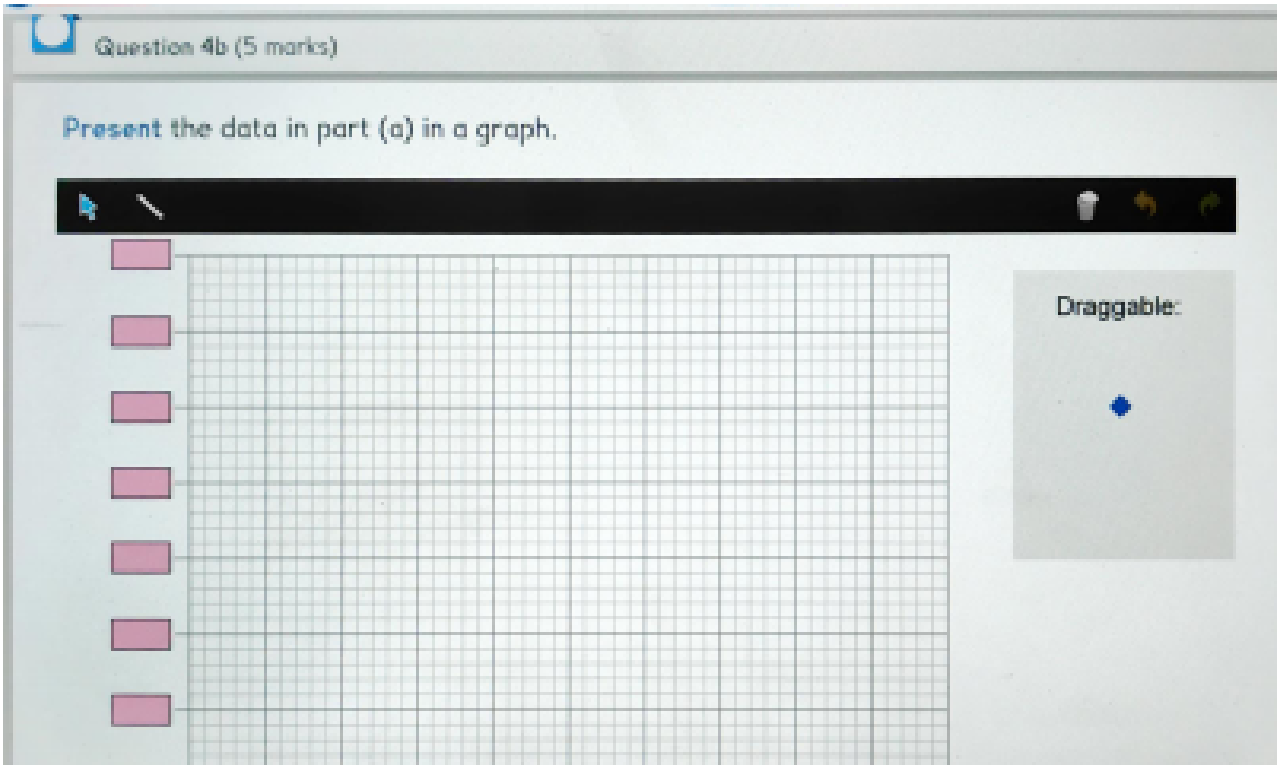
Present the student's raw data collected during the experiment in a table.

Create New Table

Reset

Question 4b (5 marks)

Present the data in part (a) in a graph.



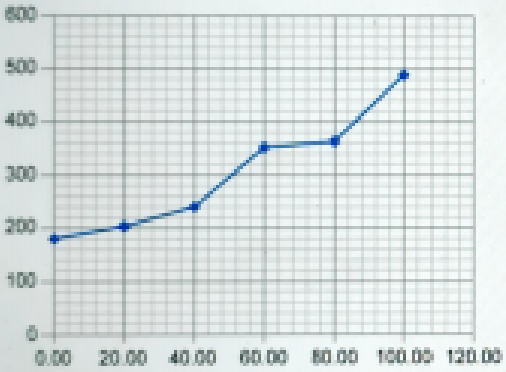
x axis label:

y axis label:

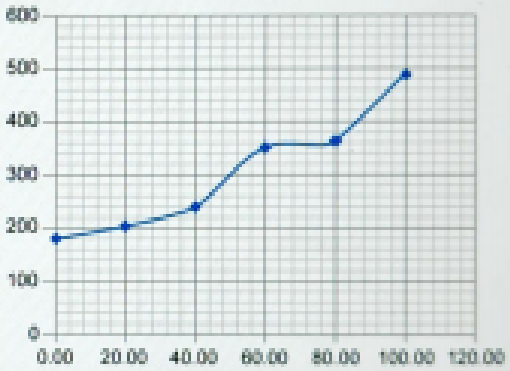
Question 4c (1 mark)

A second student repeated the investigation and plotted their results in the graphs below.

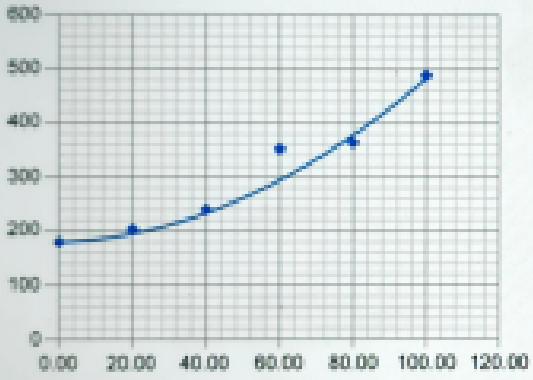
A.



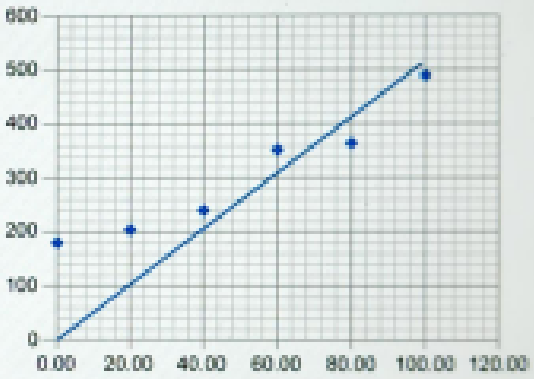
B.



C.



D.



Select the graph that shows the most appropriate line of best fit for this student's data.

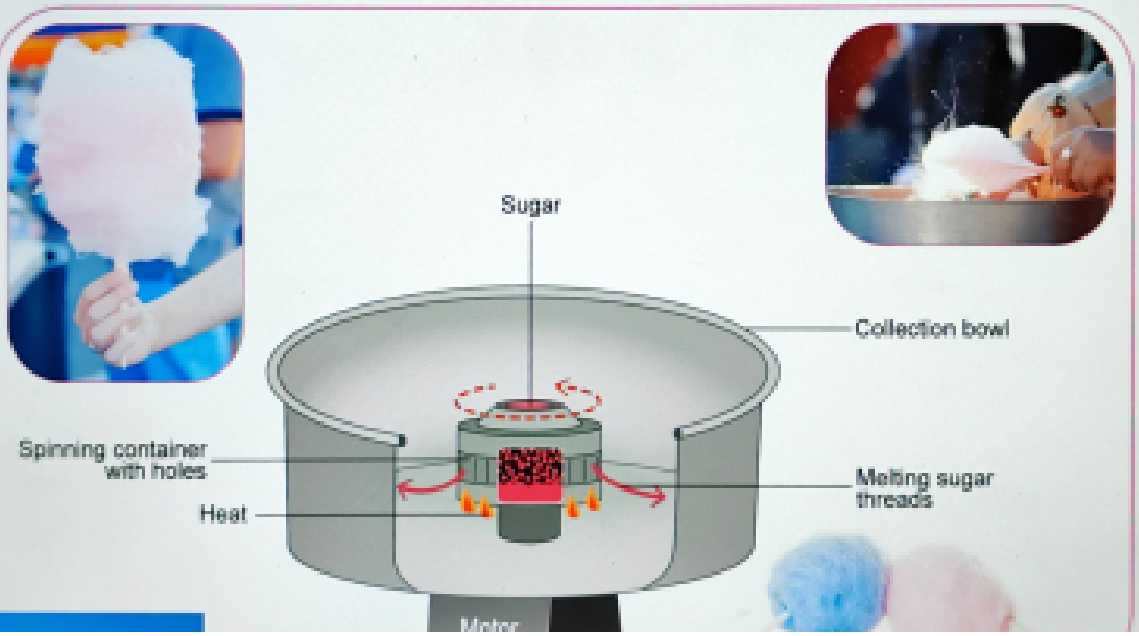
Select

Question 4d (2 marks)

Use the graphs in part (c) to **identify** the data point that is an outlier. **Suggest** what the expected mass of sugar would be.

Question 4e (4 marks)

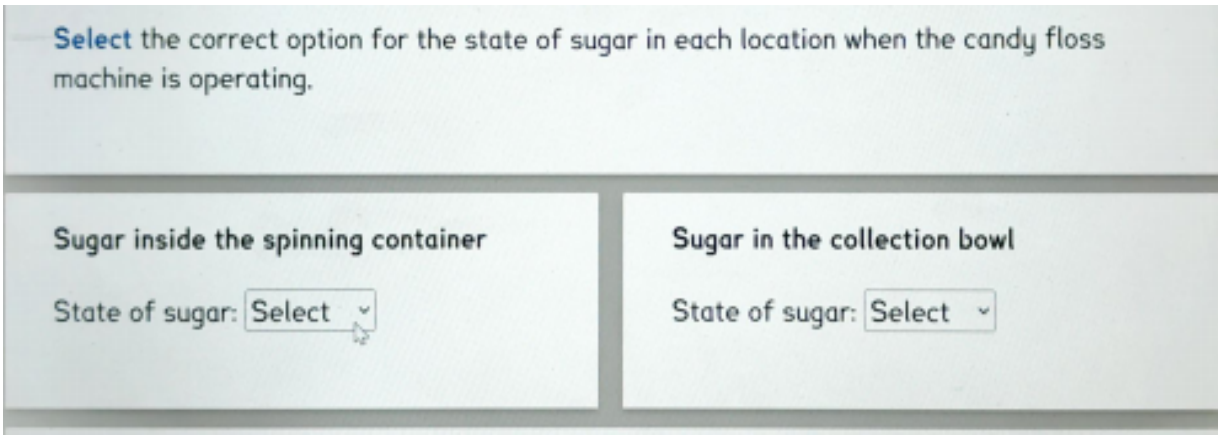
Candy floss is made from pure sugar with added colouring.

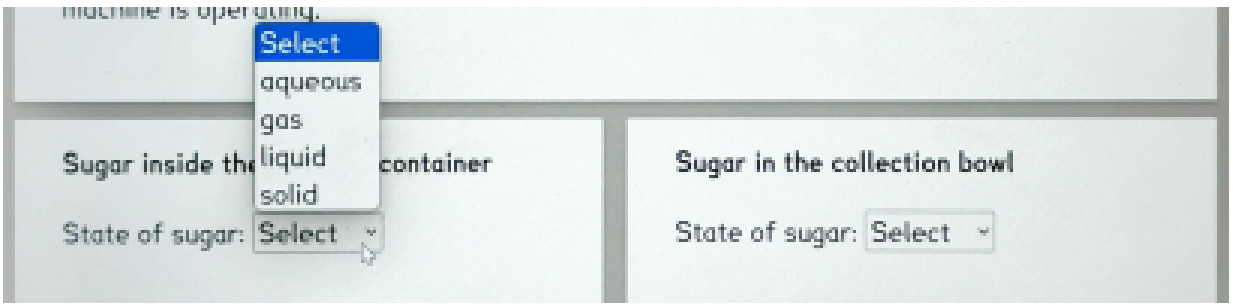


To make candy floss, the sugar is placed into a metal container with holes in its wall. The sugar is heated to 160°C at which point it starts to melt. The container starts to spin at a fast rate. The melting sugar leaves the container through the holes in the wall and cools rapidly, making threads or long lines of sugar in the collection bowl. When the threads of sugar are collected, candy floss is created.

Select the correct option for the state of sugar in each location when the candy floss machine is operating.

Scroll down to continue





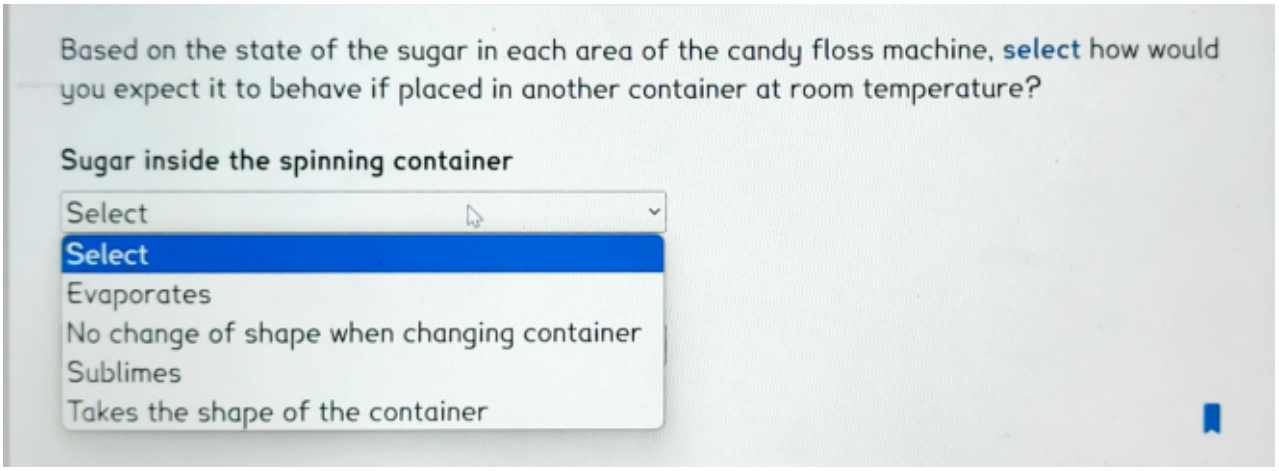
Based on the state of the sugar in each area of the candy floss machine, **select** how would you expect it to behave if placed in another container at room temperature?

Sugar inside the spinning container

Select

Sugar in the collection bowl

Select



Question 5 (12 marks)

Chemical changes take place when food is cooked. The video below gives some information about the chemical changes happening when eggs are cooked.

Video | Script

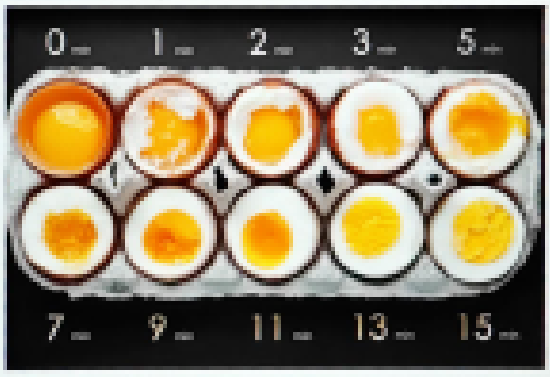
When food is cooked there can be a change in colour, state or even a gas produced, all of which are indicators that a chemical change has taken place. The bonds in the food are broken and new bonds are formed resulting in a chemical change. The chemical change is easily seen when we cook an egg. The egg white will change from colourless to white as heat is added and the egg white changes from water-soluble to insoluble when it has cooked. Chemically, the proteins have become altered and new chemical bonds have formed.

Another way to cook an egg is to place it, in its shell, in boiling water. This is called boiling an egg.

People like to cook their eggs for different lengths of time based on their personal choice.

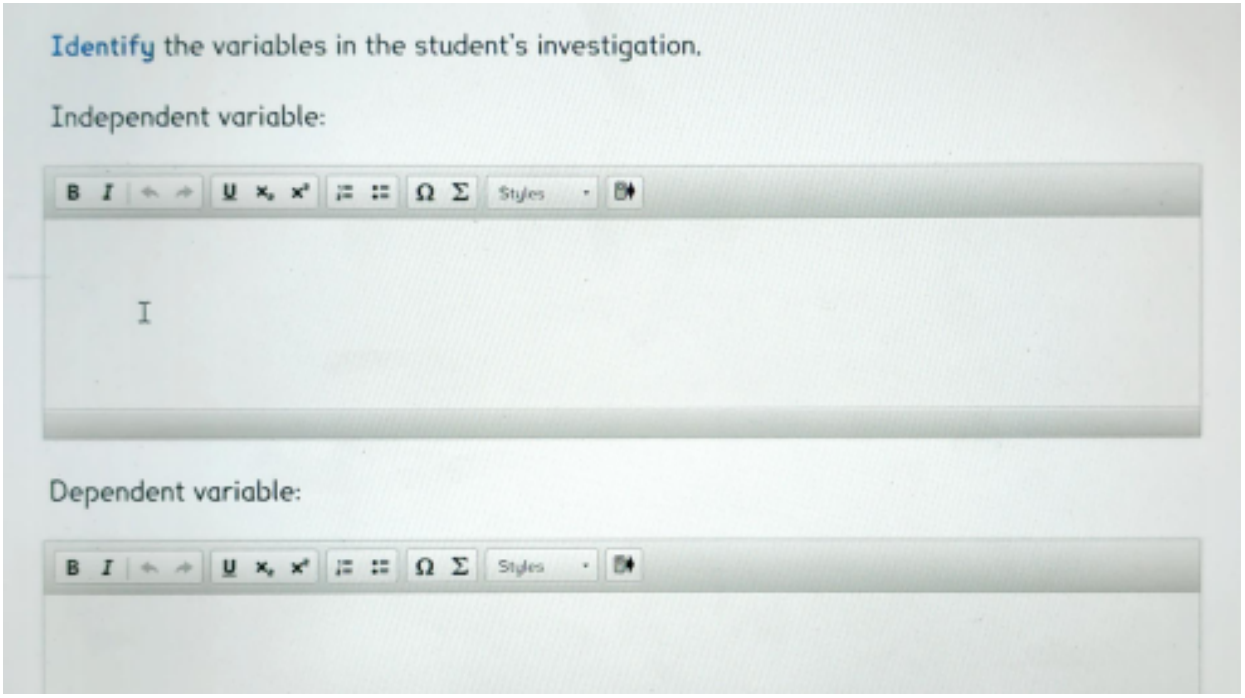
Question 5a (4 marks)

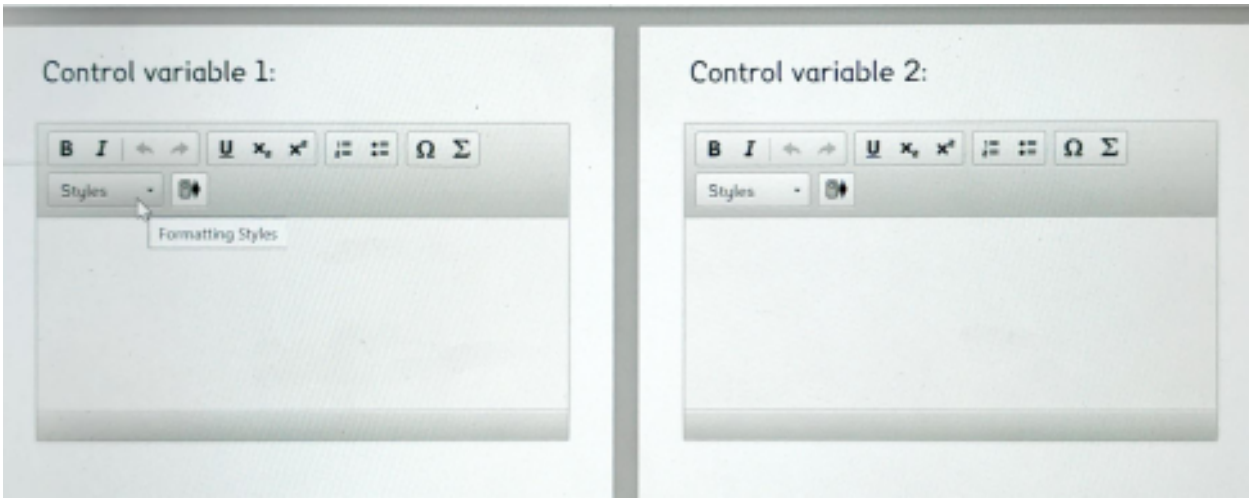
A student wanted to investigate how the appearance of eggs changes depending on the length of time they are cooked. They placed the eggs into boiling water and after a specific time removed each one and cut the top off to observe the inside. The results produced are shown below.



Identify the variables in the student's investigation.

Independent variable:


Identify the variables in the student's investigation.
Independent variable:
Styles
Dependent variable:
Styles


Control variable 1:
Styles
Formatting Styles
Control variable 2:
Styles

Question 5b (3 marks)

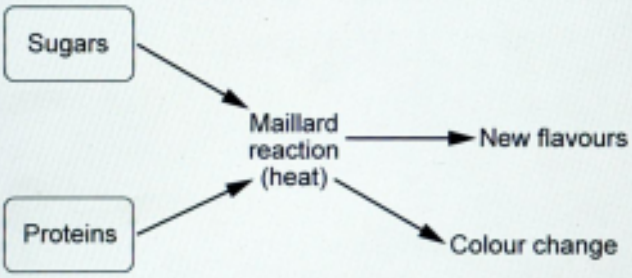
Suggest a suitable hypothesis for the investigation in part (a).

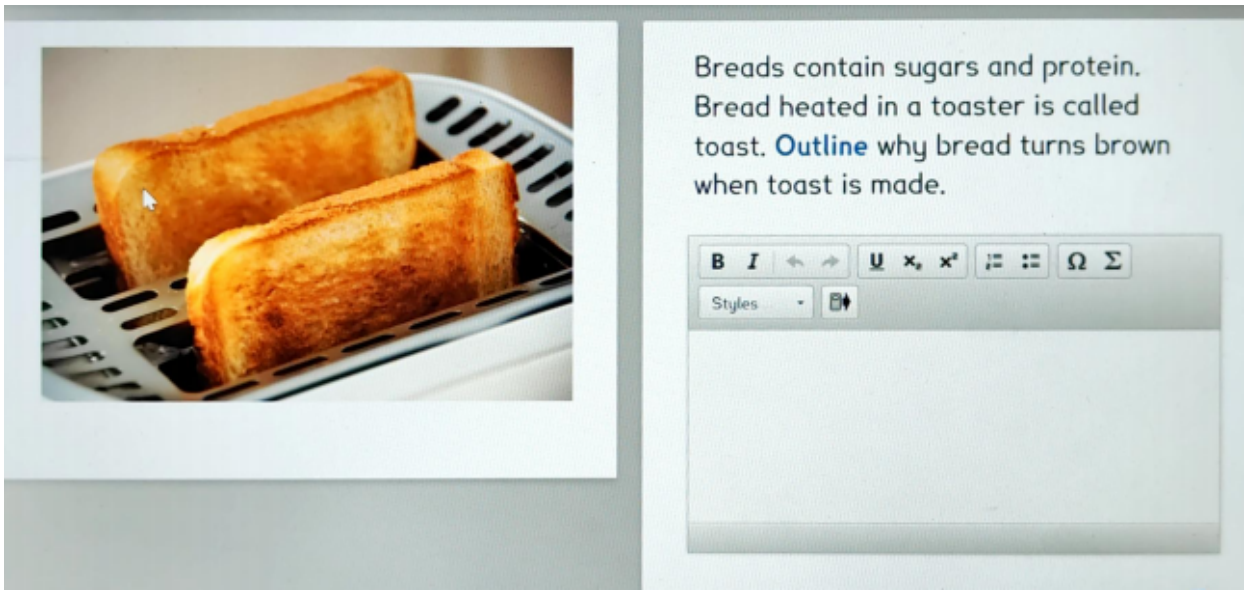
If:

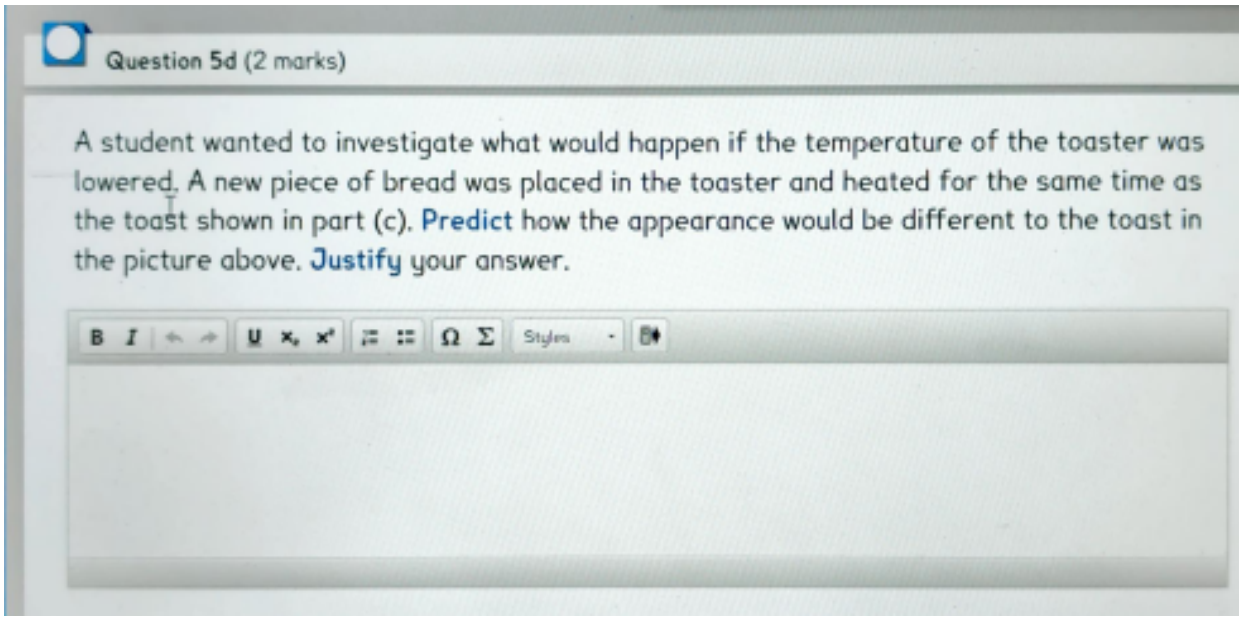
Then:

Question 5c (3 marks)

A different method of cooking involves the use of direct heat. There are two chemical reactions taking place during this type of cooking. Caramelization involves the chemical reactions of sugars, while the Maillard reaction involves chemical reactions between sugars and proteins.




Breads contain sugars and protein. Bread heated in a toaster is called toast. Outline why bread turns brown when toast is made.
Styles


Question 5d (2 marks)
A student wanted to investigate what would happen if the temperature of the toaster was lowered. A new piece of bread was placed in the toaster and heated for the same time as the toast shown in part (c). Predict how the appearance would be different to the toast in the picture above. Justify your answer.
Styles

Question 6 (25 marks)

Question 6a (2 marks)

When eggs are cooked, the proteins are changed chemically. The same change takes place when meat is cooked. Depending on the cooking method, the physical properties of cooked meat will differ.

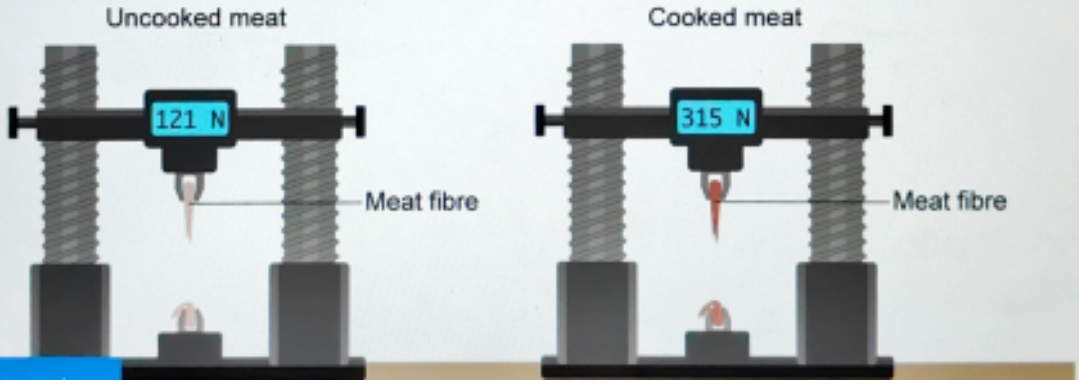
The equipment below can be used to measure the force needed to break meat fibres. Force is measured in newtons, N.

A student made the following prediction.

> If the meat is cooked for longer, then the breaking force of the cooked meat will be lower than uncooked meat because the heat will break the chemical bonds.

The student took two pieces of the same meat of identical size, one cooked and the other uncooked. They placed the meat samples in the equipment and measured the breaking force.

The results are shown below.

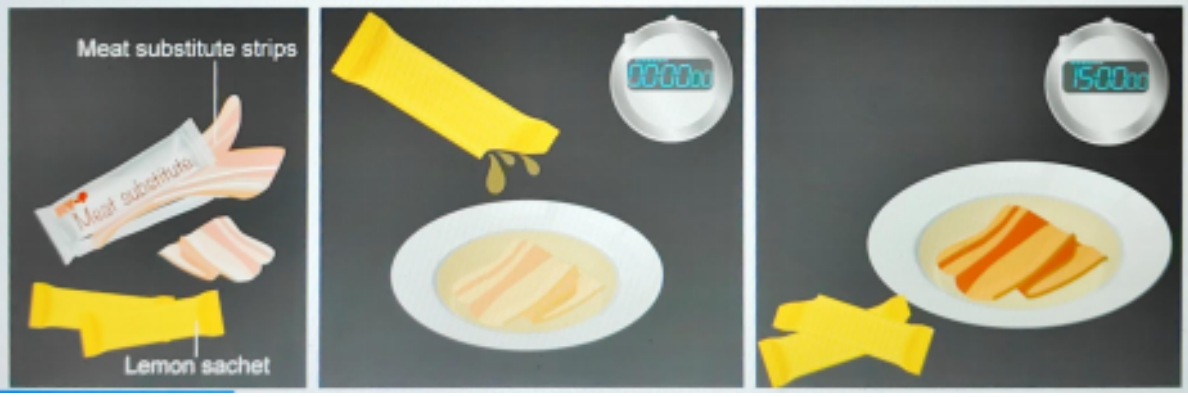


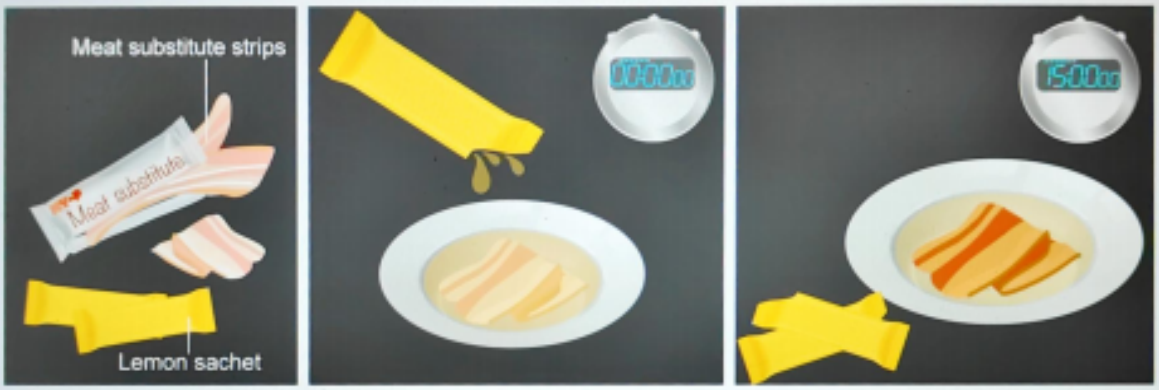
Use data from the diagrams above to **state** whether the student's hypothesis is correct. **Justify** your answer.

Question 6b (2 marks)

Another method of causing chemical change in food is to use acids from fruit juice. Ceviche is a dish commonly associated with South American cuisine where fish is placed in lime juice and lemon juice for a period of time and "cooks". The fruit juice causes a chemical change to the fish which allows it to be eaten safely. This method of cooking could be the way of the future as it does not require energy.

A company has developed a new laboratory-based meat substitute called MY-P that is cooked using lime and lemon juice. The cooking method is shown below.





After 15 minutes, the product is ready to eat. Before this time, the MY-P is not suitable to eat as it is not easily digested.

A student wanted to investigate the best juice to cook MY-P to be sure that the food was digestible. They thought that one juice would be sufficient to cook the product. The treated samples of the
MY-P were tested using the equipment in part (a).

The pH of the fruit juices used in the investigation are shown in the table below.

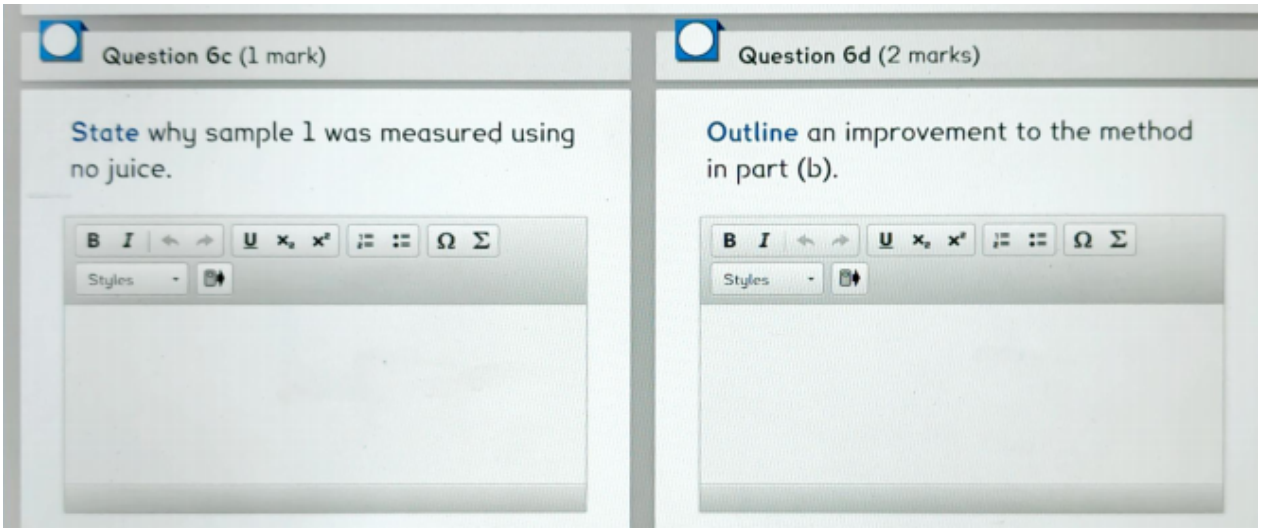
Name of juice	pH
Lime	2.0
Lemon	2.6
Orange	3.8

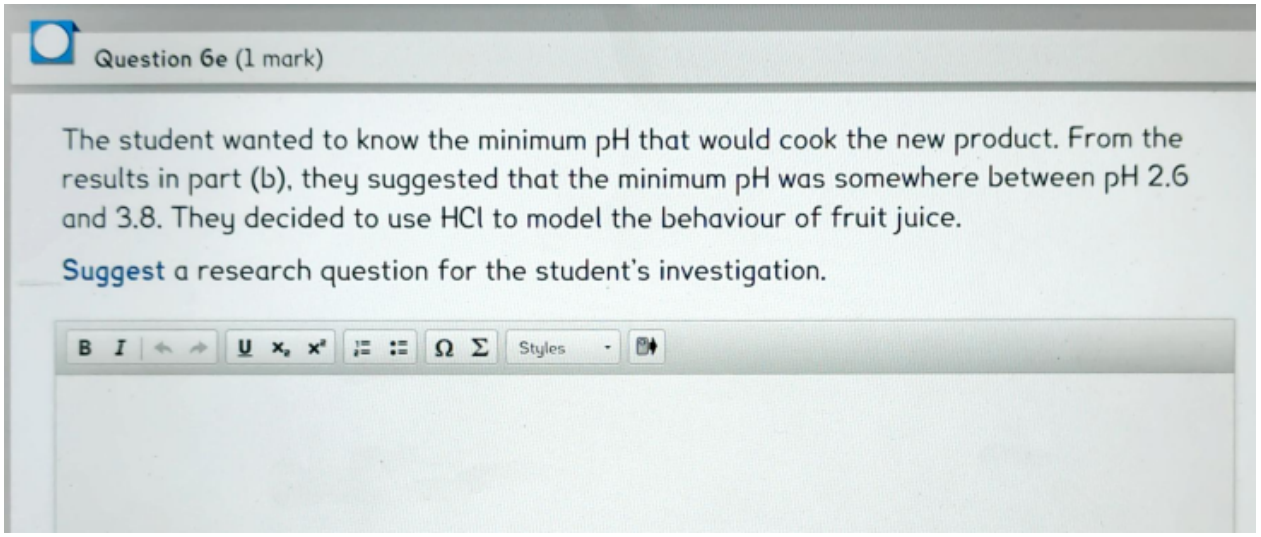
The minimum force required that would allow the product to be classed as cooked is 280 N. Use the data below to **identify** all the samples that would be suitable to eat.

Sample	Juice used to cook MY-P	Force to break MY-P / N	Suitable samples to eat
1	None	130	☐
2	Lime and lemon	300	☐
3	Orange	275	☐
4	Lemon	290	☐
5	Lime	320	☐

Justify your answer.

B I U x_2 x^2 Ω Σ Styles


Question 6c (1 mark)
State why sample 1 was measured using no juice.
Styles
Question 6d (2 marks)
Outline an improvement to the method in part (b).
Styles


Question 6e (1 mark)
The student wanted to know the minimum pH that would cook the new product. From the results in part (b), they suggested that the minimum pH was somewhere between pH 2.6 and 3.8. They decided to use HCl to model the behaviour of fruit juice.
Suggest a research question for the student's investigation.
Styles

Question 6f (17 marks)

Several different solutions of HCl were available, as well as several samples of the MY-P.

Design a method to identify the pH that would cook MY-P. In your answer you should include:

- the independent, dependent and two control variables
- a list of equipment you will use
- details of the method you will use
- details of the measurements you will take to collect sufficient data
- safety considerations.

Question 7 (9 marks)

Many people around the world, for a variety of reasons, are choosing to reduce the amount of meat they eat. The video below shows some data comparing food production of different diets.

Video Script

Protein is an important part of our diet. Many people get their protein from meat and fish, but more and more people are choosing meat-free diets. Many people want to reduce the amount of meat that they eat and vegetarians and vegans eat no meat at all. They get the protein from pulses and nuts instead.

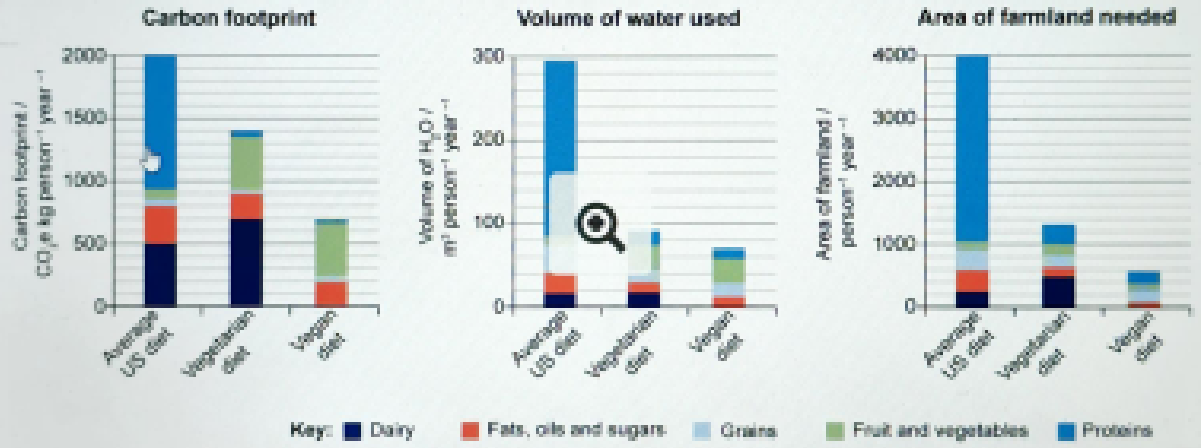
Environmental concerns are just one of the reasons why people turn to meat-free diets.

Greenhouse gases are emitted in production of all food. Different types of food emit different masses. The effects of greenhouse gases, or the carbon footprint, are measured in units of $kgCO_2e$. This mass includes all emissions of greenhouse gases, such as methane and dinitrogen oxide, in addition to carbon dioxide.

In an average American diet, most carbon dioxide comes from protein production, with dairy, fats, oils and sugar also contributing significant masses.

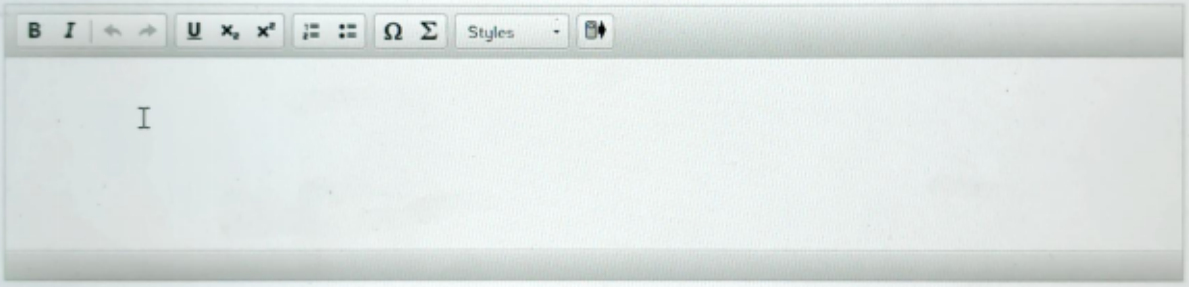
In vegetarian and vegan diets, carbon dioxide is also produced but at lower levels.

The graphs below show mass of carbon dioxide, volume of water and area of farmland needed for the production for three diets: an average American (US) diet, a vegetarian diet and a vegan diet.



Question 7a (2 marks)

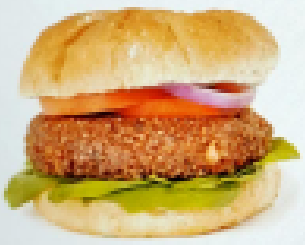
Using the graphs above, **calculate** the carbon footprint from the production of protein in the average US diet.



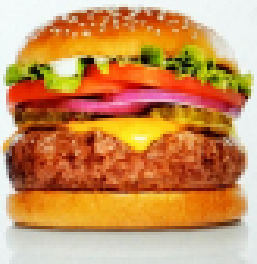
Question 7b (7 marks)

Due to increasing demand for meat substitutes, there is a growing industry that provides plant-based meat replacements such as plant-based burgers. Some plant-based products are designed to have a similar appearance, texture and taste to meat-based products, such as beef burgers and chicken nuggets. Recently, several companies have done a lot of research into creating a burger that looks and tastes like meat, even to people that are accustomed to meat. Food scientists add soy sauce, mushroom extract, or yeast extract to replicate the meaty flavour.

Plant-based burger



Meat-based burger



The table below shows nutritional information for a plant-based burger that is designed to taste like meat in comparison to a beef burger.

	Plant-based burger (patty only)	Beef burger (patty only)
Energy content / kJ	1000	1000
Total fat / g	14	13
Carbs / g	9	0
Protein / g	19	29
Fibre / g	5	0
Added sugar / g	Less than 1	0
Sodium / % of recommended daily value	16	1
Vitamin B12 / % of recommended daily value	130	48

Using the graphs in part (a) and the data in the table above, **discuss** and **evaluate** the advantages and disadvantages of plant-based burgers compared to beef burgers. In your answer, you should include:

- the advantages of the production of plant-based protein compared to meat-based protein
- a comparison of the nutritional data
- your opinion of why people may choose plant-based burgers rather than beef burgers.

Question 8 (15 marks)

In the effort to reduce the environmental impact of the meat industry and to meet the demands for protein from a growing global population, companies have developed a process to grow meat in a lab using a small sample of animal cells.

Intensive farming of animals for meat requires large areas of land, large volumes of water and produces greenhouse gases. One way to move away from intensive farming would be to grow meat in laboratories. Consumers are choosing a plant-based diet which has a lower environmental impact. Growing meat in laboratories would allow protein to be produced on a large scale to feed a growing global population.

To grow meat in a laboratory, cells are harmlessly removed from a live animal and are then grown in a nutrient-rich artificial environment.

The lab-grown cells combine to form muscle tissue. During the growth phase, the cells could be genetically modified to increase protein levels. For food safety, the lab-grown cells can be tested for animal-borne diseases.

The muscle tissue is then compressed to form burger patties and additional nutrients could be added. From one tissue sample, 80 000 burgers can be grown compared to 1200 burgers from one cow.

The cost of a lab-grown burger has reduced significantly to $10 per burger in 2020. In the future, it is anticipated that more people will choose lab-grown burgers and they will become widely available.

The farmland and water needed for food production will be greatly reduced for lab-grown meat compared to farmed meat. Large farms would no longer be needed, instead food could be grown in small laboratories. New jobs would be created and there would be opportunities for re-training.

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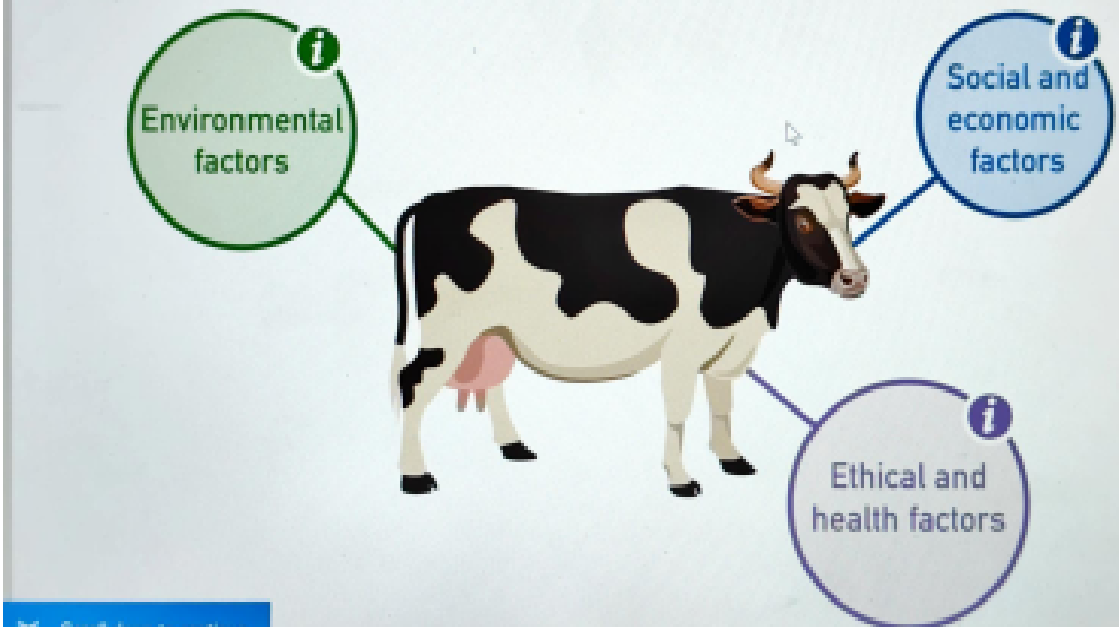
The farmland and water needed for food production will be greatly reduced for lab-grown meat compared to farmed meat. Large farms would no longer be needed, instead food could be grown in small laboratories. New jobs would be created and there would be opportunities for re-training.

The lab-grown meat produced is paler and has less taste.

Researchers hope that a less attractive appearance and taste are fair compromises for supplying protein to a growing population. Food scientists are developing additives to make the lab-grown burgers more acceptable to the mass market.

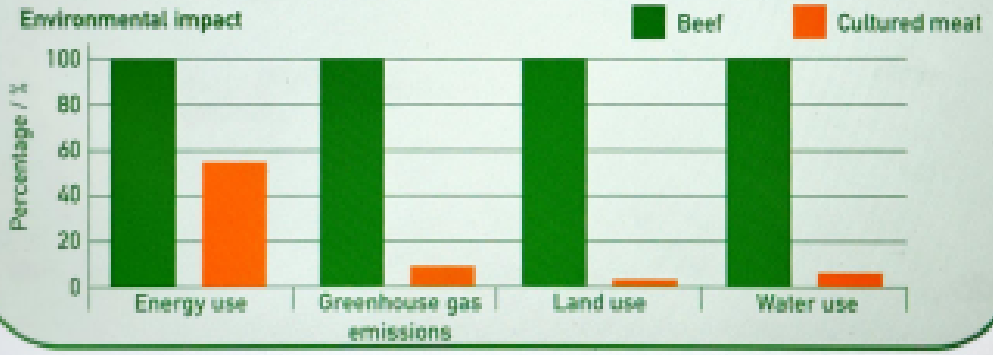
The interactive graphic below is a summary of the information in the video.

This media is interactive:



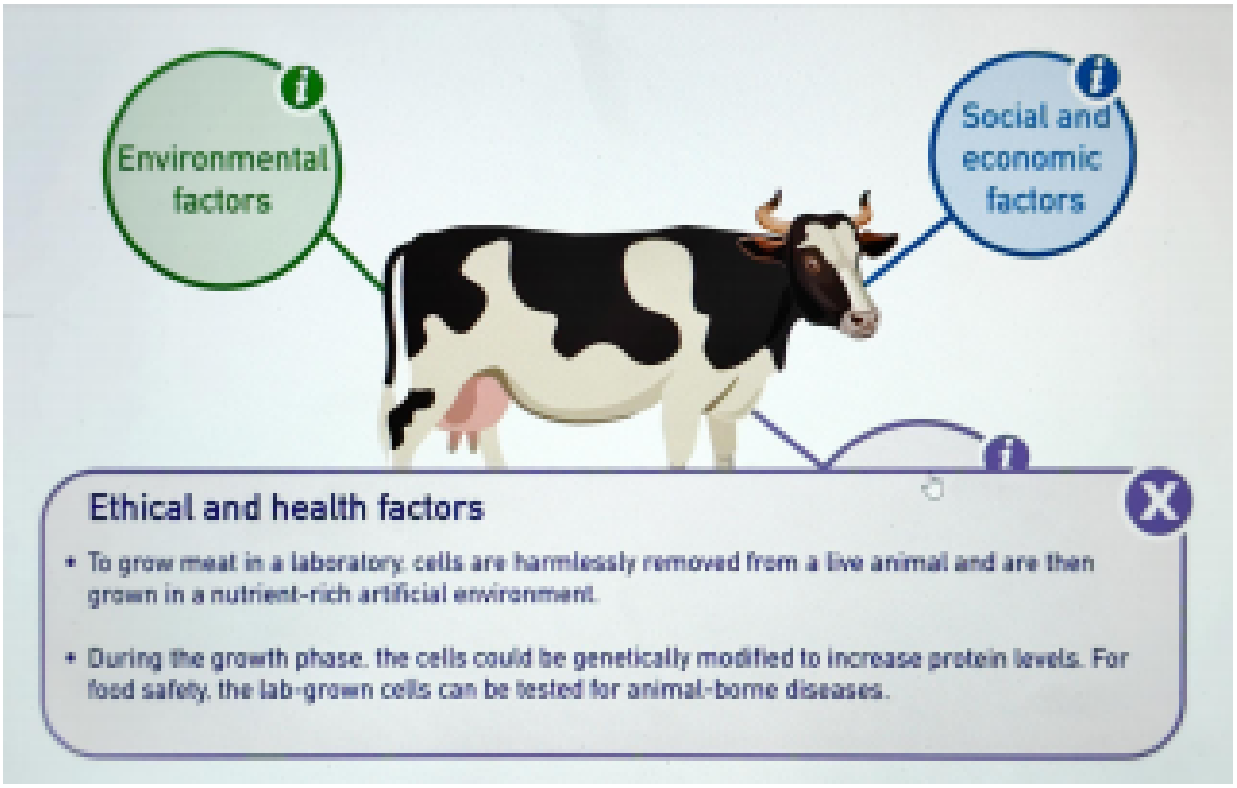
Environmental factors

- Intensive farming of animals for meat requires large areas of land, large volumes of water and produces greenhouse gases. One way to move away from intensive farming would be to grow meat in laboratories. This would be more environmentally friendly and would allow protein to be produced on a large scale to feed a growing global population.
- The farmland and water needed for food production will be greatly reduced for lab-grown meat compared to farmed meat. Large farms would no longer be needed, instead food could be grown in small laboratories. New jobs would be created and there would be opportunities for re training.



Social and economic factors

- The lab-grown cells combine to form muscle tissue.
- The muscle tissue is then compressed to form burger patties and additional nutrients could be added. From one tissue sample, 80 000 burgers can be grown compared to 1200 burgers from one cow.
- The cost of a lab-grown burger has reduced significantly to $10 per burger in 2020. By the end of the decade, it is anticipated that lab-grown burgers will be widely available.
- The lab-grown meat produced is paler and has less taste.
- Researchers hope that a less attractive appearance and taste are fair compromises for supplying protein to a growing population. Food scientists are developing additives to make the lab-grown burgers more acceptable to the mass market.



Using your experience from your wider MYP studies and the information above, **discuss** and **evaluate** the impact of lab-grown meat as a replacement for meat. In your answer you should include:

- environmental impacts of production
- ethical factors around lab-grown meat
- social and economic factors around lab-grown meat
- health benefits
- a concluding appraisal.