Question 1 (7 marks)

The ingredients of ancient toothpastes changed over time and were very different to modern varieties. Ingredients used by Ancient Egyptians included a powder of cow hoof ashes and burnt eggshells, which was combined with pumice, a type of crumbly rock. The Greeks and Romans preferred more abrasive substances and their toothpaste ingredients included crushed bones and oyster shells. In Asia a wide variety of substances such as ginseng and salt were found in toothpaste.

Question 1a (1 mark)

The main ingredient of eggshells and oyster shells is calcium carbonate. **Select** the formula of calcium carbonate.

Select

Question 1b (2 marks)

Modern toothpaste can contain sodium fluoride. Use the periodic table to **state** the group and period of sodium.

Group:

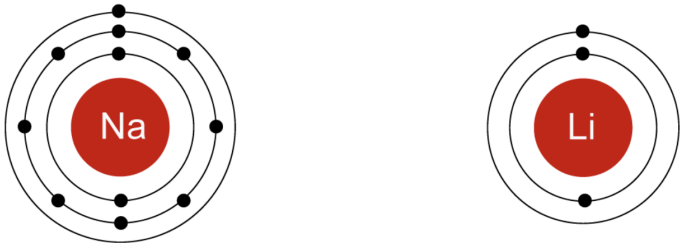
Period:

Question 1c (1 mark)

State the electron configuration of fluorine.

Question 1d (3 marks)

The diagram below shows the Bohr model of a sodium atom and a lithium atom.



Using the Bohr model, **explain** why sodium is more reactive than Lithium.

Question 2 (9 marks)

Personal hygiene products have changed as a result of developments over time. Recently, people have been using more teeth whitening products. Many of these teeth whitening products contain hydrogen peroxide as the active ingredient.

©

Question 2a (1 mark)

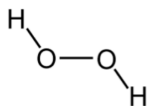
Select the type of bonds in hydrogen peroxide (H_2O_2).

- ✓ Select
- Ionic
- Covalent
- Metallic
- Coordinate

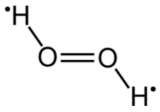
Question 2b (1 mark)

Select the Lewis structure (dot cross diagram) of hydrogen peroxide.

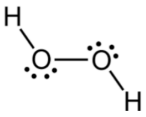
A.



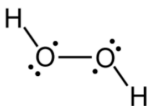
B.



C.



D.



Select

Question 2c (3 marks)

Hydrogen peroxide is unstable and decomposes slowly. As it decomposes, the teeth whitening process is less effective. When hydrogen peroxide decomposes, it forms water and oxygen.

Write down the balanced equation for the decomposition of hydrogen peroxide. You should include state symbols in your answer.

Styles

Video | Script

Over time, teeth become stained. Social media trends have resulted in more people using teeth whitening products.

Teeth can be whitened using hydrogen peroxide.

The hydrogen peroxide enters the top layer of the tooth and breaks down the molecules causing the stains.

The user is left with a bright, white smile.

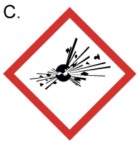
Hydrogen peroxide is an oxidizing agent so teeth whitening should only be carried out by trained professionals.

Question 2d (1 mark)

Select the hazard symbol for hydrogen peroxide.

A. 

B. 

C. 

D. 

©

Select

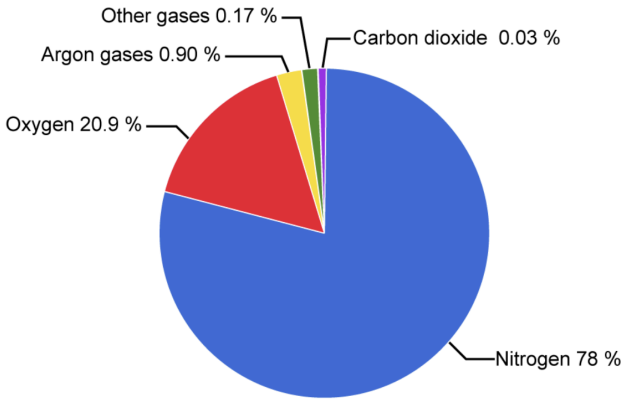
Question 2e (3 marks)

Different teeth whitening products vary in hydrogen peroxide concentration. Using information from the video and your knowledge of collision theory, **explain** how concentration affects the rate at which the teeth are whitened.

B I U x_2 x^2 Ω Σ Styles

Question 3a (2 marks)

Deodorants are used daily throughout the world and many types of these release gases into the air. Use the diagram below to **state** the two most common gases in the atmosphere and their percentage.



©

Gas 1:

Gas 2:

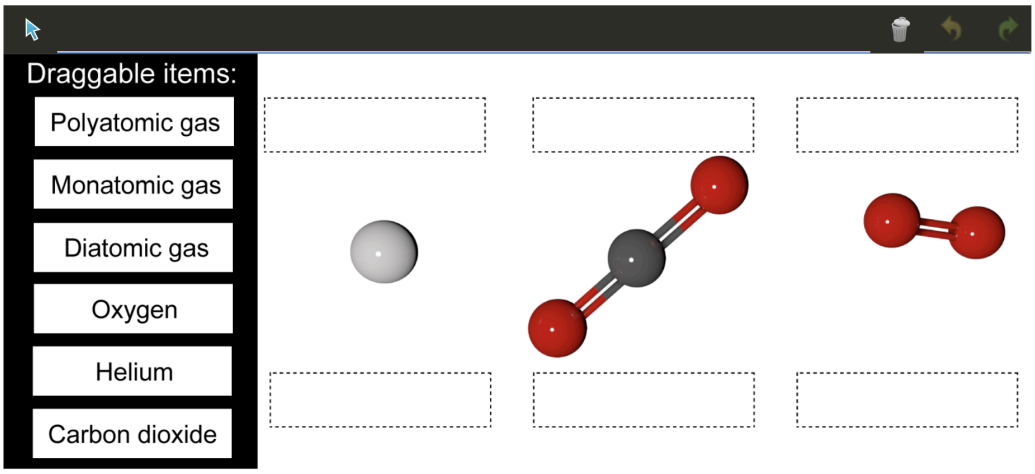
Percentage:

Percentage:

Scroll down to continue

Question 3b (3 marks)

Most of the gases in the atmosphere are diatomic or polyatomic. Noble gases, however, are monatomic. **Select** the correct location for the draggable items to complete the diagram below.

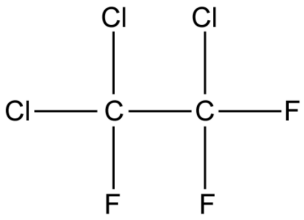


Question 3c (1 mark)

State a reason why noble gases are found naturally as a monatomic gas.

Question 3d (2 marks)

Aerosol sprays, like deodorants, are filled with a compressed gas that mixes with the deodorant liquid and sprays the liquid out of the can onto your skin. In the past, the compressed gases used in aerosols were chlorofluorocarbons (CFCs), like Freon® (chemical name trichlorotrifluoroethane). Here is the structure of Freon®.



Use the periodic table to **calculate** the relative molecular mass of Freon®.

Question 3e (3 marks)

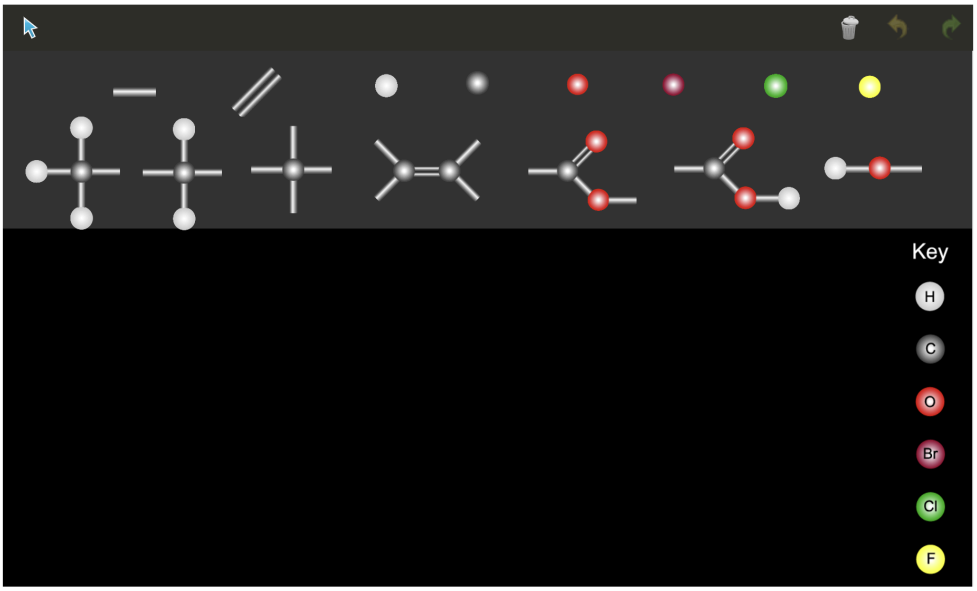
Deodorant sprays diffuse in the air, so that after some time the scent spreads further and will even fill small rooms.

Using particle theory, **explain** why it takes longer for the scent to fill a room at 4°C compared to a room at 20°C.

Question 3f (1 mark)

CFCs cause gradual thinning of the ozone layer of the atmosphere and therefore contribute to climate change. Today, industries have replaced CFCs with other gases such as propane C_3H_8.

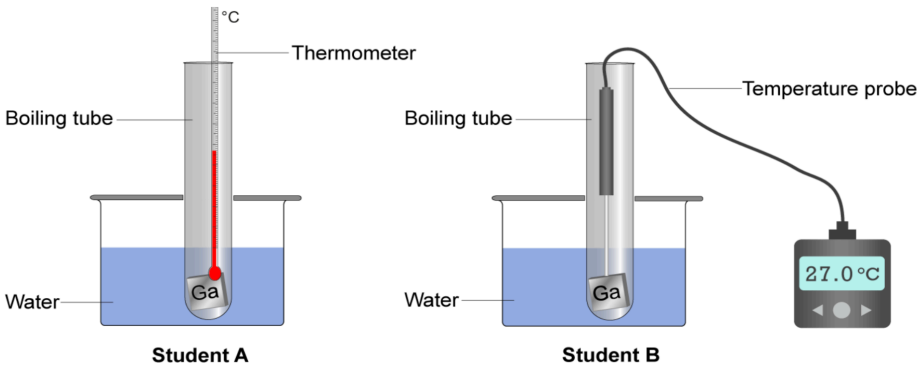
Use the tool to **draw** the structure of propane.



Question 4 (12 marks)

State of matter is a physical characteristic which allows materials to be classified and grouped together. Melting point is a useful property which is an important characteristic of materials.

Two students wanted to check the melting point of the metal gallium, symbol (Ga). One student used a thermometer and the other used a temperature probe. The samples of gallium are placed in boiling tubes which are placed in water baths as shown in the diagram below. As the temperature of the water increased, the students observed the change in state of the gallium.



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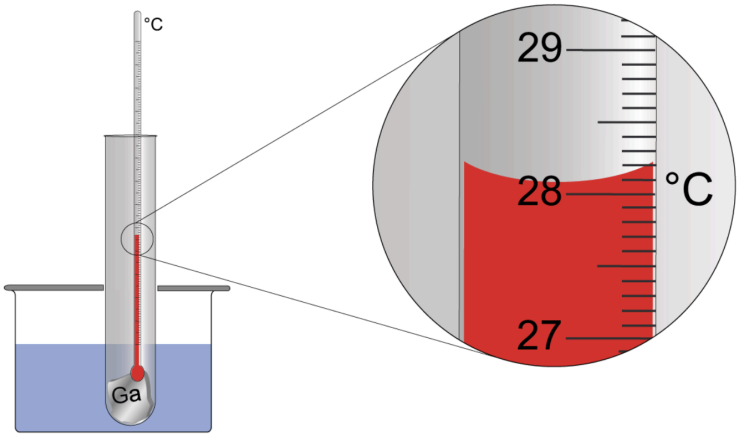
Question 4a (1 mark)

The students were told to determine the melting point of gallium. Student A used a thermometer to record the value when they saw the gallium start to melt.



©

State the temperature shown on the thermometer.

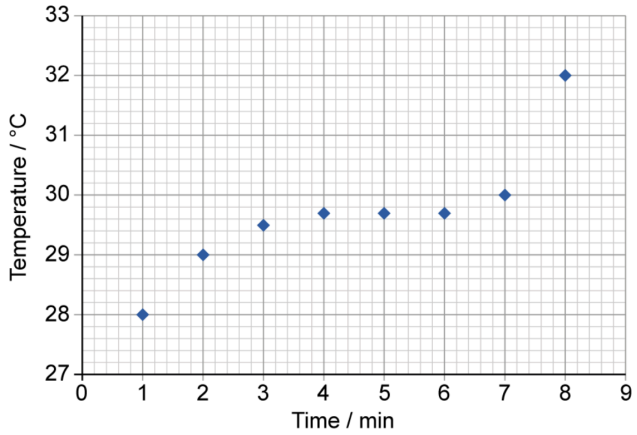
Question 4b (1 mark)

Student B used a temperature probe and recorded the following results.

Time / min	1	2	3	4	5	6	7	8
Temperature / °C	28.0	29.0	29.5	29.7	29.7	29.7	30.0	32.0

A graph of student B's data is given below.

Change in temperature over time



Using student B's data above, **determine** the melting point of gallium.

Question 4c (2 marks)

State and **justify** whether student A in part (a) or student B in part (b) obtained the correct melting point of gallium.

✓ Select
Student A
Student B

Styles

Question 4d (1 mark)

The melting points of mixtures are different to the melting points of individual elements. This can be seen when you look at the melting points of zinc (419.5°C) and copper (1085°C) compared to brass which is a mixture or alloy of zinc and copper.

Type of brass	Percentage of Cu / %	Percentage of Zn / %	Melting point / °C	Density / g cm^{-3}	Uses
A	95	5	1066	8.86	Pre-1983 coins
B	88	12	1035	8.78	Jewellery
C	85	15	1027	8.75	Electrical sockets
D	70	30	954	8.47	Radiators

Use the data in the table to **state** what happens to the melting point of the alloy as the percentage of zinc increases.

Question 4e (3 marks)

Alloys have different physical properties compared to their component elements. Pure copper has a density of 8.96 g cm^{-3} and pure zinc has a density of 7.14 g cm^{-3}.

Use the data in the table in part (d) to **formulate** a hypothesis linking the density of a brass alloy to the percentage of zinc it contains.

If:

Then:

Question 4f (2 marks)

Use the data in the table in part (d) to **predict** the melting point for a brass alloy consisting of a mix of 80 % copper and 20 % zinc.

Question 4g (2 marks)

Use the data in the table in part (d) to **select** a brass alloy that could be used for space exploration where temperatures can exceed 1050°C. **Justify** your answer.

- ✓ Select
- Type A
- Type B
- Type C
- Type D

Question 5 (7 marks)

A student knows that water freezes at 0°C but notices that other liquids freeze at different temperatures when they are put into a freezer. When chemicals are dissolved in water, the freezing point of the solution will become lower than the freezing point of water. The student wanted to know if there was a relationship between the solute and the freezing point of the solution.

The student left a bottle of soda in the freezer and the result is shown in the picture below.

Question 5a (1 mark)

State the gas that is added to drinks to make them carbonated.

Question 5b (2 marks)

The student placed salt water, sugar water, carbonated water, tap water and pure water into a freezer to investigate their freezing points.

State the variables in the student's experiment.

Independent variable:

Dependent variable:

Question 5c (2 marks)

Suggest two control variables for this investigation.

Control variable one:

Control variable two:

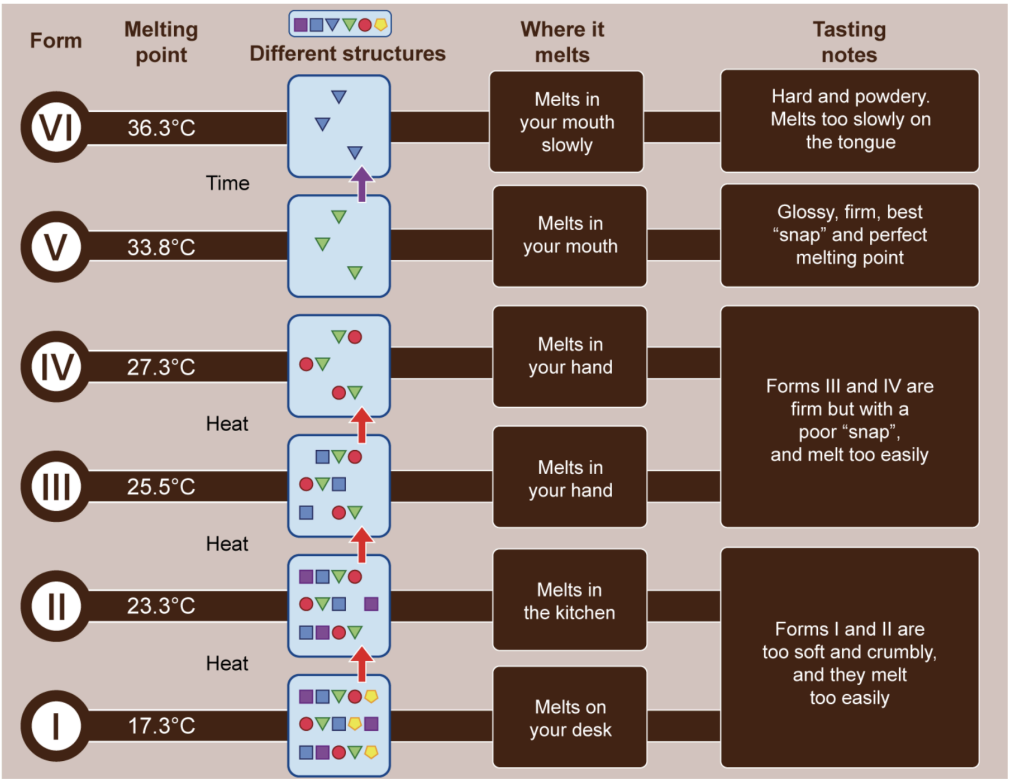
Question 5d (2 marks)

Formulate a research question for the student's investigation.

Question 6 (14 marks)

Chocolate is widely consumed around the world. The chemical composition of cocoa beans depends on the climate and location where the beans are grown. Cocoa beans are processed to produce cocoa butter and cocoa powder from which chocolate can be made.

During the manufacturing process, chocolate is melted and solidified a number of times in a process called *tempering*. This processing results in changes to the arrangement of the molecules in the cocoa butter. The different arrangements of molecules affect the taste of the chocolate.

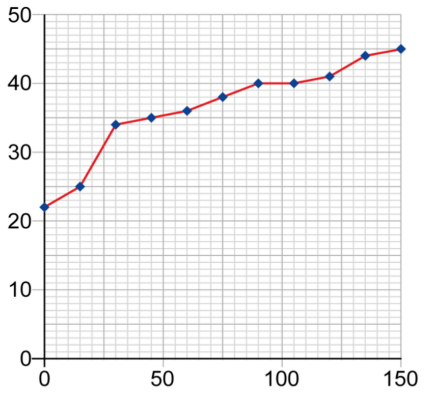


Question 6a (5 marks)

Two samples of chocolate, sample A and sample B, are heated in a water bath set to a temperature of 70°C. The data for sample A is shown in the table and graph below. The axis labels are missing from the graph.

Chocolate sample A

Time / s	Temperature / °C
0	22
15	25
30	34
45	35
60	36
75	38
90	40
105	40
120	41
135	44
150	45



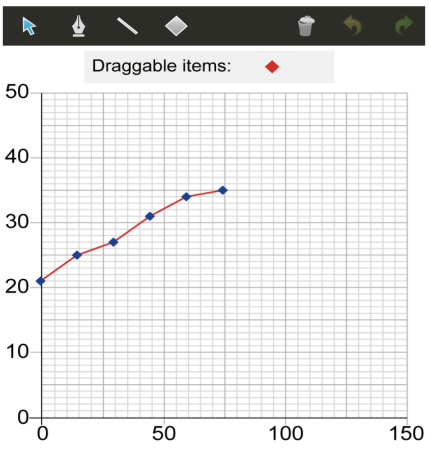
©

The data for sample B is shown in the table and graph below but this second graph is incomplete.

Plot the missing data, add an appropriate title and **label** the axes to complete the graph.

Chocolate sample B

Time / s	Temperature / °C
0	21
15	25
30	27
45	31
60	34
75	35
90	35
105	35
120	39
135	42
150	44



Scroll down to continue

Title:

Styles

x axis label:

Styles

y axis label:

Styles

Question 6b (2 marks)

Using both graphs and the infographic, **determine** whether chocolate sample A or chocolate sample B has Form V. **Justify** your answer.

Styles

Question 6c (3 marks)

A student wanted to know if the melting point of a chocolate bar was influenced by the percentage of cocoa it contained. They tested several chocolate bars and produced the following results.

Percentage of cocoa / %	Melting point / °C			Average melting point / °C
30	69.0	68.0	70.0	69.0
37	50.0	51.0	51.0	51.0
60	37.0	36.0	37.0	
70	32.4	31.6	32.0	32.0
85	28.0	27.7	27.8	27.8

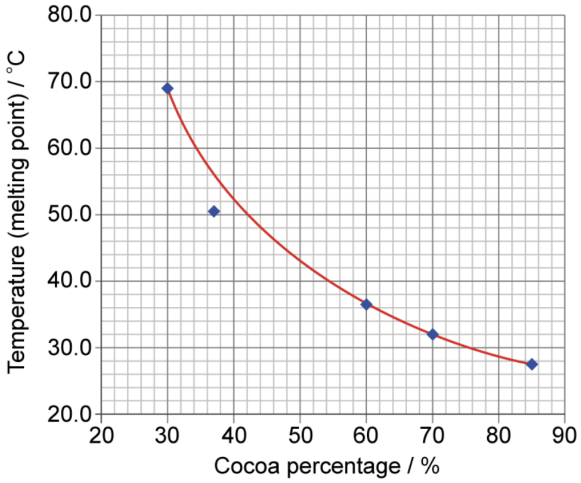
Reset

Calculate the average melting point for the chocolate with the composition 60 % cocoa and **add your value to the table**. You should show your working in the box below and give your final value to three significant figures.

Scroll down to continue

Question 6d (2 marks)

The data was presented in the graph below.



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Use the graph to **determine** the melting point of chocolate with 50 % cocoa.

Question 6e (1 mark)

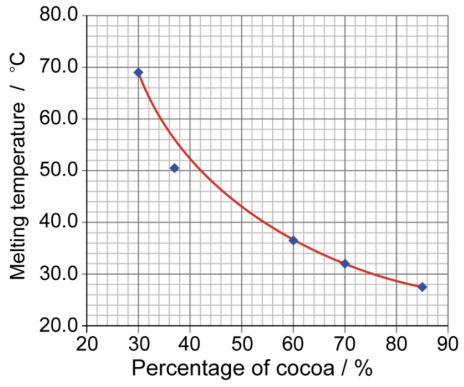
The data point at 37 % cocoa is an outlier. **Suggest** a reason why this data point does not lie on the trend line.

B I U x_2 x^2 Ω Σ Styles

Question 6f (1 mark)

A second student suggested a different trend line shown on graph 2 on the right.

Graph 1



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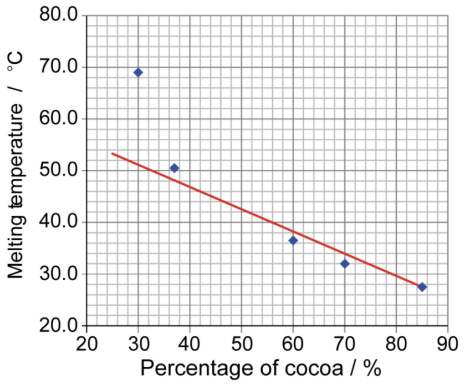
Graph 2



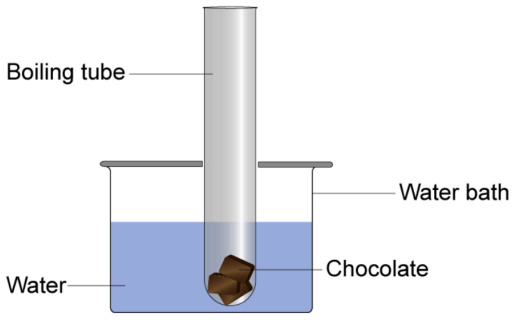
©

Suggest an improvement to the experiment to determine the correct trend line.

B I U x_2 x^2 Ω Σ Styles

Question 7 (15 marks)

A new sweet company is marketing a series of new chocolate bars with different percentage sugar contents. You are provided with a series of chocolate samples with 20 %, 30 %, 40 %, 50 % and 60 % sugar content. Some of the equipment needed is shown in the diagram below.



©

Design an experiment to investigate how the percentage of sugar in a chocolate bar will affect its melting point. In your answer, you should include:

- the independent, dependent and control variables
- a list of additional equipment you will use
- the method you will follow
- details of measurements you will take to collect sufficient data
- any safety precautions you need to take.

Question 8 (12 marks)

Cars that use petrol or diesel from crude oil are slowly being replaced by electric cars, many of which use lithium-ion batteries.

Question 8a (1 mark)

Lithium is in group 1 of the periodic table. **Write down** the symbol for a lithium ion.

B I U x_2 x^2 Ω Σ Styles

Question 8b (2 marks)

The average model of an electric car battery contains about 12 kg of lithium. **Calculate** how many moles of lithium are in 12 kg. Give your answer to one decimal place.

Question 8c (9 marks)

Whilst offering an environmentally friendly alternative, lithium-ion batteries are regarded as an example of a linear economy where products are made, used and thrown away.

It is estimated that 39 million tonnes of lithium is mined every year from places such as Argentina, Bolivia and Chile. Lithium, found as a solution of lithium carbonate in underground deposits, is pumped to the surface using fresh water and allowed to evaporate in the sun.

Initial geological surveys claimed that the mining of lithium was not likely to cause serious environmental concerns but it has become increasingly obvious that this is not the case.

This media is interactive

Environmental aspects of lithium mining	Environmental aspects of crude oil extraction

- Lithium is only mined in South America so must be transported to factories all over the world.
- Land now used for lithium mining was previously used for grazing.
- Lithium mining uses fresh water from underground water deposits to clean machinery and pipes.
- More fresh water is leaving the system through mining than is returning through rain.
- Small farms growing crops nearby are affected by the water shortage.
- Potash is an additional product of lithium mining and could be used as fertilizer but requires different processing.
- Chemicals including hydrochloric acid and waste products can leak from the evaporation pools into the water supply.

This media is interactive

Environmental aspects of lithium mining

Environmental aspects of crude oil extraction

- Crude oil is extracted in countries such as Saudi Arabia and Russia and are transported around the world.
- Drilling for crude oil disrupts wildlife habitats and landscapes.
- Inland crude oil extraction uses some fresh water which may lead to water shortages.
- Carbon dioxide and other polluting gases are released into the atmosphere in the extraction process.
- Inland crude oil extraction from fracking can cause minor earthquakes and can potentially release toxic chemicals into the water supply and atmosphere.
- Crude oil can be processed into other products such as plastics and medicines.
- Crude oil spills can be deadly to animals.

Using information from the infographic above and your wider MYP studies, **discuss** and **evaluate** the consequences of using lithium-ion batteries in electric cars to replace petrol cars. In your answer, you should include:

- environmental advantages and disadvantages of lithium-ion batteries and petrol
- social impacts of lithium-ion batteries and petrol
- an appraisal about whether lithium-ion batteries should be used to replace petrol.

Question 9 (12 marks)

The growing world population and finite natural resources make the current linear economic model unsustainable. In a traditional linear economy, products are made, used and thrown away.

In a circular economy, the linear model that promotes short-term consumption is replaced with one that encourages the reuse and recycling of resources. This model is based on the cyclical patterns in nature where materials are continually reused and recycled with minimum impact on the environment.

The video below gives further information about the transition from a linear to a circular economy.

Video | Script

In the natural cycle of life, organisms eat, grow, die and decompose to become food or a source of energy for new organisms to re-start the cycle.

In a consumer society, however, there is a linear approach to manufacturing. Raw materials are mined or extracted to make products that are used and then thrown away. For example, we buy newly released phones and throw away old ones.

A linear economy uses a large amount of raw materials to make products. At the end of life of a product, a large amount of waste is released to the environment. A circular economy would use a smaller amount of raw materials and produce less waste.

Mobile phones and other appliances such as washing machines or fridges are not biodegradable. These products contain a number of valuable metals and materials such as plastics which could be recycled instead of being thrown away. In a circular economy, components are reused in new products, making them the resources of the future.

Phones could be designed to last, to be easily disassembled and the components replaced. For an individual, it makes sense economically to upgrade a phone by replacing outdated components rather than buying an entire new phone.

In the future, phones could be eco-designed with cases made out of biodegradable plastics, recyclable screens and reusable metallic parts.

Owning a device may become a thing of the past. In the future we may rent our devices from manufacturers. After paying a fee to use the device for a fixed time.

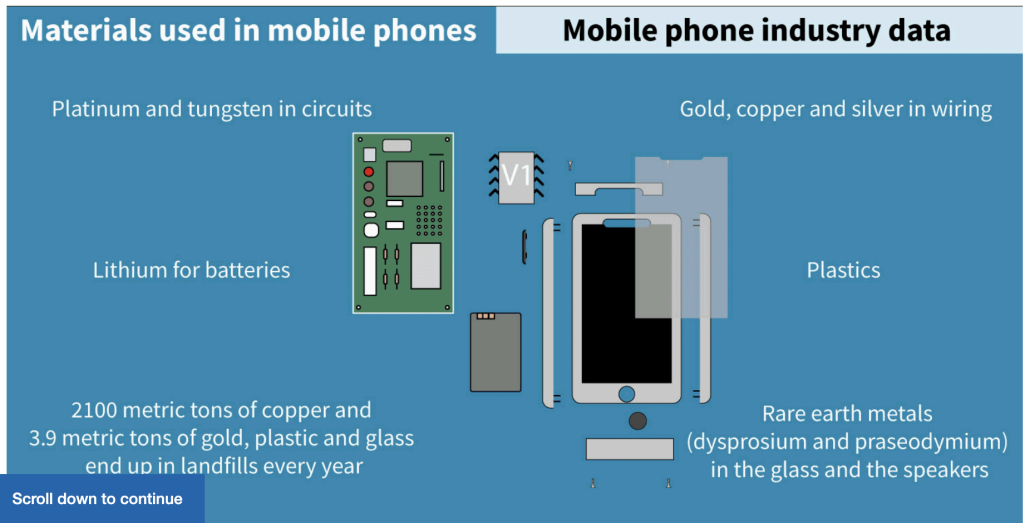
The manufacturer would provide maintenance services and replace the devices when they are not fit for purpose anymore. When returned to the manufacturer, the device may be reused, upgraded or disassembled into its components.

The circular economy model relies on manufacturers, recycling companies and consumers all working together.

The circular economy model is based on ten principles that aim to change the current social, economic and environmental model to benefit both consumers and businesses. Some of these principles are:

- Waste becomes a resource.
- Second use: rather than being thrown away, devices are repaired, updated and reused.
- Functionality economy, which aims to eliminate the sale of products to establish a system of rental economy.
- Industrial ecology, where companies and individuals working together reduce the environmental impact of industrial processes. This could include the use and distribution of materials, energy and services.

This media is interactive



Using information given in the video, infographic and your wider MYP studies, **discuss** the impact of the transition from a linear to a circular economy. In your answer, you should include:

- economic aspects of linear and circular economies
- use of resources
- social impacts for an individual and wider society
- a concluding appraisal.