



Question 1 (7 marks)



In May 2018 Kīlauea, a volcano on Hawaii's Big Island, erupted. The volcano exploded, releasing lava, ash and toxic gas. Rivers of lava from the crater flowed into the ocean and jets of steam were released. As the lava flowed into the ocean, it cooled rapidly and glass particles were formed. The emissions from the volcano could have caused damage to lungs, eyes and skin.



Question 1a (1 mark)

Lava is a liquid which cools down to form rocks.

Select the name of the physical process that takes place when lava cools down.

Select



Question 1b (2 marks)

The composition of lava is different for different volcanoes. The major component of lava is SiO_2 with oxides of iron and magnesium present in different proportions.

Determine the missing information and complete the table below.

Oxide	Formula
	SiO_2
magnesium oxide	



Scroll down to continue

Reset



Question 1c (1 mark)

Three types of lava are basaltic, andesitic and rhyolitic. The SiO_2 content for each type of lava lies within the following ranges, all of them expressed in percentage by mass:

Type of lava	Range of percentage of SiO_2 by mass / %
Basaltic	45.5 – 55.2
Andesitic	52.0 – 63.7
Rhyolitic	68.3 – 77.4

A group of geologists analysed the SiO_2 content in samples of rock from three different volcanoes: Kilauea, Mount Vesuvius and Mount Etna.

A 2.00 g sample of rock from Kilauea contained 0.994 g of SiO_2 .

A 2.00 g sample of rock from Mount Vesuvius contained 1.16 g of SiO_2 .

The table below is incomplete. You cannot write in this table.

Rock source	Mass of SiO_2 in 2.00g sample / g	Percentage SiO_2 by mass	Rock type
Kilauea	0.994	49.7	
Mount Vesuvius	1.16		

Select the type of rock from Kilauea.

Select



Question 1d (2 marks)

Calculate the percentage of SiO_2 in the rock sample from Mount Vesuvius.

B *I* ← → U \times_2 \times^n $\frac{\square}{\square}$ $\frac{\square}{\square}$ Ω Σ Styles



Scroll down to continue



Question 1e (1 mark)

Using your answer from part (d), **select** the type of rock from Mount Vesuvius.

Select ▾



Scroll down to continue



Question 2a (2 marks)

It was once believed that each volcano had its own particular type of gas: sulfur dioxide (SO_2) at Mount Etna or hydrogen chloride (HCl) at Mount Vesuvius. This proved to be untrue: volcanic gases are mixtures of water vapour and different gases, such as carbon dioxide (CO_2) and hydrogen sulfide (H_2S). In the case of Kilauea, gaseous hydrogen chloride is a major component.

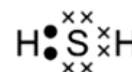
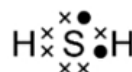
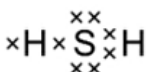
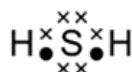
Suggest why volcano crater lakes typically have pH values as low as 0.1.

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Question 2b (1 mark)

Select the Lewis (dot cross) structure of H_2S .





Question 2c (1 mark)

Some noble gases such as helium, neon and argon can also be released into the atmosphere when volcanoes erupt.

Use the periodic table to **state** the period of argon.

B *I* ← → U \times_2 \times^n $\frac{1}{2}$ $\frac{3}{4}$ Ω Σ Styles



Question 2d (3 marks)

Neon exists as a mixture of isotopes. The most abundant isotopes of neon are ^{20}Ne , ^{21}Ne and ^{22}Ne .

Determine the number of protons, neutrons and electrons in an atom of ^{22}Ne .

Protons:

B *I* ← → U \times_2 \times^n $\frac{1}{2}$ $\frac{3}{4}$ Ω Σ Styles

Neutrons:

Rich text editor toolbar with icons for Bold (B), Italic (I), Undo, Redo, Underline (U), Subscript (x₂), Superscript (x²), Bulleted List, Numbered List, Omega (Ω), Sigma (Σ), Styles, and a trash icon. The editor area is empty.

Electrons:

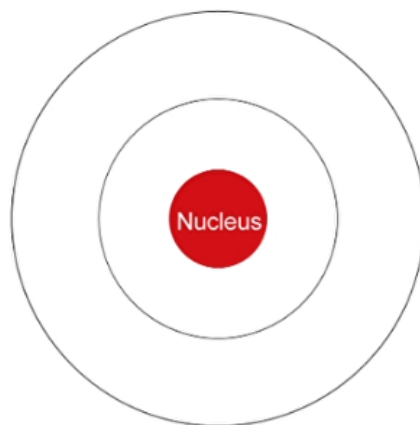
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Question 2e (2 marks)

Draw the electron configuration of neon.

Drawing toolbar with a mouse cursor icon, a trash icon, and two undo/redo arrows.



Draggable:



Scroll down to continue

Question 3 (10 marks)

The text below is part of an article published in April 2017 in *The Guardian*. The author, Dave Hall, is concerned about what he calls “throwaway culture”.

Throwaway culture has spread packaging waste worldwide: here's what to do about it

Packaging – much of it single-use food wrapping – has created a rubbish problem that now pollutes every corner of the world.



In 2003, I was told by a restaurant owner on a Thai island that local fishermen used to wrap their lunch in banana leaves, which they would then casually toss overboard when done. That was OK, because the leaves decayed and the fish ate the scraps. But in the past decade, he said, because plastic wrap had rapidly replaced banana leaves, the beach was now fringed with a crust of plastic. Beyond the merely unsightly, this plastic congregates in continent-scale garbage-gyres in our oceans, being eaten by fish; then quite possibly it'll reach your plate ... This is a worldwide problem – we can't point the finger at Thai fishermen. The west started this.



Scroll down to continue

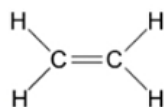


Question 3a (1 mark)

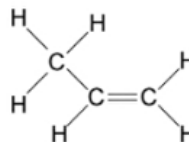
Plastics are synthetic materials. Plastics have high molecular masses meaning each molecule can have thousands of atoms bonded together. In the past, synthetic plastics were made using chemicals from oil.

The two organic compounds shown below, A and B, are used to make two common plastics.

A.



B.



Select the chemical classification of molecules A and B.

Select



Scroll down to continue



Question 3b (2 marks)

State the name of each chemical in part (a).

A:

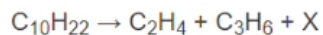
B:





Question 3c (1 mark)

Molecules A and B can be obtained by breaking down long chain molecules such as decane, $C_{10}H_{22}$.



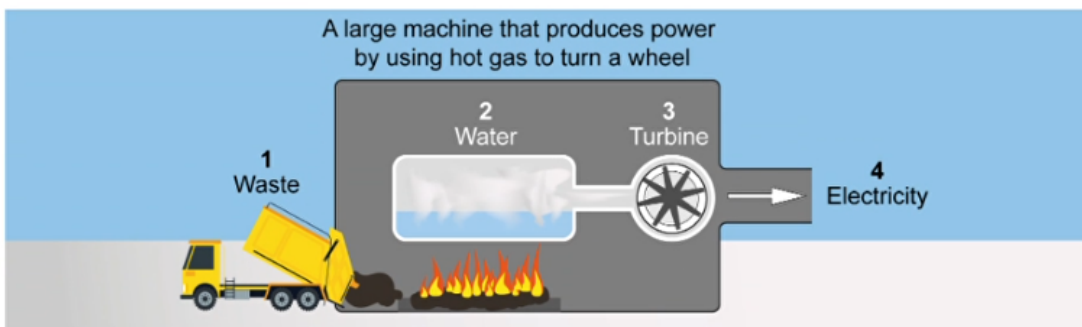
Deduce the molecular formula of the missing product X.

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Question 3d (1 mark)

For many years, non-recyclable plastic waste ended either in landfills or incinerators. However, during the last decade, many countries have implemented thermovalorization. This system makes it possible to recover energy from solid waste. The process – usually called “waste-to-energy”, can be outlined as follows: waste is burned in a plant at very high temperatures. The gases produced are treated with calcium hydroxide. The energy generated by burning waste is used to heat water, which is converted into high pressure steam. This steam is able to drive a turbine and generate electricity, later conveyed to the public grid.




State why calcium hydroxide is added to the gases produced during the incineration of waste.

B *I* ← → U \times_2 \times^2 $\frac{1}{x}$ $\frac{1}{x^2}$ Ω Σ Styles - 



Question 3e (1 mark)

State the physical change taking place between stages 2 and 3 of the thermovalorization process.

B *I* ← → U \times_2 \times^2 $\frac{1}{x}$ $\frac{1}{x^2}$ Ω Σ Styles - 





Question 3e (1 mark)

State the physical change taking place between stages 2 and 3 of the thermovalorization process.

B *I* ← → U x_2 x^e $\frac{1}{2}$ $\frac{3}{4}$ Ω Σ Styles -



Question 3f (1 mark)

In most countries, incineration of waste in this type of process is subject to strict regulations. **Suggest** one requirement that should be included in order to reduce the environmental impact of the process.

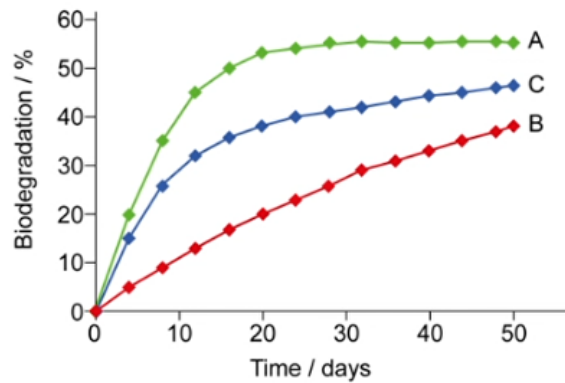
B *I* ← → U x_2 x^e $\frac{1}{2}$ $\frac{3}{4}$ Ω Σ Styles -





Question 3g (3 marks)

There has been a move away from non-biodegradable plastics to biodegradable plastics. The rate of biodegradation was tested for a given plastic. Pellets of the plastic were ground in order to obtain three samples, A, B and C with different size particles. The samples were buried in soil and tested over 50 days. The data is shown in the graph below.



List the order of the three samples in order of increasing particle size. **Justify** your answer.

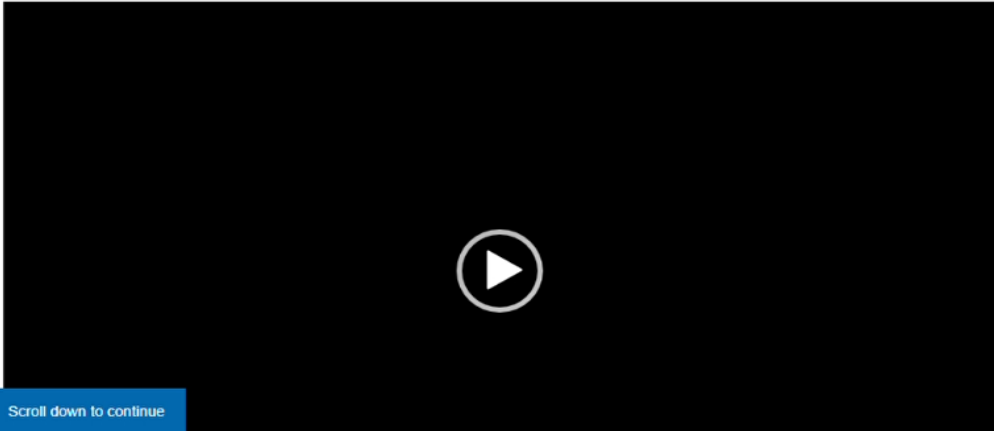
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Question 4 (17 marks)

Glow sticks produce light in a chemical reaction. They can be used by the military, by divers or just for fun.

Video Script



Scroll down to continue

Question 4 (17 marks)

Glow sticks produce light in a chemical reaction. They can be used by the military, by divers or just for fun.

Video Script

Glow sticks work by combining two chemicals to produce light in a chemical reaction known as chemiluminescence. One of the chemicals in the glow stick is a catalyst.

The catalyst is separated from the other reactants inside a sealed tube.

Keeping the catalyst separate prevents the reaction starting until light is needed. Once the tube containing the catalyst is broken, the reaction will produce light.

Scroll down to continue



Question 4a (2 marks)

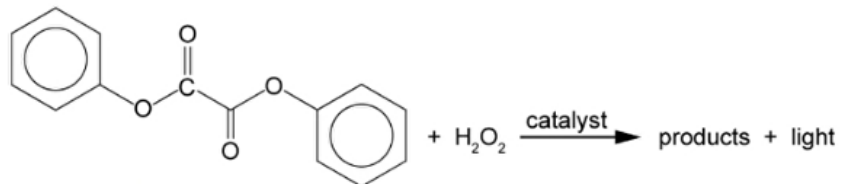
Outline the function of a catalyst.

B *I* ← → U ×₂ ×² ∑ ∑ Ω ∑ Styles

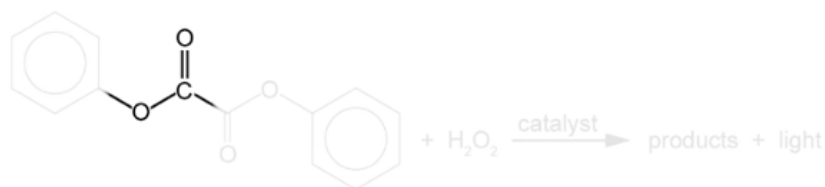


Question 4b (1 mark)

One of the chemicals involved in the reaction is called phenyl oxalate. This is a complex molecule. A simplified version of the reaction taking place in a glow stick is shown below:



Select the name of the organic functional group highlighted below from the phenyl oxalate molecule.



Select ▾

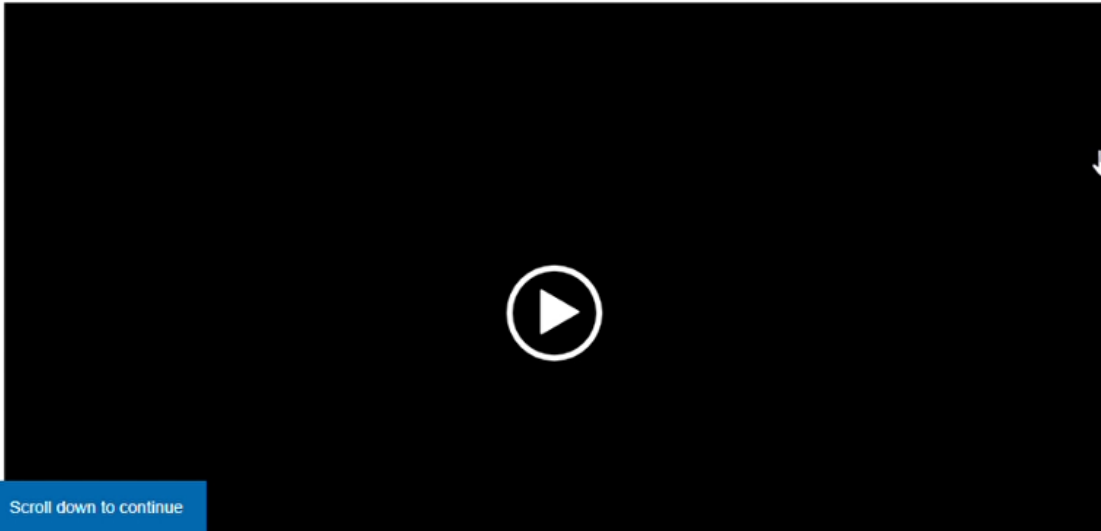




Question 4c (1 mark)

A student is interested in the length of time that glow sticks will glow at different temperatures. The student placed identical glow sticks into water at various temperatures and then broke the inner tube, starting the reaction.

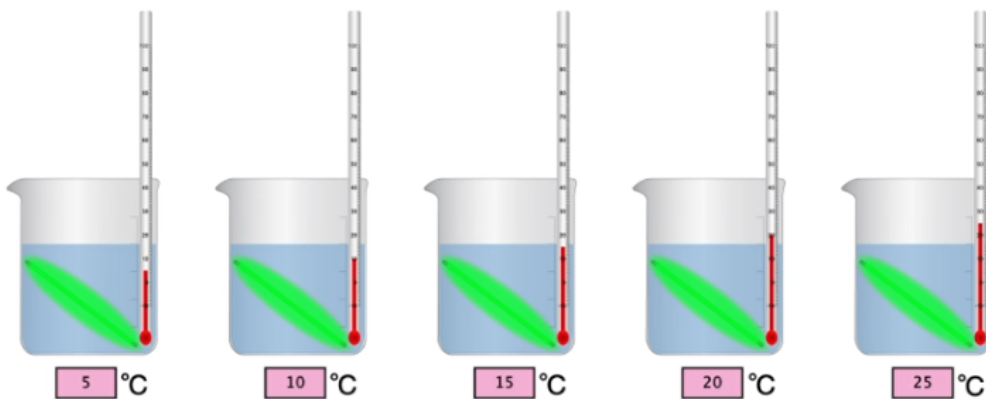
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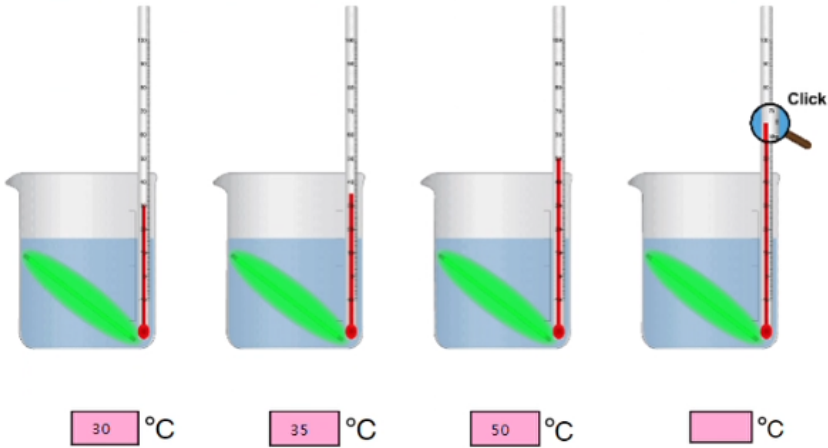


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Measure the missing temperature.

Diagram not to scale





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Question 4d (4 marks)

Identify the variables for this investigation.

Independent variable:

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Dependent variable:

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Control variable one:

B *I* ← → U x_2 x^2 $\frac{1}{x}$ $\frac{1}{x^2}$ Ω Σ Styles

Control variable two:

B *I* ← → U x_2 x^2 $\frac{1}{x}$ $\frac{1}{x^2}$ Ω Σ Styles



Question 4e (3 marks)

Formulate a suitable hypothesis for the investigation.

If:

B *I* ← → U x_2 x^2 $\frac{1}{x}$ $\frac{1}{x^2}$ Ω Σ Styles

Then:

B *I* ← → U x_2 x^2 $\frac{1}{x}$ $\frac{1}{x^2}$ Ω Σ Styles



Scroll down to continue

Because:

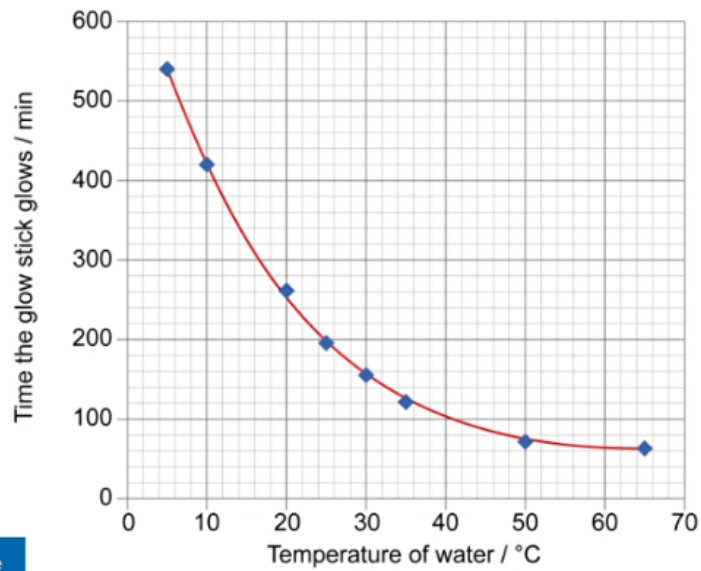
B *I* ← → U x_2 x^2 \int \sum Ω Σ Styles



Question 4f (2 marks)


The student calculated average data for the investigation and plotted a graph shown below:

Average time taken for the glow stick to stop glowing



Scroll down to continue


Predict the time taken for the glow stick to stop glowing at 15°C.

B *I* ← → x_2 x^2 $\frac{1}{x}$ $\frac{1}{x^2}$ Ω Σ Styles - 



Question 4g (4 marks)

A glow stick contains 6.58×10^5 molecules of phenyl oxalate. The time for the reaction to stop at 20°C is 260 minutes. **Calculate** the rate at which the phenyl oxalate molecules are used up at this temperature. You should include appropriate units in your answer.

B *I* ← → x_2 x^2 $\frac{1}{x}$ $\frac{1}{x^2}$ Ω Σ Styles - 



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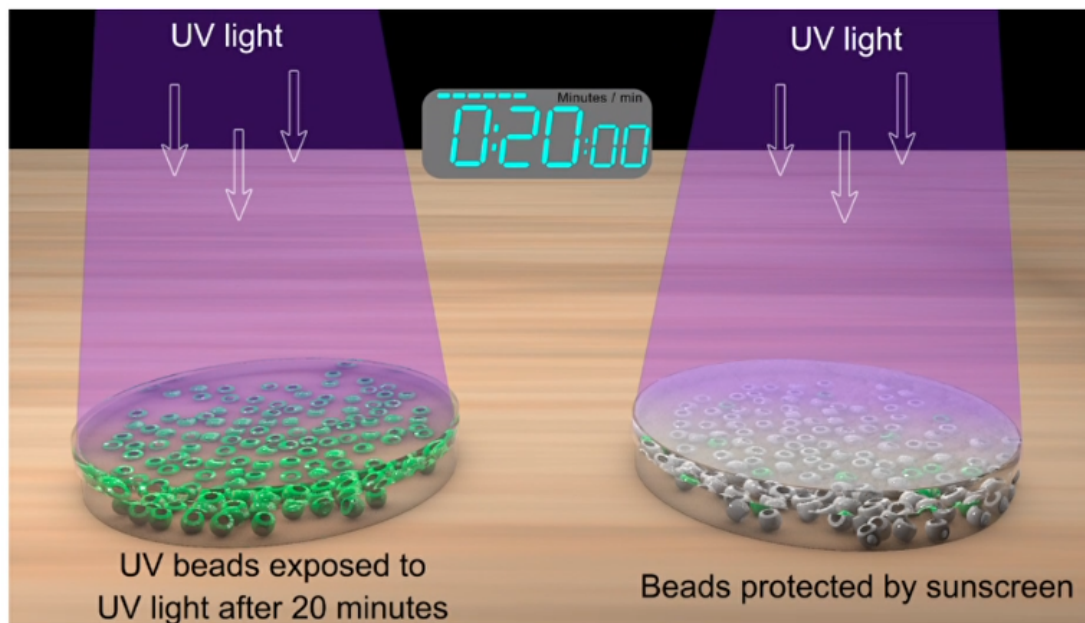
Question 5 (20 marks)



Sunlight is important for a number of reasons; it is used by plants to produce glucose, harnessed by solar panels or solar cells to produce useable energy and used by melanin in the skin to provide us with vitamin D. Melanin production in the skin prevents too much exposure from ultra-violet (UV) light and hence lowers the risk of health problems.

When in the sun, it is recommended that we apply sunscreen every 20-30 minutes as the effectiveness of its protection is limited to this length of time. Sunscreen is usually a mixture of several different chemical components. The main ones are homosalate, octisalate, titanium oxide and zinc oxide.

When white UV-reactive beads are exposed to UV light the beads will change colour. A student decided to investigate how many UV-reactive beads changed colour when protected from UV light by three different sunscreens. The sunscreen was spread over the lid of the container.





Question 5a (1 mark)



Percentage of beads that changed colour after 20 minutes in UV light

100

28

10

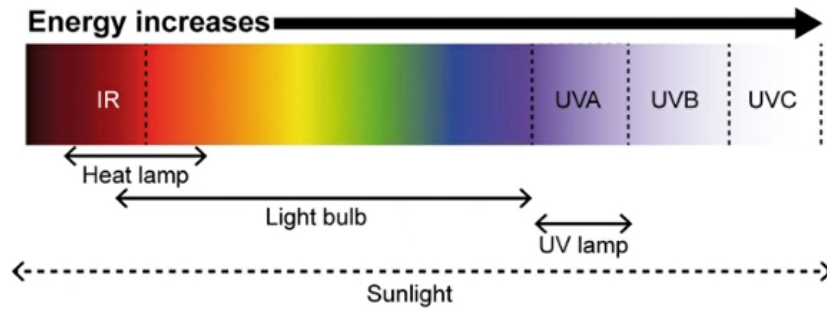
Use the information above to **state** which is the most effective sunscreen.

B *I* ← → U x_2 x^2 $\frac{1}{2}$ $\frac{3}{4}$ Ω Σ Styles



Question 5b (2 marks)

The diagram below shows the light emitted by different sources. The experimental method uses a UV lamp. **Outline** why this lamp is not a good model for natural sunlight.



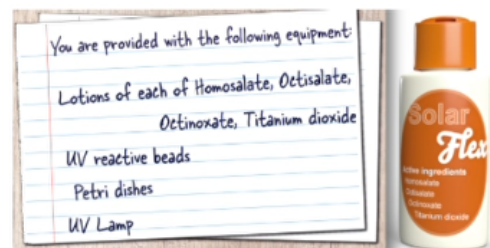
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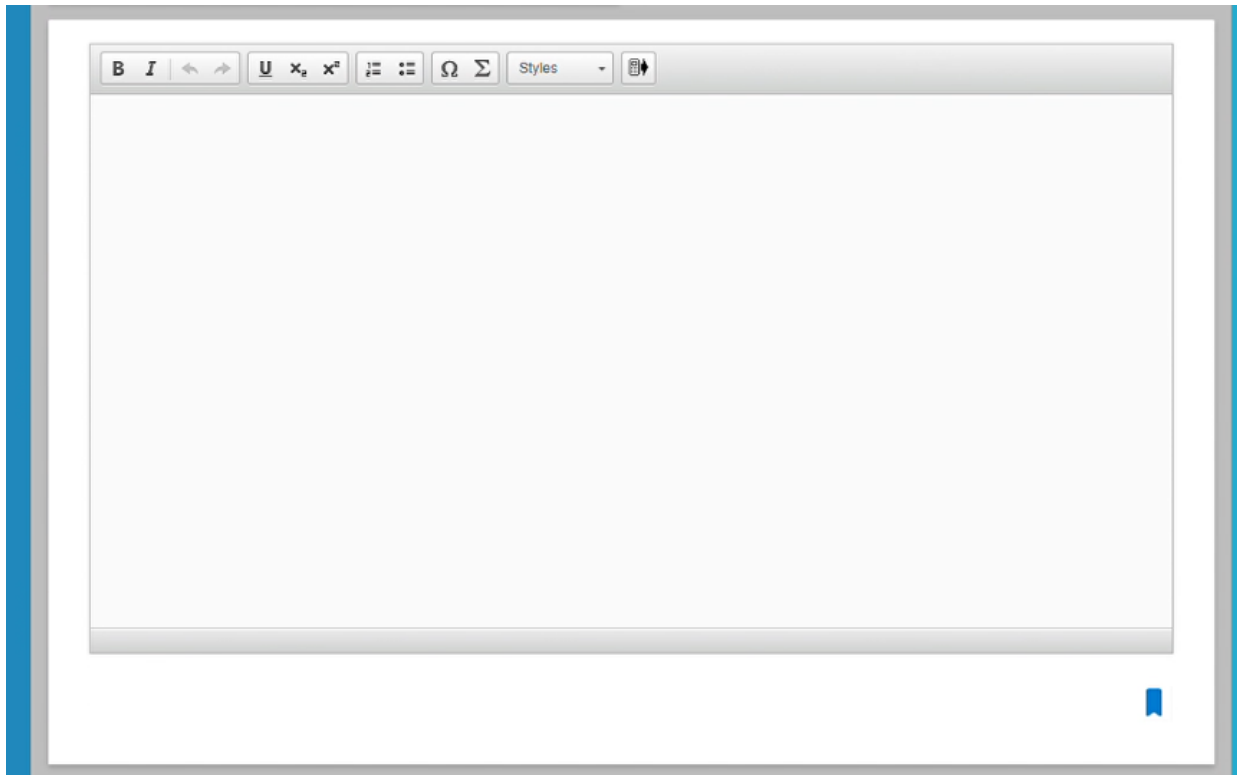
Question 5c (17 marks)

Using the equipment below, **design** an investigation to determine which of the individual chemical compounds present in Solar Flex sunscreen provides the best protection from the sun. In your answer you should include:

- an identification of the variables
- a list of the additional equipment you will use
- details of your method for manipulating the variables
- details of the data you will collect
- how you will ensure that your method is safe.



©



Question 6 (10 marks)

Question 6a (2 marks)

Solar Flex was one of the sunscreens investigated in question 5.
Solar Flex's composition is given below:
Homosalate, Octisalate, Octinoxate, Titanium dioxide

The research question suggested was:

Is titanium dioxide the best blocker of UV light?

Outline how you will use the data from the investigation in question 5 to decide if the research question is supported.

B I ← → **U** x₂ x² **☰ ☷** **Ω Σ** **Styles** - **📱**

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Question 6b (1 mark)

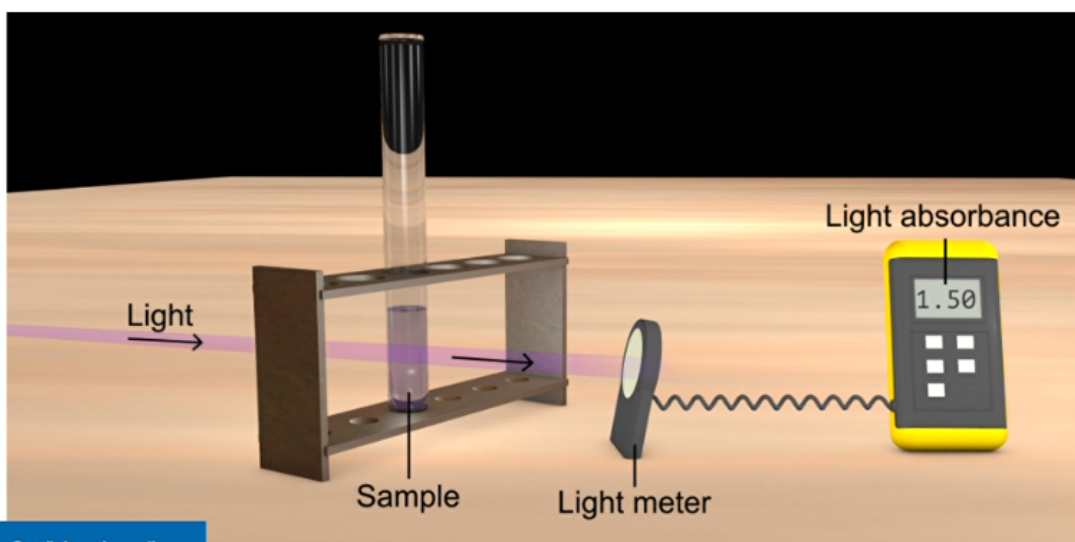
Suggest an extension that could be made to the investigation into the effectiveness of the sunscreen ingredients.

B *I* ← → U \times_2 \times^2 $\frac{1}{x}$ $\frac{1}{x^2}$ Ω Σ Styles



Question 6c (6 marks)

Chemists are analysing a new chemical, myponium, to see if it can be used to block out UV light in sunscreens. The chemists do this by making different concentrations of myponium and measuring how much light is absorbed. Absorbance is measured in absorbance units (AU). The concentrations of myponium are very low; they are measured in micromoles dm^{-3} ($\mu\text{mol dm}^{-3}$).



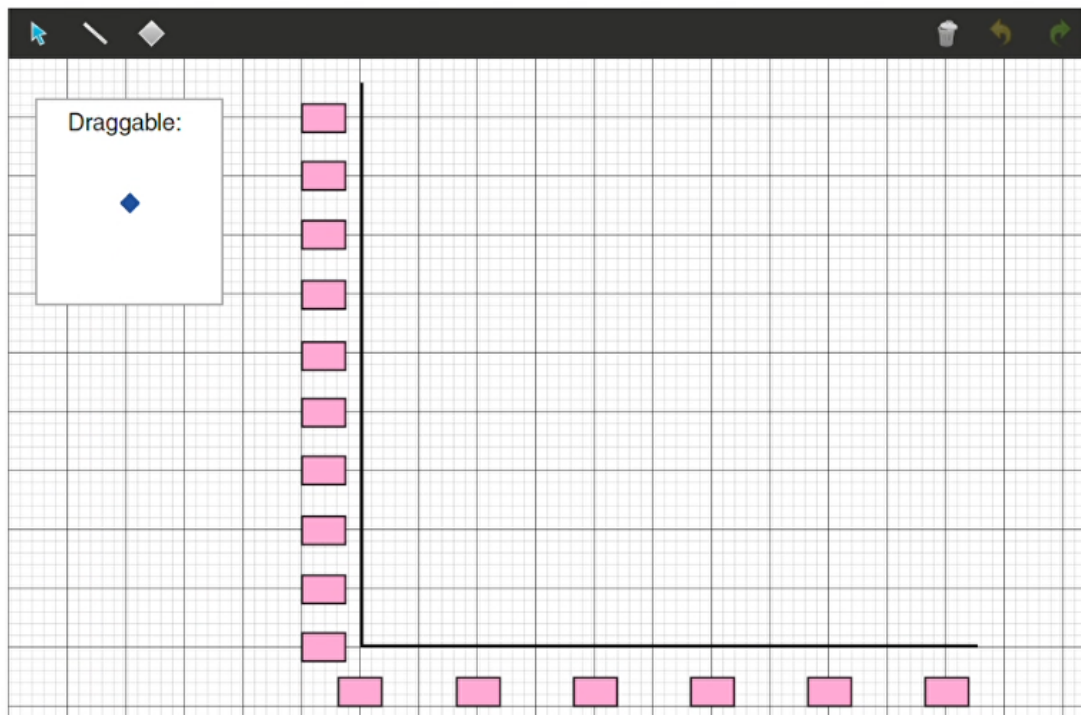
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The results are shown below:

Concentration of myponium / $\mu\text{mol dm}^{-3}$	0	10	30	50	70	90	100
Absorbance / AU	0.00	0.15	0.40	0.65	0.60	1.40	1.50

Plot a graph of the absorbance vs concentration of myponium. You should label the axes, give your graph a suitable title and add a line of best fit.

Title



Scroll down to continue

x axis label:

B *I* ← → U x_0 x^e $\frac{1}{2}$ $\frac{3}{4}$ Ω Σ Styles -

y axis label:

B *I* ← → U x_0 x^e $\frac{1}{2}$ $\frac{3}{4}$ Ω Σ Styles -



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Question 6d (1 mark)

Comment on the reliability of the data.

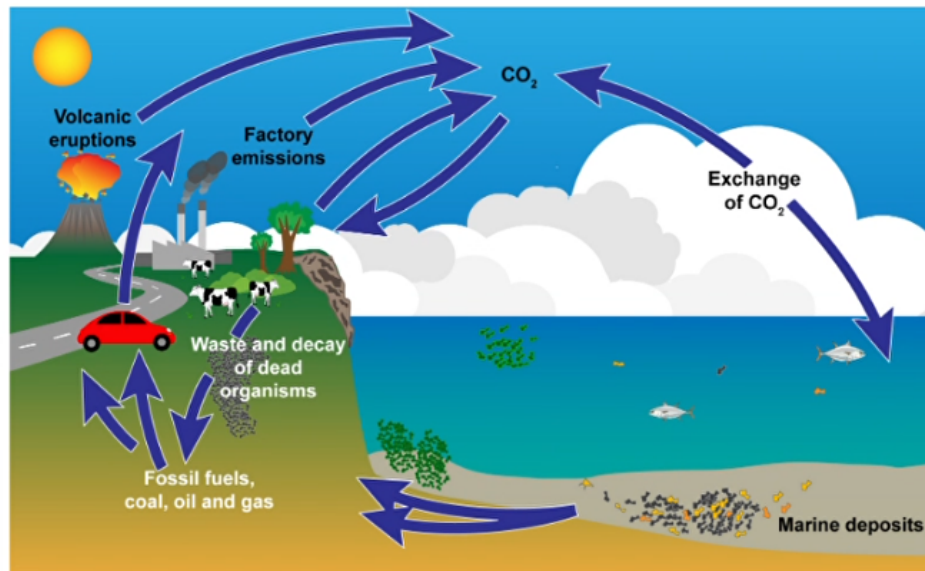
B *I* ← → U x_0 x^e $\frac{1}{2}$ $\frac{3}{4}$ Ω Σ Styles -



Question 7 (12 marks)

Climate change is a global threat recognized by the Intergovernmental Panel on Climate Change (IPCC). The cause of climate change is thought to be due to increased levels of greenhouse gases, mainly carbon dioxide. Increased levels of carbon dioxide have resulted in an increase in the average temperature of the Earth. In the future, severe droughts are predicted in some regions, while floods are predicted in other areas. Both situations will lead to famine and increased poverty.

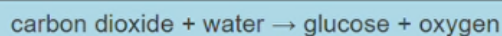
In the natural carbon cycle, carbon dioxide comes from sources such as respiration, volcanic eruptions, fossil fuels and industrial processes such as cement making. One way that carbon dioxide can be removed from the atmosphere is by photosynthesis in plants. The plants act as a natural carbon dioxide sink. Extensive deforestation means that less carbon dioxide is trapped in trees so levels are increasing in the atmosphere.





Question 7a (2 marks)

Photosynthesis is a natural process in which carbon dioxide is removed from the atmosphere. The glucose is used by plants for growth. The plants can be used as foods for local communities. The word equation for photosynthesis is shown below:



Using this equation and information from your wider MYP studies, **suggest** an impact on the **community** due to deforestation. **Justify** your answer.

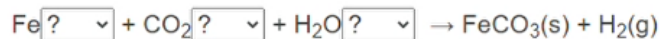
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Question 7b (2 marks)

One way to reduce carbon dioxide in the atmosphere is to react CO₂ with other chemicals to form a solid material, for example as shown in the reaction below:



Select the state symbols for the reactants in the equation if the reaction was at 25°C.



Question 7c (1 mark)

Select the name of FeCO₃.

Select





Question 7d (3 marks)

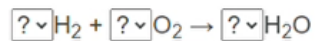
Describe what happens to iron in the reaction in part (b) in terms of redox chemistry.

B *I* ← → U \times_2 \times^d $\frac{\square}{\square}$ $\frac{\square}{\square}$ Ω Σ Styles -



Question 7e (2 marks)

The hydrogen produced in the reaction in part (b) could be used as a fuel. **Select** numbers to balance the equation below:



Scroll down to continue



Question 7f (2 marks)

Outline why the combustion of hydrogen is better for the environment than the combustion of petrol.

B *I* ← → U \times_2 \times^d $\frac{\square}{\square}$ $\frac{\square}{\square}$ Ω Σ Styles -



Question 8 (15 marks)



Scientists have been developing different systems of carbon dioxide sinks, each with their own advantages and disadvantages. A developing island nation with large industrial areas wants to follow internationally-agreed CO₂ emission levels. The island's economy is based on agriculture and tourism. 24 % of the country is desert and this is increasing, impacting the area available for agriculture and tourism.

System 1 – Ferrock

Video Script

Ferrock is a new material which absorbs carbon dioxide when it is manufactured. Ferrock is an iron carbonate.

It is made from waste iron dust and glass bottles which would normally be dumped in landfills.

Ferrock can replace cement as a construction material as it is stronger and can be used in salt water environments.

Production of Ferrock is environmentally friendly compared to cement. It uses waste materials and carbon dioxide, whereas cement production releases large amounts of carbon dioxide and relies on quarrying.

Application of science:

Ferrock is a new construction material which absorbs carbon dioxide in its manufacture. Ferrock is much harder and more stable than traditional building materials. It has high strength in land and sea water constructions.

Employment:

- Workers to collect waste glass bottles
- Workers to transport iron dust to Ferrock factory
- Workers to make Ferrock bricks

Cost:

Removal of 50 kg of CO₂ through Ferrock production costs USD263



Scroll down to continue

System 2 – Carbon dioxide capture (CDC)

Video Script

Carbon dioxide capture (CDC) uses a device that can absorb carbon dioxide from the atmosphere.

Currently in development, CDC captures carbon dioxide by dissolving it in a solution to form a carbonate solution. Development of the CDC process requires the cooperation of scientists from various areas.

Recently, scientists are exploring the combination of trapped carbon dioxide with hydrogen gas to produce hydrocarbons to be used as fuel. These hydrocarbons can reduce our dependence on fossil fuels.

Application of science:

Carbon dioxide capture technology has been developed on a small scale. This can use renewable energy to efficiently capture CO₂. Scientists are currently developing the technology on a larger scale.

Scientists are in the initial stages of research on how to combine CO₂ and H₂O to form fuels.

Employment:

- Scientists to develop carbon dioxide capture process
- Scientists to develop processes to transform captured carbon dioxide into fuel
- Workers to install and maintain equipment

Cost:

Removal of 50 kg of CO₂ costs USD10

⌵ Scroll down to continue

System 3 – Conversion of desert areas

Video Script

Deserts can be created by human activities such as deforestation and climate change. This results in disruption of the water cycle and decreasing soil quality.

Globally, the equivalent of one hundred and twenty thousand square kilometres of land are lost every year. This is the area of land needed to grow 20 million tonnes of grain. Loss of farming and habitable land forces people to migrate.

Researchers have developed simple strategies for converting desert land into arable land. A mixture of substances found in plant cell walls is added to the sand which allows it to retain water, nutrients and air.

The system has been tried in China where

Application of science:

A plant growth material which retains water and nutrients has been developed to transform desert land into [arable land](#).

This plant growth material has been used successfully in similar situations for thirty years but is new to the island.

Employment:

- Workers to manufacture the plant growth material
- Workers to cultivate land
- Scientists to ensure that the process is sustainable

Cost:

Removal of 50 kg of CO₂ costs USD3.20

Video Script

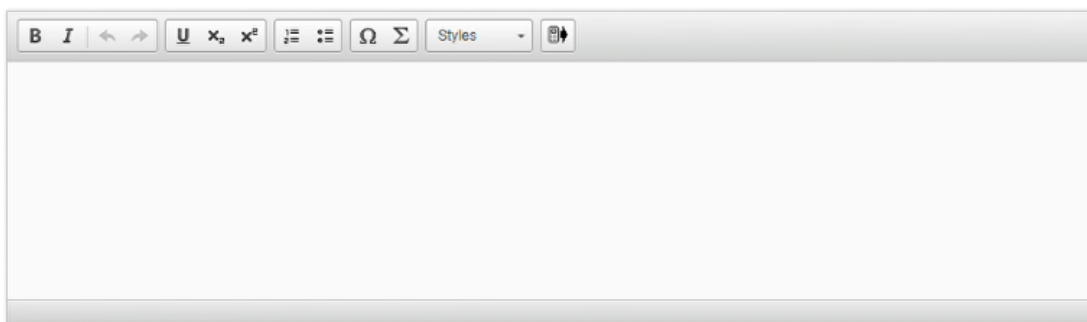
strategies for converting desert land into arable land. A mixture of substances found in plant cell walls is added to the sand which allows it to retain water, nutrients and air.

The system has been tried in China where desert lands have decreased by nearly thirteen thousand square kilometres over the past 15 years. Reducing deserts has reduced the number of sand storms. Farmers also have a much higher income and more food sources are available to communities.


At the same time, the plants from the converted arable land provide a natural carbon dioxide sink and hence reduce the amount of carbon dioxide in the atmosphere.

The media above gives information about three different possible systems to reduce the levels of carbon dioxide. Using the information in the media and your wider MYP studies, **discuss** and **evaluate two** of the three systems. In your answer you should include:

- the need for carbon dioxide sinks
- the economic impact of each system
- the social impact of each system
- scientific advantages and disadvantages of each system
- a concluding appraisal recommending which is the best system.



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 (x₂), Superscript (x²), Bulleted List (three horizontal lines with a dot), Numbered List (three horizontal lines with numbers), Link (Ω), Unlink (Σ), Styles (a dropdown menu), and a Refresh/Reset icon (circular arrow).

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