Question 1b (1 mark)

Select the states of matter to complete the table below.

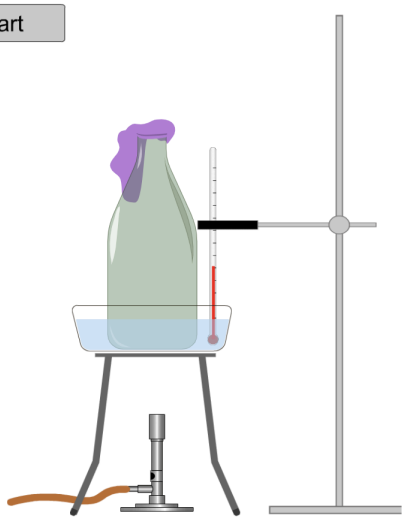
Change of state	Initial State	Final State
Condensation	Select	Select
Vaporization	Select	Select

Reset

Question 1c (3 marks)

A student conducts an experiment in which she places a balloon over a glass bottle filled with a gas at room temperature. A Bunsen burner is lit and the balloon expands as the temperature of the gas increases.

Start



©

Use kinetic theory to **explain** why the balloon expands when the Bunsen burner is lit.

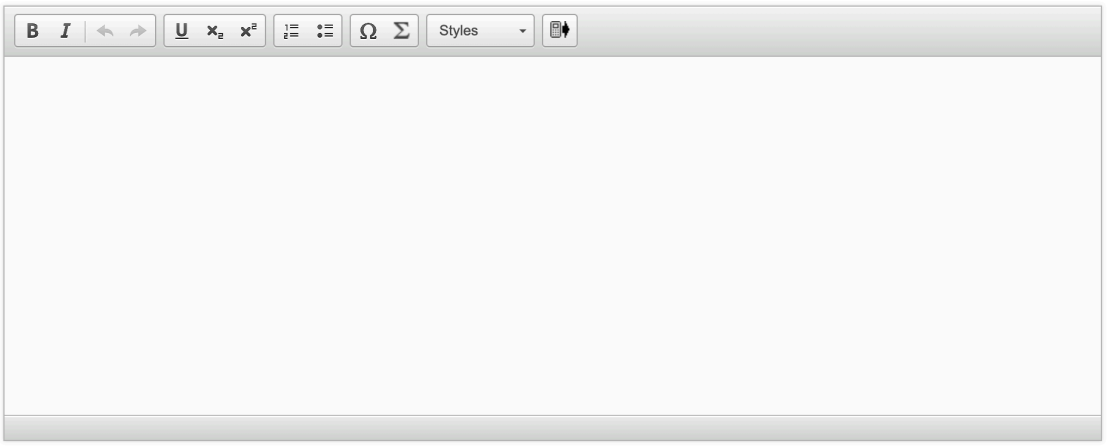
B I U Styles

Question 1d (2 marks)

The origins of kinetic theory are linked to Einstein's explanation of a phenomenon known as Brownian motion illustrated in the video below.

This media contains no audio

Use your knowledge of kinetic theory to **suggest** the cause of the observed random movement of smoke particles in air.



Question 2 (8 marks)

Another of the papers Einstein published during his *annus mirabilis* showed the relationship between the mass and the energy of an object when it is not moving. The relationship is given by the equation

$$E = mc^2$$

where E represents the energy of the object, m is the object's mass, and c is the speed of light.

Question 2a (1 mark)

Label each quantity in the equation with its SI unit (Système international d'unités).

Draggable:

kilogram	metre	metre per second
joule	second	newton

E	=	m	$(c)^2$
			metre per second

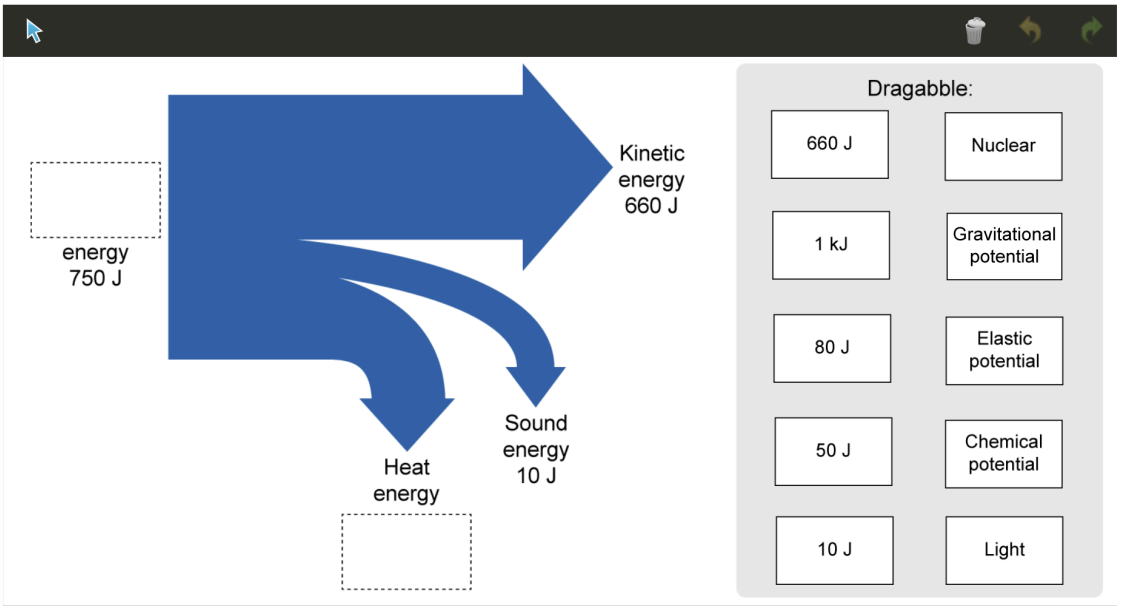
Question 2b (2 marks)

The image below shows a child moving down a slide.

©

The Sankey diagram shows the energy transformations taking place as the child moves down the slide.

Select the correct options to label the Sankey diagram.



Question 2c (3 marks)

The mass of the child is 25 kg. Use information from the Sankey diagram to **calculate** the child's velocity at the bottom of the slide. Give your answer to 2 significant figures.

B I U Styles

Question 2d (2 marks)

The laws of conservation of energy and Einstein's mass-energy relationship $E = mc^2$ apply when understanding transformations in particle physics. A positron is an example of anti-matter. When an electron and a positron meet, all of their mass is turned into energy.

Use the information in the table below to **calculate** how much energy is released in this process. The speed of light, $c = 3.0 \times 10^8$ ms^{-1}.

Particle	**Mass / kg**
Electron	**9.11×10^{-31}**
Positron	**9.11×10^{-31}**

Question 3 (12 marks)

Question 3a (1 mark)

Select the best description of a light wave.

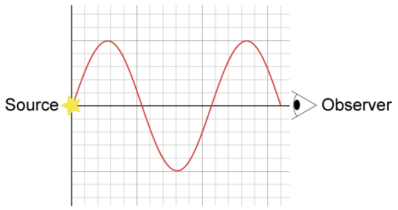
Light is an example of a ✓Select wave.

- transverse mechanical
- transverse electromagnetic
- longitudinal mechanical
- longitudinal electromagnetic

Question 3b (2 marks)

Question 3b (2 marks)

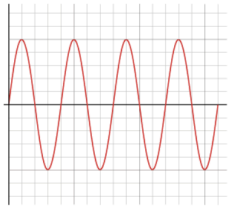
Here is a graphical representation of a light wave from a stationary source that is seen by an observer.



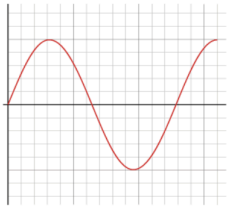
©

In astronomical observations, the properties of light can be affected by the motion of objects. **Select** the graph that shows how the appearance of the wave would change if the source was moving away from the observer. **Justify** your answer.

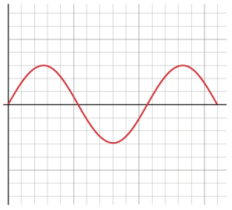
A.



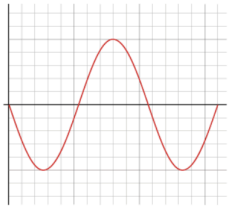
B.



C.



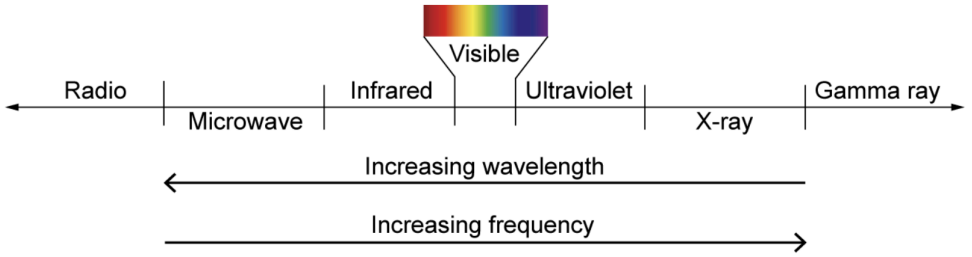
D.



©

Question 3c (2 marks)

The phenomenon in part (b) is known as red-shift. **Suggest** the meaning of the term red-shift by considering the visible light emitted by a star and by referring to the electromagnetic spectrum shown below.



©

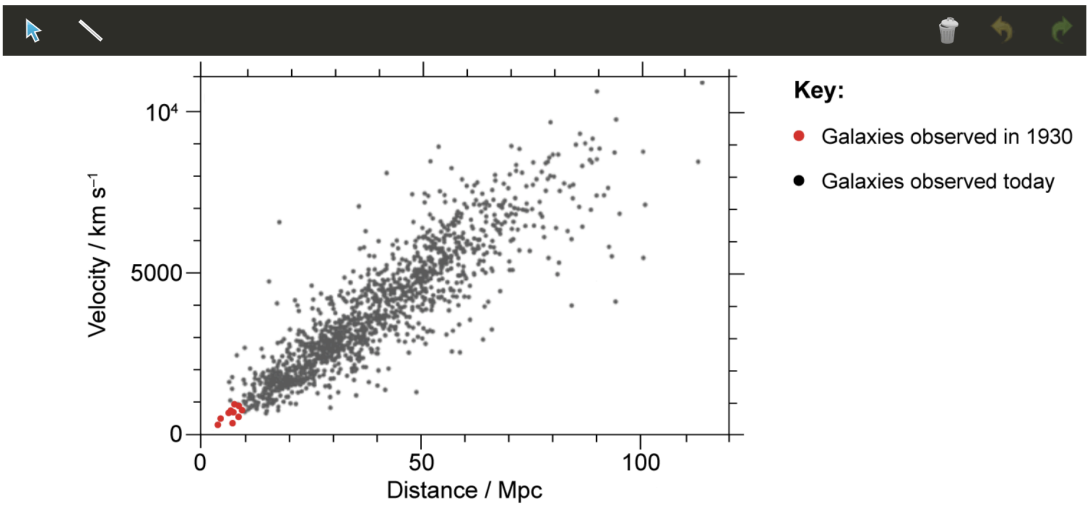
B I U Styles

Question 3d (2 marks)

Scientists use information about red-shift to make predictions about the speed of expansion of the universe.

The graph below shows the relationship between how far an object is from Earth and how quickly it is moving. Astronomical distances are very large. On the graph, these distances are shown in units called megaparsec (Mpc).

Draw a line of best fit on the graph.



Question 3e (2 marks)

Outline the relationship shown on the graph in part (d).

B I U x_2 x^2 Ω Σ Styles

Question 3f (2 marks)

The relationship in part (d) is known as Hubble's law. **Suggest** how the Big Bang theory is supported by Hubble's law.

B I U x_2 x^2 Ω Σ Styles

Question 3g (1 mark)

In 1930, Hubble used the gradient of a line of best fit on the graph to estimate the age of the universe as 1.8 billion years. We now estimate the age of the universe to be 13.8 billion years. Use the graph to **suggest** why this estimate has changed.

B I U Styles

Question 4 (16 marks)

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Georg Ohm was an important figure in describing the physics of electricity. He is probably most well-known for discovering the relationship that we now call Ohm's law.

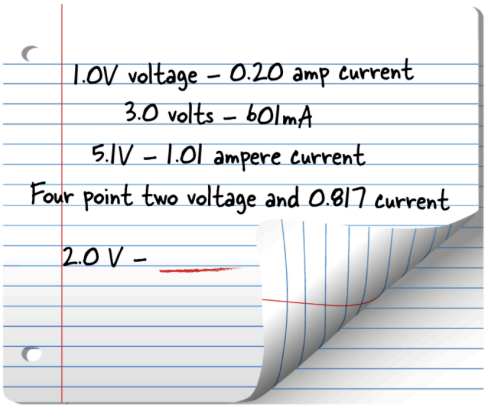
Ohm's law states that the current (I) that flows through a conductor is proportional to the voltage (V) across that conductor.

Materials that follow this relationship are known as ohmic conductors; materials that do not obey this relationship are known as non-ohmic conductors.

Classifying a component as either ohmic or non-ohmic requires accurate measurements of current and voltage.

Question 4a (6 marks)

A group of MYP students collect current and voltage data for an unknown component, which we will call *component X*. Their notebook is shown below. One of the measurements is incomplete.



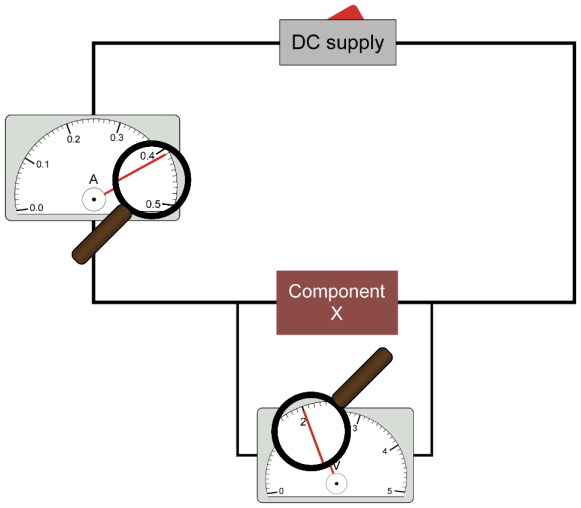
Organize and **present** the students' results in a table of raw data.

Create New Table

Reset

Measure the current in the interactive circuit below and add your value to your data table.

Click to zoom



Question 4b (3 marks)

Before collecting the data, the students formulated the following hypothesis:

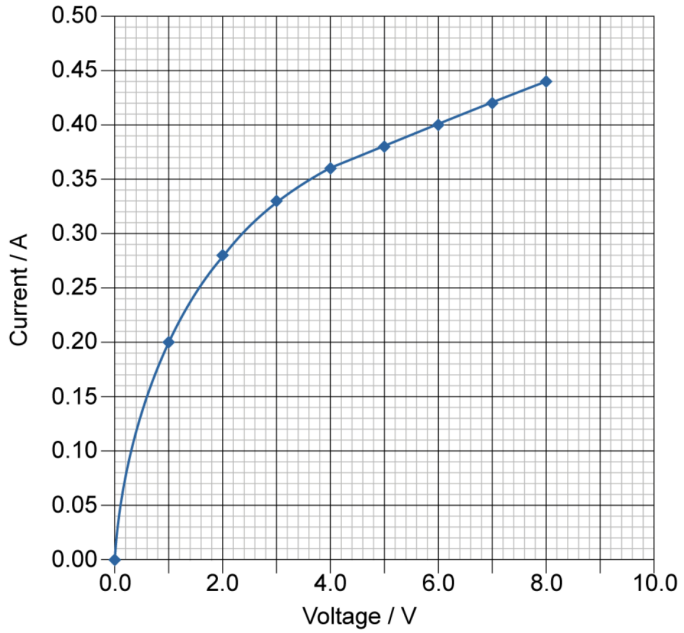
> *If the voltage across component X doubles then the current will also double because component X is an ohmic conductor and therefore current is proportional to voltage.*

Explain whether the data in the table support the students' hypothesis. You should include calculations to support your answer.

Question 4c (2 marks)

Another group of MYP students collect current and voltage data for an unknown component, which we will call *component Y*. The graph of their results is shown below.

A graph of current against voltage for component Y



Using the graph above, **outline** whether *component Y* is an ohmic conductor.

Scroll down to continue

Question 4d (1 mark)

In the investigation of *component X*, a table of data was used to explore a relationship, whereas in the investigation of *component Y* a graph was used.

Suggest why a graph is a more appropriate presentation of this data.

Question 4e (3 marks)

Using data from the graph in part (c) and the formula sheet, **calculate** the resistance of *component Y*:

when a voltage of 1.0V is across it.

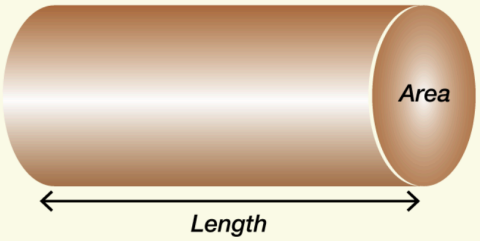
when a current of 0.40A flows through it.

Question 5 (14 marks)

Question 5a (1 mark)

An MYP student is interested in the factors that can affect the resistance of a wire. The student does some research and finds the following information in a physics textbook:

The resistance of a conductor changes with length and area



The relationship below illustrates this:

$$\text{resistance} = \frac{\text{resistivity} \times \text{length}}{\text{area}}$$

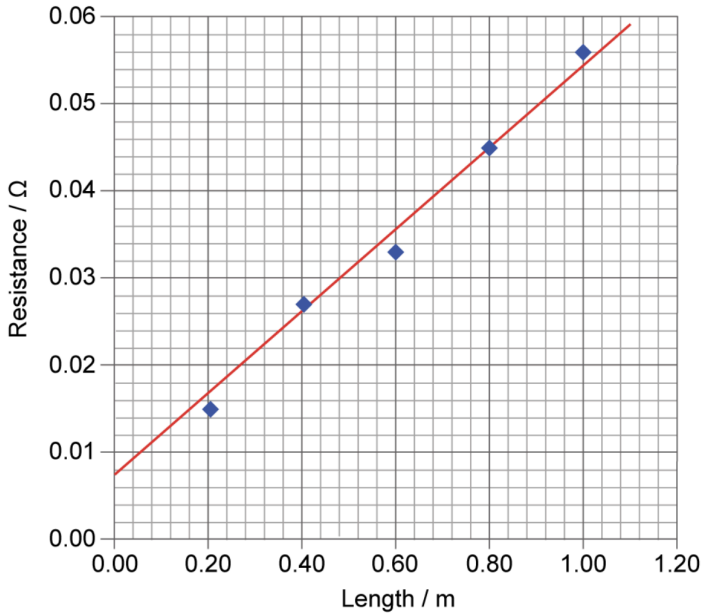
Using symbols this is written as:

$$R = \frac{\rho l}{A}$$

The quantity known as resistivity (ρ) is determined by the material that the conductor is made out of.

The student investigates how the length of the wire is related to its resistance. The results of their investigation are shown in the graph below:

A graph of resistance against length for a conducting wire



Using information from the student's research, **select** what is represented by the gradient of the graph.

$\rho \times A$ $\frac{\rho}{A}$ ρ $\frac{A}{\rho}$

Scroll down to continue

Question 5b (3 marks)

Calculate the gradient of the graph, giving your answer in appropriate units.

B I U x_2 x^2 Ω Σ Styles

Question 5c (2 marks)

Another student in the same class makes the following statement:

> *There is clear evidence of systematic error in these results.*
> *This will affect the accuracy of the gradient calculation.*

Identify the evidence for systematic error in the graph of these results. **Justify** your answer.

B I U x_2 x^2 Ω Σ Styles

Question 5d (3 marks)

Discuss the validity of the student's statement in part (c) about the accuracy of the gradient calculation.

B I U x_2 x^2 Ω Σ Styles

Question 5e (1 mark)

Suggest a possible source of the error identified by the student in part (c).

B I U x_2 x^2 Ω Σ Styles

Question 5f (4 marks)

Another student decides to investigate the relationship between resistance and the area of a wire. They know that

$$R = \frac{\rho l}{A}$$

Formulate and **explain** a hypothesis for the relationship between resistance and area. You should refer to the microscopic structure of a conducting material and the model of moving charge carriers in your explanation.

B I U x_2 x^2 Ω Σ Styles

Question 6 (20 marks)

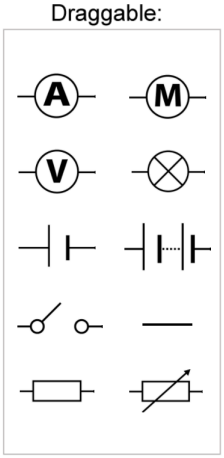
An MYP student is interested in the design of decorative lights and how the number of bulbs connected in series could affect the size of the current flowing through them.

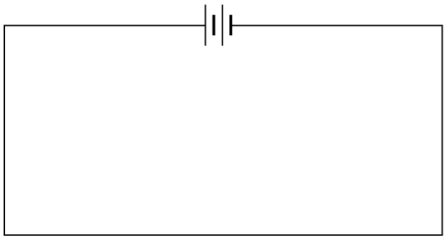
©

Question 6a (3 marks)

Construct a circuit diagram to show how you would measure the current flowing through two bulbs connected in series. The circuit diagram has been started below.

Draggable:





Question 6b (15 marks)

Design an investigation into the relationship between the number of bulbs in a series circuit and the current that flows through them for the student to follow. In your plan you should include:

- the research question that this investigation will test
- a hypothesis that can be tested by this investigation
- the independent variable and the dependent variable
- one control variable and why it should be controlled
- how you will collect sufficient relevant data
- a method detailing your procedure including any measuring equipment needed.

Question 7a (3 marks)

There are many options for electricity generation as society moves away from burning coal, oil and gas. Many of these options are carbon neutral; they do not contribute to a net increase in the levels of carbon dioxide in the atmosphere. The infographic below illustrates three of these options.

Wood burning biomass

Description
Quick growing trees, such as pine or willow, are farmed and then burned to provide the heat for a conventional power station. The area that is used to grow the trees can provide a space for people to experience woodland.

Advantages
Entirely carbon neutral, the energy that is generated is cheap and easy to harness.

Geothermal power

Description
Holes are drilled into the ground. Water is pumped down and is heated by naturally occurring hot rocks many metres down. The water is returned as steam and used to turn a turbine. If pressure builds up underground, earthquakes may be more likely to occur.

Advantages
Entirely carbon neutral, the electricity supply is stable and available continuously. As energy is continuously available, it allows for long term planning. No polluting gases are emitted.

Tidal power

Description
As the tides rise and fall, water is captured and allowed to run through turbines. The building of tidal plants requires significant up-front costs which are likely to only be available from tax payer investment.

Advantages
Entirely carbon neutral and predictable, the power plants constructed last for a long time and require little maintenance.

Select the correct disadvantage for each method of electricity generation.

Wood burning biomass	Geothermal power	Tidal power
Disadvantage	**Disadvantage**	**Disadvantage**

Draggable:

- Needs to be built in geologically suitable areas and the start-up costs are high.
- Needs to be built at considerable distance from built up areas in case of explosion. Leaves behind waste that must be stored for considerable periods of time.
- Mining of the fuel can cause damage to the environment. Produces gases that have a heating effect on the Earth's atmosphere.
- Needs a large amount of space for fuel production. There is also a time delay between planning the power plant and production beginning.
- Needs to be built in coastal areas on land and may disrupt the ecosystem.

Question 7b (2 marks)

Drag and drop the energy forms to **label** the energy flow diagram for a wood burning biomass power station.

Draggable:

Thermal | Nuclear | Chemical potential | Kinetic | Gravitational potential

[ ] → [ ] → [ ] → Electrical

Question 7c (4 marks)

Select one of the options for electricity generation that you would recommend for use in a country of your choice.

Select

Country:

Discuss the advantages and disadvantages of your selected method for electricity generation in your chosen country.

Question 8 (14 marks)

The video below shows the options that an island nation has as they attempt to reduce their reliance of oil.

Video | Script

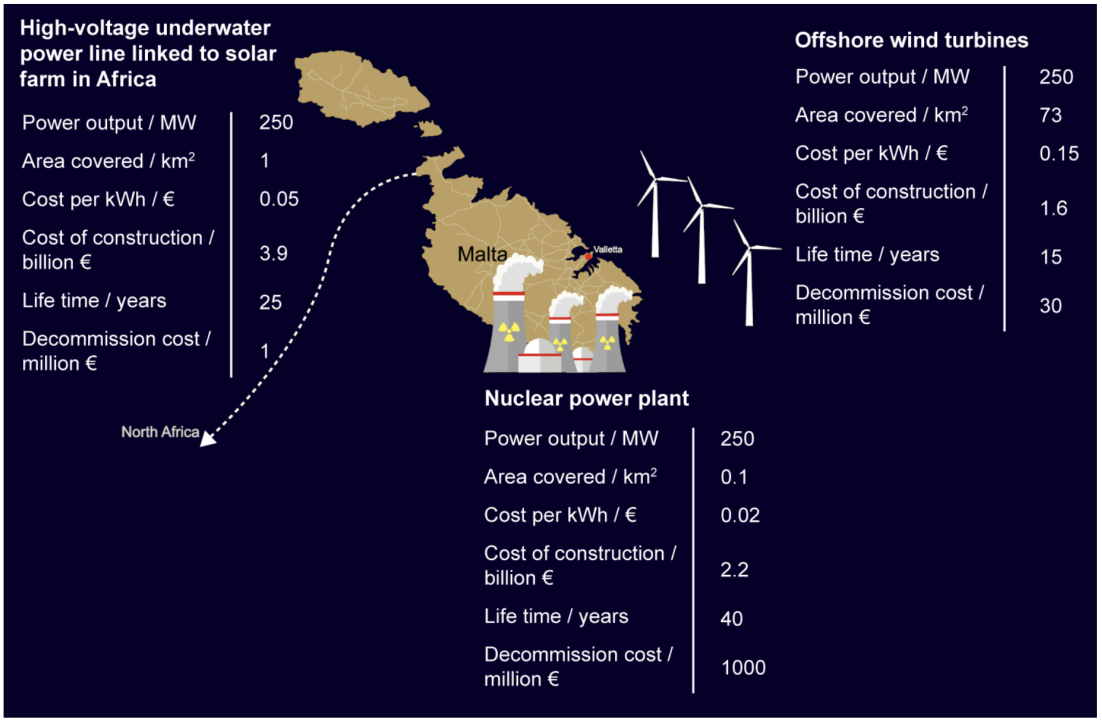
Malta is a small island nation in the Mediterranean Sea. It is one of the most densely populated countries in the world, with few natural resources. It has no land link, so access to external power sources are limited.

Currently over 90% of the electricity used on Malta is generated by burning imported oil; this is higher than for any other nation in the European Union. The remaining electricity is generated by small-scale renewable sources.

Malta plans to greatly decrease the proportion of its electricity production from fossil fuels. Three options include:

1. A high-voltage underwater power line to a solar farm in north Africa,
2. Offshore wind turbines,
3. A nuclear power plant built on the island.

The infographic gives some information about the three options.



Question 8a (2 marks)

Identify the non-renewable energy source from the three options. **Justify** your answer.

B I U x_2 x^2 Ω Σ Styles

Question 8b (12 marks)

As an advisor to the government of Malta, use information from the video to recommend one of the three options. **Select** which of the options you will recommend.

Select

Discuss and **evaluate** your selected method using data from the infographic to support your answer. You should include:

- the advantages of your method over oil-fuelled power stations
- the political implications of your method
- the economic implications of your method compared to the other two options
- a concluding appraisal.