MJSO

Malta Junior Science Olympiad

2022

SCIENCE CENTRE
PEMBROKE MALTA

Acknowledgements

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Instructions

- **SAFETY FIRST** – wearing a lab coat together with safety specs is mandatory at all times.
- You are asked to attempt all questions and to write your answers clearly in the spaces provided.
- Each team is requested to clean the lab station adequately after handing in the script to the lab supervisor.
- It is important that all laboratory equipment is handled carefully. In case of any breakages, report immediately to the lab supervisor.
- You are also reminded of the necessity of good English and orderly presentation of your answers.

Section A: Comprehension

Read the text below and answer the questions that follow. This section carries 25 marks.

Global warming is not a myth

For physicists studying climate change, "eureka" moments are unusually rare, and progress is made by meticulously collating together evidence from temperature measurements, satellite sounding and climate model experiments. Experiments where the real-world climate can be duplicated would be ideal but since this is not feasible, physicists do the next best thing; they simulate climate models.

Klaus Hasselmann and Syukoro Manabe, have pioneered climate modelling from explanations of observed climate properties to the comprehensive modelling based on numerical fluid dynamics used today. Climate modelling now transitions from weather forecasting to decade climate prediction and projection of future climate. Hasselmann and Manabe have shown that climate modelling is physics and whether the globe warms is determined by the physics of energy balance.

Manabe's initial atmospheric modelling explained the vertical temperature structure of the atmosphere and explored convection and fluid dynamics of the atmosphere.

Hasselmann, on the other hand, initially focused on 'stochastic climate models'. The idea, simply put, is that short-term weather variability leads to long term climate variability. Stochastic climate models provide three patterns demonstrating a fingerprint for human interference.

The first is greater warming of the arctic than the tropics. The second is greater warming over land than ocean and greater warming at the surface of the sea than in the deeper layers. The ocean warms more slowly because of its large thermal inertia. The latter is a property of the material that expresses the degree of slowness with which its temperature reaches that of the environment.

A third pattern of change is that while the troposphere (the lower region of the atmosphere) has warmed, the stratosphere just above it has cooled. If solar changes provided the dominant force, warming would be expected in both atmospheric levels.

In the ocean, we clearly see warming trends, which decrease with depth as expected. These changes indicate that the ocean has absorbed more than 80% of the heat added to the climate system: this heating is a major contributor to sea-level rise. Sea level rises because water expands as it is warmed and because water from melting glaciers and ice sheets is added to the oceans.

In addition, ocean salinity can act as a massive rain gauge. Waters have become saltier in lower altitudes thus changing large scale patterns of precipitation. In fact, drying has been observed in the Mediterranean, southern Africa, and southern Asia.

Long-term warming in the 21st century will be strongly influenced by the future rate of emissions. As for regional impacts, projections indicate that these will mirror the patterns observed in the last 50 years but with sizes larger than they have been so far. Estimates of the rise of sea levels range from 30 to 40 cm, sixty percent of the rise being due to thermal expansion of the ocean. Some of the largest changes are predicted for the polar regions.

Both humans and nature are affecting the future evolution of the Earth. Humans contribute to the rate of emissions. Carbon dioxide is a greenhouse gas released through human activity as well as natural processes such as metabolic reactions in organisms as well as volcanic eruptions. At present, CO_2 levels are higher than they have been in at least 3 million years. And although they still account for only 0.04% of the atmosphere, that still adds up to billions upon billions of tons of heat-trapping gas.

One of the most impactful things a person can do to fight climate change is make a few small but meaningful changes to one's diet. But the information on which foods are really "sustainable", "green" or "eco-friendly" is often confusing – and sometimes such terms are outright misleading. With products from beef to beer now being sold bearing a "carbon neutral" label, how can one make sure which food items are genuinely sustainable?

The primary challenge is knowing how to weigh up the many different factors that contribute to food's emissions. For instance, there's excellent evidence that plant-based foods require less energy (and produce less emissions) than animal-based products. Meat such as beef is known to be one of the highest-emission foods a person can consume. Animal products such as cheese, butter and eggs also rank highly when it comes to climate impact. But some plant-based foods can even have a negative climate impact (due to converting land from croplands to carbon-sequestering nut trees).

Usually, emissions are calculated by evaluating the way something is made, stored, and transported before it reaches the consumer. However, this doesn't factor in what happens when people get round to eating it.

A research study conducted by researcher Angelina Frankowska, found that 61% of the total emissions generated are linked to some foods particularly during preparation. Even toasted bread is significantly more carbon-intensive than fresh bread. Toasting adds 13% to its footprint. For foods that have already been partially pre-cooked, such as tofu and meat substitutes, finishing the job contributes around 42% of their total emissions.

Food waste is a major contributor to emissions. When food breaks down in a low-oxygen environment like a landfill, much of its carbon content turns to methane instead of CO_2. Methane is around 80 times more potent a greenhouse gas than CO_2 in its first 20 years in the atmosphere (though over time methane breaks down, whereas CO_2 is much long

term). One head of broccoli releases approximately 153 g of CO_2 if it's eaten, versus the equivalent of 2.7 times that amount if it goes to landfill (423 g of CO_2)

Human activities are known to affect our environment. Major environmental issues, during the 20th and 21st centuries include deterioration of air quality (fog, photochemical production of smog and tropospheric ozone, mercury pollution, etc.), poor water quality (due to release of pollutants to water bodies), vast pesticide usage, acid precipitation (from coal combustion that leads to SO_2 and thus sulfuric acid), ozone layer depletion (due to use of ozone depleting substances such as chlorofluorocarbons), etc. Some of these issues have been successfully tackled through national and regional legislations, international agreements, provision of alternatives, and/or changes in persons' expectations and behaviour. However, climate change due to emission of anthropogenic greenhouse gases and other chemicals into the atmosphere is now recognized to be one of the major yet unsolved challenges facing humanity in the coming decades and centuries. The impacts of anthropogenic climate change are slow in coming, it is sometimes difficult to see the signal above natural variability, and impacts are coupled to some of the most basic needs of society, such as energy production and utilization, food security, and infrastructure. Therefore, it is a very challenging and complex problem for society. After all, when it is difficult to see changes above natural variability, it is hard to act, especially when the results may be visible only in the distant future. Furthermore, the issue requires making choices between very important social behaviour and economic factors. Yet, it is clearer than ever that anthropogenic climate change is an issue to be reckoned with.

Text adapted from the following sources:

- Climate Change is Physics by Gabriel C. Hegerl (2022)
- How Exactly Does Carbon Dioxide Cause Global Warming? By Sarah Fecht (2021)
- The climate benefits of veganism and vegetarianism – BBC Future (2022)
- Role of Chemistry in Earth's Climate by A. R. Ravishankara, Yinon Rudich, and John A. Pyle (2015)

1. Mention TWO factors on which climate modelling currently depends.

_____ (2)

2. Describe the THREE patterns of climate change provided by stochastic climate models.

_____

_____

_____ (3)

3. Mention TWO factors that influence thermal inertia.

_____

_____ (2)

4. Explain why sea levels have risen.

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_____ (2)

5. From the text identify another phrase for the term 'greenhouse gas'.

_____ (1)

6. Define the term 'sustainable'. (Line 50)

_____ (1)

7. Explain why it is better to plant carbon-sequestering plants rather than crops.

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_____ (4)

8. Explain why the majority of emissions occur when food is prepared or processed.

_____

_____ (2)

9. Carbon dioxide contributes towards global warming since it is by far the most produced gas by humans. From the text, name ONE other gas that is also responsible for global warming.

_____ (1)

10. Besides being a greenhouse gas, carbon dioxide has also another effect on the environment. Name this effect.

_____ (1)

11. The burning of fossil fuels produces pollutant gases other than carbon dioxide.

a. From the text, name another pollutant gas.

_____ (1)

b. Name the kind of pollution caused by the gas mentioned in part (a).

_____ (1)

c. Write TWO balanced chemical equations to show how the gas named in part (a) causes the kind of pollution mentioned in part (b).

_____

_____ (4)

Total: 25 marks

Section B: Practicum

Biology

12. "Carbon dioxide is a greenhouse gas released through human activity as well as natural processes such as metabolic reactions in organisms as well as volcanic eruptions."

    The above statement is taken from the comprehension (line 42). Emphasis is on organisms' natural processes such as metabolic reactions including respiration.

    The majority of organisms respire aerobically releasing carbon dioxide, a by-product of this reaction, into the surrounding air. Aerobic respiration is cellular respiration, where glucose is oxidised to produce carbon dioxide and oxygen is reduced to produce water. This reaction is a strongly driven reaction and converts energy to be stored in ATP molecules.

    Germination requires a large amount of energy.

    Design an experiment to demonstrate the rate of aerobic respiration in chickpeas.

    Each group is provided with the following materials and apparatus:

Materials	**Apparatus**
Germinating chickpeas	Boiling tube
Glass wool	Rubber bung with capillary tubing
Potassium hydroxide (KOH)	Pipette
Coloured water	Glass rod
Petroleum jelly	Retort stand and clamp

Experimental suggestions:

- KOH is caustic and should be poured with caution. You may ask a technician to pour the chemical for your group.
- KOH should be poured at the bottom of the boiling tube and separated from the chickpeas by the glass wool which should not touch with the KOH solution.
- KOH absorbs carbon dioxide released by the organisms.

Your report should include:

a. The procedure carried out for this investigation.

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_____

_____ (6)

b. ONE precaution in this investigation and its justification.

_____

_____ (1, 1)

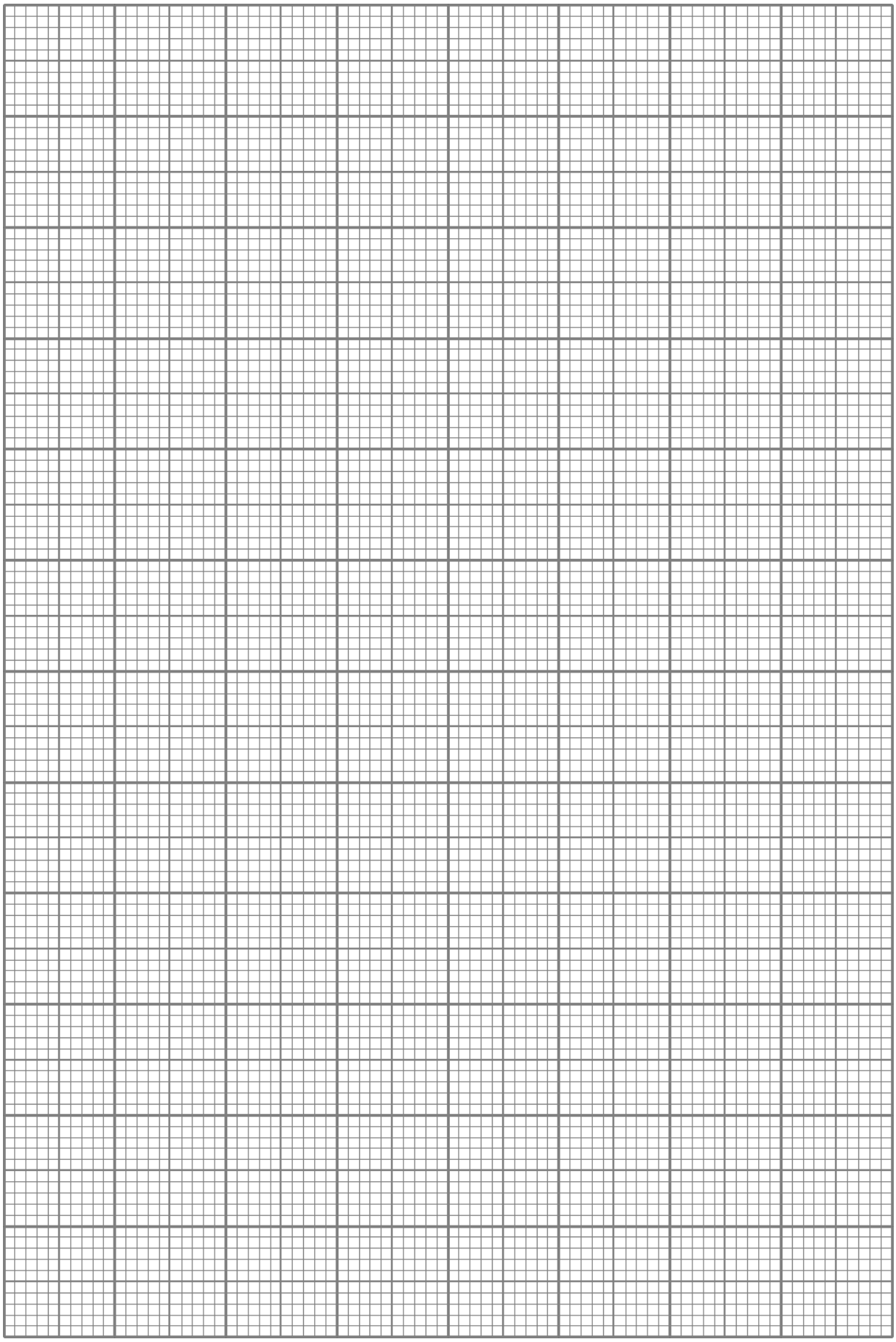
c. ONE possible source of error in this investigation

_____ (1)

d. A table of results of the rate of aerobic respiration against time.

(3)

e. Draw a graph to show the variation in the rate of aerobic respiration with increasing time. (4)



f. Describe the general trend of the graph.

_____

_____ (2)

g. Explain how the use of potassium hydroxide affects the volume of gas in the boiling tube.

_____

_____

_____ (2)

h. Ideally a control would have been used alongside the experimental set-up. What is the importance of using a control?

_____

_____

_____ (2)

Boiled chickpeas are used as a control. There is no movement of the coloured drop.

i. Why do these boiled chickpeas produce no movement of the coloured drop?

_____ (1)

j. The boiled chickpeas were also coated with a disinfectant to kill bacteria found on the peas. Give ONE reason of why this is important.

_____

_____ (1)

k. The control (with the above criteria) of a group of students showed a slight movement of the coloured drop. State ONE explanation of why this may have occurred.

_____

_____ (1)

Total:25 marks

Chemistry

13. One would be hard pressed to discuss climate change without mentioning the role of carbon dioxide.

    Your task is to design and construct a working model that illustrates the effects of excess CO_2 in the atmosphere. Labels must be included to distinguish key aspects of the model.

    You are provided with the following items:

Apparatus (Qty)	**Materials**
Small plastic cups (3)	Dilute hydrochloric acid (1 reagent bottle per lab)
Light bulb (1)	Dilute sodium hydroxide (1 reagent bottle per lab)
Plastic transparent box with lid (2)	Universal indicator (1 reagent bottle per lab)
Stand and clamp (1)	Tap water
Digital thermometer (2)	Limestone chips
A4 White paper (1)	Sodium chloride crystals
A4 Green paper (1)	Scissors (1 per lab)

    N.B. Not all apparatus and materials must be used.

    When your model is set up and working, ask your lab assistant to take ONE picture of the model setup illustrating the effects of excess CO_2. No retakes are allowed unless the lab assistant decides so. Make sure that the picture includes the team's code. Do not include your school's name.

a. Mention the effects of excess CO_2 in the atmosphere.

_____

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_____

_____ (2)

b. Draw a labelled diagram to show the setup of your model.

(5)

c. Describe how your model is designed to show the effects mentioned in part (a).

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_____ (8)

d. Write a balanced chemical equation for the reaction that was used to produce CO_2. Include state symbols.

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_____ (3)

e. State any observations and results noted while the model was running.

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_____ (2)

f. List the sources of error related to the experimental setup.

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_____ (2)

g. List the precautions taken to ensure that the model works as intended.

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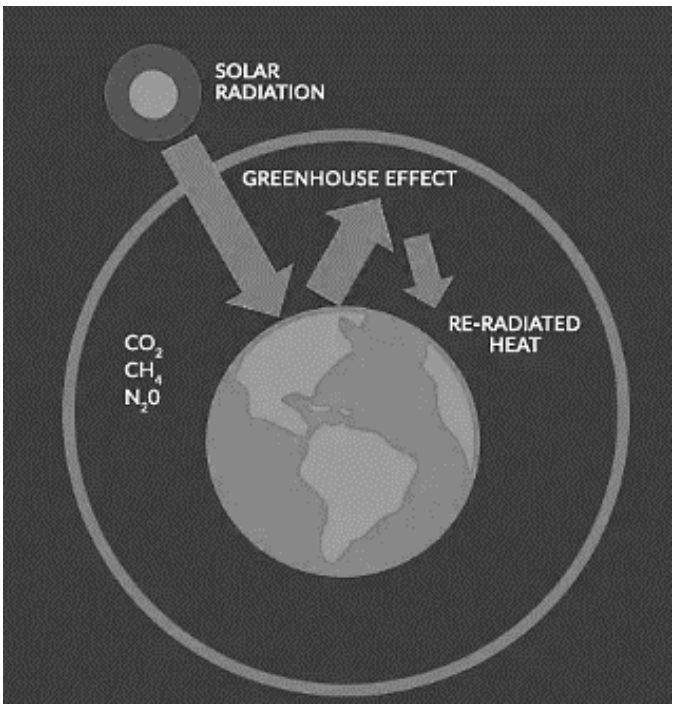
_____ (3)

Total: 25 marks

Physics

14. Global warming is real, and it is not to be blamed on the natural cycle of seasons. In fact, the Earth's greenhouse effect is what traps heat and warms the planet. The Earth has a protective layer that is made up of gases like water vapour, carbon dioxide and methane.



You need to investigate how closed (unheated) spaces are basically heat traps.

You are provided with the following apparatus:

- a plastic container
- 2 digital thermometers
- a stop clock
- a dark sheet of cardboard
- a retort stand
- filament lamp as a light source.

a. Design an experiment to show how closed spaces are basically heat traps. Include the plan of your experiment design in the space provided.

Point to consider:

Digital thermometers tend to go on standby, so ensure that the setup allows for the screen of the thermometer to be available for switching on again when in standby mode.

(5)

b. Draw a labelled diagram of the experimental setup.

(3)

c. List TWO precautions needed to carry out a fair investigation.

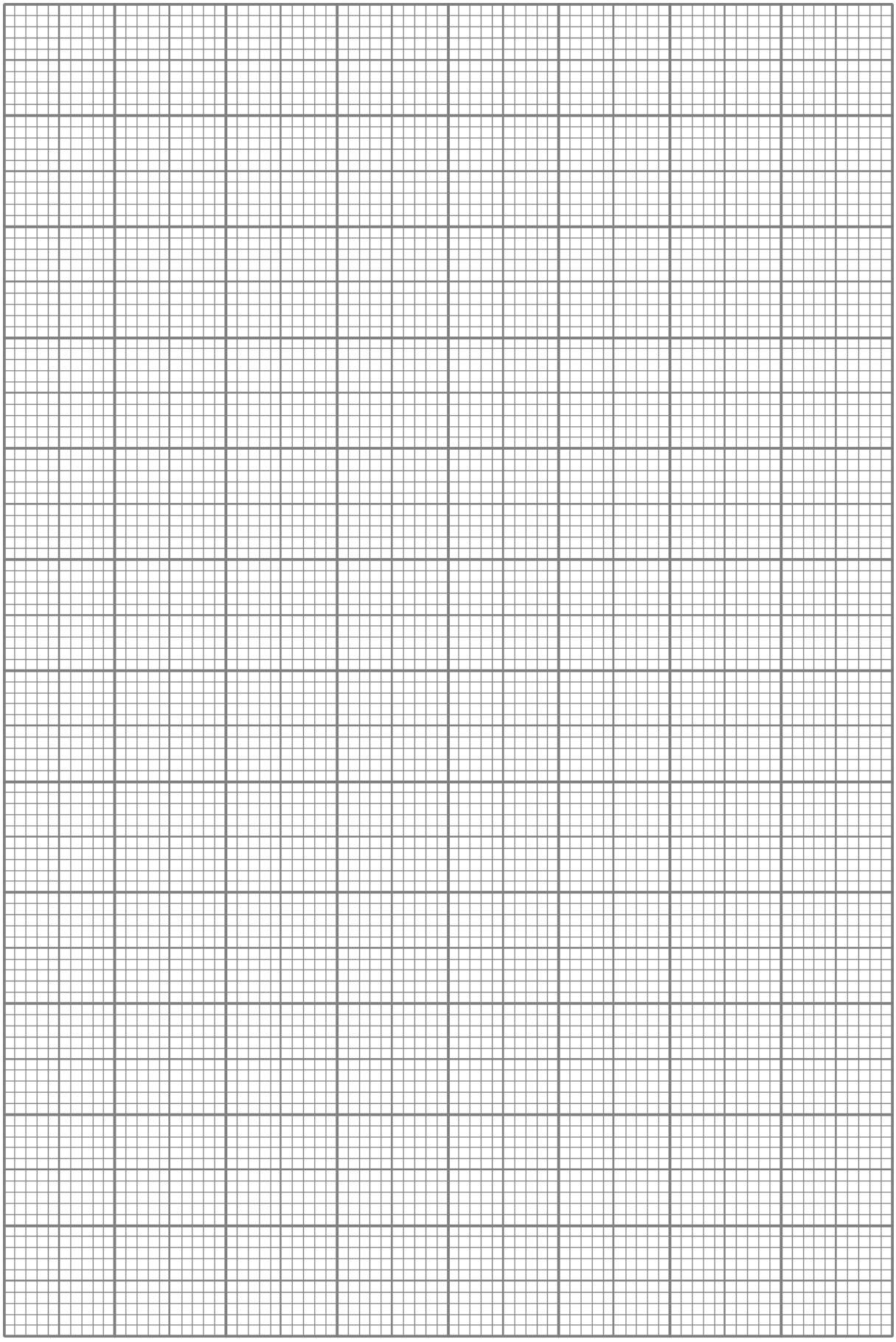
_____

_____ (2)

d. Tabulate the results obtained in the space below.

(4)

e. Use the results to plot a graph. (6)



f. Discuss your results by applying them to the Earth and the atmosphere.

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_____ (5)

Total: 25 marks