NSW Education Standards Authority

2021 **HIGHER SCHOOL CERTIFICATE EXAMINATION**

Investigating Science

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used

Total marks: 100

Section I – 20 marks (pages 2–14)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 17–36)

- Attempt Questions 21–34
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

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1 Which technology was used in the discovery of the structure of deoxyribonucleic acid (DNA)?

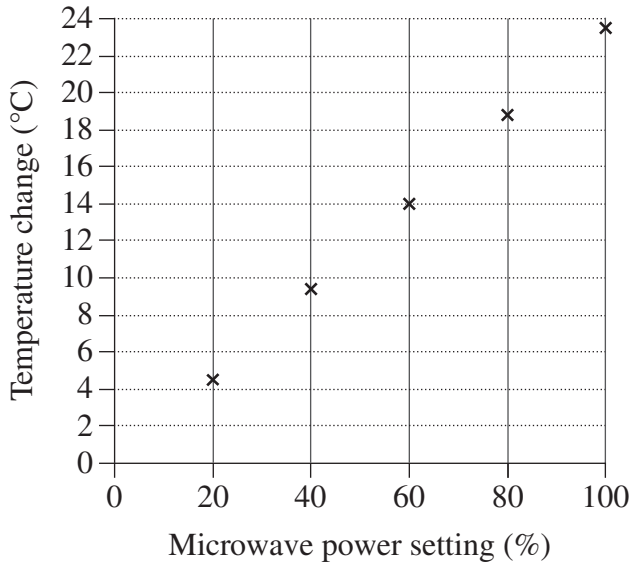
A. Seismograph

B. Geiger counter

C. Hadron collider

D. X-ray diffraction

2 A microwave oven with five power settings was investigated. It was used to heat a volume of 200 mL of water for 30 seconds on each power setting. The results are shown in the graph.



Identify the independent variable in this investigation.

A. Volume of water

B. Temperature change

C. Microwave power setting

D. Length of time the water was heated

3 Which section of a scientific paper is most likely to contain information about possible implications and future directions for research?

A. Discussion

B. Method

C. References

D. Results

4 What factor could reduce the effectiveness of the peer review process of a research paper about a particular dinosaur's diet?

A. The inability to study samples of the dinosaur's diet

B. Too few newspaper articles about the dinosaur's diet

C. A lack of experts on the subject of the dinosaur's diet

D. A poor reference list in the paper about the dinosaur's diet

5 What factor led Marshall and Warren to investigate the cause of peptic ulcers?

A. The observation of unusual bacteria in stomach ulcer biopsies

B. Direction from the government to reduce the cost of health care

C. The possibility of Marshall and Warren winning the Nobel Prize

D. The opportunity to work with pharmaceutical companies to develop new antibiotics

6 What methodology was used to collect the data analysed by Doppler?

A. Graphical analysis

B. Conducting surveys

C. Scientific observation

D. Computer simulations

7 In a chemical reaction, 25 mL of gas was produced in 9.13 seconds.

A student used a calculator correctly to determine the volume of gas produced each second. The calculator showed 2.73822563 as the answer.

Based on this information, how should this answer be reported?

A. 3 mL s^{-1}

B. 2.7 mL s^{-1}

C. 2.73 mL s^{-1}

D. 2.73822563 mL s^{-1}

8 Why is iridology a pseudoscience?

A. It makes accurate predictions based on the characteristics of the iris.

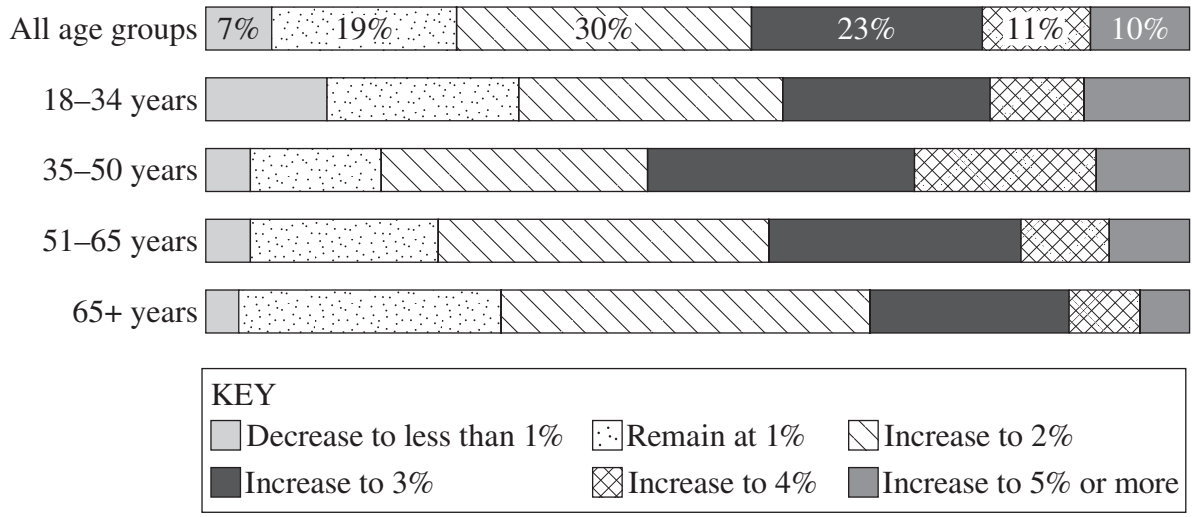
B. It is not based on quantitative observations of the characteristics of the iris.

C. It makes a hypothesis linking the characteristics of the iris and health outcomes.

D. It is not based on reproducible cause and effect relationships between the characteristics of the iris and health outcomes.

Use the information provided to answer Questions 9 and 10.

The graph shows the results of a survey conducted within a country to determine how much should be spent on scientific research. The results are divided according to age groups. Currently, the country is spending 1% of its budget on scientific research.



9 Of the total population surveyed, what percentage of people support budget spending on scientific research increasing to 2%?

A. 7%

B. 19%

C. 23%

D. 30%

10 Which age group has the largest percentage of people who support spending MORE than 1% on research?

A. 18–34

B. 35–50

C. 51–65

D. 65+

11 Five students were each provided with a thermometer of the same make and model.

Each student was asked to measure and record the temperature of the same beaker of boiling water.

Each student was then asked to measure and record the temperature of the boiling water a second time using the same thermometer.

The results are shown in the table.

Student	*First temperature recorded* (°C)	*Second temperature recorded* (°C)
1	101.5	101.5
2	99.0	99.0
3	96.5	96.5
4	103.0	103.0
5	100.0	100.0

What would be the most likely explanation for the variation between the students' results?

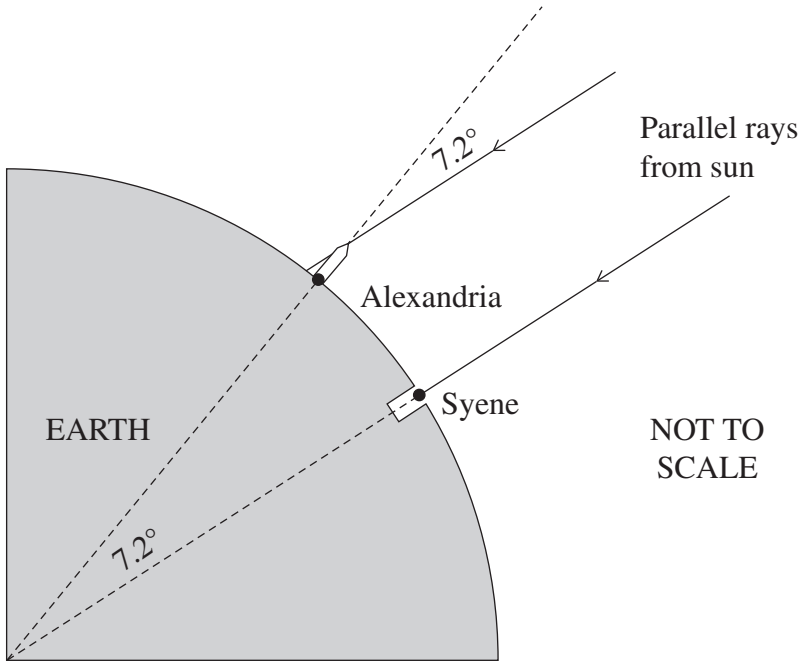
A. Systematic errors in the thermometers used

B. Parallax errors in reading the thermometers

C. Random errors in reading the thermometers

D. Changes in the temperature of the boiling water

12 The diagram shows some of the information used by Eratosthenes. The distance from Alexandria to Syene, in a straight line around Earth's surface, is 5000 *stadia* (an ancient measure of distance).



The following two ratios are equal to each other.

Ratio 1: $\frac{7.2°}{360°}$ Ratio 2: $\frac{\text{Distance between Alexandria and Syene}}{\text{Circumference of Earth}}$

Using the information provided, what is the circumference of Earth?

A. 700 stadia

B. 36 000 stadia

C. 40 000 stadia

D. 250 000 stadia

13 A researcher hypothesised that a new type of fertiliser would increase the growth of pea plants. The following experiment was designed to test this hypothesis.

- 200 pea plant seedlings were planted of which 100 received fertiliser dissolved in water and the other 100 received water alone.
- An additional substance, *X*, was added to allow the fertiliser to dissolve completely in the water.
- The plants were grown under the same conditions.
- The plant height and number of leaves were recorded.

The researcher concluded that the fertiliser increased the height of the pea plants but not the number of leaves.

Why is this experiment invalid?

A. Only one type of plant was used.

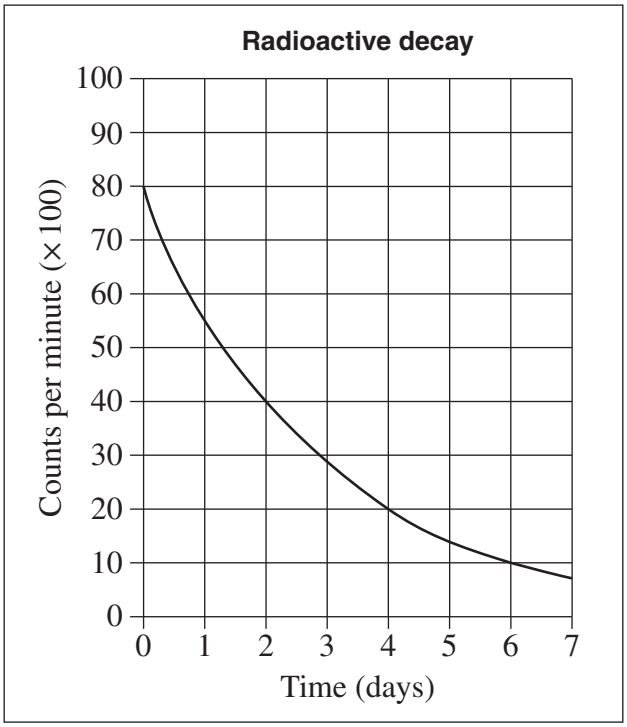
B. There are two dependent variables.

C. The effect of substance *X* on plant growth was not tested.

D. The number of plants was too small to reach a valid conclusion.

Use the information provided to answer Questions 14 and 15.

A researcher measured the radioactivity (in counts per minute) of a sample over a period of seven days. The results are shown in the graph.



14 Which of the following can be deduced from these results?

A. The radioactivity will reach zero by day ten.

B. There were 20 counts per minute at day four.

C. The rate of decay is not constant over seven days.

D. After 14 days the count will be half that at seven days.

15 The half-life of a radioactive sample is the time taken for half the atoms in the sample to decay.

What is the half-life of the sample measured in this research?

A. 1.25 days

B. 2 days

C. 3.5 days

D. 40 days

16 In 1997, more than 60 000 homing pigeons were released from France. Only about 5000 birds made it 800 km home to England. About 55 000 were never recovered.

At the same time as the pigeons were flying between the two countries, a supersonic plane flew overhead. A supersonic plane creates a very loud sound that can travel about 100 km.

Which scientific term best describes the disappearance of the birds coinciding with the flight of the plane overhead?

A. Causation

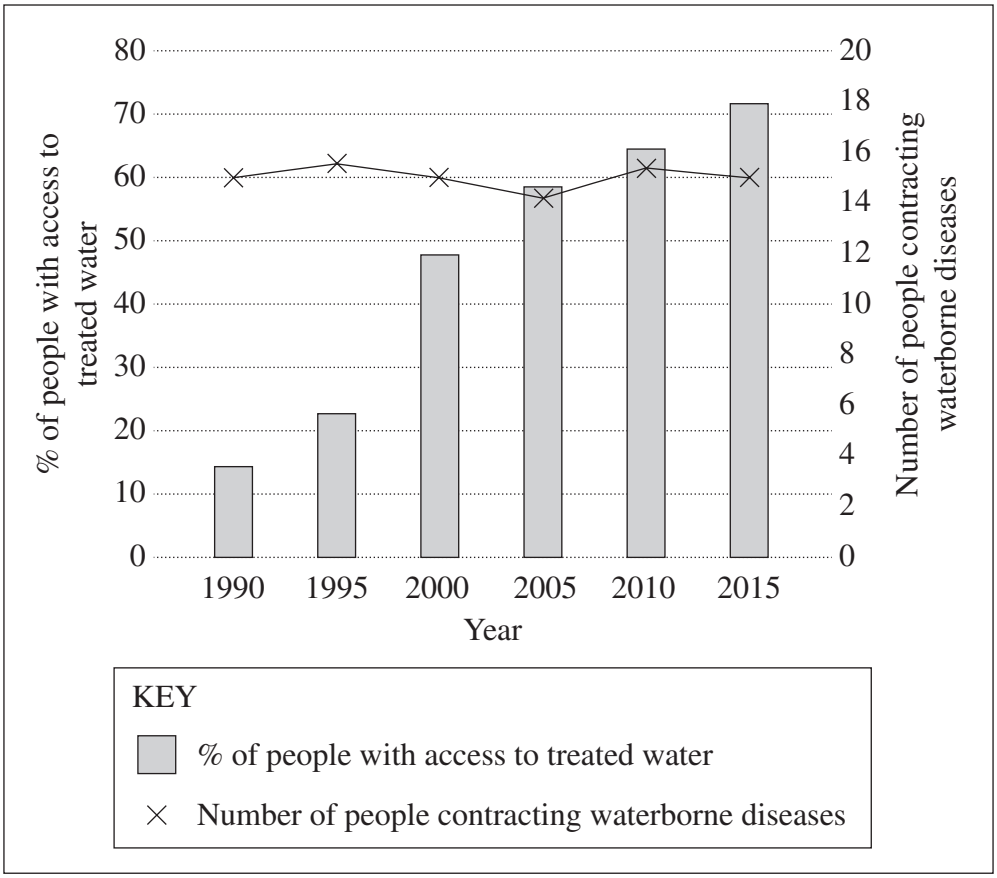
B. Conclusion

C. Correlation

D. Observation

17 Waterborne diseases are transmitted by contaminated water.

A study investigated the effectiveness of a chemical in reducing waterborne diseases. The number of people contracting waterborne diseases and the percentage of people with access to treated water were measured.



What additional piece of information is required before the effectiveness of the chemical on reducing waterborne diseases can be determined?

A. If the chemical had any side effects

B. The total number of people in the study

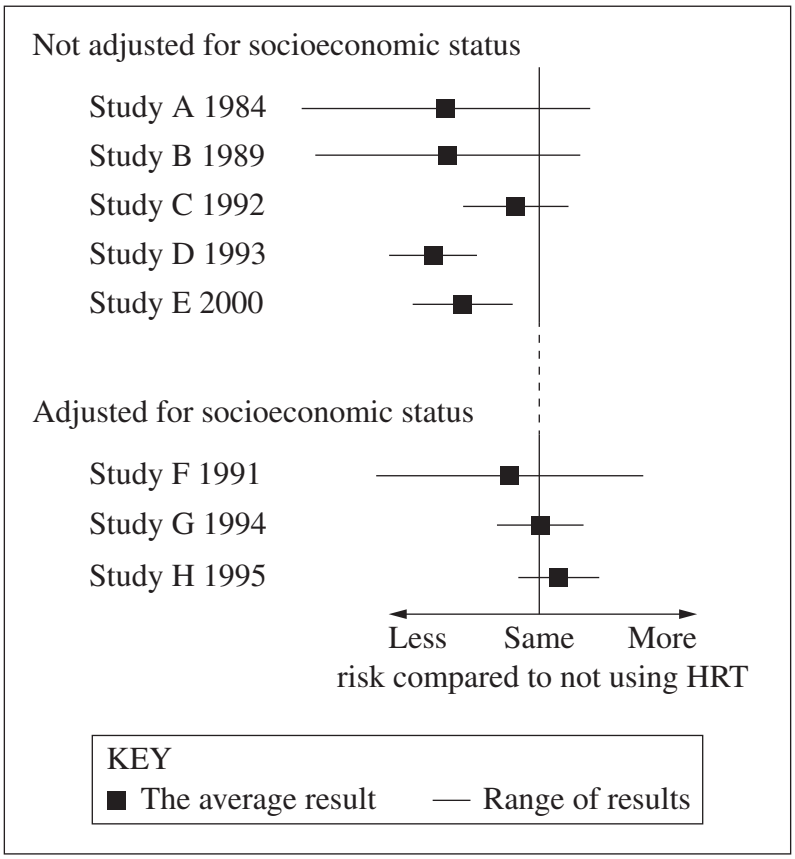
C. The type of chemical used to treat the water

D. Identification of the pathogens that cause the diseases

18 Eight studies investigating the link between women using hormone replacement therapy (HRT) and their risk of coronary heart disease were compared. Some of the studies were adjusted for socioeconomic status and some were not.

The diagram summarises the results of the studies.

Risk of coronary heart disease when using HRT



What can be concluded from this data?

A. HRT gives women a lower risk of coronary heart disease.

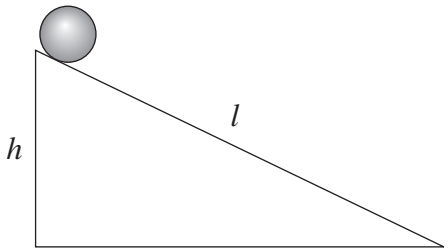
B. The range of the results is too wide to draw a valid conclusion.

C. Socioeconomic status, rather than HRT, affects women's risk of coronary heart disease.

D. When adjusted for socioeconomic status, the rate of coronary heart disease is increasing over time.

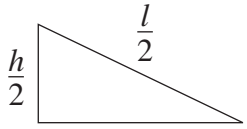
19 An experiment was designed to test the hypothesis, 'The time taken for a ball to roll down an inclined plane decreases as the vertical height (h) decreases'.

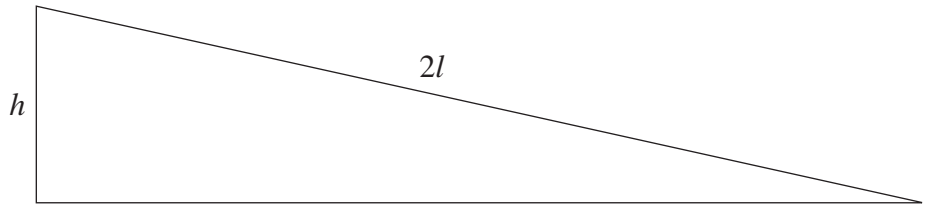
The experiment was originally set up as shown.

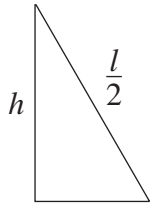


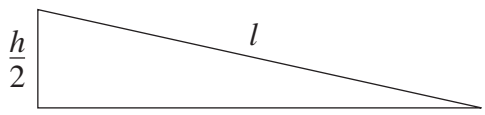
Four variations of the set-up were proposed.

Choose the proposed set-up that would allow the investigator to make a definitive choice between accepting or rejecting the hypothesis.

A. 

B. 

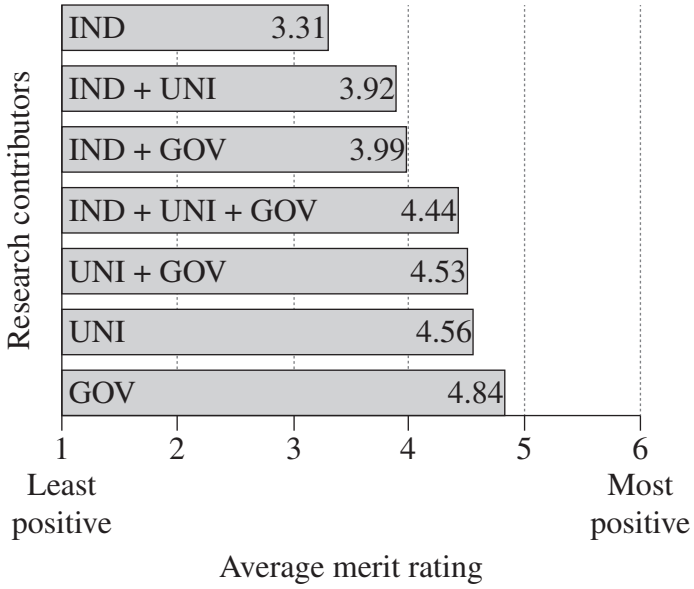
C. 

D. 

20 A survey was conducted to see if the type of contributor to a scientific study changed people's perception of the merit of the study.

Each person surveyed was asked to judge the merit of the research that had been conducted by scientists contributing from either industry (IND), university (UNI) or government (GOV), or some combination of these.

The data collected is summarised in the graph.



Which statement is consistent with this data?

A. The contribution of industry scientists always reduces the perceived merit of the research.

B. The contribution of university scientists always increases the perceived merit of the research.

C. The contribution of government scientists always increases the perceived merit of the research.

D. The contribution of more types of scientists always reduces the perceived merit of the research.

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2021 HIGHER SCHOOL CERTIFICATE EXAMINATION

Centre Number

Student Number

Investigating Science

Section II Answer Booklet

80 marks
Attempt Questions 21–34
Allow about 2 hours and 25 minutes for this section

Instructions

- Write your Centre Number and Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (3 marks)

Outline the need for regulation in EITHER scientific research or practice. Include an example to support your answer. **3**

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Question 22 (6 marks)

(a) Outline a structural feature of DNA and how this feature allows organisms to be genetically modified. **2**

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(b) A team of researchers wanted to investigate the effect of feeding genetically modified (GM) mice a high-fat diet. They hypothesised that the GM mice would gain less weight than normal mice (N). To test this hypothesis, the researchers set up the following four groups. **4**

Group 1	N mice fed a normal diet
Group 2	N mice fed a high-fat diet
Group 3	GM mice fed a normal diet
Group 4	GM mice fed a high-fat diet

Explain why the four groups were required to test the hypothesis.

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Question 23 (2 marks)

How can both the validity and reliability of information in a secondary source be determined? **2**

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Question 24 (4 marks)

Discuss whether Spencer's investigation into microwaves deviated from the linear model of scientific investigation. **4**

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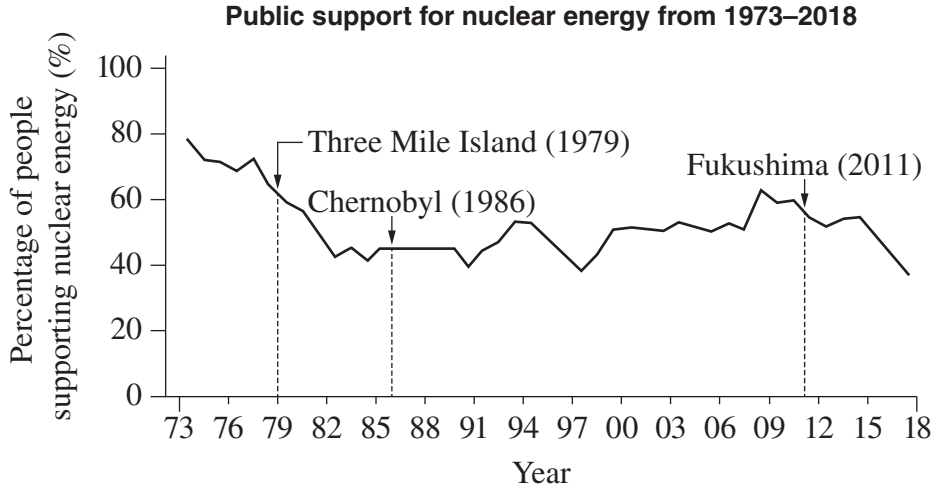
Question 25 (3 marks)

Each year since 1973, 5000 members of the general public have been surveyed and asked if they support the use of nuclear energy. The information collected is presented in the graph shown. The graph also shows when three significant nuclear accidents occurred, that released radioactive material into the environment. **3**



A hypothesis was made stating that public support declines as a result of nuclear accidents.

Explain whether the information in the graph is consistent with this hypothesis.

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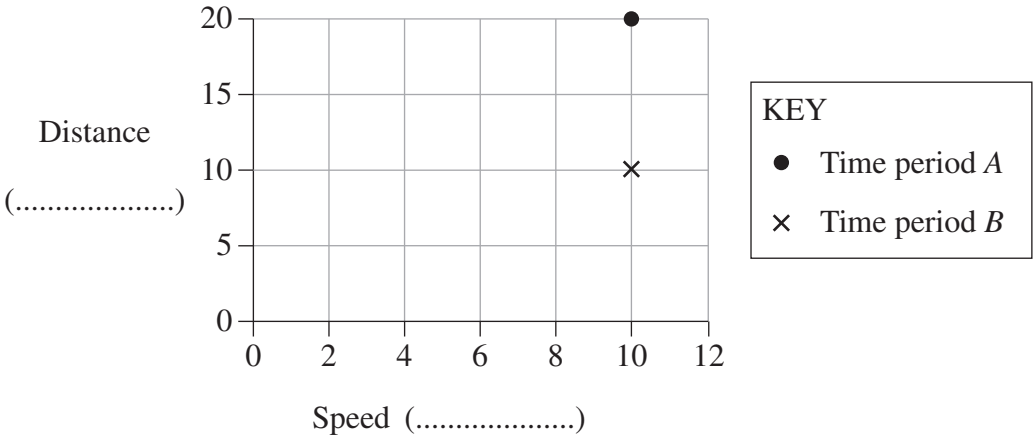
Question 26 (7 marks)

A group of students gathered data about an object that was travelling at a constant speed for two different time periods (*A* and *B*). The graph shows the data gathered by the group.



(a) Write an appropriate unit for each axis on the graph. **2**

(b) The students produced the graph from data they had tabulated. **2**

Draw a table containing the data that the students used to construct the graph. Do not include units in the table.

(c) Explain why there is a difference in the distance travelled by the object in the two time periods. Use calculations to support your answer. **3**

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Question 27 (6 marks)

Before a vaccination program against a disease can start, the safety and efficacy of possible vaccines has to be demonstrated scientifically.

A company recruited nearly 44 000 volunteers for a vaccine trial. Half of the volunteers received the vaccine and the other half received a placebo.

(a) Outline TWO pieces of information volunteers should have been provided with prior to the trial to ensure they were treated ethically. **2**

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(b) Compare the process used by this company to establish the efficacy of its vaccine with the process used in the development of the smallpox vaccine. **4**

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Question 28 (7 marks)

(a) What is the difference between a *theory* and a *law*, when these words are used scientifically? Support your answer with an example of each. **4**

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(b) The following is a quote from a media report. **3**

> When considering the impact of humans on climate change, one expert believes it's useful to compare it to another famous hypothesis, such as atomic theory or the theory of gravity.

Evaluate whether the media's use of the words *hypothesis* and *theory* are scientifically appropriate.

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Question 29 (5 marks)

The label on a container of Green Tea Extract included a claim. **5**

Describe a double-blind, placebo-controlled trial that could be used to scientifically test the claim on the container.

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Question 30 (4 marks)

During World War II, Albert Einstein, a celebrated scientist, signed a letter encouraging the American president to support ongoing research into nuclear fission, which could lead to the development of nuclear bombs. **4**

Discuss whether Einstein's endorsement could be considered to be an example of the halo effect.

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Question 31 (6 marks)

Two towns, *A* and *B*, are located on a river. It is proposed that a dam be built between the two towns.

(a) Explain ONE benefit of damming the river. **2**

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(b) Each of the towns has about 20 000 residents. The council surveyed residents of both towns and stated that 95% of the residents surveyed supported the construction of the dam. **4**

The data collected from the survey is shown.

	Number of residents surveyed		
	For	*Against*	*Total*
Town *A*	2612	159	2771
Town *B*	11	275	286
Total	2623	434	3057

With reference to data from the table, explain how the council's statement has misrepresented the views of the residents.

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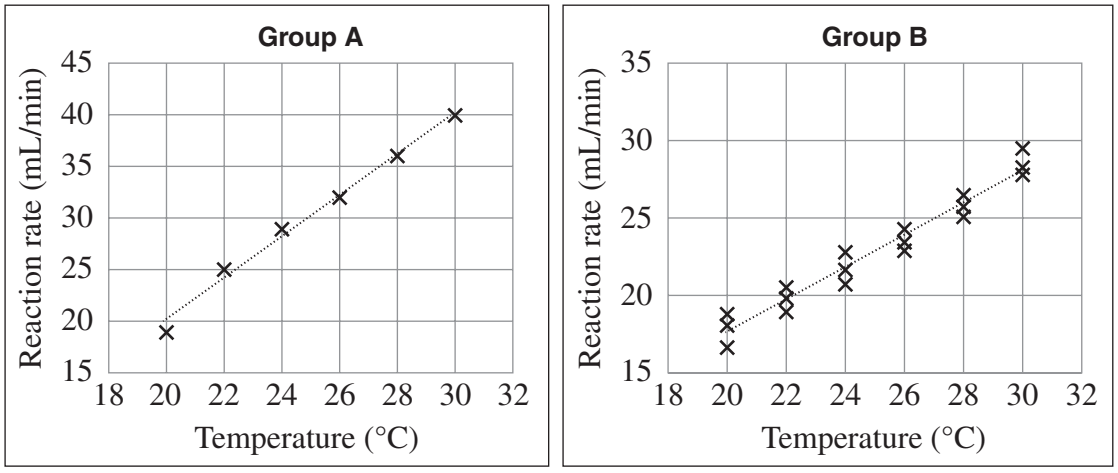
Question 32 (9 marks)

Two groups of students investigated the relationship between temperature and reaction rate. After reading the scientific literature, they found that the reaction rate between an acid and a metal doubles for each 10°C increase in temperature. **9**

The two groups reacted 10 g of metal with 200 mL of the same concentration of acid in each trial. In each trial, neither the temperature nor the concentration changed significantly while the metal was reacting.

The reaction rate, at different temperatures, was determined by measuring the volume of hydrogen gas produced in 10 seconds, and converted to a rate measured in mL/min.

All the results from the two groups are shown. Each individual trial is represented by an × on the graphs.



Analyse the reliability, accuracy (including error) and validity of the experimental results obtained by each of the two groups.

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Question 32 continues on page 29

Question 32 (continued)

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End of Question 32

Question 33 (13 marks)

A student wanted to conduct an investigation into some of the factors that allow an animal to survive. She summarised information relating to an experiment that Joseph Priestley had conducted.

> Priestley placed a live mouse inside a sealed jar and timed how long the mouse took to die.
>
> Priestley then placed a live mouse inside a sealed jar that also had a plant inside it. The mouse survived for a longer period of time.

(a) Propose a hypothesis and a conclusion for the experiment Priestley was conducting. **2**

Hypothesis: .....

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Conclusion: .....

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(b) Identify TWO variables that should be kept constant in Priestley's experiment. Justify your answer. **4**

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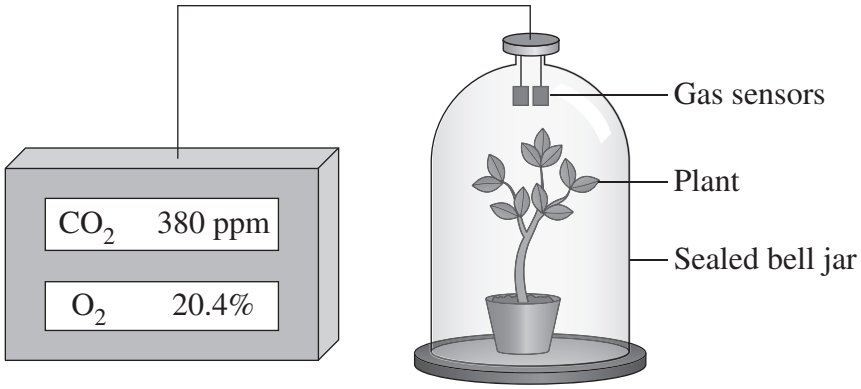
Question 33 continues on page 31

Question 33 (continued)

(c) Since Priestley's time, technologies have become available to address the limitations of his experiment. An example of such an experimental set-up is shown. **7**



Explain TWO reasons why this experiment is an improvement over Priestley's AND justify further improvements that could be made to the experiment.

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Question 33 continues on page 32

Question 33 (continued)

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End of Question 33

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Question 34 (5 marks)

Economic, social and political factors influence the choice of scientific research to be carried out. **5**

Evaluate the effect of TWO of these factors, using examples to support your answer.

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