NSW GOVERNMENT

NSW Education Standards Authority

Centre Number

Student Number

2023 **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
- Write your Centre Number and Student Number at the top of this page

Total marks: 100

Section I – 20 marks (pages 2–11)

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

Section II – 80 marks (pages 13–36)

- Attempt Questions 21–36
- 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 of these scientists conducted experiments involving the mass of a tree?

A. Spencer

B. Doppler

C. van Helmont

D. Pons and Fleischmann

2 Which measurement did Eratosthenes use to calculate Earth's circumference?

A. The diameter of Earth

B. The depth of the well at Syene

C. The angle of tilt of Earth's axis

D. The distance between Alexandria and Syene

3 A Year 10 student needed to select the highest concentration of sodium hydroxide (NaOH) solution allowable for an investigation.

The table shows information for different samples of sodium hydroxide taken from the school's chemical safety data sheet.

Which sample should the student use?

	Chemical symbol	*Concentration* (M)	*Users* (School Year)
A.	$NaOH_{(aq)}$	< 0.12	7–12
B.	$NaOH_{(aq)}$	0.12–0.50	7–12
C.	$NaOH_{(aq)}$	0.51–1.3	11–12
D.	$NaOH_{(s)}$		11–12

4 A student conducted a valid experiment to determine the effect that differing concentrations of a fertiliser would have on the growth rate of 10 plant seedlings.

The student:

- made up 10 different concentrations of the fertiliser by dissolving the fertiliser in tap water
- gave the same seedling 10 mL of the same concentration of fertiliser solution each day
- labelled an eleventh seedling as the control.

What should be provided to the control seedling when the other seedlings receive the fertiliser solution?

A. No water

B. 10 mL of tap water

C. 10 mL of distilled water

D. 10 mL of each fertiliser solution

5 The steps needed to plan and conduct a first-hand scientific investigation are shown.

1. Analyse the results
2. Formulate hypothesis
3. Conduct the experiment
4. Conduct a risk assessment

In which order should the steps be performed?

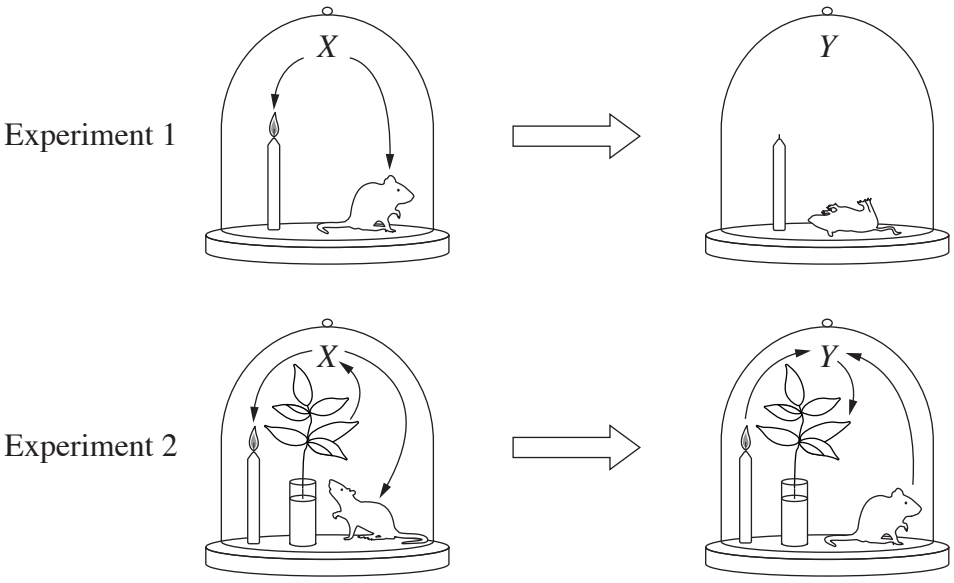
A. 2, 4, 3, 1

B. 4, 2, 3, 1

C. 2, 4, 1, 3

D. 4, 2, 1, 3

6 Priestley set up two experiments using a mouse, candle and plant in a sealed jar, as shown in the diagrams.



What substances are represented by the labels *X* and *Y*?

	X	*Y*
A.	Oxygen	Mercuric oxide
B.	Mercuric oxide	Carbon dioxide
C.	Carbon dioxide	Oxygen
D.	Oxygen	Carbon dioxide

7 A student wanted to test if the actual mass of a chocolate bar was consistent with the manufacturer's claim.

- 15 wrapped chocolate bars were used.
- One of the chocolate bars had its wrapping removed.
- The wrapping was weighed using an electronic balance and had a mass of 1.5 g.

What action should the student take prior to weighing each remaining chocolate bar with its wrapping intact?

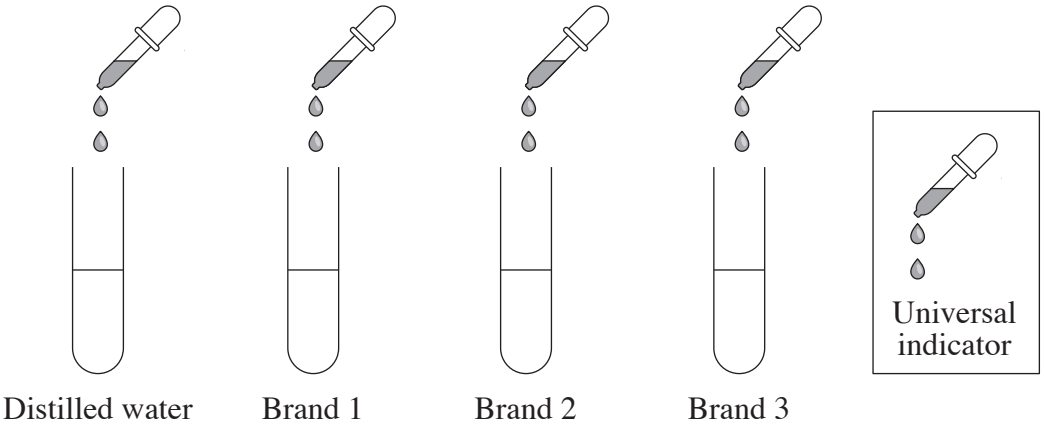
A. Adjust the balance reading by adding 1.5 g

B. Tare (zero) the balance without the wrapping

C. Calibrate the balance to remove any random error

D. Tare (zero) the balance with only the wrapping on it

8 An experiment was conducted to test the pH of different brands of alkaline water.



What is the dependent variable in this investigation?

A. pH

B. Distilled water

C. Universal indicator

D. Brand of alkaline water

9 A magazine publisher surveyed a range of people to determine the target audience for the regular astrology page. 100 people in each demographic were surveyed.

Demographic		*Surveyed population who believe in astrology* (%)
Gender	*Age* (years)	
Male	20–39	37
Female	20–39	36
Male	40–59	25
Female	40–59	32
Male	60–79	16
Female	60–79	21

Which would be the best audience for the magazine to target?

A. Males 20–59

B. Females 20–59

C. Males 40–79

D. Females 40–79

10 The input of several scientists, working in different fields, led to the discovery of the structure of deoxyribonucleic acid (DNA).

What important structural feature of DNA was revealed by their work?

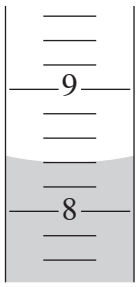
A. It contains four bases.

B. It contains a simple sugar.

C. It is a double-stranded helix.

D. It is a single-stranded protein.

11 The diagram shows part of a device that was used to accurately measure the volume of a liquid in millilitres.



What should a student record as the measured volume of the liquid?

A. 8.4 ± 0.05 mL

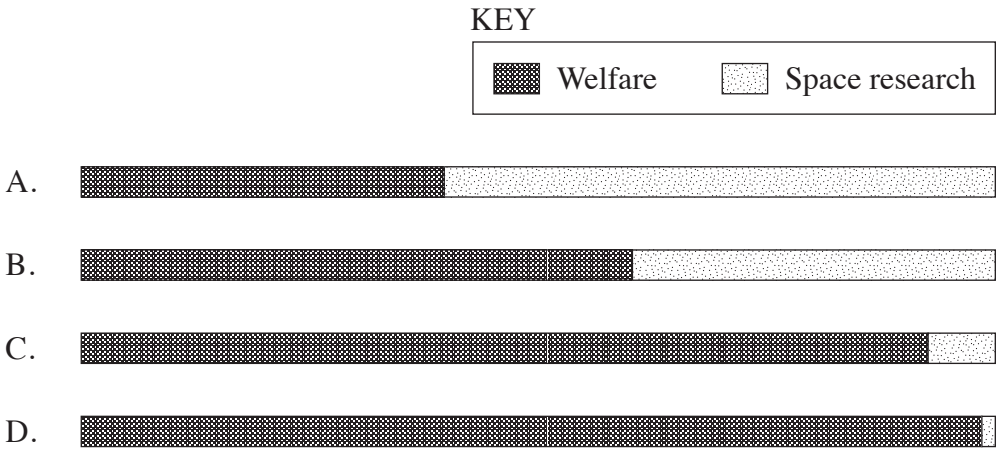
B. 8.4 ± 0.1 mL

C. 9.6 ± 0.05 mL

D. 9.6 ± 0.1 mL

12 In the USA, the 2022 budget for welfare was $\$1.6 \times 10^{12}$ and the budget for space research was $\$2.4 \times 10^{10}$.

Which graph best represents the relative amount of money budgeted for welfare and space research by the US government in 2022?



13 When a beam of sunlight passes through a glass lens in a telescope, each colour refracts at a different angle to produce a continuous spectrum.

The colours refract at different angles inside the lens because different coloured light

A. travels at the same speed.

B. travels at constant speeds.

C. has different wavelengths.

D. has a constant wavelength.

14 Iridologists claim to be able to diagnose health conditions.

Which statement supports iridology being considered a pseudo-science?

A. Iridology is widely practised by naturopaths in many countries.

B. Available data from iridologists support its use as a diagnostic tool.

C. A recent review of 77 papers submitted by iridologists showed most investigations were conducted without a control group.

D. Patients diagnosed with inflamed gallbladder disease using iridology were later confirmed by subsequent surgery to have the disease.

15 For any sample of gas that is kept at an unchanging temperature, the product of the pressure (P) and the volume (V) of the gas is always the same constant number k, measured in joules (J), as shown.

$$PV = k$$

To determine the value of k, a student measured the pressure and volume of a sample of gas while ensuring its temperature did not change.

Pressure = 100.8 kPa
Volume = 1.7 L

What value for k should the student record?

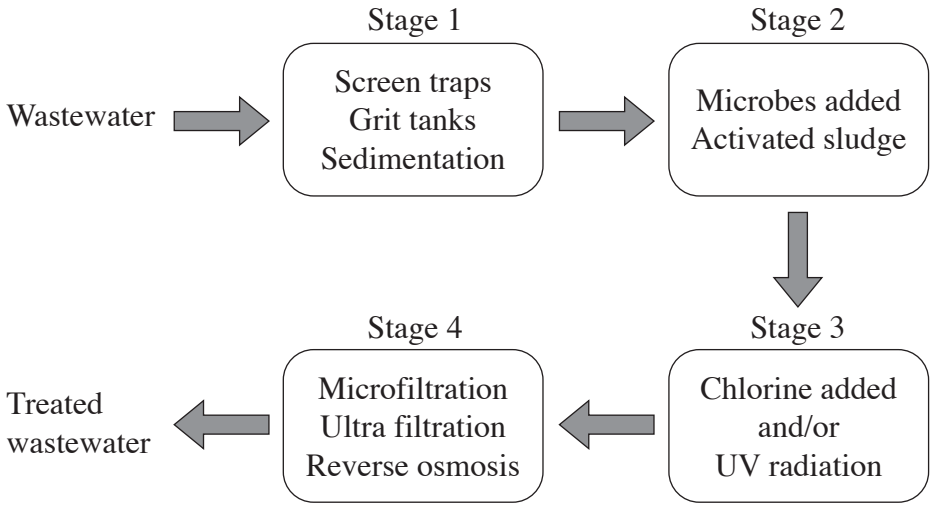
A. 1.7×10^2 J

B. 1.71×10^2 J

C. 1.714×10^2 J

D. 1.7136×10^2 J

16 The flow chart shows stages in wastewater treatment.



Which stage has the most significant impact on world health and human wellbeing?

A. Stage 1

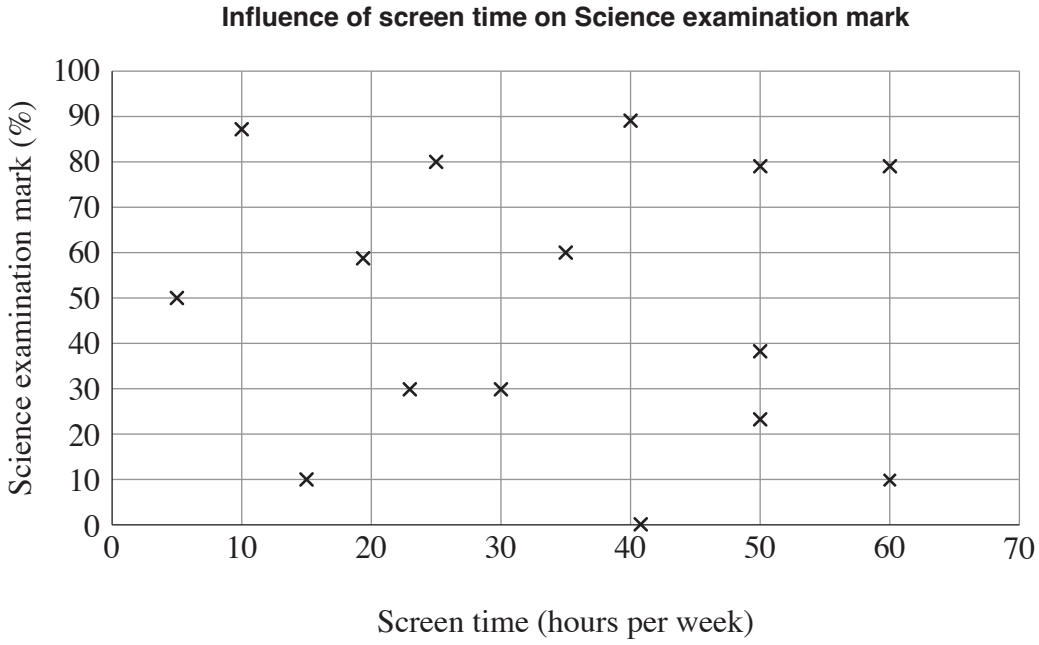
B. Stage 2

C. Stage 3

D. Stage 4

17 A survey of Year 10 students was conducted to determine if there was a relationship between screen time per week and their mark in a Science examination.

The results are shown in the graph.



Which term best describes the relationship between 50 hours per week of screen time and an examination mark of 38%?

A. Causation

B. Coincidence

C. Consistent

D. Correlation

18 The table shows the contributions that governments and large corporations made to a university budget over time.

Year	*Government contributions* ($ million)	*Large corporation contributions* ($ million)
2012	1179	321
2014	1305	356
2016	1665	458
2018	1701	766
2020	2302	802

Which statement is consistent with the data?

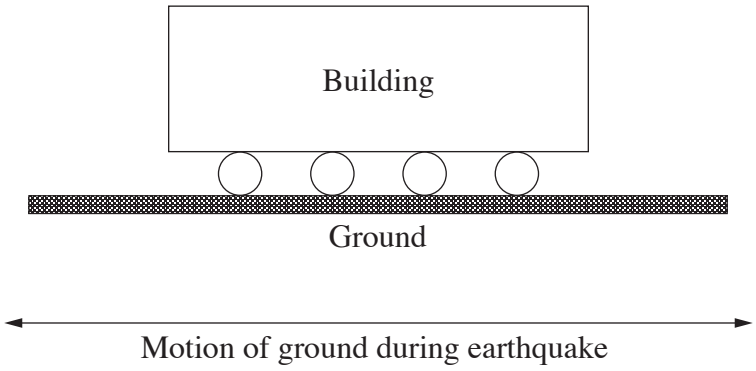
A. The proportion of funding from the government has changed over time.

B. The proportion of funding from large corporations has been constant over time.

C. The proportion of funding from the government has steadily increased over time.

D. The proportion of funding from large corporations has steadily increased over time.

19 One way to reduce the damage to buildings during earthquakes is to place the building on large rollers.



Which statement provides the best reason for the reduction in damage caused by earthquakes when this method is used?

A. The inertia of the rollers reduces the acceleration of the ground.

B. The inertia of the building reduces the acceleration of the building.

C. The acceleration of the building is reduced by the inertia of the ground.

D. The acceleration of the ground is reduced by the inertia of the building.

20 A study was carried out to investigate the links between diet and cultural identity. Three study groups of different ethnicities were used.

- All three ethnicities involved in the study traditionally perceive that a higher body mass index (BMI) indicates a higher socioeconomic status.
- All participants in the study responded by completing a common questionnaire.

	Ethnicity X	*Ethnicity Y*	*Ethnicity Z*
Number of participants	100	100	100
Age range of participants	45–49	45–49	45–49
Average BMI (kg/m^2)	23.1	28.6	23.9
Socioeconomic status	High	Low	Medium

Possible sources of error in a study such as this include:

1. Age is not controlled
2. Sample size differences
3. Sample selection differences
4. Participants complete the same questionnaire
5. Representation of genders
6. Underlying health conditions that could impact BMI
7. Participants withholding relevant information from the researcher.

Which combination of errors has NOT been addressed in this study?

A. 1, 2, 5, 6

B. 2, 4, 5, 6

C. 3, 4, 6, 7

D. 3, 5, 6, 7

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2023 HIGHER SCHOOL CERTIFICATE EXAMINATION

Centre Number

Student Number

Investigating Science

Section II Answer Booklet

80 marks
Attempt Questions 21–36
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 (2 marks)

A student gathered and recorded the data in the table over a period of one week.

Day	*Temperature* (°C)	*Number of butterflies sighted*	*Wind speed* ($m\ s^{-1}$)
1	28	37	5.3
2	32	46	0
3	27	34	7.5
4	20	14	21
5	19	12	0
6	22	15	8.3
7	29	37	0

(a) State a hypothesis that the student could have been testing, based on the data gathered. **1**

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(b) Identify a factor that should have been controlled in this investigation. **1**

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Question 22 (2 marks)

Outline an effect that ONE specific surgical procedure has had on world health. **2**

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Question 23 (3 marks)

Why is bioharvesting of plants from Country and Place becoming increasingly valued? **3**

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Question 24 (4 marks)

Water is known to boil at 100°C when the atmospheric pressure is 100 kPa. A student measures the temperature of boiling water at 100 kPa on five consecutive days using the same thermometer and the same digital temperature probe.

Day	*Temperature reading on thermometer* (°C)	*Temperature reading on digital temperature probe* (°C)
1	103.5	100.003
2	103.5	99.996
3	103.5	100.012
4	103.5	100.002
5	103.5	99.991

(a) Explain the results obtained by the thermometer. **2**

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(b) Justify the validity and accuracy of using the digital temperature probe. **2**

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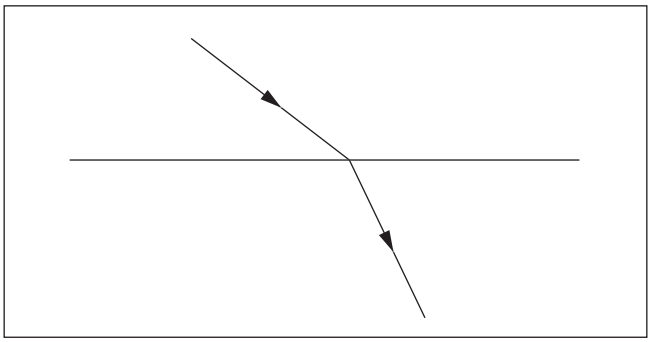
Question 25 (5 marks)

(a) Complete the table by providing an example of a scientific law and a scientific theory. **2**

	Example
Scientific law	....
Scientific theory	....

(b) The recently-launched James Webb Space Telescope makes use of reflective technology. A media report used the diagram and caption shown to explain the workings of this telescope. **3**



The Theory of Reflection as used by the James Webb Space Telescope

Evaluate the accuracy of the information presented in the diagram AND the caption used in the media report.

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Question 26 (7 marks)

(a) Justify the need for scientific research to be regulated. Refer to a specific example in your answer. **3**

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(b) Evaluate the effectiveness of a specific scientific regulation, or code of conduct, in overcoming an ethical issue in scientific research or practice. **4**

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Question 27 (3 marks)

Explain why so many scientific papers are published in fake science journals. **3**

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Question 28 (4 marks)

Evaluate the relevance of the investigation by Marshall and Warren, based on the peer-reviewed literature available at the time. **4**

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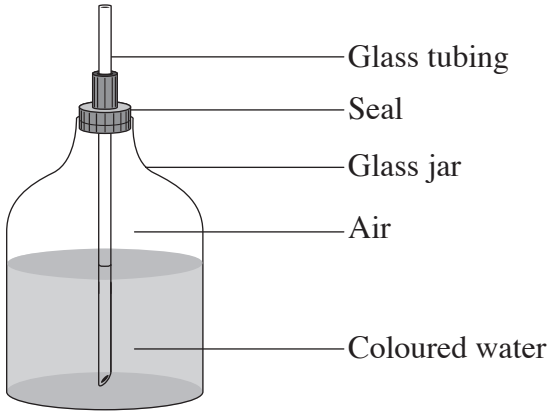
Question 29 (6 marks)

Students set up the apparatus shown to test the effect of temperature on a volume of gas.



The apparatus was placed on a hot plate. The water was heated but not boiled. The students used a calibrated ruler to make measurements and their mobile phone cameras to take images before, during and after the experiment.

(a) Complete the table to identify TWO technologies used in this experiment and a limitation of each. **3**

Technology used	*Limitation*
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Question 29 continues on page 21

Question 29 (continued)

(b) Explain the expected result of this experiment. **3**

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End of Question 29

Please turn over

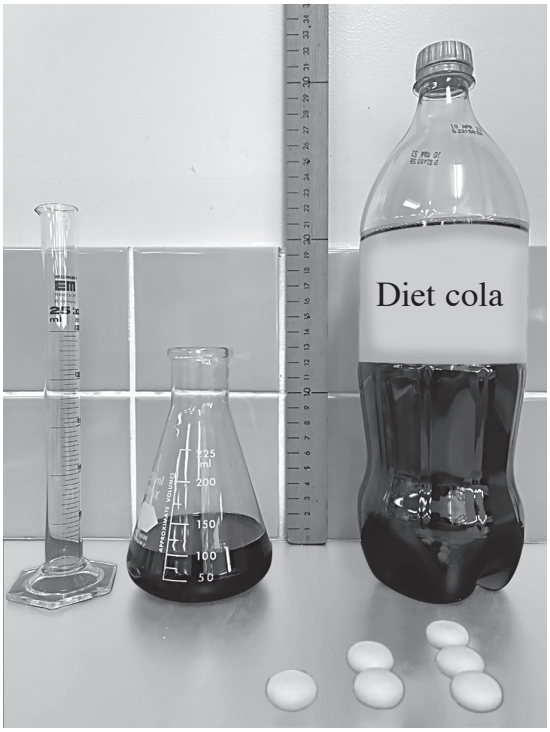
Question 30 (7 marks)

A student conducted a depth study to investigate the effect of placing lollies into a bottle of diet cola. The student presented their investigative report as shown. **7**

Depth Study Report

<table>
<tr><td>What I already know

An explosive reaction occurs between diet cola and lollies. When a lolly is dropped into diet cola, bubbles form and cause the diet cola to spurt out at high speed.</td><td rowspan="5">What I did

 
</td></tr>
<tr><td>My prediction is

There will be a bigger spurt with more lollies.</td></tr>
<tr><td>My test is safe because

Spills were cleaned up straight away, safety goggles were worn, and no one drank the diet cola.</td></tr>
<tr><td>My test is fair because

The same brand of diet cola was used and all lollies were the same size and the same ruler was used.</td></tr>
<tr><td>Was my experiment good?

The experiment tested what I thought it should. It was hard to accurately measure how high the spurt was.</td></tr>
<tr><td>To improve the investigation, I can

Record the results using a camera and zoom in to see the ruler.</td><td>Spurt height

0 lollies – nothing, 1 lolly – a bit,
2 lollies – a lot, 3 lollies – heaps</td></tr>
<tr><td>What I learnt

My hypothesis is right, as a larger spurt was seen with more lollies.</td><td>Why did this happen?

There was a larger surface area with more lollies. This means more bubbles could build up on the lollies, making more pressure and speed. This formed the larger spurt.</td></tr>
</table>

Question 30 continues on page 23

Question 30 (continued)

Evaluate the structure and language style of the student's report.

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End of Question 30

Question 31 (7 marks)

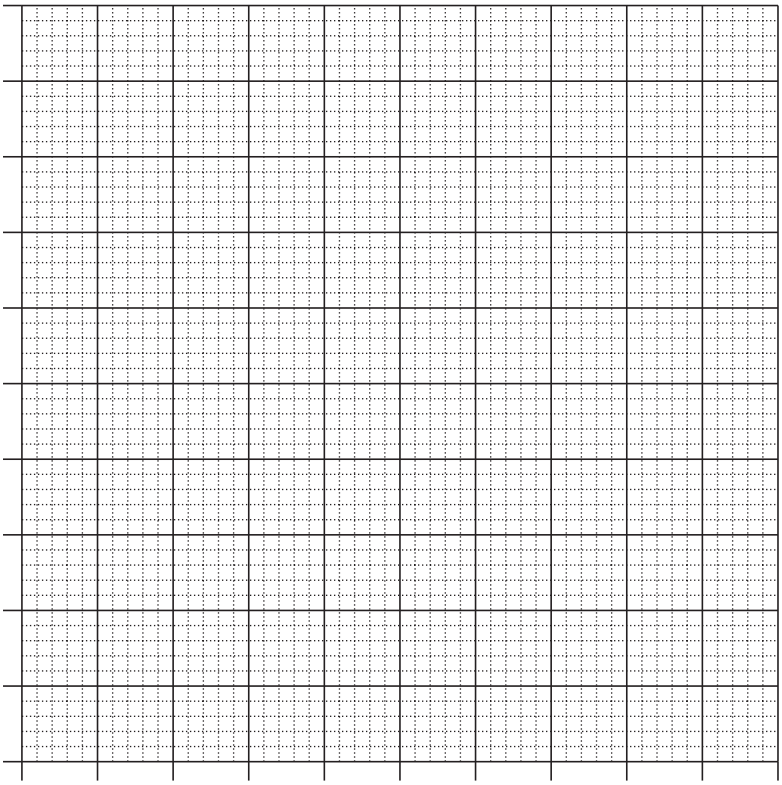
Photosynthesis requires carbon dioxide (CO_2) from the atmosphere for plant growth. Atmospheric CO_2 concentration is currently increasing. Phosphorus is also needed for plants to photosynthesise effectively.

A controlled study was conducted to test the following hypothesis:

If phosphorus levels in soil increase, trees can then use the higher CO_2 concentration available to increase their leaf mass.

Phosphorus level in soil (ppm)	*Leaf mass of 200 seedlings grown at current CO_2 concentration* (g)	*Leaf mass of 200 seedlings grown at higher CO_2 concentration* (g)
70	24	24
100	36	46
180	42	68
300	48	86
400	51	94

(a) Construct an appropriate graph of the data provided in the table. **4**



Question 31 continues on page 25

Question 31 (continued)

(b) Explain whether the results support the hypothesis. **3**

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End of Question 31

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Question 32 (5 marks)

A cosmetic company published the results from a clinical trial of a new moisturiser containing sunscreen. Forty people of varying ages and skin types participated in the trial. The participants were placed in four separate groups of 10.

The results from the clinical trial are shown in the table.

Group	*Duration on skin* (hours per day)	*Frequency of use*	*Average amount of skin damage* (%)
1	2	Saturday and Sunday only	80
2	6	Saturday and Sunday only	70
3	2	Every day	40
4	6	Every day	5

(a) Outline how one factor in the design of this trial decreases its validity. **2**

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Question 32 continues on page 27

Question 32 (continued)

(b) The new moisturiser with sunscreen was released with a marketing message on the packaging of the product. **3**

Analyse the claim made on the packaging.

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End of Question 32

Question 33 (5 marks)

In a case study undertaken by a student on the development of flight, two conflicting views were found. **5**

1. In 1903, most people did not believe reports that the Wright Brothers had flown in a machine that was heavier than air. This was mainly due to articles by prominent scientists, such as Professor Simon Newcomb, who stated that trying to fly was nonsense and impossible.
2. Eddie Rickenbacker, a famous fighter pilot in World War I (1914–1918), said that 'Aviation is proof that given the will, we have the capacity to achieve the impossible'.

Using research from your own case study and the information provided, discuss the effect that the development of flight has had on the public image of science.

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Question 34 (5 marks)

Evaluate how ONE example of scientific research has aided economic development. **5**

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Question 35 (8 marks)

(a) In this course, you were required to conduct an investigation to test a claim. **4**

State the claim tested.

Claim tested:

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Outline the procedure used to test this claim, in a series of logical steps.

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Question 35 continues on page 31

Question 35 (continued)

(b) Evaluate the impact that sample size AND sample selection can have on the results of an investigation. **4**

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End of Question 35

Please turn over

Question 36 (7 marks)

Analyse how a development in technology led to an advancement in a scientific model, theory or law that, in turn, resulted in the development of a new technology. **7**

Question 36 continues on page 33

Question 36 (continued)

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