Government of **Western Australia**
School Curriculum and Standards Authority

ATAR course examination, 2020

Question/Answer booklet

INTEGRATED SCIENCE

Please place your student identification label in this box

WA student number: In figures

In words

Time allowed for this paper

Reading time before commencing work: ten minutes
Working time: three hours

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer booklet
Multiple-choice answer sheet

Number of additional answer booklets used (if applicable):

To be provided by the candidate

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: up to three calculators, which do not have the capacity to create or store programmes or text, are permitted in this ATAR course examination

Important note to candidates

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised material. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

2021/2766
Web version of 2020/58607

Ref: 20-038

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of examination
Section One Multiple-choice	20	20	30	20	20
Section Two Short response	5	5	90	92	50
Section Three Extended response	2	2	60	63	30
				Total	100

Instructions to candidates

1. The rules for the conduct of the Western Australian external examinations are detailed in the *Year 12 Information Handbook 2020: Part II Examinations*. Sitting this examination implies that you agree to abide by these rules.

2. Answer the questions according to the following instructions.

   Section One: Answer all questions on the separate Multiple-choice answer sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. Do not use erasable or gel pens. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections Two and Three: Write your answers in this Question/Answer booklet.

3. You must be careful to confine your answers to the specific questions asked and to follow any instructions that are specific to a particular question.

4. Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

See next page

Section One: Multiple–choice **20% (20 Marks)**

This section has **20** questions. Answer **all** questions on the separate Multiple-choice answer sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. Do not use erasable or gel pens. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 30 minutes.

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1. Domestic wastewater that is untreated and pumped into waterways poses a risk to ecosystems by causing

   (a) biomagnification.
   (b) eutrophication.
   (c) global warming.
   (d) osmoregulation.

2. The form of water that has the greatest effect in warming the Earth's climate is

   (a) water vapour.
   (b) clouds.
   (c) oceans.
   (d) polar ice caps.

3. Workers at nuclear power stations use personal protective equipment, including

   (i) safety glasses.
   (ii) lead aprons.
   (iii) safety boots.
   (iv) radiation monitoring badges.

   Which of the equipment listed above is necessary to safeguard workers against exposure to dangerous levels of radiation?

   (a) i and iv
   (b) ii and iv
   (c) i, ii and iv
   (d) i, ii, iii and iv

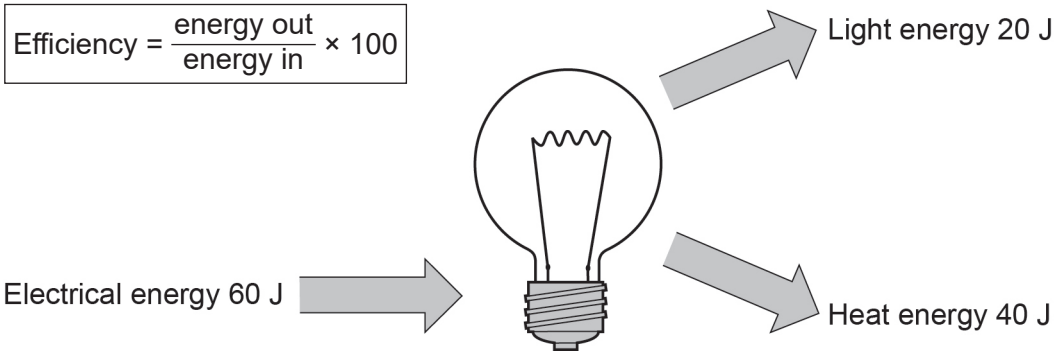
4. An environmental impact of the infrastructure required for electricity generation is the

   (a) high cost.
   (b) large amount of liquid waste produced.
   (c) disturbance of the natural ecosystem.
   (d) high water consumption.

See next page

5. Determine the energy efficiency of the light globe shown below.

$$\text{Efficiency} = \frac{\text{energy out}}{\text{energy in}} \times 100$$



(a) 40 J
(b) 20 J
(c) 33%
(d) 67%

6. An outcome of hydraulic fracturing is that it

(a) produces no pollution.
(b) produces biofuels.
(c) reduces carbon emissions.
(d) increases natural gas resources.

7. The heat generated beneath the Earth's surface that can be used as an alternative source of energy is called

(a) hydrography.
(b) geothermal.
(c) exothermal.
(d) solar.

8. The factors that affect the solubility of salts in water are

(a) temperature, pressure and concentration gradient.
(b) pressure, density and concentration gradient.
(c) density and pressure.
(d) polarity, density and osmotic pressure.

9. At which stage(s) of the investigative process should a student consider research ethics?

(i) when planning the investigation
(ii) when collecting and analysing data
(iii) when compiling an investigation report

(a) i only
(b) i and ii
(c) i and iii
(d) i, ii and iii

See next page

10. Macro-invertebrate sampling can be used to assess water quality. Which characteristics of macro-invertebrates are considered when interpreting the data?

(i) abundance
(ii) diversity
(iii) size
(iv) sensitivity index
(v) method of movement

(a) i, ii and iv
(b) i, ii and v
(c) ii, iii and iv
(d) ii, iii and v

11. Processes used in the treatment of domestic wastewater before its safe return to the environment include

(a) screening, aeration and sedimentation.
(b) sedimentation, chlorination and fluoridation.
(c) screening, reverse osmosis and disinfection.
(d) clarification, sedimentation and filtration.

12. There are many processes used to make water potable. Which of the following would **only** be used in a desalination plant?

(a) aeration
(b) reverse osmosis
(c) chlorination
(d) filtration

13. Oil pollution can affect the ecology of aquatic ecosystems by

(a) reducing eutrophication.
(b) increasing algae and phytoplankton levels.
(c) increasing the diversity in populations of aquatic bacteria.
(d) decreasing photosynthesis of aquatic plants.

14. The process of disposing of nuclear waste by burying it in storage repositories deep underground is used **mainly** for which type of material?

(a) tools and clothing used in hospitals during radiotherapy
(b) waste from uranium mines
(c) contaminated materials from nuclear reactors that have been shut down
(d) spent fuel rods from nuclear reactors

See next page

15. A student measured a 254 mm object three times with a ruler and reported the length to be 244 mm, 245 mm and 243 mm. The student demonstrated

    (a) low precision and high accuracy.
    (b) high precision and high accuracy.
    (c) high precision and low accuracy.
    (d) low precision and low accuracy.

16. How much power does an electric toaster use when it converts 36 000 joules of electrical energy to heat energy in one minute? Power can be calculated using $P = \frac{E}{t}$.

    (a) 60 W
    (b) 600 W
    (c) 3600 W
    (d) 36 000 J

17. One strategy for reducing the risk of dry land salinity is to plant more large, deep-rooted trees. This will

    (a) lower the depth of the groundwater.
    (b) reduce the amount of salt contained in the soil.
    (c) raise the depth of the groundwater.
    (d) remove the pollution found in the soil.

18. Which of the following statements regarding the generation of electricity using electromagnetic induction is correct?

    (a) magnet + coil of wire + electricity → movement
    (b) magnet + coil of wire + movement → electricity
    (c) heat + magnet + movement → electricity
    (d) magnet + coil of wire + generator → electricity

19. Which of the following properties of water enable it to have a high specific heat capacity?

    (a) It freezes at 0 °C.
    (b) It is liquid at room temperature.
    (c) It readily dissolves salts.
    (d) It forms hydrogen bonds between molecules.

20. The **most** common effects of radiation on the human body include

    (a) nausea, vomiting and changes to DNA.
    (b) nausea, burns to the skin and bleeding from the ears.
    (c) diarrhoea, burns, rashes and bleeding from the ears.
    (d) vomiting, dizziness and diabetes.

End of Section One

See next page

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Section Two: Short response **50% (92 Marks)**

This section has **five** questions. Answer **all** questions. Write your answers in the spaces provided.

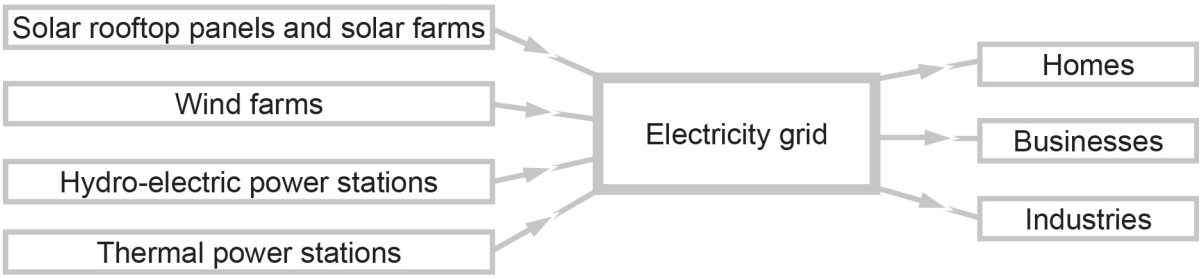
Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 90 minutes.

Question 21 **(20 marks)**

To power our homes and businesses, Australia generates electricity from coal and gas fired power stations, as well as a range of renewable energy sources including large-scale hydropower facilities, wind farms and solar rooftop panels.

The range of electricity sources that are integrated into our electricity grid are summarised below.



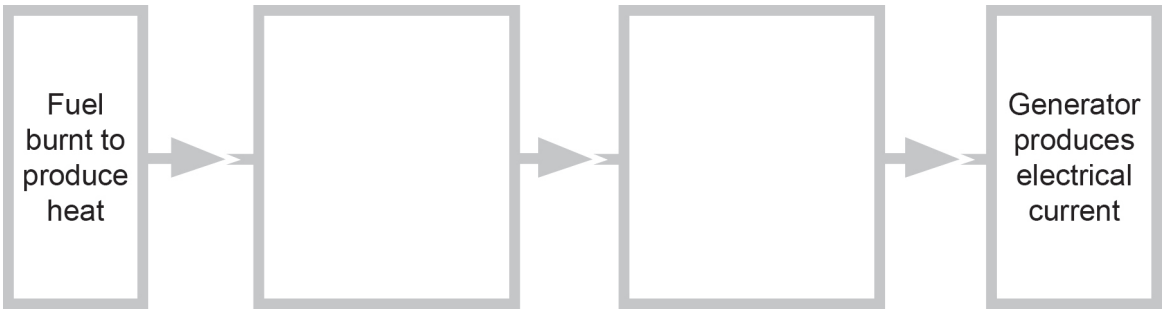
Individual homes can meet their own electricity needs or contribute to the electricity grid through the use of photovoltaic cells (PV).

(a) Describe how photovoltaic cells generate electrical current. (4 marks)

A conventional power station uses certain processes to transform the energy stored in fossil fuels (such as coal or natural gas) into electricity.

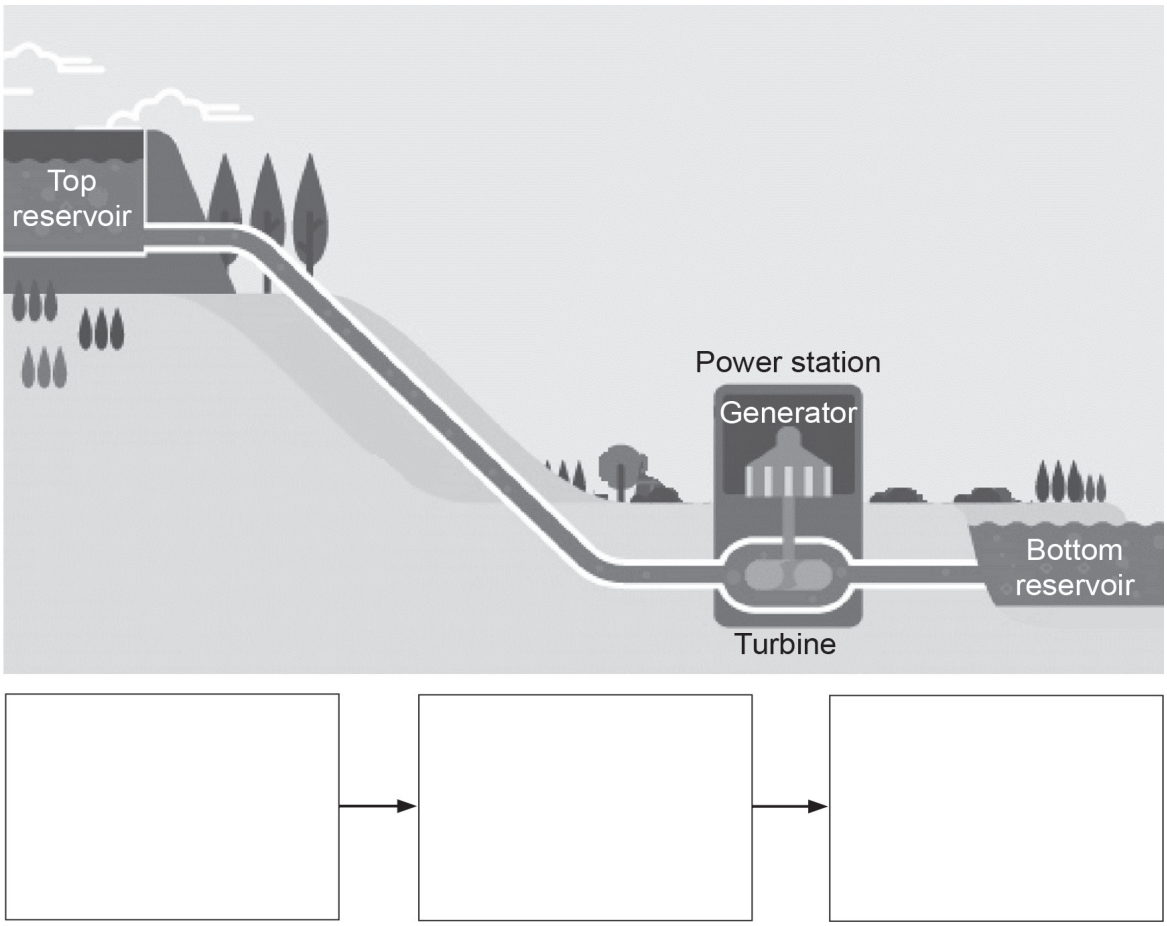
The process of electricity generation involves several stages.

(b) Complete the two missing stages involved in producing electrical current from coal. (2 marks)



In hydro-electric power stations, energy transformations occur in the generation of electricity.

(c) Complete the flow diagram below to show the different energy transformations that occur in a hydro-electric power station. (3 marks)



See next page

Question 21 (continued)

Australia does not use nuclear energy for power generation. A strategy for reducing our carbon emissions would be to replace old coal-fired power stations with nuclear power stations.

(d) Compare the processes of electrical generation that occur in a coal-fired power station and in a pressurised water reactor nuclear power station. (5 marks)

Coal-fired and nuclear power stations are capable of providing a base load supply of electricity.

(e) Define 'base load supply'. (2 marks)

(f) State how coal-fired and nuclear power stations are different in terms of their efficiency and cost, providing reasons. (4 marks)

Efficiency:

Cost:

Question 22 **(21 marks)**

Seagrasses are underwater plants that produce flowers and have root systems that grow into the sand. They provide a source of food and shelter for a large variety of marine animals, resulting in complex food webs.

A certain seagrass meadow receives 1150 MJ of light energy per square metre annually. However, only 22 500 kJ of energy per square metre is stored in the seagrasses annually.

(a) Calculate the percentage of light energy stored by the seagrasses annually. Show your workings. (3 marks)

Answer:

Figure 1 below shows an energy pyramid for a marine food chain.

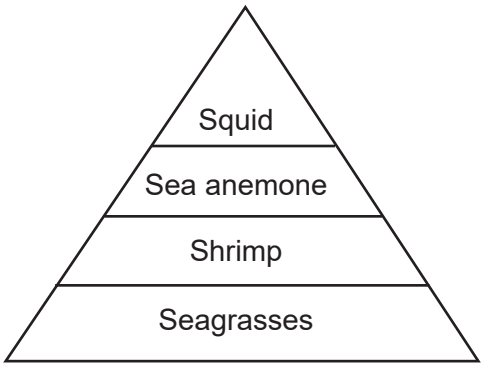


Figure 1: A marine energy pyramid

(b) Draw a food chain for the energy pyramid shown in Figure 1. (1 mark)

(c) If the energy store of the seagrasses in Figure 1 is 96 000 kJ m^{-2} annually, determine the approximate amount of energy transferred annually to the sea anemone. Justify your answer. (2 marks)

Question 22 (continued)

(d) Outline **four** reasons why the squid would transfer much less energy than the seagrasses in Figure 1. (4 marks)

One: _____

_____

Two: _____

_____

Three: _____

_____

Four: _____

_____

A large population of seagrasses is found in Shark Bay, Western Australia. Below is one food web in the Shark Bay ecosystem.

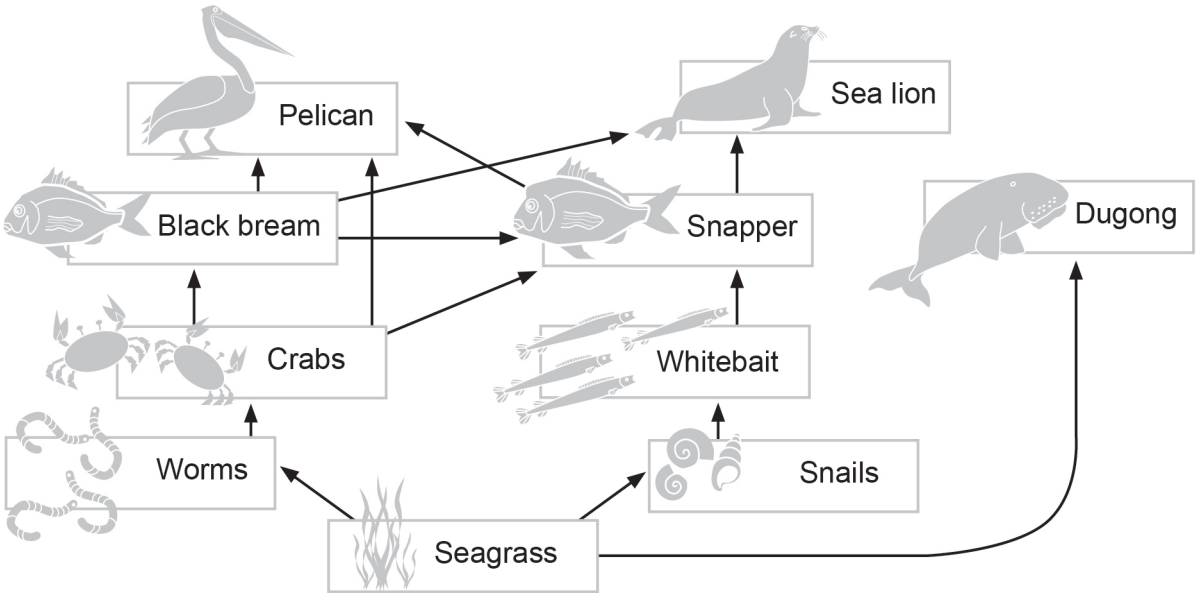


Figure 2: A Shark Bay food web

(e) Name the trophic level that is **not** represented in the food web above and outline its role in the ecosystem. (2 marks)

_____

_____

_____

_____

Recreational fishing has resulted in a significant decrease in the crab population.

(f) Describe **two** impacts this would have on the food web in Figure 2, giving reasons for your answers. (4 marks)

One: _____

Two: _____

The diversity and abundance of aquatic life in the Shark Bay ecosystem is due partly to the physical and chemical conditions of the water. Seagrass beds assist in maintaining conditions to ensure high water quality.

(g) Describe how seagrass beds affect the amount of dissolved oxygen and nutrients in the Shark Bay ecosystem. (4 marks)

Dissolved oxygen: _____

Nutrients: _____

(h) State **one** human activity in the Shark Bay area that could result in increased nutrients in the aquatic ecosystem. (1 mark)

_____

Question 23 **(13 marks)**

Energy exists in many forms. These can be categorised as either kinetic or potential energy.

(a) Describe kinetic and potential energy and provide a form of energy for each. (4 marks)

Kinetic energy

Description: _____

_____

Form: _____

Potential energy

Description: _____

_____

Form: _____

(b) State the Law of Conservation of Energy. (2 marks)

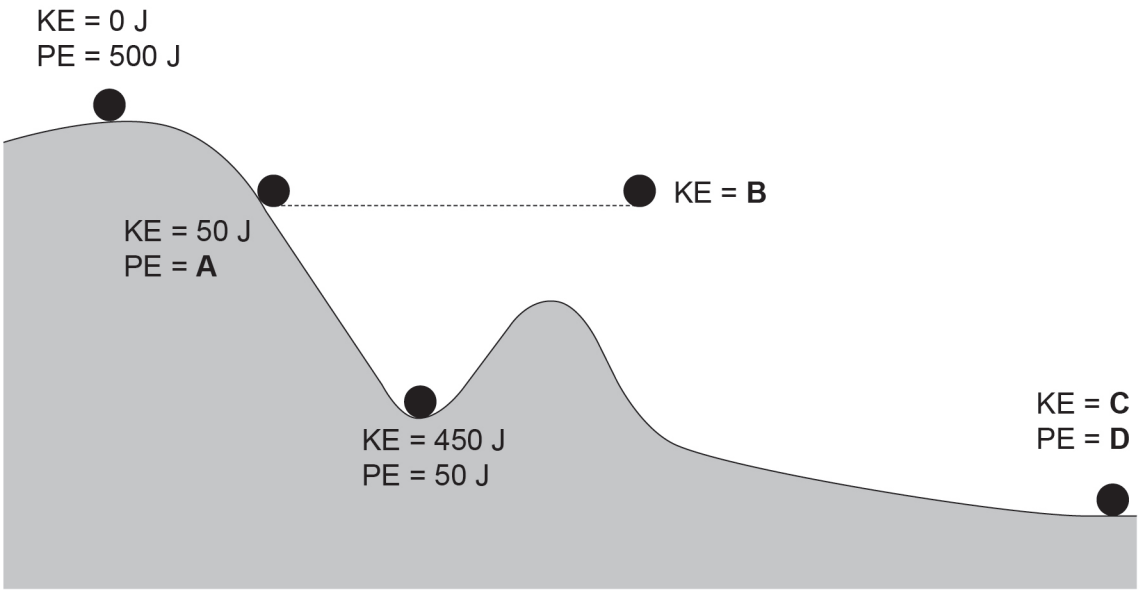
_____

_____

_____

_____

As shown in the diagram below, a ball starts at the top of a hill, rolls down the hill and up the second hill, then flies into the air, lands on the ground and continues rolling.



(c) Use the Law of Conservation of Energy (assuming no friction) to determine the amount of energy at **A**, **B**, **C** and **D** on the diagram above. (4 marks)

Kinetic energy = KE Potential energy = PE

A: _____ **C**: _____

B: _____ **D**: _____

Energy can be defined as the ability of a system to do work.

(d) Determine whether each of the situations below demonstrates work being done. **Circle** the correct answer for each situation. (3 marks)

A teacher pushes on a wall for a short period of time and becomes exhausted.

Yes / No

A book is pushed off a table and falls to the ground.

Yes / No

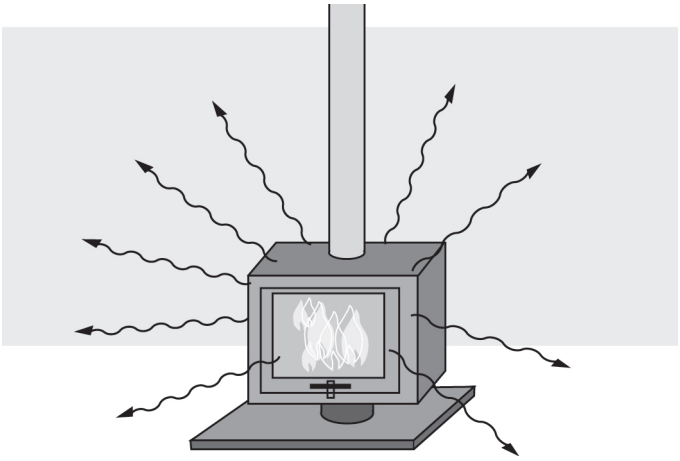
A student holds a basketball above their head with a straight arm and walks at a constant speed across a level room.

Yes / No

See next page

Question 24 **(15 marks)**

In 2014, the main heating method used in approximately 900 000 Australian households was the burning of wood. The diagram below shows a wood-fired heater.



(a) Identify the **three** methods of heat transfer from the heater and describe how each method assists in increasing the air temperature in a room. (6 marks)

Method of heat transfer	**How this assists in increasing the air temperature in a room**
One:	
Two:	
Three:	

See next page

The use of solar design features can help to reduce the high demand for energy in homes.

(b) Identify passive solar design features that would keep a building warm during winter. Include **two** that would prevent heat loss and **two** that would increase heat gain. (4 marks)

Features preventing heat loss

One: _____

Two: _____

Features increasing heat gain

One: _____

Two: _____

(c) Explain what is meant by the enhanced greenhouse effect. (3 marks)

_____

_____

_____

_____

_____

_____

(d) Provide **two** advantages of burning wood instead of coal for the generation of electricity. (2 marks)

One: _____

_____

Two: _____

_____

Question 25 **(23 marks)**

Aquatic environments provide a unique ecosystem for organisms, due to the unusual properties of water.

(a) Draw a labelled diagram of a water molecule to illustrate its polarity. (3 marks)

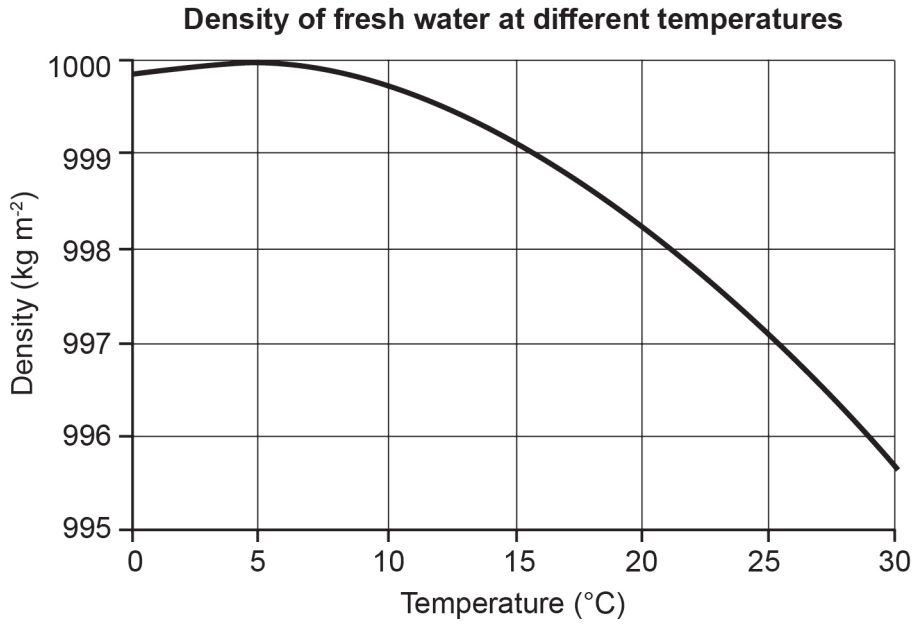
(b) Explain how the specific heat capacity of water provides a desirable environment for aquatic organisms. (2 marks)

Water striders are able to walk across the surface of water.

(c) Use your knowledge of water polarity to explain why water striders can walk on water. (3 marks)

See next page

The density of fresh water varies with temperature, as shown in the graph below.



(d) A light piece of wood floats in fresh water at 4 °C. Describe the change in buoyancy of the wood as the temperature of the water increases above 4 °C. (2 marks)

(e) Explain why the density of fresh water decreases as the temperature drops below 4 °C. (3 marks)

See next page

Question 25 (continued)

Over time, the average water temperature of the Earth's oceans has increased.

(f) What effect has this change had on dissolved oxygen and carbon dioxide gas levels in aquatic environments? (1 mark)

Fish and other aquatic organisms obtain oxygen from water through the use of specialised structures for gas exchange called gills.

(g) Describe **three** characteristics of structures that enable efficient gas exchange. (6 marks)

One:

Two:

Three:

Fish in ocean environments must cope with high levels of salinity.

(h) State **three** osmoregulation mechanisms these fish utilise to balance internal salt concentration. (3 marks)

One:

Two:

Three:

End of Section Two

See next page

Section Three: Extended response **30% (63 Marks)**

This section contains **two** questions. You must answer **both** questions. Write your answers in the spaces provided.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 60 minutes.

Question 26 **(34 marks)**

Generally, water resources fall into two categories – groundwater and surface water.

(a) Identify **two** main ways in which surface water is stored for drinking. (2 marks)

One: _____

Two: _____

(b) Explain how water is collected in catchment areas. (3 marks)

_____

_____

_____

_____

_____

_____

Question 26 (continued)

Management of land use in catchment areas ensures that the high quality of drinking water is maintained.

(c) Describe a management strategy that could be used to prevent the likelihood of water being affected by dry land salinity, turbidity and eutrophication. (6 marks)

Dry land salinity: _____

_____

_____

Turbidity: _____

_____

_____

Eutrophication: _____

_____

_____

Most lakes on the Swan Coastal Plain do not have streams whose water flows into and out of them. These lakes are in low-lying areas of the land and extend below the water table.

Perth is increasingly relying on groundwater to top up its drinking water supply.

(d) Explain **two** negative effects the increased use of groundwater would have on lakes and their ecosystems. (6 marks)

One: _____

_____

_____

_____

_____

Two: _____

_____

_____

_____

_____

A group of students studied a freshwater lake on the Swan Coastal Plain. The water quality of the lake was monitored annually over three years. The results can be seen in Table 1.

Table 1: Mean annual water quality data for a freshwater lake

Water quality condition	**Year**		
	2017	**2018**	**2019**
Temperature (°C)	25	27	28
Turbidity (NTU)	<10	20	40
pH	8.3	8.2	8.4
Salt concentration (ppt)	0.2	0.4	0.8
Dissolved oxygen (mg L^{-1})	5.5	9	
Phosphate (mg L^{-1})	0.02	0.03	0.08
Nitrate (mg L^{-1})	0.05	0.1	0.4

(e) On the basis of the results in Table 1, describe the trend in salinity levels over the three years and propose a reason for this trend. (3 marks)

See next page

Question 26 (continued)

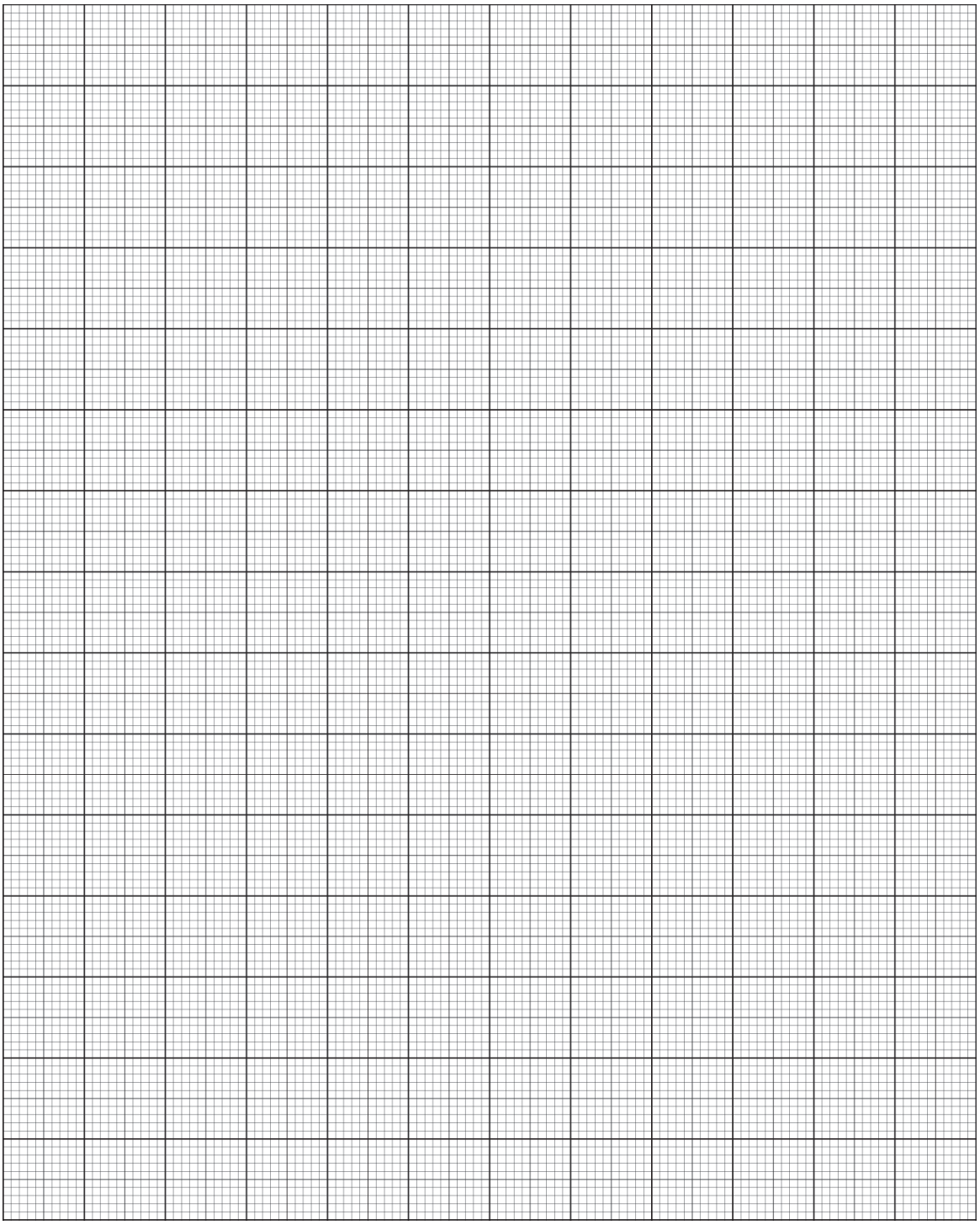
The following data shows the average oxygen concentration for fresh and salt water at different temperatures.

Table 2: Average dissolved oxygen content in fresh and salt water at different temperatures

	Oxygen content (mg L^{-1})	
Temperature (°C)	**Fresh water**	**Salt water**
0	14	11
5	13	10
10	12	9
15	11	8.25
20	10	7.5
25	9.25	6.75
30	8.5	6.25
35	7.75	5.75
40	7.25	5.5
45	6.75	5.25
50	6.5	5

(f) Graph the data from Table 2 on the following grid. (6 marks)

See next page



A spare grid is provided at the end of this Question/Answer booklet. If you need to use it, cross out this attempt and indicate that you have redrawn it on the spare grid.

See next page

Question 26 (continued)

(g) Identify **one** trend shown in the graph. (1 mark)

(h) Use your graph to predict the missing 2019 dissolved oxygen content for the freshwater lake in Table 1 on page 23. (1 mark)

_____ mg L^{-1}

The 2019 dissolved oxygen content was measured as 4.1 mg L^{-1}, which is not consistent with the graph. It is believed this lower concentration of dissolved oxygen was caused by eutrophication.

(i) Describe the stages in the process of eutrophication that lead to decreased dissolved oxygen levels. (6 marks)

See next page

Question 27 **(29 marks)**

Students were asked to compare the amount of energy released by a range of biofuels. They chose to use E85 (a fuel made up of 85% bioethanol and 15% petrol), bioethanol, and biojet (a biodiesel). The diagram below shows the equipment used to conduct the experiment.

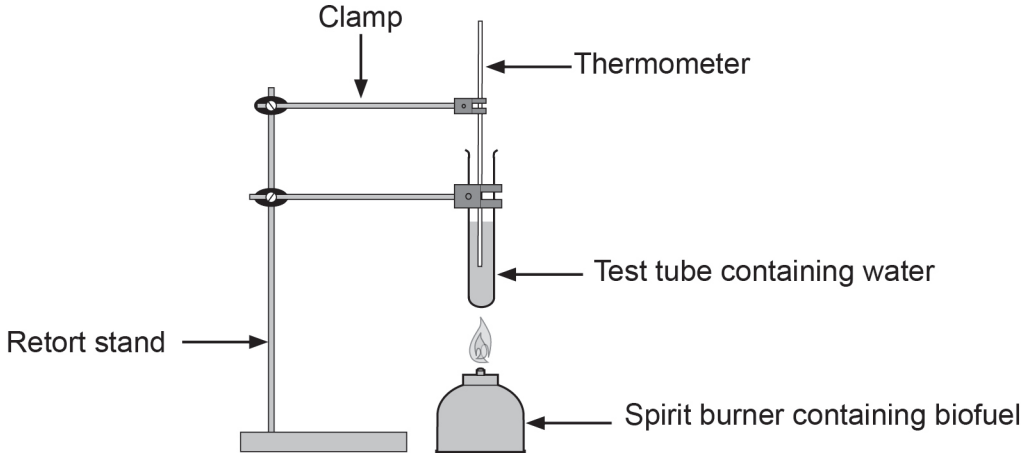


Table 3: Data for biofuels energy experiment

Biofuel	Mass of the fuel (g)	Time taken (min)	Mass of the water (g)	Starting water temperature (°C)	Final water temperature (°C)	Temperature change (°C)	Heat energy released (J)
E85	2	10	20	19.5	40.2	20.7	1730.52
Bioethanol	2	10	20	20.2	38.6		
Biojet	2	10	20	20.5	42.5	22	1839.20

(a) Referring to the diagram and Table 3, write a possible procedure for this experiment. (6 marks)

See next page

Question 27 (continued)

(b) Using the data from Table 3, calculate the heat energy in joules absorbed by the water from burning the bioethanol. Show your workings. (3 marks)

Use the formula $Q = mc\Delta T$, where the specific heat capacity of water is 4.180 J g^{-1}.

Answer:

(c) Table 4 below shows the experimental and theoretical values of heat energy released, when 1.0 g of each biofuel is burned completely.

Table 4: Comparison data for biofuels

Biofuel	Experimental value (J)	Theoretical value (J)
E85	865	1650
Bioethanol	769	1420
Biojet	919	1840

(i) Provide **one** reason why the experimental values are lower than the theoretical values. (1 mark)

(ii) Referring to the data in Table 4, state whether the differences between values could be a result of random or systematic errors. (1 mark)

(iii) Why is bioethanol considered to be a biofuel? (1 mark)

See next page

(d) State **two** disadvantages of using biofuels. (2 marks)

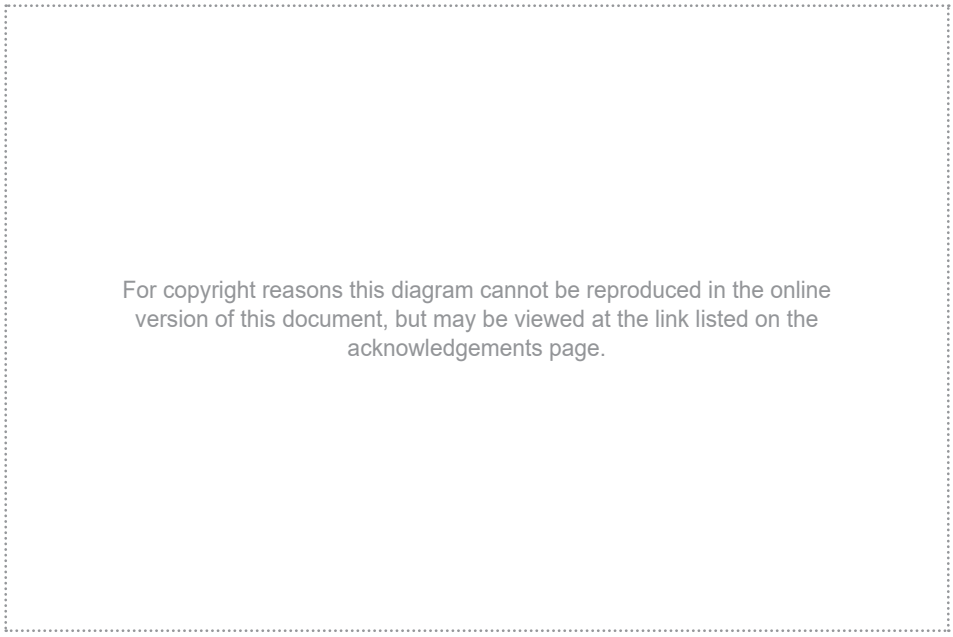
One: _____

_____

Two: _____

_____

Petrol and diesel are still the most commonly-used fuels in internal combustion engines. While companies make individual changes to their own engine designs, there are common components and processes in all of these engines.



(e) State what is occurring during each of the four strokes of the engine cycle. (4 marks)

Intake	
Compression	
Combustion	
Exhaust	

See next page

Question 27 (continued)

More people are choosing to use vehicles powered by electric motors as alternatives to fossil fuel-powered internal combustion engines.

(f) Describe the differences between an electric vehicle motor and an internal combustion engine, referring to:

- efficiency
- environmental impact
- impact on resources. (6 marks)

Efficiency: _____

_____

_____

_____

_____

Environmental impact: _____

_____

_____

_____

_____

Impact on resources: _____

_____

_____

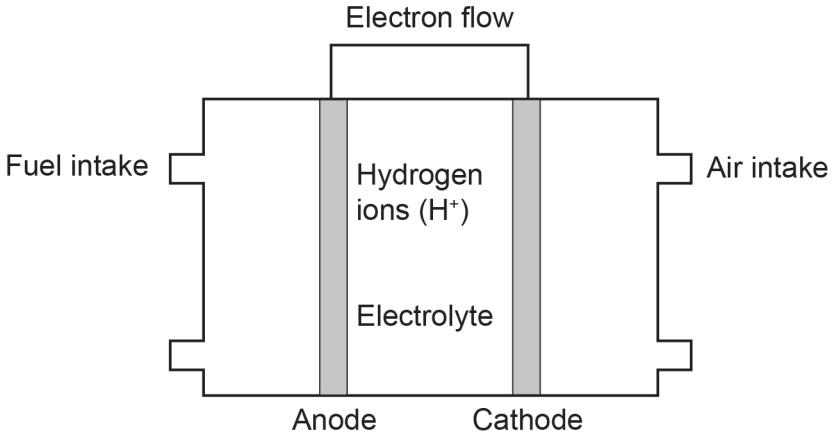
_____

_____

See next page

Hydrogen fuel cells offer an alternative fuel that can be used to run some electric vehicles. While such vehicles are not yet for sale in Australia, they are available in some other countries. They rely on the use of a hydrogen fuel cell to provide energy for motion.

Consider the diagram of a hydrogen cell shown below.



(g) Explain how a hydrogen fuel cell functions to produce electricity. In your answer, provide a general description of the processes that occur, referring to the diagram above.

(5 marks)

End of questions

Supplementary page

Question number: _____

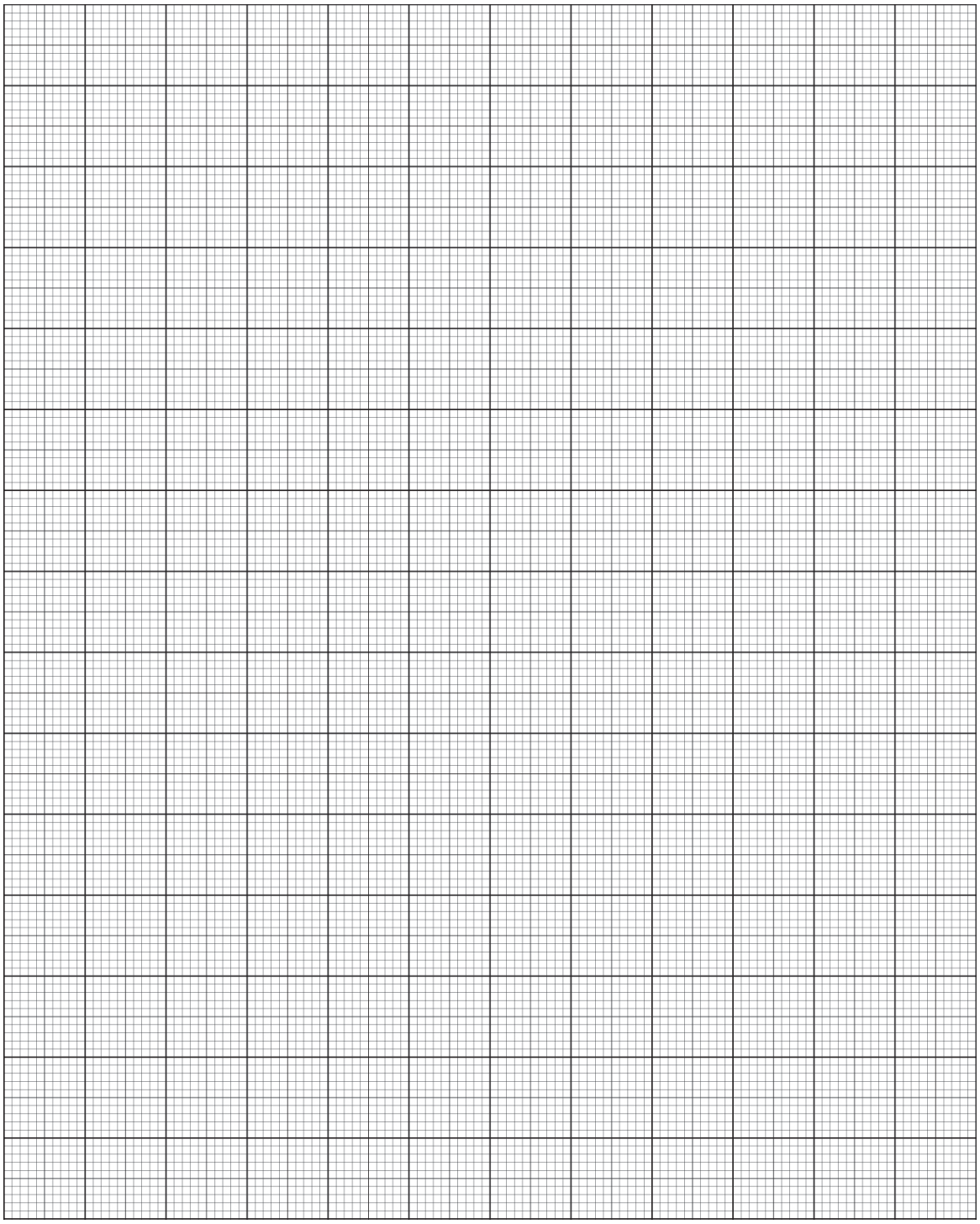
Supplementary page

Question number: _____

Supplementary page

Question number: _____

Spare grid



ACKNOWLEDGEMENTS

Question 21 Quote adapted from: Clean Energy Regulator. (2018). *About the renewable energy target*. Retrieved June, 2020, from http://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target
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Question 21(c) Image adapted from: Australian Renewable Energy Agency (ARENA). (2018). *Pumped hydro storage, how it works* [Infographic]. Retrieved June, 2020, from https://arena.gov.au/blog/4800mw-pumped-hydro/
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Question 27(e) Diagram adapted from: Pippin, M. (n.d.). [Diagram of an internal combustion engine]. Retrieved June, 2020, from https://easyscienceforkids.com/all-about-internal-combustion-engines/

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