Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3440UA0-1

Z22-3440UA0-1

WEDNESDAY, 15 JUNE 2022 – MORNING

APPLIED SCIENCE (Single Award)
UNIT 1: Science in the Modern World

HIGHER TIER

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**19**	
2.	**6**	
3.	**13**	
4.	**15**	
5.	**8**	
6.	**14**	
Total	**75**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator, pencil and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

Question **4**(a)(i) is a quality of extended response (QER) question where your writing skills will be assessed.

You are reminded to show all your workings. Credit is given for correct workings even when the final answer given is incorrect.

A Periodic Table is printed on page 20.

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Answer **all** questions.

1. Different techniques can be used to monitor the quality of water.

(a) Good river water quality is needed to support fish, vegetation, wetlands and birds.

The table below shows the results of tests carried out by students on two compounds, **A** and **B**, found in river water. The compounds were known to contain four of the following ions:

- sulfate
- calcium
- carbonate
- sodium
- chloride
- potassium
- iodide

Compound	Test used to identify positive ion		Test used to identify negative ion	
	Test using solid	Result	Test using solution	Result
A	Flame test	Lilac flame	Add dilute nitric acid followed by silver nitrate solution.	Yellow precipitate
B	Flame test	Brick red flame	Add dilute hydrochloric acid. Bubble gas through limewater.	Fizzing and limewater turns milky

Use the information in the table above to identify compounds **A** and **B**. [4]

Compound **A**: .....

Compound **B**: .....

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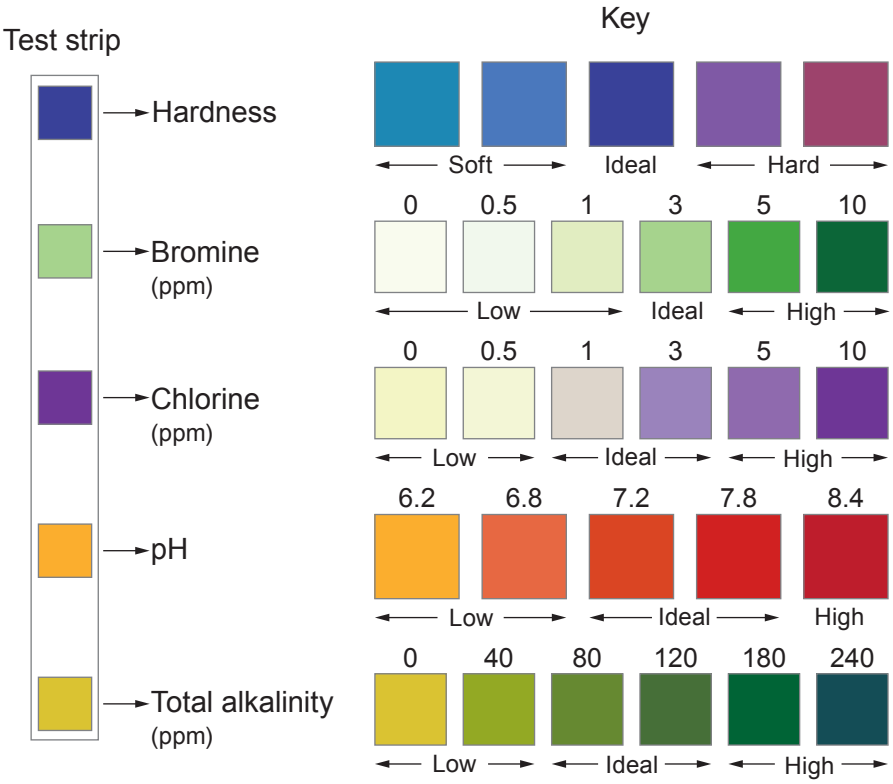
(b) Colour test strips can also be used to identify pollutants in water. They can also provide other information.

Ideal water quality in swimming pools and hot tubs is essential to prevent harm to people using them.

The colour test strip below has been produced from a swimming pool water sample. It is alongside a key.



One opinion suggests that it is safe for people to use the pool. Use the information above to explain whether you agree. [3]

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Turn over.

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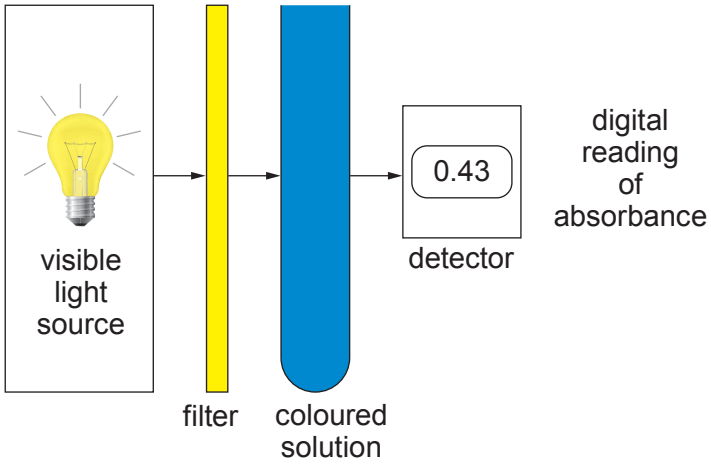
(c) Colorimetry is a method of determining the concentration of a substance in a solution by measuring the absorption of light. The instrument which is used to make these measurements is called a colorimeter. The diagram below shows how a colorimeter works.



Light is passed through a filter to select the most appropriate wavelength of light, some of which is then absorbed by the solution. The amount of light absorbed is measured and is called the absorbance.

A calibration graph using known concentrations of the tested solution is produced. The results of a calibration test using copper sulfate solutions of known concentrations are shown below.

Concentration (mol / dm^3)	Absorbance (units)
0.00	0.00
0.01	0.11
0.02	0.22
0.05	0.55
0.06	0.66
0.08	0.88

(i) Use the data to plot a graph on the grid opposite and draw a suitable line. [4]

(ii) Describe the relationship between absorbance and the concentration of the solution. [2]

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(iii) A copper sulfate solution of unknown concentration was tested in the colorimeter and the absorbance was found to be 0.35 units. Use your graph to find the concentration of the solution. [1]

concentration = ... mol / dm^3

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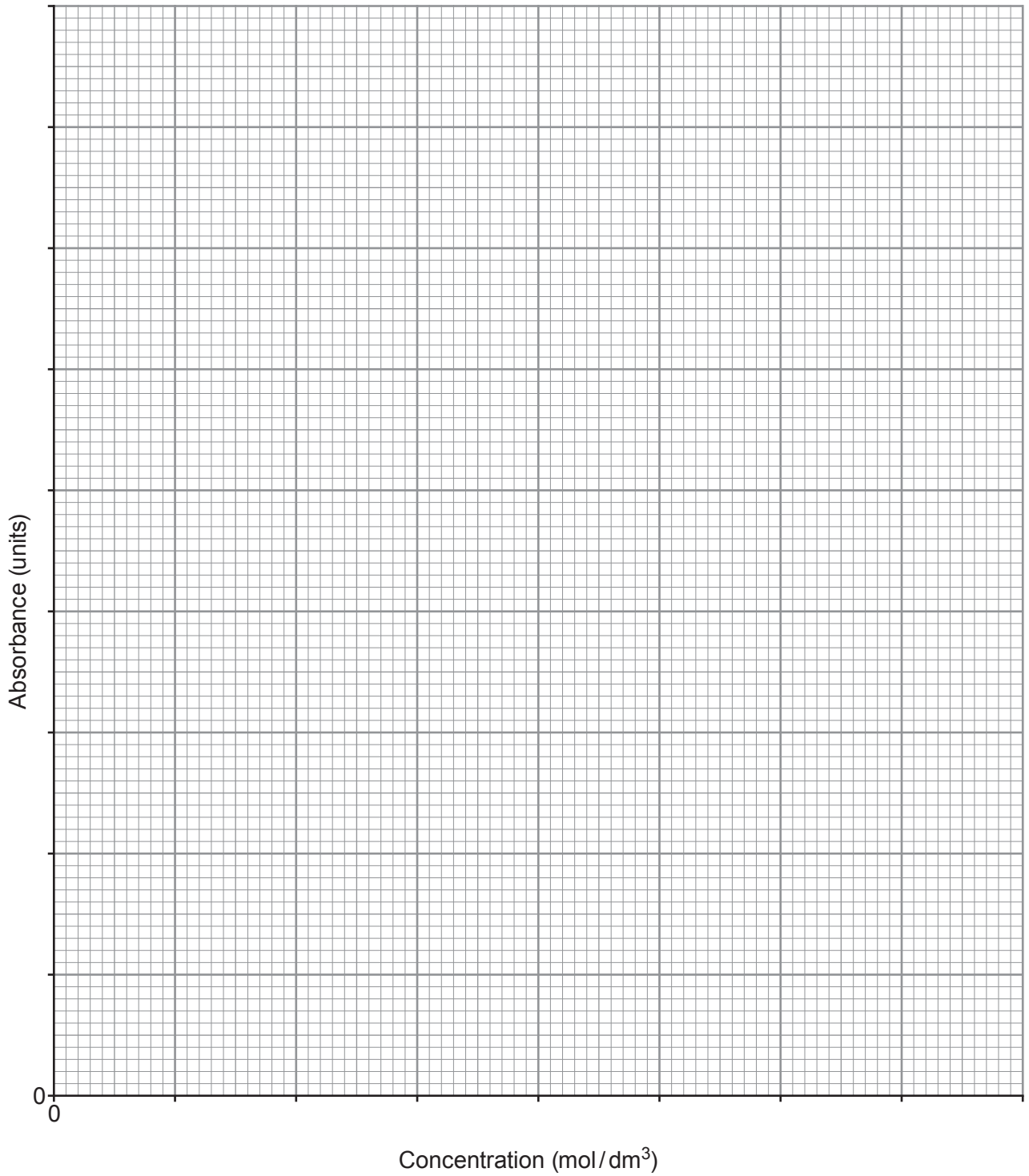

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(iv) The filter used in the colorimeter is chosen to select the band of wavelengths which are most strongly absorbed by the coloured solution. When testing copper sulfate solution a yellow filter is used.

Wavelength band (nm)	Colour of the solution	Colour of the filter
400–435	violet	yellowish-green
435–480	blue	yellow
500–560	green	purple
580–595	yellow	blue
595–610	orange/brown	greenish-blue
610–750	red	bluish-green

I. Iodine dissolved in potassium iodide solution is yellow at low concentrations and brown at higher concentrations. Explain how you would change the experiment to find the unknown concentration of iodine. [3]

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II. Zinc sulfate solution is colourless. Explain whether the concentration of a zinc sulfate solution can be found by using coloured filters. [2]

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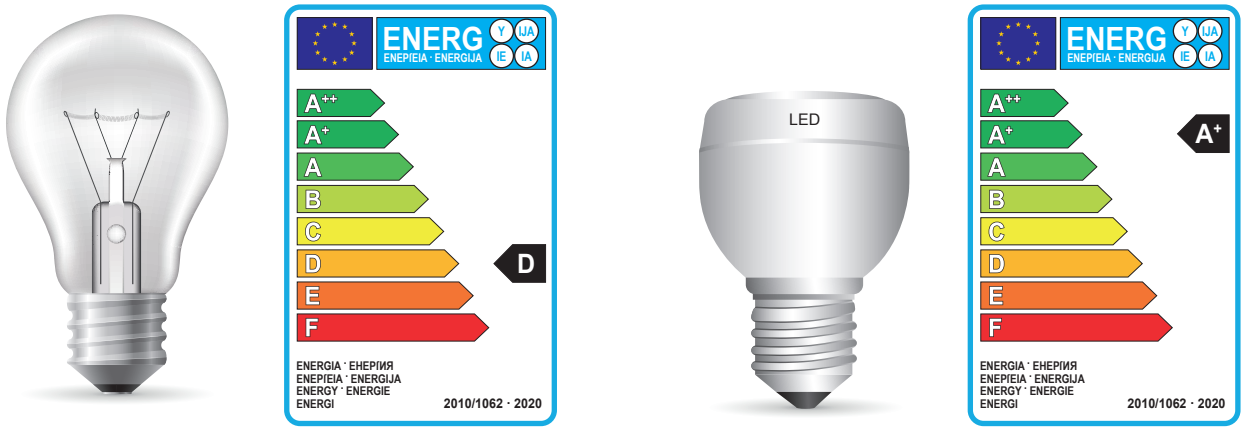
2. Halogen lamps are rated D on energy performance certificates. They are being replaced by LED lamps which are rated A^+ or A^{++}.



(a) A 230 V mains LED lamp operates on a current of 22 mA.

Use the equation

$$\text{power} = \text{voltage} \times \text{current}$$

to calculate the power of the lamp.
$1\,\text{mA} = 10^{-3}\,\text{A}$ [3]

power = ... W

(b) LED lamps have efficiencies of 30%.
The efficiency of halogen lamps is much lower however. A 42 W halogen lamp is only 5% efficient.

Use the equation

$$\%\ \text{efficiency} = \frac{\text{power usefully transferred}}{\text{power supplied}} \times 100$$

to calculate the power usefully transferred by the halogen lamp. [3]

useful power = ... W

6

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3. Energy is expensive so it is important that it is not wasted in homes.

(a) The table below shows the amount of heat energy lost through different parts of a house and how it depends on the temperature in the house. It shows how these values change as improvements are made. The values show how much energy is lost per **minute**.

Part of house	Type of insulation	Cost of insulation (£)	Energy lost per minute at the given house temperature (J/minute)		
			20°C	21°C	22°C
cavity walls	none		39900	43800	47600
	foam filled	1200	12700	14200	17300
windows	single glazed	1400	27700	29600	34800
	double glazed	2600	18800	21500	27900
loft	none		49700	58100	61300
	fibre glass	700	14300	15600	17500

Use the data in the table to answer the following questions.

(i) An advertising campaign claims that homeowners can save money and help the environment if they reduce the temperature inside their homes by 1°C. Explain whether you agree with these claims. [3]

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(ii) A homeowner spends money on installing loft insulation and cavity wall insulation. Previously, neither were present. Using the figures in the table, find the heat energy savings achieved each **second**, after these changes are made, if the homeowner maintains a temperature of 21°C in the home. [3]

heat energy savings = ... J/s

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(iii) Use your answer to part (a)(ii) to calculate the power saving to the home in kW. [1]

power saving = ... kW

(b) A different homeowner insulates their house at a cost of £2400. They use a 32 kW gas central heating system.
Before the insulation was installed the gas system operated for 4 hours a day.
Afterwards, it operated for 3.5 hours a day.

(i) Use the equations:

units used (kWh) = power (kW) × time (h)

cost = units used × cost per unit

to calculate the money saved each **week** on the gas bill in **pence** after installing the insulation. [4]

(1 unit of gas costs 12 p)

saving each week = ... p

(ii) Using the weekly saving you have found in part (b)(i), calculate how many weeks it would take to pay back the cost of the insulation for this house. [2]

payback time = ... weeks

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4. Welsh Water has responsibility for providing water supplies to 1.4 million homes and businesses in Wales. It also runs 838 sewage treatment works.

(a) (i) Describe the causes of hardness in water and distinguish between hard and soft water by

- their action with soap
- their effect on the hot water system in a house. [6 QER]

(ii) Explain **one** health benefit of drinking hard water. [2]

Examiner only

(iii) State the advantages and disadvantages of using ion exchange to soften water. [3]

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(b) Explain why ozone is added during water treatment. [2]

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(c) Explain the role of microbes in the treatment of sewage. [2]

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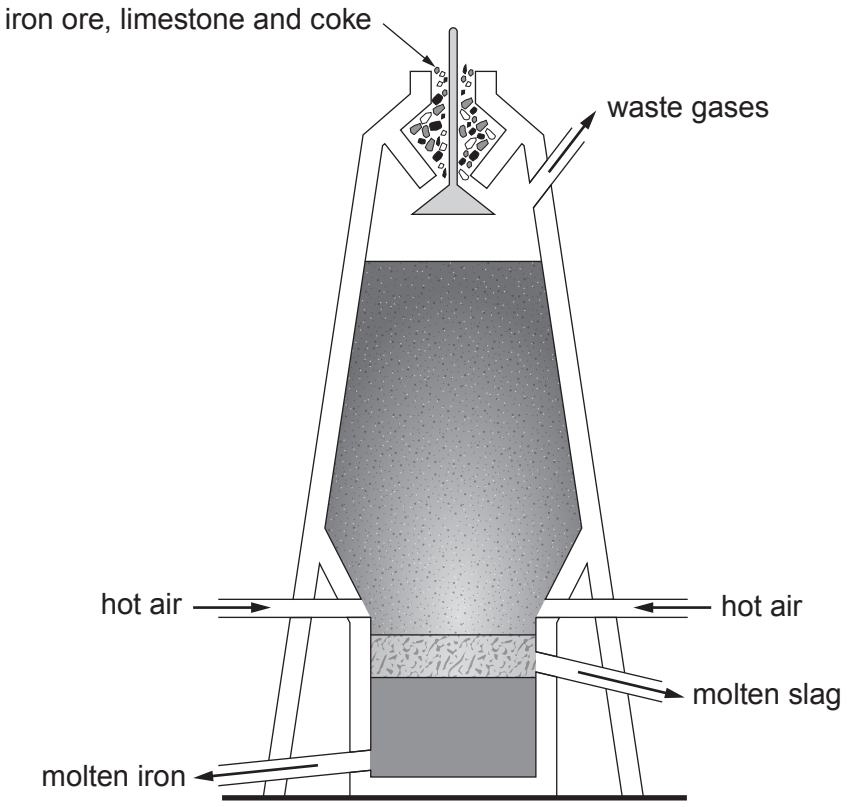
5. Iron is extracted from its ore in a blast furnace.



(a) The word equation shows the reaction that forms iron.

iron(III) oxide + carbon monoxide ⟶ iron + carbon dioxide

Complete the balanced symbol equation for this reaction. [3]

Fe_2O_3 + ... ⟶ ..... + ...

(b) Explain why the lifetime of iron garden furniture is limited. [2]

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Examiner only

(c) State the factors that make the production of iron from its ore so expensive. [3]

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8

Examiner only

6. The Sun emits all of the different kinds of electromagnetic (em) radiation, but 99% of its energy is emitted in the form of visible light, ultraviolet light, and infrared rays.

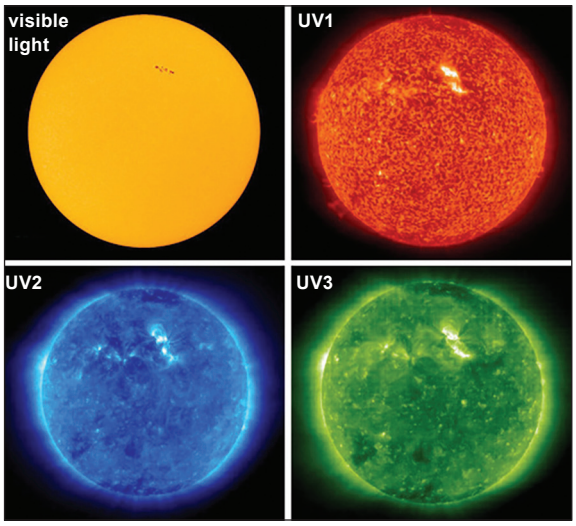
(a) All em waves transfer energy. The table below shows energy values in an **incorrect order**. Arrange the energy values in the **correct order**. [2]

Region	Energy (J) in **incorrect order**	Energy (J) in **correct order**
radio	$> 2 \times 10^{-14}$	.....
microwave	3×10^{-19} to 5×10^{-19}	.....
visible	2×10^{-17} to 2×10^{-14}	.....
X-ray	2×10^{-24} to 2×10^{-22}	.....
gamma ray	$< 2 \times 10^{-24}$	.....

(b) Photographs of the Sun are shown below. One is a visible light image and the others are ultraviolet (UV) images.

The wavelengths used to take the UV images are as follows:

UV1 = 30.4 nm
UV2 = 25.3 nm
UV3 = 19.5 nm



(i) State which image is taken with the lowest frequency UV light. [1]

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(ii) Use the equation

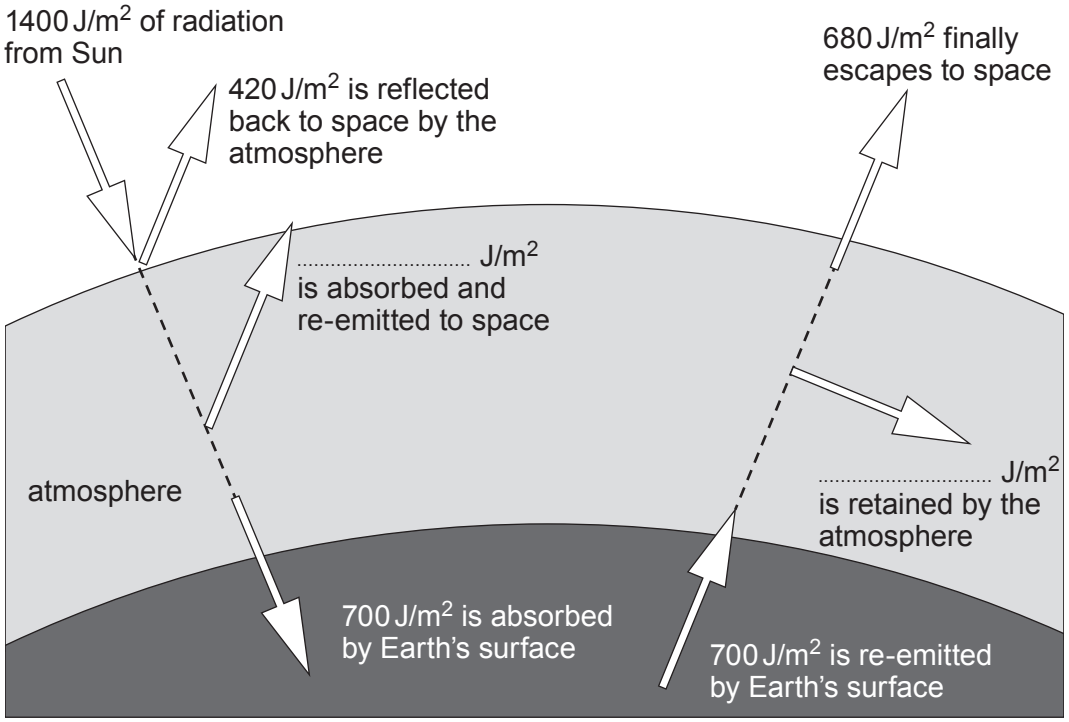
wave speed = frequency × wavelength

to calculate the frequency used to take the lowest frequency UV image opposite and state the unit. [4]

(Speed of em waves in space = 3×10^8 m/s; 1 nm = 10^{-9} m)

frequency = ... unit .....

(c) Some of the energy from the Sun strikes the Earth. The diagram shows what happens to the energy falling on each m^2 every second at one particular time.



(i) **Complete** the diagram by filling in the missing energy values. [2]

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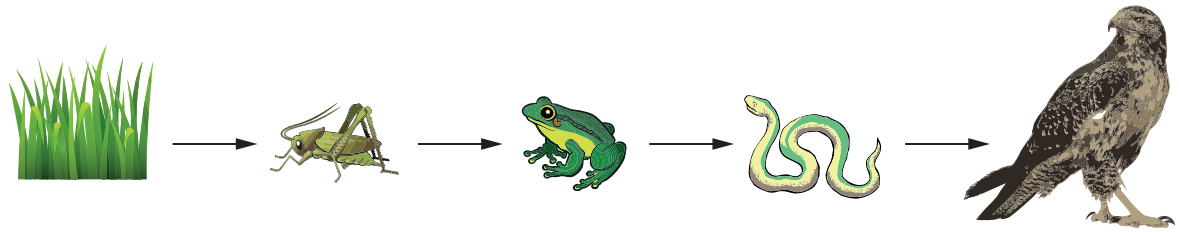
(ii) Radiation from the Sun is the source of energy for most ecosystems.



Producer | Primary consumer | Secondary consumer | Tertiary consumer | Top consumer

Explain how this energy is captured in the food chain shown and why there is a loss of energy at each stage of the chain. [3]

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(iii) As each consumer is killed by its predator for food, uneaten parts will decay releasing nitrates into the soil.
Explain how plants use the nitrates in the soil. [2]

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END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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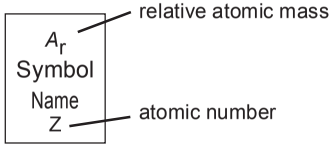
THE PERIODIC TABLE

Group 1	2											3	4	5	6	7	0
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key



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