OCR
Oxford Cambridge and RSA

Wednesday 8 June 2022 – Morning

Level 3 Cambridge Technical in Applied Science

05848/05849/05874 Unit 3: Scientific analysis and reporting

Time allowed: 2 hours
C342/2206

You must have:
- a ruler (cm/mm)

You can use:
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink.

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- The Periodic Table is on the back page.
- This document has **32** pages.

ADVICE
- Read each question carefully before you start your answer.

FOR EXAMINER USE ONLY	
Question No	**Mark**
1	/17
2	/13
3	/19
4	/15
5	/11
6	/15
7	/10
Total	**/100**

Answer **all** the questions.

1 Jamila is investigating the movement of a mass on the end of a chain of springs.

She attaches one end of the chain of springs to a hook on the ceiling and the other end to the hook of a mass hanger.

The arrangement of the apparatus is shown in **Fig. 1.1**.

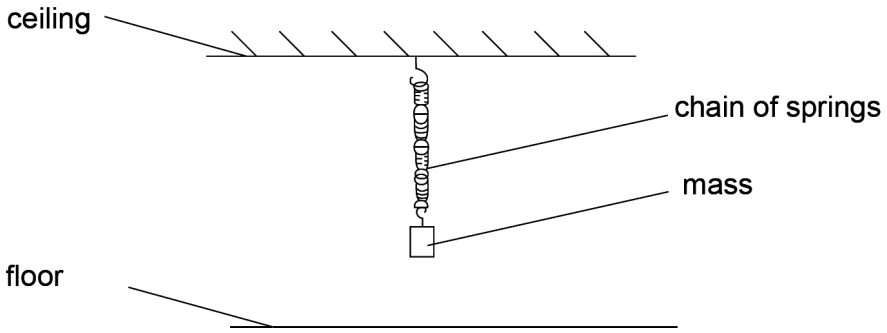

Fig. 1.1

- Jamila pulls the mass down to the floor.
- She then releases the mass and starts a stopwatch.
- She stops the stopwatch when the mass returns to its starting position.

(a) In her first experiment, she uses a 600 g mass and carries out a total of nine repeats.

Her results are shown in **Table 1.1**.

Repeats	1	2	3	4	5	6	7	8	9
Time (s)	2.45	2.43	2.22	2.62	2.58	2.69	2.54	2.45	2.64

Table 1.1

(i) Jamila analyses her data using some calculations.

Draw straight lines to link each type of **analysis** to the correct **result** of the analysis.

There is one **result** you do not need to use.

Analysis	**Result**
mean	2.54
median	2.51
mode	0.235
range	2.45
	2.22 to 2.69

[4]

(ii) The stopwatch can be read to the nearest ± 0.10 s. Jamila estimates that her reaction time between starting and stopping the stopwatch is about 0.2 s.

Identify:

- the type of error in the stopwatch reading

.....

- the type of error due to Jamila's reaction time.

.....

[2]

(iii) Calculate the total error in Jamila's readings and use this value to estimate the percentage uncertainty in Jamila's lowest reading from **Table 1.1**.

Total error = ...

Percentage uncertainty =.....

[2]

(b) Jamila then repeats the experiment. She keeps the number of springs in the chain constant and varies the mass. Her results are shown in **Table 1.2**.

Mass (g)	550	350
Average time (s)	2.27	2.15

Table 1.2

One of Jamila's friends suggests that the time, t, might be directly proportional to the mass, m.

This would mean that t = *k* m where *k* is a constant.

Jamila decides to test out her friend's theory using the data in **Table 1.2**.

(i) Use the data in **Table 1.2** to calculate two values of *k*. Give your answers to a suitable number of significant figures

Value of *k* when m is 550 g = ...

Value of *k* when m is 350 g = ...

[2]

(ii) Explain the number of significant figures you have given in your values of *k*.

.....

..... **[1]**

(iii) Determine the percentage difference in the two values of k calculated in **(b)(i)**.

Use the equation:

$$\text{percentage difference} = \frac{(k_2 - k_1) \times 100}{k_{ave}}$$

where k_2 is the value of k when m is 350 g and k_1 is the value of k when m is 550 g. k_{ave} is the average of these two k values.

Show your working.

Percentage difference = ……..……..... % **[2]**

(c) Jamila writes a conclusion in her laboratory notebook.

The suggested relationship t = km is **not** supported by the evidence.

Discuss whether Jamila's conclusion is correct by comparing your answers to **(a)(iii)** and **(b)(iii)**.

.....

.....

.....

..... **[2]**

(d) Jamila repeats her analysis. She uses a different value from **Table 1.1** for her calculation in **(a)(iii)** to compare with her calculation in **(b)(iii)**.

Explain why using any other value from **Table 1.1** means that Jamila can be even more confident that her conclusion in **(c)** is correct.

.....

.....

..... **[2]**

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Turn over for the next question

2 Leo is a science student.

He is studying the rate of reaction between nitric acid and sodium thiosulfate solution.

Leo wants to find out how the concentration of sodium thiosulfate affects the rate of reaction.

- He marks an **'X'** on a piece of paper and places a flask containing 10 cm^3 of nitric acid on top of the **'X'**.
- He adds 10 cm^3 of sodium thiosulfate solution, swirls the flask and immediately starts a stopwatch. Sulfur is produced causing the mixture to become cloudy.
- Leo stops the stopwatch when he can no longer see the cross.

The experiment is shown in **Fig. 2.1**.

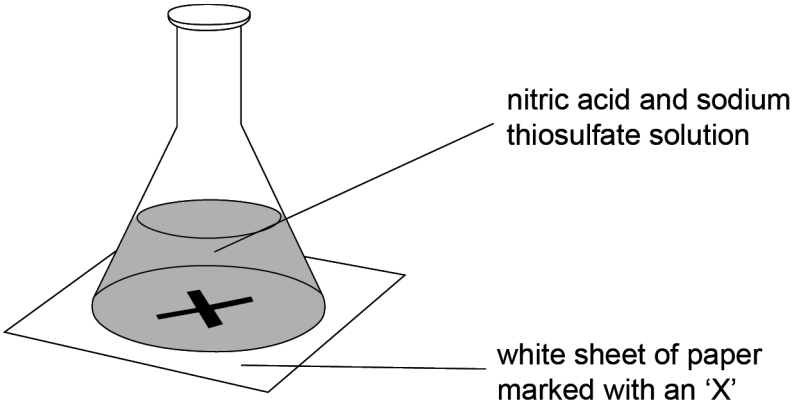


Fig. 2.1

- Leo repeats the experiment using different concentrations of sodium thiosulfate.
- For each concentration he times how long it takes for the cross to be obscured.

His results are shown in **Table 2.1**.

Experiment	Concentration of sodium thiosulfate (%)	Time taken to obscure the cross, t (s)	Relative rate, 1/t (s^{-1})
A	50	16	
B	40	21	
C	30	33	
D	20	39	
E	10	91	

Table 2.1

(a) The relative rate is equal to 1/t.

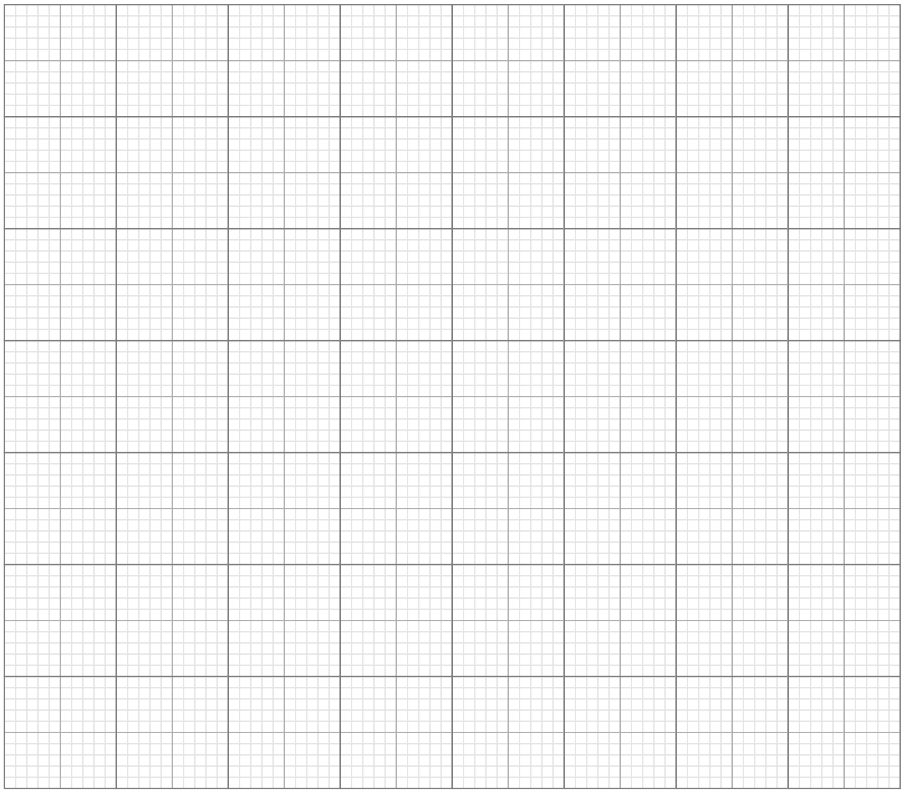
Complete **Table 2.1** by calculating the relative rates of reaction for each of the experiments.

Give your answers to **2** significant figures.

[2]

(b) **(i)** On the grid below plot a graph of relative rate (vertical axis) against % concentration (horizontal axis).

- Start your graph at the origin on both axes and label the axes.
- Draw the straight line of best fit.



[2]

(ii) Draw a circle around the anomalous result. **[1]**

(iii) Determine the gradient of the line of best fit.

Show your working.

Gradient = ……..……..... **[2]**

(c) Leo repeats the experiment using a serial dilution of sodium thiosulfate.

He puts 27 cm^3 of water in four test-tubes. He adds 3 cm^3 of the original sodium thiosulfate solution to test-tube A.

He then takes 3 cm^3 of the solution from test-tube A , adds it to test-tube B and mixes the solution. Then, he takes 3 cm^3 of the solution from B, adds it to test-tube C and mixes the solution. He repeats this procedure from C to D.

The serial dilution is shown in **Fig. 2.2**.

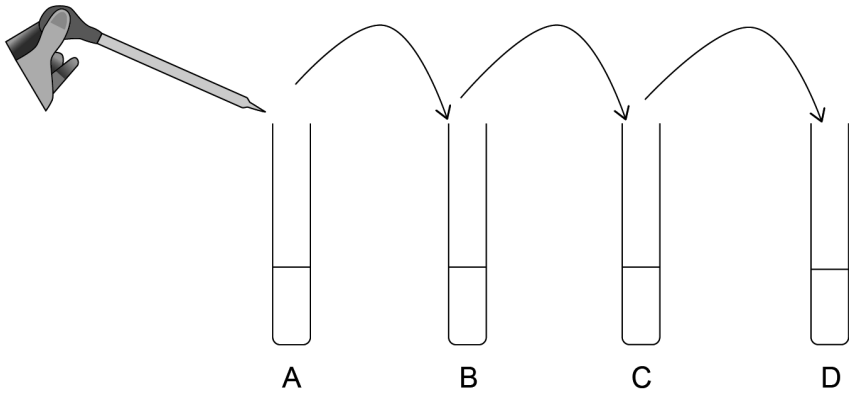


Fig. 2.2

(i) Calculate the dilution factor of the sodium thiosulfate in test-tube A.

Give your answer as a fraction.

Dilution factor = …….……..... **[1]**

(ii) The initial concentration of the sodium thiosulfate solution is 0.15 g cm^{-3}.

Calculate the concentration of sodium thiosulfate in test-tube D.

Give your answer in standard form.

Concentration = …….……..... g cm^{-3} **[2]**

(d) (i) The equation for the reaction between sodium thiosulfate, $Na_2S_2O_3$, and nitric acid, HNO_3 is shown below.

$$Na_2S_2O_3 + 2HNO_3 \rightarrow Na_2SO_4 + S + 2NO_2 + H_2O$$

The relative molecular mass of sodium thiosulfate is 158.2, and the relative atomic mass of sulfur is 32.1.

Calculate the expected mass of sulfur produced when 3.17 g of sodium thiosulfate reacts with nitric acid.

Expected mass of sulfur = ……..……..... g **[2]**

(ii) The actual mass of sulfur produced was 0.463 g.

Calculate the % yield of sulfur using the equation:

$$\% \text{ yield} = \frac{\text{actual mass of product} \times 100}{\text{expected amount of product}}$$

% yield of sulfur = ……..……..... % **[1]**

3 Emma is trying to find ways of reducing air pollution around schools and shops in the city where she lives.

- She gathers data on the amount of time that the engine of a bus spends at different engine speeds on its route around the city. Engine speed is not the same as the speed of the bus.
- When the bus is stationary, with the engine on, the engine speed is at 15 % of its maximum speed and it is said to be idling.
- Idling is bad for the environment because although it does not use much fuel, the fuel that it uses does not combust completely and this causes air pollution.
- Emma's aim is to recommend 'no idling zones' around schools and busy shopping areas.

Emma presents her data for bus route **1** in the chart shown in **Fig. 3.1**.

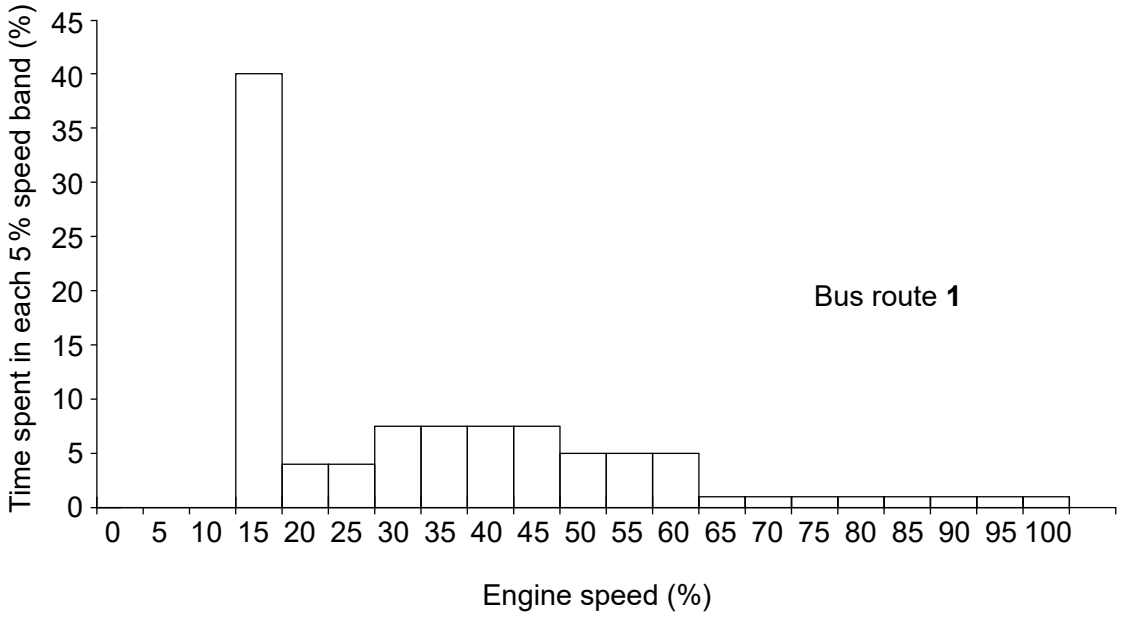


Fig. 3.1

(a) Complete the following sentences using the % values or words/phrases from the list.

Each % value or word/phrase may be used once, more than once, or not at all.

5%	**15%**	**20%**	**30%**	**40%**	**45%**	**60%**	**100%**

bar graph	**continuous**	**discontinuous**	**histogram**

The type of chart shown is a ……..... .

The data is ……..... and has a bin width of

……..... .

The percentage of time spent idling is ……..... .

For approximately 30% of the time the speed of the engine is between

……..... and ……..... .

[5]

(b) Emma repeats her investigation on a different bus route, bus route **2**.

She presents her data in a new chart shown in **Fig. 3.2**.

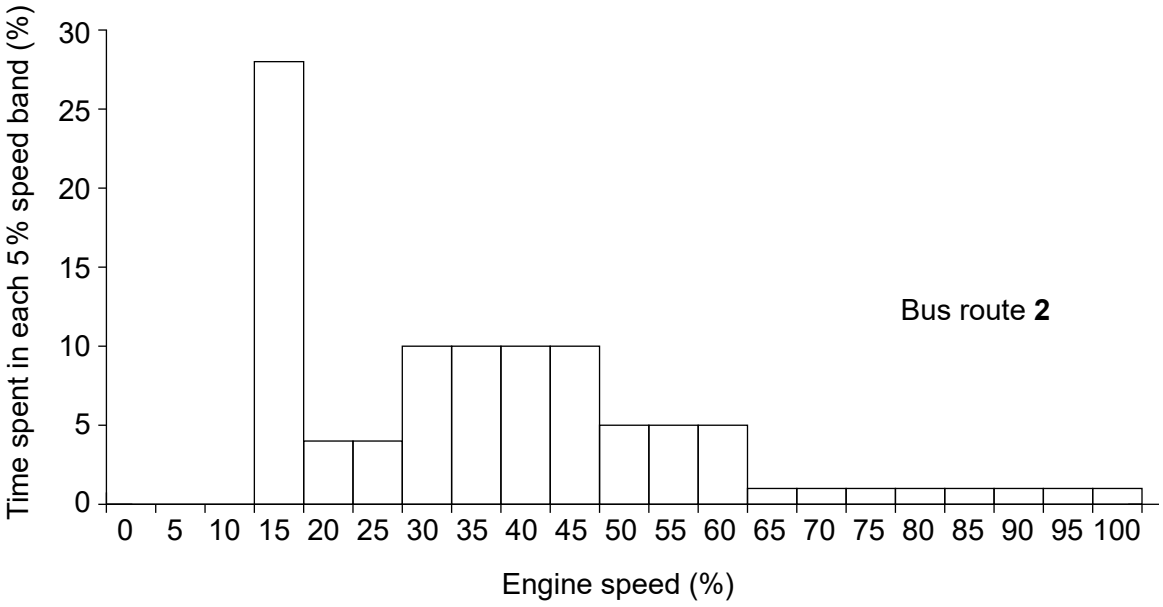


Fig. 3.2

Emma compares both charts and writes a conclusion in her report

'Bus route 1 creates greater pollution than bus route 2.'

Discuss why the data in **Figs 3.1** and **3.2** does **not** support Emma's conclusion and suggest further evidence that would make her conclusion more secure.

.....

.....

.....

.....

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.....

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.....

.....

..... **[6]**

(c) The engine speed is shown by the tachometer or rev counter on the dashboard of a bus. When the engine is switched off the rev counter should be zero.

Fig. 3.3 shows the rev counter from a bus on route **3** when the engine is switched off.

Emma reads this value as 250 RPM.

Fig. 3.3

(i) Identify the type of error shown in **Fig. 3.3**.

..... **[1]**

(ii) The rev counter should be 1200 RPM when the bus is idling. This is 15 % of the maximum engine speed of 8000 RPM.

Discuss how the error indicated in **Fig. 3.3** might affect Emma's conclusions about bus route **3** when the data is presented in a graph.

You may use a calculation to support your answer.

.....

.....

.....

.....

..... **[2]**

(d) Emma needs to determine which elements of her data collecting were repeatable and which were reproducible.

Complete **Table 3.1** by placing **one** tick (✓) in each row.

	Repeatable	**Reproducible**
Same observer		
Different routes		
Same measuring instrument		
Same measurement procedure		
Different buses		

Table 3.1

[5]

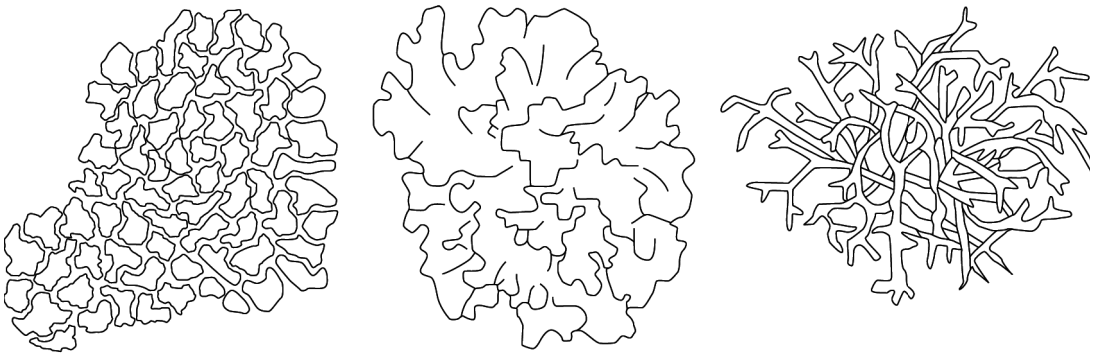
4 Kareem is examining the distribution of lichens in an ecosystem.

- Lichens can often look like plants, growing on bricks, rocks and tree trunks.
- However, they are a complex association between an algae and a fungus.
- The main body of the lichen is called the thallus.
- Lichens are especially sensitive to air polluted with sulfur dioxide (SO_2).
- They die if SO_2 levels in air are too high.

Kareem wants to find out if reductions in SO_2 levels in air have led to a recovery in lichen populations.

There are three main kinds of lichen, characterised by their general habit of growth as shown in the drawings in **Fig. 4.1**.

Lichens are also characterised by the way they are attached to the object on which they grow.



A **B** **C**

Fig. 4.1

(a) Identify lichens **A**, **B** and **C** from the following descriptions:

(i) Fruticose: thallus (body) is either erect and bushy or pendent (hanging down) and tassel-like.

Lichen ..... **[1]**

(ii) Foliose: thallus creeps horizontally and is like a leaf or scale, or more usually a system of numerous leaves and scales.

Lichen ..... **[1]**

(iii) Crustose: thallus is like a crust and lacks distinct lobes but is divided up into tiny, irregular-shaped areas.

Lichen ..... **[1]**

(b) Kareem takes a photograph of a grey reindeer lichen as shown in **Fig. 4.2**.

Fig. 4.2

(i) State the type of data shown in **Figs 4.1** and **4.2**.

Fig. 4.1 .....

Fig. 4.2 .....

[1]

(ii) Give **three** pieces of evidence in **Fig. 4.2** which show that Kareem's photograph is fit for purpose.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

(c) Kareem investigates the possibility of designing a dichotomous key to identify lichen species.

He starts by reading the descriptions of three lichen species.

Species 1 … is common on hard siliceous rocks in upland areas. It has rather a thick, yellowish grey, warted and cracked thallus.The chemical reaction test with potassium hydroxide solution is positive with a yellow result.

Species 2 … is an eastern and lowland species. It grows on the bark of old trees. The thallus does not creep close to the substratum but has an ascending sometimes arching habit. When dried it varies in colour from whitish to brownish grey; when wet it is greenish. Increasingly rare due to atmospheric pollution.

Species 3 … grows in a variety of habitats from moorlands to logs and tree bases in damp woods. The chemical reaction tests with potassium hydroxide and para-phenylenediamine (PD) are negative but in one subspecies the potassium hydroxide test is positive with a yellow result and the PD test is also positive with an orange result.

(i) Use these descriptions to identify the features that Kareem could use to design his key.

Complete the table.

The first feature has been done for you.

Number	Feature
1	The type of substratum it grows on (such as rocks, trees or logs).
2	
3	
4	
5	
6	
7	

[6]

(ii) Explain **one** advantage and **one** disadvantage of using species 2 as an indicator species.

Advantage .....

.....

Disadvantage .....

.....

[2]

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Turn over for the next question

5 Sara is a food scientist working in a nutrition laboratory.

She is researching the impact of recent legislation to reduce the amount of sugar in processed food.

Sara studies the chart shown in **Fig. 5.1** to understand how glucose in the blood varies in normal, pre-diabetic and diabetic patients after they have eaten a meal.

'Normal' means blood glucose levels are within normal range.

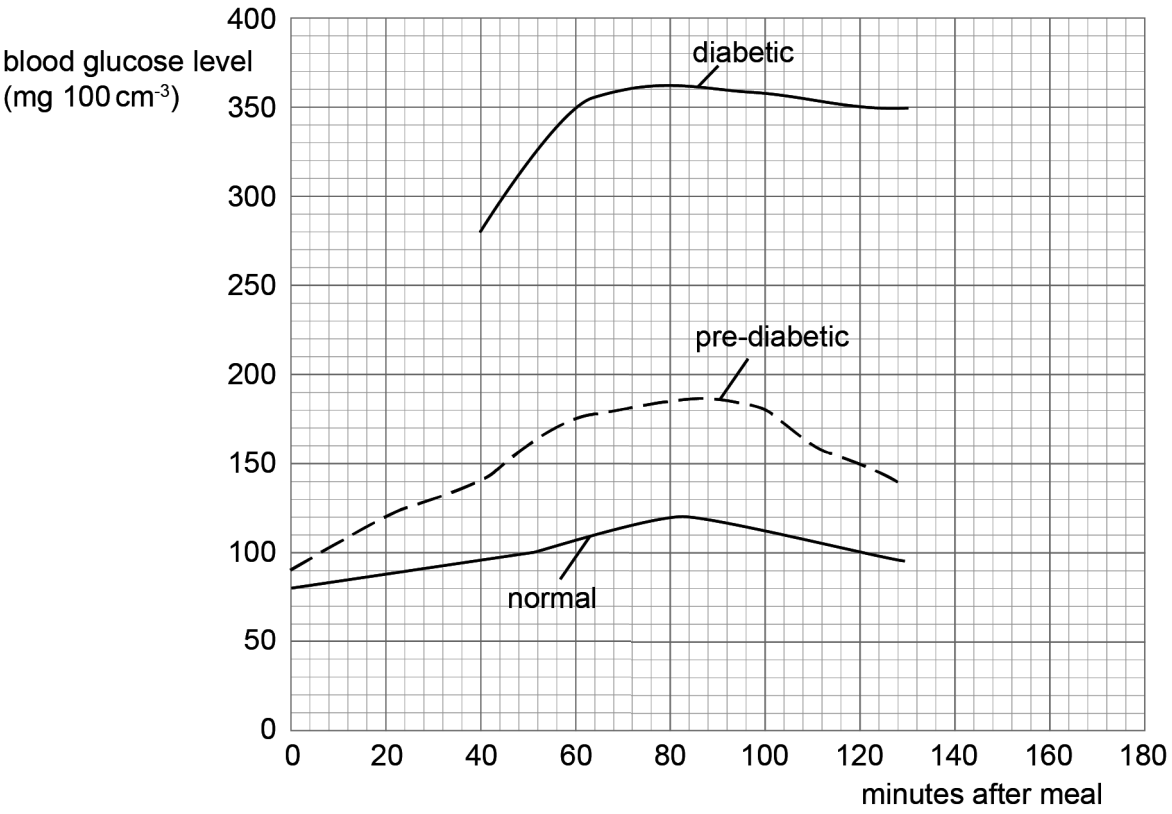

Fig. 5.1

(a) Thirty minutes after the meal the blood glucose level of the diabetic patient is in the range 210 to 270 mg 100 cm^{-3}

On **Fig. 5.1**:

(i) Draw the range bar of the blood sugar level for diabetic patients at 30 minutes.

[1]

(ii) Show how to determine the y-intercept of the diabetic patient graph and record the value.

y-intercept = …….……..... **[2]**

(b) Describe **four** trends shown in **Fig. 5.1**.

1 .....

.....

2 .....

.....

3 .....

.....

4 .....

.....

[4]

(c) Sara studies a Public Health England report on a sugar reduction programme which aimed to reduce the average sugar content of food products and individual food categories by 20 % by the year 2020.

The chart in **Fig. 5.2** shows the change in sugar content over the period from 2015 to 2018 by category of food.

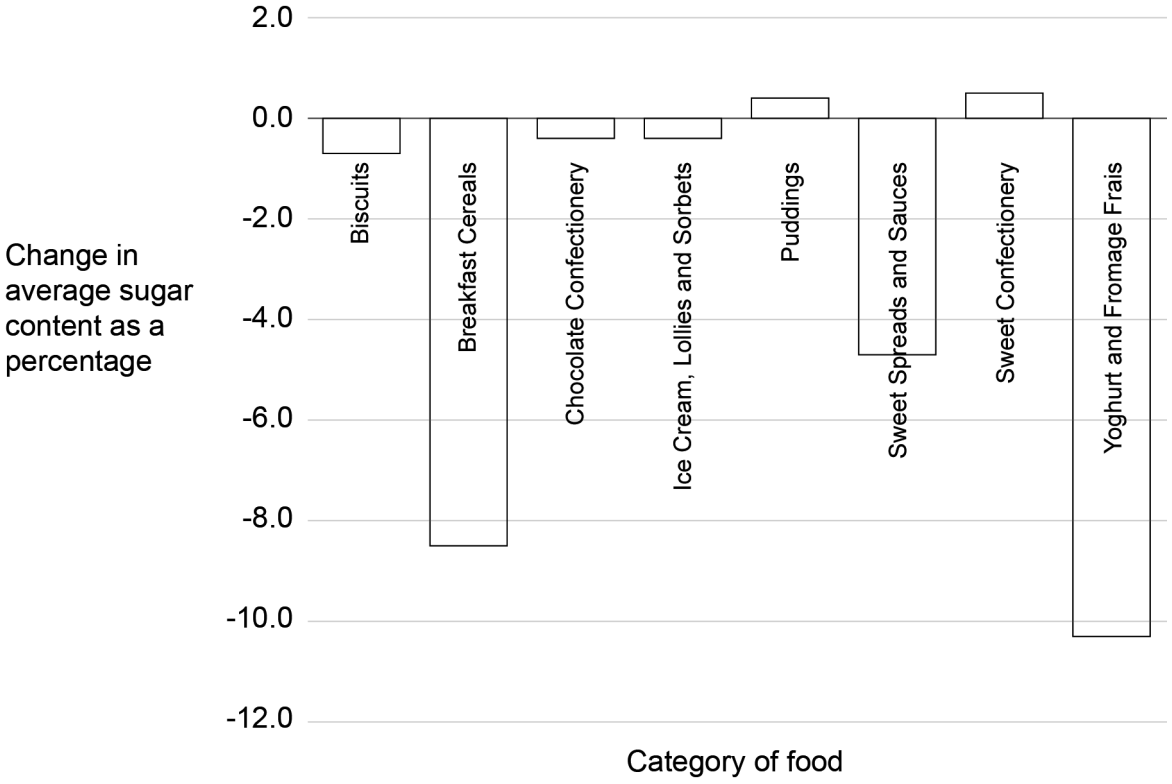

Fig. 5.2

(i) State and explain the type of data presentation in **Fig. 5.2**.

.....

.....

..... **[2]**

(ii) **Fig. 5.2** shows that the recipes used to make many food products have been changed to **reduce** the amount of sugar they contain.

Sara reads a section of the sugar reduction programme report which summarises the main findings.

One paragraph in the report states:

'Overall, the total tonnes of sugar sold in food included in the programme has increased by 2.6 % between 2015 and 2018.'

Which of the following conclusions might explain this conflicting evidence?

Tick (✓) **two** boxes.

biscuit sales have fallen	☐
people are eating less suger	☐
puddings contain large amounts of sugar	☐
some products are more easily reformulated to contain less sugar	☐
some product ranges are not included in the report	☐
yoghurt is sold as a health food	☐

[2]

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6 A sequence of seven steps is often required to make permanent microscope slides.

Fig. 6.1 shows the first four steps in order.

(a) (i) Draw straight lines to link each step to its correct function.

Step	Function
1. Killing	Removes all traces of water to allow further processing
2. Fixing and hardening	Colours parts of the specimen for clear differentiation of structures
3. Staining	Makes the tissue ready for subsequent processing and able to take up stains
4. Dehydration	Instantaneous stoppage of processes to stop post-mortem changes

Fig. 6.1

[3]

(ii) Describe **one other** step involved in the preparation of permanent microscope slides.

..... **[1]**

(b) The process of staining can be used in many different ways.

Complete the sentences using the correct words or phrases from this list:

fluorescence **emittance** **viability** **transparency** **dead**
living **fully repaired** **colour** **frozen**

1. Some stains can absorb light of one wavelength and then emit light of a longer wavelength. The stained cells and tissues are seen to be much brighter and appear to glow. This is feature is known as ……..... .
2. Stains that are actively transported out of cells can be used to show cell ……..... .
3. Fixed cells are …… .

[3]

(c) List **three** disadvantages of preparing permanent microscope slides.

1 .....

2 .....

3 .....

[3]

(d) **(i)** Stains can also be used in culture media to identify colonies of bacteria.

Put a tick (✓) in the box next to the correct term for this kind of media.

Selective media	
Nutrient agar	
Differential media	
Minimal media	

[1]

(ii) Another technique used to identify bacteria and other microorganisms is colony morphology.

Fig. 6.2 shows an agar plate which has been used to culture bacteria collected from the surface of human skin.

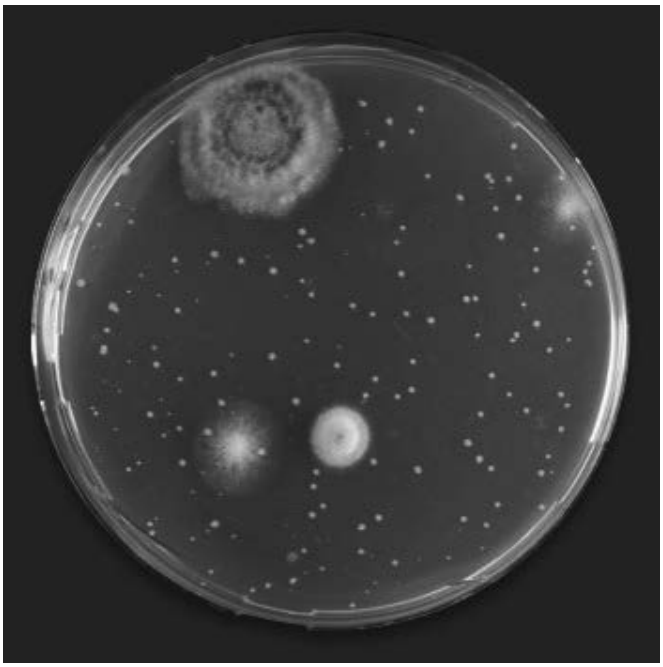


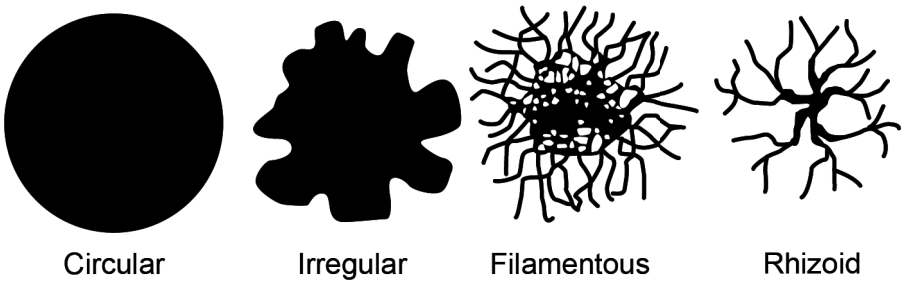
Fig. 6.2

State how many different types of microorganism are growing on the plate in **Fig. 6.2**.

..... **[1]**

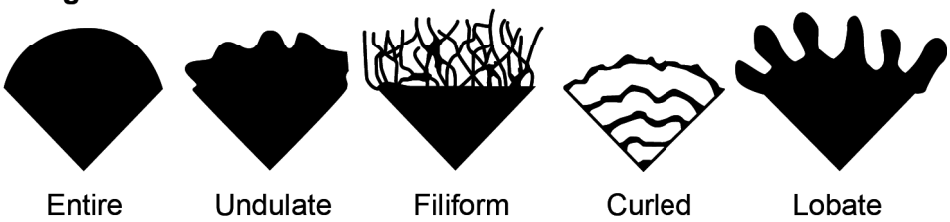
(e) Some images of common colony morphologies are shown below.

Form



Elevation

Margin



(i) Fungi often form colonies that are filamentous with a filiform margin.

State how many different kinds of fungi are seen on the plate in **Fig. 6.2**.

..... **[1]**

(ii) Suggest why it is not possible to identify the elevations of the different colonies of fungi seen in **Fig. 6.2**.

..... **[1]**

(iii) Suggest why it is not possible to identify the margin morphology of the bacterial colonies seen in **Fig. 6.2**.

..... **[1]**

7 Scientists often use photographs to record data and monitor changes on the surface of the earth over time.

Some photographs are taken from satellites.

Fig. 7.1 is a satellite photograph taken of the Larsen ice shelf in Antarctica.

Fig. 7.2 is a photograph taken of the same area several months later.

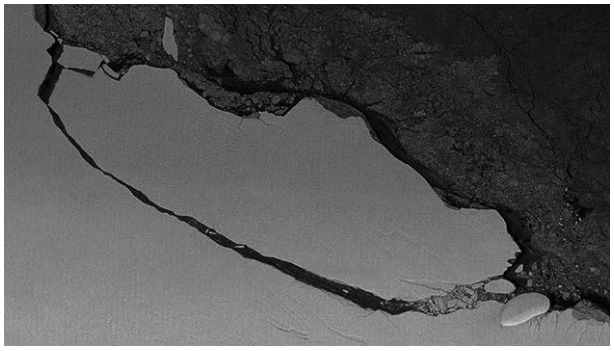


Fig. 7.1

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Fig. 7.2

(a) Use the scale bar in **Fig. 7.2** to estimate the area of the iceberg that has broken off the ice shelf.

Area = ……..…….....km^2 **[1]**

(b) Suggest **two** other pieces of information (in addition to the area of the iceberg) that should be collected with the satellite photographs to confirm what has happened.

1 .....

2 .....

[2]

(c) Suggest **two** advantages that photographs taken from satellites have compared to photographs taken from the Earth.

1 .....

2 .....

[2]

(d) Suggest **two** limitations of using satellites to obtain photographic data.

1 .....

2 .....

[2]

(e) Describe **two** changes, apart from breaking off the ice shelf, that have happened to the iceberg between taking **Figs 7.1** and **7.2**.

1 .....

2 .....

[2]

(f) Data taken from several different sources, including satellite photographs, can be linked together and modelled using GIS.

Put a tick (✓) in the box next to the correct meaning of GIS.

Graphical Information Survey	☐
Geological Implementation Security	☐
General Instrumentation System	☐
Geographical Information System	☐

[1]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown in the margins – for example, 3(b) or 5(c)(i).

The Periodic Table of the Elements

Key
atomic number
Symbol
name
relative atomic mass

(1)	(2)											(3)	(4)	(5)	(6)	(7)	(0)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1 **H** hydrogen 1.0																	2 **He** helium 4.0
3 **Li** lithium 6.9	4 **Be** beryllium 9.0											5 **B** boron 10.8	6 **C** carbon 12.0	7 **N** nitrogen 14.0	8 **O** oxygen 16.0	9 **F** fluorine 19.0	10 **Ne** neon 20.2
11 **Na** sodium 23.0	12 **Mg** magnesium 24.3											13 **Al** aluminium 27.0	14 **Si** silicon 28.1	15 **P** phosphorus 31.0	16 **S** sulfur 32.1	17 **Cl** chlorine 35.5	18 **Ar** argon 39.9
19 **K** potassium 39.1	20 **Ca** calcium 40.1	21 **Sc** scandium 45.0	22 **Ti** titanium 47.9	23 **V** vanadium 50.9	24 **Cr** chromium 52.0	25 **Mn** manganese 54.9	26 **Fe** iron 55.8	27 **Co** cobalt 58.9	28 **Ni** nickel 58.7	29 **Cu** copper 63.5	30 **Zn** zinc 65.4	31 **Ga** gallium 69.7	32 **Ge** germanium 72.6	33 **As** arsenic 74.9	34 **Se** selenium 79.0	35 **Br** bromine 79.9	36 **Kr** krypton 83.8
37 **Rb** rubidium 85.5	38 **Sr** strontium 87.6	39 **Y** yttrium 88.9	40 **Zr** zirconium 91.2	41 **Nb** niobium 92.9	42 **Mo** molybdenum 95.9	43 **Tc** technetium	44 **Ru** ruthenium 101.1	45 **Rh** rhodium 102.9	46 **Pd** palladium 106.4	47 **Ag** silver 107.9	48 **Cd** cadmium 112.4	49 **In** indium 114.8	50 **Sn** tin 118.7	51 **Sb** antimony 121.8	52 **Te** tellurium 127.6	53 **I** iodine 126.9	54 **Xe** xenon 131.3
55 **Cs** caesium 132.9	56 **Ba** barium 137.3	57–71 lanthanoids	72 **Hf** hafnium 178.5	73 **Ta** tantalum 180.9	74 **W** tungsten 183.8	75 **Re** rhenium 186.2	76 **Os** osmium 190.2	77 **Ir** iridium 192.2	78 **Pt** platinum 195.1	79 **Au** gold 197.0	80 **Hg** mercury 200.6	81 **Tl** thallium 204.4	82 **Pb** lead 207.2	83 **Bi** bismuth 209.0	84 **Po** polonium	85 **At** astatine	86 **Rn** radon
87 **Fr** francium	88 **Ra** radium	89–103 actinoids	104 **Rf** rutherfordium	105 **Db** dubnium	106 **Sg** seaborgium	107 **Bh** bohrium	108 **Hs** hassium	109 **Mt** meitnerium	110 **Ds** darmstadtium	111 **Rg** roentgenium	112 **Cn** copernicium		114 **Fl** flerovium		116 **Lv** livermorium		

57 **La** lanthanum 138.9	58 **Ce** cerium 140.1	59 **Pr** praseodymium 140.9	60 **Nd** neodymium 144.2	61 **Pm** promethium 144.9	62 **Sm** samarium 150.4	63 **Eu** europium 152.0	64 **Gd** gadolinium 157.2	65 **Tb** terbium 158.9	66 **Dy** dysprosium 162.5	67 **Ho** holmium 164.9	68 **Er** erbium 167.3	69 **Tm** thulium 168.9	70 **Yb** ytterbium 173.0	71 **Lu** lutetium 175.0
89 **Ac** actinium	90 **Th** thorium 232.0	91 **Pa** protactinium	92 **U** uranium 238.1	93 **Np** neptunium	94 **Pu** plutonium	95 **Am** americium	96 **Cm** curium	97 **Bk** berkelium	98 **Cf** californium	99 **Es** einsteinium	100 **Fm** fermium	101 **Md** mendelevium	102 **No** nobelium	103 **Lr** lawrencium