OCR
Oxford Cambridge and RSA

Monday 5 June 2023 – Afternoon

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C342/2306

C342/I/2306

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

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

0 5 8 4 8 – 0 3

Please write clearly in black ink. **Do not write in the barcodes.**

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.

1 Owls are birds of prey, which means they kill and eat small animals.

Owl pellets contain the undigested parts of their prey, such as bones and fur. The pellets are regurgitated (coughed up) through the owl's beak.

Alex collects samples of owl pellets. She records the mass of each pellet and analyses the bones to identify the species of the owl's prey in each pellet.

The table below shows Alex's data.

Pellet	Mass (g)	Number of different species of prey present
1	25	1
2	130	3
3	64	2
4	94	3
5	71	1
6	75	1
7	82	2
8	63	2
9	100	1
10	45	1

(a) Use the data in the table to:

(i) calculate the mean mass of the pellets.

Mean mass = ……..……..... g **[2]**

(ii) determine the median mass.

Median mass = ……..……..... g **[1]**

(iii) determine the mode of the number of different prey species in one pellet.

Mode = ……..……..... **[1]**

(b) Calculate the variance $\mathbf{s^2}$ and standard deviation **s** of the mass values shown in the table.

Use the equation:

$$s^2 = \frac{\Sigma(X-\overline{X})^2}{N-1}$$

where N is the number of samples, X is the mass of each pellet and $\overline{X}$ is the mean mass calculated in **(a)(i)**.

Show your working.

Give **both** your answers to **3** significant figures.

$\mathbf{s^2}$ = ……..…….....

s = ……..…….....
[6]

(c) Use your answers in **(a)(i)** and **(b)** to determine the percentage of Alex's sample of pellets shown in the table whose mass is within one standard deviation above and below the mean.

Percentage of sample = ……..……..... % **[2]**

(d) Alex suggests that:

"Pellet 1, pellet 6 and pellet 9 in the table could contain the same species of prey."

(i) Explain how the mass of these pellets can be used to support her suggestion.

.....

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

(ii) What **two** further pieces of information should Alex record in her table to make her suggestion more secure?

1 .....

2 .....

[2]

(e) Alex finds the remains of only four different species in the ten pellets sampled.

Almost half of the animal remains come from one species.

Alex also obtains data about the percentage of these species in the habitat.

She finds that the percentage of a prey species found in the pellets is **not** the same as the percentage of this prey species in the habitat.

Suggest **two** reasons, relating to owl hunting behaviour, that would explain why the two values are **not** the same.

1 .....

.....

2 .....

.....

[2]

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Turn over for the next question

2 There are about 2000 species of firefly.

Fireflies are nocturnal members of the family *Lampyridae*.

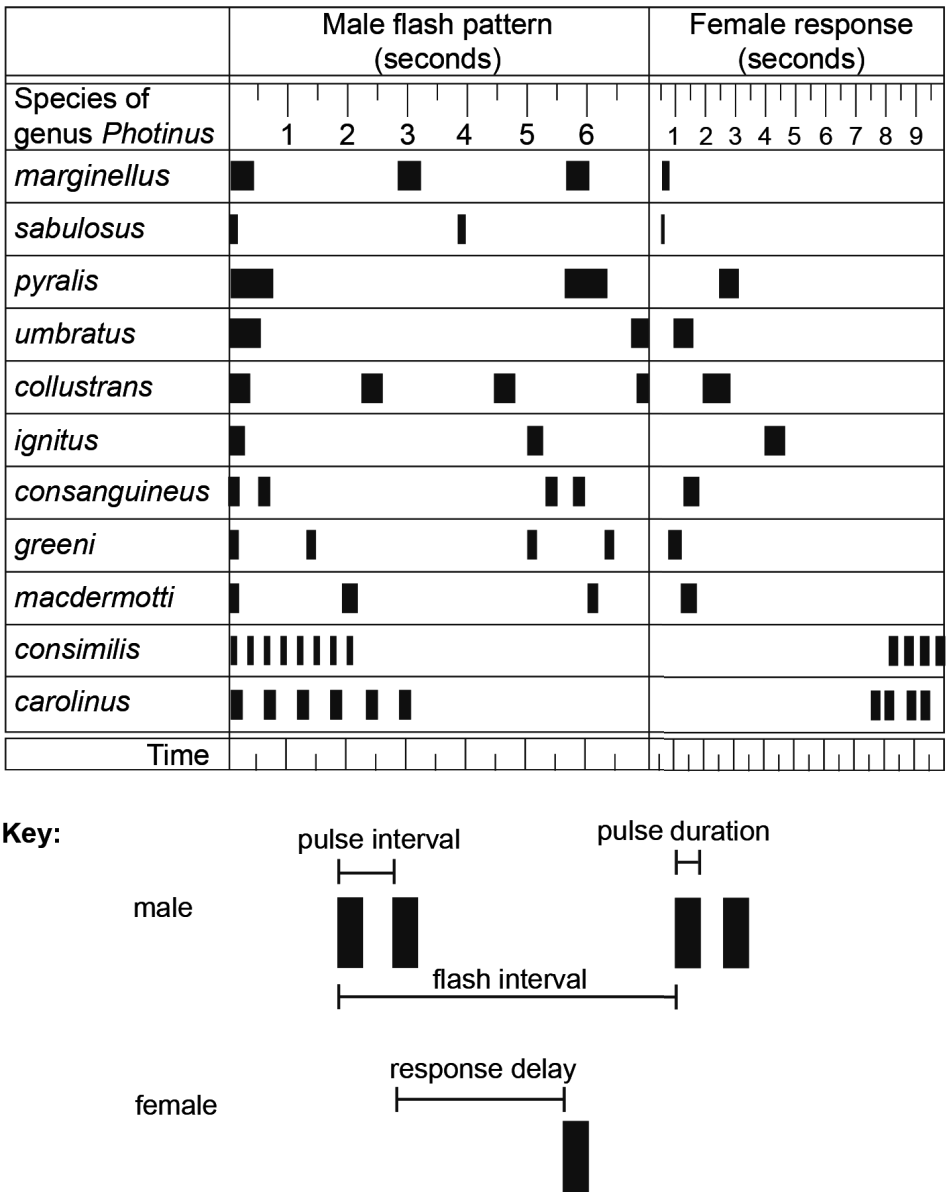
This means that they are active at night and, as the name suggests, they produce flashes of light.

The patterns of flashing light produced by male fireflies and the response patterns shown by the females are unique to each species.

Each pattern is a signal that helps fireflies find potential mates.

Fig. 2.1 shows the male flash patterns and the female response patterns for some of the species of the firefly genus, *Photinus*.

Fig. 2.1



(a) (i) Use the information in **Fig. 2.1** to identify the firefly species with the following **male** flash patterns:

- a 0.75 s pulse duration and 5 s flash interval.

Species = ……..…….....

- a 0.30 s pulse interval.

Species = ……..…….....
[2]

(ii) In terms of the pulse interval, pulse duration and flash interval shown in **Fig. 2.1**, describe the flash pattern of **male** *consanguineus*.

.....

.....

..... **[3]**

(iii) Identify the firefly species with the following **female** response patterns:

- a response delay of 7.5 seconds.

Species = ……..…….....

- a response that mimics the male of the species.

Species = ……..…….....
[2]

(b) (i) Explain why Latin and Ancient Greek are often used in the classification of living things.

.....

.....

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

(ii) Give **one** advantage of binomial nomenclature.

.....

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

(c) **Fig. 2.1** is an example of secondary data.

(i) Give **one** example of primary data.

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

(ii) Some female fireflies have been observed mimicking the response pattern of the females of **other** firefly species.

Explain how scientists should use this observation and the data in **Fig. 2.1** to determine more accurately which species of firefly are present in a habitat.

.....

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

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Turn over for the next question

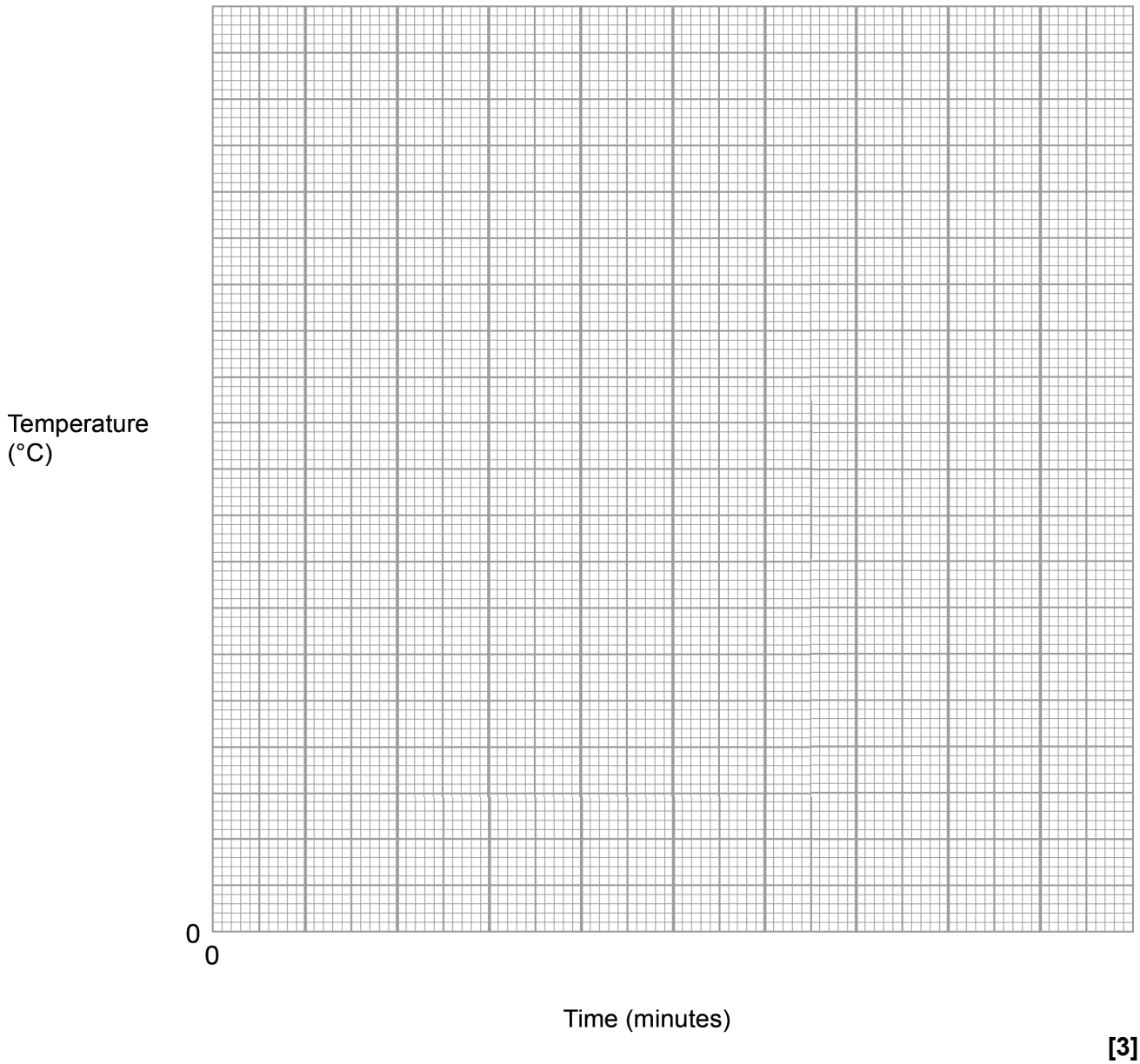
3 Jamal is investigating how the temperature of oil changes when it is heated by a candle flame.

He records the temperature of the oil every minute during his investigation.

His results are shown in the table below.

Time (min)	1	2	3	4	5	6	7	8
Temperature (°C)	25	31	41	52	62	71	78	83

(a) On the grid below plot a line graph of temperature on the y-axis against time on the x-axis and draw the curved line of best fit.



[3]

(b) Jamal did **not** record the **initial** temperature of the oil at the start of his investigation.

On the grid show how Jamal should use the curved line of best fit to estimate a value for the initial temperature of the oil.

Record this temperature.

Initial temperature of the oil = ……..……..... °C **[2]**

(c) **(i)** Suggest a numerical value for the level of uncertainty in the initial temperature of the oil recorded in **(b)**.

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

(ii) Calculate the percentage uncertainty in the initial temperature of the oil.

Percentage uncertainty = ……..……..... **[1]**

(d) **(i)** Draw a tangent to the curve when the time is 6 minutes and determine the gradient of your tangent.

Gradient = ……..……..... °C min^{-1} **[3]**

(ii) Jamil decides to convert his value of the gradient into SI units.

State the SI units of the gradient and explain how he would convert his value to SI units.

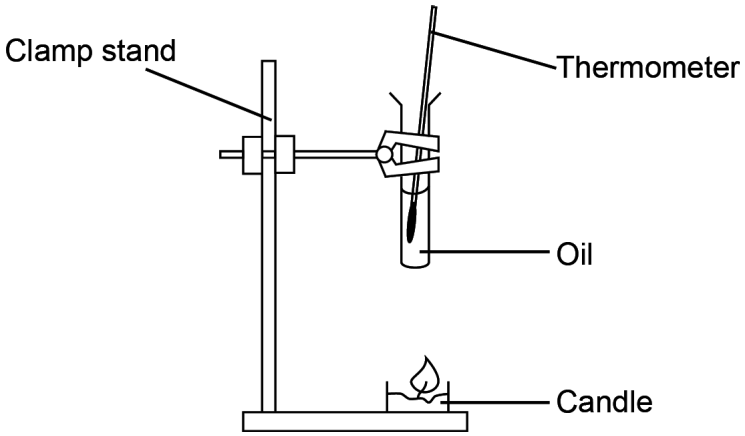
Units .....

Explanation .....

.....

[3]

(e) Jamal draws a diagram of his apparatus.



Jamal needs to provide more details about his method and results so that his investigation is **repeatable** and **reproducible**.

Discuss the difference between repeatability and reproducibility and describe what further information Jamal should provide.

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

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Turn over for the next question

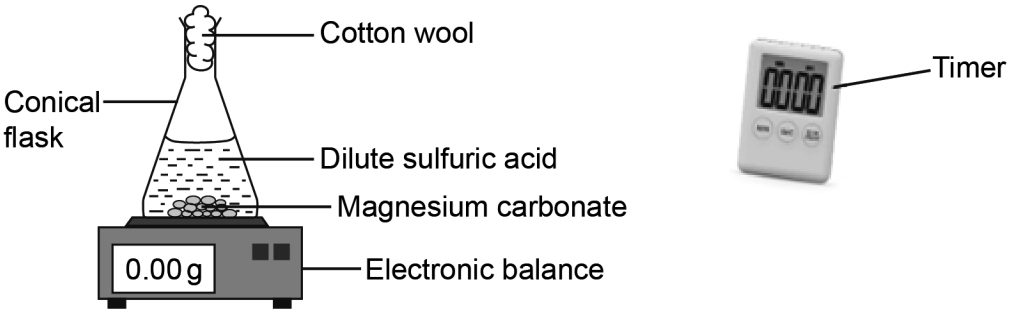
4 Leo is a chemistry student investigating the rate of reaction between magnesium carbonate, $MgCO_3$, and sulfuric acid, H_2SO_4.

$MgCO_3(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2O(l) + CO_2(g)$

As the reaction proceeds, carbon dioxide gas is released, causing the mass of the reaction mixture to decrease.

Leo decides to monitor the rate of reaction by measuring the loss in mass at 10 second intervals.

He sets up the apparatus as shown and follows the method outlined below.



Method

- Pour 25 cm^3 of 1.0 mol dm^{-3} sulfuric acid into the conical flask and stand it on the electronic balance.
- Add 1.25 g of magnesium carbonate and immediately start the timer.
- Record the reading on the balance every 10 seconds.
- Calculate the loss in mass by subtracting each reading from the initial mass.
- Repeat the experiment twice more using the same mass of magnesium carbonate and the same volume of 1.0 mol dm^{-3} sulfuric acid.

The table shows Leo's results.

Time (s)	Loss in mass (g)			Mean loss in mass (g)
	Experiment 1	Experiment 2	Experiment 3	
0	0.00	0.00	0.00	0.00
10	0.18	0.19	0.18	0.187
20	0.41	0.36	0.42	0.415
30	0.54	0.55	0.53	0.540
40	0.57	0.63	0.58	0.575
50	0.61	0.61	0.62	0.613
60	0.62	0.63	0.63	0.627
70	0.63	0.63	0.63	0.630
80	0.63	0.63	0.63	0.630

(a) Explain why Leo stops recording his measurements after 80 s.

.....

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

(b) **(i)** Suggest why Leo carries out repeat measurements.

Put a (ring) around the correct answer.

To increase accuracy **To reduce the effect of random error**

To reduce the effect of systematic error

[1]

(ii) Leo thinks that his results are precise.

Explain what **precise** means in relation to Leo's results.

.....

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

(c) Explain why the mean mass Leo calculates at 40 s is **not** the mean of all three mass readings.

.....

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

(d) Leo uses a two decimal place balance for his mass readings.

What is the uncertainty in each mass reading?

Put a (ring) around the correct answer.

±0.01 g **±0.005 g** **±0.10 g**

[1]

(e) Leo decides to assess the accuracy of his experiment.

He uses the reaction quantities and the balanced equation to calculate that the loss in mass should be 0.650 g.

Leo compares this calculated value with his experimental value.

His experimental value is the mean loss in mass, 0.630 g, recorded after 80 s (as shown in the table).

Calculate the percentage difference between the calculated value and his experimental value using the following equation.

$$\% \text{ difference} = \frac{(\text{calculated value} - \text{experimental value}) \times 100}{\text{calculated value}}$$

[2]

(f) Kareem is another chemistry student investigating the rate of reaction between magnesium carbonate, $MgCO_3$, and sulphuric acid, H_2SO_4.

$MgCO_3(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2O(l) + CO_2(g)$

He decides to measure the reaction rate by timing how long it takes for the reaction to stop.

(i) Suggest **two** observations he could make which indicate that the reaction has finished.

.....

.....

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

(ii) Kareem carries out the reaction three times, keeping the mass of magnesium carbonate and the volume of sulphuric acid the same each time, but changing the concentration of the acid.

His results are shown in the table below.

Experiment	**Concentration of acid (mol dm^{-3})**	**Time taken for reaction to stop (s)**	**$\frac{1}{time}$ (s^{-1})**
1	0.5 mol dm^{-3}	135	
2	1.00 mol dm^{-3}	70	
3	2.00 mol dm^{-3}	36	

Complete the table by calculating $\frac{1}{time}$ for each experiment.

Give your answers to **3** decimal places.

[2]

(iii) $\frac{1}{time}$ is a measure of the rate of reaction.

State what Kareem's results show about the effect of acid concentration on the rate of reaction.

.....

.....

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

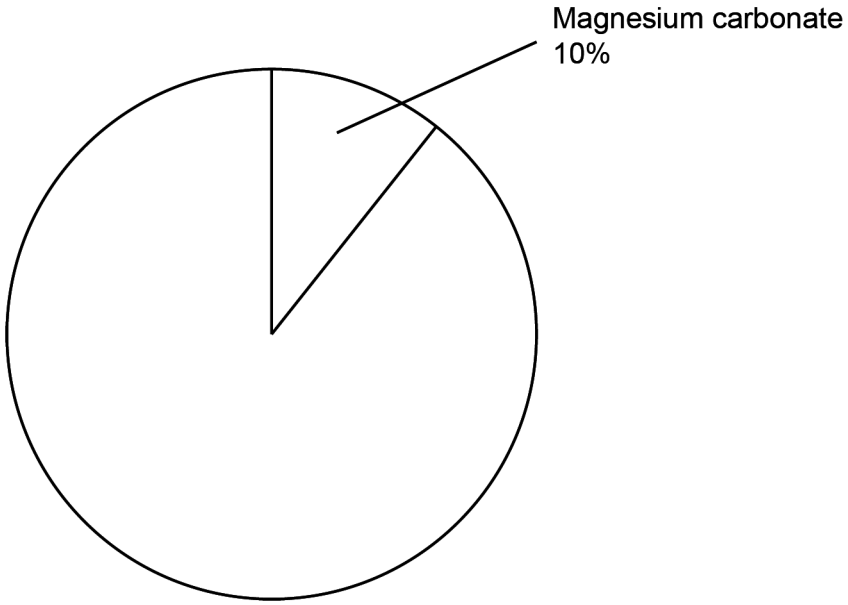
(g) Magnesium carbonate is an ingredient in many common indigestion tablets.

A typical indigestion tablet contains several components.

The table shows the % by mass of each component found in one type of indigestion tablet.

Substance	**Percentage by mass**
Magnesium carbonate	10%
Alginic acid	15%
Glucose	45%
Calcium carbonate	30%

The pie chart below shows the percentage by mass of magnesium carbonate in the tablets.



(i) Explain how the size of the slice of the pie chart labelled magnesium carbonate has been calculated.

.....

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

(ii) Complete the pie chart to show the slices of the pie chart that represent the other three substances.

Label each of the three segments.

[2]

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Turn over for the next question

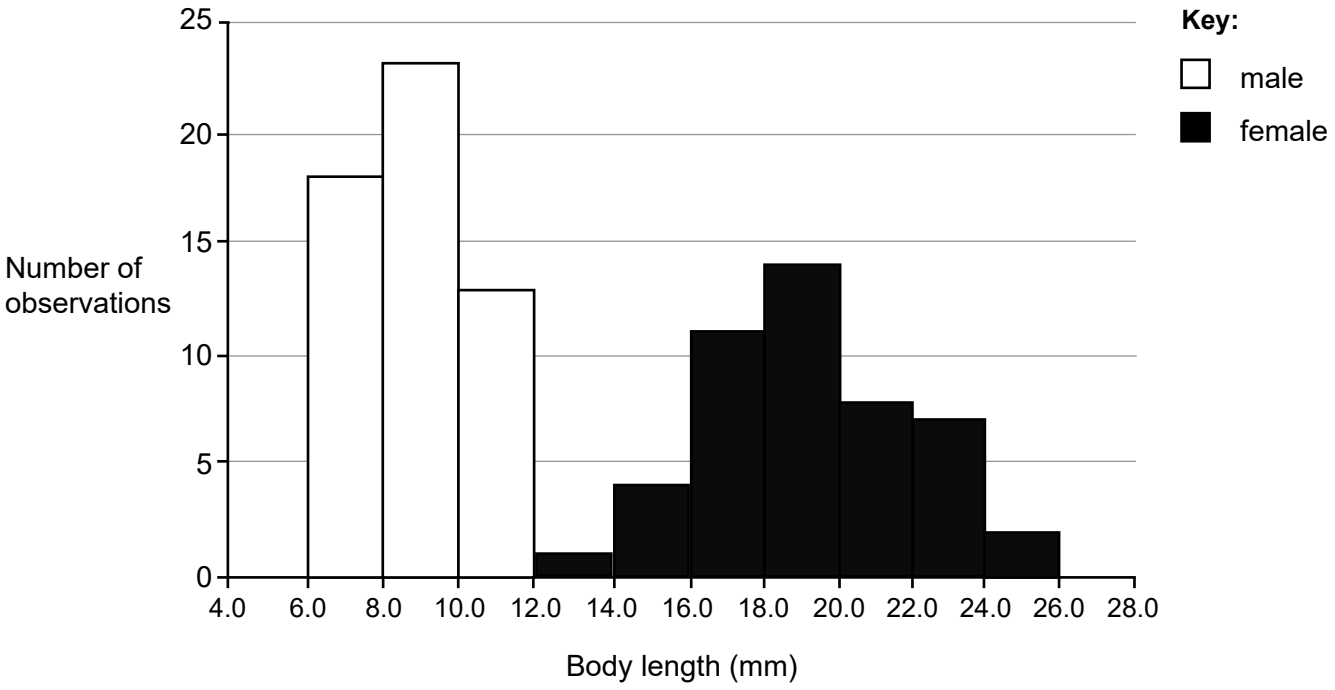
5 Jane is investigating a species of shrimp that is found in mountain streams.

She gathers a sample of the shrimps.

For each shrimp in the sample Jane measures its body length and determines whether it is male or female.

Jane presents her data in a chart as shown in **Fig. 5.1**.

Fig. 5.1



(a) (i) State what type of chart is shown in **Fig. 5.1**.

Give **two** reasons for your answer.

Type of chart .....

Reason 1 .....

Reason 2 .....

[3]

(ii) Use **Fig. 5.1** to estimate the number of male shrimps collected by Jane.

.....

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

(b) Describe the distribution in the body length of female shrimps.

.....

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

(c) Suggest **three** conclusions Jane can make using the data in **Fig. 5.1**.

1 .....

2 .....

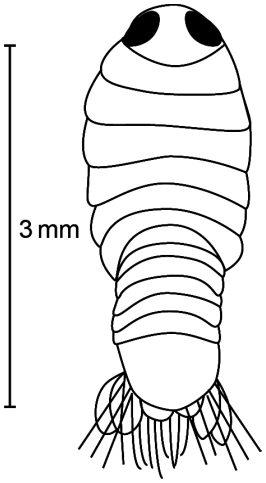
3 .....

[3]

(d) Jane finds a diagram of the shrimp species in an online academic journal.

Fig. 5.2 shows the dorsal side of the shrimp, when viewed from above.

Fig. 5.2



(i) What types of information sources (primary or secondary) are shown in **Fig. 5.1** and **Fig. 5.2**?

Fig. 5.1 .....

Fig. 5.2 .....

[1]

(ii) The online journal identifies the image in **Fig. 5.2** as a female.

Use the measurements shown in **Fig. 5.1** and **Fig. 5.2** to suggest why this is an example of conflicting evidence.

.....

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

(iii) Suggest what further information is needed to make the identification in **(d)(ii)** more secure.

.....

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

6 Beth is a technician working in a hospital pathology laboratory.

She tests patient samples to determine whether they have a bacterial infection and if so, what types of bacteria are present.

(a) Her initial investigations involve gram staining to determine whether the bacteria are gram-positive or gram-negative.

(i) Gram staining involves the use of different stains.

Tick (✓) the boxes next to **two** of the stains used for the gram staining process.

Crystal violet	☐
Leishman's stain	☐
Methylene blue	☐
Safranin	☐
Sudan III	☐
Toluidine blue	☐

[2]

(ii) The gram stains attach to the polymer peptidoglycan.

Gram-positive bacteria contain more peptidoglycan than gram-negative bacteria.

Identify the location of peptidoglycan in bacteria.

Put a (ring) around the correct location.

cell wall **cytoplasm** **plasmid**

[1]

(iii) Suggest **one** reason why bacteria in a blood sample are grown on an agar medium before carrying out the gram staining process.

.....

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

(b) Beth uses different media for growing and identifying bacteria.

Draw lines to connect each type of growth medium with its correct use.

Growth medium	Use
Differential media	Contain dyes or specific substrates so that different bacteria can be recognised on the basis of their colony colour.
Enriched media	Contain specific antibiotics to prevent the growth of some bacteria while promoting the growth of others.
Selective media	Contain specific nutrients to increase the relative concentration of certain bacteria in the culture.

[3]

Question 6(c) begins on page 24

(c) Some bacteria can ferment lactose and others cannot.

MacConkey agar (MAC) is a type of medium that helps microbiologists to identify lactose fermenting bacteria.

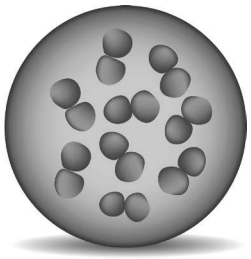
Lactose fermenting bacteria produce pink colonies on MAC but non-lactose fermenting bacteria appear as colourless colonies on the growth medium.

Beth believes that a sample taken from one her patients contains one of the bacteria listed in **Table 6.1**.

Table 6.1

Name of bacteria	Cell shape of bacteria	Gram-negative?	Lactose Fermenter?
Escherichia coli	rods	Yes	Yes
Salmonella enterica	rods	Yes	No
Neisseria lactamica	cocci (round)	Yes	Yes
Moraxella catarrhalis	cocci (round)	Yes	No

The results of Beth's tests are shown below.

Collection of bacterial cells seen under light microscope	Appearance of bacterial colonies when grown in MacConkey agar
	Pink colonies

(i) State the name of the bacteria in **Table 6.1** that could be the bacteria in her sample.

Explain your answer.

Name of bacteria .....

Explanation .....

.....

.....

[3]

(ii) Explain why Beth cannot be 100% confident that the type of bacteria identified in **(c)(i)** is correct.

.....

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

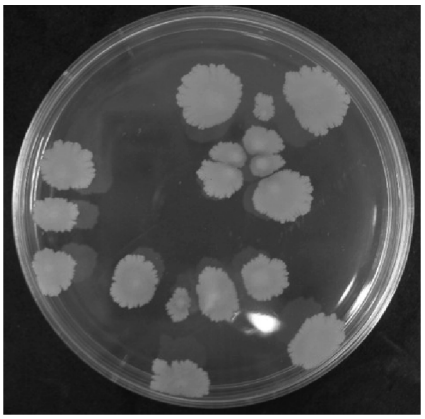
(d) Beth is told that one of the patients has a wound, which has been in contact with soil.

She is concerned that the patient may have been infected with a type of soil-borne bacterium.

Beth decides to test a sample of the soil.

She grows her sample on a nutrient agar plate.

The appearance of the colony is shown below.



Beth concludes that the type of bacteria is *Bacillus subtilis* because of the colony shape.

(i) Tick (✓) **one** box that describes the colony shape shown.

Circular	☐
Filamentous	☐
Rhizoid	☐
Spindle	☐

[1]

(ii) Beth takes a sample of the bacteria growing on her agar plate to prepare a permanent slide.

She has already stained the bacterial cell contents but must follow three further steps before completing the process.

The steps are shown in the table below but are **not** in the correct order.

Put the numbers **1 to 3** in the boxes to indicate the correct order of steps.

Step	**Order**
Clearing	
Dehydration	
Mounting	

[1]

(iii) Beth labels the microscope slide.

Suggest **one** feature of the slide to be written on the label.

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

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Turn over for the next question

7 The European New Car Assessment Programme (EuroNCAP) uses crash-test dummies to investigate the safety of new cars.

(a) **Fig. 7.1** shows crash-test data presented on the EuroNCAP website.

The star system indicates how well the car performed in the crash-tests.

Cars awarded five stars are the safest.

Fig. 7.1

Give **two** advantages of presenting data in this way on a website.

1 .....

2 .....

[2]

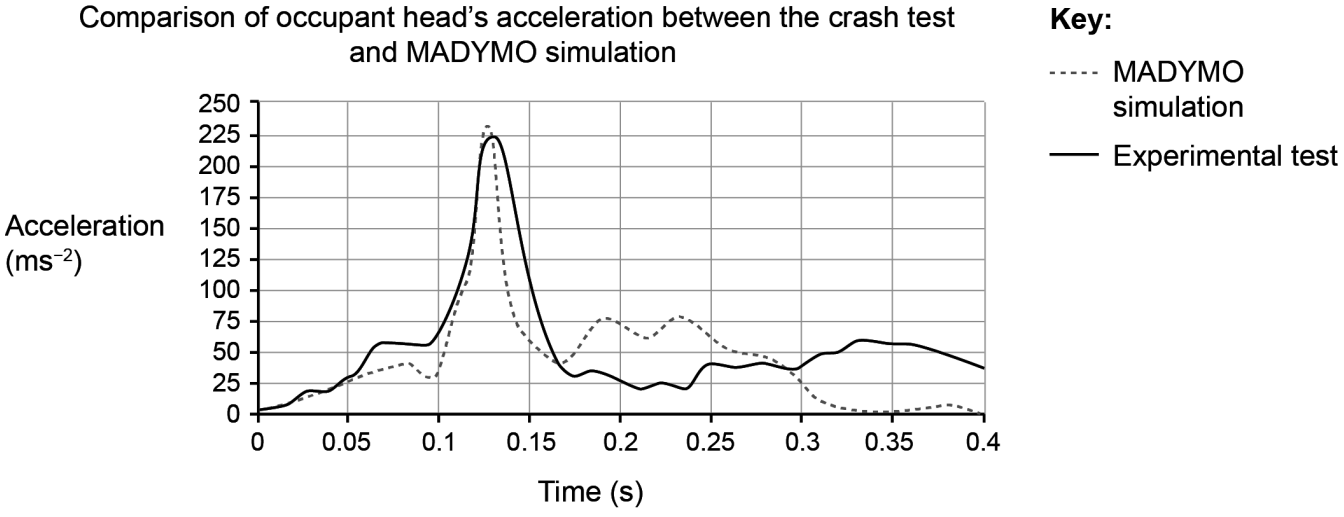
(b) The crash-test dummies are fitted with over 200 sensors that measure acceleration on different parts of the dummy's body during a simulated crash.

The data are stored in the dummy and then downloaded onto a computer programme after the crash. Each crash is filmed using a high-resolution, high-speed video camera.

In addition to the data measured in crash-test experiments, data can also be obtained by mathematical modelling.

Fig. 7.2 shows a graph comparing crash-test data and mathematical modelling (MADYMO) data.

Fig. 7.2



(i) Suggest **two** advantages of using mathematical modelling to collect data.

1 .....

2 .....

[2]

(ii) Describe **two** ways that the crash-test data in **Fig. 7.2** validates the mathematical modelling data.

1 .....

2 .....

[2]

(iii) Suggest **two** advantages of recording crash-test data on video.

1 .....

2 .....

[2]

(c) The target audiences for the information shown in **Fig. 7.1** and **Fig. 7.2** are different.

Suggest what the target audiences might be.

Fig. 7.1 .....

Fig. 7.2 .....

[2]

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(e) or 4(a).

The Periodic Table of the Elements

Key
atomic number **Symbol** name relative atomic mass

1 (1)	2 (2)	3	4	5	6	7	8	9	10	11	12	13 (3)	14 (4)	15 (5)	16 (6)	17 (7)	18 (0)
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