OCR
Oxford Cambridge and RSA

Tuesday 3 June 2025 – Afternoon

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C342/2506

C342/2506

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

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

05848/03

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 **28** pages.

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

1 The concentration of nitrogen dioxide (NO_2) in air is an important measure of air quality.

In the UK, the concentration of NO_2 is subject to Air Quality Standards Regulations (2010). NO_2 can cause inflammation of the airways and increase susceptibility to respiratory infections and to allergens.

The table shows how the mean annual concentration of NO_2 changed in London, UK between 2013 and 2019.

Year	**NO_2 ($\mu g\,m^{-3}$)**	**NO_2 ($\mu g\,m^{-3}$) (to one decimal place)**
2013	50.02	
2014	60.34	
2015	44.91	
2016	47.17	
2017	41.75	
2018	40.10	
2019	34.83	

(a)

(i) The NO_2 values in the table are recorded to the same number of significant figures.

How many significant figures are recorded?

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

(ii) Complete the empty column of the table by rounding each NO_2 value to one decimal place. **[1]**

(iii) Determine the mean concentration of NO_2. Use the values you calculated in **(a)(ii)**.

Give your answer to **three** significant figures.

Mean = ... $\mu g\,m^{-3}$ **[2]**

(iv) Determine the median and the range of the values you calculated in **(a)(ii)**.

Median ..... $\mu g\,m^{-3}$

Range ..... $\mu g\,m^{-3}$

[2]

(b)

(i) Convert the 2018 value (recorded to one decimal place) of the NO_2 concentration to $g\,m^{-3}$.

Give your answer in standard form.

..... $g\,m^{-3}$ **[2]**

(ii) State the names of the SI units of mass and length.

Mass .....

Length .....

[2]

(c) A molecule of NO_2 contains one atom of nitrogen and two atoms of oxygen.

The relative atomic masses of nitrogen and oxygen are: N = 14 and O = 16.

- Calculate the molar mass of NO_2.

Molar mass = ... $g\,mol^{-1}$

- Calculate the percentage by mass of oxygen in NO_2.
  Give your answer to **three** significant figures.

% by mass of O = ...%

[2]

(d) Nitrogen dioxide, NO_2, is a polluting gas that is produced by car engines during the combustion of fossil fuels. It is monitored by specialised sensing devices placed at various roadside and other urban and rural locations (monitoring stations).

(i) Suggest **two** explanations for the trend in NO_2 concentration and suggest further evidence that would support your explanations.

reason 1 .....

supporting evidence .....

.....

reason 2 .....

supporting evidence .....

.....

[4]

(ii) The information relating to all types of air pollution has improved since 2015.

Suggest **three** reasons why the quality of data relating to air pollution has improved since 2015.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

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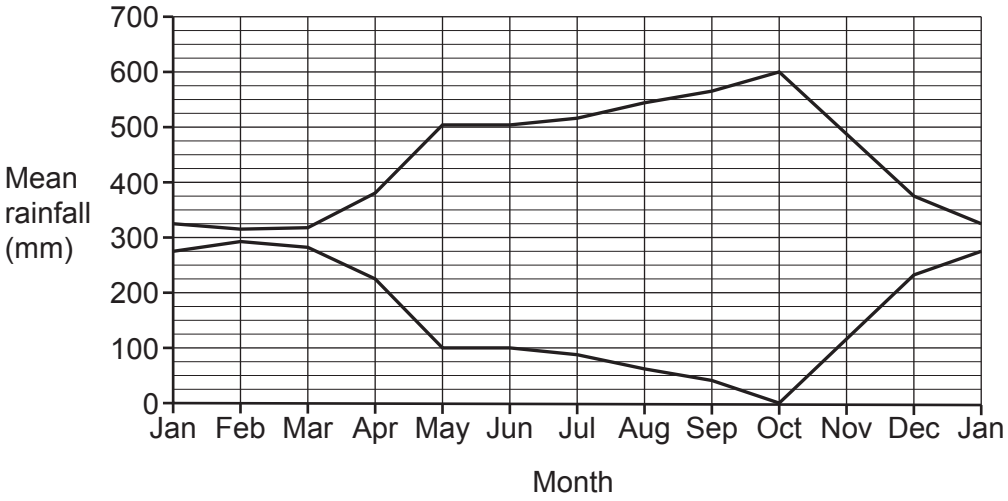
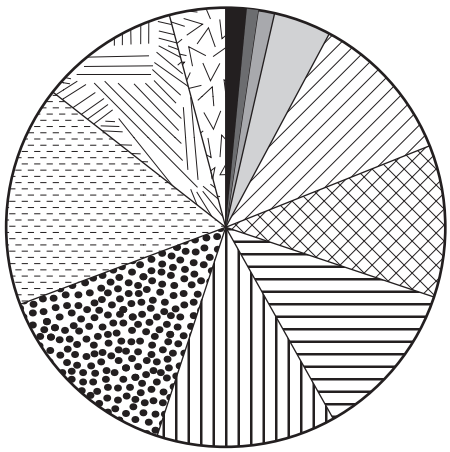
2 An environmental scientist is investigating rainfall data over a one-year period for a tropical island.

The scientist uses two different graphical methods to present the rainfall data, as shown below.

Method 1



Method 2



Key

Jan Feb Mar Apr May Jun

Jul Aug Sep Oct Nov Dec

(a) Identify the two graphical methods shown.

Explain the advantages and limitations of each method for representing the rainfall data. **[6]**

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(b) State **two** other graphical methods that the environmental scientist could use to present the rainfall data.

1 .....

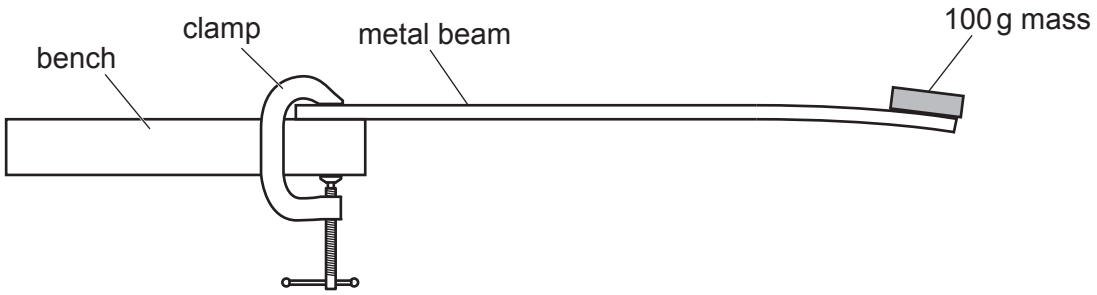
2 .....

[2]

3 An engineer is designing a buggy for a small child.

The wheels of the buggy must be able to move up and down so that the buggy can travel smoothly when pushed over uneven ground.

The engineer makes a model to see how a 100 g mass moves up and down at the end of a metal beam.



(a) The engineer uses a piece of adhesive material to attach a 100 g mass to the end of the metal beam.

Explain why there is a systematic error in the actual mass at the end of the beam and suggest what the engineer should do to correct this error.

.....

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.....

.....

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

(b) The engineer uses a 30 cm ruler with millimetre divisions.

The ruler is used to measure the length *L* of the beam from the edge of the bench to the centre of the 100 g mass.

(i) What is the precision of this ruler?

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

(ii) Explain why there is an uncertainty of at least 2 mm in the measurement of *L* when using this ruler.

.....

.....

.....

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

(iii) The engineer holds the ruler next to the beam. The engineer looks to the left and notes the scale reading at the bench and then looks to the right and notes the scale reading at the centre of the mass.

The engineer estimates that the total uncertainty in length L is 5 mm.

Suggest **three** sources of error in the method used to measure L that causes the additional uncertainty.

1 .....

2 .....

3 .....

[3]

(iv) The engineer determines that L = 17.5 cm and the uncertainty is 5 mm.

Calculate the percentage uncertainty.

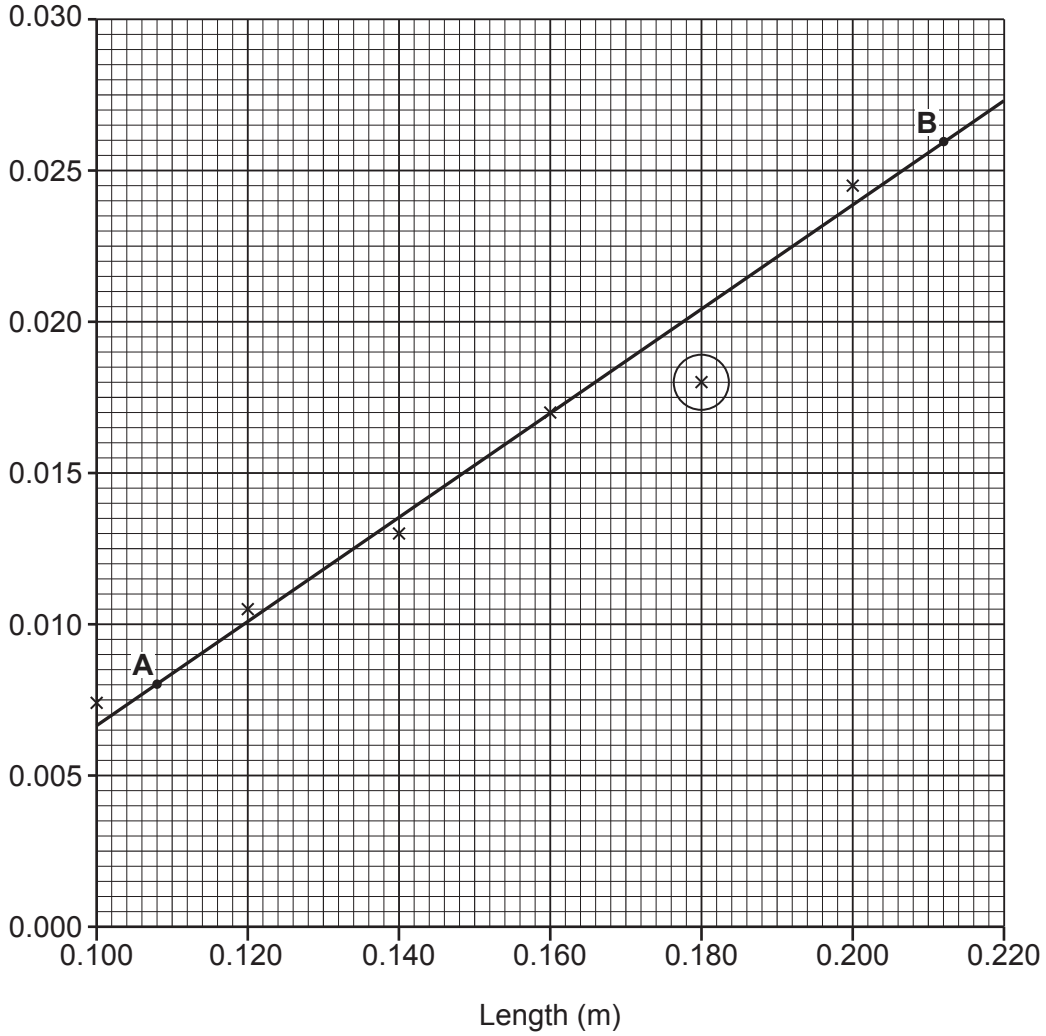
Give your answer to **two** significant figures.

Percentage uncertainty ..... % **[2]**

(c) The engineer takes measurements to find the time t in seconds for one up-and-down movement of the mass using different lengths L between 10 cm and 20 cm.

The results, marked as crosses, are shown in the graph.

.....



(i) Label the y-axis on the dotted line beside the graph.

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

(ii) What type of graph is shown?

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

(iii) Explain why the engineer has drawn a circle around the point at L = 18 cm.

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

(iv) Explain why the line of best fit is **NOT** correct.

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

(v) The engineer marks point **A** on the graph at $x = 0.108$ and $y = 0.008$.

Determine the x and y value of point **B** on the graph.

x = ...

y = ...

[2]

(vi) Using the x and y values of points **A** and **B** determine the gradient of the engineer's line.

Show your working and determine the SI unit of this line.

Gradient .....

SI unit .....

[2]

(vii) The engineer calculates the percentage uncertainty in t.

At $L = 0.16\,\text{m}$, this gives an uncertainty in t of ± 0.002.

Draw a range bar on the graph to show this uncertainty. **[1]**

(d) Another engineer repeats the experiment.

Suggest **two** pieces of information about the metal beam that this engineer should be given to ensure that the experiment is repeatable.

1 .....

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2 .....

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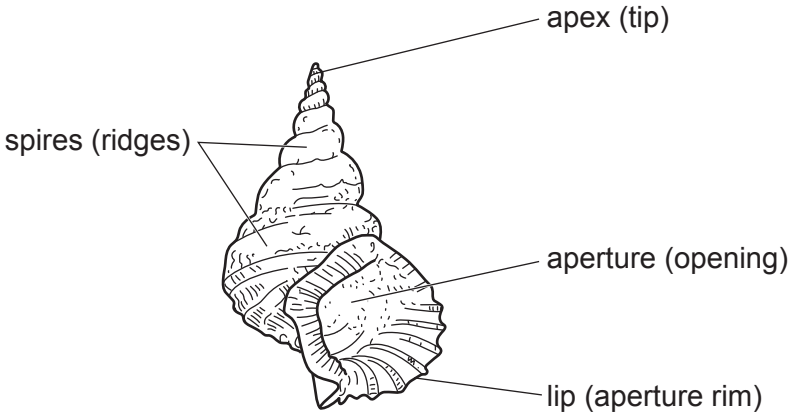
[2]

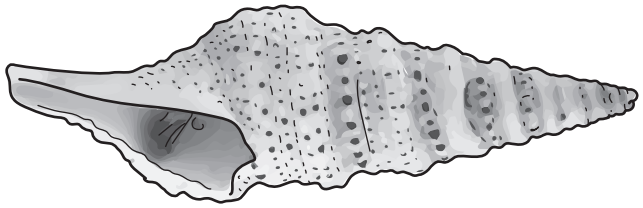
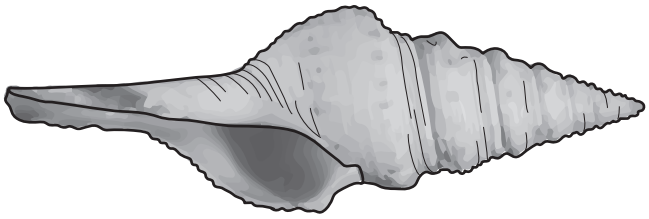
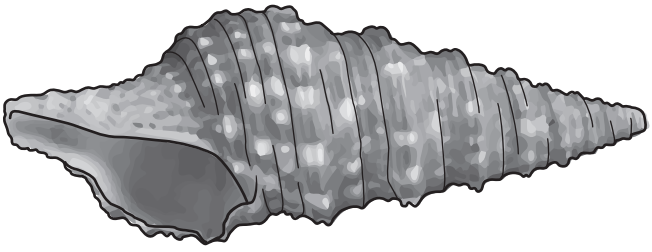
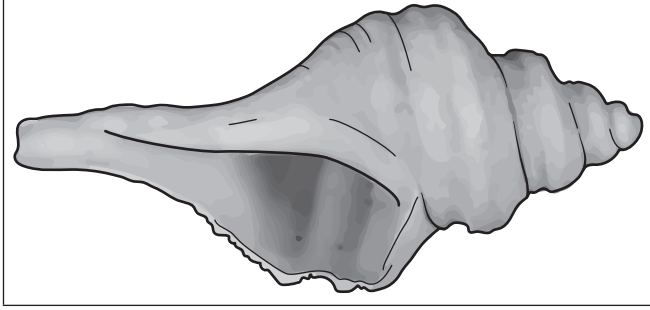
4 The shells of different types of sea snail share a number of external features.

The external features are shown in the diagram.



An ecologist collects data to identify different types of sea snails.

The shells of four of the sea snails are shown in the table.

	*Lophiotoma acuta*. Location Japan.
	*Lophiotoma capricornica*. Location Australia.
	*Lophiotoma ruthveniana*. Location Mauritius.
	*Lophiotoma pseudoannulata*. Location Antarctica.

(a)

(i) Use information shown in the diagram and table to:

- suggest **two** measurements that can be recorded to classify the different sea snails,
- suggest **two** ratios that can be calculated using these and other measurements.

Measurements

1 .....

2 .....

Ratios

1 .....

2 .....

[4]

(ii) Suggest **one** advantage and **one** disadvantage of using external features only for the classification of organisms such as the sea snail.

Advantage

.....

Disadvantage

.....

[2]

(iii) Each type of shell is named according to binomial nomenclature.

Use the sea snail, *Lophiotoma pseudoannulata*, to explain what is meant by the term binomial nomenclature.

.....

.....

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

(iv) Sea snails are animals.

They are classified as members of Kingdom Animalia.

Give the names of **two** other types of Kingdom.

..... and .....

[2]

(v) Kingdom Animalia is divided into further sub-groups or taxa.

Which type of sub-group within Kingdom Animalia contains the largest number of organisms?

Put a tick (✓) in the correct box.

class	
family	
order	
phylum	

[1]

(b) The table shows some of the criteria used to evaluate the quality of data collected for this and other types of scientific investigations.

	Criteria for evaluation
A	Accuracy: the closeness of the measured value to the true value
B	Availability: how easily the data can be accessed and obtained for analysis
C	Consistency: the degree of agreement across different sources if multiple sources of data are used
D	Relevance: how well the data address the research objectives
E	Source credibility: the reliability and reputation of the organisation or individual that collected and published the data
F	Timeliness: how current and up-to-date the data are
G	Validity: the suitability of the method used to answer the question being asked

(i) State the letters (**A** to **G**) of **two** criteria used to judge the quality of primary data.

..... and .....

[2]

(ii) State the letters (**A** to **G**) of **two** criteria used to judge the quality of secondary data.

..... and .....

[2]

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5

(a) The relative atomic mass (A_r) of an element is the weighted average of the masses of its isotopes compared to 1/12th of the mass of one atom of Carbon-12.

The mass number of an atom is the number of protons plus neutrons in the nucleus of an atom.

Table 5.1 shows the relative atomic masses of all the elements that begin with the letter A.

Table 5.1

Element	Relative atomic mass
Actinium	227.029
Aluminium	26.982
Americium	243.061
Antimony	121.760
Argon	39.948
Arsenic	74.922
Astatine	209.987

In 1917, relative atomic mass was known as atomic weight.

Atomic weights were calculated by comparing the mass of an element's atoms with a reference element. In one system, atomic weight was determined by comparing the mass of an atom with the mass of one hydrogen atom. In another system, atomic weight was determined by comparing the mass of an atom with 1/16th of the mass of an oxygen atom.

The calculated atomic weights were slightly different depending on which reference element was used.
Table 5.2 shows the atomic weights (calculated in 1917) of all the elements that begin with the letter A.

Table 5.2

	Atomic weight (calculated in 1917)	
Element	**Compared to hydrogen**	**Compared to oxygen**
Aluminium	26.8	27.1
Antimony	119.2	120.1
Argon	39.6	39.9
Arsenic	74.37	74.96

(i) Explain why there are more elements listed in **Table 5.1** compared with **Table 5.2**.

.....

.....

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

(ii) Hydrogen has one proton and oxygen has eight protons.

Suggest how the number of protons in the reference elements (hydrogen and oxygen) affect the calculated value of the atomic weight of aluminium shown in **Table 5.2**.

.....

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

(iii) Explain whether your suggestion in **(a)(ii)** is supported by the data for argon in both of the tables.

.....

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

(b) **Table 5.2** shows some more data relating to the element antimony.

Table 5.2

Symbol	Atomic number	Relative atomic mass (A_r)	Mass numbers of the stable isotopes	
Sb	51	121.76	121	123

(i) Explain why the mass numbers are whole numbers, but the relative atomic mass is not a whole number.

.....

.....

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

(ii) What can you conclude about the relative abundance of the two isotopes of antimony?
Give a reason for your answer.

.....

.....

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

(c) Aluminium is the most abundant metal in the Earth's crust.

The main source of aluminium is Bauxite which is a rock containing aluminium oxide, Al_2O_3.

Aluminium is extracted by electrolysis of molten aluminium oxide.

The overall equation is for this process is shown below.

$2Al_2O_3 \rightarrow 4Al + 3O_2$

(i) Calculate the expected mass of aluminium which would be produced from 1500 g Al_2O_3 if the yield was 100%.

The molar mass of Al_2O_3 is 102 g mol^{-1} and the relative atomic mass of Al is 27.

Give your answer to the nearest whole number.

Expected mass ..... **[2]**

(ii) A chemical engineer finds that 1500 g of Al_2O_3 produces 720 g of aluminium.

Calculate the percentage yield of aluminium using the equation:

$$\text{percentage yield} = \frac{\text{amount of product obtained} \times 100}{\text{expected amount of product}}$$

% yield = ... **[1]**

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6

(a) A food scientist carries out an investigation to determine the concentration of vitamin C in oranges. The method involves a redox titration using iodine.

The scientist uses the following method.

1. Take 100 g of an orange and cut it into small pieces.

2. Add about 50 cm^3 water and blend in a food processor.

3. Strain the mixture to remove the pulp and make the extracted solution up to 100 cm^3 in a volumetric flask.

4. Pipette 20.0 cm^3 of the orange juice into a conical flask, add a suitable indicator and titrate against 0.005 $mol\,dm^{-3}$ iodine solution.

5. Repeat step 4 until concordant titres are obtained.

(i) State the name of the indicator and describe how the end point is detected.

Indicator .....

Observation at the end point

.....

[2]

(ii) Explain what is meant by concordant titres.

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

(iii) The scientist obtains a mean titre of 12.05 cm^3 0.005 mol dm^{-3} iodine.

Determine the mass, in mg, of vitamin C in 100 g of orange using the following steps.

You will need to use the following equations in your calculations:

$$\text{Number of moles} = \frac{\text{concentration in mol dm}^{-3} \times \text{volume in cm}^3}{1000}$$

Mass in g = number of moles × molar mass (g mol^{-1})

- Use the mean titre to calculate the number of moles of iodine required to reach the end point.

- Vitamin C is ascorbic acid. During the titration one mole of ascorbic acid reacts with one mole of iodine.
  Deduce the number of moles of ascorbic acid in 20.0 cm^3 of orange juice.

- The molar mass of ascorbic acid is 176 g mol^{-1}.
  Calculate the mass, in mg, of ascorbic acid in 100 g of orange.
  Give your answer to **two** significant figures.

Mass of vitamin C in 100 g of orange ..... mg **[5]**

(b) Spinach leaves are a good source of iron.

The food scientist is tasked with finding out how the iron content in spinach is affected by the cooking time.

The food scientist oxidises the spinach leaves to ensure that all the iron is in the form of iron(III).

The scientist then determines the iron(III) content by colorimetry using potassium thiocyanate to produce a coloured iron(III)-thiocyanate complex.

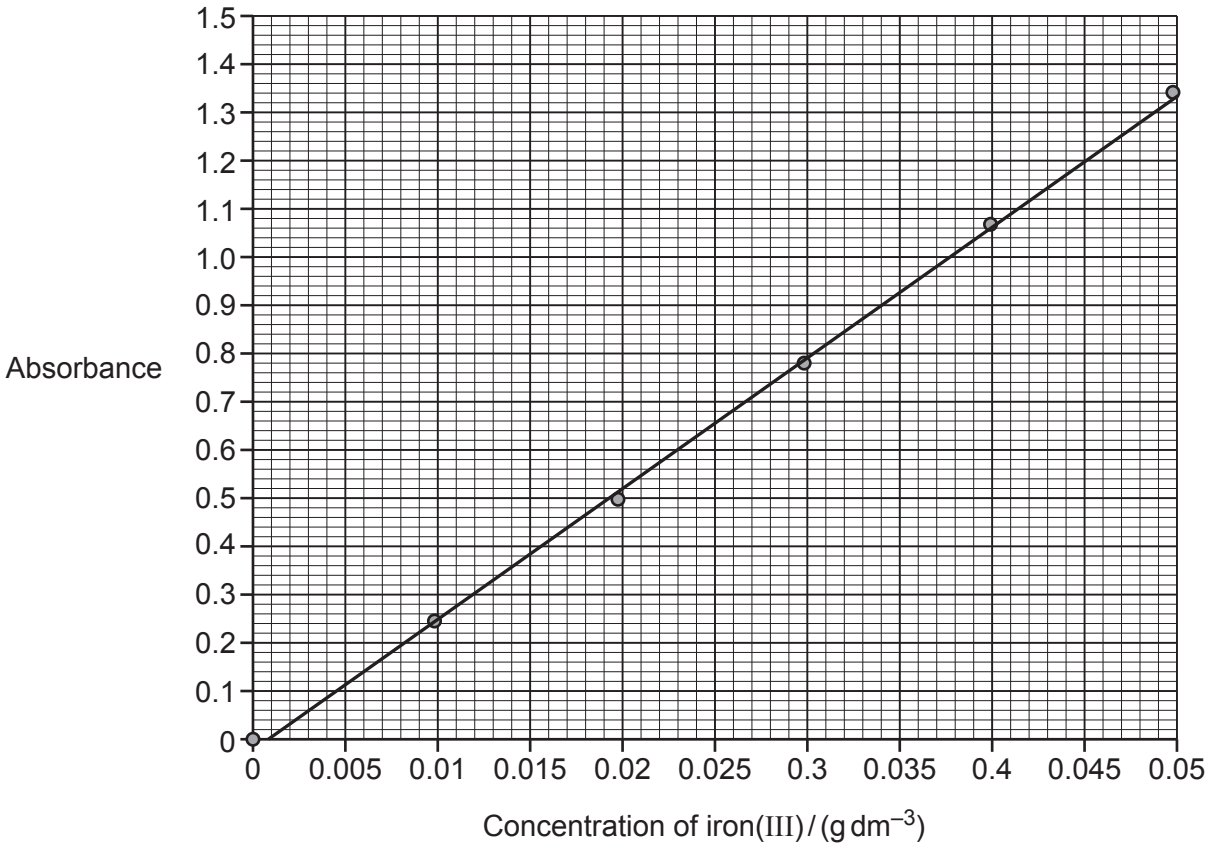
(i) Describe what the scientist would observe when potassium thiocyanate is added to a solution containing iron(III) ions.

.....

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

(ii) The food scientist uses a colorimeter to measure the absorbance of known concentrations of iron(III) solutions which have been treated with potassium thiocyanate.

A graph of absorbance reading against concentration of iron(III) is shown below.



A weighed sample of uncooked spinach leaves is oxidised and treated with potassium thiocyanate. The absorbance reading for the sample is found to be 1.2.

Use the graph to determine the concentration of iron in uncooked spinach.

Concentration of iron in uncooked spinach ..... g dm^{-3} **[1]**

(iii) The scientist boils the oxidised spinach leaves for different lengths of time using the same mass of spinach as the raw sample. After treating each sample with the same volume of potassium thiocyanate, the scientist measures the absorbance.

The results are shown below.

Boiling time / mins	0	2	4	6	8	10
Absorbance reading	1.2	0.65	0.38	0.24	0.15	0.14

- Describe what these results tell us about the effect of boiling on the iron content of spinach leaves.

  .....

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

- Calculate the percentage of iron remaining in the spinach leaves after cooking for 6 minutes.

% iron remaining ..... **[1]**

(c) The food scientist uses a range of redox titrations to determine the amounts of metal ions in food supplements.

Draw a line to link the metal ion with the reagent used in the titration.

Calcium ions	EDTA
	Potassium manganate(VII)
Iron(II) ions	Silver nitrate
	Sodium thiosulfate

[2]

7 Battery electric vehicles (BEVs) are becoming increasingly popular in the UK as people become more environmentally aware.

(a) The table below shows the number of BEVs on the UK's roads since 2015.

Year	2015	2017	2019	2021	2023
Number of BEVs	24 000	50 000	105 000	313 000	980 000

(i) Data can be displayed in different ways.

Suggest how data in the table could be presented to the wider public.

Give a reason for your answer.

.....

.....

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

(ii) Many stakeholders are interested in this information. These include members of the public, car manufacturers, garage mechanics, and politicians.

Explain why this information is useful to each stakeholder.

- Members of the public

.....

.....

- Car manufacturers

.....

.....

- Garage mechanics

.....

.....

- Politicians

.....

.....

[4]

(b) On a long journey, drivers will need to recharge the electric vehicle battery.

- The average time for a rapid charger to charge this type of battery is about 45 minutes.
- Some charging devices can charge more than one car at the same time, others can only charge one at a time.
- Different models of car require different connectors.

One of the main concerns for drivers of BEVs is the number and type of public rapid charging devices available. Many BEV drivers use a charging device App which tells them the location, type of connector and availability of charging points.

The following information was obtained from the most popular EV charging device App and published by the Department for Transport.

The data shows the number of electric vehicles per rapid charging device since 2017.

Year	2017	2018	2019	2020	2021	2022
Number of BEVs per public rapid charging devices	41	43	35	37	56	81

(i) Data validity is a measure of the accuracy and reliability of data.

Explain whether you think data in the table are valid.

.....

.....

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

(ii) Identify the main trends shown by the data and explain what impact this data has on BEV drivers.

.....

.....

.....

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

(iii) Suggest **one** additional piece of information about chargers which drivers would find useful.

.....

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

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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