OCR
Oxford Cambridge and RSA

Monday 16 January 2023 – Morning

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C342/2301

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

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

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.

Answer **all** the questions.

1 The top ten windiest areas of the UK are listed in the table.

The data show the annual average wind speed (in knots) recorded between 1981 and 2010.

Location	**Annual average wind speed (knots)**
Shetland	14.6
Orkney	14.3
Western Isles	12.6
Argyll and Bute	12.1
Gwynedd	11.3
Tweeddale	11.0
Ross and Cromarty	10.9
Banffshire	10.9
Sutherland	10.8
Isle of Wight	10.7

(a) Use the data in the table to:

(i) determine the mode, median and range of the annual average wind speed values.

mode = ...

median = ...

range = ...

[3]

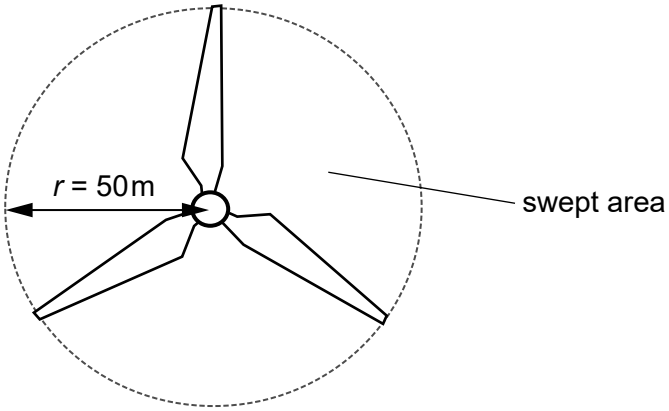
(ii) calculate the mean of these annual average wind speeds.

Mean = ... **[1]**

(b) Wind turbines work by converting kinetic energy in the wind to electrical energy in the national grid.

The blades of a vertical wind turbine are shown below. Each blade is 50 m long.

The area covered by one rotation of the turbine blades is called the swept area.



(i) Calculate the swept area A of the turbine.

Use the equation

$A = \pi r^2$

A = ... m^2 **[2]**

(ii) The mass of air moving through the turbine each second M is calculated using the equation:

$M = \rho A v$

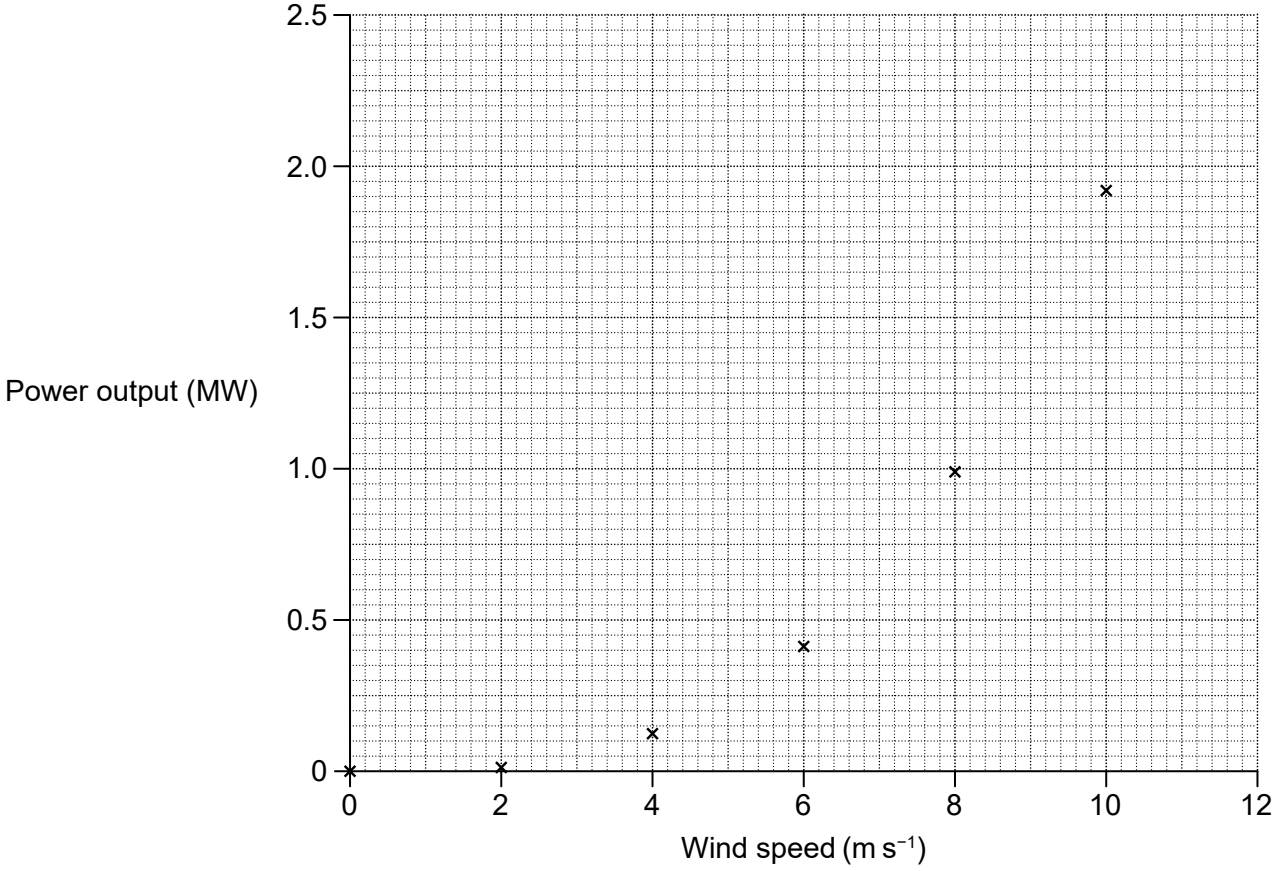
where ρ, the density of the air = 1.23 $kg\,m^{-3}$ and A is the swept area calculated in **(b)(i)**.

Calculate M when the wind speed v = 7.0 $m\,s^{-1}$.

Give your answer to **2** significant figures and state the units.

M = ... units..... **[4]**

(c) The graph below shows the relationship between the wind speed and the power output of a wind turbine.



(i) On the graph draw the curved line of best fit. **[1]**

(ii) On the graph, show how you determine the power output of the wind turbine when the wind speed is 8.4 m s^{-1}.

Record this power output in **Watts** using standard form.

Power output = ... W **[2]**

(iii) Describe the trend in the graph.

.....

.....

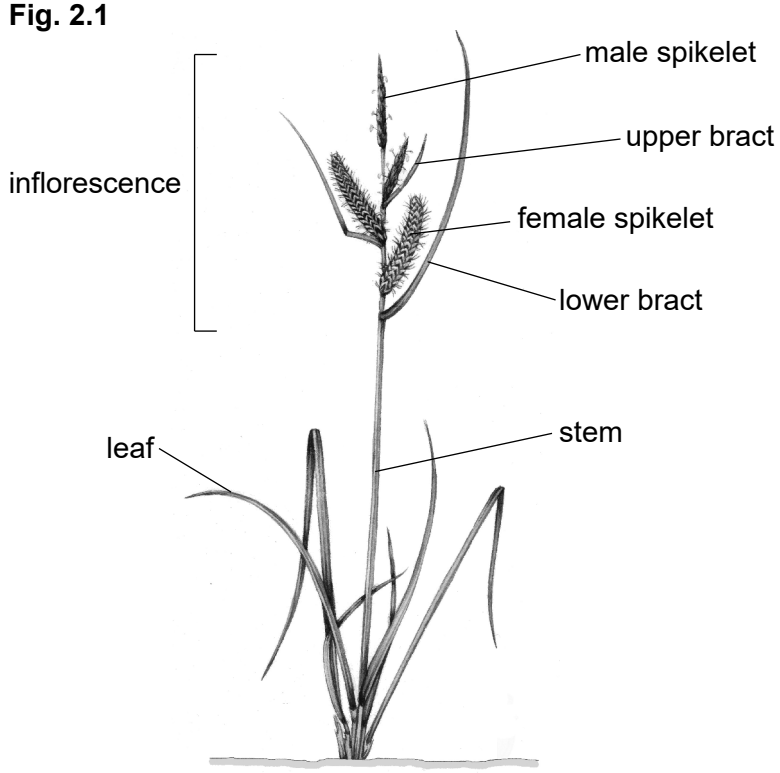
..... **[2]**

2 *Carex* is a genus of more than 2000 species of grass-like plants in the family *Cyperaceae*.

These plants are commonly known as sedges.

Fig. 2.1 is a diagram adapted from a botany textbook showing the structure of a typical sedge plant.

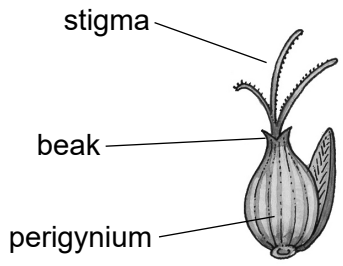
Fig. 2.1



Sedges have the following features:

- The flowering structure in *Carex* is called the inflorescence.
- The inflorescence consists of male and female spikelets.
- Male and female spikelets can be found on the same stem or on different stems.
- Each female floret develops into a structure called a perigynium (plural, perigynia) as shown in **Fig. 2.2**.

Fig. 2.2



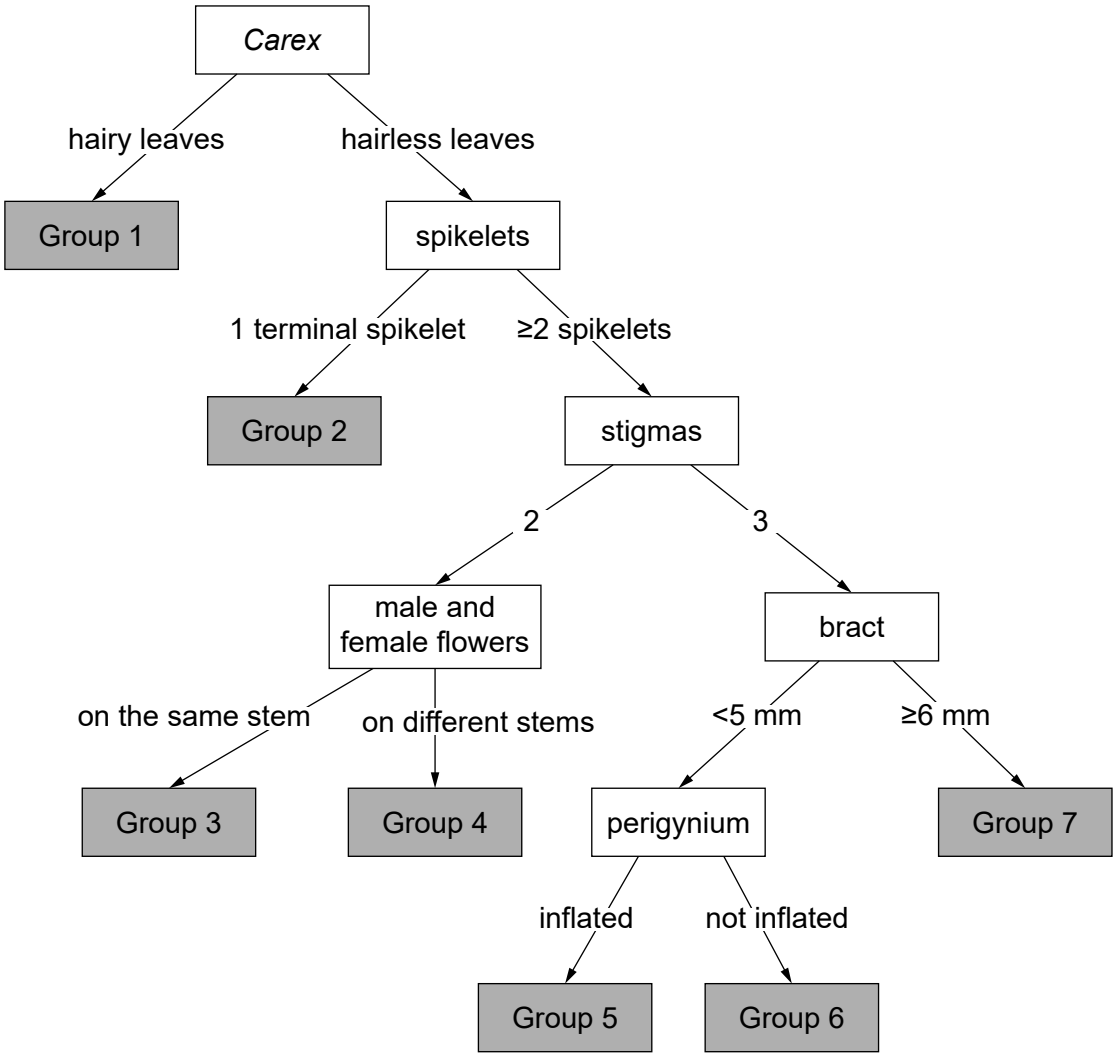
The variations in size, shape and colour of the leaf, bract and perigynia are used to identify different species of *Carex*.

(a) Explain why **Figs 2.1** and **2.2** are examples of secondary evidence.

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

(b) **Fig. 2.3** shows features of *Carex* used to place species native to California into seven different groups.

Fig. 2.3



(i) What type of key is shown in **Fig. 2.3**?

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

(ii) Describe how the diagram shown in **Fig. 2.3** is used to identify which group a particular sedge plant belongs to.

.....

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

(iii) Give **three** reasons why using the diagram in **Fig. 2.3** is **not** totally reliable.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

(c) (i) Suggest why the *Carex* shown in **Figs 2.1** and **2.2** could be in either Group 5, Group 6 or Group 7 of **Fig. 2.3** and explain why you cannot be certain which group it belongs to.

.....

.....

.....

.....

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

(ii) Use **Fig. 2.3** to identify **two** features that the plant in **Figs 2.1** and **2.2** has in common with the *Carex* species in Group 3.

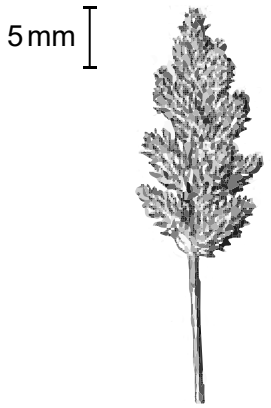
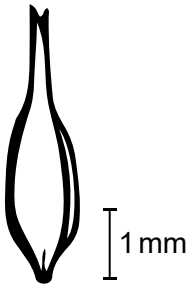
1 .....

2 .....

[2]

(d) The perigynium (female floret) and inflorescences of two of the Group 3 *Carex* species that are native to California are shown in **Fig. 2.4**.

Fig. 2.4

	Surface view of perigynium	**Inflorescence (flowering structure)**
Carex arcta		
Carex bolanderi		

Use **Fig. 2.4** to identify **three** structural differences to distinguish between *Carex arcta* and *Carex bolanderi*.

1 .....

.....

2 .....

.....

3 .....

.....

[2]

(e) Many species of *Carex* are indicator species.

Suggest **one** reason why.

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

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Turn over for the next question

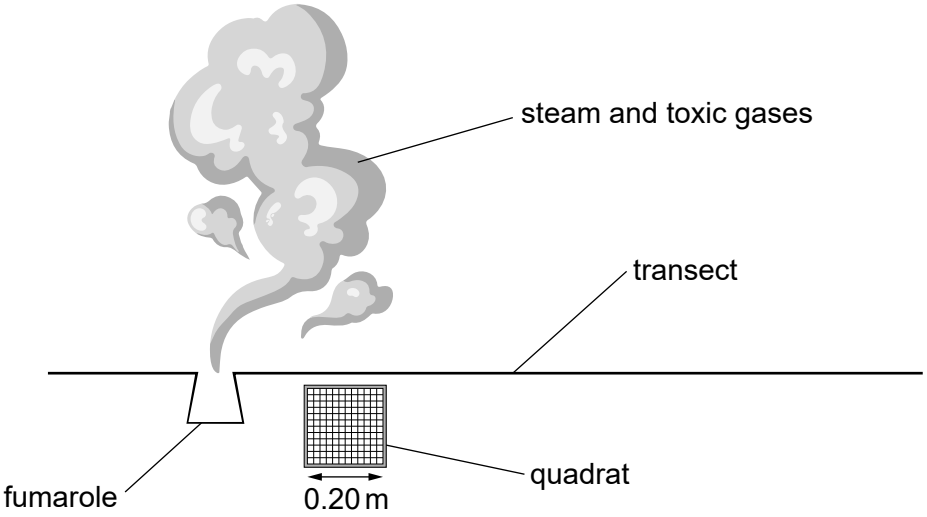
3 A fumarole is an opening in the Earth's surface that emits steam and toxic gases, such as sulfur dioxide and hydrogen sulfide. Fumaroles can occur as holes, cracks or fissures near active volcanoes.

Azmi is investigating the distribution of different species of lichen plants growing on the rocks around a fumarole.

Lichen species may look like plants but they are a combination of a fungus and an alga. They are sensitive to very high temperatures and toxicity.

Azmi measures the percentage (%) area covered by three species of lichen (**X**, **Y** and **Z**) in quadrats along a transect.

A diagram of Azmi's method is shown below.



Her results are shown in the table.

Lichen species	**Distance along the transect from fumarole (m)**						
	25	30	35	40	45	50	55
	% area covered						
X	1	5	3	0	1	3	5
Y	4	5	0	2	6	4	0
Z	2	0	5	0	1	2	2

(a) (i) Many species of lichen do **not** grow where the air is very toxic or the temperature is high.

Use the data in the table to suggest a location along the transect where it may be too hot or too toxic for lichen to grow.

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

(ii) In addition to measuring the % covered by each of the three lichen species, suggest **two** further readings that Azmi must take to find out if the answer in **(a)(i)** is correct.

Reading 1 .....

Reading 2 .....

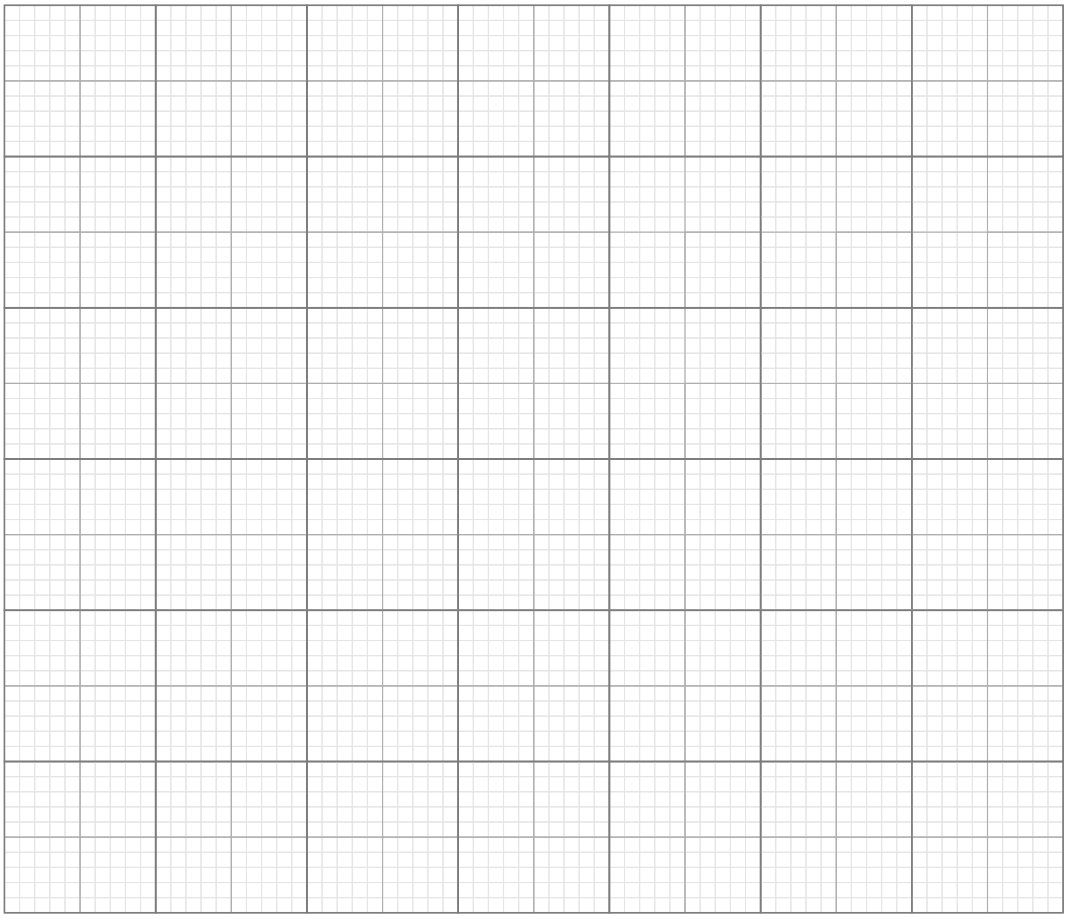
[2]

(iii) Suggest **two** ways in which Azmi can ensure that the measurements described in **(a)(ii)** are repeatable.

.....

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

(b) On the grid, draw a kite diagram of the percentage (%) cover of species **X** against distance from the fumarole.



[4]

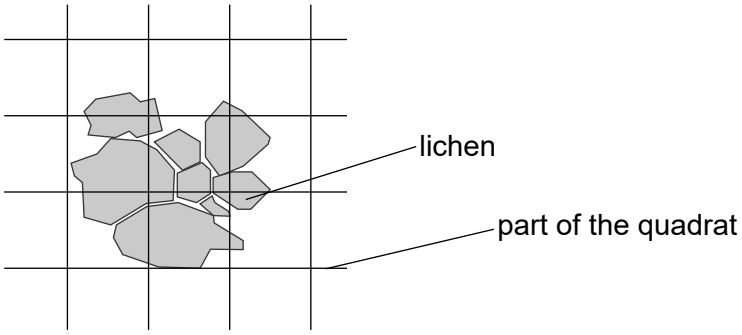
(c) Azmi uses a quadrat to estimate the % area of rock covered by the lichen species.

The quadrat is a square with 0.2 m sides.

The quadrat is divided into 400 smaller squares.

Each small square of the quadrat has an area of 1.0 cm^2.

The figure below shows **one** of Azmi's observations in part of the quadrat.



(i) Azmi determines a value for the shaded area, *A*, covered by the lichen in the figure.

Explain why there is uncertainty in the measurement of *A*.

.....

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

(ii) Determine a possible value for *A* and a reasonable value for the uncertainty in *A*.

A = ... cm^2

Uncertainty = ...

[2]

(iii) Some species of lichen look very similar.

Identifying a species **incorrectly** is a source of error.

Identify this type of error.

Draw a (ring) around the correct type.

instrument **measurement** **systematic**

[1]

4 Sara is a chemist working for an Environment Agency. One of her jobs is to use spectrophotometry to determine the concentration of iron(II) ions in waste water.

Sara uses a spectrophotometer which is designed to determine concentrations of iron(II) ions between 0 and 4 mg dm^{-3}.

She first needs to calibrate the instrument using a stock solution containing 100 mg dm^{-3} of iron(II) ions.

Explain how she would use the stock solution to produce a calibration curve, and describe the measurements needed to determine the concentration of iron(II) ions in waste water samples.

.....

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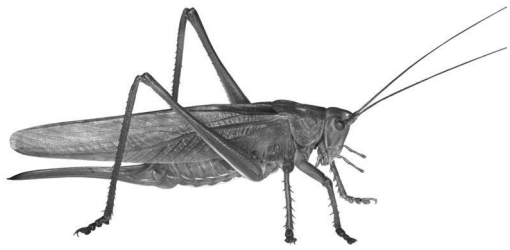
..... **[6]**

5 A cricket is an insect that produces sounds, or chirps, by scraping its wings together.

A cricket is shown in **Fig. 5.1**.

Fig. 5.1



Taylor is a student investigating the claim that the number of cricket chirps counted in a period of time can be used to calculate an accurate value of the temperature.

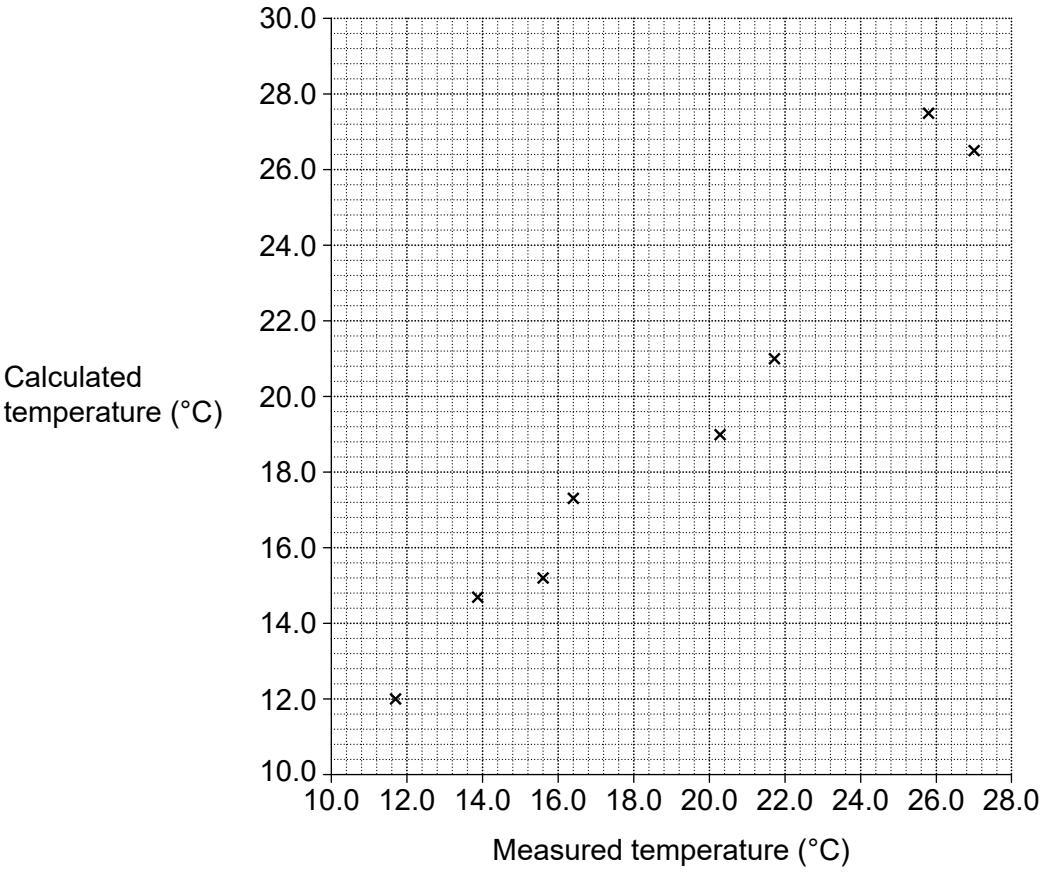
He counts the number of chirps, N, in 15 seconds over a wide range of measured temperatures.

Taylor then calculates the temperature, T_c, in Celsius using the equation:

$$T_c = 9 + \frac{N}{2}$$

Fig. 5.2 is a graph of Taylor's calculated temperatures against his measured temperatures.

Fig. 5.2



(a) What type of graph is shown in **Fig. 5.2**?

Tick (✓) one box.

histogram ☐

line ☐

scatter ☐

[1]

(b) In one observation, Taylor counts 37 chirps in 15 s at a measured temperature of 24.8 °C.

(i) Calculate T_c.

T_c = ... °C **[2]**

(ii) On **Fig. 5.2** use a cross (X) to plot your value of T_c calculated in **(b)(i)**. **[1]**

(iii) On **Fig. 5.2** draw the line of best fit and circle the point that is an outlier. **[2]**

(c) Calculate the gradient *G* of this line of best fit.

Use the equation $G = \frac{\text{change in y}}{\text{change in x}}$

Show your working on **Fig. 5.2**.

G = ... **[4]**

(d) Discuss whether the information from the graph and your answer to **(c)** supports the claim that the number of cricket chirps counted in a period of time can be used to calculate an accurate value of the temperature.

.....

.....

.....

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

(e) Taylor has **not** provided all the information about his investigation.

His data is not reproducible by other scientists without this information.

(i) Explain what reproducible means.

.....

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

(ii) Suggest **three** pieces of information that Taylor must provide so that other scientists are able to reproduce his data.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

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Turn over for the next question

6 Nina uses an app on her smartphone to measure atmospheric air pressure.

She records the air pressure (p) in hPa for one minute indoors, and for one minute outdoors.

1 hPa (hectopascal) = 100 Pa (pascal)

Her results are shown in **Figs 6.1** and **6.2**.

Fig. 6.1

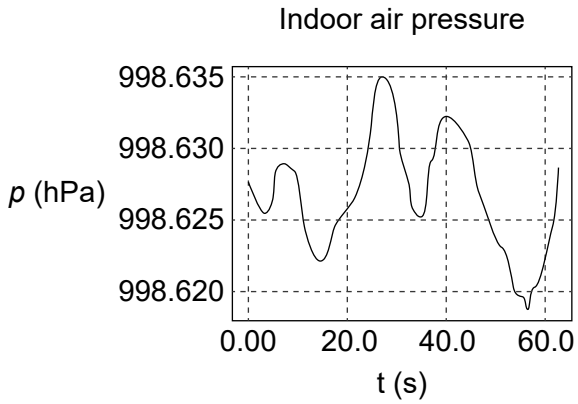
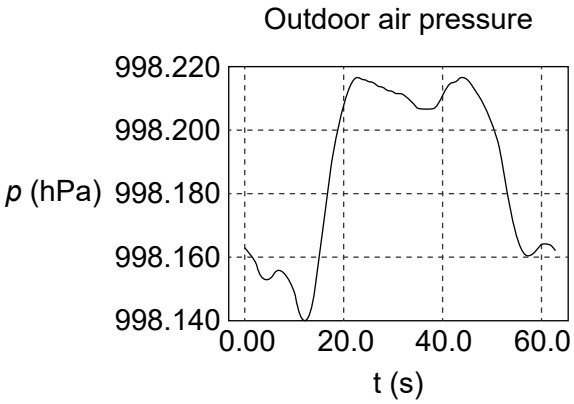


Fig. 6.2



(a) Complete the following sentences by putting a (ring) around the correct word in each bracket.

The data in **Figs. 6.1** and **6.2** show random error because the measurements vary in **(predictable / unpredictable)** ways and **(can / cannot)** be corrected for.

Whenever a measurement is taken, random error is always **(expected / unexpected)**.

[3]

(b) Use **Fig. 6.1** to explain why the pressure measurements are precise.

.....

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

(c) At the same time as Nina takes her own measurements, she also collects data from the website of a weather station at her local airport.

Location:	Local airport
Latest report:	18 Jan 2021, 14:20
Air pressure:	1016 hPa
Temperature:	6 °C
Conditions:	Mostly cloudy
Humidity:	76%

(i) Nina decides to use the air pressure reading at the weather station as the 'accepted value'.

Calculate the percentage error in Nina's minimum outdoor air pressure measurement when p = 998.140 hPa.

Use the equation:

$$\text{percentage error} = \frac{(\text{accepted value} - \text{measurement value}) \times 100}{\text{accepted value}}$$

Percentage error = ... **[2]**

(ii) Nina concludes that

"The atmospheric air pressure measured by my smartphone is accurate."

State and explain whether Nina's conclusion is supported by your calculation in **(c)(i)** and suggest **one** piece of further information that would make her conclusion more secure.

Explanation

.....

.....

Further information

.....

.....

[2]

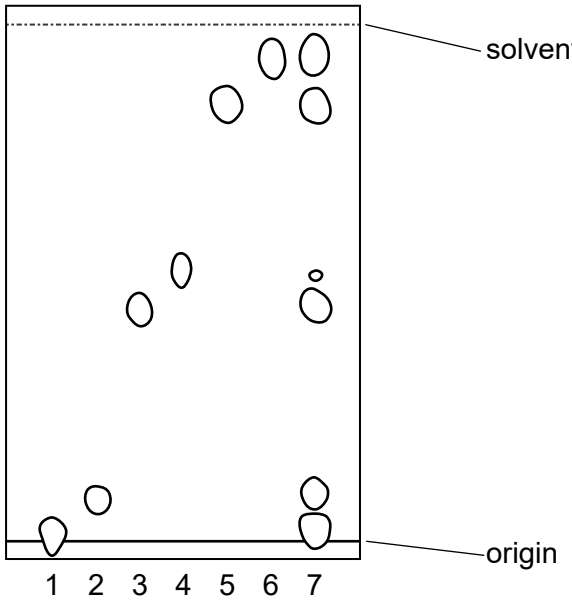
7 Amaya works for a pharmaceutical company which manufactures a range of painkillers. Many painkillers such as morphine and codeine are alkaloids which occur naturally in poppy seeds. Amaya is investigating which species of poppy have seeds that contain codeine so that it can be extracted for use as a painkiller.

(a) Amaya uses thin layer chromatography (TLC) to identify which alkaloids are present in poppy seeds.

She runs 6 known alkaloids (numbered 1 to 6) against a sample of the poppy seed extract (number 7).

Fig. 7.1 shows the chromatogram she obtained.

Fig. 7.1



(i) Explain why Amaya runs her chromatogram using known alkaloids as well as the extract from the poppy seeds.

.....

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

(ii) Use the chromatogram in **Fig. 7.1** to state the number of alkaloids in the poppy seed extract.

.....

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

(iii) One of the known alkaloids (1 to 6) is thebaine. The *Rf* value for thebaine is 0.47. Write the letter **T** on **Fig. 7.1** to indicate which of the known alkaloid spots corresponds to thebaine. **[1]**

(iv) Amaya thinks that one of the spots in her poppy seed extract might be due to more than one alkaloid with the same *Rf* value.

Describe how Amaya could use the **same** TLC plate to investigate this.

.....

.....

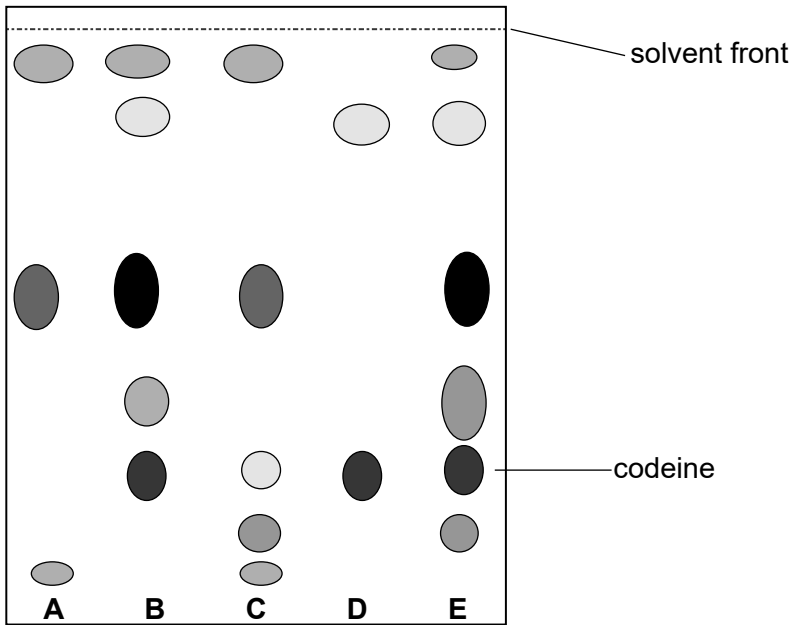
..... **[2]**

(b) Amaya then finds out which poppy plants could be used as a source of codeine.

- She runs a TLC plate using poppy seeds from 5 different plants, **A** to **E**.
- She uses the same mass of seeds to prepare each extract.
- After running the TLC she uses a locating agent to reveal the positions of the spots, and then draws a circle round each spot.

The chromatogram obtained is shown in **Fig. 7.2**.

Fig. 7.2



(i) Explain why Amaya draws round each spot immediately after using the locating agent.

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

(ii) Use **Fig. 7.2** to suggest why Amaya might choose plant **D** to extract codeine from to make painkiller tablets.

.....

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

(iii) Complete the sentences about the elution technique using words from the list.

The words may be used once, more than once or not at all.

chamber	**mass spectrometer**	**oven**
paper	**plate**	**salt solution**
solute	**solvent**	**spectrophotometer**

Scrape the (codeine) spot from the ..... .

Elute the codeine using a suitable ..... .

Place in a ..... to measure how much light is absorbed.

[3]

(iv) Tick (✓) the box next to the name of a method other than elution that Amaya could use to determine the amount of codeine in the sample.

calorimetry ☐

colorimetry ☐

densitometry ☐

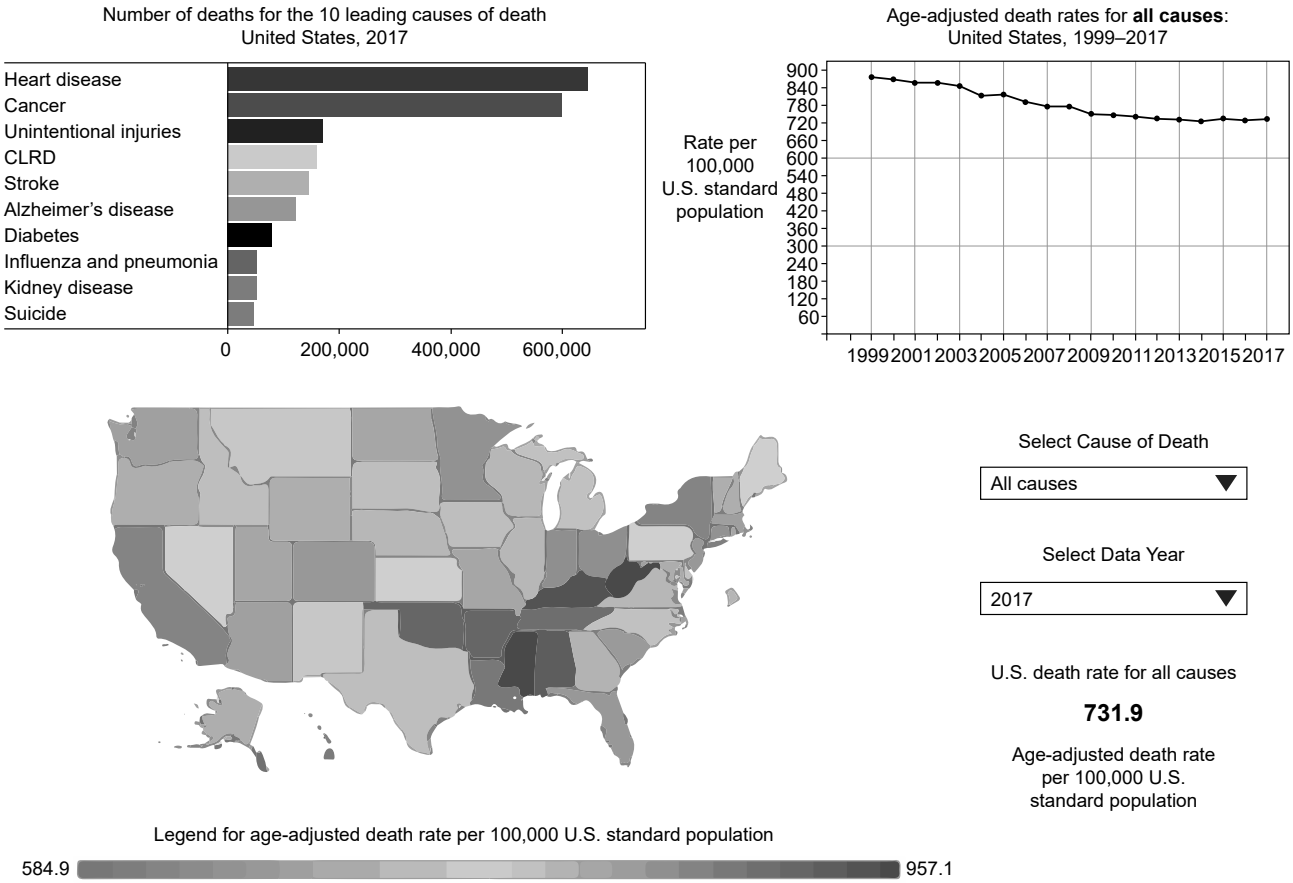
micrometry ☐

titration ☐

[1]

8 The Centers for Disease Control and Prevention (CDC) in the United States of America (USA) collects and collates data on the causes of death in the USA. The results are published on their website, part of which is shown in **Fig. 8.1**.

Fig. 8.1



(a) List **three** methods of displaying data that can be seen on the website shown in **Fig. 8.1**.

1 .....

2 .....

3 .....

[3]

(b) Describe and explain **one** advantage of publishing data on the internet rather than in printed publications.

.....

.....

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

(c) Suggest why data published by the CDC in **Fig. 8.1** is likely to be accepted as reliable by its intended audience.

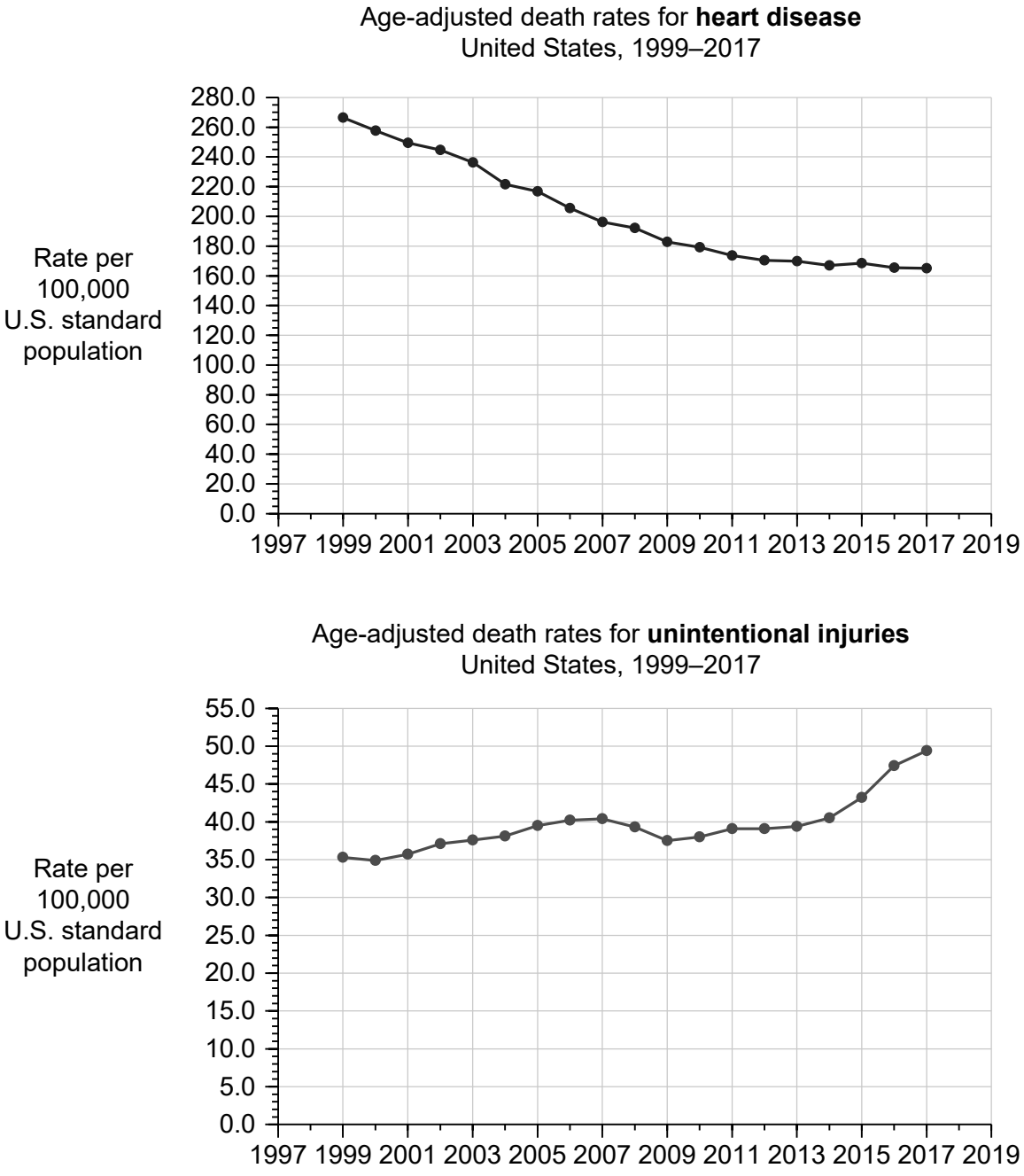
.....

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

(d) The CDC website can also be used to obtain additional information about death rates from different causes.

Fig. 8.2 shows how the death rate from heart disease and unintentional injuries (accidents) have changed between 1999 and 2017.

Fig. 8.2



(i) Describe the trends shown in the two graphs.

Heart disease .....

.....

Unintentional injuries (accidents) .....

.....

[3]

(ii) Suggest how the data shown in **Fig. 8.2** could be useful to the US government.

Heart disease .....

.....

.....

Unintentional injuries (accidents) .....

.....

.....

[4]

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, 4 or 5(d).

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	(3) 13	(4) 14	(5) 15	(6) 16	(7) 17	(0) 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