Oxford Cambridge and RSA

Monday 18 January 2021 – Morning

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C342/2101

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	/21
2	/20
3	/14
4	/11
5	/8
6	/16
7	/10
Total	**/100**

Answer **all** the questions.

1 Alex is investigating the dispersal of seeds from a sycamore tree.

Sycamore seeds are wing shaped as shown in **Fig.1.1.**

Their shape causes them to spin away from the tree as they fall through the air.

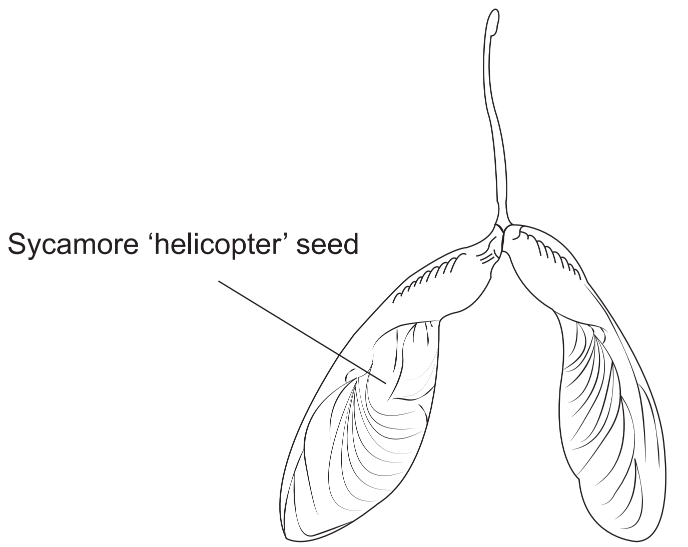


Fig. 1.1

Alex counts the number of seeds in quadrats on one side of a 10 m line transect.

The quadrat used is a wire square-shaped grid (0.5 × 0.5 m) divided into 100 equal sections. The sections make it easier for Alex to count the seeds.

Fig. 1.2 is a diagram of Alex's method.

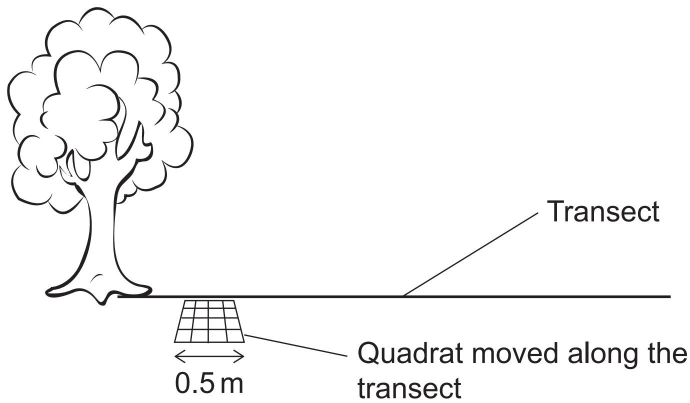


Fig. 1.2

Alex's results are shown in **Table 1.1.**

Distance from tree along the transect line (m)	1	2	3	4	5	6	7	8	9	10
Number of sycamore seeds in each quadrat	39	36	27	18	16	16	10	12	3	0

Table 1.1

(a) Alex uses the scale in **Table 1.2** to convert the number of seeds shown in **Table 1.1** into an abundance rating.

Number of seeds per quadrat	Abundance rating
28 or more	5
22 to 28	4
15 to 21	3
8 to 14	2
1 to 7	1

Table 1.2

(i) Complete **Table 1.3** to show the abundance rating of sycamore seeds at each distance from the tree.

Distance from tree (m)	1	2	3	4	5	6	7	8	9	10
Number of seeds	39	36	27	18	16	16	10	12	3	0
Abundance rating										

Table 1.3

[1]

(ii) Use your answer in **Table 1.3** to draw a kite diagram on the grid in **Fig. 1.3**.

Your kite diagram should show how the abundance rating of sycamore seeds varies with distance from the tree.

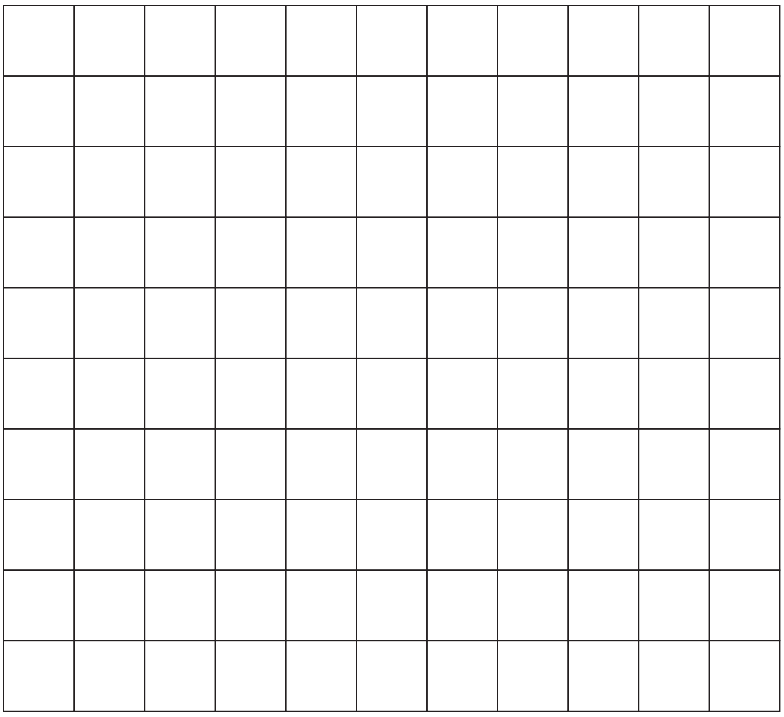


Fig. 1.3

[4]

(b) Alex repeats his investigation.

He places the transect line in different directions around the tree and counts the number of sycamore seeds in the quadrat along the length of each position of the transect line.

Alex then calculates the number of seeds in each direction as a percentage of the total number of seeds in all directions.

His results are shown in **Table 1.4**.

Direction	**Percentage of total number of seeds**
north (0°)	5
north-east (45°)	40
east (90°)	25
south-east (135°)	10
south (180°)	5
south-west (225°)	5
west (270°)	5
north-west (315°)	5

Table 1.4

Complete the pie chart in **Fig. 1.4** to show the percentage of seeds in the **north-east**, **east** and **south-east** directions.

Label these three sectors.

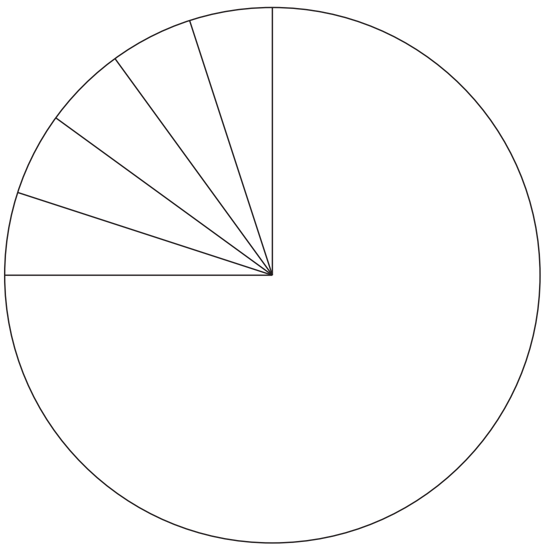


Fig. 1.4

[3]

(c) Alex looks online for an explanation of the seed dispersal.

He finds the chart in **Fig. 1.5** in a journal about UK weather.

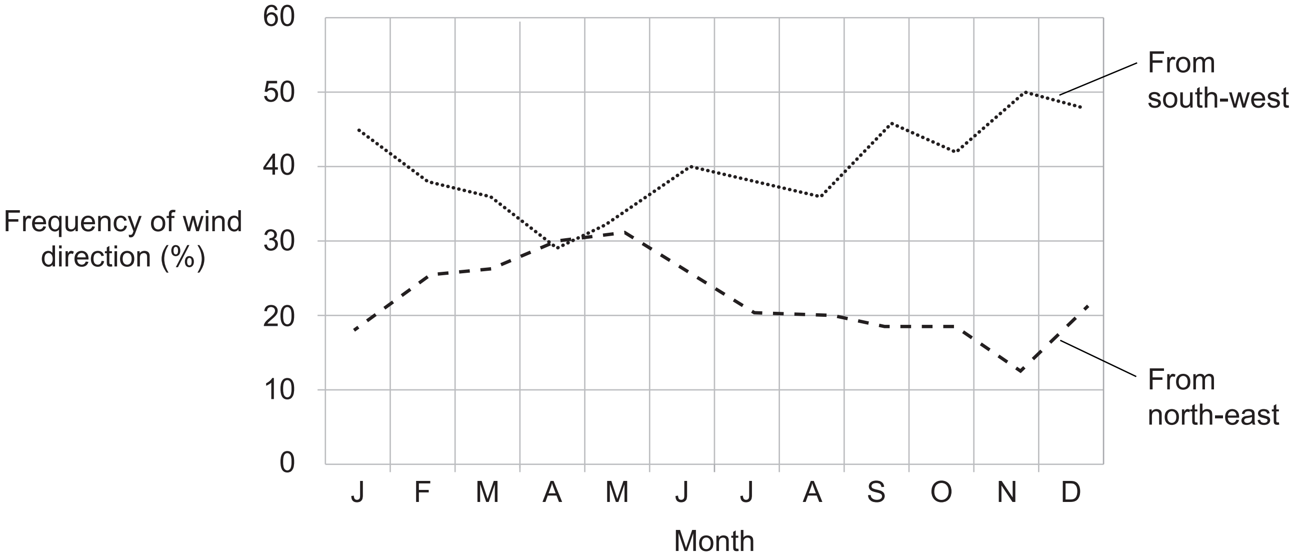


Fig. 1.5

He knows that wind blowing from one direction will blow seeds in the opposite direction.

For example, wind from the south-west will blow seeds in the north-east direction.

(i) Use the data in **Fig. 1.5** to complete the sentence.

In April and ……………………….................. there is a ………..………….................. %

chance that the wind will be blowing from either the north-east or the

……………………….................. . **[3]**

(ii) Discuss whether the evidence in **Fig. 1.5** explains the data in **Table 1.4**.

....

....

....

....

....

....

....

....

....

....

.... **[5]**

(iii) Identify which **three** of the following are **most** likely to make a conclusion more secure.

Tick (✓) **three** boxes.

Obtain frequency data for other wind directions. ☐

Repeat the method in **Fig. 1.2** and find the average. ☐

Repeat the measurements in **Table 1.4** using more directions. ☐

Collect seed dispersal data from different tree species. ☐

Collect seed dispersal data from more than one year. ☐

Obtain wind direction frequency data from more than one year. ☐

[3]

(d) Describe the conflicting evidence in **Table 1.4** and **Fig. 1.5**.

....

....

....

.... **[2]**

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

2 Mia is an astrophysicist.

She studies the relationship between the size of stars and their temperatures.

(a) To calculate the volume of a star Mia uses the formula: Volume of star = $\frac{4}{3}\pi r^3$

(i) Determine the value of $\frac{4}{3}\pi$ as a decimal.

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

$\frac{4}{3}\pi$ = ... **[2]**

(ii) The average radius, r, of the Sun is 7.0×10^8 m.

Calculate the volume of the Sun.

Give your answer in **standard form**.

Volume of the Sun = ... m^3 **[3]**

(iii) The mass of the Sun is 2.0×10^{30} kg.

Calculate the density of the Sun.

Use your answer to **(a)(ii)** and the equation: mass = volume × density.

Give your answer to **2** significant figures and give the SI unit of density.

Density of the Sun = ... unit .... **[3]**

(b) Astronomers measure star brightness in terms of luminosity and magnitude.

Luminosity is the amount of light that a star emits from its surface.

Magnitude is a measure of how bright the star appears. The lower the magnitude, the brighter is the star.

The Sun is a main sequence star.

The two charts in **Fig. 2.1** show the relationships between some of the physical properties of main sequence stars.

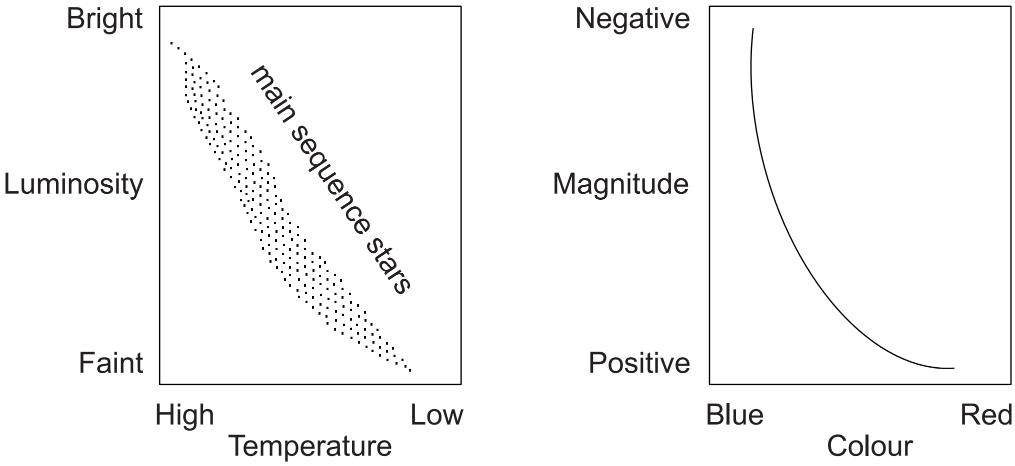


Fig. 2.1

(i) Complete the following sentences to describe the trends in **Fig. 2.1**.

Choose from the following list of words.

You may use each word once, more than once, or not at all.

blue	**bright**	**colour**	**faint**	**increases**	**magnitude**
negative	**neutral**	**positive**	**red**	**temperature**	

As the …………………….................. of main sequence stars becomes increasingly positive, their colour changes from …………………….................. to ………….………….................. .

As their …………………….................. increases, their luminosity changes from …………………….................. to ………….………….................. .

[4]

(ii) Mia studies White Dwarf stars. These are the remnants of main sequence stars. White Dwarf stars are in the region below and to the left of the main sequence stars in both charts in **Fig. 2.1**.

Use the information shown in **Fig. 2.1** to describe White Dwarf stars.

....

....

....

....**[2]**

(c) Only main sequence stars within a certain range of mass become White Dwarfs.

The relationship between the mass of a White Dwarf (compared to the Sun) and its radius (compared to the Sun) is shown in **Fig. 2.2**.

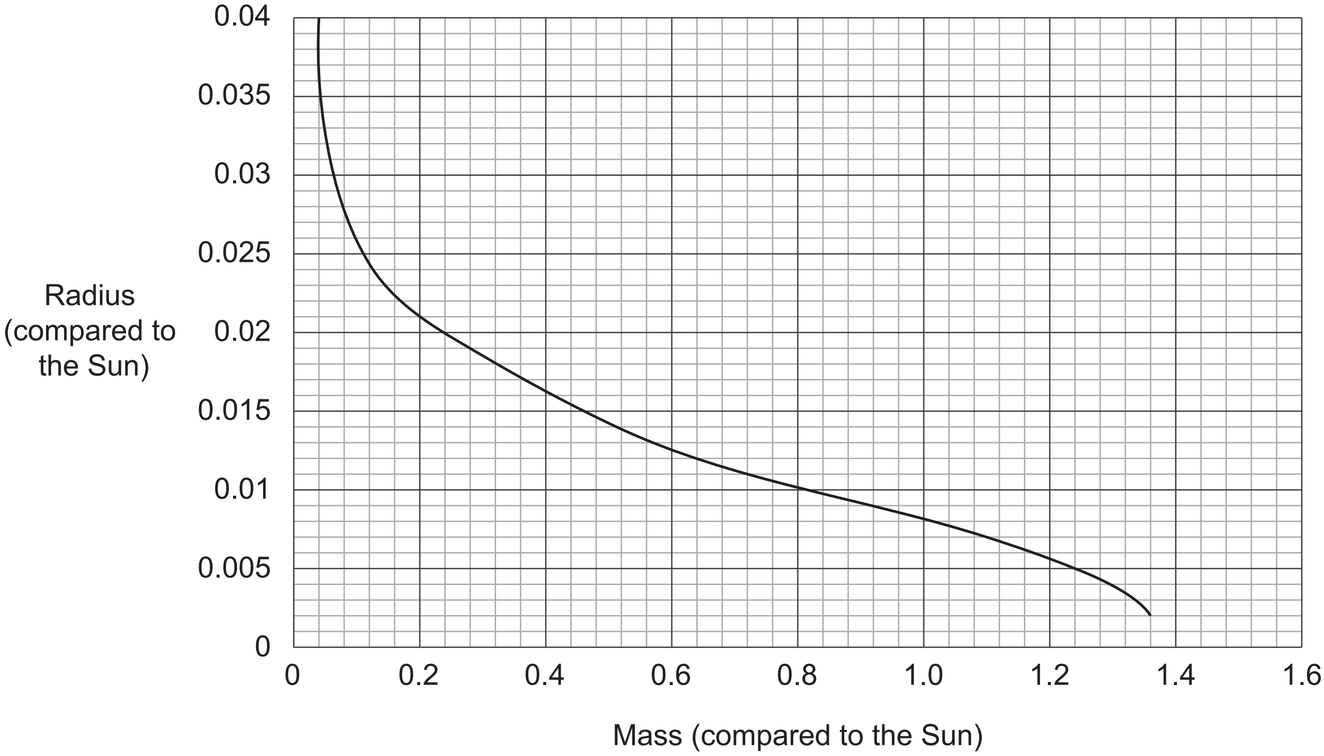


Fig. 2.2

(i) Use **Fig. 2.2** to determine the radius (compared to the Sun) of a White Dwarf formed by a star with a mass of 1.0 (compared to the Sun).

Radius (compared to the Sun) = ………………….…................. **[1]**

(ii) Calculate the volume of a White Dwarf with the same mass as the Sun as a percentage of the Sun's volume.

Percentage volume = ……………………….................. % **[3]**

(iii) Describe the trend shown by the graph in **Fig. 2.2**.

....

.... **[1]**

(iv) Beyond a certain mass, a White Dwarf collapses forming a Black Hole.

Use the graph in **Fig. 2.2** to determine the upper limit to the mass of a White Dwarf.

.... **[1]**

3 Fungi are classified into different families.

One family is called Agaricaceae.

Fig. 3.1 shows some of the structural features of Agaricaceae fungi.

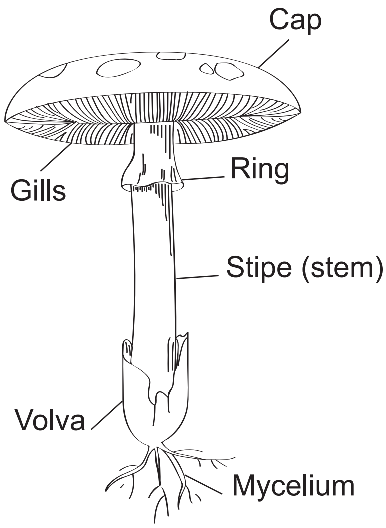


Fig. 3.1

The attachment of each gill to the stipe (stem) of a fungus is called the hymenium.

There are different types of hymenium, as shown in **Table 3.1**.

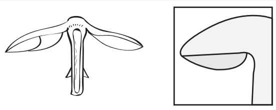
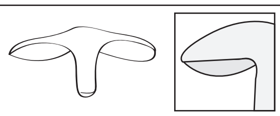
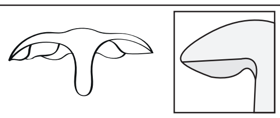
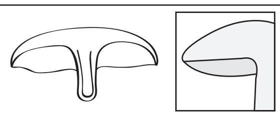
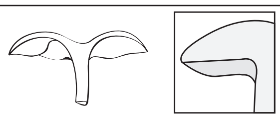
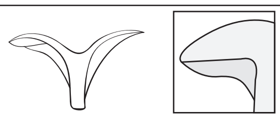
Hymenium		**Description**
	free	gills do not reach the stipe (stem)
	adnexed	gills are narrowly attached to the stipe (stem)
	sinuate	gills curve back down the stipe (stem) before attaching
	adnate	gills are broadly attached to the stipe (stem)
	subdecurrent	gill extends down slightly just as it reaches the stipe (stem)
	decurrent	the whole gill extends down the stipe (stem)

Table 3.1

(a) Use the information in **Table 3.1** to complete the sentences below.

The gills of the fungus shown in **Fig. 3.1** do **not** extend to the base of the stipe (stem).

This means that the hymenium **cannot** be ……………………….................. .

The cap of the fungus in **Fig. 3.1** is the same shape as fungi with a

……………………................... hymenium.

The stipe (stem) of the fungus in **Fig. 3.1** is the same shape as fungi with a

……………………................... hymenium.

[3]

(b) Suggest **three** reasons why biologists use dichotomous keys.

1 ....

....

2 ....

....

3 ....

....

[3]

(c) **Table 3.2** shows some of the habitats and features of different fungi.

You will need to refer to **Fig. 3.1** and **Table 3.1** to see the different types of stipe (stem) and hymenium.

Fungus name	Habitat	Features		
		Stipe (stem)	Spores	Hymenium
Amanitopsis vaginata	grassland	volva	white	free
Entoloma cetratum	woodland	free	pink	sinuate
Galerina marginata	on wood	ring	brown	adnexed
Lepiota procera	grassland	ring	white	free
Paxillus involutus	woodland	free	brown	decurrent
Pholiota squarosa	woodland	ring	brown	adnate
Pleurotus ostreatus	on wood	free	white	decurrent
Pluteus cervinus	on wood	free	pink	free
Tricholoma gambosum	grassland	free	white	sinuate
Volvariella speciosa	grassland	volva	pink	free

Table 3.2

Use the information in **Table 3.2** to complete the blank spaces in the key in **Fig. 3.2**.

Give the **feature** of the fungus in the blank **grey** rectangles.

Give the **fungus name** in the blank **unshaded** rectangles.

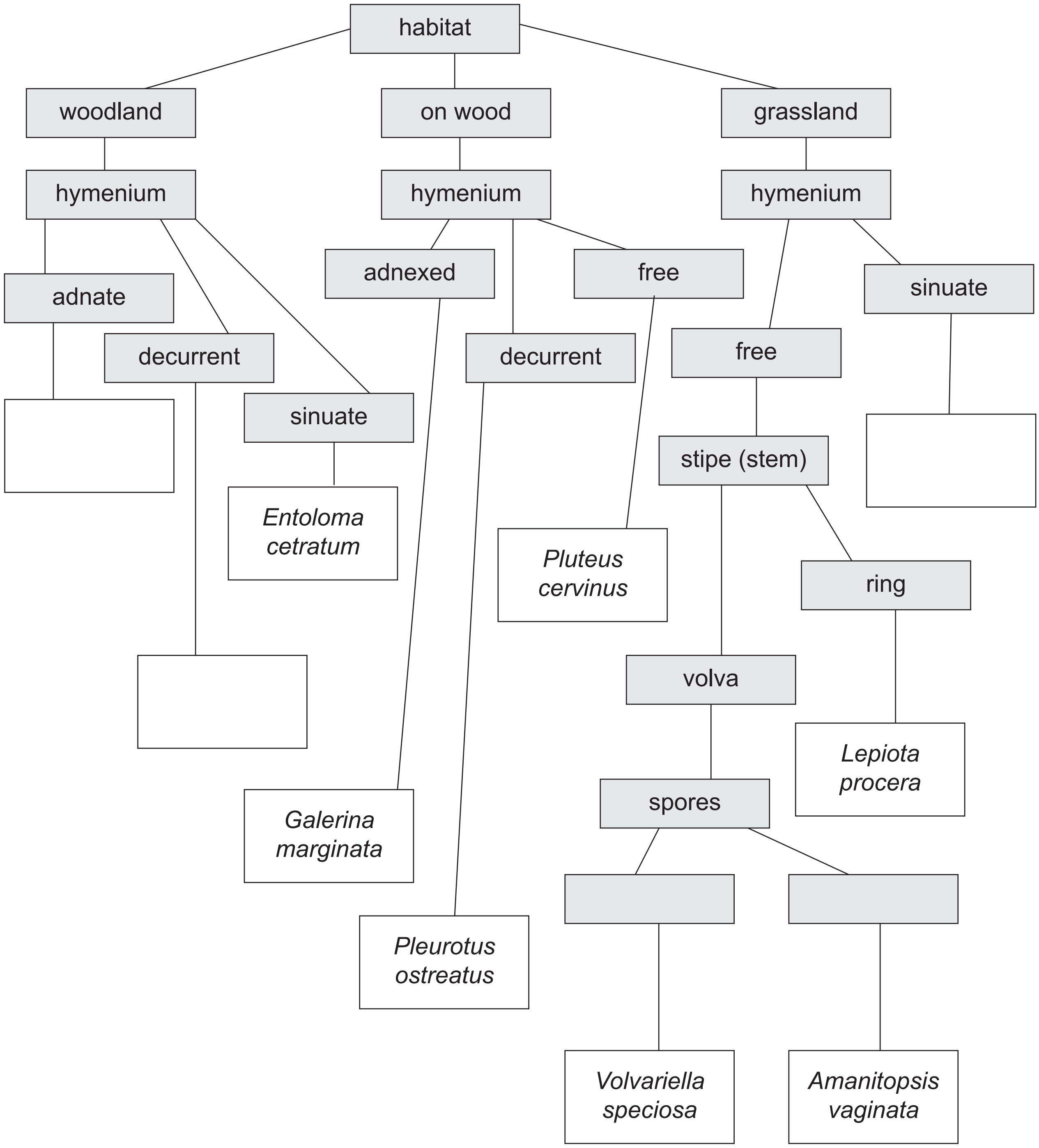


Fig. 3.2

[5]

(d) A fungus described in **Table 3.2** is shown in **Fig. 3.3**.

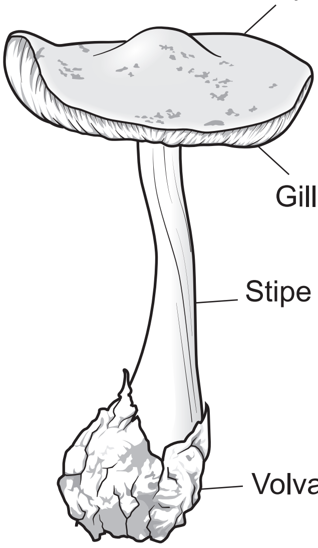


Fig. 3.3

(i) Use **Table 3.2** or the **key in Fig. 3.2** to identify the name of the fungus shown in **Fig. 3.3**.

Tick (✓) **one** box.

Amanitopsis vaginata ☐

Entoloma cetratum ☐

Galerina marginata ☐

Lepiota procera ☐

[1]

(ii) The names of the fungi in **Table 3.2** are based on binomial nomenclature.

Describe the key features of binomial nomenclature and **one** advantage of using this naming system.

Key features ....

....

Advantage ....

....

[2]

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

4 Eve is investigating reflections in plane mirrors.

She places a coin between two mirrors.

Fig. 4.1 shows the coin and two images of the coin reflected in the mirrors.

Fig. 4.1

Eve adjusts the angle between the mirrors.

She observes that there is a range of angles between which whole images first appear and just before another image begins to appear.

(a) Identify what Eve needs to specify to ensure that her investigation is repeatable.

Tick (✓) **three** boxes.

The range of angles between the mirrors.	☐
The diameter of the coin.	☐
The distance between the coin and the junction between the mirrors.	☐
The position of the observer relative to the mirrors.	☐
The number of images.	☐
The surface area of the mirrors.	☐
The thickness of the coin.	☐

[3]

(b) Eve starts her investigation with the two mirrors at an angle of 180°.

As she reduces the angle between the mirrors from 180° to 166°, Eve observes one image of the coin.

When she reduces the angle to 165°, a second image starts to appear.

She continues to reduce the angle between the mirrors until a third image begins to appear. She measures this angle to be 98°.

(i) Describe the relationship between the variables.

....

....**[2]**

(ii) Determine the range and interval of angles for the appearance of two images.

Range = ...

Interval = ...

[2]

(c) Eve finds this formula for the number of images n formed between two plane mirrors:

$$n = \frac{360}{\theta} - 1$$

where θ is the angle between the mirrors.

(i) Use the formula to determine the angle of θ that gives two whole images.

θ = ……………………................. ° **[1]**

(ii) Calculate the number of images which (according to the formula) should be produced when the angle between the mirrors is 165°.

Give your answer to **1** decimal place.

Number of images = ……………………................. **[1]**

(iii) Calculate the error of the observed angle, 98°, as a percentage of the angle calculated in **(c)(i)**.

Use the equation: Percentage error = $\frac{(O - A)}{A} \times 100$

where A is the calculated angle in **(c)(i)**, and O is the observed angle.

Percentage error of 98° = ……………………................. % **[2]**

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

5 Kai is investigating how the angle θ of a sloping track affects the acceleration a, of a glass ball as it rolls down the track.

The track is shown in **Fig. 5.1**.

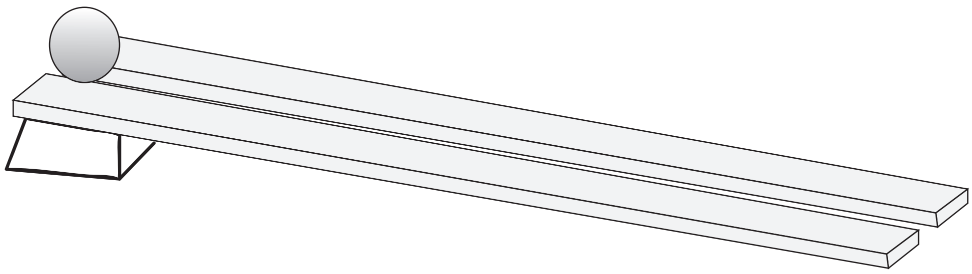


Fig. 5.1

Before he starts the investigation, he uses this equation to calculate some theoretical results:
$a = g \sin \theta$

This equation determines the horizontal component of the acceleration.

Kai uses a value of the acceleration due to gravity, g = 10 m s^{-2}.

He then plots these results on the graph in **Fig. 5.2**.

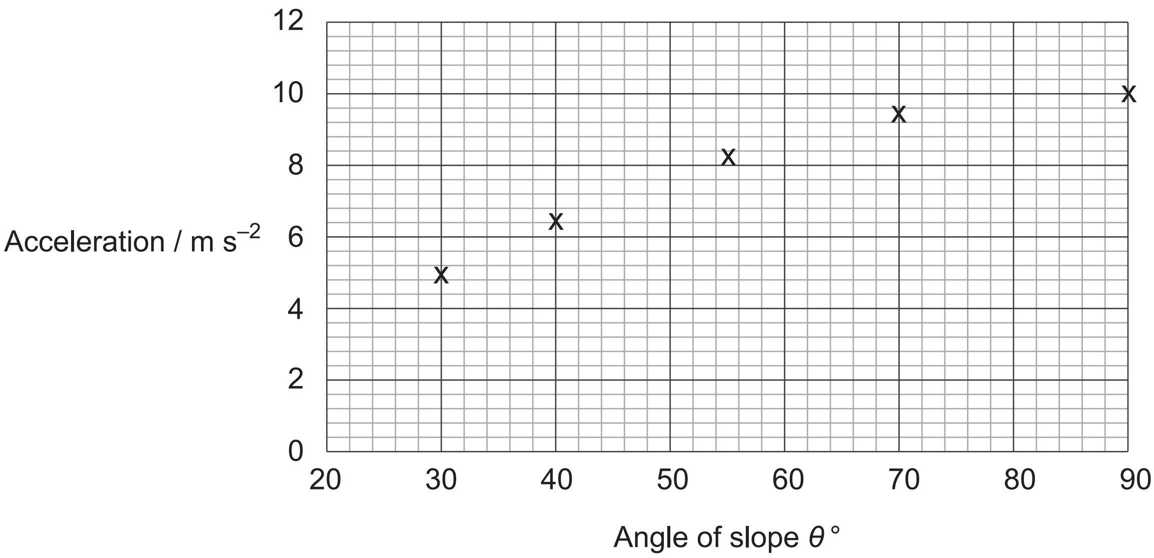


Fig. 5.2

(a) **(i)** On **Fig. 5.2** draw a curve of best fit.

[1]

(ii) Use your curve to determine the acceleration of the ball on a track with an angle of slope θ = 20°.

Acceleration = ……………………………….............. m s^{-2} **[1]**

(iii) Calculate the gradient of the curve of best fit when the angle of the slope is 55°.

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

Gradient at 55° = ……………………….................. **[3]**

(b) Suggest **two** reasons why Kai's theoretical results are **not** accurate.

1 ....

....

2 ....

....

[2]

(c) Suggest why Kai produces theoretical results to compare with the actual results of his investigation.

....

....**[1]**

6 Jack is a technician working in a food science laboratory.

(a) Jack uses a colorimeter to determine the mass of iron in 100 g of spinach leaves.

He knows that when ammonium thiocyanate is added to a solution containing Fe^{3+} ions, a red complex is formed.

Jack obtains a calibration graph by following four steps:

Step 1 He puts 2 cm³ of water in a cuvette in the colorimeter and adjusts the absorbance reading to give a value of zero.

Step 2 He prepares 5 solutions of iron(III) chloride of known concentrations as shown in **Table 6.1**.

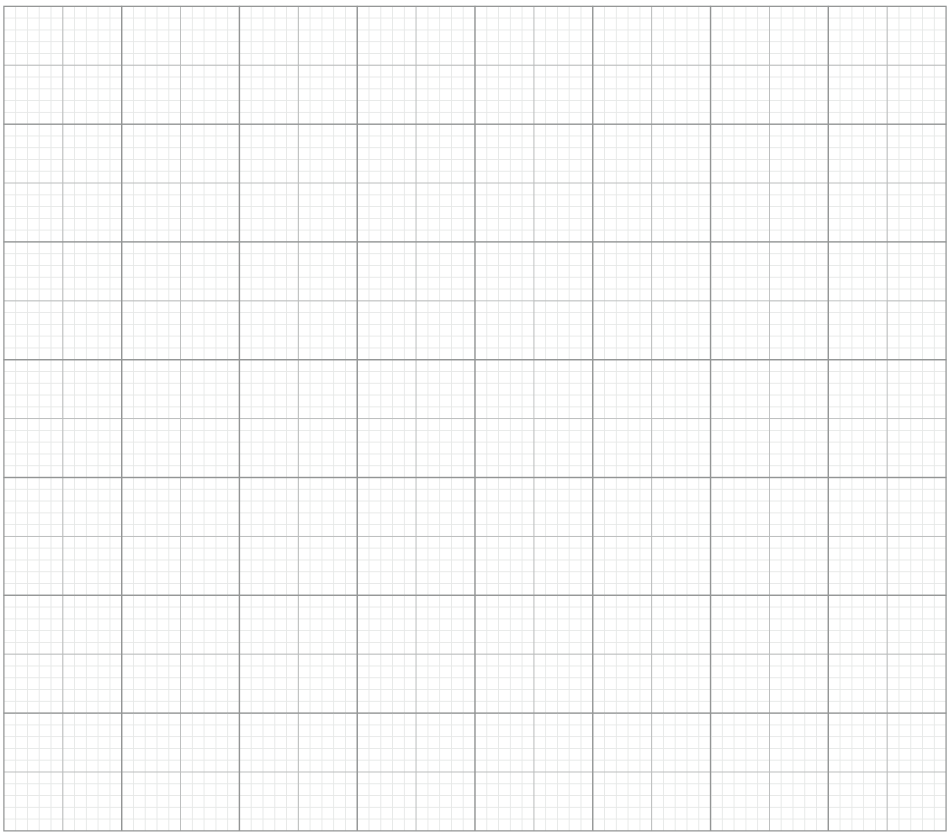
Step 3 He takes 10 cm³ of each solution, adds 10 cm³ of ammonium thiocyanate and mixes thoroughly so that the red colour is evenly distributed.

Step 4 He records the absorbance of 2 cm³ of each solution as shown in **Table 6.1**.

Concentration of Fe^{3+}/ mg dm^{-3}	**Absorbance**
2.6	0.19
5.2	0.58
7.8	0.67
10.4	0.89
13.0	1.11

Table 6.1

(i) Plot a graph of concentration of Fe^{3+} (x-axis) against absorbance (y-axis).



[4]

(ii) Draw a line of best fit on the graph and circle the outlier.

[2]

(b) Jack then uses his calibration graph to find the amount of iron in spinach leaves.

- He gently heats 3.60 g of spinach leaves until they have all burnt.
- He adds 10 cm³ of water and filters the mixture to remove the ash.
- He then adds 10 cm³ of ammonium thiocyanate solution to the 10 cm³ of spinach extract and measures the absorbance.

He finds that the **absorbance value** is 0.70.

Use the following steps to calculate the mass of iron in 100 g of spinach leaves.

(i) Use the graph to determine the concentration of iron (in mg dm^{-3}) in the spinach extract.

Show your working on the graph.

Concentration of iron = ……………………................... mg dm^{-3} **[1]**

(ii) Your answer to **(b)(i)** is the number of mg of iron in 1000 cm³ of the solution.

Use this value to calculate the mass of iron in **10 cm³** of the spinach extract.

Mass of iron in 10 cm³ of the spinach extract = ……………………................... mg **[1]**

(iii) Jack uses 3.60 g of spinach leaves in his experiment.

Use your answer to **(b)(ii)** to calculate the mass in mg of iron in **100 g** of spinach leaves.

Mass of iron in 100 g of spinach leaves = ……………………................... mg **[1]**

(c) The recommended dietary allowance (RDA) of iron in an average person's diet is 14 mg.

Calculate what percentage of the RDA of iron an average person will get by eating 100 g of the spinach leaves used in Jack's experiment.

Percentage of the RDA of iron = ……………………................... % **[1]**

(d) Another technician, Amaya, carries out a titration experiment to compare the vitamin C content of three fruit juices.

One way to determine the amount of vitamin C is to carry out a redox titration using a standard solution of iodine.

When iodine solution is gradually added to a solution containing vitamin C in the presence of starch indicator, iodine is converted to iodide ions.

Once all the vitamin C in the sample has been used up, any further addition of iodine will not react. This excess iodine reacts with starch to form a blue-black complex.

The endpoint of the titration is when the blue-black colour first appears.

Amaya is provided with three different fruit juices, a standard solution of iodine and some starch solution.

She has access to normal glassware apparatus needed for carrying out a titration.

Describe the steps Amaya should follow to find out which fruit juice contains the highest concentration of vitamin C.

In your answer include the names of the apparatus Amaya should use.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

.... **[6]**

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

7 Scientific journal publications contain peer-reviewed articles. Such articles often contain tables of data.

Fig. 7.1 is an example of a table taken from an article which evaluates three different cell counting methods.

The three cell counting methods used were:

- a manual method using a hemocytometer
- a semi-automated method using a Countess cell-counter
- a fully automated method using a Vi-Cell analyser.

Cell counting system	Auto sample	Staining options	Size range (μm)	Sample volume (μL)	Concentration range (cells/mL)	Imaging technology
Hemocytometer [a,b,c]	No	Erythrosin B, Nigrosin, Safranin, Methylene blue and Trypan blue	Undefined	50	$2.5x10^5$ $8.0x10^6$	Microscope objective 40x
Countess cell-counter	No	Trypan blue	8-60	20	$1x10^4$ $1x10^7$	Camera 2.3x objective and 3.1 Megapixel
Vi-Cell® analyser	Yes	Trypan blue	2-70	500	$5x10^4$ $1x10^7$	Auto-focus routine firewire camera 1394x 1040CCD array

[a] Bastidas O. Cell counting with Neubauer chamber. Technical note. Celeromics 1-6

[b] Hsiung F McCollum T, Hefner E and Rubio T. Comparison of count reproducibility, accuracy, and time to results between a hemocytometer and TC20™ Automated cell counter. Technical note: Bio-Rad Laboratories, Inc., 2013.

[c] Maruhashi F, Murakami S, Baba K. Automated monitoring of cell concentration and viability using image analysis system. Cytotechnology 1994; 15: 282-289.

Fig. 7.1

(a) Give **one** reason why a table is a useful way to show this kind of information.

....**[1]**

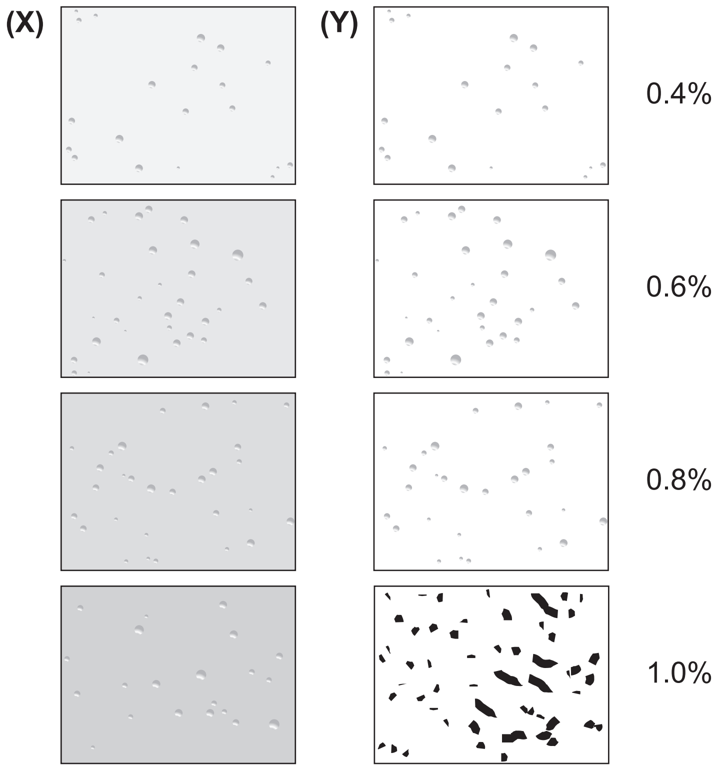
(b) Suggest why the authors of the research article have included references in the table.

....

....**[1]**

(c) The authors presented some of their data in photographic form.

An example of this form of data presentation is shown in **Fig. 7.2**.



Comparison of images produced using the Countess cell-counter with different concentrations of the staining solution.
(X) shows images from the camera, **(Y)** represents images as analysed by computer software

Fig. 7.2

State **two** advantages of presenting data in photographic form in a scientific publication.

1 ....

2 ....
[2]

(d) Data can also be presented graphically.

One of the graphs included in the research paper is shown in **Fig. 7.3**.

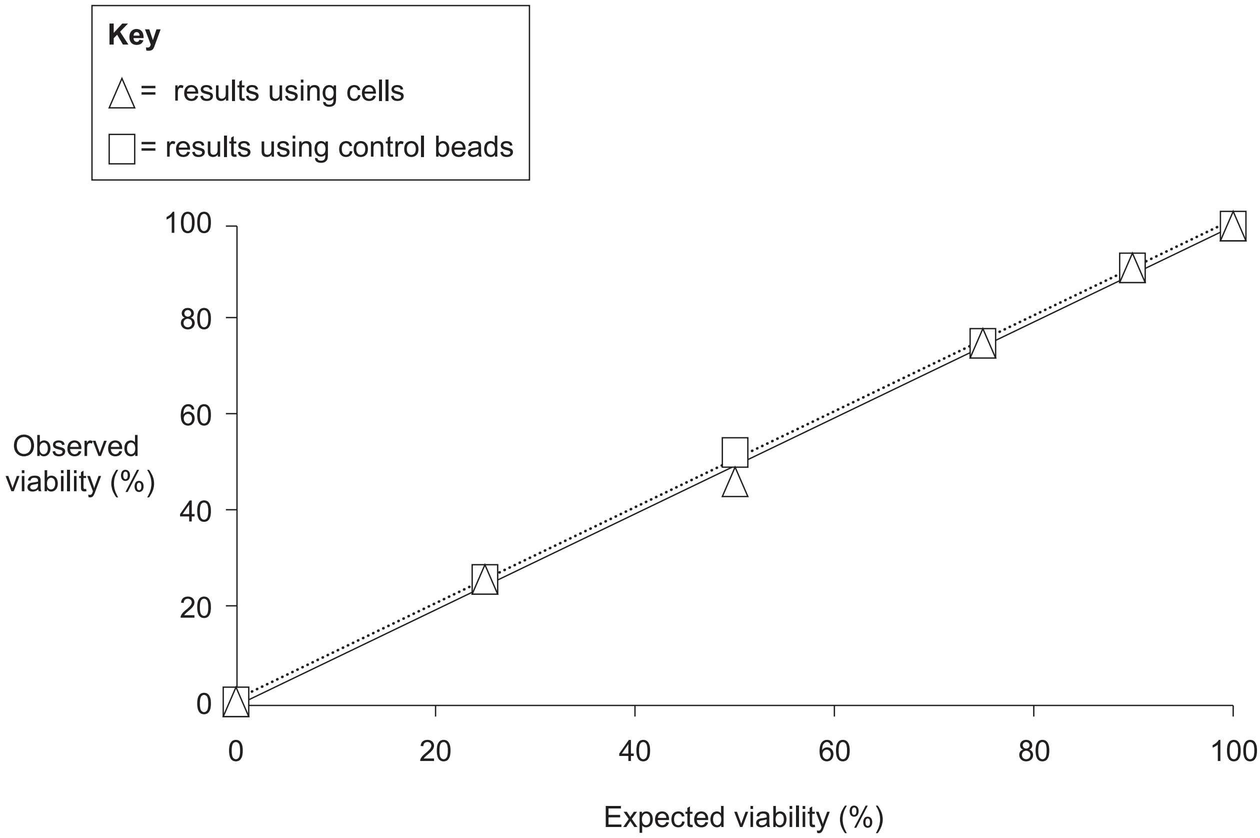


Fig. 7.3

Suggest **two** reasons why the authors chose to show the data in **Fig. 7.3** graphically.

1 ....

2 ....

[2]

(e) In addition to tables, photographs and graphs, data can be recorded in other ways.

List **two** other ways that scientific data can be recorded.

1 ....

2 ....

[2]

(f) In terms of scientific data, explain the meaning of validity and accuracy.

Validity ....

Accuracy ....

[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, 1(c) or 4(a).

The Periodic Table of the Elements

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

Key
atomic number
Symbol
name
relative atomic mass

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

Oxford Cambridge and RSA