OCR
Oxford Cambridge and RSA

Thursday 17 January 2019 – Afternoon

LEVEL 3 CAMBRIDGE TECHNICAL IN APPLIED SCIENCE

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

Duration: 2 hours

C342/1901

You must have:
- a ruler

You may use:
- a scientific or graphical calculator

First Name		Last Name	
Centre Number		Candidate Number	
Date of Birth	D D M M Y Y Y Y		

INSTRUCTIONS
- Use black ink.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer **all** the questions.
- If additional answer space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- The Periodic Table is printed on the back page.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **32** pages.

FOR EXAMINER USE ONLY	
Question No	**Mark**
1	/17
2	/12
3	/15
4	/17
5	/13
6	/16
7	/10
Total	**/100**

Answer **all** the questions.

1 The formation and decay of strong magnetic fields in the solar atmosphere causes sunspots on the Sun's surface.

Table 1.1 shows the number of sunspots each year from 1999 and 2011.

Year	Number of sunspots
1999	93
2000	120
2001	111
2002	104
2003	64
2004	40
2005	30
2006	15
2007	8
2008	3
2009	3
2010	17
2011	56

Table 1.1

(a) Calculate the median number of sunspots in **Table 1.1**.

median = ...
[1]

(b) Calculate the mean number of sunspots in **Table 1.1**.

Show your working.

mean = ...
[2]

(c) The formula below can be used to calculate the standard deviation for the data in **Table 1.1**.

standard deviation $s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(x_i - \overline{x}\right)^2}$

N = 13, the number of years from 1999 to 2011

x_i is the number of sunspots in a particular year

$\overline{x}$ is the mean calculated in **(b)**

Use the formula above to calculate the standard deviation for the data in **Table 1.1**.

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

Show your working.

standard deviation = ...
[6]

(d) The relative sunspot number is a quantity that measures the number of sunspots and groups of sunspots present on the surface of the Sun.

The relative sunspot number is calculated using the formula: $R = k\,(10g + s)$

s is the number of individual spots

g is the number of sunspot groups

k is a factor that varies with location and instrumentation

Rearrange the relative sunspot number formula to make g the subject.

g = ...
[2]

(e) **(i)** The solar constant G_{SC} is the radiation received by the Earth when it is at the mean distance from the Sun.

$G_{SC} = 1.361\ kW\ m^{-2}$

The radius (r) of the Earth is 6371×10^3 m.

Calculate the total radiation received, per second, by the Earth.

Use the formula: Area = πr^2

$\pi = 3.14$

total radiation = ...kJ s^{-1}
[3]

(ii) The Earth's orbit is elliptical.

The distance between the Sun and the Earth varies by 1.7%.

Calculate the difference between the maximum and the minimum radiation received per second by Earth. Use your answer from **(e)(i)**.

Show your working.

energy difference = ...kJ
[3]

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Turn over for the next question

2 Mia is investigating the distribution of plants in a field.

She uses quadrats to survey four plant species growing in a field surrounding a tree.

She counts the number of each plant species on both sides of a 10 m line transect.

A quadrat is shown in **Fig 2.1**.

Fig. 2.1

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

	Distance from tree (m)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Number of each plant species	**A. Stinging nettle**	1	4								
	B. Rough hawkbit			1	1		1				
	C. Common chickweed				2	8					
	D. White clover						10	9	9	4	

Table 2.1

(a) Mia decides to present the data from **Table 2.1** in another table to show the species total and the percentage of each species.

(i) Complete **Table 2.2** for species **B**, **C** and **D**. Species A has already been calculated.

Distance from tree (m)	**Species total**	**Percentage of total number of plants (%)**
A. Stinging nettle	5	10
B. Rough hawkbit		
C. Common chickweed		
D. White clover		
Total	50	100

Table 2.2

[3]

(ii) Complete the pie chart in **Fig. 2.2** using the data from **Table 2.2**.

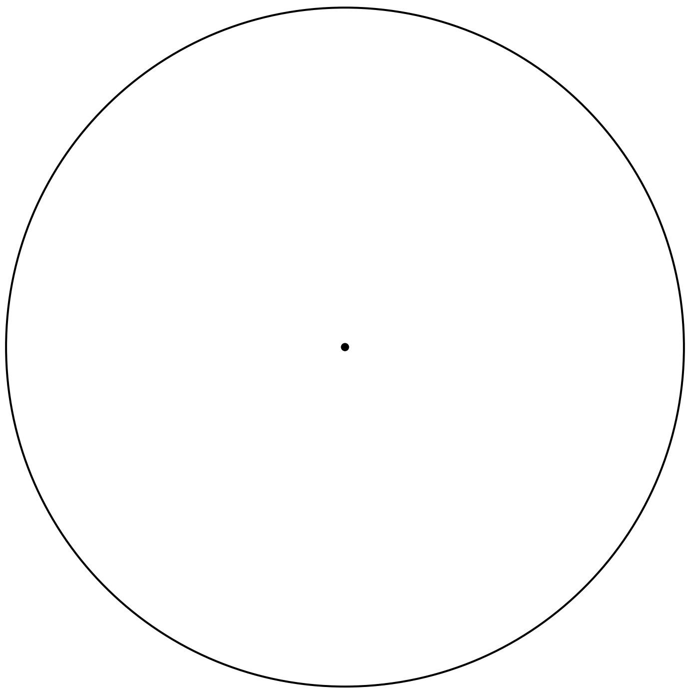

Fig. 2.2

[2]

(b) Mia also plots the graph in **Fig. 2.3** to show how light intensity varies with distance from the tree along the 10 m line transect.

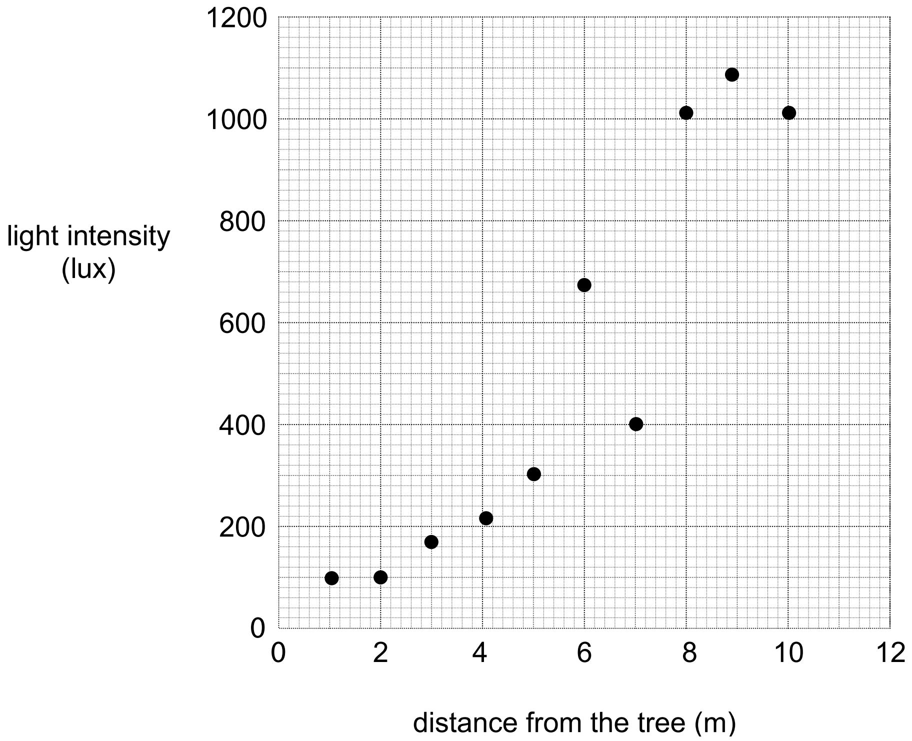

Fig. 2.3

(i) On the graph in **Fig. 2.3** draw a curve of best fit.

[1]

(ii) Draw a circle around the outlier in the graph in **Fig. 2.3**.

[1]

(iii) Use the graph in **Fig. 2.3** to identify the value of light intensity that Mia should expect to find at the outlier.

expected value = ...lux
[1]

(iv) Calculate the gradient of the graph in **Fig. 2.3** at a distance of 4.0 m from the tree.

Give the units.

Show your working.

gradient = ... units ....
[4]

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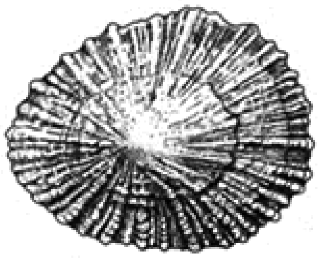
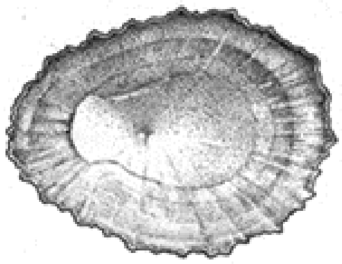
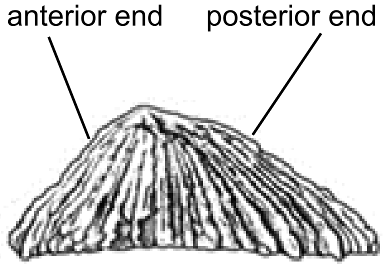
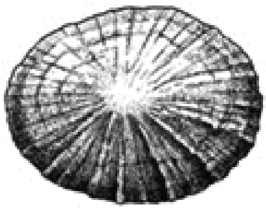
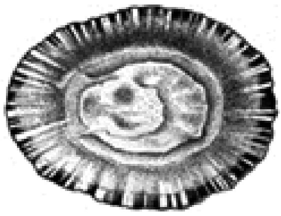
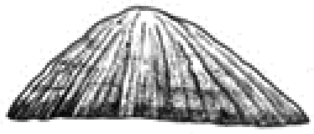
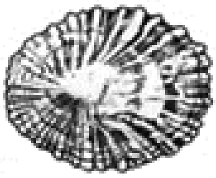
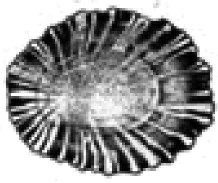
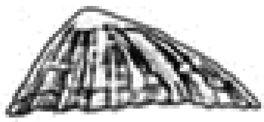
Turn over for the next question

3 Layla is on a field trip to a seashore.

She is investigating the features of three species of limpet, **A**, **B** and **C**.

Her teacher has given her some drawings of the empty shells of adult sized limpets of the three species as shown in **Table 3.1**.

Limpet	Top view	Internal view	Side view
A			
B			
C			

2 cm

Table 3.1

(a) The three species of limpet in **Table 3.1** are *Patella depressa*, *Patella ulyssiponensis* and *Patella vulgata*.

(i) What is indicated by the term '*Patella*'?

.... **[1]**

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

.... **[1]**

(iii) An internet source describes:

- *Patella ulyssiponensis* as a limpet with a low cone with an apex noticeably anterior to centre
- *Patella vulgata* as a limpet with an anterior end which is noticeably narrower than the posterior end.

Use **Table 3.1** to identify *P. ulyssiponensis* and *P. vulgata*.

Choose **A**, **B** or **C**.

Justify your choice.

P. ulyssiponensis is .... because ....

....

P. vulgata is .... because ....

.... **[4]**

(b) Layla designs an identification key for the limpets in **Table 3.1** using the format as shown in **Fig. 3.1**.

1a ……………………………go to 2
1b ……………………………go to 3

2a ……………………………(answer)
2b ……………………………(answer)

Fig. 3.1

Give the name of the identification key shown in **Fig. 3.1**.

....**[1]**

(c) (i) What type of data is shown in **Table 3.1**?

....**[1]**

(ii) Give **one advantage** and **one disadvantage** of using the data shown in **Table 3.1** to identify limpets.

advantage ....

....

disadvantage..

.... **[2]**

(d) Limpets attach themselves to rocks with a strong muscular foot. During the field trip Layla was told **not** to detach any limpets from the rocks.

Explain why **not** detaching any limpets may be a disadvantage when trying to identify the limpet species.

....

....

....**[2]**

(e) Layla also has a description of the seashore as shown in **Fig. 3.2**.

High tide zone: Shoreline. Covered with seawater only during high tides.

Middle tide zone: Two times a day seaweeds and animals are covered and uncovered by seawater, allowing exposure to air.

Low tide zone: Seaweeds and animals are almost always covered with seawater and exposed to air only at the lowest of tides.

Fig. 3.2

Explain how the information in **Fig. 3.2** may be used to identify species of limpet and why Layla should only count the limpets that are attached to the rocks.

....

....

....

....

....**[3]**

4 Alex is an oceanographer.

He calculates the depth of the ocean floor using an instrument that emits a pulse of sound. He measures the time taken for the pulse of sound to return.

He needs to estimate the speed of sound through seawater to complete his calculation.

(a) Alex uses the data in **Table 4.1** to calculate the maximum and minimum values for the speed of sound through water.

Temperature *T* (°C)	**Salinity S (ppt)**	**Depth *D* (m)**	**Speed of sound in seawater *c* (ms^{-1})**
20.5	36.75	0	1525.2
19.5	33.25	0	1517.7
14.0	36.75	500	1514.0
12.0	33.25	500	1502.7
4.0	36.75	1000	1485.3
2.0	33.25	1000	1472.1

Table 4.1

(i) Determine the **three** intervals of the temperature measurements in **Table 4.1**.

....

....

....

.... **[3]**

(ii) Determine the interval of salinity measurements in **Table 4.1**.

....

.... **[1]**

(iii) Describe the relationships between *T* and *D*, *T* and *c*, and *S* and *c*.

T and *D* ....

....

T and *c* ....

....

S and *c* ....

.... **[3]**

(b) Alex uses a salinometer to measure the salinity (amount of dissolved salt) of the seawater.

The salinometer contains a probe which is inserted into a sample of seawater.

Alex calibrates the salinometer using a standard sample of salinity 20.0 ppt. After the first test he adjusts the salinometer and repeats the test.

Table 4.2 shows the results of the two tests.

	Repeat				
	1	2	3	4	5
Test A	21.6	21.5	21.4	21.5	21.4
Test B	20.1	20.0	19.9	20.0	19.9

Table 4.2

(i) What type of error is shown in **Test A**?

Tick (✓) **one** box.

Measurement error ☐

Random error ☐

Systematic error ☐

[1]

(ii) Suggest a possible cause of the error identified in **(b)(i)**.

....

....**[1]**

(iii) What type of error is shown in **Test B**?

Tick (✓) **one** box.

Measurement error ☐

Random error ☐

Systematic error ☐

[1]

(iv) Suggest how the error identified in **(b)(iii)** can be minimised.

....

....**[1]**

(v) Describe what Alex must do to ensure that there is **no** instrument error.

....

....

....**[2]**

(c) The instrument used by Alex to emit a pulse of sound down to the seabed is called a fathometer. The fathometer has a range of timer options.

Alex uses the data in **Table 4.2** to calculate an average speed of sound as 1504.3 m s^{-1}.

He uses the time measurement and the average speed to calculate the depth of the seabed.

(i) Complete **Table 4.3**.

Use the equation: depth = 0.5 × speed × time

	Time (s)	**Average speed (m s^{-1})**	**Depth (m)**
Timer (option 1)	2.60	1504.3	
Timer (option 2)	2.64	1504.3	
Timer (option 3)	2.644	1504.3	

Table 4.3

[3]

(ii) The more sensitive the timer, the higher the cost of the fathometer.

Explain why a very high sensitivity is **not** necessary.

....

....**[1]**

5 James is a crop nutritionist. He works with farmers to increase their crop yields.

He visits five fields and carries out some soil tests to estimate the amount of nitrogen, N, available in the soil.

The results of the soil tests are shown in **Table 5.1**.

	Field				
	1	**2**	**3**	**4**	**5**
Estimate of soil nitrogen content (kg N/ha)	110	140	210	120	100

Table 5.1

The farmers are planning to grow wheat crops in each of the fields.

James uses the internet to check the recommended amount of nitrogen fertiliser to add to the soil.

He finds the following information:

- Less than 120 kg N/ha soil content – apply 200 kg N/ha fertiliser
- At or over 120 kg N/ha soil content – apply only 40 kg N/ha fertiliser

(a) **(i)** What recommendations should James make for each field?

Field 1 ....

Field 2 ....

Field 3 ....

Field 4 ....

Field 5 ....
[2]

(ii) James checks the values shown in **Table 5.1** and considers that one of the values is an anomaly.

Identify the anomaly in **Table 5.1** and explain why you have chosen this value.

The anomaly is in field ....

Explanation ....

....

....

....**[3]**

(iii) James must present his findings to all five farmers. He cannot simply delete the conflicting anomaly because he needs a value for each field.

Suggest what James should do to overcome this problem.

....

....

....

....**[2]**

(b) James reads a fertiliser manual to find out about the economic rates of nitrogen fertilisers. The economic rate is the cost of fertiliser nitrogen as £/kg N divided by the value of grain as £/kg.

He reads the statement in **Fig. 5.1**.

Research has shown that the main causes of yield variation in wheat crops between fields (soil type, rotational position, sowing date or variety) may not be associated with variations in the economic rate of nitrogen (N) fertiliser.

Fig. 5.1

What further evidence could James collect so he can make a conclusion about the effect of nitrogen fertiliser on the yield of wheat crops?

....

....

....

....

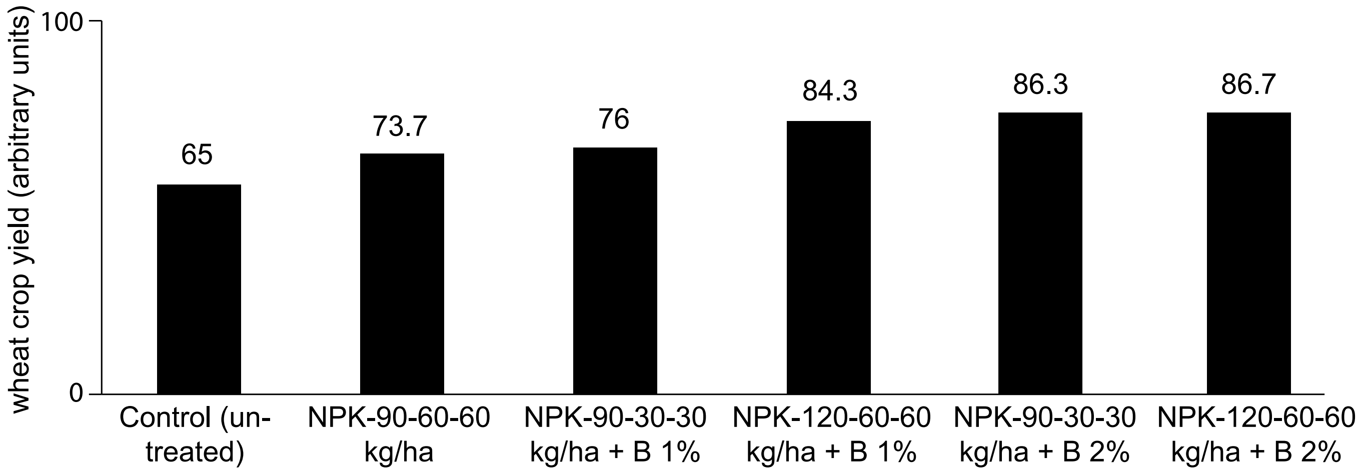
....

....**[4]**

(c) Nitrogen is often applied as part of a combined fertiliser known as NPK (nitrogen (N), phosphorous (P) and potassium (K)).

A team of crop scientists investigate the effect of different concentrations of N, P and K plus the addition of boron (B) on the yield of wheat crops.

The results of their investigation are shown in **Fig. 5.2**.



(**Key:** NPK is applied as kg/ha and B is applied as a %percentage value.)

Fig. 5.2

Identify the **two** correct conclusions based on the data shown in **Fig. 5.2**.

Tick (✓) **two** boxes.

The addition of B to NPK fertiliser at 90-30-30 does not affect the yield of wheat.	☐
The application of twice as much N within NPK fertiliser has the greatest impact on wheat yield.	☐
The application of NPK fertiliser increases wheat yield in relation to the control (untreated).	☐
Changing the nitrogen content of NPK does not have an effect on wheat yield.	☐
The application of B at 2% causes a greater increase in wheat yield than the application of B at 1%.	☐

[2]

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Turn over for the next question

6 Sam is a microbiologist working at a brewery. She monitors the condition of the yeast cells during beer fermentation.

Sam uses the stain methylene blue to estimate numbers of living yeast cells in the yeast culture used to brew the beer.

Methylene blue is decolorised by living yeast cells. She counts numbers of blue and colourless cells using a counting chamber.

The results of one of her yeast cell counts is shown in **Table 6.1**.

Number of cells stained blue	Number of colourless cells
54	823

Table 6.1

(a) Calculate the viability of the culture using the equation:

$$\text{viability} = \frac{\text{number of colourless cells}}{\text{total number of cells}} \times 100$$

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

viability = ... %
[3]

(b) The graph shown in **Fig. 6.1** shows how the viability of yeast cells in a culture changes over a period of time.

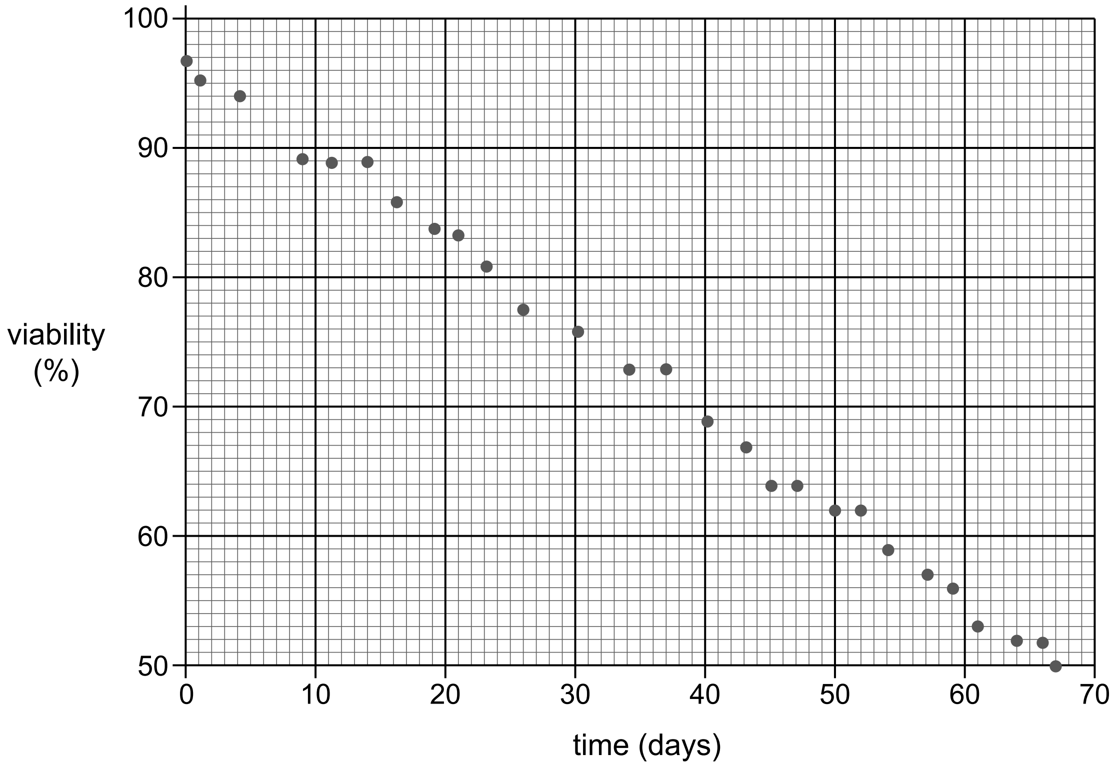

Fig. 6.1

(i) Draw an appropriate line of best fit on the graph in **Fig. 6.1**.

[1]

(ii) To start a fermentation satisfactorily, the viability of the culture must be over 92 %.

Using your line of best fit for **Fig. 6.1**, state the maximum age of a culture that would be able to start a fermentation.

maximum age =.......................................days

[1]

(c) Sam tests for microbiological contaminants in beer, which include yeasts found naturally in the environment (‘wild yeasts’), and bacteria.

The tests she uses are shown in **Table 6.2** on page 23.

(i) Name the test in **Table 6.2** that can be used to identify an organism as a **fungus**.

Tick (✓) **one** box.

Lin's Cupric Sulfate Medium (LCSM) ☐

Acid production ☐

Catalase production ☐

Oxidase production ☐

Lactophenol blue stain ☐

[1]

(ii) Name the test in **Table 6.2** that would identify 'wild yeasts'.

Tick (✓) **one** box.

Lin's Cupric Sulfate Medium (LCSM) ☐

Acid production ☐

Catalase production ☐

Oxidase production ☐

Lactophenol blue stain ☐

[1]

(iii) Name the test in **Table 6.2** that can be used to distinguish a species of *Lactobacillus* from the two types of bacteria.

Tick (✓) **one** box.

Lin's Cupric Sulfate Medium (LCSM) ☐

Acid production ☐

Catalase production ☐

Oxidase production ☐

Lactophenol blue stain ☐

[1]

Contaminant organism	**Type of organism**	**Result of test**				
		Growth on Lin's Cupric Sulfate Medium (LCSM)	**Acid production**	**Catalase production**	**Oxidase production**	**Lactophenol blue stain**
Acetobacter sp.	Bacterium	✗	✓	✓	✗	✗
Brettanomyces spp. – wild yeasts	Fungus	✓	✓	✓	✗	✓
Lactobacillus spp.	Bacterium	✗	✓	✗	✗	✗
Saccharomyces cerevisiae – brewer's yeast	Fungus	✗	✗	✓	✗	✓

Table. 6.2

(d) At regular intervals, Sam prepares some permanent slides of the yeast culture used by the brewery.

She carries out the following steps for each microscope slide. They are in the **incorrect** order.

A	clear in xylene
B	stain using lactophenol blue
C	mount using Canada Balsam
D	fix using acetic acid alcohol
E	dehydrate (in increasing concentrations of alcohol)
F	add a drop of albumin to stick the yeast cells to the surface of the slide

Put the steps in the correct order. One has been done for you.

Complete the table below.

F					

[4]

(e) An optimum calcium ion concentration in water is essential when used for brewing.

From time to time, chemists at the brewery monitor the calcium ion concentration of water from the brewery well.

Describe a titration technique that could be used to determine the calcium ion concentration.

....

....

....

....

....

....**[4]**

7 Plastics are made from polymers.

(a) Plastics become an environmental hazard when they are discarded into the sea.

A study on plastics at different locations in the sea around the UK identified different types of plastic litter.

Plastic litter varies in shape, size, colour and polymer type.

The results of the study are shown in **Table 7.1**.

Type of plastic litter	Percentage of total litter sampled (%)
Beads	3
Fibres	58
Fragments from larger plastic pieces	34
Macroplastics (> 5 mm)	5

Table 7.1

(i) Suggest **two** methods of recording the different types of plastic litter found in the sea around the UK.

1 ....

....

2 ....

....
[2]

(ii) Describe how data showing the location of plastic litter can be captured, stored and displayed.

....**[1]**

(iii) Suggest how the data in **Table 7.1** could be presented to the wider public.

....**[1]**

(b) Plastic litter can also be found as very small particles (<5mm) called microplastics.

A team of scientists reviewed two recent investigations into the types of microplastic, including their use and amount released into the environment and the microplastics found in marine fish.

The results from the investigation into the types of microplastic are shown in **Table 7.2**.

Type of microplastic	Use of microplastic	Amount released to environment (t yr^{-1})
Primary microplastic (produced intentionally)	Plastic pellets used as a raw material	400
	Laundry products	40
Secondary microplastic (formed when larger pieces of plastic break down)	Released from plastic football pitches	3000
	Released from the abrasion of tyres	77 000

Table 7.2

The results from the second investigation into the microplastics found in marine fish are shown in **Table 7.3**.

Fish	Marine habitat	Size of microplastic particles found	Percentage of fish containing microplastic particles (%)
Cod	lives on sea floor	> 500 μm	1.2
Herring	coastal water	none	0.0
Mackerel	coastal water	> 500 μm	13.0

Table 7.3

Use the information in **Table 7.2** and **Table 7.3** to write a report on the two investigations.

It should be written to inform the public about the results and possible conclusions of the investigations on microplastic waste.

....

....

....

....

....

....

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....

....

....**[6]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s) – for example 1(a) or 3(b).

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

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