OCR
Oxford Cambridge and RSA

Friday 17 May 2024 – Morning

Level 3 Cambridge Technical in Applied Science

05847/05848/05849/05874/05879 Unit 2: Laboratory techniques

Time allowed: 2 hours
C341/2406

You must have:
- the Data Sheet (inside this document)
- 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 page 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 **90**.
- The marks for each question are shown in brackets **[ ]**.
- The Periodic Table is on the back page.
- This document has **24** pages.

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

1 A new analytical chemistry laboratory is being set up.

Laws and regulations need to be followed to keep staff safe.

(a)
(i) State **two** of the employer's main duties under The Management of Health and Safety at Work Regulations 1974 (updated 1999).

....

....

....

.... **[2]**

(ii) Explain the differences between hazards and risks and how the risks can be minimised.

Use **examples** that are relevant to people working in an analytical chemistry laboratory.

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.... **[6]**

(b) Glassware is used frequently in the laboratory.

Describe **two** procedures that should be followed when clean glassware is broken.

1 ....

....

2 ....

....
[2]

(c) One procedure carried out in the laboratory involves the use of dichloromethane which is a halogenated solvent. One advantage of using halogenated solvents is that they are not flammable.

(i) Dichloromethane is a serious health hazard.

Which hazard symbol would be used to show dichloromethane is a health hazard?

Put a (ring) round the correct symbol.

[1]

(ii) The waste solvent must be disposed of safely and adequate records need to be kept.

State **three** pieces of information that should be recorded.

1 ....

2 ....

3 ....
[3]

2 Some students are studying pigments in plant leaves.

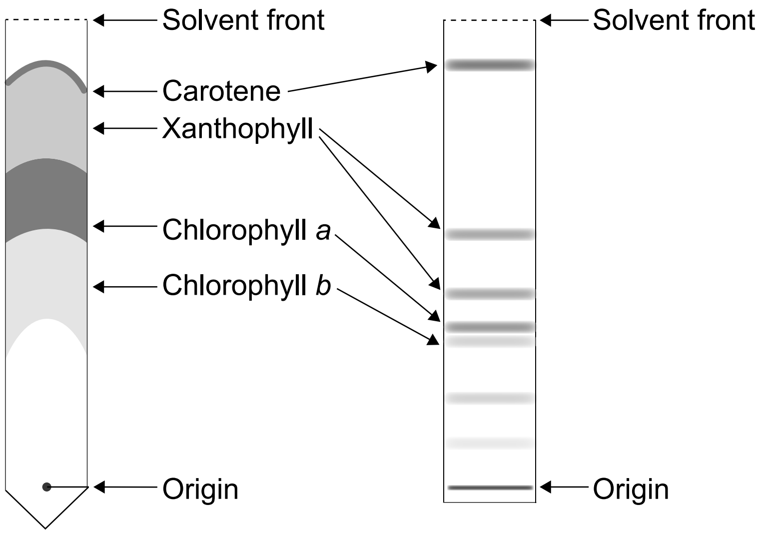
They separate the pigments using chromatography.

Fig. 2.1 shows a paper chromatogram of the leaf pigments.

Fig. 2.2 shows a TLC chromatogram of pigments from the same type of leaves.

The pigment chlorophyll *a* is labelled on both chromatograms.

Fig. 2.1 **Fig. 2.2**



(a) State what TLC stands for.

.... **[1]**

(b) The students note the similarities and differences between the chromatograms.

Describe **two** advantages of TLC compared to paper chromatography which can be seen in **Fig. 2.1** and **Fig. 2.2**.

1 ....

....

2 ....

....

[2]

(c) The students use **Fig. 2.2** to determine the R_f value of chlorophyll *a*.

Measure the distance from the origin to the solvent front and the distance travelled by chlorophyll *a*.

Use the two measurements to calculate the R_f value of chlorophyll *a*.

R_f value = ... **[3]**

(d) The chromatograms shown in **Fig. 2.1** and **Fig. 2.2** were produced using the same solvent as the mobile phase.

Tick (✓) **one** box that explains why the R_f value for chlorophyll *a* is smaller in **Fig. 2.2** than in **Fig. 2.1**.

Chlorophyll *a* has a greater affinity for the stationary phase in paper chromatography.	☐
Chlorophyll *a* has a lower affinity for the stationary phase in paper chromatography.	☐
In TLC the solvent runs faster than paper chromatography.	☐
Paper chromatography uses a lid.	☐
The chlorophyll *a* is different in the two chromatograms.	☐

[1]

(e) Explain why the R_f value for chlorophyll *a* determined from TLC (**Fig. 2.2**) is more accurate than from paper chromatography (**Fig. 2.1**).

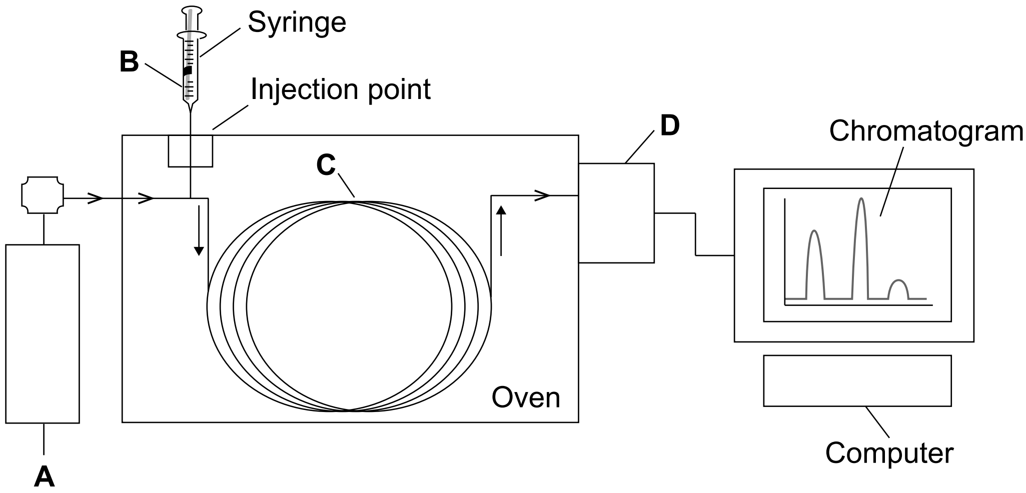
....

....

.... **[2]**

(f) Gas chromatography linked to a mass spectrometer (GC-MS) is an instrumental technique used in chemical analysis.

(i) The image below is a block diagram of the equipment used in gas chromatography.



Identify parts **A**, **B**, **C**, and **D**.

A ....

B ....

C ....

D ....

[4]

(ii) State **two** advantages of gas chromatography compared to TLC.

1 ....

....

2 ....

.... **[2]**

(iii) Explain why gas chromatography is usually linked to a mass spectrometer.

....

....

.... **[2]**

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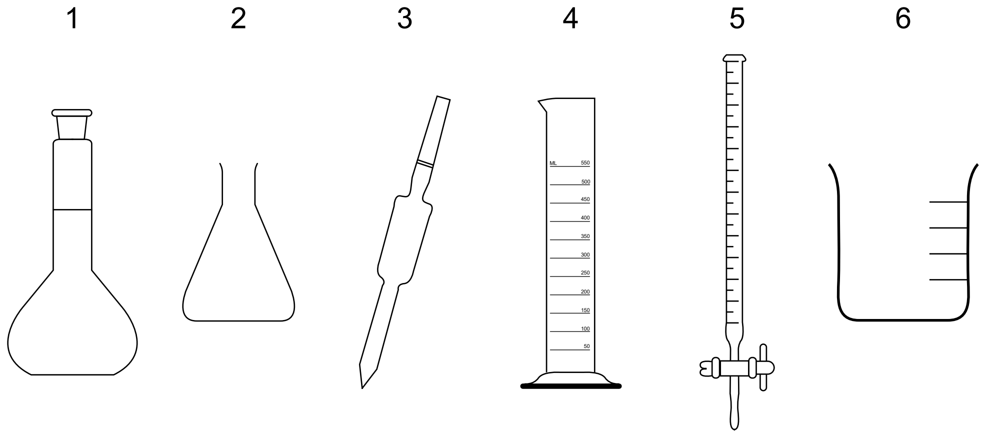
Turn over for the next question

3 Dilute ammonia solution, $NH_{3\,(aq)}$, is a weak alkali. It is an ingredient in many household cleaning agents.

(a) A scientist does a titration to determine the concentration of ammonia in a brand of window cleaning solution.

The diagram shows the equipment the scientist uses.



(i) Name the pieces of equipment labelled 1 to 6 in the diagram.

1 ....

2 ....

3 ....

4 ....

5 ....

6 ....

[3]

(ii) The scientist titrates the window cleaning solution against 0.100 $mol\,dm^{-3}$ hydrochloric acid.

Methyl orange is used as the indicator for the titration.

Tick (✓) **one** box that shows the colour change of methyl orange.

Acidic conditions	**Basic conditions**	
Yellow	Blue	
Colourless	Pink	
Red	Yellow	
Pink	Colourless	

[1]

(iii) The pH range of methyl orange is 3.2 to 4.4.

Explain why methyl orange is a suitable indicator for this titration.

....

....

.... **[2]**

(b) An auto-titrator can be used to obtain more accurate results.

State how the equivalence point of the titration is determined using an auto-titrator.

....

.... **[1]**

(c) The scientist uses an auto-titrator to determine the concentration of ammonia in a brand of window cleaning agent.

The scientist follows the method below:

Step 1 Dilution
Measure out 5.00 cm^3 of the cleaning agent and make up to a volume of 250.0 cm^3 with deionised water.

Step 2 Auto-titration
Titrate 10.0 cm^3 of the diluted cleaning agent from **step 1** against 0.100 mol dm^{-3} HC*l*.

The mean volume of 0.100 mol dm^{-3} HC*l* required to neutralise 10.0 cm^3 diluted cleaning agent was found to be 3.62 cm^3.

The equation for the reaction is:

$NH_3\ (aq) + HCl\ (aq) \rightarrow NH_4Cl\ (aq)$

Use the following steps to calculate the concentration of ammonia in the window cleaning agent.

(i) Calculate the number of moles of HC*l* in 3.62 cm^3 of 0.100 mol dm^{-3} HC*l*.

You will need to use the following equation in your calculation.

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

Number of moles HC*l* = ... mol **[1]**

(ii) Calculate the concentration of NH_3, in mol dm^{-3}, in the **diluted** cleaning agent.

Concentration of diluted cleaning agent = ... mol dm^{-3} **[2]**

(iii) The cleaning agent was diluted in **step 1**.

Calculate the dilution factor and use this value to calculate the concentration of NH_3 in $mol\,dm^{-3}$ in the undiluted cleaning agent.

Dilution factor = ...

Concentration of undiluted cleaning agent = ... $mol\,dm^{-3}$ **[2]**

(iv) Concentrations in household products are usually given as a percentage.

A 1% ammonia solution means that there is 1.00 g of ammonia in 100 cm^3 of solution.

The molar mass of NH_3 is 17 $g\,mol^{-1}$.

Use your value for the concentration of NH_3, in $mol\,dm^{-3}$, to calculate the percentage of ammonia in the cleaning agent.

% NH_3 = ... **[2]**

(d) Explain why an auto-titrator delivers more accurate results than a manual titration using an indicator.

....

....

....

.... **[2]**

(e) A brand of window cleaning agent contains a blue dye. Suggest why a manual titration involving an indicator cannot be used to determine the ammonia concentration.

....

.... **[1]**

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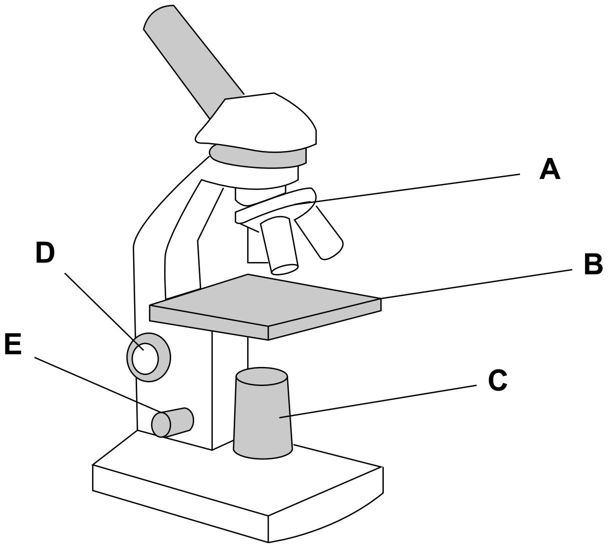
Turn over for the next question

4 Forensic biologists often use light microscopy in their work.

(a) The diagram shows a light microscope with 5 parts labelled **A** to **E**.



(i) Name the part labelled **B**.

.... **[1]**

(ii) State the purpose of the part labelled **C**.

.... **[1]**

(iii) Explain why there are two focussing knobs (**D** and **E**).

....

....

....

.... **[3]**

(iv) Label **A** shows the objective lenses.

Explain why there are **three** objective lenses on this microscope.

....

....

....

.... **[2]**

(b) A forensic biologist uses microscopy to view fibres found at a crime scene so that the crime scene fibres can be compared to reference fibres.

A suspect can be linked to the crime scene if fibres from the crime scene match those found on the suspect.

There are six suspects for the crime. Fibre samples are taken from their clothes.

The fibre diameter (mm) and colour are shown in the table.

Suspect	Fibre diameter / mm	Fibre colour
A	0.060	Red
B	0.040	Blue
C	0.010	Red
D	0.030	Blue
E	0.020	Red
F	0.020	Blue

Fig. 4.1 shows some reference fibre types.

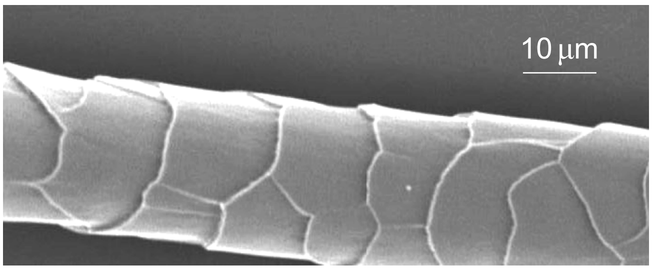
Fig. 4.1

Coarse wool Silk Cotton
Cashmere Linen Polyester

A sample of fibre is found at the crime scene and viewed using a scanning electron microscope (SEM).

The detailed, microscopic appearance of the fibre is shown in **Fig. 4.2**.

Fig. 4.2



(i) The forensic biologist concludes that the fibre found at the crime scene is cashmere.

Explain how the forensic biologist came to this conclusion.

....

.... **[1]**

(ii) Use the scale bar in **Fig. 4.2** to estimate the diameter in **mm** of the fibre.

1 mm = 1000 μm.

Diameter = ... mm **[1]**

(iii) Identify which **two** suspects could have been at the crime scene.

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

(iv) Take a suitable measurement from **Fig. 4.1** and calculate the magnification of the image.

Magnification .... x **[3]**

(c)
(i) State **one** advantage of using SEM compared to light microscopy.

....

.... **[1]**

(ii) Tick (✓) **one** box to explain why light microscopy would be better to determine which of the suspects from **(b)(iii)** was at the crime scene.

Light microscopy can reveal the colour of the fibres.	☐
Light microscopy can determine the chemical composition of the fibres.	☐
Light microscopy can be used to estimate the diameter of the fibres more accurately.	☐

[1]

5 Ion Chromatography (IC) and Atomic Emission Spectroscopy (AES) can be used to analyse water samples.

(a) Use ticks (✓) to show which features apply to IC and AES.

Each row can have **one or two** ticks.

Feature	**IC**	**AES**
Can detect anions **AND** cations.		
Can detect very low concentrations.		
Can determine concentrations of ions in solutions.		
Uses a flame as a heat source.		

[2]

(b) Use words from this list to describe the principles of IC.

absorbed	**affinity**	**detected**	**dissolved**	**eluent**
higher	**lower**	**plate**	**tube**	

The ions are .... by a resin matrix.

.... is passed through the column.

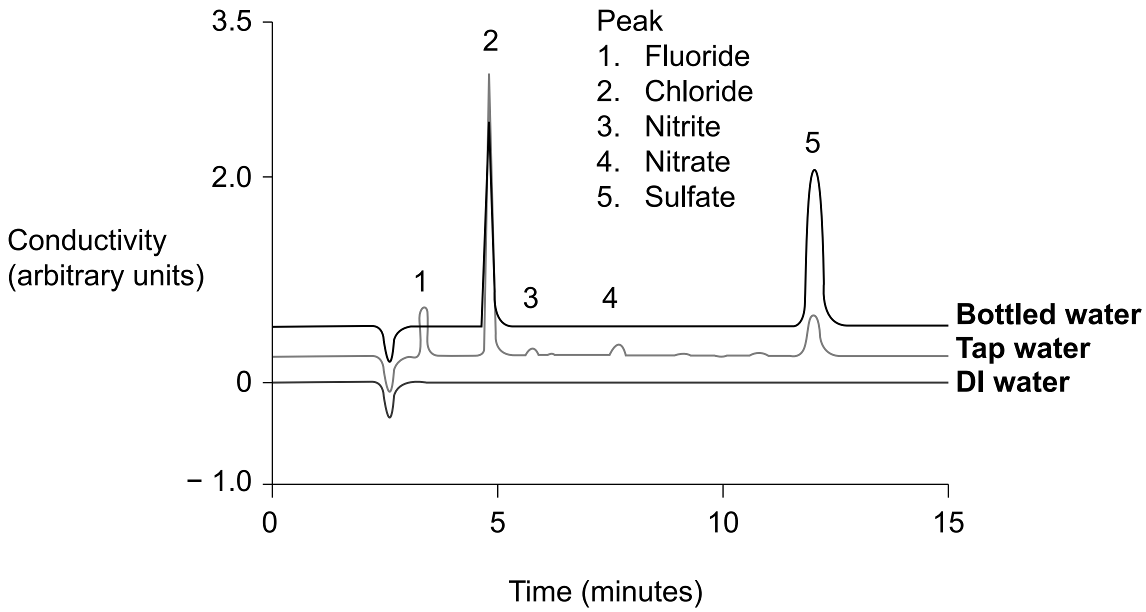
Ions with a .... affinity for the resin matrix pass through the column more slowly.

As they leave the column, the ions are .... by measuring their electrical conductivity.

[3]

(c) A chemist uses IC to compare the anions present in tap water, bottled water and deionised (DI) water.

A printout of the chromatogram is shown below.



(i) Which **two** ions are present in bottled water and in tap water?

.... **[1]**

(ii) Three other ions are also present in tap water. Which of these other three ions has the highest concentration?

Explain your answer.

....

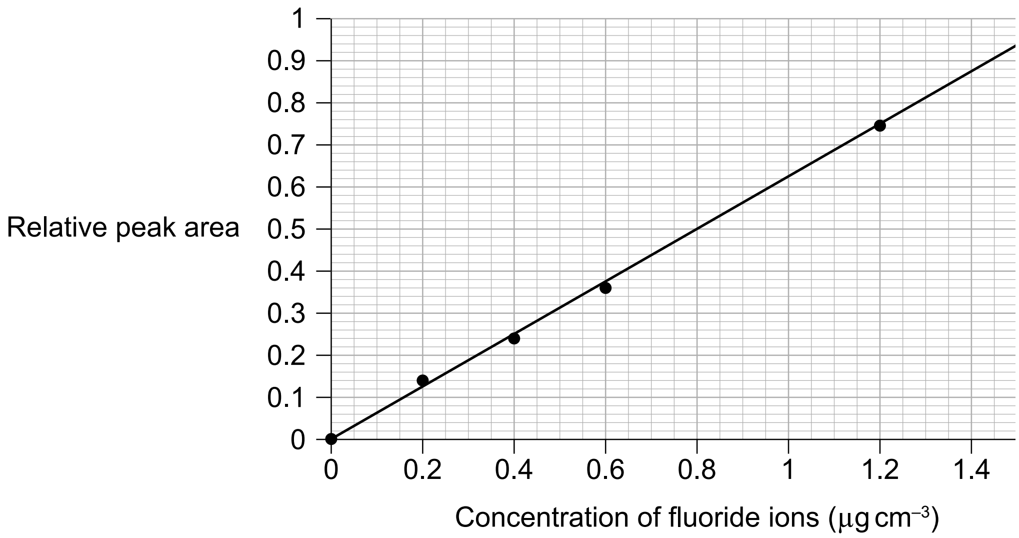
....

.... **[2]**

(iii) Fluoride is added to tap water in the UK to help protect people's teeth. The recommended range of fluoride ions in tap water is between 0.7 and 1.5 $\mu g\,cm^{-3}$.

The chemist is testing a water supply to check whether the fluoride ion concentration is within the recommended range.

The chemist first uses IC to produce a calibration graph as shown below.



The chemist then determines the relative peak area of a sample from the water supply. The relative peak area of the water sample was found to be 0.52.

Use the graph to determine whether the fluoride ion concentration is within the recommended range.

.... **[2]**

(d) State **two** other uses for IC, in addition to measuring ion concentrations.

1 ....

....

2 ....

....

[2]

(e) The chemist uses AES to determine which metal ions are present in the water supply.

Outline the scientific principles involved in this technique.

....

....

.... **[2]**

6 One important role of a food technologist is to check that food safety standards are met.

A food technologist uses a plate count method to estimate the number of colonies of bacteria in a sample of food.

Method

1 Blend 25.0 g of the food sample with a sterile buffer solution and make up the volume to 50.0 cm^3 with the buffer solution. This is a 1x solution.

2 Prepare a ten-fold dilution series from this 1x solution to make 1/10, 1/100 and 1/1000 dilutions. Sterile buffer solution is used for all dilutions.

3 Spread 0.5 cm^3 of each dilution of the sample onto separate agar plates and incubate to allow any colonies to grow.

4 Spread 0.5 cm^3 of the sterile buffer solution onto an agar plate.

(a)
(i) The equipment used by the food technologist to make this dilution series is shown in the table below.

Put **one** tick (✓) in each row to show the correct procedure to sterilise that equipment.

Each procedure can be used once, more than once or not at all.

	Procedure		
	Autoclaving	**Dry heat**	**Flaming**
Agar for the agar plates			
Glass pipettes			
Sterile buffer solution			

[3]

(ii) Outline the steps the food technologist should follow to obtain the ten-fold dilution series.

....

....

....

....

....

....

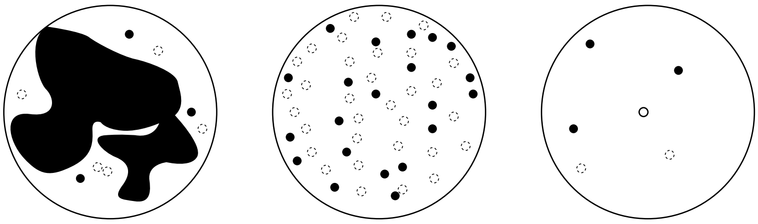
.... **[3]**

(iii) Explain why an agar plate is spread with 0.5 cm^3 of **sterile** buffer solution.

.... **[1]**

(b) The diagrams below show colonies of bacteria growing on the three spread plates after they were incubated.

The dots (○ and •) show different colonies of bacteria.



1/10 dilution **1/100 dilution** **1/1000 dilution**

(i) Explain why the 1/10 plate cannot be used to calculate the number of colonies on the food sample.

....

.... **[1]**

(ii) Explain why the 1/100 plate is more effective than the 1/1000 plate for determining the number of colonies per gram.

....

.... **[1]**

(c) The maximum permitted number of colonies in the food sampled is 1×10^7 colonies per gram.

(i) Use the 1/100 plate to calculate the number of colonies per gram.

The number of colonies in the 1/100 plate is 53.

Number of colonies per gram = ... **[3]**

(ii) What can you conclude from your calculation of the number of colonies per gram of food growing on the 1/100 plate?

Tick (✓) **one** box to show the correct answer.

The number of colonies in the food is **less than** the allowed maximum number. ☐

The number of colonies in the food is **the same** as the allowed maximum number. ☐

The number of colonies in the food is **more than** the maximum allowed number. ☐

[1]

END OF QUESTION PAPER

EXTRA ANSWER SPACE

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

The Periodic Table of the Elements

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

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