OCR
Oxford Cambridge and RSA

Wednesday 21 May 2025 – Morning

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C341/2506

C341--2506

You must have:
- the Data Sheet (inside this document)
- a ruler (cm/mm)

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

05847-02

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 **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 chemistry technician plans to carry out an annual check on a range of laboratory glassware.

(a) The technician starts by checking the calibration of a 25.0 cm^3 pipette.

Complete the following sentences to outline the steps involved in the procedure.

Use the pipette to measure 25.0 cm^3 of ..... .

Put a small beaker on a ..... and press the tare button.

Run the ..... from the pipette into the beaker and note the reading

on the ..... .

If the pipette is correctly calibrated the reading should be ..... .

[3]

(b) After checking the calibration of the pipette, the technician uses the equipment to complete a range of acid-base titrations.

Before starting the experimental work for the titrations, the technician completes a risk assessment.

(i) Explain the difference between a hazard and a risk.

.....

.....

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

(ii) Identify **two** hazards associated with completing an acid-base titration.

1 .....

2 .....

[2]

(iii) Suggest **two** control measures to minimise the hazards given in **(ii)**.

1 .....

.....

2 .....

.....

[2]

(c) The technician works in a laboratory which produces hazardous biological and chemical waste.

Describe the standard procedures for dealing with and disposing of hazardous biological **and** chemical wastes.

Refer to **specific** examples of waste in your answer.

.....

.....

.....

.....

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.....

.....

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

2 HPLC is a technique used to separate and identify the components in a mixture.

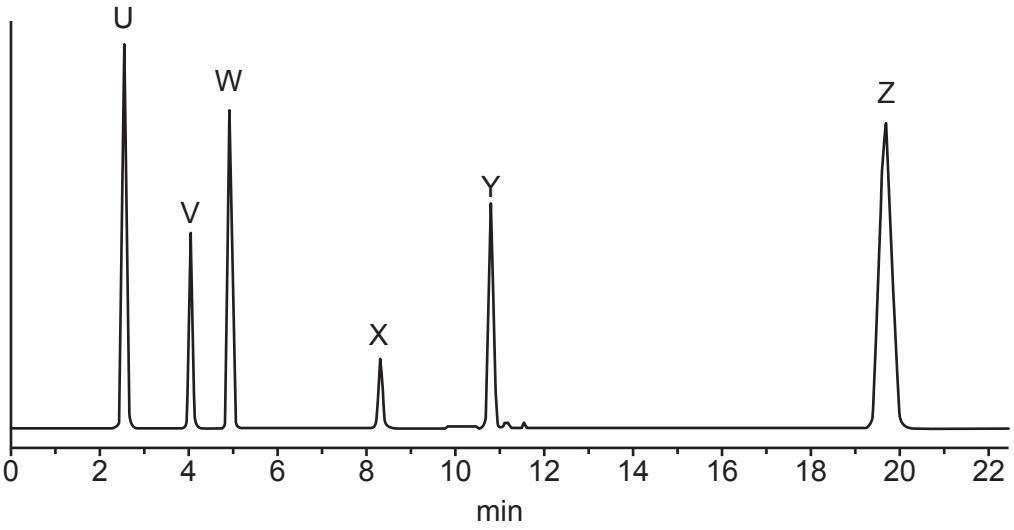
(a) State what the abbreviation HPLC stands for.

.....

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

(b) **Fig. 2.1** shows the HPLC chromatogram of a health supplement containing some unknown vitamins.

Fig. 2.1



(i) Estimate the retention time of vitamin W.

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

(ii) Estimate which vitamin is present in the lowest amount.

Put a (ring) around the correct answer.

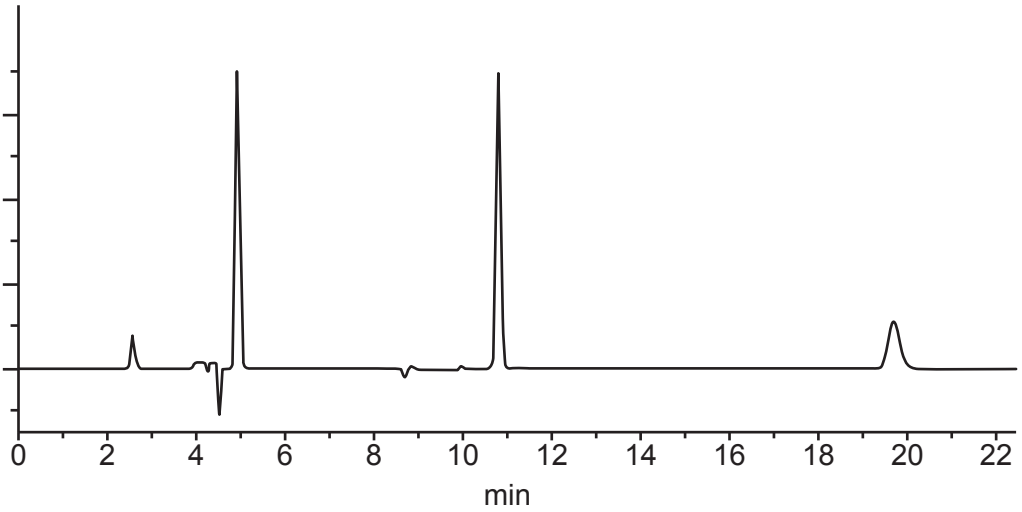
U **V** **W** **X** **Y** **Z**

[1]

(iii) Some vitamins are water-soluble and some are fat-soluble.

Fig. 2.2 shows the HPLC chromatogram for a mixture containing the four fat-soluble vitamins in the health supplement.

Fig. 2.2



Use **Figs. 2.1** and **2.2** to identify which vitamins in the health supplement are fat-soluble and which are water-soluble.

Fat-soluble .....

.....

Water-soluble .....

.....

[2]

(c) A mass spectrometer is often linked to an HPLC instrument.

(i) Describe **two** advantages of linking an HPLC instrument to a mass spectrometer.

1 .....

.....

2 .....

.....

[2]

(ii) Mass spectrometry involves five stages.

Name the stages by completing the table below. The stages must be in the correct order from 1 to 5.

Stage 2 has been done for you.

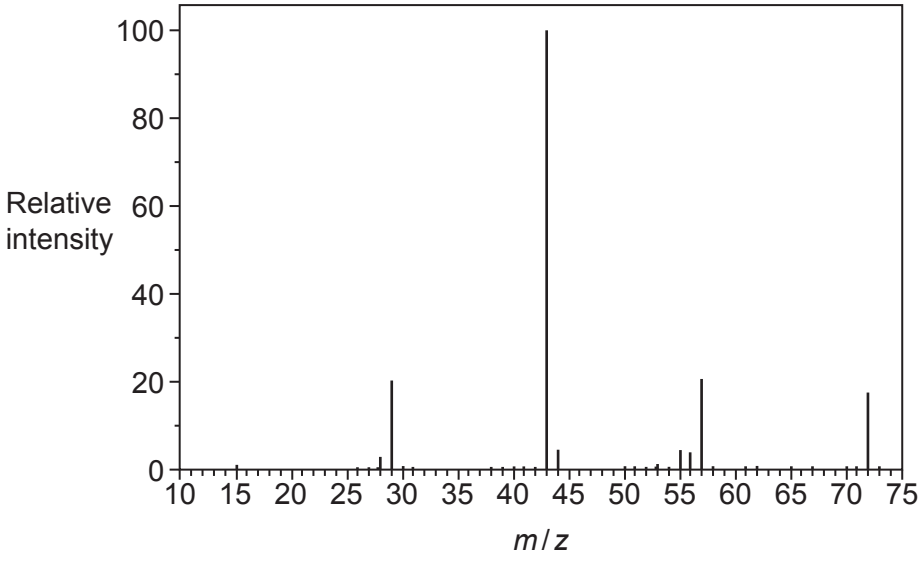
Stage	Name
1	
2	fragmentation
3	
4	
5	

[4]

(d) A mixture of hydrocarbons is separated by HPLC and each component is then analysed using mass spectrometry.

One of the components is pentane, $CH_3CH_2CH_2CH_2CH_3$.

The mass spectrum of pentane is shown below.



(i) How does the spectrum confirm that pentane has a molecular formula C_5H_{12}?

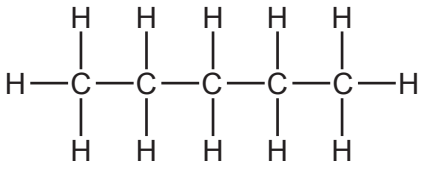
(Relative atomic masses: H = 1, C = 12)

.....

.....

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

(ii) The displayed formula of pentane is



During fragmentation, the C – C bonds in pentane are broken at different points along the chain.

Identify the fragment ions that give rise to the following peaks in the mass spectrum.

m/*z* 57 is .....

m/*z* 43 is .....

[2]

3 A group of students is finding out about titration curves.

You will need to use the following equations in your answers to the numerical questions.

- Number of moles = $\frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1})}$
- Number of moles = $\frac{\text{concentration in mol dm}^{-3} \times \text{volume in cm}^3}{1000}$

(a) A laboratory technician plans to prepare 250 cm^3 of 0.0500 mol dm^{-3} potassium hydroxide, KOH (aq).

The molar mass of KOH is 56.1 g mol^{-1}.

(i) Calculate the number of moles of KOH required to make a final volume of 250 cm^3 of a 0.0500 mol dm^{-3} standard solution.

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

(ii) Calculate the mass of KOH needed to give this number of moles.

Mass = ... g **[1]**

(iii) Name the piece of laboratory equipment that would be most suitable to make the standard solution up to 250 cm^3.

Put a (ring) around the correct name.

beaker **burette** **measuring cylinder** **pipette** **volumetric flask**

[1]

(b) The students investigate how the pH changes when they add a strong base such as potassium hydroxide to a strong acid such as hydrochloric acid.

The students use a pH meter to measure the pH.

(i) A pH meter must be calibrated before use.

State the name of the type of solution used to calibrate a pH meter.

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

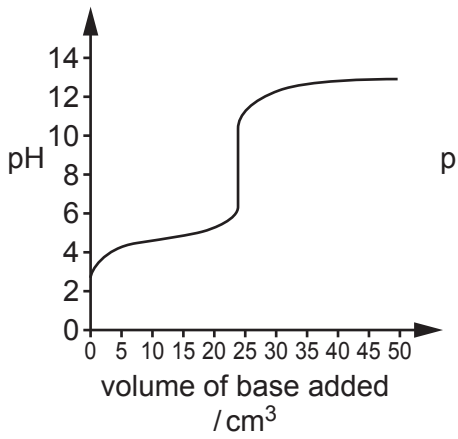
(ii) They gradually add 0.0500 mol dm^{-3} potassium hydroxide to 25.0 cm^3 0.0500 mol dm^{-3} hydrochloric acid and measure the pH after each addition of the base.

Three pH curves (**A to C**) are shown below.

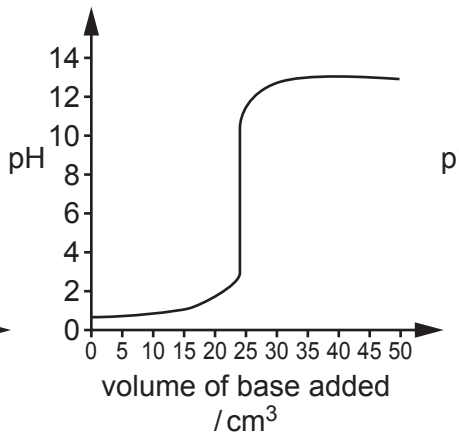
Identify which of the three pH curves applies to the addition of a strong base to a strong acid.

Put a (ring) around the correct letter.

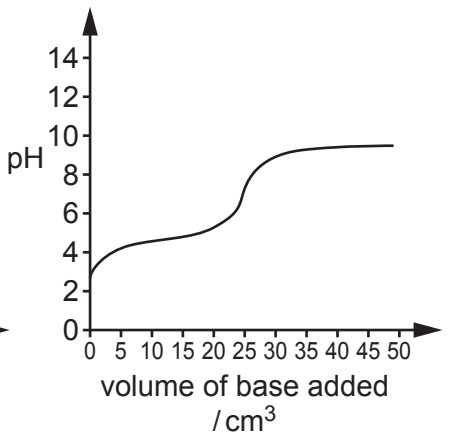
A



B



C



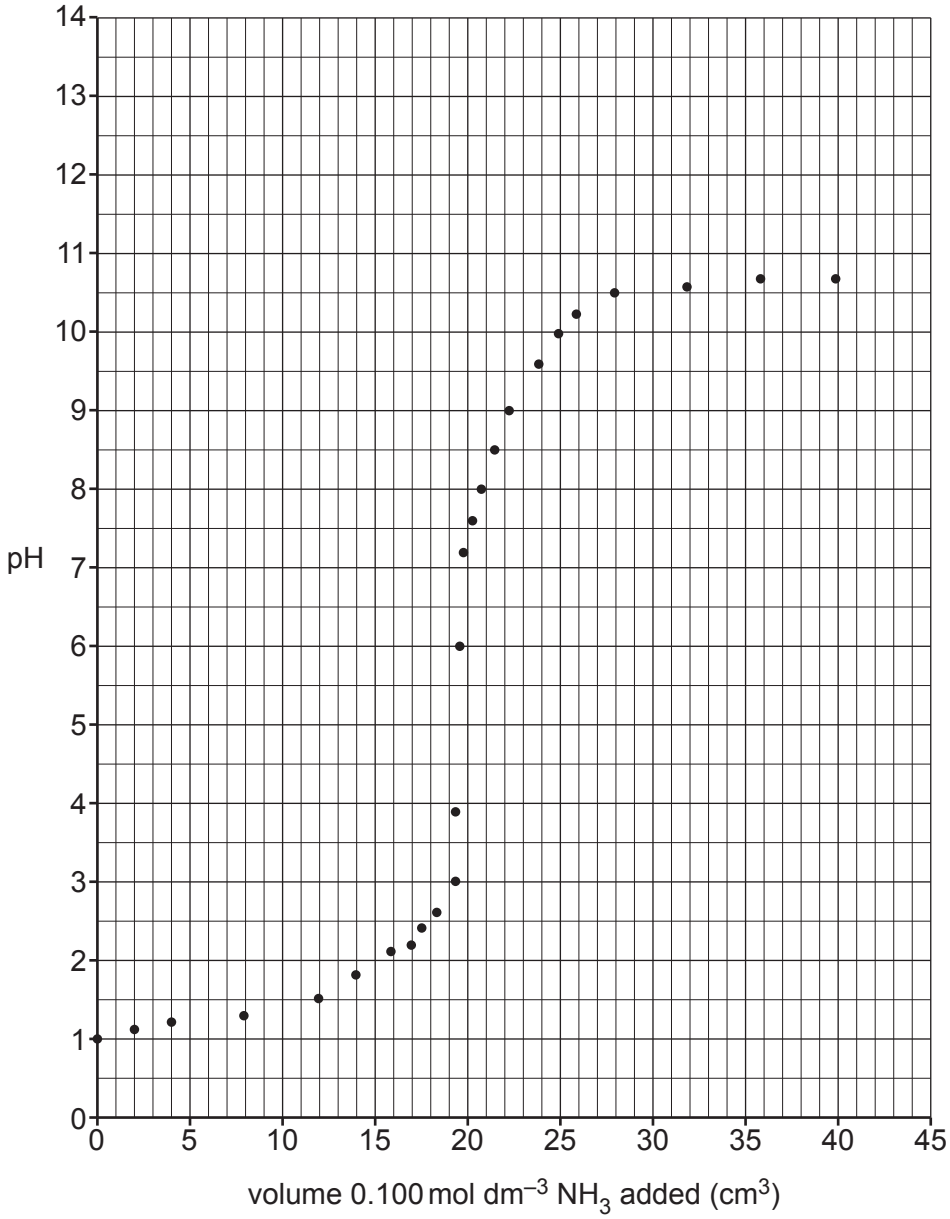
[1]

(c) The students then investigate how the pH changes when they add a weak base such as aqueous ammonia to a strong acid such as hydrochloric acid.

They gradually add 0.100 mol dm^{-3} aqueous ammonia, $NH_3(aq)$ to 25.0 cm^3 hydrochloric acid, $HCl(aq)$, and measure the pH after each addition of base.

They then plot a graph of pH against volume of 0.100 mol dm^{-3} ammonia solution added.

Their graph is shown below.



(i) Draw a curve through the points. **[1]**

(ii) Use the graph to estimate

- the pH range of the vertical portion of the graph,

.....

- the volume of 0.100 mol dm^{-3} NH_3(aq) required to reach the equivalence point.

.....

[2]

(iii) Use the volume of 0.100 mol dm^{-3} NH_3(aq) required to reach the equivalence point to calculate the concentration of the HCl(aq).

The equation for the reaction between HCl and NH_3 is

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

Concentration of HCl(aq) = ... mol dm^{-3} **[3]**

(iv) The pH range of an indicator is the range of pH values over which the indicator changes colour. Different indicators change colour at different pH values.

The table shows the pH range of three indicators.

Indicator	pH range
Bromothymol blue	6.0 – 7.6
Methyl orange	3.1 – 4.4
Phenolphthalein	8.3 – 10.0

State which indicator is suitable for the titration between HCl(aq) and NH_3(aq).

Explain your answer.

Indicator: .....

Explanation: .....

.....

[2]

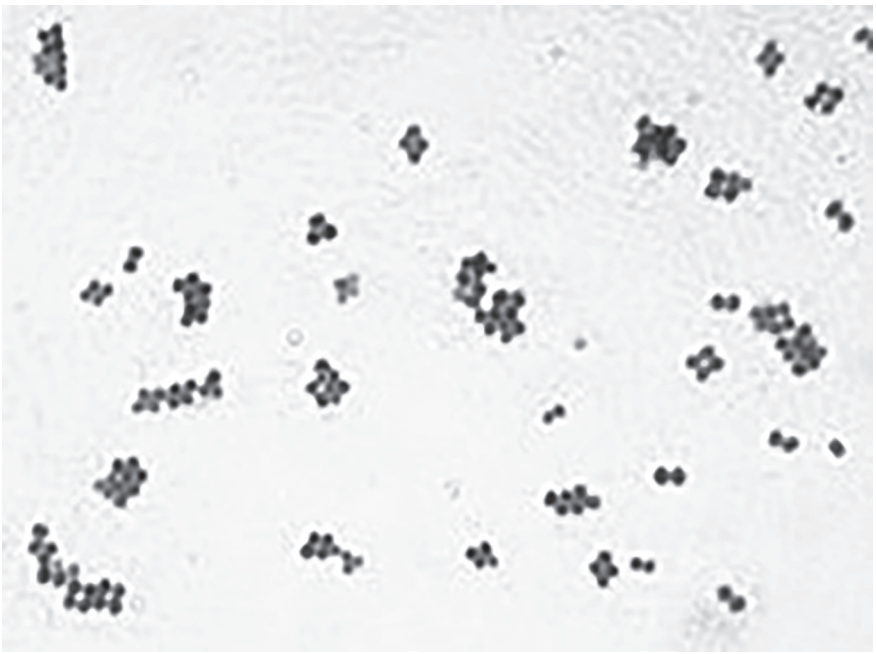
4

(a) A student is investigating different types of microscope.

The student uses a light microscope to study biological specimens.

Fig. 4.1 shows what the student observes through the eyepiece of the light microscope.

Fig. 4.1



(i) The image was viewed through a 10× eyepiece lens and a 100× objective lens.

Calculate the overall magnification of the microscope.

Magnification ..... × **[1]**

(ii) Explain the difference between the magnification and the resolution of light microscopes.

Magnification .....

.....

Resolution .....

.....

[2]

(iii) State what limits the resolution of a light microscope.

.....

.....

.....

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

(iv) Put a (ring) around the best estimate of the resolution of light microscopy using both a 10× eyepiece lens and a 100× objective lens.

2nm **20nm** **200nm** **2000nm**

[1]

(v) Name the **two** pieces of equipment needed to measure the length of specimens when viewed using a light microscope.

1 .....

2 .....

[2]

(vi) The student identifies the type of biological specimen viewed using the light microscope.

Tick (✓) **one** box to confirm the identity of the biological specimen seen.

cells ☐

organelles ☐

tissues ☐

[1]

(vii) Give **one** advantage of using a light microscope to view biological specimens.

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

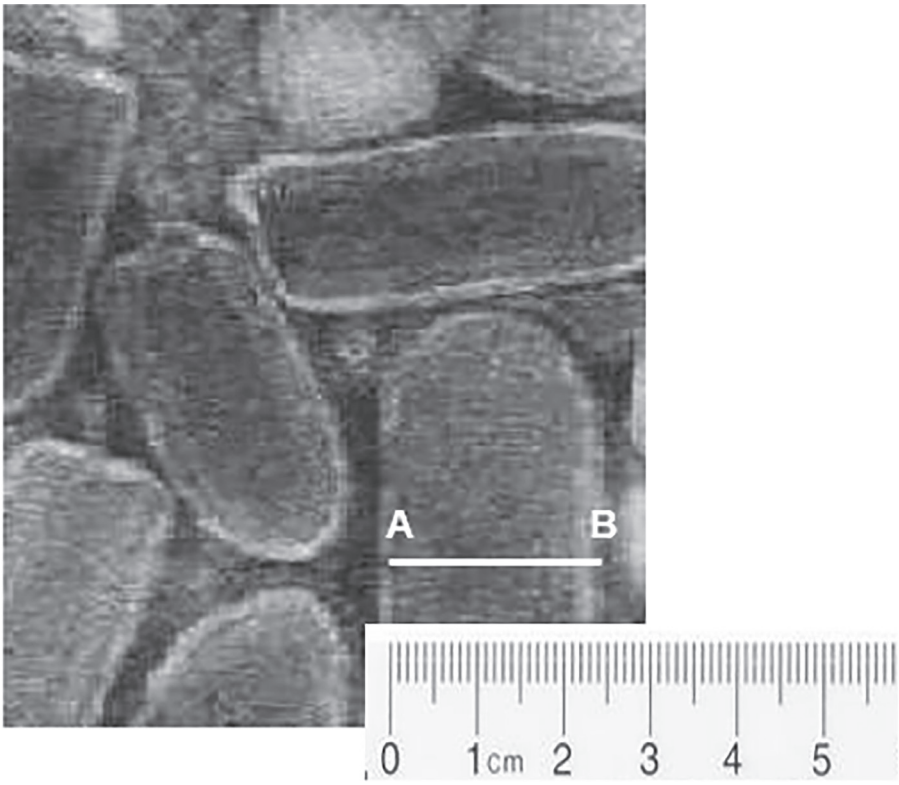
(b) The Rabies virus is far too small to be seen using a light microscope.

(i) Name **one** piece of equipment that could be used to observe the Rabies virus.

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

Fig. 4.2 shows an image of Rabies viruses.

Fig. 4.2



(ii) Measure the width of a Rabies virus along the line labelled **AB** using the ruler on **Fig. 4.2**.

Give your answer in mm.

Width of Rabies virus ..... mm **[1]**

(iii) The actual width of a Rabies virus is 62.5 nm.

Calculate the magnification of the image.

Magnification = ... **[3]**

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5

(a) Flame tests are used to identify which cation is present in a sample.

(i) Describe how to perform a flame test.

.....

.....

.....

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

(ii) State the colour of the flame given by these cations.

Barium Ba^{2+} .....

Lithium Li^{+} .....

[2]

(b) Aqueous sodium hydroxide is used as a chemical test to identify cations in ionic compounds.

A student has two crystalline solids in different containers, but they are not labelled.

The student is told that one of the solids is iron(II) sulfate and the other is aluminium sulfate. Both compounds are soluble in water.

Describe how the student would use sodium hydroxide solution to positively identify which solid is iron(II) sulfate and which is aluminium sulfate.

You should outline the method the student would use and describe what would be observed for iron(II) sulfate and for aluminium sulfate.

Method .....

.....

.....

.....

Observations .....

.....

.....

.....

[4]

(c) The student is asked to identify a white powder labelled Compound **X**.

When tested using a flame test the student observes a violet flame.

The student dissolves the sample in water and adds a few drops of dilute hydrochloric acid followed by a few drops of aqueous barium chloride.

The student observes that a white precipitate is formed.

Use the student's results to identify Compound **X**.

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

(d) Emission spectroscopy is an important technique for analysing substances.

(i) Give **two** advantages of using emission spectroscopy compared to flame tests and chemical tests.

1 .....

.....

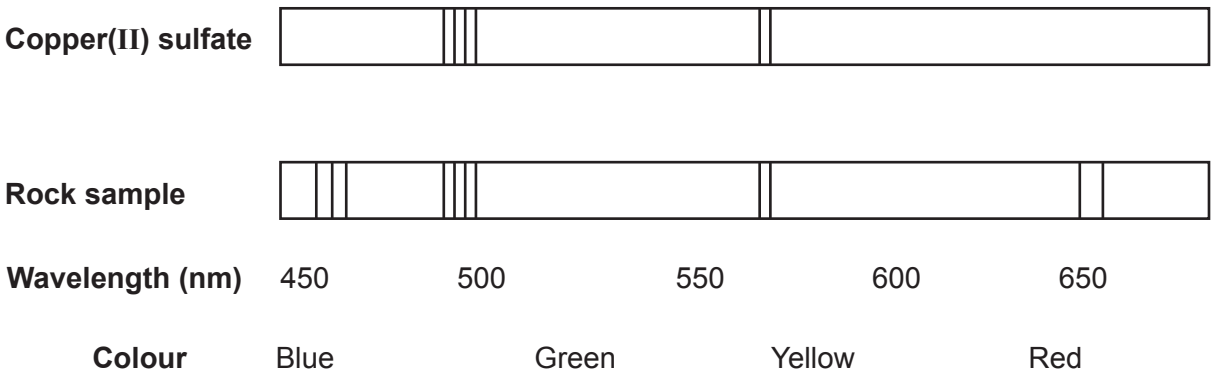
2 .....

.....

[2]

(ii) A geologist uses emission spectroscopy to determine whether copper is present in a rock sample.

The geologist compares the spectrum of copper(II) sulfate with the spectrum of the rock sample.



What can the geologist conclude about the rock sample?

Explain your answer.

.....

.....

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

6 Micro-organisms can grow in diesel fuel which has been stored for a long time.

This contaminated diesel fuel can cause damage to engines.

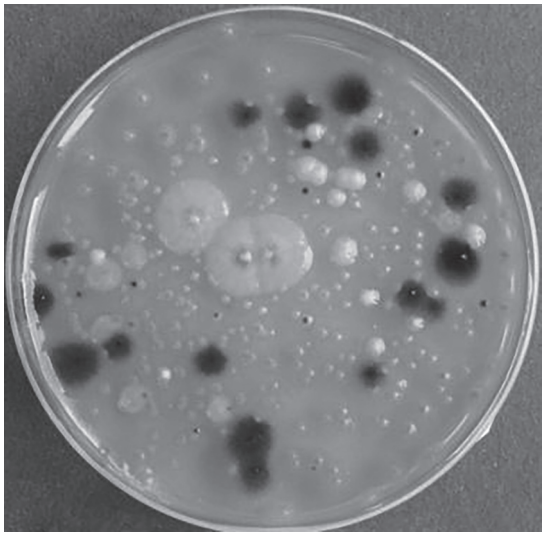
This microbial contamination is called “diesel bug” but it is not caused by a single micro-organism.

A team of scientists are investigating the micro-organisms that cause diesel bug.

(a) The scientists grow micro-organisms from a sample of contaminated diesel fuel on an agar plate.

Fig. 6.1 shows the appearance of the agar plate after a 12 hour incubation period at 30 °C.

Fig. 6.1



(i) Suggest the minimum number of different types of micro-organism growing in the contaminated diesel fuel.

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

(ii) Explain why this is the minimum number.

.....

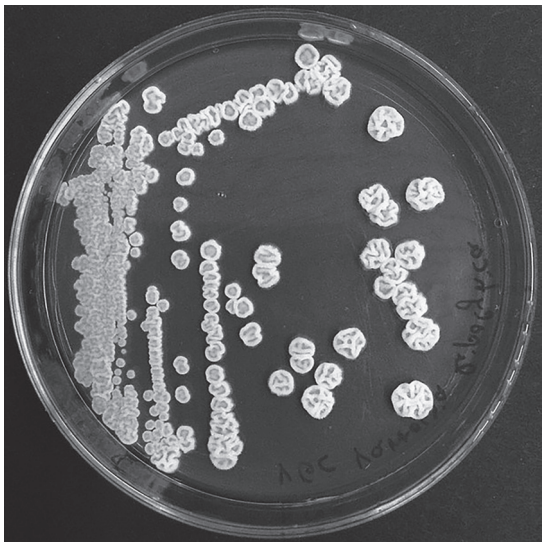
..... **[2]**

(b) The scientists decide to study the different types of micro-organisms in isolation.

To do this they select an individual colony from the plate and streak it onto another agar plate.

Fig. 6.2 shows the appearance of this second agar plate after it was incubated under the same conditions.

Fig. 6.2



(i) Draw a label line and add the word “started” on **Fig. 6.2** to show where the streaking process was started. **[1]**

(ii) Draw a second label line and add the word “ended” on **Fig. 6.2** to show where the streaking process ended. **[1]**

(iii) Describe a procedure used to streak a single colony onto the plate, resulting in the appearance of the agar plate shown in **Fig. 6.2**.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[5]**

(c)

(i) The agar plates must be disposed of using the correct protocol when the investigations are completed.

Describe the correct protocol to dispose of the agar plates.

.....

.....

.....

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

(ii) Suggest **one** piece of personal protective equipment (PPE) to be used by the scientists when disposing of the agar plates.

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

(d) The scientists work for a company that makes test kits for diesel bug.

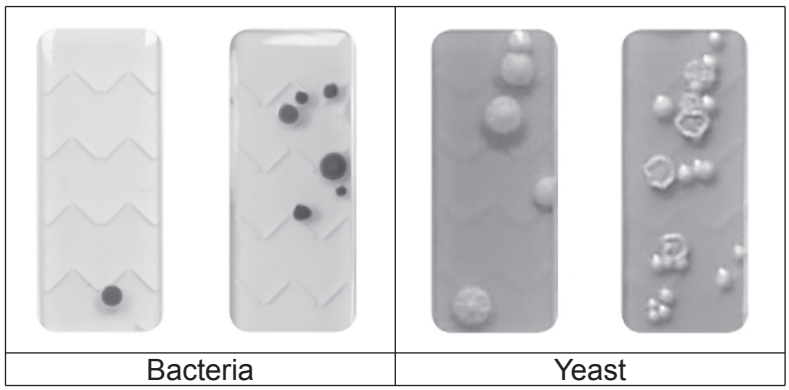
(i) Explain why sterile conditions are required when the test strips are being manufactured.

.....

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

(ii) **Fig. 6.3** is an image of a test kit showing positive results for the presence of bacteria and yeast from a sample of diesel.

Fig. 6.3

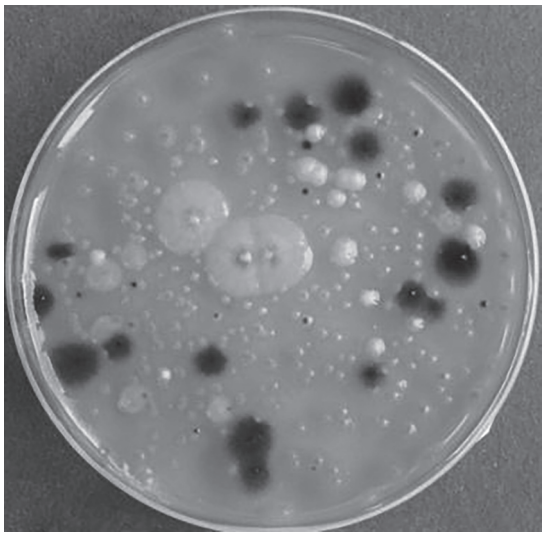


Use the test kit image shown in **Fig. 6.3** to identify and label **one** colony of bacteria and **one** colony of yeast on **Fig. 6.1**.

Fig. 6.1 is repeated below.

Draw **one** line from each label to **one** colony.

Fig. 6.1



colony of bacteria

colony of yeast

[2]

END OF QUESTION PAPER

EXTRA ANSWER SPACE

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

The Periodic Table of the Elements

(1)	(2)											(3)	(4)	(5)	(6)	(7)	(0)
1																	**18**
1 **H** hydrogen 1.0	**2**											**13**	**14**	**15**	**16**	**17**	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	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	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

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