OCR
Oxford Cambridge and RSA

Monday 15 January 2024 – Morning

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C341/2401

C341/2401

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

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

0 5 8 4 7 – 0 2

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 **28** pages.

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

1 Beth is a forensic scientist.

She is called out to a crime scene where she uses swabs to collect blood samples.

The blood samples will be sent to the laboratory for analysis.

The results of the tests can be used as evidence in court.

(a)

(i) State **one** hazard that each blood sample presents to Beth.

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

(ii) Name **one** item of PPE that Beth should wear to minimise this hazard.

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

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

.....

.....

.....

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

(b) Beth puts each swab inside a separate tube.

She then puts each tube inside a bag.

She seals each bag, labels them all and sends them back to the laboratory where they are stored in a fridge before being analysed.

(i) Suggest **two** things Beth should include on the labels of the blood sample bags.

1 .....

2 .....

[2]

(ii) Suggest **two** reasons why the evidence bags must be sealed before they are transported.

1 .....

2 .....

[2]

(iii) Explain why the swabs are stored at low temperatures while they are waiting to be analysed.

.....

.....

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

(c) The laboratory she works in contains many chemicals. There are rules about how these chemicals must be labelled, stored and disposed of.

(i) Draw lines to link the type of chemical to the correct storage location.

Chemical	Storage location
Concentrated hydrochloric acid	Flammables cupboard
Ethanol	Toxic chemicals locker
Sodium cyanide	Corrosives cupboard

[2]

(ii) Draw lines to link the type of waste to a standard disposal method.

Type of waste	Standard disposal method
A shattered beaker	Pour down a designated sink
The sample swabs	Place in a broken glassware box
1 mol dm^{-3} hydrochloric acid	Place in an autoclave

[2]

2 Digoxin is a medication used to treat various heart conditions. It belongs to a group of chemicals called alkaloids.

Digoxin and other alkaloids can be extracted from the leaves of some plants using solvents.

The extracted mixture of alkaloids can then be separated using HPLC.

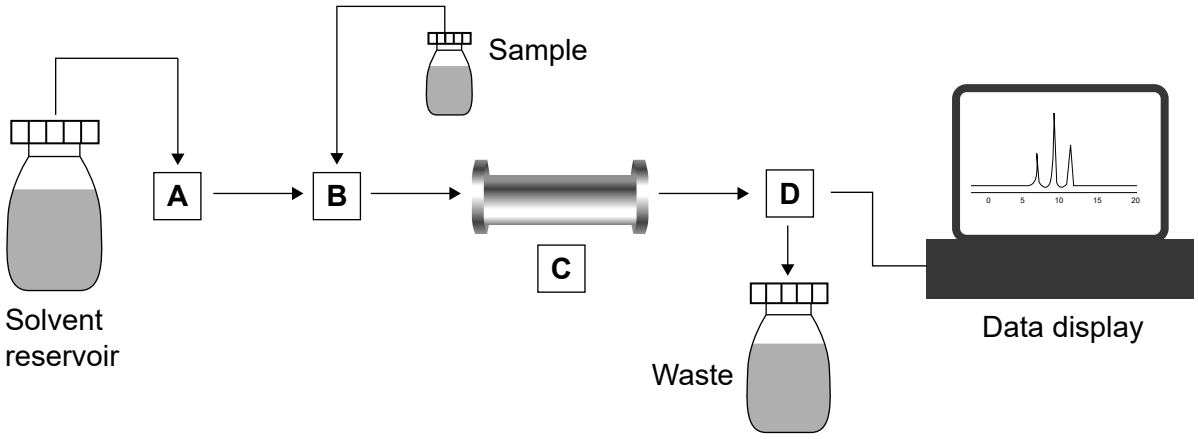
(a)

(i) State what HPLC stands for.

.....

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

(ii) A partially labelled block diagram of an HPLC system is shown below.



Four labels have been done for you.

Identify **A**, **B**, **C** and **D** using words from the list below.

detector **HPLC column** **pump** **sample injector**

A .....

B .....

C .....

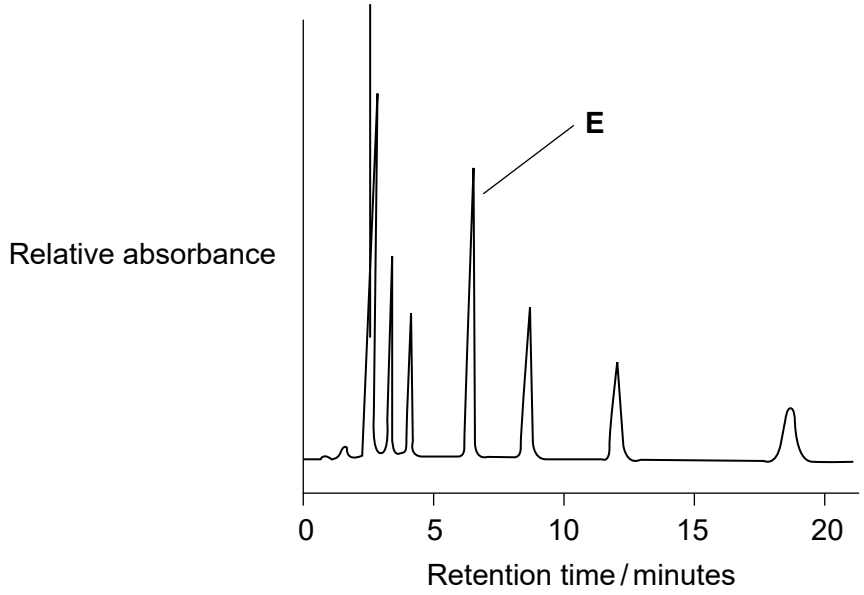
D.....

[3]

(b) Mia and Kofi work for a pharmaceutical company. They are using HPLC to separate alkaloids extracted from plants.

An HPLC chromatogram of extracted alkaloids is shown below.

The peak that Mia and Kofi think is digoxin is labelled **E**.



(i) Estimate the retention time of the peak labelled **E**.

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

(ii) Mia thinks there are eight different alkaloids in the extract.

State how the chromatogram shows this.

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

(iii) Use the chromatogram to explain how the **relative** amount of digoxin in the sample can be determined.

.....

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

(iv) Describe how Mia and Kofi could determine the **actual** amount of digoxin in the sample.

.....

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

(c) The alkaloids extracted from plants can be positively identified using MS.

(i) Put a (ring) around the correct meaning of MS from this list.

Mass spectrometry **Mass standards**

Measurement standards **Molar spectrometry**

[1]

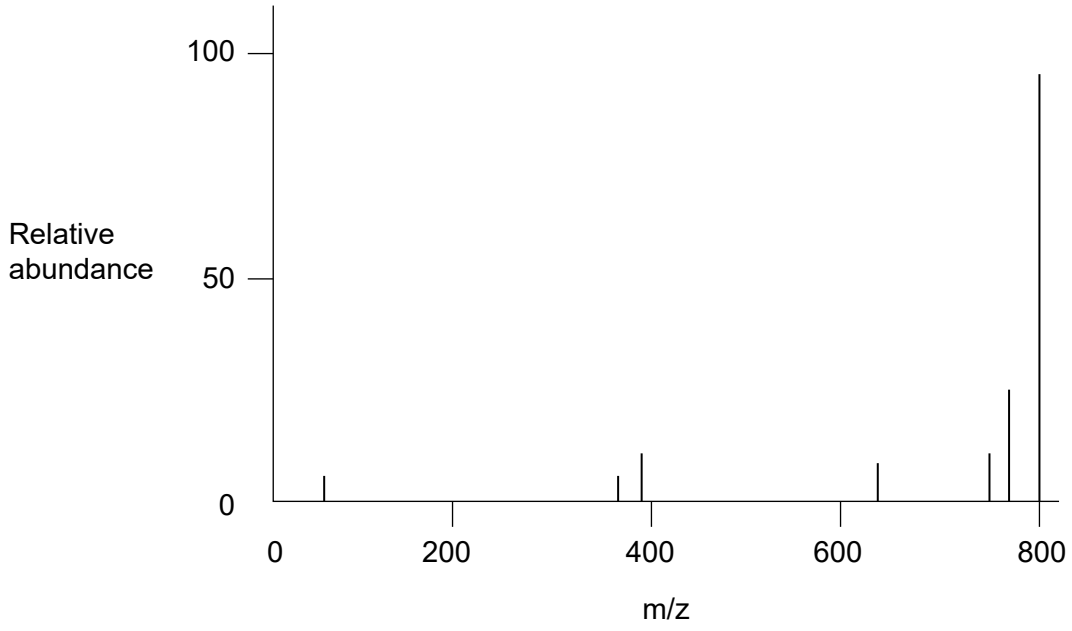
(ii) A series of five steps occur inside an MS machine.

Number the steps in the order they occur. The first one has been done for you.

Steps	Order
Fragmentation	
Ionisation	1
Detection	
Deflection	
Acceleration	

[2]

(iii) The spectrum obtained for digoxin is shown below.



Use the spectrum to estimate the molar mass of digoxin.

..... $g\,mol^{-1}$ **[1]**

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PLEASE DO NOT WRITE ON THIS PAGE

Turn over for the next question

3 Jane and James are laboratory technicians working for a chemical company that manufactures household cleaners.

The active ingredient in drain cleaners is sodium hydroxide, NaOH.

They plan to do a titration with hydrochloric acid, HC*l* to determine the concentration of NaOH in a drain cleaner.

They need to use the following equations in their calculations.

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

(a) For the titration they need a 0.100 mol dm^{-3} solution of HC*l* which they make from concentrated (12.05 mol dm^{-3}) hydrochloric acid.

(i) Calculate the volume, in cm^3, of 12.05 mol dm^{-3} hydrochloric acid that contains 0.100 mole of HC*l*.

Volume = ... cm^3 **[1]**

(ii) Complete the sentences below using words from the list.

1 dm^3 measuring cylinder	**10 cm^3 graduated pipette**	**1 dm^3 beaker**
1 dm^3 volumetric flask	**10 cm^3 measuring cylinder**	**10 cm^3 beaker**

1. The volume of concentrated HC*l* calculated in **(a)(i)** should be measured using

   a .....

2. The correct volume of concentrated HC*l* should be transferred to

   a ..... and made up to 1 dm^3 with distilled water.

[2]

(b) Jane and James dilute 50 cm^3 of drain cleaner by a factor of 5.

They then do a titration with the diluted drain cleaner.

They use the following method for the titration:

- Transfer 25.0 cm^3 of the diluted drain cleaner into a conical flask.
- Add 3 drops of a suitable indicator.
- Fill a burette with 0.100 mol dm^{-3} HC*l*.
- Titrate the diluted drain cleaner against the 0.100 mol dm^{-3} HC*l*.

(i)* Describe **and** explain the steps the technicians should take to ensure that their results are as accurate as possible.

Include the name of the apparatus they would use to measure out the 25.0 cm^3 of diluted drain cleaner, and the name of a suitable indicator.

.....

.....

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

(ii) The technicians obtained the following results.

	Rough Titration	**Titration 1**	**Titration 2**	**Titration 3**
Final reading /cm^3	32.60	32.50	32.60	32.50
Initial reading /cm^3	0.00	0.20	0.05	0.10
Titre /cm^3	.....	.....	.....	.....

Complete the table, state which titres are concordant and explain how the technicians should use their results to calculate the mean titre.

.....

.....

.....

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

(c) Complete steps **(i)** to **(iv)** to calculate the concentration of NaOH in the drain cleaner.

(i) Use the mean titre to calculate the number of moles of HC*l* used in the titration.

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

(ii) In the titration, 1 mole of HC*l* neutralises 1 mole of NaOH.

Use your answer to **(c)(i)** to deduce the number of moles of NaOH in 25.0 cm^3 of the diluted drain cleaner.

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

(iii) Calculate the number of moles of NaOH in 1 dm^3 of the diluted drain cleaner.

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

(iv) The drain cleaner was originally diluted by a factor of 5.

The molar mass of NaOH is 40.0 g mol^{-1}.

Calculate the concentration of NaOH in g dm^{-3} of the **undiluted** drain cleaner.

Give your answer to **3** significant figures.

Concentration of NaOH ..... g dm^{-3} **[2]**

4 Radiographers can use ultrasound and X-ray images to reveal structures hidden inside the human body.

(a) An ultrasound scanner being used on a patient's abdomen is shown below.

(i) Complete the following sentence.

Ultrasound waves are sound waves with a frequency .....

than the range of human hearing. **[1]**

(ii) Name the part labelled **A**.

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

(iii) Tick (✓) **one** box that best describes the function of the part labelled **A**.

To direct the ultrasound into the patient and receive the reflected ultrasound from the patient.	☐
To direct the ultrasound into the patient's abdomen.	☐
To produce the ultrasound image.	☐
To receive the reflected ultrasound from the patient.	☐

[1]

(iv) Name the substance labelled **B**.

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

(b) An ultrasound scan of a 12 week foetus is shown below.

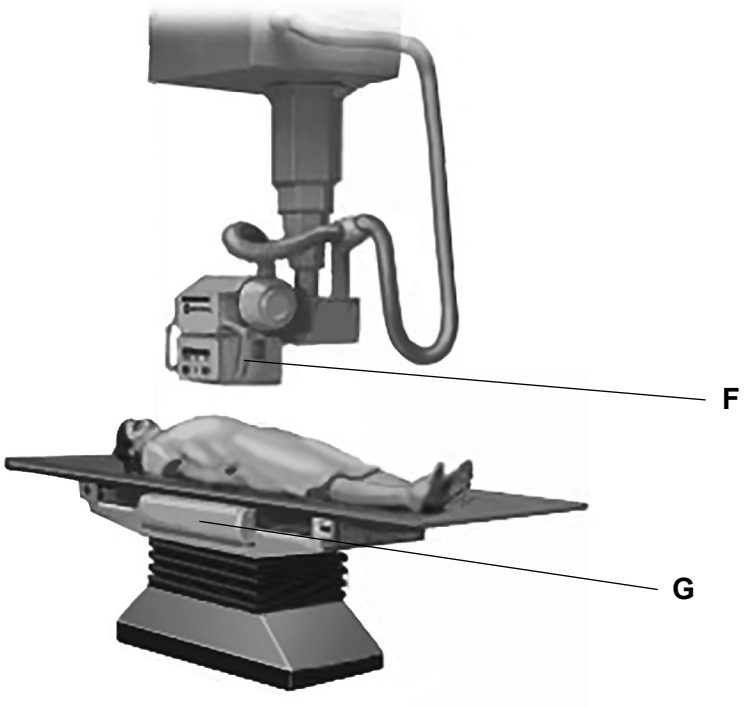
(i) Which area, **C**, **D** or **E**, is most likely to be fluid-filled?

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

(ii) Name the type of tissue or organ protected by **C**.

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

(c) An image of a patient having an X-ray scan is shown below.



(i) Complete the sentence below using words from this list.

electromagnetic high longitudinal low medium sound

X-rays are ..... energy .....

waves used for medical diagnosis.

[2]

(ii) Name the part labelled **F**.

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

(iii) Tick (✓) **one** box that best describes the function of the part labelled **F**.

To detect the X-rays that leave the patient.	☐
To produce X-rays and direct them to the patient.	☐
To produce X-rays and to detect the X-rays that leave the patient.	☐
To reflect X-rays.	☐

[1]

(iv) Name the part labelled **G**.

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

(v) Tick (✓) **one** box that best describes the function of the part labelled **G**.

To detect the X-rays that leave the patient.	☐
To generate the X-ray image.	☐
To produce X-rays and direct them to the patient.	☐
To produce X-rays and to detect the X-rays that leave the patient.	☐

[1]

(d) Explain why pregnant women are more likely to be scanned using ultrasound rather than X-rays.

.....

.....

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

5

(a) A group of students has been asked to identify two ionic compounds: **X** and **Y**.

The tests they plan to use are:

- Flame test
- Barium chloride test
- Sodium hydroxide test
- Silver nitrate test.

(i) The table shows steps for the sodium hydroxide test.

Number the steps in the order they occur. The first one has been done for you.

Step	**Order**
Add a few drops of aqueous sodium hydroxide.	
Add the aqueous sodium hydroxide until it is in excess and record the result.	
Dissolve a small quantity of the unknown solid in distilled water.	1
Place about 5 cm^3 of the solution into a test tube.	
Record the colour of any precipitate that is formed.	

[2]

(ii) The students obtained the following results.

Test	**Results for compound X**	**Results for compound Y**
Flame test	Lilac flame	No change to normal flame colour
Addition of aqueous barium chloride	No precipitate	White precipitate
Addition of aqueous sodium hydroxide	No precipitate	Green precipitate which is insoluble in excess NaOH(aq)
Addition of aqueous silver nitrate	Yellow precipitate	No precipitate

Use the results to identify compounds **X** and **Y**.

Compound **X** .....

Compound **Y** .....

[4]

(iii) The students were then asked to show that a third compound, **Z**, contained carbonate ions.

Describe the test they would use and what they would observe.

.....

.....

.....

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

(iv) Put a ring around the correct formula of the carbonate ion.

CO_3^- **CO^{2-}** **CO_2^{3-}** **CO_3^{2-}** **[1]**

Question 5(b)(i) begins on page 18

(b) Cadmium is a metal that is toxic to humans. Some food contains very small amounts of cadmium ions.

For milk to be safe to drink, the concentration of cadmium ions must be below 10 $\mu g\,dm^{-3}$.

Analytical laboratories use ICP-AES to determine the concentration of cadmium ions in samples of milk.

(i) A technician working in the analytical laboratory first produces a calibration graph.

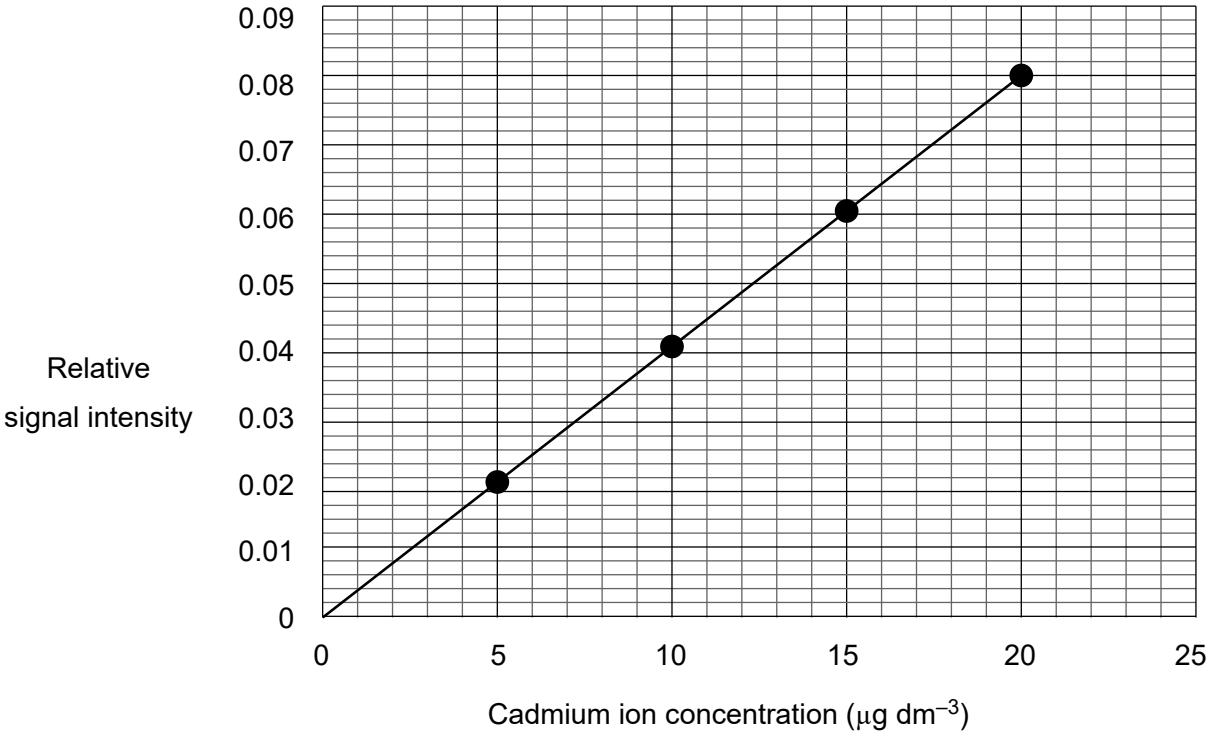
The technician uses ICP-AES to measure the intensity of the emitted radiation using four different concentrations of cadmium ions.

The technician starts by preparing a solution with a cadmium ion concentration of 20 $\mu g\,dm^{-3}$.

What technique is used to prepare the other solutions for the calibration?

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

(ii) The technician obtains the following calibration graph.



The technician then prepares and analyses a sample of milk using ICP-AES.

The relative signal intensity was found to be 0.032.

Explain if the milk is safe to drink. Show your working on the graph.

.....

.....

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

(iii) ICP-AES is used to identify many different metals, but AES can only identify a small number of metals.

Put a (ring) around each cation in the list below that can be identified using AES.

Li^+ **Mg^{2+}** **Ni^{2+}** **Zn^{2+}** **[1]**

Turn over for the next question

6 Vaccines for influenza (flu) can be manufactured in eggs using the following steps:

- Injecting eggs with live influenza virus
- Allowing the virus to multiply inside the eggs
- Purifying the influenza virus from the eggs
- Processing the virus so that it is attenuated (no longer harmful to humans)
- Packaging the attenuated virus (vaccine) into glass vials.

(a) The figure below shows influenza virus being injected into an egg.

What is the most effective way of sterilising the surface of the eggs?

Tick (✓) **one** correct method.

Autoclaving the eggs. ☐

Irradiating the eggs with gamma rays. ☐

Wiping the eggs with a disinfectant. ☐

[1]

(b) The influenza-inoculated eggs are then incubated in a clean room, as shown below.

(i) Bacteria can contaminate the virus-inoculated eggs.

Suggest how the number of bacteria in the air of the clean room could be reduced.

.....

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

(ii) Describe how the number of bacteria in the air of the clean room can be monitored.

.....

.....

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

(iii) Name **three** pieces of PPE that **can be seen** in the figure that would prevent contamination of the employee by virus particles in the air.

1 .....

2 .....

3 .....

[3]

(iv) Suggest another reason for the employee wearing the PPE in the figure.

.....

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

(c) The influenza virus can be observed using a transmission electron microscope (TEM) or a scanning electron microscope (SEM).

Transmission electron microscopes and scanning electron microscopes have different features.

Put ticks (✓) in the correct boxes to indicate the features of the two types of microscopes.

Feature	TEM	SEM
Electrons are reflected off the surface of the virus.		
The image produced is two dimensional.		
Maximum magnification can be up to x 50 million.		
A typical resolution of 0.4 nm is achieved.		

[3]

(d) Some new influenza vaccines are produced by growing influenza viruses in animal cells that are being grown in sealed bioreactors, as shown below.

Explain why this new production method is safer for employees than the older method.

.....

.....

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

(e) Give **three** examples, other than vaccine and pharmaceutical production, of laboratory work where aseptic technique is required.

1 .....

2 .....

3 .....

[3]

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

Key
atomic number
Symbol
name
relative atomic mass

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

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