OCR
Oxford Cambridge and RSA

Thursday 10 January 2019 – Afternoon

LEVEL 3 CAMBRIDGE TECHNICAL IN APPLIED SCIENCE

05847/05848/05849/05874/05879 Unit 1: Science fundamentals

Duration: 2 hours

C340/1901

C340--1901

You must have:
- a ruler
- the Data sheet (Insert) (C349)

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.
- Write your answer to each question in the space provided.
- 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 **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **24** pages.

FOR EXAMINER USE ONLY	
Question No	**Mark**
1	/19
2	/14
3	/11
4	/15
5	/15
6	/8
7	/8
Total	**/90**

Answer **all** the questions.

1 **Fig. 1.1** shows the arrangement of electrons in an atom of element **Y**.

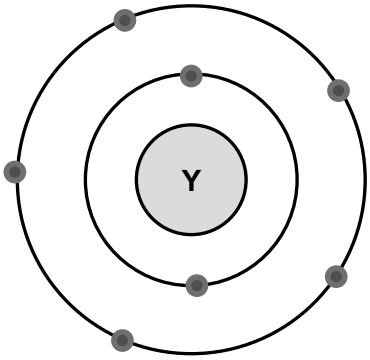


Fig. 1.1

(a) How many protons are in the nucleus of an atom of element **Y**?

Put a (ring) around the correct answer.

2 **5** **7** **8**

[1]

(b) **Fig. 1.2** shows the bond between two atoms of element **Y**.

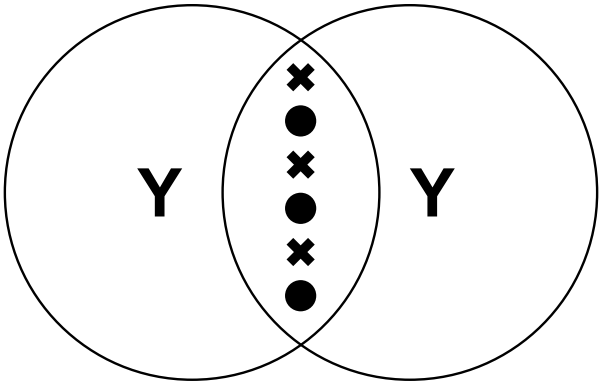


Fig. 1.2

Describe the bond between the two atoms of element **Y**.

.....

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

(c) **(i)** The distance between two nuclei of atoms of element **Y** is 3.1×10^{-10} m.

Explain why the nuclei cannot come any closer together.

.....

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

(ii) What is the name of the element **Y**?

Put a (ring) around the correct answer.

Chlorine **Helium** **Nitrogen** **Oxygen**

[1]

(d) The relative atomic mass of a different element, **Z**, is 24.305.

(i) What is the name of element **Z**?

Put a (ring) around the correct answer.

Calcium **Chromium** **Magnesium** **Sodium**

[1]

(ii) Explain why the relative atomic mass of **Z** is not a whole number.

.....

.....

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

(e) The nuclear radius R, of an atom can be approximated using the formula $R = r_0 A^{1/3}$, where A is the nucleon number (atomic mass number) and $r_0 = 1.25 \times 10^{-15}$ m.

The formula can be rearranged to give: $A = \left(\frac{R}{r_0}\right)^3$

Element **W** has a nuclear radius $R = 3.55 \times 10^{-15}$ m.

(i) Calculate the nucleon number (atomic mass number) A of element **W**.

Give your answer to the nearest whole number.

nucleon number (atomic mass number) A = …….....**[3]**

(ii) Complete the half-equation to show how an atom of element **W** becomes an ion.

$$W \longrightarrow W^{+} + ...$$

[1]

(f) Elements in the Periodic Table show a periodic trend in atomic radius from **Li** to **F**.

(i) What trend is shown in the atomic radius from **Li** to **F**?

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

(ii) Explain your answer to **(f)(i)**.

.....

.....

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

(g) The relative masses and relative charges of some subatomic particles are shown in **Table 1.1**.

Subatomic particle	Relative mass	Relative charge
A	1	+1
B	1	0
C	1/1836	-1

Table 1.1

Identify subatomic particles **A**, **B** and **C** by drawing a line to the correct name for the particle.

Subatomic particle	Name
A	**Neutron**
B	**Proton**
C	**Electron**

[3]

2 Andy is investigating reactions in chemical and biological systems.

His teacher tells him that reactions are affected by a number of different factors including temperature.

(a) Andy writes some sentences about the relationship between temperature and the rate of a reaction.

Complete the sentences below using the words listed. The words can be used once, more than once or not at all.

at the same rate	**kinetic**	**slower**	**increases**	**nuclear**
faster	**heat**	**decreases**	**stays the same**	

As temperature increases the molecules move ..... and as a result, the molecules have more ..... energy.

The number of collisions that can overcome the activation energy for the reaction ..... with an increase in temperature.

[3]

(b) **(i)** Andy also investigates the effect of enzymes on the rate of reactions.

What term is used to define an enzyme?

Put a (ring) around the correct answer.

Activist	**Catalyst**	**Energy**	**Product**	**Reactant**

[1]

(ii) Andy looks at the graph in **Fig. 2.1** which shows the energy profile of a reaction, with and without an enzyme present.

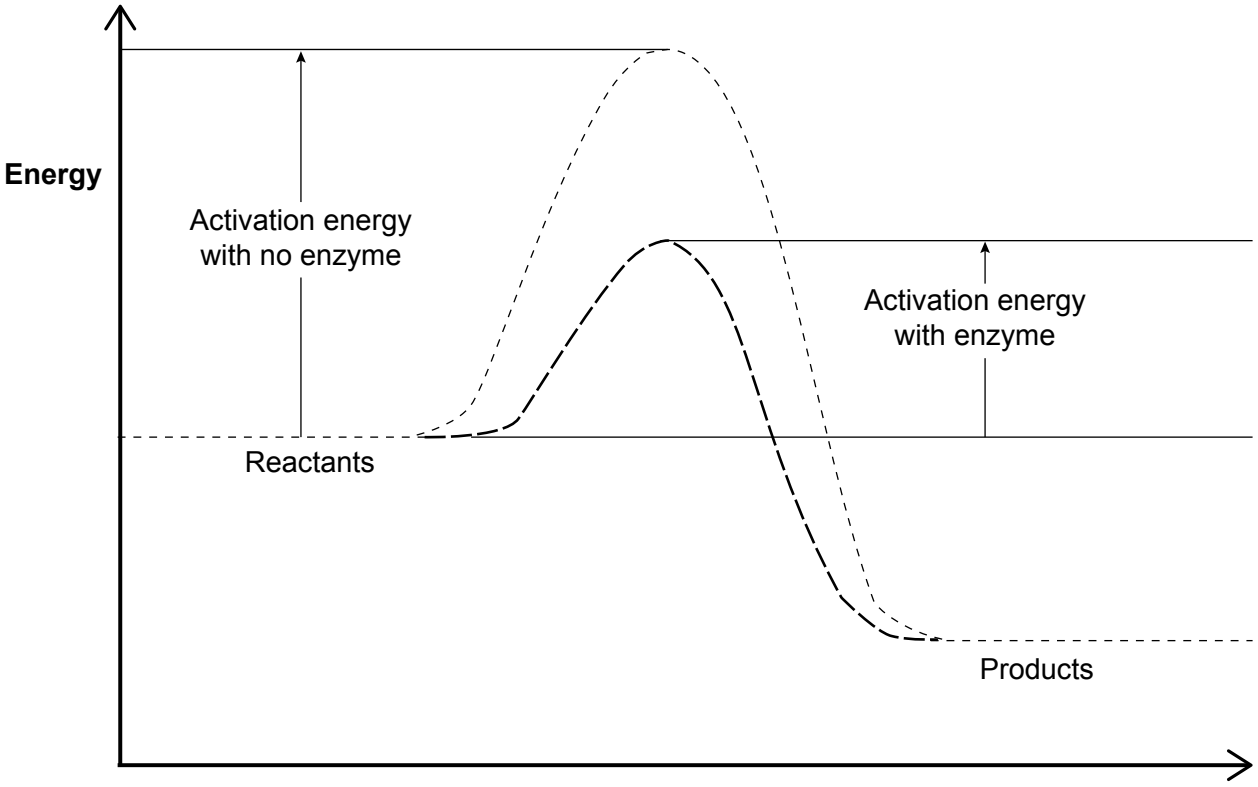


Fig. 2.1

Describe the key features of the graph shown in **Fig. 2.1**.

.....

.....

.....

.....

.....

.....

.....

.....**[4]**

(iii) Suggest **two** ways of measuring the progress of the reaction shown in **Fig. 2.1**.

1 .....

2 .....

[2]

(c) The lock and key hypothesis is used to describe how enzymes work.

The hypothesis includes a number of steps.

Below is a list of the key steps but they are **not** in the correct order.

Put a number in each box to show the correct order. The first one has been done for you.

Description	Step
An enzyme/reactant complex forms.	
The products are released from the active site.	
The reactant fits into the active site of the enzyme.	**1**
The enzyme returns to its original state.	
An enzyme/product complex forms.	

[4]

3 *Cymbomonas* is a single-celled green alga. *Cymbomonas* is able to engulf bacteria.

When there is a lot of light, *Cymbomonas* carries out the process of photosynthesis.

If light levels fall, it will start to engulf bacteria and the bacteria collect in the cell vacuole.

Fig. 3.1 shows a transmission electron micrograph of *Cymbomonas*.

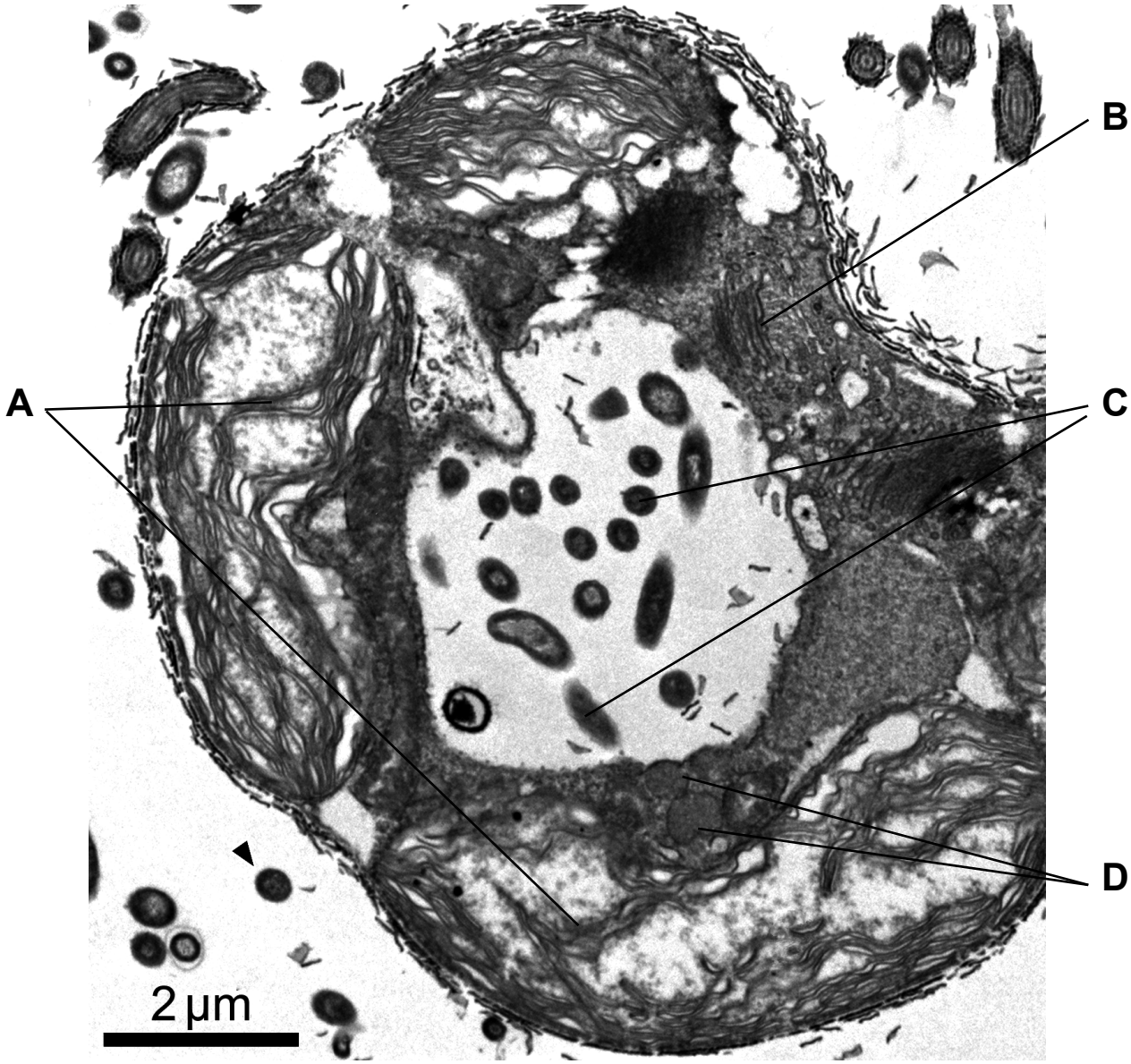


Fig. 3.1

Key
A = two parts of a single chloroplast
B = Golgi apparatus
C = bacteria inside the cell vacuole
D = mitochondria

(a) (i) State **one** function of the Golgi apparatus in **Fig. 3.1**.

.....

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

(ii) State **one** function of the mitochondria in **Fig. 3.1**.

.....

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

(b) Suggest why the single chloroplast appears as two distinct structures in the transmission electron micrograph shown in **Fig. 3.1**.

.....

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

(c) The image in **Fig.3.1** shows some of the features of the chloroplast in a *Cymbomonas* cell.

Name **one** feature of a chloroplast and explain how this enables the chloroplast to function.

.....

.....

.....

.....

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

(d) **Fig. 3.1** shows a number of bacteria in the vacuole of the cell.

Which organelle in a cell normally breaks down bacteria?

Tick (✓) **one** box.

Endoplasmic reticulum	☐
Lysosome	☐
Nucleus	☐
Ribosome	☐

[1]

(e) Bacteria are prokaryotic.

Cymbomonas is eukaryotic.

(i) State **one difference** between prokaryotic and eukaryotic cells that is **visible** in **Fig. 3.1**.

.....

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

(ii) State **two similarities** between prokaryotic cells and eukaryotic cells that are **not visible** in **Fig. 3.1**.

1 .....

.....

2 .....

.....

[2]

(iii) State **two differences** between prokaryotic cells and eukaryotic cells that are **not visible** in **Fig. 3.1**.

1 .....

.....

2 .....

.....

[2]

4 Polymers can be found all around us and are either synthetic or natural.

Natural polymers are found in plants and animals.

(a) (i) DNA is an example of a natural polymer. DNA is made up of four different monomers.

What is the name of the monomers that make up DNA?

Tick (✓) **one** box.

Alkenes ☐

Amino acids ☐

Glucose ☐

Nucleotides ☐

[1]

(ii) Each monomer in DNA has three parts – a sugar group, a phosphate group and one of four different bases.

Name **two** bases found in **DNA**.

Tick (✓) **two** boxes.

Adenine ☐

Adrenaline ☐

ATP ☐

Cellulose ☐

Thymine ☐

Thyroxine ☐

Uracil ☐

[2]

(iii) Natural polymers are also organic compounds.

There are different types of these compounds due to the nature of the carbon atom and the presence of other elements.

Some of the compounds are listed and described below.

Draw a line to link **each** type of compound to its correct description.

Type of compound	Description
Alkane	Organic compounds containing the C=O group.
Alkene	Organic compounds containing the COOH group.
Aldehyde	Organic compounds containing the OH group.
Carboxylic acid	Saturated hydrocarbons containing single C-C and C-H bonds.
Alcohol	Unsaturated hydrocarbons containing a C=C double bond.

[5]

(b) Synthetic polymers are used to make plastics and are produced from oil.

Many polymers are produced from the polymerisation of alkenes.

Poly(propene) is produced from the polymerisation of the alkene propene.

Poly(propene) can be represented as shown in **Fig. 4.1**.

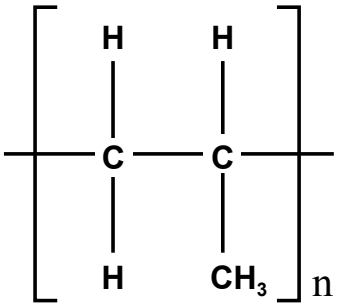


Fig. 4.1

Draw the structural formula of the monomer poly(propene) is formed from.

[2]

(c) Scientists in the USA have found a method of producing a polymer called polyhydroxybutyrate (PHB). They can produce PHB by inserting genes from a bacterium into a type of grass called switchgrass.

The final stage in the production of PHB is controlled by an enzyme called PHB-synthase (PhaC).

Since PhaC is an enzyme, it is a type of protein.

Describe how PhaC is produced from the genetically-modified DNA of the switchgrass.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

5 Manganese is one of the most abundant transition metals on Earth.

It is an essential trace element.

(a) Manganese compounds are added to animal feed.

Suggest **one** reason for the addition of manganese compounds to animal feed.

.....

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

(b) Table **5.1** shows the average concentration of manganese found in some tissues and organs of four different types of farm animals.

Tissue or organ	Average concentration of manganese (mg kg^{-1})			
	Cattle	**Chickens**	**Ducks**	**Pigs**
Kidney	1.4	2.4	2.5	1.6
Liver	3.5	4.1	10.4	4.2
Muscle	0.3	0.2	0.3	0.1

Table 5.1

(i) Which tissue or organ in **Table 5.1** has the highest concentration of manganese?

Put a (ring) around the correct answer.

Kidney **Liver** **Muscle**

[1]

(ii) Which animal in **Table 5.1** has the lowest concentration of manganese?

Put a (ring) around the correct answer.

Cattle **Chickens** **Ducks** **Pigs**

[1]

(c) The most common oxidation states of manganese are +2, +3, +4, +6 and +7.
Only +2, +3 and +4 have been found in mammalian tissues.

Complete **Table 5.2** by filling in the oxidation states of the manganese compounds listed.

One has been done for you.

Manganese compound	Oxidation state
$MnCl_2$	+2
Mn_2O_3	
MnO_2	

Table 5.2

[2]

(d) What happens during the oxidation of an atom?

Tick (✓) **one** box.

Electrons are gained ☐

Electrons are lost ☐

Neutrons are gained ☐

Neutrons are lost ☐

Protons are gained ☐

Protons are lost ☐

[1]

(e) The disease bovine spongiform encephalopathy (BSE) or 'mad cow disease' usually affects cows.

The disease mostly affects the brain, where an abnormal form of a protein called prion accumulates. Normal and abnormal prion proteins are thought to contain a metal.

Scientists have studied the concentration of manganese in prion proteins in different parts of the nervous systems and blood of cows with BSE and those without the disease.

The results from the study are shown in **Table 5.3**.

Region of body	Condition of cow	Concentration of manganese (ppb)
Brain cortex	Without BSE	326
	BSE	34
Brain stem	Without BSE	191
	BSE	415
Spinal cord	Without BSE	266
	BSE	365
Blood	Without BSE	49
	BSE	83

Table 5.3

Describe the trend and the conclusions that can be drawn from the data in **Table 5.3**.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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

(f) **Table 5.4** shows the results of a study in the USA on the effects of manganese on a form of arthritis called rheumatoid arthritis.

The scientists estimated the risk of developing the condition from estimates of manganese intake in people's diet.

Less than 2.09	2.09 – 3.00	Greater than 3.00
1.00	0.93	1.07

Table 5.4

What conclusion can be drawn from the results in **Table 5.4**?

.....

.....

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

(g) Manganese is just one of many metal ions with biological functions.

Three of the other metal ions are: **iron**, **nickel** and **calcium**.

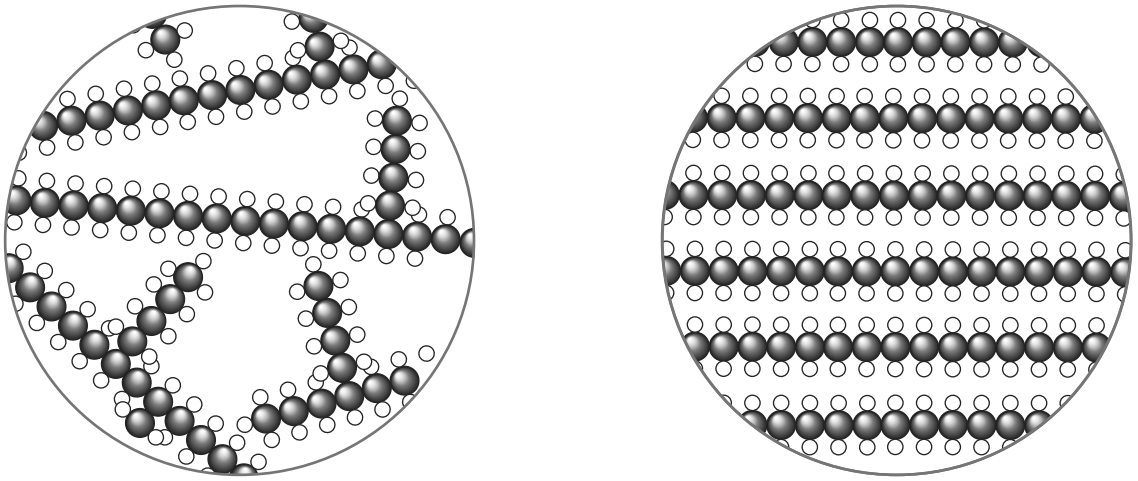
Draw a line to link each function to the correct ion.

Function	Ion
Carriage of oxygen in haemoglobin and myoglobin.	**Calcium**
Component of the enzyme, hydrolase.	**Iron**
Needed for the formation of bone matrix.	**Nickel**

[2]

6 Alice is investigating the features of poly(ethene).

Fig. 6.1 shows two forms of the molecular structure of poly(ethene).



Form 1 **Form 2**

Fig. 6.1

(a) Identify **two** differences between the molecular structures of poly(ethene) **Form 1** and **Form 2** shown in **Fig. 6.1**.

1.....

2.....

[2]

Alice takes samples of each of the two forms of poly(ethene) and tests them to measure their tensile strength, hardness and melting point.

Table 6.1 shows the results of the tests.

Form of poly(ethene)	Tensile strength (MPa)	Hardness	Melting point (°C)
1	9	48	112
2	32	68	131

Table 6.1

(b) Suggest **three** conclusions that can be made from the results in **Table 6.1**.

.....

.....

.....

.....

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

(c) Explain how the differences in structure between **Form 1** and **Form 2** produce the different properties shown in **Table 6.1**.

.....

.....

.....

.....

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

7 A rechargeable battery contains twelve cells connected in series with a resistor **X**.

Each cell has an internal resistance r_c, of 0.5 Ω and an electromotive force (e.m.f.) of 2.3 V.

(a) (i) Calculate the e.m.f. of the rechargeable battery.

e.m.f. = ... V

[1]

(ii) Calculate the internal resistance r_B of the rechargeable battery.

internal resistance r_B = ... Ω

[1]

(b) The rechargeable battery is connected to a direct current supply with an e.m.f of 100 V.

The e.m.f. of the rechargeable battery opposes the e.m.f of the power supply.

(i) Calculate the **net** e.m.f. of the circuit.

net e.m.f. = ... V

[1]

(ii) The current in the circuit is 2.6 A.

Calculate the resistance of resistor X.

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

resistance of **X** = ... Ω

[5]

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(b) or 3(b).

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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

OCR
Oxford Cambridge and RSA