Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

New Template Exemplar
Time: 1 hour 15 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care on these questions with your spelling, punctuation and grammar, as well as the clarity of expression.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

N36145A

N 3 6 1 4 5 A 0 1 2 8

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 25 minutes on this section. For each question, select one answer from A to D and put a cross in the box (☒). If you change your mind, put a line through the box (☒) and then mark your new answer with a cross (☒).

Use the Periodic Table as a source of data.

1 Going across a period in the Periodic Table from left to right, the general trend is that

☒ **A** the bonding in the element itself changes from ionic to covalent

☒ **B** the number of neutrons in the nucleus increases

☒ **C** the first ionisation energy decreases

☒ **D** the metallic character increases

(Total for Question 1 = 1 mark)

2 The electron configurations of argon, iron, chlorine and one other element are given below, but not in order. Which one represents the unnamed element?

☒ **A** $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^6\,4s^2$

☒ **B** $1s^2\,2s^2\,2p^6\,3s^2\,3p^6$

☒ **C** $1s^2\,2s^2\,2p^6\,3s^2\,3p^4$

☒ **D** $1s^2\,2s^2\,2p^6\,3s^2\,3p^5$

(Total for Question 2 = 1 mark)

3 Buckminsterfullerene is a carbon molecule with formula C_{60} which can trap metal ions in its structure. Which of the following compounds of buckminsterfullerene would give a line of mass/charge ratio at 837.3 in a mass spectrometer?

☒ **A** Na_4C_{60}

☒ **B** K_3C_{60}

☒ **C** Ca_3C_{60}

☒ **D** AgC_{60}

(Total for Question 3 = 1 mark)

4 This question is about the following equations:

A $Cu(NO_3)_2(s) \rightarrow CuO(s) + 2NO_2(g) + O_2(g)$

B $2HCl(aq) + CuO(s) \rightarrow H_2O(l) + CuCl_2(aq)$

C $C_4H_9OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$

D $C_8H_{18}(l) + 8½O_2(g) \rightarrow 8CO(g) + 9H_2O(l)$

(a) Which equation is **not** balanced?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which equation shows incomplete combustion?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 4 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

5 Which of the equations shown below represents the reaction for which ΔH is the standard enthalpy change of formation, $\Delta H^{\ominus}_{f\,298}$, for ethanol, C_2H_5OH. Ethanol melts at 156 K and boils at 352 K.

☒ **A** $2C(g) + 6H(g) + O(g) \rightarrow C_2H_5OH(g)$

☒ **B** $2C(s) + 3H_2(g) + O_2(g) \rightarrow C_2H_5OH(l)$

☒ **C** $2C(s) + 3H_2(g) + O(g) \rightarrow C_2H_5OH(g)$

☒ **D** $2C(s) + 3H_2(g) + ½O_2(g) \rightarrow C_2H_5OH(l)$

(Total for Question 5 = 1 mark)

6 Use the data about four fuels given below to answer this question.

Fuel	Formula	Name	Enthalpy change of combustion /kJ mol^{-1}	Molar mass /g mol^{-1}
A	CH_4	methane	–890	16
B	CH_3OH	methanol	–726	32
C	C_3H_8	propane	–2219	44
D	C_4H_{10}	butane	–2877	58

(a) Which fuel, A, B, C or D, produces most energy per gram on complete combustion?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Scientists give governments advice on technical issues. What information would scientists use when advising governments on the choice of one of these fuels, if the aim was to minimise carbon dioxide production?

(1)

☒ **A** mass of carbon per gram of fuel

☒ **B** mass of carbon per kilojoules produced

☒ **C** number of kilojoules produced per gram

☒ **D** number of kilojoules produced per mole

(Total for Question 6 = 2 marks)

7 Which of the following equations represents the first ionisation of sulfur?

☒ **A** $S(s) + e^- \rightarrow S^-(g)$

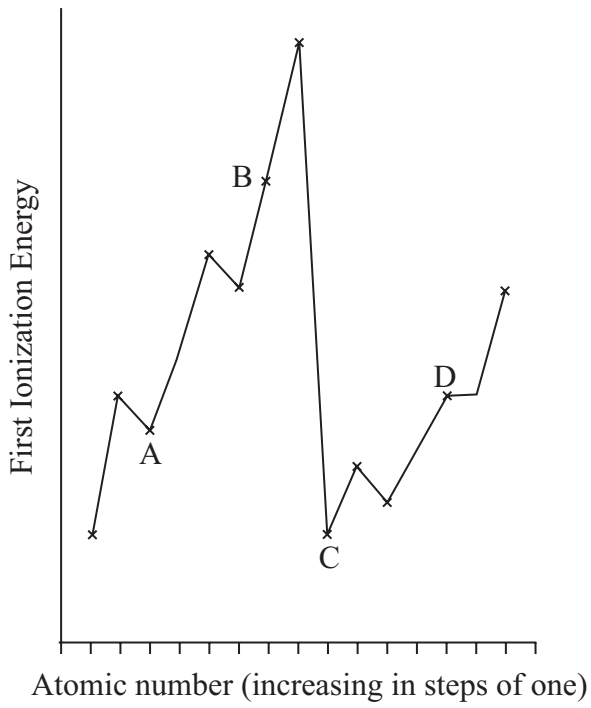
☒ **B** $S(g) + e^- \rightarrow S^-(g)$

☒ **C** $S(s) \rightarrow S^+(g) + e^-$

☒ **D** $S(g) \rightarrow S^+(g) + e^-$

(Total for Question 7 = 1 mark)

8 Which element marked on this graph is a halogen?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 8 = 1 mark)

9 Question 9 is about the following ionisation energy sequences.

The values are all in kJ mol^{-1}.

A	1400	1000	950	830	700
B	420	3100	4400	5900	8000
C	1000	1250	1520	420	590
D	1520	2700	3900	5800	7200

Select from A to D the sequence which is most likely to represent the following:

(a) The first ionisation energies of five consecutive members of the same group in the Periodic Table, in order of increasing atomic number.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) The first five ionisation energies of an s-block element.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) The first five ionisation energies of a noble gas.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 3 marks)

10 Question 10 is about four hydrocarbons with molecular formulae as shown.

A C_2H_2

B C_3H_6

C C_3H_8

D C_4H_{10}

(a) Which hydrocarbon has the same empirical formula as its molecular formula?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

Use this space for any rough working. Anything you write in this space will gain no credit.

(b) Which has a molecular ion in the mass spectrum at mass/charge ratio = 58?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which is neither an alkane nor an alkene?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) Which could be 2-methylpropane?

(1)

☒ **A**

☒ **B**

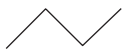
☒ **C**

☒ **D**

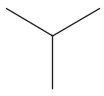
(Total for Question 10 = 4 marks)

11 Question 11 is about the following organic compounds with skeletal formulae as shown:

A

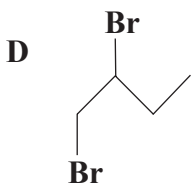


B



C

D



(a) Which compound could be made from one of the others in an addition reaction?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

Use this space for any rough working. Anything you write in this space will gain no credit.

(b) Which compound has E–Z isomers?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 11 = 2 marks)

12 Chemists investigating the mechanism of the reaction of ethene and bromine thought that the first step was the addition of Br^+. To test this, they reacted bromine with ethene in the presence of sodium chloride.

If their theory about the first step of the reaction was correct, which product might form as well as 1,2-dibromoethane?

☒ **A** CH_2BrCH_2Na

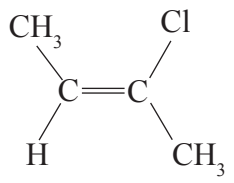
☒ **B** CH_2BrCH_2Cl

☒ **C** CH_2ClCH_2Cl

☒ **D** CH_2NaCH_2Na

(Total for Question 12 = 1 mark)

13 Which of the following is the correct name for the compound below?



☒ **A** Z-3-chlorobut-2-ene

☒ **B** E-3-chlorobut-2-ene

☒ **C** E-2-chlorobut-2-ene

☒ **D** Z-2-chlorobut-2-ene

(Total for Question 13 = 1 mark)

TOTAL FOR SECTION A = 21 MARKS

SECTION B

Answer ALL questions. Write your answers in the spaces provided.

14 Copper(II) sulfate solution can be prepared from solid copper(II) carbonate by reaction with hot dilute sulfuric acid.

(a) Write the equation for the reaction, including state symbols.

(1)

(b) The experiment was carried out using 0.025 moles of sulfuric acid of concentration 2.0 mol dm^{-3}. What volume of this sulfuric acid was used?

(1)

(c) (i) It is usual to react the sulfuric acid with a slight excess of copper(II) carbonate.

Calculate the mass of copper(II) carbonate needed if a 10% excess is required.

[Molar mass of copper(II) carbonate = 123.5 g mol^{-1}]

(2)

(ii) A student doing this experiment chose to use a balance reading to 0.01 g in an attempt to work accurately.

Was this choice of balance necessary from the point of view of accuracy? Explain your answer.

(1)

.....

.....

(d) The sulfuric acid is heated to boiling and the copper(II) carbonate is added in small portions.

State the next step needed to prepare pure copper(II) sulfate solution. Justify your answer.

(1)

.....

.....

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.....

(e) When the solution of copper(II) sulfate is allowed to crystallise, the crystals which are produced have the formula $CuSO_4.5H_2O$.

(i) What is the molar mass of $CuSO_4.5H_2O$?

(1)

(ii) 3.98 g of $CuSO_4.5H_2O$ crystals were obtained. Calculate the percentage yield in this experiment.

(2)

(Total for Question 14 = 9 marks)

15 This question is about magnesium and magnesium oxide.

*(a) Describe the bonding in magnesium and explain why it is a good conductor of electricity.

(3)

(b) Draw a diagram (using dots or crosses) for the ions in magnesium fluoride showing **all** the electrons and the ionic charges on:

(i) the magnesium ion

(1)

(ii) the fluoride ion.

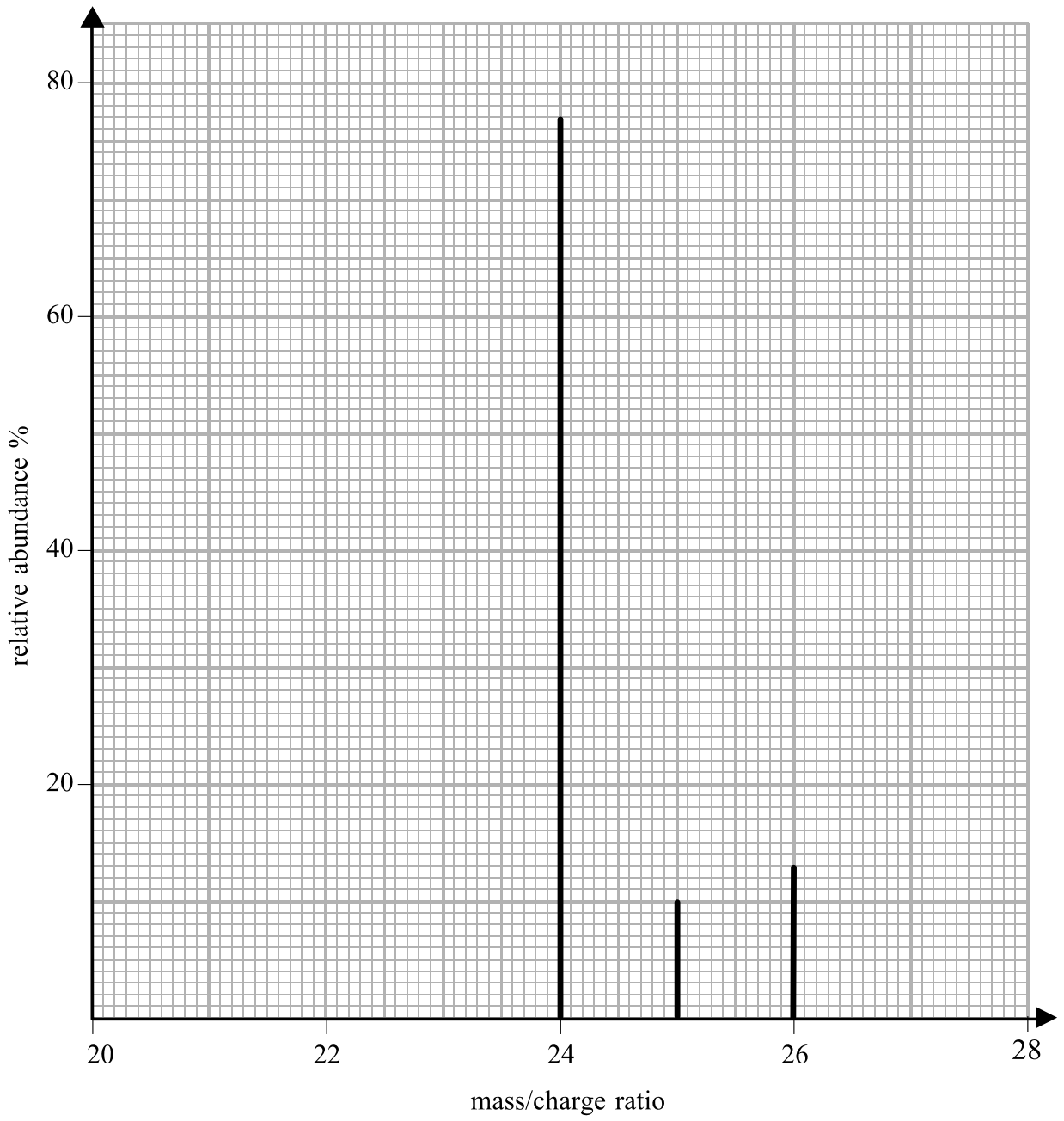
(1)

(c) Under what conditions does magnesium fluoride conduct electricity?

Explain your answer.

(1)

(d) The mass spectrum of a sample of magnesium is shown below.



(i) Use the data above to estimate the percentage isotopic composition of the sample of magnesium. Hence calculate the average atomic mass of the sample of magnesium.

(2)

(ii) Why do the three isotopes have the same chemical properties?

(1)

.....

.....

(e) (i) Oceanographers studying plankton found that a sample of seawater contained 1.20 nanomol dm^{-3} of chlorophyll, $C_{55}H_{77}MgN_4O_5$. (1 nanomol = 1×10^{-9} mol)

What mass of magnesium would be present in 1.00 cm^3 of this sample of seawater? Give your answer to **three** significant figures.

(2)

(ii) X-ray diffraction can be used to locate atoms or ions in molecules like chlorophyll. X-rays are scattered by the electrons in atoms and ions. In chlorophyll the atoms of one of the elements still cannot be located with certainty by this technique.

Suggest which element is most difficult to locate.

(1)

.....

.....

(Total for Question 15 = 12 marks)

16 Airbags, used as safety features in cars, contain sodium azide, NaN_3. An airbag requires a large volume of gas to be produced in a few milliseconds. The gas is produced in this reaction:

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g) \qquad \Delta H \text{ is positive}$$

When the airbag is fully inflated, 50 dm^3 of nitrogen gas is produced.

(a) Calculate the number of molecules in 50 dm^3 of nitrogen gas under these conditions.

[The Avogadro constant = 6.02×10^{23} mol^{-1}. The molar volume of nitrogen gas under the conditions in the airbag is 24 dm^3 mol^{-1}].

(2)

(b) Calculate the mass of sodium azide, NaN_3, that would produce 50 dm^3 of nitrogen gas.

(3)

(c) What will happen to the temperature in the airbag when the reaction occurs?

(1)

.....

.....

*(d) The airbag must be strong enough not to burst in an accident. An airbag which has burst in an accident is hazardous if the sodium azide in it has decomposed.

Explain why this is so.

(2)

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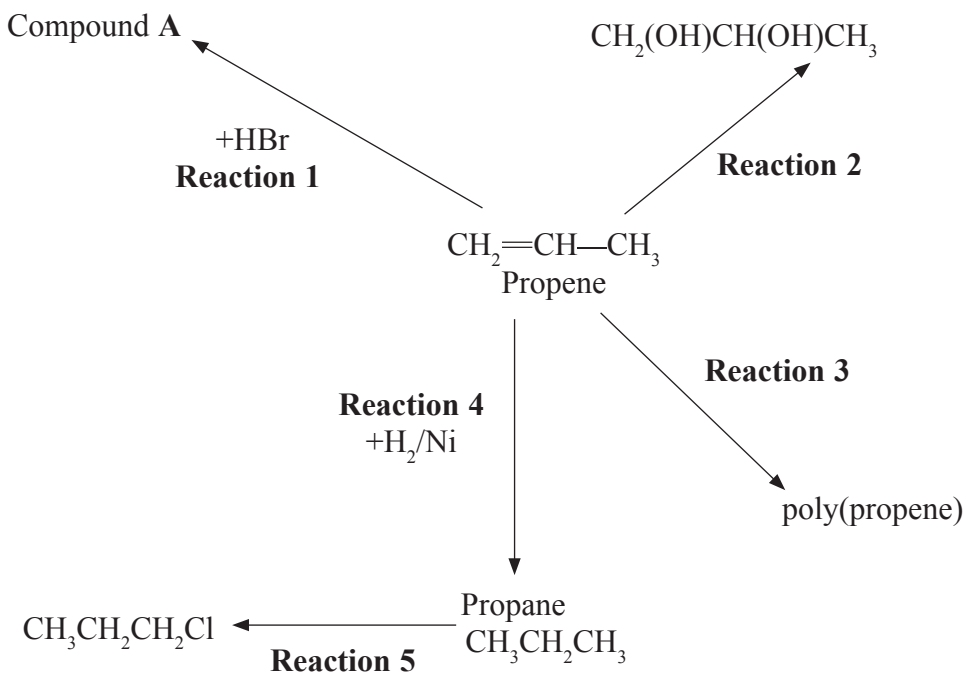
(Total for Question 16 = 8 marks)

17 Propene can be used to make other important chemical products. The processes involved can be summarised in the diagram:



(a) (i) Give the mechanism for **Reaction 1**.

(3)

(ii) Explain why compound **A** and **not** its structural isomer is the major product in **Reaction 1**.

(1)

.....

.....

.....

(iii) Name compound **A** formed in **Reaction 1**.

(1)

Name .....

(b) What is added in **Reaction 2** to make the product $CH_2(OH)CH(OH)CH_3$?

(1)

.....

(c) Complete the balanced equation for the formation of poly(propene) in **Reaction 3** using **displayed** formulae.

(2)

$n(CH_2{=}CHCH_3) \rightarrow$

(d) Poly(propene) fibres can be used to make fleece which is used at several horse racing courses to prevent the ground becoming frozen.

State **one** advantage of using poly(propene) instead of natural fibres of similar cost.

(1)

.....

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.....

(e) (i) One stage in the mechanism of **Reaction 5** is shown below.

$CH_3CH_2CH_3 + Cl^{\bullet} \rightarrow CH_3CH_2CH_2^{\bullet} + HCl$

What is this step?

(1)

.....

(ii) Give the name **or** formula of the trace product present in the final mixture which gives evidence for this mechanism.

(1)

.....

(Total for Question 17 = 11 marks)

18 A student investigated a reaction which could be used to warm up coffee in self-heating cans.

$$Mg(s) + Cu(NO_3)_2(aq) \rightarrow Mg(NO_3)_2(aq) + Cu(s)$$

In the self-heating cans, the bottom has a compartment containing copper(II) nitrate solution. When a button on the bottom of the can is pressed, the magnesium powder is released into the compartment where it reacts with the copper(II) nitrate solution.

(a) A student investigated the enthalpy change for this reaction by measuring

50.0 cm^3 of 0.300 mol dm^{-3} copper(II) nitrate solution into a 100 cm^3 beaker and adding 1 g (an excess) of magnesium powder.

The results are shown below.

Temperature of copper(II) nitrate solution at start	=	22 °C
Temperature of mixture after reaction	=	43 °C

(i) Calculate the energy change which took place. The specific heat capacity of the solution is 4.20 J $g^{-1}K^{-1}$.

Which is the correct value for the energy change in joules?

(1)

(ii) How many moles of copper(II) nitrate were used in the experiment?

(1)

(iii) Calculate the enthalpy change for the reaction. You should include a sign and units in your answer.

(2)

*(iv) Suggest **two** changes you would make to **the equipment** used in order to improve the accuracy of the result.

(2)

.....

.....

.....

.....

(b) The ionic equation for the reaction is shown below:

$Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$ $\Delta H = -532 \text{ kJ mol}^{-1}$

Would the following affect the value of the experimental result?

Explain your answer, stating the effect, if any, on the value of the enthalpy change obtained.

*(i) The student used 2 g rather than 1 g of magnesium.

(2)

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.....

.....

.....

*(ii) The heat losses that occurred from the student's beaker.

(2)

.....

.....

.....

.....

(c) The temperature in the self-heating can needs to increase by 60 °C to produce a hot drink.

Suggest a change you could make to the mixture in the experiment in (a) to produce a greater temperature rise. You are **not** expected to do a calculation.

(1)

.....

.....

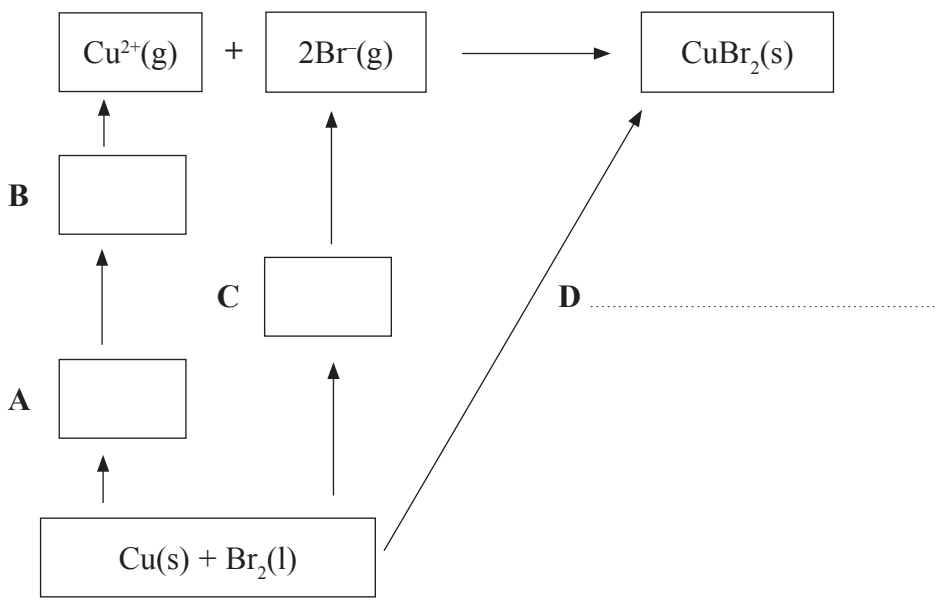
(Total for Question 18 = 11 marks)

19 The following data can be used in a Born-Haber cycle for copper(II) bromide, $CuBr_2$.

Enthalpy change of atomisation of bromine $\Delta H^{\ominus}_{at}[\frac{1}{2}Br_{2(l)}]$	+111.9 kJ mol^{-1}
Enthalpy change of atomisation of copper, $\Delta H^{\ominus}_{at}[Cu(s)]$	+338.3 kJ mol^{-1}
First ionisation energy of copper, E_{m1} [Cu(g)]	+746.0 kJ mol^{-1}
Second ionisation energy of copper, E_{m2} [Cu(g)]	+1958.0 kJ mol^{-1}
Electron affinity of bromine, E_{aff}[Br(g)]	–342.6 kJ mol^{-1}
Enthalpy change of formation of $CuBr_2$(s), $\Delta H_f^{\ominus}$ [$CuBr_2$(s)]	–141.8 kJ mol^{-1}

(a) On the following outline of a Born-Haber cycle complete the boxes **A**, **B**, and **C** by putting in the formula and state symbol for the appropriate species and writing the name of the enthalpy change **D**.

(3)



(b) Use the data to calculate a value for the lattice energy of copper(II) bromide.

Give a sign and units in your answer.

(3)

(c) When the lattice energy of copper(II) bromide is calculated from ionic radii and charges, the result is a value numerically about 10% less than the one obtained from the Born-Haber cycle.

(i) What does this suggest about the nature of the bonding in copper(II) bromide?

(1)

.....

.....

(ii) Draw a diagram to show how the smaller copper ion alters the shape of the larger bromide ion.

(1)

(Total for Question 19 = 8 marks)

TOTAL FOR SECTION B = 59 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)				Key							(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4				relative atomic mass **atomic symbol** name atomic (proton) number							10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lathanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103