Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Monday 14 October 2024

Morning (Time: 1 hour 30 minutes)

Paper reference **WCH12/01**

Chemistry

International Advanced Subsidiary/Advanced Level
UNIT 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

You must have:
Scientific calculator, Data Booklet, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- In the question marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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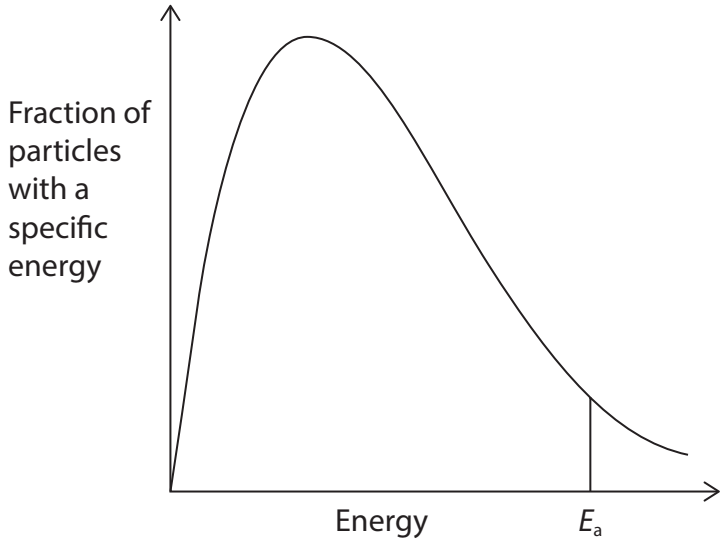
SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 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 ☒.

1 A Maxwell–Boltzmann curve showing the distribution of molecular energies is shown.



(a) What happens to the curve when the temperature is **increased**?

(1)

☒ **A** the peak becomes higher and further to the right

☒ **B** the peak becomes higher and further to the left

☒ **C** the peak becomes lower and further to the right

☒ **D** the peak becomes lower and further to the left

(b) How does the diagram change if a catalyst is added?

(1)

☒ **A** the activation energy moves to the right and the peak stays the same

☒ **B** the activation energy moves to the left and the peak moves to the right

☒ **C** the activation energy moves to the left and the peak stays the same

☒ **D** the activation energy stays the same and the peak moves to the right

(Total for Question 1 = 2 marks)

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2 The equilibrium between methane and steam is shown.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +206\,kJ\,mol^{-1}$$

(a) What would be the effect of **lowering** the temperature?

(1)

- ☒ **A** rate increases, yield increases
- ☒ **B** rate increases, yield decreases
- ☒ **C** rate decreases, yield increases
- ☒ **D** rate decreases, yield decreases

(b) What would be the effect of **increasing** the pressure?

(1)

- ☒ **A** rate increases, yield increases
- ☒ **B** rate increases, yield decreases
- ☒ **C** rate decreases, yield increases
- ☒ **D** rate decreases, yield decreases

(c) Some bond enthalpies are shown.

Bond	Bond enthalpy / kJ mol^{-1}
H—H	436
C≡O	1077
O—H	464

What is the bond enthalpy, in kJ mol^{-1}, of the C—H bond?

(1)

- ☒ **A** 198
- ☒ **B** 313
- ☒ **C** 416
- ☒ **D** 532

(Total for Question 2 = 3 marks)

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3 Which equation shows the reaction that occurs when the standard enthalpy change of formation of copper(II) carbonate is measured?

- ☒ **A** $Cu(s) + C(s) + 3O(g) \rightarrow CuCO_3(s)$
- ☒ **B** $2Cu(s) + 2C(s) + 3O_2(g) \rightarrow 2CuCO_3(s)$
- ☒ **C** $Cu(g) + C(g) + 1\frac{1}{2}O_2(g) \rightarrow CuCO_3(s)$
- ☒ **D** $Cu(s) + C(s) + 1\frac{1}{2}O_2(g) \rightarrow CuCO_3(s)$

(Total for Question 3 = 1 mark)

4 Which statement about Group 2 elements and their compounds is **true**?

- ☒ **A** calcium hydroxide is less soluble than magnesium hydroxide in water
- ☒ **B** all Group 2 metals give a characteristic flame test colour
- ☒ **C** magnesium carbonate does **not** thermally decompose when heated
- ☒ **D** the first ionisation energy of magnesium is greater than that of calcium

(Total for Question 4 = 1 mark)

5 A compound, which is a white solid, gives a red flame test and produces a colourless, acidic gas when heated.

What is the identity of the compound?

- ☒ **A** calcium carbonate
- ☒ **B** calcium nitrate
- ☒ **C** sodium carbonate
- ☒ **D** strontium nitrate

(Total for Question 5 = 1 mark)

6 Which statement explains the origin of a flame test colour?

- ☒ **A** electrons absorb energy as they jump to a higher energy level
- ☒ **B** electrons emit energy as they jump to a higher energy level
- ☒ **C** electrons absorb energy as they drop to a lower energy level
- ☒ **D** electrons emit energy as they drop to a lower energy level

(Total for Question 6 = 1 mark)

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7 Sulfuric acid and sodium hydroxide react as shown.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

Which sample of sulfuric acid solution will be exactly neutralised by $20\,cm^3$ of $0.5\,mol\,dm^{-3}$ sodium hydroxide?

		Volume of sulfuric acid / cm^3	Concentration of sulfuric acid / $mol\,dm^{-3}$
☒	**A**	20	0.25
☒	**B**	20	0.5
☒	**C**	40	0.5
☒	**D**	10	1.0

(Total for Question 7 = 1 mark)

8 A 20 g sample of iron(III) sulfate, $Fe_2(SO_4)_3$, was dissolved in water.
How many sulfate ions are in the solution formed?

[Assume M_r $Fe_2(SO_4)_3 = 400$
Avogadro constant, $L = 6.0 \times 10^{23}\,mol^{-1}$]

☒ **A** 3×10^{22}

☒ **B** 9×10^{22}

☒ **C** 1.2×10^{23}

☒ **D** 1.5×10^{23}

(Total for Question 8 = 1 mark)

9 Which substance is formed when concentrated sulfuric acid reacts with solid potassium chloride?

☒ **A** Cl_2

☒ **B** S

☒ **C** H_2S

☒ **D** $KHSO_4$

(Total for Question 9 = 1 mark)

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10 What is the colour of the solution formed when iodine dissolves in cyclohexane?

- ☒ **A** blue-black
- ☒ **B** grey
- ☒ **C** purple
- ☒ **D** yellow

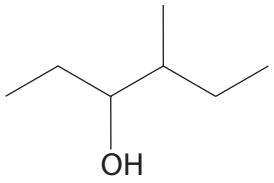
(Total for Question 10 = 1 mark)

11 Which alkane has the **highest** boiling temperature?

- ☒ **A** hexane
- ☒ **B** pentane
- ☒ **C** 2-methylpentane
- ☒ **D** 2,3-dimethylbutane

(Total for Question 11 = 1 mark)

12 What is the name of the alcohol shown?



- ☒ **A** 4-ethyl-4-methylbutan-3-ol
- ☒ **B** 4-methylhexan-3-ol
- ☒ **C** 3-methylhexan-3-ol
- ☒ **D** 2-ethylpentan-3-ol

(Total for Question 12 = 1 mark)

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

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13 Chloroethane reacts with aqueous potassium hydroxide to produce ethanol.

(a) What is the role of the hydroxide ion in this reaction?

(1)

☒ **A** reducing agent

☒ **B** nucleophile

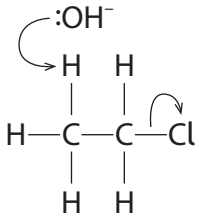
☒ **C** electrophile

☒ **D** base

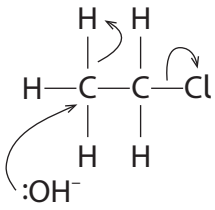
(b) Which mechanism shows the correct movement of electrons in this reaction?

(1)

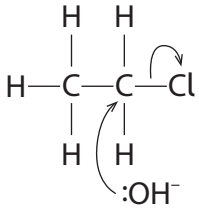
☒ **A**



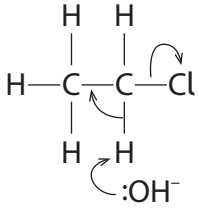
☒ **B**



☒ **C**



☒ **D**



(Total for Question 13 = 2 marks)

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14 This question is about four organic compounds.

propan-1-ol
propan-2-ol
propanal
propanone

(a) Which compound would **not** give a colour change when heated with acidified potassium dichromate(VI) solution?

(1)

☒ **A** propan-1-ol

☒ **B** propan-2-ol

☒ **C** propanal

☒ **D** propanone

(b) Which compound could give peaks at $m/z = 31$ **and** $m/z = 60$ in its mass spectrum?

(1)

☒ **A** propan-1-ol

☒ **B** propan-2-ol

☒ **C** propanal

☒ **D** propanone

(Total for Question 14 = 2 marks)

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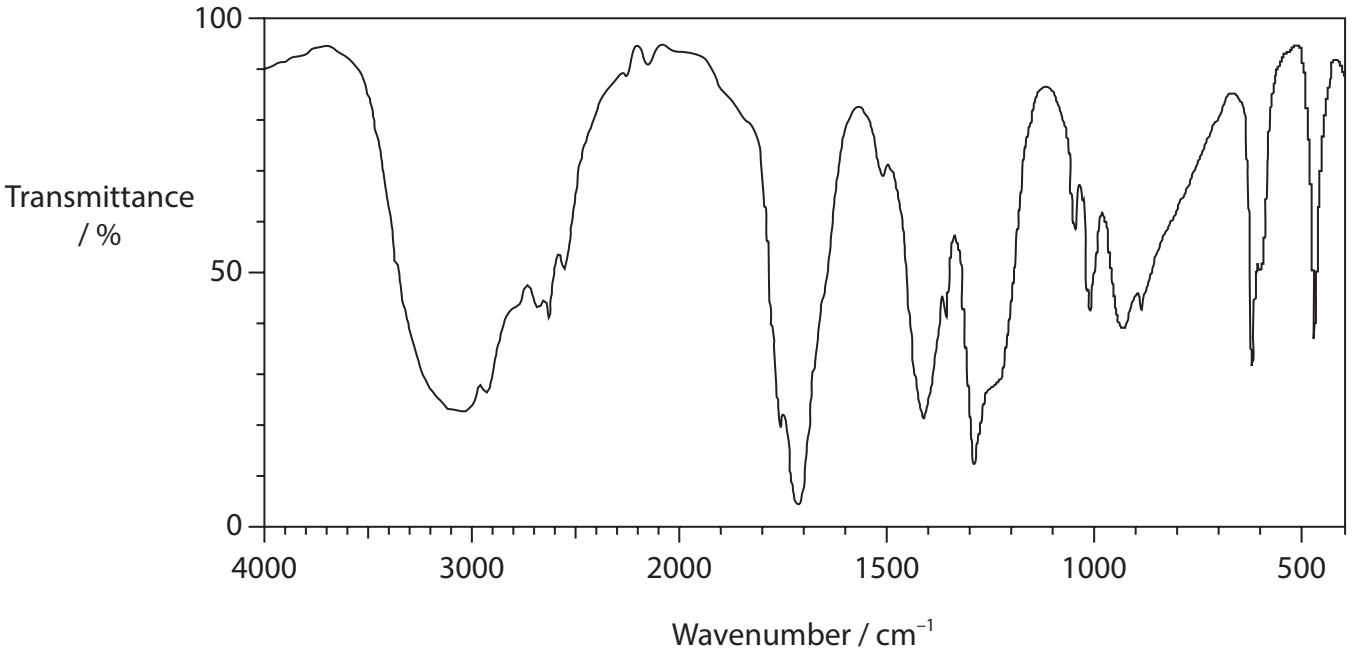
15 An infrared spectrum for a compound containing **one** functional group is shown.



Which functional group is most likely to be present in this compound?

Refer to your Data Booklet.

- ☒ **A** an aldehyde
- ☒ **B** an alcohol
- ☒ **C** a carboxylic acid
- ☒ **D** a ketone

(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

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

16 This question is about magnesium sulfate, a white ionic solid that is very soluble in water.
Hydrated magnesium sulfates have the general formula of $MgSO_4 \cdot xH_2O$, where x is the number of water molecules of crystallisation.

(a) A sample of hydrated magnesium sulfate was heated until all the water had been removed from the crystals.

The mass of the sample decreased from 6.92 g to 6.04 g.

[M_r $MgSO_4$ = 120.4]

(i) State how you could ensure that all the water had been removed from the crystals.

(1)

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.....

.....

(ii) Calculate the number of water molecules of crystallisation, x, in the formula of this sample of hydrated magnesium sulfate.

(3)

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(b) The most common form of hydrated magnesium sulfate is $MgSO_4 \cdot 7H_2O$.
A student carried out two experiments to determine the enthalpy change when anhydrous magnesium sulfate forms $MgSO_4 \cdot 7H_2O$.

$$MgSO_4(s) + 7H_2O(l) \rightarrow MgSO_4 \cdot 7H_2O(s)$$

(i) In the first experiment, the student determined the enthalpy change when dissolving anhydrous magnesium sulfate.

$$MgSO_4(s) + (aq) \rightarrow MgSO_4(aq)$$

100.0 g of distilled water was placed in a polystyrene cup and the temperature recorded.

0.0628 mol of anhydrous magnesium sulfate was added to the distilled water, the mixture stirred and the maximum temperature recorded.

Results

Starting temperature of distilled water / °C	16.6
Maximum temperature of solution / °C	29.4

Calculate the enthalpy change for this reaction.
Give your answer to an appropriate number of significant figures and include a sign and units.

[Assume: Specific heat capacity of the solution is 4.18 J g^{-1} $°C^{-1}$
Density of the solution is 1.00 g cm^{-3}]

(4)

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(ii) In the second experiment, the student determined the enthalpy change when dissolving hydrated magnesium sulfate.

$$MgSO_4 \cdot 7H_2O(s) + (aq) \rightarrow MgSO_4(aq) \qquad \Delta H = +15.8\,kJ\,mol^{-1}$$

Complete the Hess cycle.

(2)

(iii) Calculate the enthalpy change when anhydrous magnesium sulfate forms hydrated magnesium sulfate, using the completed Hess cycle and your answer in (b)(i).

(2)

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(c) Magnesium sulfate is very soluble in water.

(i) Draw a labelled diagram showing how both the magnesium ion and the sulfate ion interact with water molecules.

(2)

(ii) Barium ions are toxic in aqueous solution. If a solution containing barium ions enters the body, barium poisoning occurs.

Describe how drinking magnesium sulfate solution can reduce the extent of the poisoning.
Include an ionic equation with state symbols in your answer.

(2)

(Total for Question 16 = 16 marks)

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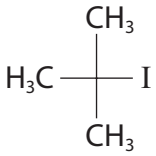
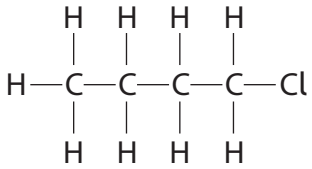
17 This question is about two halogenoalkanes, **A** and **B**, which have the structures shown.



A



B

(a) (i) Name compound **A**.

(1)

.....

(ii) Draw the **skeletal** formula of **B**.

(1)

(b) (i) Describe what you would observe when separate samples of **A** and **B** are warmed with silver nitrate dissolved in aqueous ethanol.

(2)

Observation with **A**

.....

Observation with **B**

.....

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(ii) Give **two** reasons why **A** reacts more quickly than **B** when warmed with silver nitrate dissolved in aqueous ethanol.

(2)

(c) (i) Write an equation for the reaction of **B** with an alcoholic solution of potassium cyanide and name the organic product.

(2)

Equation:

Name

(ii) Suggest why this type of reaction is important in organic synthesis.

(1)

(Total for Question 17 = 9 marks)

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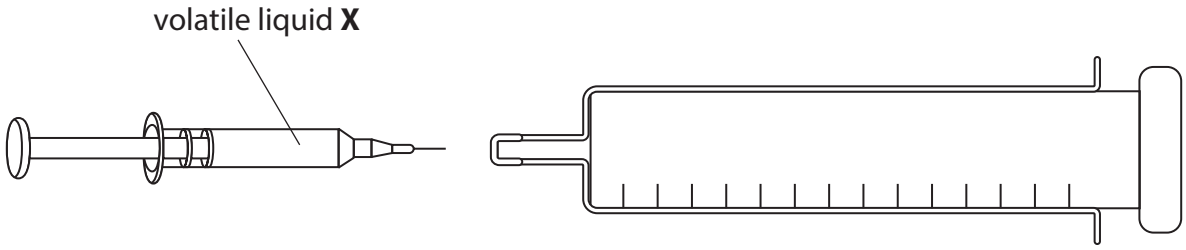
18 A student determined the molecular mass of an unknown volatile organic liquid, **X**, using the apparatus shown.
The student used a hypodermic syringe to inject a sample of liquid **X** into a gas syringe.
The gas syringe was placed in an oven and liquid **X** vaporised.



hypodermic syringe gas syringe

Results

Mass of hypodermic syringe and liquid **X** before injection	5.71 g
Mass of hypodermic syringe and liquid **X** after injection	5.59 g
Mass of **X** added to the gas syringe	0.12 g
Temperature of oven	95 °C
Pressure of gas in the gas syringe	99 kPa
Volume of gas syringe after **X** had been vaporised	81 cm^3

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(a) Calculate the relative molecular mass of liquid **X**.

$pV = nRT$ Gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$

(5)

(b) Each molecule of **X** contains carbon atoms, hydrogen atoms, and **one** atom of oxygen.
Identify **X**, by name or formula, using your answer from (a).

(1)

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(Total for Question 18 = 6 marks)

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19 This question is about Group 7 hydrides.

(a) The table shows the boiling temperatures of some Group 7 hydrides.

Hydrogen halide	Boiling temperature / °C
HCl	–85
HBr	–67
HI	–35

The increase in boiling temperature in these hydrogen halides is due to London forces.

(i) Describe how London forces arise.

(2)

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(ii) State why the London forces in hydrogen iodide are stronger than those in hydrogen chloride and hydrogen bromide.

(1)

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(iii) The boiling temperature of hydrogen fluoride is +20 °C.

State what causes hydrogen fluoride to have such an unusually high boiling temperature.

(1)

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(b) Chlorine reacts with water as shown.

$$Cl_2(aq) + H_2O(l) \rightleftharpoons HOCl(aq) + HCl(aq)$$

(i) Explain why this is a disproportionation reaction by referring to relevant oxidation numbers.

(3)

(ii) State and explain what happens to the position of equilibrium when sodium hydroxide solution, NaOH(aq), is added to this equilibrium mixture.

(2)

(Total for Question 19 = 9 marks)

TOTAL FOR SECTION B = 40 MARKS

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SECTION C

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

20 This question is about lithium and some of its compounds.
Lithium has an atomic number of 3 and is the least dense of all the solid elements.

(a) Lithium hydroxide solution can be made by reacting lithium with water.

(i) Write an equation for the reaction that occurs.
Include state symbols in your answer.

(2)

(ii) Give **two** observations you would make during this reaction.

(2)

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(b) Lithium metal is stored under oil.
When a piece of lithium metal is removed from the oil, the surface quickly tarnishes. One compound formed is lithium nitride.

State how lithium nitride is formed, including the formula of lithium nitride.

(2)

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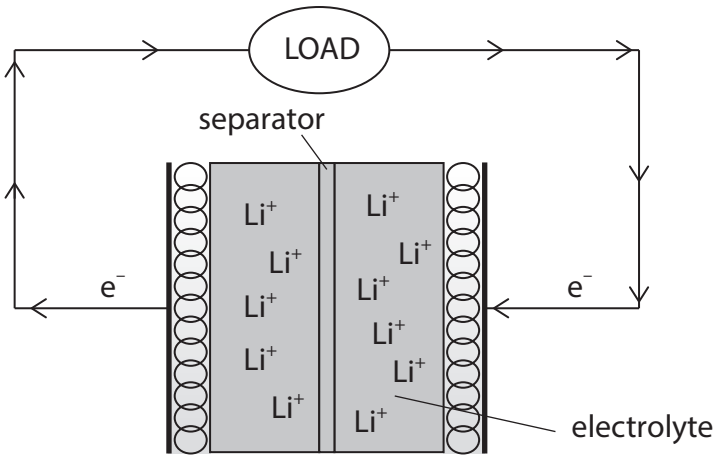
(c) Mobile phones rely on rechargeable lithium batteries.
The cell of one type of battery consists of an anode containing a compound of lithium and carbon, C_6Li, and a cathode containing cobalt(IV) oxide, CoO_2.
The two electrodes are kept apart by a separator.

When the cell is in use and current flows, at the anode the Li atoms lose electrons and form Li^+ ions. The ions travel through the separator and the electrons travel through the external circuit to the cathode.
At the cathode, the cobalt(IV) oxide combines with the Li^+ ions and electrons and forms $LiCoO_2$.



Reactions: $C_6Li \rightarrow C_6 + Li^+ + e^-$ $CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$

(i) Give the overall equation when the cell is being used.
State symbols are not required.

(1)

(ii) Describe, with reference to oxidation numbers, what happens to Co when the cell is in use.

(2)

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(iii) Suggest **one** property the separator must have to ensure the lithium battery is viable.

(1)

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(d) Lithium is often added to aluminium to make aluminium-lithium alloys. These alloys have a variety of uses, including aircraft manufacture. One alloy contains only aluminium and lithium. It contains 2.45 % of Li by mass.

(i) Calculate the molar ratio of Al : Li in this alloy.

(3)

(ii) Suggest a reason why this alloy is better than pure aluminium for aircraft manufacture.

(1)

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*(e) Compounds of lithium (Group 1) and compounds of magnesium (Group 2) have similar properties.
Explain why:

- the ionic radii of Li^+ and Mg^{2+} are similar
- the thermal decomposition of lithium nitrate is similar to that of magnesium nitrate but different from the thermal decomposition of sodium nitrate.

Include relevant chemical equations in your answer.

(6)

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(Total for Question 20 = 20 marks)

TOTAL FOR SECTION C = 20 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* lanthanum 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	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
* Actinide series	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

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