Q1. Choose the correct answer

1. **Aluminium can be extracted from its ore by**
   a. Filtration
   b. Reducing agent such as carbon
   c. Blast furnace
   d. Electrolysis

2. **Cryolite is used instead of Al_2O_3 in the extraction process to**
   a. Increase the melting point
   b. Reduce the melting point
   c. Extract Al easier
   d. Decrease the solubility of Al_2O_3

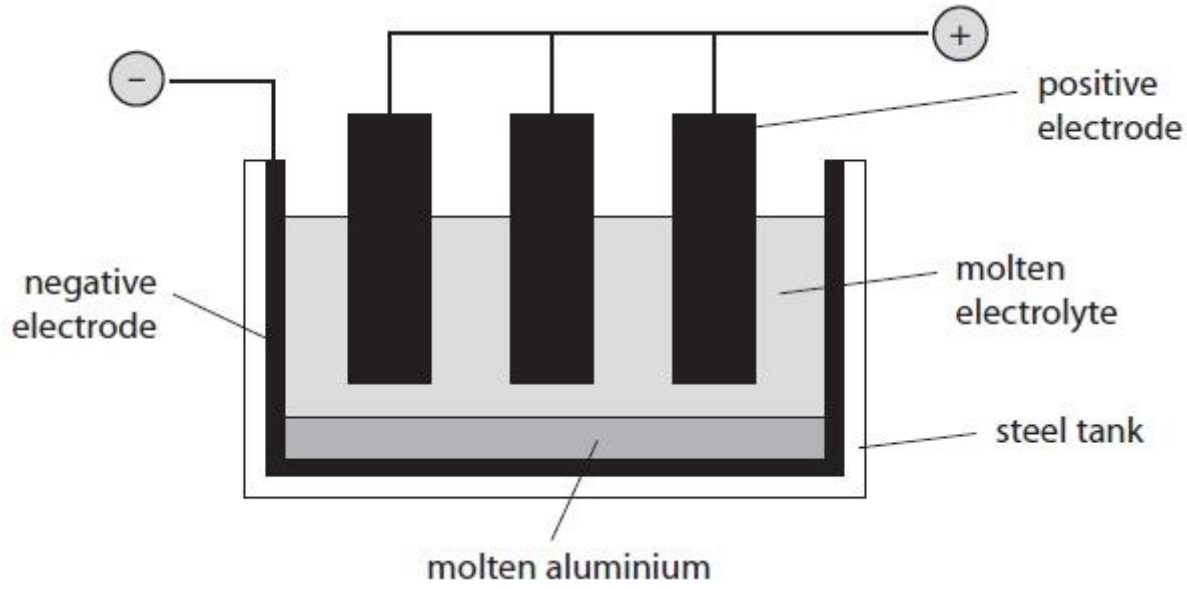
3. **During the electrolysis of molten NaCl**
   a. Na^+ is attracted to the anode and Cl^- attracted to the cathode
   b. Both ions are attracted to the cathode
   c. Both ions are attracted to the anode
   d. Na^+ is attracted to the cathode and Cl^- attracted to the anode

4. **Which statement is correct about electrolysis?**
   a. Oxidation occurs at the cathode and reduction at the anode
   b. Both oxidation and reduction occur at the cathode
   c. Both oxidation and reduction occur at the anode
   d. Reduction occurs at the cathode and oxidation at the anode

Maximum mark is 4

Q2. This question is about the extraction and uses of aluminium.

(a) Aluminium is extracted from aluminium oxide by electrolysis.



What are the electrodes made of?

(2)

Negative electrode

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Positive electrode

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(b) (i) Explain why the operating temperature would need to be very high if pure aluminium oxide were used as the electrolyte.

(1)

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(ii) Describe how the operating temperature is kept low.

(1)

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(c) The ionic half-equation for the reaction at the negative electrode is

$$Al^{3+} + 3e^{-} \rightarrow Al$$

What type of reaction is occurring at the negative electrode?
Explain your answer.

(2)

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(d) The waste gases escaping from the electrolysis cell contain carbon dioxide.
Describe how the carbon dioxide is formed.

(2)

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(e) Aluminium is used to make cans for food and drinks.

State two properties of aluminium that make it suitable for this use.
You should not refer to cost in your answers.

(2)

1.....
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2.....
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Maximum mark is 10

Q3. Iron and aluminium are two important metals extracted from their ores on a large scale.

In the extraction of iron, three different raw materials are put into the top of a blast furnace.

(a) The following equations represent reactions in the blast furnace.

A $C + O_2 \rightarrow CO_2$
B $CaCO_3 \rightarrow CaO + CO_2$
C $C + CO_2 \rightarrow 2CO$
D $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
E $CaO + SiO_2 \rightarrow CaSiO_3$

Choose from the letters **A**, **B**, **C**, **D** or **E** to answer parts (i) − (iv).
Each letter may be used once, more than once or not at all.

(4)

(i) A reaction that is used to produce heat
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(ii) A neutralisation reaction
.....
(iii) A decomposition reaction
.....
(iv) A reaction that forms a reducing agent
.....

(b) Molten iron and another molten substance collect at the bottom of the blast furnace.
What is the common name of this other molten substance?

(1)

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(c) Aluminium is extracted from its ore by electrolysis. This is a more expensive process than using a blast furnace.
(i) Why is a different method used for aluminium?

(1)

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(ii) State the major reason for the high cost of extracting aluminium.

(1)

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(d) Coke used in the blast furnace contains carbon. Carbon is also used in the extraction of aluminium, but for a different purpose.
What is this purpose?

(1)

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(e) The extraction of aluminium can be represented by the chemical equation:

$$2Al_2O_3 \rightarrow 4Al + 3O_2$$

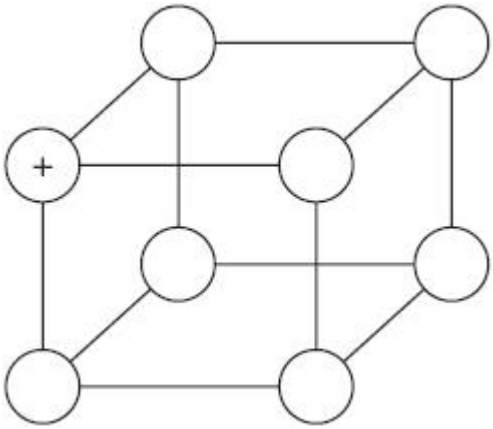
Write the two ionic half-equations that can also be used to represent this extraction.

(3)

Half-equation 1
.....
.....
Half-equation 2
.....
.....**Maximum mark is 11**

Q4. Potassium chloride, KCl, is very similar to sodium chloride, NaCl. They have the same type of crystal structure, and their aqueous solutions can be electrolysed to give similar products.

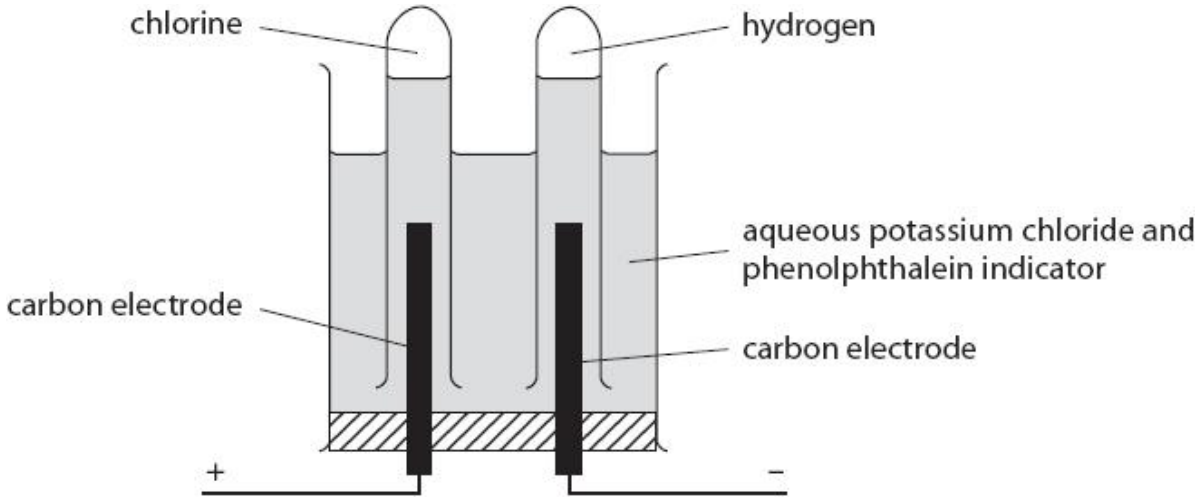
(a) The diagram shows part of the structure of potassium chloride.



The plus (+) sign shows the position of one potassium ion.
Complete the diagram using a plus (+) sign to show the position of each potassium ion, and a minus (–) sign to show the position of each chloride ion.

(2)

(b) The diagram shows apparatus used to electrolyse aqueous potassium chloride in the laboratory.



(i) Chlorine is formed at the positive electrode.
The ionic half-equation for the formation of chlorine at the positive electrode **(2)**

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(ii) Hydrogen gas is formed at the negative electrode.
Write an ionic half-equation for the formation of hydrogen.

(2)

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(iii) The solution used in this electrolysis contains phenolphthalein. During the electrolysis, the colour of the solution around the negative electrode goes pink. Explain why the solution goes pink, and give the formula of the ion responsible for causing the colour change.

(2)

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Maximum mark is 8

Q5 Zinc metal is obtained from sulfide ores.

The most common ore of zinc is sphalerite, which contains zinc sulfide (ZnS) and a small amount of cadmium sulfide (CdS).

The stages involved in the extraction of zinc from sphalerite are:

Stage 1 Sphalerite is strongly heated in air.

$$2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$$

$$2CdS(s) + 3O_2(g) \rightarrow 2CdO(s) + 2SO_2(g)$$

Stage 2 The mixture of oxides is reacted with sulfuric acid.

$$ZnO(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2O(l)$$

$$CdO(s) + H_2SO_4(aq) \rightarrow CdSO_4(aq) + H_2O(l)$$

Stage 3 Zinc dust is added to the solution containing zinc sulfate and cadmium sulfate to remove the cadmium ions.

$$Cd^{2+}(aq) + Zn(s) \rightarrow Cd(s) + Zn^{2+}(aq)$$

Stage 4 The solid cadmium is filtered off and the pure zinc sulfate solution is electrolysed.

(a) State how the reaction in stage 3 shows that zinc is more reactive than cadmium.

(1)

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(b) (i) During the electrolysis in stage 4, zinc is deposited on the cathode.

Write an ionic half-equation for the reaction that occurs.

(1)

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.....

(ii) Complete the ionic half-equation for the reaction occurring at the anode.

..... H_2O → .....H^+ + O_2 + ... e^-

(1)

(iii) Explain how the pH of the solution surrounding the anode changes during the electrolysis.

(2)

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(c) Zinc is mixed with copper to make the alloy brass.

Explain why brass is harder than pure copper.

(3)

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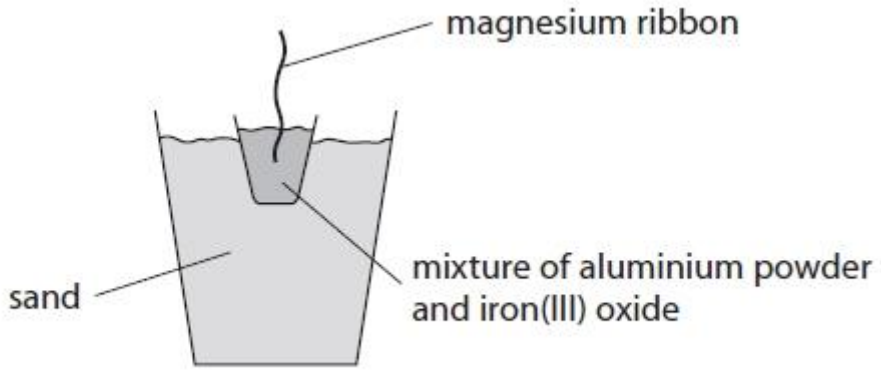
(Total for question = 8 marks)

Q6 The reaction between aluminium and iron(III) oxide is known as a thermite reaction.

The diagram shows how this thermite reaction can be carried out.



The magnesium ribbon is lit to ignite the reaction mixture.
The reaction is highly exothermic.
The equation for the reaction is

$$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$$

(i) Explain, in terms of its structure, why aluminium is a good conductor of electricity

(2)

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(ii) What does the reaction suggest about the reactivity of aluminium compared to the reactivity of iron?
Explain your answer.

(2)

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(iii) Which element is oxidised in this thermite reaction?
Give a reason for your answer.

(2)

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Maximum mark is 6

Chemistry yr 11 - Mark scheme:

Q1

1. d 2. b 3. d 4. d one mark for each (total 4 marks)

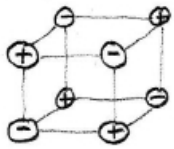
Q2

Question number	Answer	Accept	Reject	Marks
(a)	**M1 (n**egative electrode) – graphite **M2** (positive electrode) – graphite	carbon carbon		2
(b) (i)	it/aluminium oxide/alumina has a (very) high m.pt **IGNORE** high b.pt/references to strong bonding/bauxite has a		aluminium has a high melting point	1
(ii)	high m.pt/lot of energy needed to melt it aluminium oxide/alumina is dissolved in/mixed with (molten/liquid) cryolite **IGNORE** cryolite lowers the m.pt of aluminium oxide/alumina	added to Na_3AlF_6 for cryolite cryolite is used as the solvent (for aluminium oxide/alumina)	aluminium is dissolved in cryolite	1
(c)	**M1** reduction **M2** (it/aluminium ions/Al^{3+}) gain of electron(s) **IGNORE** references to loss of oxygen **M2** dep on **M1**	reacts with/combines with decrease in oxidation number/oxidation number changes from +3 to 0	redox for **M1** only Al/aluminium gains electrons	1 1
(d)	**M1** oxygen formed/produced (at the positive electrode/anode) **IGNORE** oxygen from the aluminium oxide **M2** reacts with the carbon/the (positive) electrode **M2** not dep on **M1**, but must mention oxygen	oxygen from the electrolysis anode / graphite	any indication that the oxygen is from the air for **M1** only cathode/ negative electrode	1 1
(e)	Any two from: **M1** malleable **M2** low density **M3** does not react <u>with food/drink(s)</u> **IGNORE** light(er)/high strength to weight ratio/references to cost/lightweight/does not rust	 easy to shape/easy to bend/easy to extrude bend non-toxic/does not corrode		2
			Total	**10**

Q3

a	(i)	M1	A		1
	(ii)	M1	E		1
	(iii)	M1	B		1
	(iv)	M1	C		1
b		M1	slag	Accept calcium silicate Ignore formula	1
c	(i)	M1	aluminium/it is more reactive than iron/carbon OR above iron/carbon in reactivity series OR cannot be reduced by/does not react with carbon (monoxide) OR cannot be displaced by carbon	Comparison with iron or carbon must be stated or implied, eg not just aluminium is (very/too) reactive Accept reverse argument for iron	1
	(ii)	M1	(cost of) electricity	Accept keeping electrolyte molten Accept high current Ignore energy Ignore references to electrode replacement	1
d		M1	electrode(s) / to conduct electricity	Accept cathode / anode	1
e		M1	$Al^{3+} + 3e \rightarrow Al$ $2O^{2-} \rightarrow O_2 + 4e$ / $2O^{2-} - 4e \rightarrow O_2$	M1 for both aluminium formulae on correct sides of equation M2 for both oxygen formulae on correct sides of equation M3 for balancing both equations even if one or both reversed	3
		M2			
		M3			
				Accept in either order	
				Total 13 marks	

Q4

Question number	Answer	Notes	Marks
(a)		M1 for front face all correct M2 for rear face all correct M2 DEP on M1 Do not penalise X in place of + Ignore symbols such as K and Cl Do not penalise use of Na^+ in place of K^+	2
(b) (i)	$2Cl^- \rightarrow Cl_2 + 2e^-$	M1 for correct reactants M2 for correct product	2
(ii)	$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ OR $2H^+ + 2e^- \rightarrow H_2$	M1 for H_2O on lhs AND H_2 and OH^- on rhs and no other formulae M1 for H^+ on lhs AND H_2 on rhs and no other formulae M2 for $e^{(-)}$ and balancing of correct equation Accept M1 $H^+ + e^- \rightarrow H$ M2 $2H \rightarrow H_2$ M2 DEP on M1 Ignore state symbols	2
(iii)	M1 alkaline / alkali formed M2 OH^-	Accept pH above 7 Ignore names Mark independently	2

Q5

Question number	Answer	Mark
(a)	Zinc has displaced cadmium	1

Question number	Answer	Mark
(b)(i)	$Zn^{2+} + 2e^{(-)} \rightarrow Zn$ (1)	1

Question number	Answer	Mark
(b)(ii)	$2H_2O \rightarrow 4H^+ + O_2 + 4e^-$	1

Question number	Answer	Additional guidance	Mark
(b)(iii)	An explanation that links the following two points: • pH decreases • hydrogen ion/H^+ (ion) concentration increases	accept hydrogen ions are formed	2

Question number	Answer	Additional guidance	Mark
(c)	An explanation that links three of the following points: • the ions of (pure) copper are the same size (1) • the layers (of ions) can easily slide over one another (1) • the ions of zinc and copper have different sizes (1) • this disrupts the layers/structure/arrangement of the copper ions (1) • hence it is more difficult for the layers (of ions) to slide over one another (1)	accept atoms/particles for ions reject molecules once only	3

Total 8 Marks

Q6

(c) (i)	Free delocalized electrons that can move around the positive ions			2
(ii)	**M1** - (aluminium/it is) more reactive	iron is less reactive		1

	M2 – (aluminium/it) displaces iron (from its oxide) M2 DEP on M1	replaces it/aluminium takes oxygen away from iron (oxide)		1
(iii)	**M1** – aluminium	loses (three) electrons /oxidation number increases		1
	M2 – gains oxygen **M2** DEP on **M1** IGNORE references to magnesium	combines with oxygen / forms aluminium oxide		1