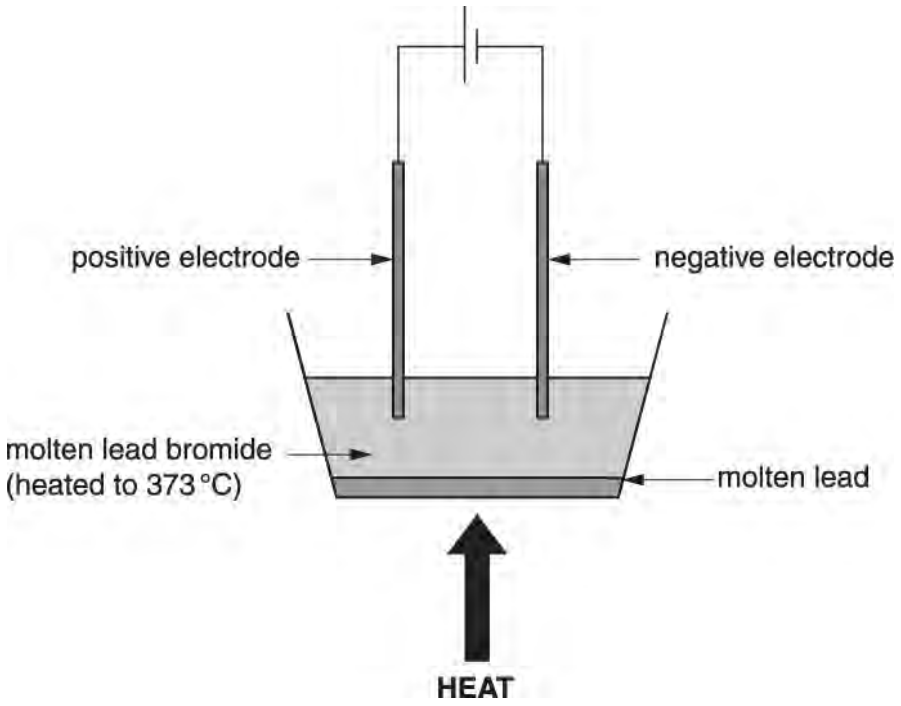
1(a). The melting point of lead bromide is 373 °C.

Molten lead bromide can be electrolysed using this apparatus.



During the electrolysis lead forms at one electrode.
The lead collects as a liquid at the bottom of the container.

What does this tell you about the melting point of lead?

---

[1]

(b). At which electrode would you expect lead to form?
Explain your reasoning.

---

[1]

(c). The formula for lead bromide is $PbBr_2$.

This is the half equation that shows what happens to the bromide ions during the electrolysis.

$$2Br^- \rightarrow Br_2 + 2e^-$$

Write a half equation to show what happens to the lead ions during the electrolysis.

[2]

2. Aluminium is extracted by electrolysis of molten aluminium oxide.

Complete and balance the ionic equations to show what happens during the electrolysis of molten aluminium oxide.

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

$$\text{.....}O^{2-} \rightarrow O_2 + \text{.....}$$

[2]

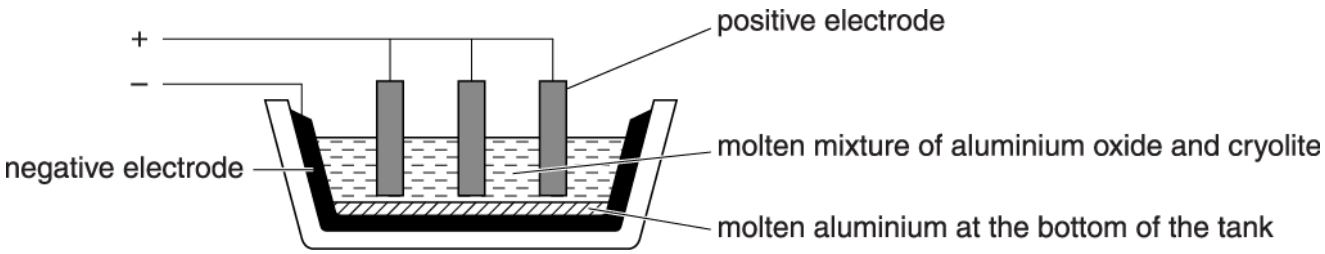
3. This question is about extracting metals.

Aluminium is extracted from aluminium oxide by electrolysis.

The melting point of **pure** aluminium oxide is about 2000 °C.

In the industrial process, aluminium oxide is mixed with cryolite. The **mixture** melts at 900 °C.

The process works at about 1000 °C. Molten aluminium collects at the bottom of the electrolysis tank.



(i) Which of the following statements about electrolysing aluminium oxide are **true** and which are **false**?

Put a tick (?) in one box in each row.

	true	false
Melting pure aluminium oxide uses more energy than melting a mixture of aluminium oxide and cryolite.		
After the mixture melts, it contains ions arranged in a regular lattice.		
The melting point of aluminium is above 1000 °C.		
A gas is made at the positive electrode.		
Below 900 °C the mixture does not conduct electricity.		

[2]

(ii) Aluminium ions (Al^{3+}) are attracted to the negative electrode.

Explain what happens to aluminium ions at the negative electrode.

You may use an equation to support your answer.

---

[2]

4.

Hydrogen for use as a fuel can be made by the electrolysis of water.

Which statements about the electrolysis of water are correct?

Tick (✓) **two** boxes.

The equation for the formation of hydrogen gas is $2H^+ + 2e^- \rightarrow H$. ☐

Hydrogen is produced at the cathode. ☐

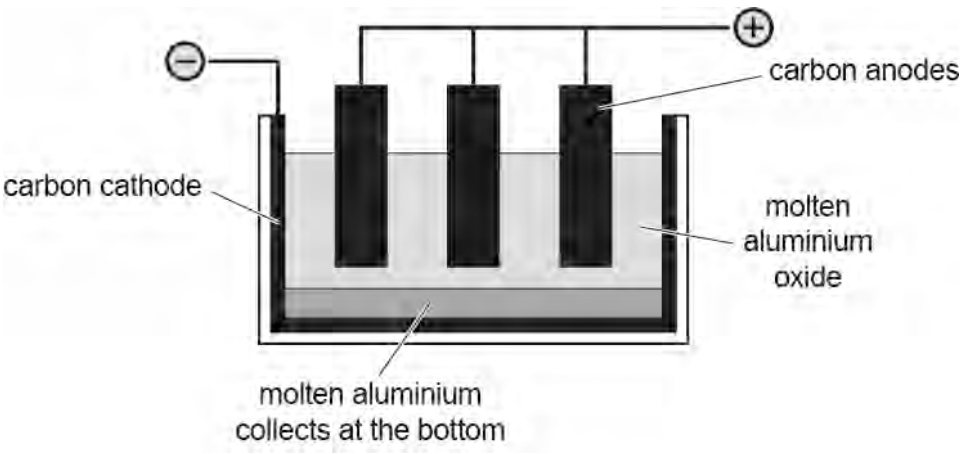
Water contains H^+ and OH^- ions. ☐

Hydrogen ions are oxidised. ☐

[1]

5.

Aluminium is made by the electrolysis of molten aluminium oxide.



The ions present in molten aluminium oxide are Al^{3+} and O^{2-}.

Write **half-equations** for the formation of aluminium and oxygen in the electrolysis cell.

Formation of aluminium ----------

Formation of oxygen ----------

[2]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a		It is below 373°C / below melting point of lead bromide	1	**Accept** 'it IS 373 °C' or 'before 373 °C' **Ignore** boiling point **Examiner's Comments** Vague answers such as 'the melting point is low' or 'the melting point is high' or incorrect answers such as 'it is lower than bromine' were common. Few stated clearly that it would be lower or equal to the melting point of lead bromide (373 °C).
	b		(negative/cathode) because lead is a metal / because it is a positive ion / it is a cation / needs to gain electrons;	1	Do **not accept** 'positive electrode' **Accept** idea that Pb is a positive ion, even if charge is incorrect e.g. 'because it is Pb^{2+} or 'because it is Pb^{+}' **Ignore** numbers of electrons **Examiner's Comments** No marks were given for stating 'negative electrode' alone, the correct electrode needed to be linked to the correct reason. This proved very challenging for candidates. The fact that metals are always discharged at the cathode was not well known. Hence only about a third of candidates gained this mark.
	c		$Pb^{2+} + 2e^{?}$? Pb Pb^{2+} (1) Equation fully correct (2)	2	**Accept** Pb^{2+} ? Pb ? $2e^{?}$ **Accept** Pb^{+2} **Examiner's Comments** This question demanded that candidates work out the charge on a lead ion and then use the symbol for the lead ion to construct a half equation. This is a higher demand task. Less than 10% of the candidates gained a mark for this question.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
2			Al^{3+} / Al^{+3} $2(O^{2?})$ 4e / $4e^{?}$	2	all correct = 2 1/2 correct = 1 **Examiner's Comments** Candidates found this equation very challenging. Over half of the candidates did not score. The most common route to a one mark answer was to correctly balance the oxygen atoms. Few knew the symbol for an aluminium ion and very few could balance the ionic equation by inserting electrons.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
3		i	TFFTT	2	All correct = (2) 3/4 correct = (1) Examiner's Comments Most candidates gained at least one mark, showing sound understanding of electrolysis. However, the marking scheme demanded that candidates correctly identify three of the five statements as being true or false to gain one of the available two marks. About a quarter of candidates did not do this and so failed to score.
		ii	Any 2 from Gain electrons; 3 electrons; to form (aluminium) atoms;	2	MP1 and MP2 can be scored from a correct equation (Al^{3+} +3e? ? Al) Ignore equation if it is incorrect Allow 'lose 3 electrons' for 1 mark maximum Ignore 'forms Al' alone Examiner's Comments Candidates found this question very challenging. Although most stated that aluminium ions are attracted to the negative electrode, they could not express what happens to them there, other than that they 'lose their charge'. Some thought electrons were lost. However, about a third of candidates stated that aluminium gains three electrons and many of these gave a fully correct equation.
			Total	4	
4			Hydrogen is produced at the cathode Water contains H^+ and OH^- ions	1 (AO 1.1)	Both needed
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
5			$Al^{3+} + 3e \rightarrow Al$ ✓ $2O^{2-} \rightarrow O_2 + 4e$ ✓	2 (AO 2 × 1.2)	**ALLOW** equations with electrons on the right (eg $Al^{3+} \rightarrow Al - 3e$) **ALLOW** $O^{2-} \rightarrow ½O_2 + 2e$ **ALLOW** (1) mark if number of electrons are correct for both equations but on incorrect sides of both equations (even if oxygen is shown as O) <u>Examiner's Comments</u> Half equations are very challenging. Some candidates gave the correct equation for the formation of aluminium. The loss of electrons from two oxygen ions to make a single oxygen molecule was a very difficult equation and only correctly given by very able candidates.
			Total	2	