5.1 Electricity and chemistry

01. 0620_s21_qp_41 Q: 3

Potassium reacts with chlorine to form potassium chloride, KC*l*.

(a) Write a chemical equation for this reaction.

..... [2]

(b) Potassium chloride is an ionic compound.

Complete the diagram to show the electron arrangement in the outer shells of the ions present in potassium chloride.

Give the charges on both ions.

.....

.....

[3]

(c) Molten potassium chloride undergoes electrolysis.

(i) State what is meant by the term *electrolysis*.

.....

..... [2]

(ii) Name the products formed at the positive electrode (anode) and negative electrode (cathode) when molten potassium chloride undergoes electrolysis.

anode .....

cathode .....

[2]

(d) Concentrated aqueous potassium chloride undergoes electrolysis.

(i) Write an ionic half-equation for the reaction at the negative electrode (cathode).

..... [2]

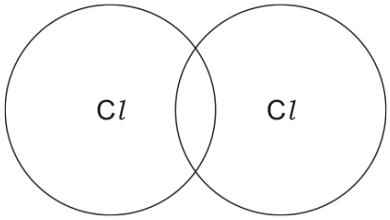
(ii) Name the product formed at the positive electrode (anode).

..... [1]

(iii) Name the potassium compound that remains in the solution after electrolysis.

..... [1]

(e) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of chlorine, Cl_2.
Show the outer electrons only.



[1]

(f) The melting points and boiling points of chlorine and potassium chloride are shown.

	melting point /°C	boiling point /°C
chlorine	–101	–35
potassium chloride	770	1500

(i) Deduce the physical state of chlorine at –75 °C. Use the data in the table to explain your answer.

physical state .....

explanation .....

.....

[2]

(ii) Explain, in terms of structure and bonding, why potassium chloride has a much higher melting point than chlorine.

Your answer should refer to the:
- types of particle held together by the forces of attraction
- types of forces of attraction between particles
- relative strength of the forces of attraction.

.....

.....

.....

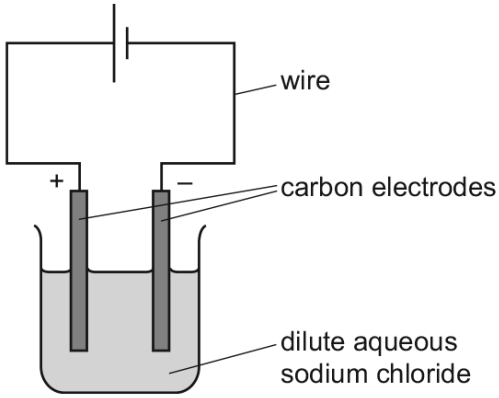
.....

..... [3]

[Total: 19]

02. 0620_s21_qp_42 Q: 4

A student carries out an electrolysis experiment using the apparatus shown.



The student uses dilute aqueous sodium chloride.

(a) State the name given to any solution which undergoes electrolysis.

..... [1]

(b) Hydroxide ions are discharged at the anode.

(i) Complete the ionic half-equation for this reaction.

.....$OH^-(aq)$ → ..... + $O_2(g)$ + $4e^-$ [2]

(ii) Explain how the ionic half-equation shows the hydroxide ions are being oxidised.

..... [1]

(c) Describe what the student observes at the cathode.

..... [1]

(d) Write the ionic half-equation for the reaction at the cathode.

..... [2]

(e) The student repeats the experiment using concentrated aqueous sodium chloride.

(i) Describe what the student observes at:

- the cathode .....
- the anode. .....

[2]

(ii) The student added litmus to the solution after the electrolysis of concentrated aqueous sodium chloride.

State the colour seen in the solution. Give a reason for your answer.

colour of solution .....

reason .....

[2]

(f) Carbon electrodes are used because they are inert.

State another element that can be used instead of carbon.

..... [1]

[Total: 12]

03. 0620_s21_qp_43 Q: 3

Sodium reacts with fluorine to form sodium fluoride, NaF.

(a) Write a chemical equation for this reaction.

..... [2]

(b) Sodium fluoride is an ionic compound.

Complete the diagram to show the electron arrangement in the outer shells of the ions present in sodium fluoride.

Give the charges on both ions.

[3]

(c) Aqueous sodium fluoride undergoes electrolysis.

(i) State what is meant by the term *electrolysis*.

.....

..... [2]

(ii) Name the products formed at the positive electrode (anode) and the negative electrode (cathode) when dilute aqueous sodium fluoride undergoes electrolysis.

anode .....

cathode .....

[2]

(d) Molten sodium fluoride undergoes electrolysis.

(i) Name the products formed at the positive electrode (anode) and the negative electrode (cathode) when molten sodium fluoride undergoes electrolysis.

anode .....

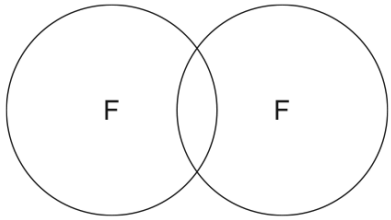
cathode .....

[2]

(ii) Write the ionic half-equation for the reaction at the negative electrode (cathode).

..... [1]

(e) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of fluorine, F_2.
Show the outer electrons only.



[1]

(f) The melting points and boiling points of fluorine and sodium fluoride are shown.

	melting point /°C	boiling point /°C
fluorine	–220	–188
sodium fluoride	993	1695

(i) Deduce the physical state of fluorine at –195 °C. Use the data in the table to explain your answer.

physical state .....

explanation .....

.....

[2]

(ii) Explain, in terms of structure and bonding, why sodium fluoride has a much higher melting point than fluorine.

Your answer should refer to the:
- types of particle held together by the forces of attraction
- types of forces of attraction between particles
- relative strength of the forces of attraction.

.....

.....

.....

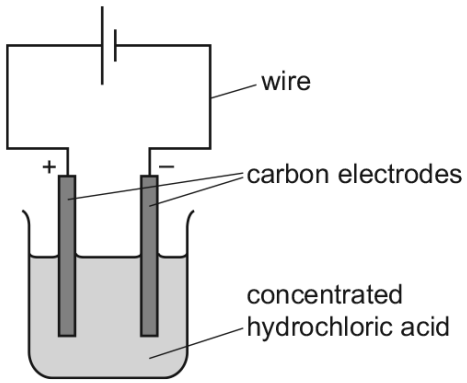
..... [3]

[Total: 18]

04. 0620_w21_qp_41 Q: 3

This question is about electrolysis.

Concentrated hydrochloric acid is electrolysed using the apparatus shown.



(a) Chloride ions are discharged at the anode.

(i) Complete the ionic half-equation for this reaction.

.....Cl^-(aq) → .....(g) + ...e^- [2]

(ii) State whether oxidation or reduction takes place. Explain your answer.

.....

..... [1]

(b) Describe what is seen at the cathode.

..... [1]

(c) Write the ionic half-equation for the reaction at the cathode.

..... [2]

(d) The pH of the electrolyte is measured throughout the experiment.

(i) Suggest the pH of the electrolyte at the beginning of the experiment.

..... [1]

(ii) State how the pH changes, if at all, during the experiment.

Explain your answer.

.....

..... [2]

(e) The electrolysis is repeated using molten lead(II) bromide.

Describe what is seen at the:

- cathode .....
- anode. .....

[2]

(f) State **two** properties of graphite (carbon) which make it suitable for use as an electrode.

1 .....

2 .....

[2]

[Total: 13]

---

05. 0620_w21_qp_43 Q: 2

This question is about electrolysis.

(a) State the meaning of the term *electrolyte*.

.....

..... [2]

(b) The table gives information about the electrolysis of two electrolytes. Carbon (graphite) electrodes are used in each experiment.

(i) Complete the table to show the observations and products of electrolysis.

	positive electrode (anode)		negative electrode (cathode)	
electrolyte	observations	name of product	observations	name of product
aqueous copper(II) sulfate	colourless bubbles			
concentrated aqueous sodium bromide			colourless bubbles	hydrogen

[5]

(ii) Hydrogen is produced at the negative electrode (cathode) during the electrolysis of concentrated aqueous sodium bromide.

Write the ionic half-equation for this reaction.

..... [2]

(iii) State **two** reasons why carbon (graphite) is suitable to use as an electrode.

1 .....

2 .....

[2]

(iv) Name the particle responsible for the conduction of electricity in the metal wires used in a circuit.

..... [1]

[Total: 12]

06. 0620_s20_qp_42 Q: 5

Electrolysis of concentrated aqueous sodium chloride using inert electrodes forms chlorine, hydrogen and sodium hydroxide.

(a) What is meant by the term *electrolysis*?

.....

.....

..... [2]

(b) Name a substance that can be used as the inert electrodes.

..... [1]

(c) Write an ionic half-equation for the formation of hydrogen during this electrolysis.

..... [1]

(d) Give the formulae of the **four** ions present in concentrated aqueous sodium chloride.

..... [2]

(e) Explain how sodium hydroxide is formed during this electrolysis.

.....

.....

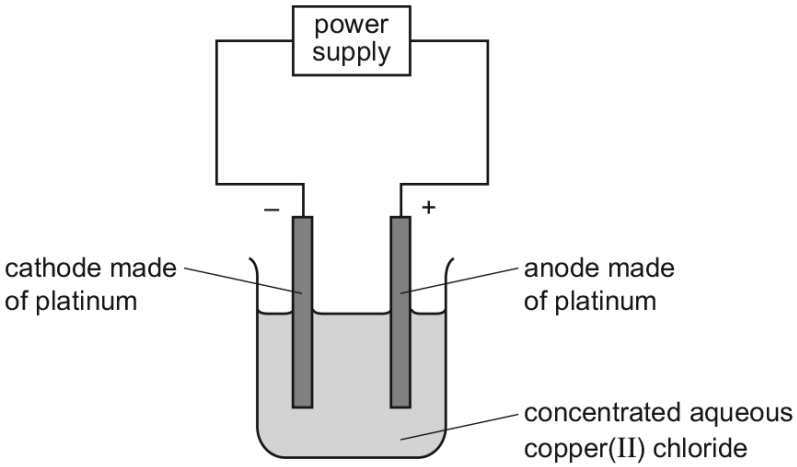
..... [2]

[Total: 8]

07. 0620_s19_qp_43 Q: 4

Solutions of ionic compounds can be broken down by electrolysis.

(a) Concentrated aqueous copper(II) chloride was electrolysed using the apparatus shown.



The ionic half-equations for the reactions at the electrodes are shown.

negative electrode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

positive electrode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

(i) Platinum is a solid which is a good conductor of electricity.

State **one** other property of platinum which makes it suitable for use as electrodes.

.....

..... [1]

(ii) State what would be **seen** at the positive electrode during this electrolysis.

.....

..... [1]

(iii) State and explain what would happen to the mass of the negative electrode during this electrolysis.

.....

.....

..... [2]

(iv) The concentrated aqueous copper(II) chloride electrolyte is green.

Suggest what would happen to the colour of the electrolyte during this electrolysis.
Explain your answer.

.....

.....

..... [2]

(v) Identify the species that is oxidised during this electrolysis.
Explain your answer.

species that is oxidised .....

explanation .....

.....
[2]

(b) Metal objects can be electroplated with silver.

(i) Describe how a metal spoon can be electroplated with silver.
Include:

- what to use as the positive electrode and as the negative electrode
- what to use as the electrolyte
- an ionic half-equation to show the formation of silver.

You may include a diagram in your answer.

.....

.....

.....

ionic half-equation .....
[4]

(ii) Give **one** reason why metal spoons are electroplated with silver.

.....

..... [1]

[Total: 13]

08. 0620_w19_qp_41 Q: 6

Dilute hydrochloric acid, $HCl(aq)$, reacts with aqueous sodium carbonate, $Na_2CO_3(aq)$.

The chemical equation for the reaction is shown.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$$

(a) A 25.0 cm^3 portion of $Na_2CO_3(aq)$ was placed in a conical flask with a few drops of a suitable indicator. It was titrated against $HCl(aq)$ of concentration 0.180 mol/dm^3.

20.0 cm^3 of $HCl(aq)$ was required to reach the end-point.

Calculate the concentration of the $Na_2CO_3(aq)$, in mol/dm^3, using the following steps.

- Calculate the number of moles of HCl used in the titration.

..... mol

- Calculate the number of moles of Na_2CO_3 contained in the 25.0 cm^3 portion of $Na_2CO_3(aq)$.

..... mol

- Calculate the concentration of the $Na_2CO_3(aq)$ in mol/dm^3.

..... mol/dm^3
[3]

(b) In another experiment, the volume of carbon dioxide, CO_2, produced was 48.0 cm^3, measured at room temperature and pressure.

How many moles of CO_2 is this?

moles of CO_2 = ... mol [1]

(c) A sample of concentrated hydrobromic acid, HBr(aq), was electrolysed using platinum electrodes.
The concentration of the hydrobromic acid was 8.89 mol / dm^3.

(i) Calculate the concentration of the HBr(aq) in g / dm^3.

concentration of HBr(aq) = ... g / dm^3 [1]

(ii) Explain why concentrated HBr(aq) can conduct electricity.

.....

.....

..... [2]

(iii) Magnesium is **not** a suitable material from which to make the electrodes.

Explain why.

.....

..... [1]

(iv) Predict the product formed at the anode when concentrated HBr(aq) is electrolysed.

..... [1]

(v) Write the ionic half-equation for the reaction occurring at the cathode.

..... [2]

[Total: 11]

09. 0620_w19_qp_42 Q: 4

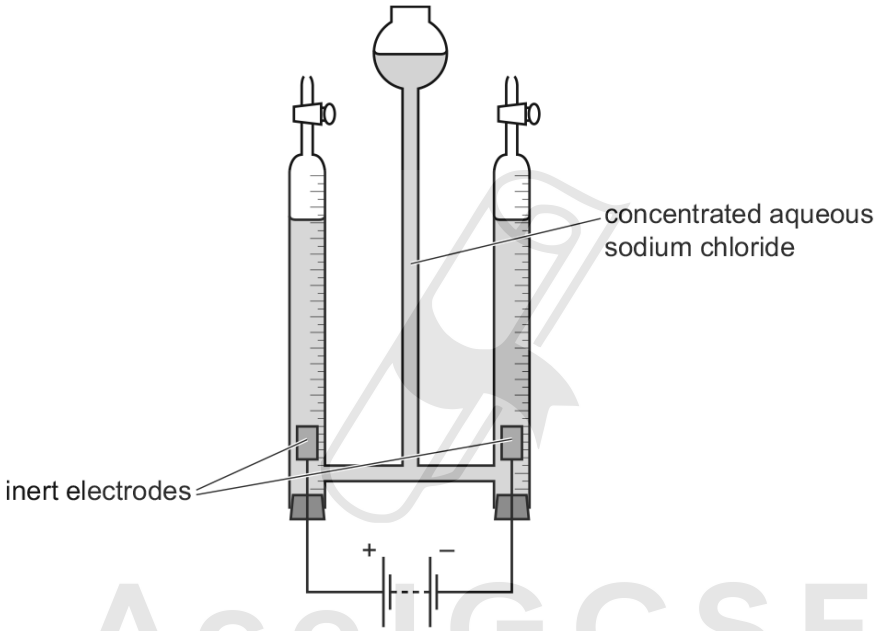
Many substances conduct electricity.

(a) Identify all the particles responsible for the passage of electricity in:

- graphite .....
- magnesium ribbon .....
- molten copper(II) bromide. .....

[4]

(b) A student used the following apparatus to electrolyse concentrated aqueous sodium chloride using inert electrodes.



(i) Suggest the name of a metal which could be used as the inert electrodes.

..... [1]

(ii) Name the gas formed at the positive electrode.

..... [1]

(iii) Write an ionic half-equation for the reaction occurring at the negative electrode. Include state symbols.

..... [3]

(iv) How, if at all, does the pH of the solution change during the electrolysis? Explain your answer.

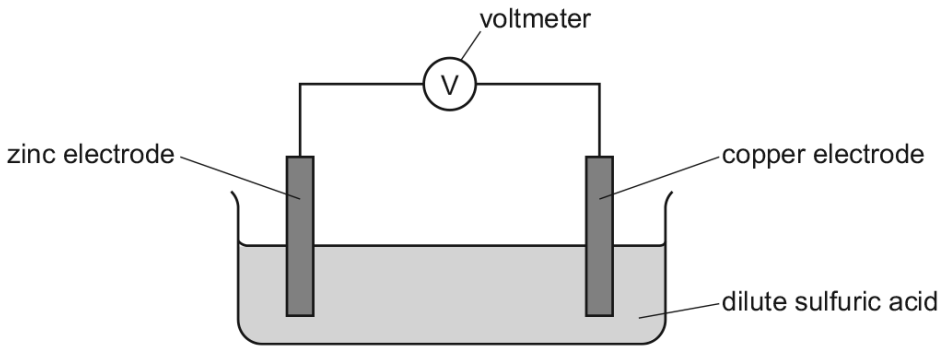
.....

.....

..... [3]

(c) A student used the following electrochemical cell.

The reading on the voltmeter was +1.10 V.



(i) Draw an arrow on the diagram to show the direction of electron flow. [1]

(ii) Suggest the change, if any, in the voltmeter reading if the zinc electrode was replaced with an iron electrode. Explain your answer.

.....

..... [2]

(iii) The zinc electrode was replaced with a silver electrode. The reading on the voltmeter was –0.46 V.

Suggest why the sign of the voltmeter reading became negative.

.....

..... [1]

[Total: 16]

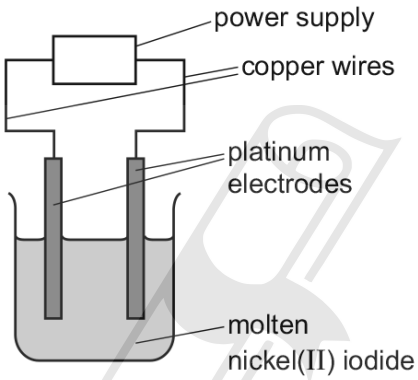
10. 0620_s18_qp_43 Q: 5

(a) Nickel(II) iodide crystals are hydrated. A sample of hydrated nickel(II) iodide crystals has the following composition by mass: Ni, 14.01%; I, 60.33%; H, 2.85%; O, 22.81%.

Calculate the empirical formula of the hydrated nickel(II) iodide crystals.

empirical formula = ... [2]

(b) Molten nickel(II) iodide can be electrolysed using the apparatus shown.



During electrolysis, charge is transferred through the copper wires and through the molten nickel(II) iodide.

(i) Name the type of particles which transfer charge through the copper wires.

..... [1]

(ii) Name the type of particles which transfer charge through the molten nickel(II) iodide.

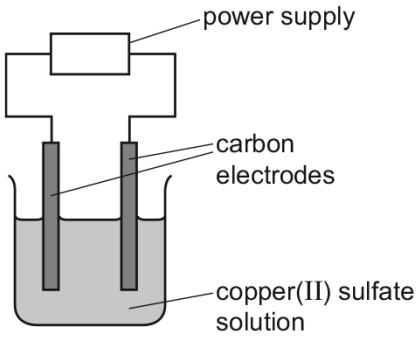
..... [1]

(iii) Predict the products of the electrolysis of molten nickel(II) iodide. Write an ionic half-equation for the formation of **one** of these products.

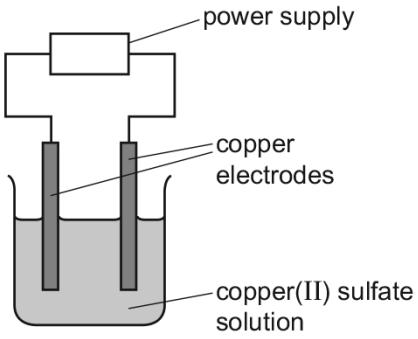
products .....

ionic half-equation .....
[3]

(c) A student electrolysed copper(II) sulfate solution using the two sets of apparatus shown.



apparatus **A**



apparatus **B**

In apparatus **A** the student used carbon electrodes.
In apparatus **B** the student used copper electrodes.

The student made the following observations.

apparatus **A**	apparatus **B**
The mass of the negative electrode increased.	The mass of the negative electrode increased.
The mass of the positive electrode stayed the same.	The mass of the positive electrode decreased.
Bubbles were seen at the positive electrode.	No bubbles were seen at the positive electrode.

(i) Explain why the mass of the negative electrode increased in **both** sets of apparatus.

.....

..... [1]

(ii) Name the gas that formed the bubbles seen in apparatus **A**.

..... [1]

(iii) Explain why the mass of the positive electrode decreased in apparatus **B**.

.....

..... [1]

(iv) Suggest what happens to the colour of the solution in apparatus **A** and apparatus **B** as the electrolysis progresses.
Explain your answer.

colour of the solution in apparatus **A** .....

colour of the solution in apparatus **B** .....

explanation .....

.....

.....

[3]

[Total: 13]

11. 0620_w18_qp_43 Q: 2

This question is about electrolysis.

(a) (i) What is meant by the term *electrolysis*?

.....

..... [2]

(ii) Name the type of particle responsible for the conduction of electricity during electrolysis in:

the metal wires .....

the electrolyte .....

[2]

(b) The table gives information about the products of the electrolysis of two electrolytes. Platinum electrodes are used in each case.

(i) Give **two** reasons why platinum is suitable to use as an electrode.

1 .....

2 .....

[2]

(ii) Complete the table.

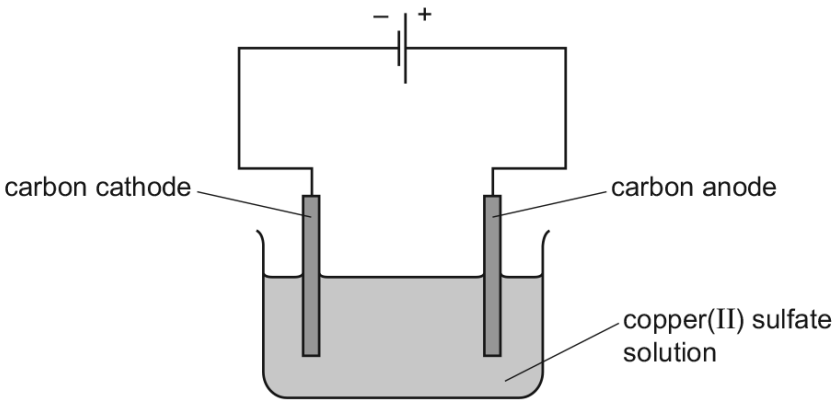
electrolyte	observation at the anode (+)	name of product at the anode (+)	observation at the cathode (–)	name of product at the cathode (–)
concentrated aqueous potassium chloride			bubbles of colourless gas	
aqueous copper(II) sulfate	bubbles of colourless gas			

[6]

[Total: 12]

12. 0620_m17_qp_42 Q: 4

Copper(II) sulfate solution was electrolysed using the apparatus shown.



(a) (i) Draw an arrow on the diagram to show the direction of movement of electrons in the wire. Label the arrow **A**. [1]

(ii) Draw an arrow on the diagram to show the direction of movement of positive ions in the copper(II) sulfate solution. Label the arrow **B**. [1]

(b) Oxygen was formed at the anode and copper was formed at the cathode.

(i) The ionic half-equation for the formation of oxygen is shown.

$$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$$

Explain why this reaction is oxidation.

..... [1]

(ii) Write the ionic half-equation for the formation of copper at the cathode.

..... [2]

(c) The electrolysis was repeated using copper electrodes in place of carbon electrodes.

State and explain what happens to the masses of the anode and the cathode during this electrolysis.

.....

.....

.....

.....

..... [4]

[Total: 9]

13. 0620_s16_qp_41 Q: 4

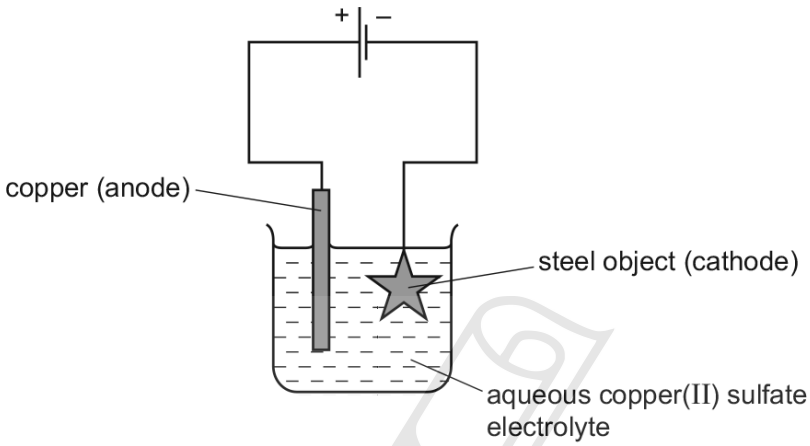
Electroplating steel objects with silver involves a three-step process.

step 1 A coating of copper is applied to the object.

step 2 A coating of nickel is applied to the object.

step 3 The coating of silver is applied to the object.

(a) A diagram of the apparatus used for **step 1** is shown.



(i) The chemical process taking place on the surface of the object is

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

Explain whether this process is oxidation or reduction.

.....

..... [1]

(ii) Explain why the concentration of copper ions in the electrolyte remains constant throughout **step 1**.

.....

.....

..... [2]

(b) Give **two** changes which would be needed in order to coat nickel onto the object in **step 2**.

.....

.....

.....

..... [2]

(c) Copper, nickel and silver are transition elements.
Typical physical properties of transition elements are a high density and a high melting point.

Give **three** different properties of transition metals which are not typical of other metals.

.....

.....

..... [3]

[Total: 8]

14. 0620_w16_qp_43 Q: 4

Silicon(IV) oxide and sodium chloride have different types of bonding and structure.

(a) Name the type of bonding present in

silicon(IV) oxide, ...

sodium chloride. .....
[2]

(b) Name the type of structure present in silicon(IV) oxide.

..... [1]

(c) **(i)** Silicon(IV) oxide has a high melting point. Explain why.

.....

..... [2]

(ii) Silicon(IV) oxide is a poor conductor of electricity. Explain why.

..... [1]

(d) Solid sodium chloride does not conduct electricity. However, it conducts electricity when molten.

Explain why solid sodium chloride does **not** conduct electricity, whereas molten sodium chloride does conduct electricity.

.....

.....

.....

..... [3]

(e) A **concentrated** aqueous solution of sodium chloride is electrolysed using carbon electrodes.

(i) Name the products formed at the electrodes.

product at the positive electrode (anode) .....

product at the negative electrode (cathode) .....
[2]

(ii) Write an ionic half-equation for the reaction occurring at the negative electrode.

..... [1]

(f) A **dilute** aqueous solution of sodium chloride is electrolysed using carbon electrodes.

Name the main product formed at the positive electrode.

..... [1]

(g) Molten sodium chloride is electrolysed using carbon electrodes.

(i) Name the product formed at the negative electrode.

..... [1]

(ii) Write an ionic half-equation for the reaction occurring at the negative electrode.

..... [1]

(iii) Chlorine is produced at the positive electrode.

Give the test for chlorine.

test .....

result .....

[2]

[Total: 17]

15. 0620_w15_qp_33 Q: 3

Lithium bromide is an ionic compound. It can be electrolysed when it is molten or in aqueous solution. It cannot be electrolysed as a solid.

(a) Solid lithium bromide is a poor conductor of electricity. The ions cannot move to the electrodes, they are held in an ionic lattice by strong forces.

(i) Describe the motion of the ions in the solid state.

..... [1]

(ii) Define the term *ionic bonding*.

.....

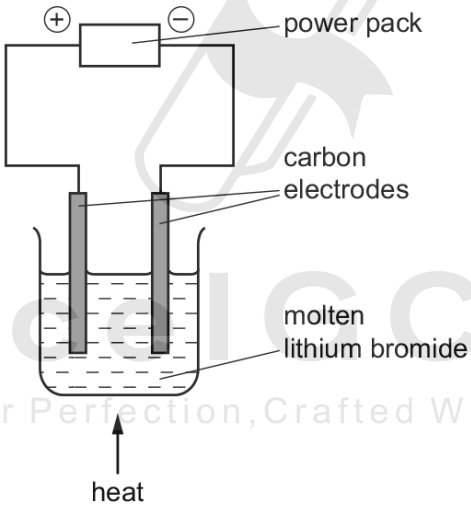
..... [2]

(iii) What is meant by the term *ionic lattice*?

.....

..... [2]

(b) The diagram shows the electrolysis of molten lithium bromide.



(i) Mark on the diagram the direction of the electron flow. [1]

(ii) Write an ionic equation for the reaction at the negative electrode (cathode).

..... [1]

(iii) Write an ionic equation for the reaction at the positive electrode (anode).

..... [2]

(iv) Which ion is oxidised? Explain your answer.

.....

..... [2]

(c) When aqueous lithium bromide is electrolysed, a colourless gas is formed at the negative electrode and the solution becomes alkaline.

Explain these observations and include an equation in your explanation.

.....

.....

.....

..... [3]

[Total: 14]

---

16. 0620_s14_qp_33 Q: 7

Aluminium is obtained from purified alumina, Al_2O_3, by electrolysis.

(a) Alumina is obtained from the main ore of aluminium.
State the name of this ore.

..... [1]

(b) Describe the extraction of aluminium from alumina. Include the electrolyte, the electrodes and the reactions at the electrodes.

.....

.....

.....

.....

.....

.....

..... [6]

(c) Aluminium is resistant to corrosion. It is protected by an oxide layer on its surface.
The thickness of this oxide layer can be increased by anodising.

(i) State a use of aluminium due to its resistance to corrosion.

..... [1]

(ii) Anodising is an electrolytic process. Dilute sulfuric acid is electrolysed with an aluminium object as the anode. The thickness of the oxide layer is increased. Complete the equations for the reactions at the aluminium anode.

$$\text{.....}OH^- \rightarrow O_2 + 2H_2O + \text{.....}e^-$$

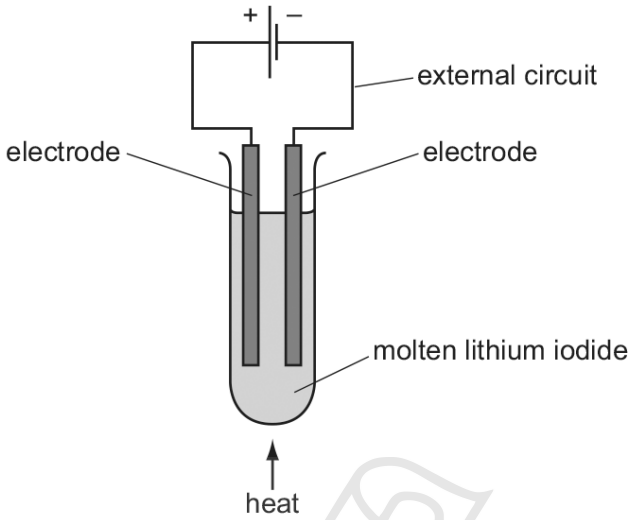
$$\text{....}Al + \text{.....} \rightarrow \text{.....}Al_2O_3$$ [4]

[Total: 12]

17. 0620_w12_qp_32 Q: 6

During electrolysis, ions move in the electrolyte and electrons move in the external circuit. Reactions occur at the electrodes.

(a) The diagram shows the electrolysis of molten lithium iodide.



(i) Draw an arrow on the diagram to show the direction of the electron flow in the external circuit. [1]

(ii) Electrons are supplied to the external circuit. How and where is this done?

.....

..... [2]

(iii) Explain why solid lithium iodide does not conduct electricity but when molten it is a good conductor.

.....

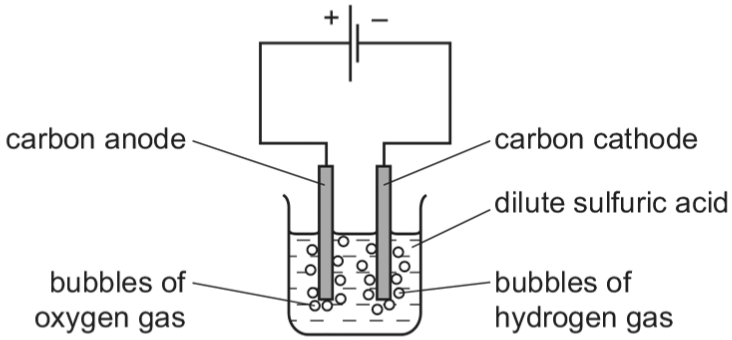
..... [1]

(b) The results of experiments on electrolysis are shown in the following table. Complete the table. The first line has been done as an example.

electrolyte	electrodes	product at cathode	product at anode	change to electrolyte
molten lithium iodide	carbon	lithium	iodine	used up
aqueous copper(II) sulfate	platinum		oxygen	
concentrated aqueous potassium chloride	carbon		chlorine	

[4]

(c) The diagram below shows the electrolysis of dilute sulfuric acid. Hydrogen is formed at the negative electrode (cathode) and oxygen at the positive electrode (anode) and the concentration of sulfuric acid increases.



The ions present in the dilute acid are $H^+(aq)$, $OH^-(aq)$ and $SO_4^{2-}(aq)$.

(i) Write an equation for the reaction at the negative electrode (cathode).

..... [2]

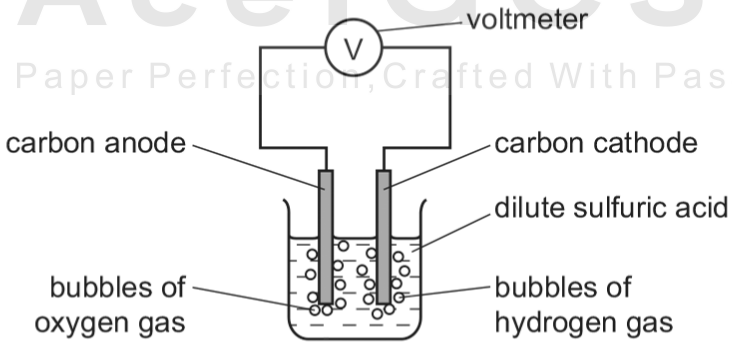
(ii) Complete the equation for the reaction at the positive electrode (anode).

$$4OH^-(aq) \rightarrow O_2(g) + ...H_2O(l) + ... \quad [1]$$

(iii) Suggest an explanation of why the concentration of the sulfuric acid increases.

..... [1]

(d) In the apparatus used in **(c)**, the power supply is removed and immediately replaced by a voltmeter.



A reading on the voltmeter shows that electrical energy is being produced. Suggest an explanation for how this energy is produced.

.....

.....

..... [3]

[Total: 15]

01. 0620_s21_ms_41 Q: 3

Question	Answer	Marks
(a)	$2K + Cl_2 \rightarrow 2KCl$ Cl_2 on left hand side (1) equation fully correct (1)	2
(b)	K outer shell with **8 crosses** (1) Cl outer shell with **7 dots and 1 cross** (1) $^+$ and $^-$ (1)	3
(c)(i)	**breakdown** by (the passage of) **electricity** (1) of an **ionic compound** in **molten or aqueous** (state) (1)	2

Question	Answer	Marks
(c)(ii)	(anode) chlorine (cathode)potassium	1
(d)(i)	$2H^+ + 2e(^-) \rightarrow H_2$ H+ and e($^-$) on left hand side (1) equation fully correct (1)	2
(d)(ii)	chlorine	1
(d)(iii)	potassium hydroxide (1)	1
(e)	one shared pair of electrons and 6 non-bonding electrons on each chlorine atom	1
(f)(i)	liquid (1) **BOTH** melting point is below –75 °C **AND** boiling point is above –75 °C **OR** **BOTH** –75 °C is higher than –101 °C / melting point **AND** lower than –35 °C / boiling point **OR** **–75 °C is between** melting point or –101 °C **and** boiling point or –35 °C	2
(f)(ii)	**ionic bonds** in KCl (1) attraction **between molecules** in Cl_2 (1) weak**er** attraction (between particles) in Cl_2 **ORA** (1)	3

02. 0620_s21_ms_42 Q: 4

Question	Answer	Marks
(a)	electrolyte	1
(b)(i)	$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ balance of charge (1) rest of equation (1)	2
(b)(ii)	(OH^-(aq) ions) lose electrons	1
(c)	fizzing	1
(d)	$2H^+ + 2e^- \rightarrow H_2$ species correct (1) fully correct equation (1)	2
(e)(i)	fizzing (1) green gas (1)	2
(e)(ii)	(litmus turns) blue **and** alkali / base forms (1) Sodium hydroxide / NaOH (forming) (1)	2
(f)	platinum	1

03. 0620_s21_ms_43 Q: 3

Question	Answer	Marks
(a)	$2Na + F_2 \rightarrow 2NaF$ F_2 (1) equation fully correct (1)	2
(b)	Na outer shell with 8 crosses (1) F outer shell with 7 dots and 1 cross (1) Na^+ and F^- (1)	3
(c)(i)	**breakdown** by (the passage of) **electricity** (1) of an **ionic compound** in **molten / aqueous** (state) (1)	2

Question	Answer	Marks
(c)(ii)	oxygen hydrogen	2
(d)(i)	(anode) fluorine (1) (cathode) sodium (1)	2
(d)(ii)	$Na^+ + e(^-) \rightarrow Na$	1
(e)	one shared pair of electrons and 6 non-bonding electrons on each fluorine atom	1
(f)(i)	liquid (1) **BOTH** melting point is below –195 °C **and** boiling point is above –195 °C **OR** –195 °C is in between melting point and boiling point / –220 °C and –188 °C (1) **OR** **BOTH** –195 °C is higher than –220 °C / melting point **AND** lower than –188 °C / boiling point	2
(f)(ii)	**ionic bonds** in NaF (1) attraction **between molecules** in F_2 (1) weaker attraction (between particles) in F_2 **ORA** (1)	3

04. 0620_w21_ms_41 Q: 3

Question	Answer	Marks
(a)(i)	$2Cl^- \rightarrow Cl_2 + 2e^-$ Cl_2 (1) rest of equation (1)	2
(a)(ii)	Oxidation AND lose electrons	1
(b)	effervescence (of colourless gas)	1
(c)	$2H^+ + 2e^- \rightarrow H_2$ $H^+ + e$ as only species on LHS (1) rest of equation fully correct (1)	2
(d)(i)	1	1
(d)(ii)	**M1** increase (1) **M2** H+ ions being removed (1)	2
(e)	**M1** cathode: silver / grey solid (1) **M2** anode: bubbles of orange / brown gas (1)	2
(f)	**M1** inert (1) **M2** conducts electricity (1)	2

05. 0620_w21_ms_43 Q: 2

Question	Answer	Marks
(a)	**M1** ionic compound **AND** either molten or aqueous(or both)(1) **M2** conducts electricity / undergoes electrolysis(1)	**2**
(b)(i)	**M1** oxygen (1) **M2** pink / brown solid (1) **M3** copper (1) **M4** orange / brown / yellow liquid (1) **M5** bromine (1)	**5**

Question	Answer	Marks
(b)(ii)	$2H^+ + 2e(^-) \rightarrow H_2$ (2)	**2**
(b)(iii)	**M1** inert (1) **M2** good conductor of electricity (1)	**2**
(b)(iv)	electron	**1**

06. 0620_s20_ms_42 Q: 5

(a)	**breakdown** of an ionic **compound** when molten or in aqueous solution (1) (using) electricity / electric current / electrical energy (1)	**2**
(b)	platinum / graphite	**1**
(c)	$2H^+ + 2e \rightarrow H_2$	**1**

(d)	Na^+ H^+ Cl^- OH^- all four (2) 3 or 2 (1)	**2**
(e)	H^+ and Cl^- are discharged / removed (1) Na^+ and OH^- remain (1)	**2**

07. 0620_s19_ms_43 Q: 4

(a)(i)	inert / unreactive / does not react with chlorine	**1**
(a)(ii)	bubbles / fizzing / effervescence	**1**
(a)(iii)	**M1** increases **M2** (solid) copper deposited	**2**
a(iv)	**M1** colour fades / becomes pale(r) / becomes colourless / becomes lighter **M2** copper (ions) removed (from solution)	**2**
(a)(v)	**M1** species oxidised: chloride (ions) / Cl^- **M2** explanation: loss of electrons / increase in oxidation state	**2**
(b)(i)	**M1** spoon as cathode **M2** (pure)silver as anode **M3** aqueous silver nitrate as electrolyte **M4** $Ag^+ + e^- \rightarrow Ag$	**4**
(b)(ii)	any one from: □ Improves appearance □ prevent / resist corrosion / oxidation □ antibacterial	**max 1**

08. 0620_w19_ms_41 Q: 6

(a)	correct final answer = 0.072(0) **M1** moles HC*l* = 0.0036(0) **M2** moles Na_2CO_3 = 0.0018(0) (**M1** / 2) **M3** concentration Na_2CO_3 = 0.072 (**M2** / 0.025)	**3**
(b)	0.002(00)	**1**
(c)(i)	720(.09)	**1**
(c)(ii)	(it contains) ions (1) (ions) are able to move (1)	**2**
(c)(iii)	magnesium is not inert	**1**
(b)(iv)	bromine / Br_2	**1**
(b)(v)	H^+ and $e^{(-)}$ on LHS (1) fully correct, i.e.: $2H^+ + 2e^- \rightarrow H_2$ (1)	**2**

09. 0620_w19_ms_42 Q: 4

(a)	electrons (1) electrons (1) Cu^{2+} (ions) (1) Br^- (ions) (1)	**4**
(b)(i)	platinum	**1**
(b)(ii)	chlorine	**1**
(b)(iii)	$2H^+(aq) + 2e^- \rightarrow H_2(g)$ $H^+ + e^-$ on left hand side (1) rest of equation (1) state symbols of (aq) $\rightarrow$ (g) (1)	**3**
(b)(iv)	increases (sodium) hydroxide is formed (sodium) hydroxide is an alkali	**3**
(c)(i)	arrow (anywhere) going from Zn $\rightarrow$ Cu	**1**
(c)(ii)	reading would decrease (1) Fe less reactive than Zn (1) **OR** difference in reactivity (between Fe and Cu) is smaller	**2**
(c)(iii)	Ag less reactive than Cu	**1**

10. 0620_s18_ms_43 Q: 5

(a)	14.01/59 : 60.33/127 : 2.85/1 : 22.81/16 **OR** 0.237 : 0.475 : 2.85 : 1.43	1
	$NiI_2H_{12}O_6$	1
(b)(i)	electrons	1
(b)(ii)	(positive and negative) ions	1
(b)(iii)	nickel	1
	iodine	1
	$Ni^{2+} + 2e^- \rightarrow Ni$ **OR** $2I^- \rightarrow I_2 + 2e^-$	1
(c)(i)	copper formed/copper deposited	1
(c)(ii)	oxygen	1
(c)(iii)	copper removed or copper lost **or** copper forms ions	1
(c)(iv)	any **three** from: (apparatus **A**): solution becomes paler/fades in **A** (apparatus **B**): solution stays the same colour in **B** (explanation): copper ions removed (but not added) copper ions not replaced in **A** **OR** copper ions both removed and added (at the same rate) copper ions are being replaced (continually)	3

11. 0620_w18_ms_43 Q: 2

(a)(i)	**M1** breakdown of an ionic **compound** when molten or in aqueous solution **M2** (using) electricity / electric current	2
(a)(ii)	**M1** electron(s) **M2** ion(s)	2
(b)(i)	**M1** inert / unreactive **M2** conducts **electricity**	2

(b)(ii)		observation at anode(+)	name of product at anode(+)	observation at cathode(–)	name of product at cathode(–)
		M1 green / yellow bubbles	**M2** chlorine		**M3** hydrogen
			M4 oxygen	**M5** pink / brown solid	**M6** copper

12. 0620_m17_ms_42 Q: 4

(a)(i)	arrow labelled **A** on or near wire going in an anti-clockwise direction	**1**
(a)(ii)	arrow labelled **B** in electrolyte pointing towards the cathode	**1**
(b)(i)	electrons are lost	**1**
(b)(ii)	**M1** Cu^{2+} ions on left	**1**
	M2 rest of equation correct and correctly balanced ($Cu^{2+} + 2e^- \rightarrow Cu$ scores [2])	**1**
(c)	**M1** anode mass decreases	**1**
	M2 copper lost as ions **OR** copper (atoms) becomes ions **OR** $Cu \rightarrow Cu^{2+} + 2e^-$	**1**
	M3 cathode mass increases	**1**
	M4 copper deposited / layer of copper forms / copper collected at cathode **OR** $Cu^{2+} + 2e^- \rightarrow Cu$	**1**

13. 0620_s16_ms_41 Q: 4

(a)(i)	reduction **and** (the Cu^{2+} ion / copper ions) is gaining electrons / is decreasing in oxidation number;	**1**
(a)(ii)	formation of Cu^{2+} / copper ions at the anode happens at the same rate as; removal of Cu^{2+} / copper ions at the cathode ora;	**2** 1 1
(b)	replace (anode of) copper with nickel; replace electrolyte with nickel(II) sulfate / $NiSO_4$;	**2** 1 1
(c)	(good) catalysts; variable oxidation numbers; form coloured compounds / coloured ions;	**3** 1 1 1

14. 0620_w16_ms_43 Q: 4

(a)	*silicon(IV) oxide*: covalent *sodium chloride*: ionic / electrovalent	1 1
(b)	giant molecular / macromolecular / giant covalent / giant atomic	1
(c)(i)	**M1** (covalent) bonds are strong **M2** a lot of heat or energy is needed to break / weaken / overcome bonds **OR** there are no weak bonds **OR** there are no intermolecular forces **OR** covalent bonds are the only bonds **OR** strong bonds are the only bonds	2
(c)(ii)	(it has) no moving ions / no moving electrons / all electrons are used in bonding / no moving charged particles	1
(d)	(sodium chloride contains) ions / is ionic in the solid ions are not moving / they are in fixed positions ions can move when molten	1 1 1
(e)(i)	*product at the positive electrode:* chlorine *product at the negative electrode:* hydrogen	1 1
(e)(ii)	$2H^+ + 2e(^-) \rightarrow H_2$ **OR** $2H_3O^+ + 2e(^-) \rightarrow H_2 + 2H_2O$	1
(f)	oxygen	1
(g)(i)	sodium	1
(g)(ii)	$Na^+ + e(^-) \rightarrow Na$	1
(g)(iii)	*test:* (damp blue) litmus *result:* bleached / removes colour / (turns) white	1 1

15. 0620_w15_ms_33 Q: 3

(a)(i)	vibrate (about fixed position) / vibration;	1
(a)(ii)	electrostatic force of) attraction; (between) positive ions and negative ions / oppositely charged ions / unlike charged ions / cations and anions;	1 1
(a)(iii)	regular / repeated / pattern / framework / ordered / alternating / organised (arrangement of); positive and negative ions / oppositely charged ions / cations and anions / unlike charged ions;	1 1
(b)(i)	correct direction (going towards negative electrode);	1
(b)(ii)	$Li^+ + e^- \rightarrow Li$ / $Li^+ \rightarrow Li - e^-$;	1
(b)(iii)	$2Br^- \rightarrow Br_2 + 2e^-$ / $2Br^- - 2e^- \rightarrow Br_2$ formulae; balancing;	2
(b)(iv)	Br^- / bromide (ion); electron lost / donated electrons / increased oxidation state / increased oxidation number / oxidation numbers changed from –1 to 0 / increased valency;	1 1

(c)	**M1** (gas) hydrogen (given off at cathode) / H_2; **M2** hydroxide ions / lithium hydroxide / OH^- / LiOH are alkali(ne); **M3** $2LiBr + 2H_2O \rightarrow 2LiOH + H_2 + Br_2$; **or** $2H^+ + 2e^- \rightarrow H_2$ / $2H^+ \rightarrow H_2 - 2e^-$; **or** $2Br^- \rightarrow Br_2 + 2e^-$ / $2Br^- - 2e^- \rightarrow Br_2$; **or** $2H^+ + 2Br^- \rightarrow H_2 + Br_2$;	3

16. 0620_s14_ms_33 Q: 7

(a) bauxite (1) [1]

(b) electrolyte alumina / aluminium oxide dissolved in molten cryolite (1)
use cryolite to reduce mp / comparable idea / temperature of electrolyte 900 to 1000 °C (1)
electrodes carbon (1)
aluminium formed at cathode / $Al^{3+} + 3e \rightarrow Al$ (1)
oxygen formed at anode / $2O^{2-} \rightarrow O_2 + 4e$ (1)
anode burns / reacts to carbon dioxide / $C + O_2 \rightarrow CO_2$ (1) [6]

(c) **(i)** food containers / window frames / cooking foil / cars / bikes / drink cans (1) [1]

(ii) $4OH^- \rightarrow O_2 + 2H_2O + 4e$ (2) [2]

$4Al + 3O_2 \rightarrow 2Al_2O_3$ (2) [2]

[Total: 12]

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17. 0620_w12_ms_32 Q: 6

(a) **(i)** correct arrow from negative terminal of battery or from anode; [1]

(ii) from battery / power supply / cell; [1]
from negative electrode of battery to external circuit; [1]
or from anode;
from iodide ion losing electron **or** oxidation of anion;

(iii) ions cannot move in solid / ions can move in liquid; [1]

(b) copper; [1]
(changes to) sulfuric acid; [1]

hydrogen; [1]
(changes to) potassium hydroxide; [1]

(c) **(i)** $2H^+ + 2e \rightarrow H_2$ [2]
not balanced = [1]

(ii) $4OH^- \rightarrow O_2 + 2H_2O + 4e$ [1]

(iii) water used up; [1]

(d) it is a cell; [1]
hydrogen reacts with oxygen; [1]
this reaction produces energy / is exothermic / produces flow of electrons / changes chemical energy to electrical energy; [1]

[Total: 15]
