(a)  (i) so ions can move (and carry charge)
accept so current can flow
allow so it can conduct (electricity)
allow so charged particles can move
do not accept so electrons can move

(ii) because zinc ions gain electrons
accept because zinc ions are reduced

2 (electrons)
zinc is formed
accept correct half equation for 3 marks
if no mark gained allow
positive ions go to negative electrode or
opposites attract or
reduction (of zinc) or
(zinc) gains electrons for 1 mark

(iii) $2 \text{Cl}^- \rightarrow \text{Cl}_2 + 2 \text{e}^-$
must be completely correct

(b)  (i) because the magnesium is a gas
allow magnesium goes from solid to gas

(ii) (a reaction which) takes in energy (from the surroundings)
accept more energy needed to break bonds than released by forming bonds
accept correct reference to energy level diagram
allow (a reaction which) takes in heat (from the surroundings)

(iii) $(M, \text{MgO} =) 40$
accept $(2 M, \text{MgO} =) 80$

$1.2 / 24 (x40)$ or $0.05 (x40)$
or
$40 / 24 (x1.2)$ or $1.67 (x1.2)$
allow ecf from step 1

2(.0)
allow ecf carried through from step 1

correct answer with or without working gains 3 marks

(iv) 75(%)  

(v) any one from:
• the reaction is reversible
  accept incomplete reaction
  ignore equilibrium not reached
• some lost / escaped / released (when separated)
• some of the reactant may react in different ways from the expected reaction
• impure reactant(s)
  ignore reactant(s)
  ignore measurement and calculation errors

(a) (i) because they are positively charged
  accept they are positive / H^+
  accept oppositely charged or opposites attract
  ignore they are attracted

(ii) gains one / an electron
  accept H^+ + e^- → H or multiples
  allow gains electrons

(b) 3 bonding pairs
  1 lone pair
  accept 2 non-bonding electrons on outer shell of nitrogen

(c) (i) hydroxide / OH^−
  do not accept sodium hydroxide

(ii) H^+ + OH^− → H_2O
  ignore state symbols
  ignore word equation
(d) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Reference material.

**0 marks**
No relevant content.

**Level 1 (1-2 marks)**
There are basic descriptions of advantages or disadvantages of the electrolysis cells.

**Level 2 (3-4 marks)**
There are clear descriptions of environmental or economic advantages or disadvantages of the electrolysis cells. Comparisons may be implied.

**Level 3 (5-6 marks)**
There are detailed descriptions of environmental and economic advantages and disadvantages, comparing the electrolysis cells.

**Examples of chemistry points made in the response:**

Accept converse where appropriate.

- mercury cell is more expensive to construct
- mercury is recycled but membranes must be replaced
- mercury is toxic but membrane / polymer is not
- removing traces of mercury from waste is expensive
- mercury cell uses more electricity
- mercury cell produces chlorine that is purer
- mercury cell produces higher concentration / better quality of sodium hydroxide (solution)

(a) Will kelp last longer than coal as an energy source?

(b) any two from:

- cannot be determined by experiment
  
  *allow can't predict how long kelp / coal will last*  
  *allow more testing needed*

- based on opinion

- ethical or environmental or economic reason
  
  *allow could damage ecosystem allow reference to cost*
(c) (i) 7

(ii) sodium (atom) loses (electron) **and** iodine (atom) gains (an electron)

*reference to incorrect bonding or incorrectly named particle*

= max 2

*any or all marks can be obtained from a labelled diagram*

*ignore inner shell electrons if shown*

1 electron

(electrostatic) attraction **or** forms ionic bond(s)

(iii) **ions** can move (in the solution)

(iv) \[ 2 \text{I}^- \rightarrow \text{I}_2^- + 2\text{e}^- \]

(v) hydrogen is formed

because sodium is more reactive (than hydrogen)

[11]

(a) cannot move

(b) (i) a positive charge

(ii) atoms

(a) (i) aluminium oxide

*ignore (III) after aluminium*

(ii) (because it provides) heat / energy (to overcome activation energy)

(b) (i) contains only one sort of atom

(ii) the atoms (in cast iron) are different sizes

*any mention of molecules, maximum 1 mark*

*accept layers are distorted or structure is disrupted*
which prevents the layers / rows sliding

accept an answer in terms of pure iron being softer than cast iron for both marks

(c) (i) because aluminium is more reactive than carbon

‘it’ = aluminium must be a comparison between the elements

or

because aluminium is above carbon in the reactivity series

*do not* accept any comparison of the reactivity of aluminium and iron

(ii) reduces / lowers the temperature for the process *or* lowers the operating temperature *or* allows ions to move

ignore any temperature values

allow reduces the (effective) melting point (of Al₂O₃)

(iii) 3

accept multiples

(iv) electrons are gained (by Al³⁺)

ignore any numbers

ignore any reference to oxygen

(v) electrodes are made of carbon

*allow graphite / coke*

oxygen is produced (at the positive electrode / anode)

*accept 2O²⁻ → O₂ + 4e⁻*

so the electrodes react with the oxygen / are oxidised

producing carbon dioxide (gas)

*accept C + O₂ → CO₂ for marking points 3 and 4.*
(a) any two from:

- copper / ores are running out / harder to find

- there are no / very small amounts of high-grade copper ores left

- copper metal is in demand

- copper is expensive

- now economical to extract copper from low-grade ores
  
  \[
  \text{it = copper}
  \]

  allow new methods of extraction e.g. bioleaching and phytomining
  
  allow high-grade ores are running out for 2 marks

(b) (i) large amounts / 98% of rock to dispose of as waste

  accept contains toxic (metal) compounds / bioleacher

  or

  waste rock takes up a lot of space

(ii) (copper sulfide reacts with oxygen to) produce sulfur dioxide / SO\(_2\)

  allow (sulfur reacts with oxygen to) produce sulfur dioxide / SO\(_2\)

  that causes acid rain

  allow description of effects of acid rain or sulfur dioxide

  if no other mark awarded allow CO\(_2\) produced which causes global warming or CO\(_2\) produced by burning fuel or heating the furnace for 1 mark

(iii) any one from:

- large amounts of fuels / energy used (for the furnace and electrolysis)

  allow large amounts of electricity needed

  ignore high temperature / electrolysis unqualified

- (the extraction has) many steps / stages / processes

  allow (extraction) is a long process / takes a lot of time

- large amounts of ore / material have to be mined

  allow ores contain a low percentage of copper

(iv) (copper ions move towards) the negative electrode / cathode
because copper ions / Cu\(^{2+}\) are positively charged or are oppositely charged or copper ions need to gain electrons

allow because metal ions are positive or opposites attract

(v) (growing) plants

(a) (i) was well qualified

(ii) check the results of the experiment

(b) (i) cannot move

(ii) melt it / make it a liquid

allow heat it

allow dissolve (in water) / make a solution

(iii) they are positive

allow opposites attract or opposite charges

(iv) atoms

(a) (i) current / charge couldn't flow

allow could not conduct (electricity)

because the ions / particles couldn’t move

do not accept electrons / molecules / atoms

or

(salt) needs to be molten / (1) dissolved (to conduct electricity)

so that the ions / particles can move (1)

do not accept electrons / molecules / atoms

(ii) he had status

accept he had authority or experience

or

he had evidence / proof

accept the experiment could be repeated
(b) hydrogen / H₂

*do not* allow hydrogen ions

the ions are positive

*accept because opposite (charges) attract*

potassium is more reactive (than hydrogen)

*accept potassium ions are less easily discharged (than hydrogen) or potassium ions are less easily reduced (than hydrogen)*

(c) (i) gain electron(s)

*accept fully balanced correct equation for 2 marks*

one electron

*if no other marks awarded allow (potassium ions) reduced for 1 mark*

(ii) \(2 \text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-\)

*must be completely correct, including charge on electron accept correct multiples*

(iii) 2, 8, 8

*accept any combination of dots, crosses, “e” or any other relevant symbol ignore any charges if given*

(a) *reduction*

(b) carbon is less reactive than aluminium

(c) aluminium (ions) / they are positively charged

*they = aluminium ions ignore particle names accept aluminium (ions) / they are cations allow aluminium (ions they have an opposite charge*
so they are attracted or they move towards the negative electrode

OR

aluminium (ions) / they need to gain electrons (1)

which come from the negative electrode (1)

if no other marks awarded allow ‘opposites attract’ for 1 mark

(d) aluminium has a low density

aluminium is resistant to corrosion

(e) advantage less carbon dioxide is produced

disadvantage used aluminium cans have to be collected and transported