M1.(a)  

(i)  calcium oxide  

\[ \text{in either order} \]

\[ \text{carbon dioxide} \]

\[ \text{accept correct formulae} \]  

\[ \text{(ii) } C(s) + CO_2(g) \rightarrow 2\text{CO(g)} \]

\[ \text{allow multiples} \]  

\[ \text{(iii) } 210 \text{ (tonnes)} \]

\[ \text{award 3 marks for the correct answer with or without working} \]

\[ \text{allow ecf for arithmetical errors} \]

\[ \text{if answer incorrect allow up to 2 marks for any of the steps below:} \]

\[ 160 \rightarrow 112 \]

\[ 300 \rightarrow 112 / 160 \times 300 \]

\[ \text{or} \]

\[ \text{moles Fe}_3\text{O}_4 = 1.875 \times 10^6 \text{ or } 300 / 160 \]

\[ \text{moles of Fe} = 3.75 \times 10^6 \text{ or } 2 \times \text{moles Fe}_3\text{O}_4 \]

\[ \text{mass Fe} = \text{moles Fe} \times 56 \]

\[ 105 \text{ (tonnes)} \text{ scores 2 (missing 1:2 ratio)} \]

\[ 420 \text{ (tonnes)} \text{ scores 2 – taken M_r of iron as 112} \]  

(b)  

(i)  aluminium is more reactive than carbon  or  carbon is less reactive than aluminium  

\[ \text{must have a comparison of reactivity of carbon and aluminium} \]

\[ \text{accept comparison of position in reactivity series.} \]  

(ii)  (because) aluminium ions are positive  

\[ \text{ignore aluminium is positive} \]

\[ \text{and are attracted / move / go to the negative electrode / cathode} \]

\[ \text{where they gain electrons / are reduced} / \text{Al}^{1+} + 3e^- \rightarrow \text{Al} \]

\[ \text{accept equation or statements involving the wrong number of electrons.} \]
(iii) (because) the anodes or (positive) electrodes are made of carbon / graphite

1

oxygen is produced (at anode)

1

which reacts with the electrodes / anodes

_ do not accept any reference to the anodes reacting with oxygen from the air_

_ equation \( C + O_2 \rightarrow CO_2 \) gains 1 mark (M3) _

1 [13]

M2.(a) left hand: (conical) flask

_ do not accept round bottomed flask or container which is not a flask _

1

right hand: beaker / trough

_ accept plastic box _

1

(b) (i) 157

1

(ii) all calcium carbonate used up or reaction stopped

_ do not accept all acid used up _

1

(c) (i) 0.007(272727…)

_ correct answer with or without working gains 2 marks _

_ if answer incorrect, allow (0.32 / 44) for 1 mark _

2

(ii) 0.007(272727…)

_ allow ecf from (c)(i) _

1
(iii) \( M = \frac{\text{mass}}{\text{moles}} = \frac{1}{0.00727 \ldots} = 137.5 \) or 138

allow ecf from (c)(iii)
if use 0.00943 moles then = 106
if use 0.007 allow 143 (142.857)

(iv) \((138) - 60 (= 78)\)
\[\frac{23}{85}\]

\((78 / 2) = 39\)

potassium

sodium / rubidium

identity of metal ecf on A, but must be Group 1

If no working max 1 mark

(d) (i) (relative atomic mass) would decrease

because the mass lost greater

so moles carbon dioxide larger or moles metal carbonate greater

(ii) no change

because the acid (already) in excess
so the amount carbon dioxide lost is the same

M3. (a) copper has delocalised electrons

- accept copper has free electrons
- ignore sea of electrons or mobile electrons

(electrons) which can move through the metal / structure
- allow (electrons) which can carry a charge through the metal / structure

(b) (i) (\(M_{FeCl_3} = \)) 162.5

- correct answer with or without working gains 3 marks
- can be credited from correct substitution in step 2

or

2 (moles of) \(FeCl_3\) = 325

or

112 → 325

\[
\frac{11.20}{56} \times 162.5
\]

- allow ecf from step 1

\[
\frac{325}{112} \times 11.2
\]

- accept
(ii) 74.8
    accept 74.77 - 75
    accept ecf from (b)(i)
    if there is no answer to part(i)
    or
    if candidate chooses not to use their answer then accept
    86.79 - 87

M4.(a) (i) CH₄
    allow H, C
    do not allow lower-case h
    do not allow superscript

(ii) single

(iii) alkanes

(b) (i) carbon / C
    any order
    hydrogen / H
    allow phonetic spelling
sulfur / sulphur / S

(ii) air / atmosphere

(iii) acid rain

damages trees / plants or kills aquatic organisms or damages buildings / statues or causes respiratory problems
allow harmful to living things

(c) carbon / C
accept soot / particulates / charcoal

(d) any four from:

• (supports hypothesis) because when the fuel contained more carbon the temperature of the water went up more / faster (in 2 minutes)
• (does not support hypothesis as) temperature change per gram decreases as the number of carbons increases
• (does not support hypothesis) because the more carbon in the fuel the more smoke or the dirtier / sootier it is
• only tested hydrocarbons / alkanes / fuels with between 5 and 12 carbon atoms
• valid, justified, conclusion
accept converse statements

(e) (i) 0.15

correct answer with or without working gains 2 marks
if answer incorrect, M. carbon dioxide = 44 gains 1 mark
allow 0.236 / 0.24 / 0.2357142 (ecf from M, of 28) for 1 mark
(ii) \[ 0.4(0) \]

(iii) \( \text{C}_3\text{H}_8 \)

**Correct formula with or without working scores**: 2 marks

\[ \frac{0.15}{0.05} = 3 \]

*allow ecf from (e)(i)*

**and**

\[ \frac{0.4}{0.05} = 8 \]

*allow ecf from (e)(ii)*

*allow 1 mark for correct empirical formula from their values*

If use ‘fall-back-values:

\[ \frac{0.50}{0.05} = 10 \]

**and**

\[ \frac{0.20}{0.05} = 4 \]

*1 mark*

\( \text{C}_4\text{H}_{10} \)

*1 mark*

*if just find ratio of C to H using fall-back values, get C\(_3\)H\(_8\)*

*allow 1 mark*