1 **(a) (i)** insufficient/limited oxygen [1]
or $2C + O_2 \rightarrow 2CO$

coke/carbon reacts with carbon dioxide [1]
or $C + CO_2 \rightarrow 2CO$

(ii) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
species (1) balancing (1) [2]

(b) (i) carbon dioxide [1]

(ii) $CaO + SiO_2 \rightarrow CaSiO_3$ [2]
[1] each side correct

(iii) (molten) iron higher density (than slag) [2]

(iv) No oxygen in contact with iron **or** layer of slag prevents hot iron reacting with oxygen/air **or** (all) oxygen reacts with carbon (so no oxygen left to react with iron) [1]

(c) (i) air/oxygen and water (need both) [1]

(ii) aluminium oxide layer is impervious **or** non-porous **or** passive **or** unreactive **or** will not allow water/air to pass through it (rust allows passage of water **or** air **or** it flakes off) [1]

(d) zinc more reactive (than iron/steel) [1]
loses electrons [1]
electrons move (from zinc) to iron [1]
Zinc reacts (with air and water) **or** zinc corrodes **or** zinc is oxidised **or** zinc is anodic **or** zinc forms positive ions **or** zinc forms Zn^{2+} **or** iron and steel don't react with air/water **or** iron and steel are not oxidised **or** iron and steel do not form ions **or** iron and steel do not lose electrons **or** iron and steel are cathodic [1]

(ii) R to L in wire [1]

(iii) $2H^+ + 2e \rightarrow H_2$
species (1) balancing (1)

[Total: 19]

2 **(a** $Al^{3+} + 3e \rightarrow Al$ [2]
species (1) balancing (1)

(b) **(i)** $AlCl_3 + 3Na \rightarrow 3NaCl + Al$ [2]
species (1) balancing (1)

(ii) M1 electrolysis [1]

M2 molten sodium chloride [1]
or
M1 Add named more reactive metal (e.g. K)
M2 Molten sodium chloride

(c) **(i)** bauxite [1]

(ii) M1 aluminium oxide / amphoteric oxide dissolves OR iron(III) oxide / basic oxide does not [1]

M2 Filter **COND** on M1 [1]

(iii) Any **two** from:
Lowers (working) temperature or lowers mpt (of mixture)
increases conductivity
reduces cost OR energy need [2]

(iv) M1 = Any one correct equation.

M2 Oxygen mark
Oxygen comes from oxide ions
or $2O^{2} \rightarrow O_2 + 4e$

M3 Carbon dioxide mark
Anode reacts with oxygen / burns to form CO_2
or $C + O_2 \rightarrow CO_2$

M4 Carbon monoxide mark
Anode reacts with limited oxygen / incompletely burns to form carbon monoxide
or $2C + O_2 \rightarrow 2CO$
or CO_2 reacts with the anode to form carbon monoxide
or $CO_2 + C \rightarrow 2CO$

M5 Fluorine mark
Fluorine comes from cryolite or fluoride ions
or $2F \rightarrow F_2 + 2e$ [5]

(d) **(i)** Has an impervious **or** non-porous **or** passive **or** unreactive **or** protective oxide layer [1]

(ii) Any **two** from:
good conductor of heat
high melting point
Unreactive towards foods [2]

3 **(a** Rb loses 1 electron/1 electron in outer shell/1 valency or valence electron [1]

Sr loses 2 electrons/2 electrons in outer shell/2 valency or valence electrons [1]

(b) (i) (mix solutions of) rubidium carbonate/Rb_2CO_3 [1]

strontium chloride/$SrCl_2$ **or** strontium nitrate/$Sr(NO_3)_2$ **or** strontium sulfate/$SrSO_4$ **or** strontium hydroxide/$Sr(OH)_2$ [1]

COND (on two correct reactants) filter **or** centrifuge **or** decant (the residue) [1]

wash <u>with water</u> **and** dry/press between filter paper/put in (low) oven/put on a (sunny) windowsill/put in sun/heat [1]

(ii) $SrCO_3 \rightarrow SrO + CO_2$ [1]

(c) rubidium nitr**<u>ite</u>** or nitr**<u>ate(III)</u>** [1]

(ii) $2Sr(NO_3)_2 \rightarrow 2SrO + 4NO_2 + O_2$ [2]
Species (1) Balancing (1)

[Total: 10]

4 **(a** M1: (zinc sulfide) heated / roasted / burnt in **air** (1)

M2: zinc oxide formed (1)

M3: zinc oxide **reduced** (1)

M4: (by adding) coke or carbon (1)

M5: Balanced equation (any one of) (1) [5]

$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$
$2ZnO + C \rightarrow 2Zn + CO_2$
$ZnO + C \rightarrow Zn + CO$
$ZnO + CO \rightarrow Zn + CO_2$

(b) Any **two** from: [2]

- (making) brass **or** alloys (1)
- galvanising (1)
- sacrificial protection (1)
- batteries (1)

[Total: 7]

5 **(a) (i)** heat limestone / calcium carbonate (1)
fractional distillation (1)
liquid air (1) [3]

(ii) any **two** of the oxides, C, S, P and Si, mentioned (1)
carbon dioxide and sulfur dioxide escape / are gases (1)

phosphorus oxide **or** silicon(IV) oxide react with calcium oxide /
phosphorus oxide **or** silicon(IV) oxide are acidic and calcium oxide is basic (1)

to form a slag **or** calcium silicate **or** calcium phosphate (1)

must have correct equation for one of the above reactions (1) [5]

(b) lattice / rows / regular arrangement of cations / positive ions / Fe^{2+} (1)
mobile / free / delocalised / sea of electrons (1) [2]

(ii) the rows of ions / ions can move past each other (1)
without the metal breaking / bonds are not directional / not rigid (1) [2]

(iii) carbon particles / atoms different size (1)
prevents movement of rows, etc. (1) [2]

[Total: 14]