Question	Answer	Marks
1(a)(i)	red **and** (the Cu^{2+} ion / copper ions) is gaining electrons / is decreasing in oxidation number;	**1**
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
1(b)	replace (anode of) copper with nickel; replace electrolyte with nickel(II) sulfate / $NiSO_4$;	**2** 1 1
1(c)	(good) catalysts; variable oxidation numbers; form coloured compounds / coloured ions;	**3** 1 1 1

Question	Answer	Marks	Guidance
2(a)(i)	Al^{3+} + 3e $\rightarrow$ Al formula of Al^{3+} ion; rest correct;	**2**	multiples **I** state symbols **A** – 3e on right

Question	Answer	Marks	Guidance
2(a)(ii)	^{2} → O_2 + 4e species; balancing;	**2**	multiples **I** state symbols **A** – 4e on left
2(a)(iii)	end **AND** (electrical) energy supplied;	**1**	**A** energy required to break bonds
2b)(i)	exot **AND** (electrical) energy release;	**1**	heat energy
2(b)(ii)	magnesium forms ions (in solution) **OR** magnesium loses electrons **OR** magnesium is oxidised; copper is deposited (on the electrode) **OR** copper ions become copper atoms **OR** copper ions gain electrons **OR** copper ions are reduced;	**2**	**A** magnesium dissolves / goes into solution **A** equation (balanced or unbalanced) **A** equation (balanced or unbalanced) **I** use of terms anode or cathode
2(b)(iii)	M1 set up a magnesium / manganese cell; M2 the negative electrode (is the more reactive) **OR** the electrode that loses mass (is more reactive); **OR** M1 replace magnesium with manganese; M2 if voltage less (positive) manganese is less reactive **OR** if voltage is more (positive) manganese is more reactive;	**2**	**A** replace Cu with Mn **A** converse
2(c)	$_{3}H_8$ + $5O_2$ → $3CO_2$ + $4H_2O$ species; balancing;	**2**	**A** multiples **I** state symbols
2(d)(i)	(light from the) sun / sunlight;	**1**	**A** uv
2(d)(ii)	carbon dioxide + water → glucose + oxygen;	**1**	starch / sugar / (named)carbohydrate **I** energy or light on LHS

3 **(a** M1 brass [1]

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

(b) (i) $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ [2]
species (1) balancing (1)

(ii) Manufacture of sulfuric acid
or bleach or making wood pulp or making paper
or food or fruit juice or wine preservative
or fumigant or sterilising [1]

(c) (i) sulfuric acid [1]

3 **(c (ii)** $Zn^{2+} + 2e \rightarrow Zn$ [1]

oxygen or water Allow O_2 and H_2O if no name seen [1]

sulfuric acid [1]
Allow: H_2SO_4 if no name seen

3 **(d) (i)** from zinc to carbon
(clockwise direction on or near the wire) [1]

(ii) to allow ions to flow [1]

(iii) oxidation
and loss of electron(s) or increase in oxidation number/state [1]

reduction
and decrease in oxidation number/state or gain of electron(s) [1]

[Total: 13]

4 **(a** carbon dioxide/CO_2 [1]

(b) $2H_2 + O_2 \rightarrow 2H_2O$ [1

(c) anode/negative electrode **and** electrons lost(by hydrogen/H/H_2)/electrons move from this electrode [1]

(ii) $H_2 \rightarrow 2H^+ + 2e(\ ) / H_2 - 2e(\ ) \rightarrow 2H^+$ **/** $H_2 + 2OH \rightarrow 2H_2O + 2e(\ ) / H_2 + 2OH - 2e(\ ) \rightarrow 2H_2O$ [2]
Species (1) Balancing (1)

(d) Any **two** from:

CELL:	lightweight
	quieter
	fewer working parts/less maintenance
	more efficient **or** less energy wasted **or** more energy produced
SUSTAINABILITY:	conserves a limited resource/petroleum/fossil fuels
	unlimited supplies of renewable resource(of hydrogen from water)
POLLUTION:	No or less greenhouse effect
	No or less acid rain
	No or less toxic gases
	No or less smog
POLLUTANTS:	No or less C/soot
	No or less CO_2
	No or less CO
	No or less SO_2
	No or less oxides of nitrogen/NO/NO_2/N_2O_4/NO_x
	No or less (unburnt) hydrocarbons
	No or less low level ozone
	H_2O is the **only** product

[Total: 7]

5 (a (i) incomplete combustion **or** limited oxygen / less oxygen / not enough oxygen (1) [1]

(ii) any **two** from:

(forward) reaction is endothermic (1)

high temperature increases yield / favours forward reaction / shifts equilibrium to right (1)

faster reaction (rate) (1) [2]

(iii) any **two** from:

high pressure reduces yield **or** favours LHS (1)

because LHS has smaller volume **or** number of moles / number of molecules (of gas) ORA (1)

(high pressure plant is) expensive / dangerous / explosion / leaks [2]

5 (b hydrogen **and** chlorine / H_2 **and** Cl_2 (1)

sodium hydroxide / NaOH / Na^+OH (1)

$2H^+ + 2e \rightarrow H_2$ / $2H^+ \rightarrow H_2 - 2e$ (1)

$2Cl \rightarrow Cl_2 + 2e$ / $2Cl - 2e \rightarrow Cl_2$ (1)

Hydrogen / H_2 / H / H^+ at cathode **and** chlorine / chloride / Cl_2 / Cl / Cl at anode (1) [5]

5 (c <u>each</u> chlorine 1 bond pair and 3 non-bond pair (1)

oxygen atom 2 non-bond pairs and 2 bond pairs as double bond (1)

carbon atom 4 bond pairs including 2 bond pairs as double bond (1) [3]

[Total: 13]

6 **(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) 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]