1 **(a** rates equal; [1]
concentrations do not change / macroscopic properties remain constant; [1]

(b) endothermic **and** because this direction is favoured by high temperatures; [1]
note: reason is required

(c) (i) move to left hand side / reactants favoured **and** because bigger volume / more moles on left hand side [1]
note: reason is required

(ii) less (yellow) solid / more (dark brown) liquid / green gas visible / turns darker brown / smell chlorine [1]
allow: ecf from **(c)(i)**

(d) (bond breaking =) 151 + 242 = 393; [1]
(bond making =) 208 × 2 = –416; not: 416 [1]
(overall =) 393 – 416 = –23; allow: ecf [1]
note: sign must be given

(e) Any two from:
diagram shows exothermic reaction;
activation energy shown;
reactants and products labelled / both axes labelled;
note: labelling is one mark only
allow: ecf from **(d)** [2]

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

Question	Answer	Marks	Guidance
(a)(ii)	^{2} → O_2 + 4e species; balancing;	**2**	multiples **I** state symbols **A** – 4e on left
(a)(iii)	end **AND** (electrical) energy supplied;	**1**	**A** energy required to break bonds
(b)(i)	exot **AND** (electrical) energy release;	**1**	heat energy
(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

(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
(c)	$_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ species; balancing;	**2**	**A** multiples **I** state symbols
(d)(i)	(light from the) sun / sunlight;	**1**	**A** uv
(d)(ii)	carbon dioxide + water → glucose + oxygen;	**1**	starch / sugar / (named)carbohydrate **I** energy or light on LHS

3 **(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]

4 **(a) (i)**

aqueous solution	lead Pb	magnesium Mg	zinc Zn	silver Ag
lead (II) nitrate		✓	✓	✗
magnesium nitrate	✗		✗	✗
zinc nitrate	✗	✓		✗
silver(I) nitrate	✓	✓	✓	

each horizontal line correct (1) [3]

(ii) Zn (1)

An arrow **from** Zn **to** Zn^{2+} (1) [2]

(iii) $Zn + 2Ag^{+} \rightarrow Zn^{2+} + 2Ag$ (1) [1]

(b) correct direction from zinc to lead (1) [1]

(ii) metals react by **losing electrons** (1)

the more reactive metal / zinc will lose electrons more readily (making the electrode negatively charged). (1) [2]

(iii) manganese **and** zinc are more reactive than lead (and / or copper) (1)

lead is more reactive than copper (1) [2]

(iv) the **polarity** of a Mn / Zn (cell)
or the **voltages** of Zn / Pb **and** Mn / Pb (cells) (1) [1]

[Total: 12]

5 **(a) (i)** the (forward) reaction is endothermic [1]

(ii) none [1]
volume of reactants and products the same [1]
ACCEPT: number of moles or molecules

(iii) the reaction (between oxygen and nitric oxide) is <u>exothermic</u> [1]
high temperatures push equilibrium to left / high temperatures decrease yield of products / low temperatures favour forward reaction [1]

(iv) $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ [2]
not balanced = (1) only

(v) (cost of) high amount of electricity / energy [1]

(b) (i) contains more nitrogen [1]

(ii) photosynthesis
chlorophyll is catalyst / chlorophyll absorbs light [1]
carbon dioxide and water react [1]
to make glucose / carbohydrates / starch / sugar / named sugar [1]

[Total: 13]

6 **(a)** (making) fertilisers / nitric acid / nylon / refrigeration / explosives / cleaning products; [1]

(b) alkane / named alkane; [1]
water / steam; [1]
heat / catalyst; [1]

or electrolysis; [1]
suggest suitable electrolyte; (**allow:** water) [1]
hydrogen at cathode; [1]

or cracking; [1]
alkane / named alkane; [1]
heat or catalyst [1]

(c) any five from:
faster; (rate) [1]

more collisions / molecules closer together / more particles per unit volume; [1]

(collisions) more frequent / more often / more chance / more effective or successful collisions / more collisions with Ea / increase rate of collisions; [1]

higher yield / moves (equilibrium) to RHS / more ammonia / to side of products / high pressure favours the reaction with less moles; [1]

less moles / molecules / volume on RHS ORA (can be implied in previous comments) [1]

high pressure means lower temperature can be used to achieve comparable rate (thus saving energy); [1]

7 **(d)** **(i)** endothermic takes in / absorbs / uses / needs / gains energy / heat **and** exothermic gives out / loses energy / heat; [1]

(ii) 2328 (ignore + or –) / 6 × 388 (not evaluated); [1]

944 + 1308 / 2252 **and** endothermic and exothermic in table; [1]

2328>2252 or (–) 76 kJ;

or energy of products / RHS > reactants / LHS
or energy needed to break bonds < energy given out on formation of bonds.

[Total: 13]