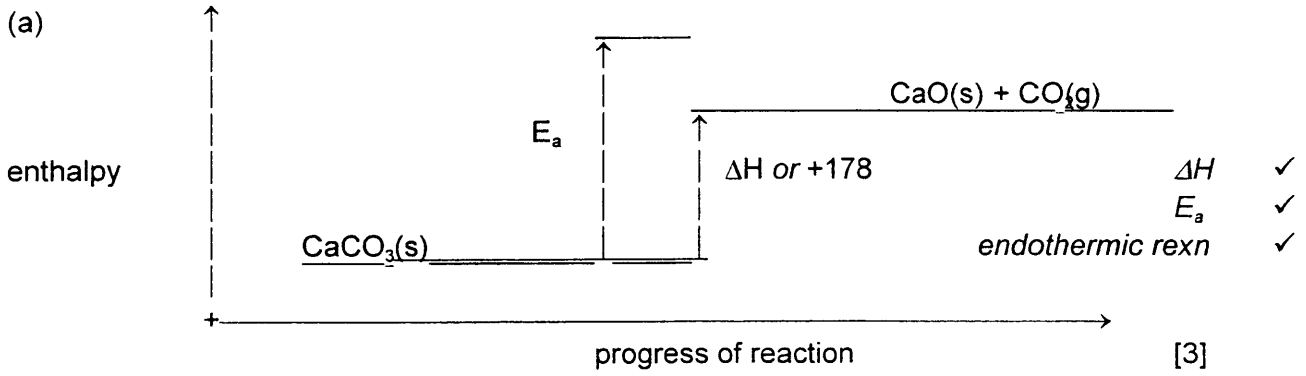
1 (a) $E = -(31.9-18.0) \times 4.18 \times 100$ ✓
$E = (-)5810$ J ✓ ~~[3]~~ [2]
(allow 2905 for [1] mark, also allow 5.81 **J** for [1])

(b) $2.0 \times 50/1000 =$ **0.1 moles** ✓ [1]

(c) $-5810/(0.1 \times 1000) =$ **-58.1 kJ mol^{-1}** ✓(sign, u/c) ✓ecf ~~[1]~~ [2]
(allow ecf for (ans to (a))/(ans to (b) x 1000), allow sign mark even if value is wrong)

Total: **5**

2 (a)



ΔH ✓
E_a ✓
endothermic rexn ✓
[3]

(marks for E_a and ΔH are for label + arrow. Allow double-headed arrows *or* lines. Last mark is for products being higher than reactants. If arrow is single-headed its direction must be consistent with height of products (i.e .in the exo or endothermic direction))

(b) (high T) speeds up reaction *or* (gives energy to) overcome activation energy ✓
or provides energy to break bonds *or* reaction has a big E_a.
and (gives the energy needed to carry out the) **endothermic** reaction ✓
or reaction takes in heat
[2]

(c) $\Delta H = 82 - 178 = -96$ kJ mol^{-1} ✓(sign) ✓ [2]
(allow [1] only for +96 *or* 96 *or* ±260, sign mark is conditional on 96 being correct)

Total: **7**

3 (a) (i) reaction 3.1: 413 - 432 = **-19** (kJ mol^{-1}) ✓
reaction 3.2: 243 - 327 = **-84** (kJ mol^{-1}) ✓ [2]
(if both signs are wrong, i.e. +19 and +84, penalise once only, and award [1])

(ii) reaction 3.2 is faster, because weaker bonds are being broken *or* lower likely E_{act} *or* less energy needed ✓ [1]

(b) for reaction 3.3: a comparison of E(C-Cl) with *either* E(C-H) *or* E(H-Cl) *or* a calculation, e.g. ΔH = 413 - 327 = +86 ✓ [1]
(the reaction is) is too endothermic (to take place) *or* it has a highly positive ΔH ✓ [1]
or too high an E_a *or* too much energy is needed
Total: **5**

4 (a) C_8H_{18} + **12.5** O_2 ⟶ **8** CO_2 + **9** H_2O (*or* doubled) ✓ [1]

(b) (i) + (ii) ✓✓✓✓[4]

fuel	ΔH_c per mole of alkane burned (kJ mol^{-1})	ΔH_c per mole of CO_2 produced (kJ)	moles of CO_2 produced per kJ of heat given out
methane	-890	***-890***	***1.1 – 1.15 x 10^{-3}*** **(a)** ecf
octane	-5479	***-684** to **-685*** ecf from incorrectly balanced equation	***1.4 – 1.5 x 10^{-3}*** **(b)** ecf (needs a calc. - not just a ratio)

(iii) ratio (= 1.124/1.462) = 0.7 – 0.8 ✓ecf, i.e. any **(a)/(b)** [1]
(allow a whole number fraction)

(c) (i) unburned h/c low-level ozone *or* smog *or* greenhouse gas *or* carcinogenic
NOT ozone depletion, smoke, pollution, sootiness etc
CO poisonous/toxic (to animals - ignore refs to trees etc) *or* reacts with haemoglobin
(mention of greenhouse gas *or* acid rain *or* ozone depletion **negates** any valid CO effect mentioned)
NO smog *or* acid rain *or* bad for lungs *or* causes respiratory problems *or* irritant NOT poisonous. (Ignore ozone depletion) ✓✓✓ [3]

(ii) from the combination of N_2 and O_2 (from the air) (or equation) ✓ [1]

(iii) NO + CO ⟶ ½N_2 + CO_2 (*or* double) ✓ [1]

(iv) Pt *or* Pd *or* Rh *or* all (any other metal negates the mark) ✓ [1]

(v) in a different phase/state (to the reactants) *or* a solid reacting with gases ✓ [1]

(vi) rate of reaction is increased the hotter it is *or* more molecules with E > E_a *or* more energy available to break bonds *or* more energy available to overcome activation (barrier) *or* increased collision rate ✓ [1]
Total: **14**

5 (a) pressure increases the rate of reaction ✓
because the molecules are pushed closer together *or* become more concentrated *or* collide more often *or* more collisions
(NOT because they are travelling faster *or* have more energy – mention of either of these **negates** any correct comment) ✓ [2]

(b) (i) (increasing T will) increase yield *or* drive equilibrium over to right ✓
or favour the forward reaction
because it's an endothermic reaction *or* ΔH is positive ✓ [2]

(ii) (increasing P will) decrease yield *or* drive equilibrium over to left ✓
or favour the backward reaction
because there are more (gas) moles on the right than the left. ✓ [2]

(c) *either* each reaction requires different conditions of temperature *or* pressure
or the reaction use different catalysts (N.B. not just unspecified "different conditions")✓ [1]

Total: **7**

6 acid = contains H^+ *or* proton donor *or* $\rightarrow H^+$ in an equation *or* an electron **pair** acceptor ✓

4 main reactions: HCl(aq) + metal (from Ca to Fe in reactivity)
HCl(aq) + (insoluble) metal oxide
HCl(aq) + soluble metal hydroxide *or* ammonia
HCl(aq) + carbonate (any one - allow hydrogencarbonate too)
also allow: HCl(aq) + an alcohol + $ZnCl_2$, giving a chloroalkane

an example of each to include the name or correct formula of reactant (can be read into an equation) ***and*** a description of the observation ✓✓✓
[if none of these 3 marks has been awarded there are 2 ways in which a **salvage mark** may be given for stating 3 correct reagents but no observations ***or*** for stating the 3 general (word) equations for acid reactions]

observations: ***metal*** dissolves *or* H_2 evolved *or* gas evolved/produced/formed *or* fizzes
(in words, not to be read from $H_2(g)$ in the equation)
carbonate dissolves *or* CO_2 evolved *or* gas evolved *or* fizzes
(in words, not to be read from $CO_2(g)$ in the equation)
metal oxide dissolves
soluble hydroxide heats up *or* changes the colour of an indicator
(for any metal that gives coloured salts, allow the correct colour of the solution as an observation)
also allow: solution (of alcohol) turns cloudy

balanced chemical equations (any two from the five reaction types above)✓✓
[for reactive metals, e.g. Na, allow [1] for balanced equation, but not the observation mark]

ionic equations (any two) [these must not include any spectator ions] ✓✓
[8] max [6]

QWC (two informative sentences) ✓ [1]

Total: **7**