

- 1(a) any two from
 produces heat/ exothermic/ produces high temperature (1)
 has low toxicity (1)
 is easily ignited/ easily flammable/ burns easily (1) [2]
- (b)(i) reaction carried out at 298K and 1 atm pressure (or other relevant units) (1) [1]
- (ii) enthalpy change when 1 mole (1)
 (of substance) is burnt in excess oxygen (1) [2]
- (iii) $4\text{CO}_2 + 5\text{H}_2\text{O}$ at lower energy than reagents (1)
 E_a marked correctly (1)
 ΔH marked correctly (1) [3]
- (c)(i) $4\text{C}(\text{s}) + 5\text{H}_2(\text{g}) \rightarrow \text{C}_4\text{H}_{10}(\text{g})$
 reagents and products (1)
 state symbols (1) [2]
- (ii)
- $$4\text{C} + 5\overset{\text{x}}{\text{H}_2} \rightarrow \text{C}_4\text{H}_{10}$$
- $$4(-394) \quad 5(-286) \quad -2877$$
- $$4\text{CO}_2 \quad 5\text{H}_2\text{O}$$
- cycle (1)
 correct values (1)
 answer (1)
 $X - 2877 = 4(-394) + 5(-286)$
 $X = -129 \text{ (kJ mol}^{-1}\text{)}$ [3]

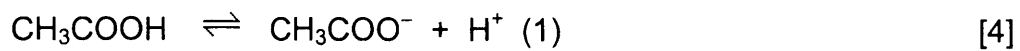
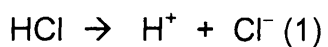
[Total: 13]

- 2(a) if the **conditions** on a system in **equilibrium** are changed (1)
the equilibrium moves to try to minimise the effects of the change (1) [2]
- (b)(i) time less (1)
 E_a lowered (1) [2]
- (ii) time less (1)
more collisions/ particles **exceed** E_a (1) [2]
- (iii) time more (1)
particles are **further apart** and therefore less (frequent) collisions (1) [2]
- (c)(i) no effect because it only increases rate of reaction (1) [1]
- (ii) moves to LHS/ more N_2 and H_2 / less NH_3 (1)
forward reaction is exothermic (1) [2]
- (iii) moves to LHS / more N_2 and H_2 / less NH_3 (1)
fewer moles on RHS (1) [2]
- (d) temperature is compromise – high gives better rate but lower yield (1)
danger/costs of higher pressure not justified by increased rate/ by increased yield / 200 atm gives a high rate and a high yield (1) [2]

[Total: 15]

3(a) acids are proton/ H⁺ **donors** (1)

a strong acid is completely dissociated but a weak acid is partly dissociated (1)



(b)(i) hydrogen/ H₂ (1) [1]

(ii) marks are for reason

(to produce hydrogen at the same rate), each acid must have the same concentration of H⁺ (1)

the ethanoic acid was more **concentrated** (1) [2]

[Total: 7]

- 4(a)(i) $C_8H_{18} + 12\frac{1}{2}O_2 \rightarrow 8CO_2 + 9H_2O$
reagents and products (1)
balancing (1) [2]
- (ii) from nitrogen in air and oxygen (1) [1]
- (b)(i) any two from Pt/ Rh/ Pd [1]
- (ii) adsorbed (1)
bonds within molecule weakened (1)
desorbed/ description (1) [3]
- (iii) $CO + NO \rightarrow \frac{1}{2}N_2 + CO_2$
reagents and products (1)
balancing (1) [2]
- (c) ozone/ NO_2 / nitric acid (1) [1]
- [Total: 10]