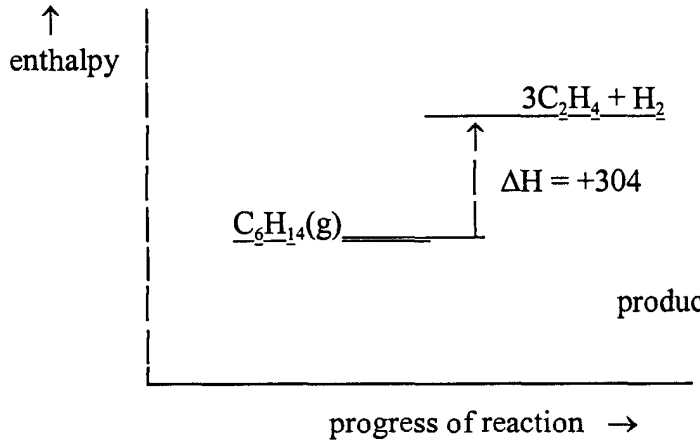
1 (a) (i) the energy required to <u>break</u> ✓
<u>1 mole</u> of bonds ✓ [2]

(ii) bonds broken: 5x (C-C) + 14 x (C-H) = 1750 + 5740 = 7490 ✓
bonds formed: 3 x (C=C) + 12 x (C-H) + (H-H) = 1830 + 4920 + 436 = 7186 ✓

ΔH = (+)304 kJ mol^{-1} ✓ [3]

(b)



labels ✓
products higher than reactant (ecf from a(ii)) ✓
ΔH shown (or value) (ecf) ✓ [3]

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2 (a) ΔH°_r = $4 \times 90 + 6 \times (-242) - 4 \times (-)46$

= -908 kJ mol^{-1}

✓✓✓ [3]

(b) (i) a change in conditions *or* a disturbance will cause a shift in the (position of) equilibrium ✓
in the direction that minimises/opposes/reduces/attempts to balance out/compensates for [NOT cancels out] the effect of the change ✓ [2]

(ii) the equilibrium will move to the left hand side ✓
because there are fewer moles (of gas on that side) ✓ [2]

(c) (i) (heterogeneous) catalyst *or* to speed up the reaction *or* to increase surface area ✓ [1]

(ii) to allow time for the (slow) reaction to take place (on the surface)
or to allow adsorption to take place ✓ [1]

(d) $4NO + 2H_2O + 3O_2 \longrightarrow 4HNO_3$ balancing of oxygen ✓
balancing of C and H ✓ [2]

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3 (a) *any 2 of:*

- forward rate = reverse rate (***not** concentration of reactants and products are equal)*
- can be approached from either direction *or* reversible reaction *or* (constant) change from reactants to products and vice versa
- no change in overall macroscopic properties (*or* one specified property, e.g. colour/concentration) *or* appears to have stopped
- takes place in a closed system

✓✓ [2]

(b) (i) (orange means that the solution has become weakly) **acidic** ✓

adding $CO_2(g)$ pushes each of the above equilibria to the right hand side *or* forms more products ✓ [2]

(ii) (conc sulphuric acid provides) $H^+(aq)$ ions ✓

(adding $H^+(aq)$ pushes the) equilibria/reactions over to the left hand side *or* favours the reverse reaction ✓ [2]

6

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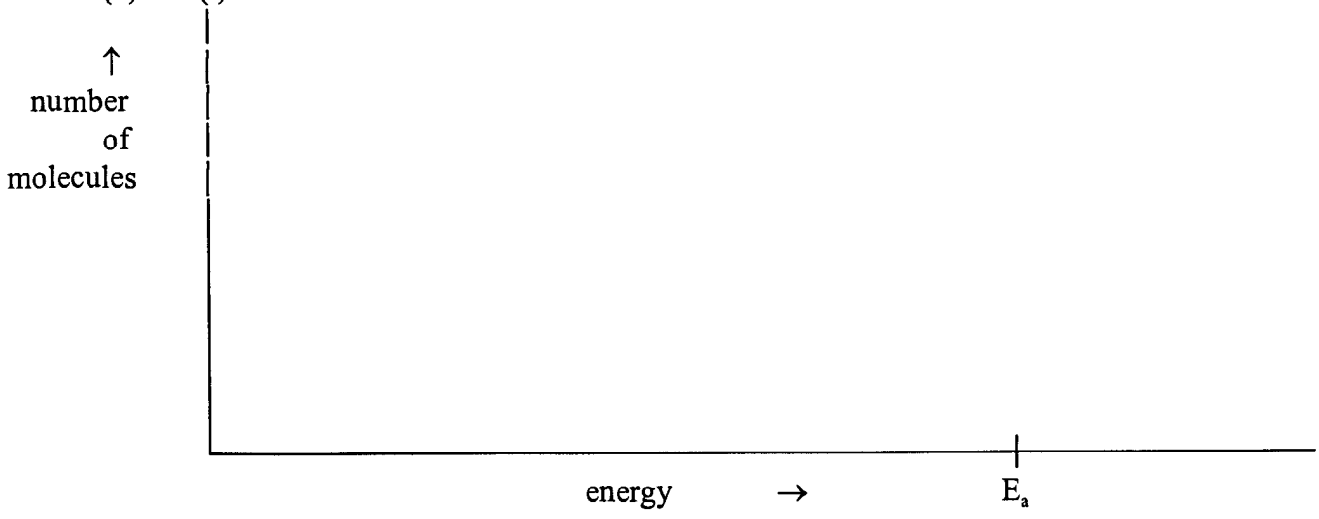
4 (a) more molecules of the reagent in the same space *or* molecules closer together ✓

leading to more chance of *or* greater frequency/rate of collisions ✓ [2]

(b) (i)



maximum at higher E ✓

at lower peak height ✓ [2]

(check that the line is NOT steeper at the start, or turned up at the end, and that it crosses the original line to the right of the maximum)

(ii) higher proportion of/more molecules have $E > E_a$ at T_2 ✓

therefore more collisions are effective/successful OWTTE ✓ [2]

6

5 (a) (i) effervescence/fizzing/gas evolved ✓ [1]

(ii) $H_2SO_4 + Na_2CO_3 \longrightarrow Na_2SO_4 + H_2O + CO_2$

Na_2SO_4 ✓

$H_2O + CO_2$ ✓ [2]

(b) (i) ammonia is a base/alkali/proton acceptor/electron pair donor ✓ [1]

(ii) $(NH_4)_2SO_4 = 2 \times (14 + 4) + 32 + 4 \times 16 = 132$ ✓

$\%N = 100 \times 28/132$

$= 21.2\%$ ✓ [2]

(iii) as a fertiliser ✓ [1]

7

6

- process **A** is photosynthesis. [1]
- process **B** is respiration *or* the burning/combustion of food [1]
- process **C** is combustion *or* the/burning of fuels [1]

- process **A** occurs in plants [1]
- process **B** occurs in animals [1]
- process **C** occurs in cars etc [1]

- process **A** is endothermic; process **B** and process **C** are exothermic ([2]for all three correct, [1] for two correct, [0] for only one correct) [2]

- the energy of sunlight is 'captured' in photosynthesis/process **A** (OWTTE) [1]

9 max 7