1. (a) Activation energy;-
The minimum energy needed for a reaction to occur / start **(1)**

1

(b) Catalyst effect:-
Alternative route (or more molecules have Ea) **(1)**
Lower activation energy **(1)**

2

(c) Increase in moles of gas:-
Position of E_{mp} unchanged **(1)**
More molecules with E_{mp} **(1)**
Area under curve increases **(1)**
Molecules with $E \geq E_a$ increased **(1)**
Temperature decreased:-
Position of E_{mp} moves to the left **(1)**
More molecules with E_{mp} **(1)**
Area under curve unchanged **(1)**
Molecules with $E \geq E_a$ decreased **(1)**
Catalyst introduced:-
Position of E_{mp} unchanged **(1)**
Molecules with E_{mp} unchanged **(1)**
Area under curve unchanged **(1)**
Molecules with $E \geq E_a$ increased **(1)**

12

[15]

2. (a) <u>minimum</u> energy **(1)**
required before a reaction can occur or go or start **(1)**

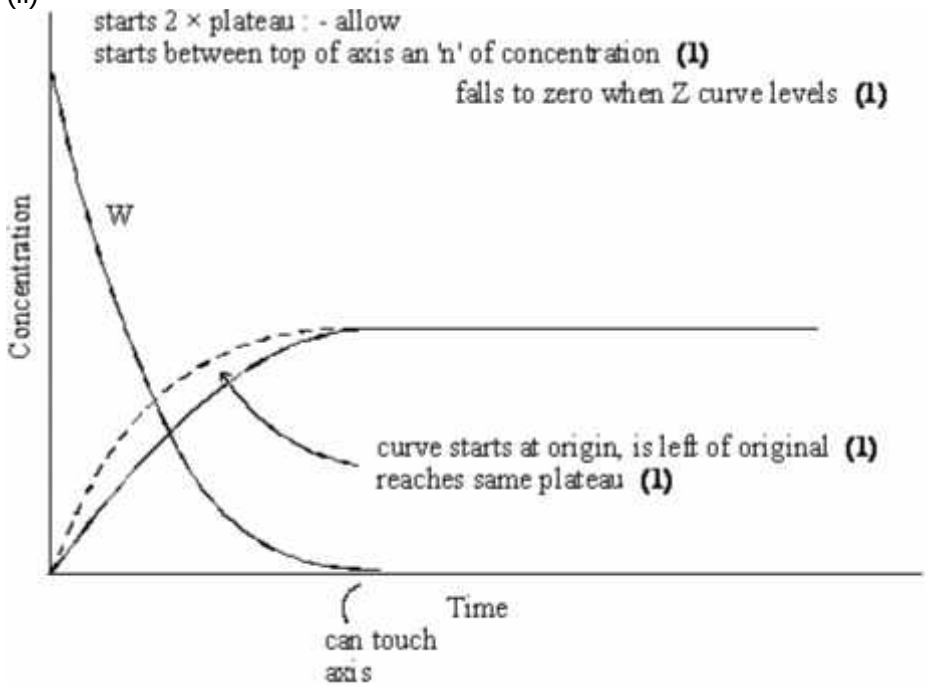
2

(b) speeds up (changes) reaction rate **(1)**
without being (chemically) changed **(used up) (1)**

2

(c) (i)

(ii)

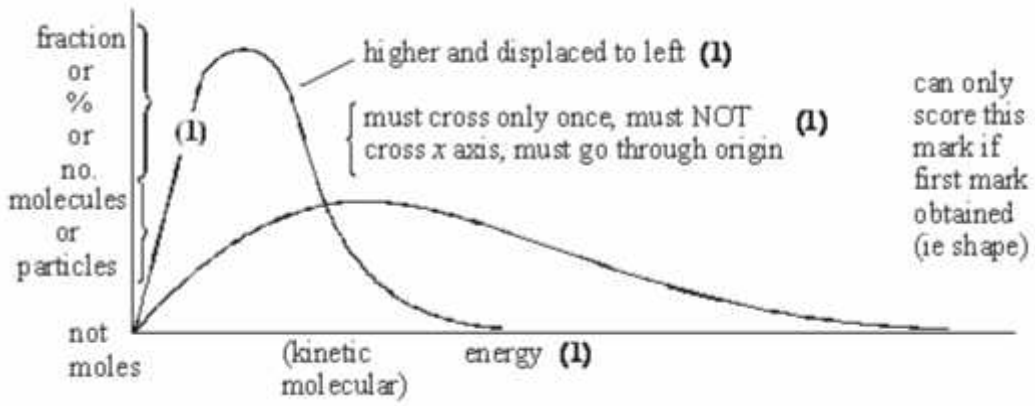


(iii) fewer collisions **(1)**
W used up **(1)**
or reactants
or reagents
or fewer particles

6

[10]

3. (a)



2

(b) See above

2

(c) Energy < E_a or must have enough energy (to react) **(1)**

1

(d) Increase concentration (or pressure) **(1)**

1

(e) Many **(1)** more molecules have E > E_a / enough energy **(1)**

NOT KE increases with T

2

[10]

4. (a) Stoppered flask or similar with side arm

Allow gas outlet through stopper.

1

Calibrated container for collection eg gas syringe

Allow collection over water but must use calibrated vessel for collection.

Lose 1 mark if apparatus is not gas tight.

1

(b) Plot a graph of 'volume (of gas)' against 'time'

1

Determine the slope (gradient) at the beginning

1

(c) Repeat with same volume **or** concentration of hydrogen peroxide and at the same temperature

Ignore references to results.

Do not allow 'keep everything the same' or words to that effect. Must mention volume or concentration and temperature.

1

Add cobalt(II) chloride to one experiment

1

[6]

5. (a) (i) C + 3D → 2A + B

1

(ii) $mol^{-1}\ dm^3$ **1**

(iii) (forward reaction is) exothermic or more products formed **1**

(b) (i) for N_2O_4 M_r = 92.0 **1**

$\frac{36.8}{92.0} = 0.400$

Mol = **1**

(ii) mol N_2O_4 reacted = 0.400 – 0.180 = 0.220 **1**

mol NO_2 formed = 0.440 **1**

(iii) $K_c = \frac{(NO_2)^2}{(N_2O_4)}$ **1**

$= \frac{(0.44/16)^2}{(0.18/16)}$ **1**

= 0.067 **1**

(iv) move to NO_2/ to right / forwards **1**

none **1**

[12]

6. (a) (i) Increase (if wrong no further marks in part (i)) **1**

higher *P* gives lower yield or moves to left **1**

Eqm shifts to reduce *P* or eqm favours side with fewer moles **1**

(ii) Endothermic if wrong no further marks in part (ii) **1**

increase *T* increases yield or moves to right **1**

Eqm shifts to reduce *T* or eqm favours endothermic direction **1**

(b) (i) Moles of iodine = 0.023

If wrong no marks in (i)

1

Moles of HI = 0.172

1

If × 2 missed, max 1 in part (iv)

$$\frac{[H_2][I_2]}{[HI]^2}$$

(ii) K_c =

must be square brackets (penalise once in paper)
– if round, penalise but mark on in (iv)
if K_c wrong, no marks in (iv) either but mark on from a minor slip in formula

1

(iii) V cancels in K_c expression

or no moles same on top and bottom of expression
or total moles reactants = moles products, i.e. total no of moles does not change

1

$$\frac{(0.023)^2}{(0.172)^2}$$

(iv) K_c =

Conseq on (i)

1

= 0.0179 or 1.79×10^{-2}

Allow 0.018 or 1.8×10^{-2}

1

(v) K_c = 55.9 or 56

Conseq i.e. (answer to (iv))$^{-1}$

1

[13]

7. (a) Rate forward reaction = rate backward reaction (1)

Concentrations of reactants and products are constant (1)

2

(b) System opposes change (1)

Moves to the side with fewer moles (1)

In this case NH_3 (2 moles) on right side < N_2 + H_2 together (4 moles) on left side of equation (1)

3

(c) Too expensive to generate etc (1)

1

(d) (i) Yield of ammonia increases (1)

Exothermic reaction favoured (1)

System moves to raise temp / or oppose decrease in temp (1)

3

(ii) Faster reaction (1)

1

(iii) Balance between rate and yield (1)

1

[11]

8. C

[1]

9. B

[1]

10. B

[1]

11. D

[1]

12. A

[1]