M1. (a) the minimum energy;

1

Energy required for a reaction to occur;

(or to start a reaction or for successful collisions)

1

(b) axes labelled:- y: number *(or fraction or %)* of molecules *(or particles)* x: energy *(or KE);*

1

curve starts at origin;

1

skewed to right;

1

approaches x axis as an asymptote;

(penalise a curve that levels off > 10% of max peak height or a curve that crosses the energy axis)

1

second curve displaced to the left (and does not cross T_1 curve for a second time)

1

and peak higher;

1

many fewer molecules;

1

fewer molecules have $E > E_a$;

(can score this mark from suitably marked curves)

1

(c) molecules *(or particles or collisions)* do not have enough energy;

(or orientation may be wrong)

1

increase the pressure;

1

(or increase the concentration or reduce the volume) increases the collision frequency;

(or more collisions)
(do not allow if stated to be due to increase in energy implied by temperature increase)

1

add a catalyst;

1

lowers activation energy (or E_a) *(Q of L mark);*

1

[15]

M2. (a) Graph starts at origin

1

Graph skewed to left and has decreasing gradient to maximum

1

Graph after maximum decreases in steepness, never touches *x* axis, levels out less than 5 mm from *x* axis.

1

(b) Minimum energy

1

To start a reaction (*or for a reaction to occur*)

1

(c) Molecules gain energy (*or always some molecules have* $E > E_a$)

1

Due to collisions

1

(d) Decreases

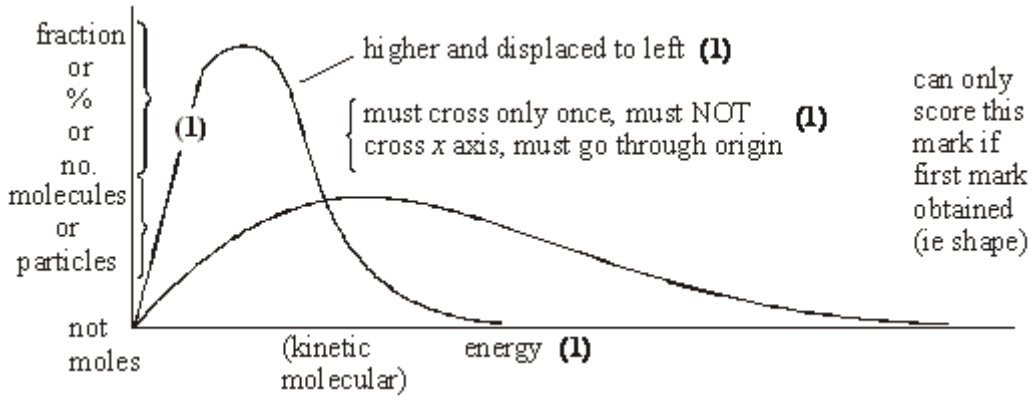
1

E_a lowered **(1)**
By alternative route **(1)**
So more molecules have energy > E_a **(1)**

max 2

[10]

M3. (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

(f) Lowers E_a **(1)**
alternative route **(1)**

2

[10]

M4. D

[1]

M5. (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)**

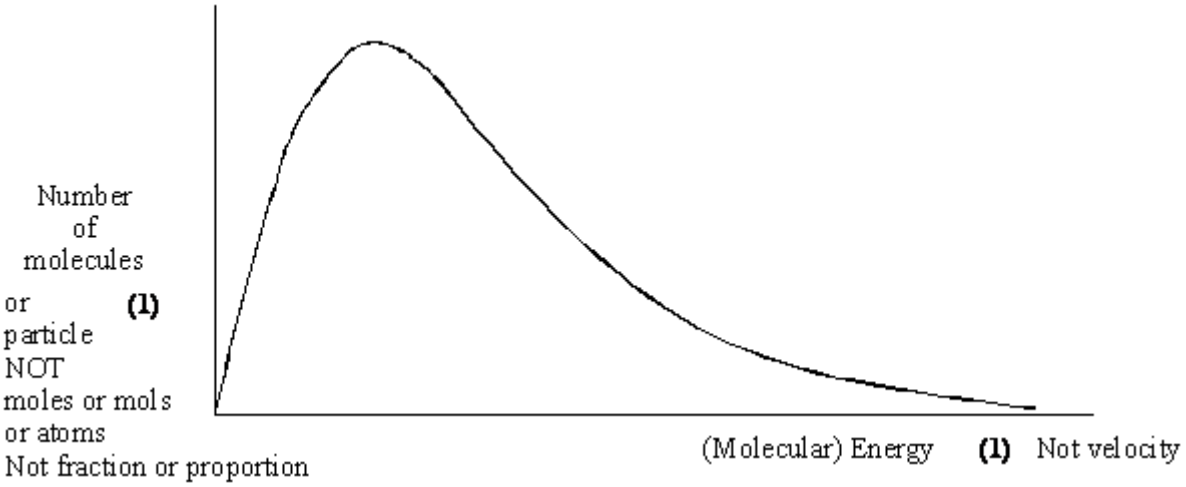
2

(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]

M6. (a) (i)



(ii) The total number of particles (or molecules) in the sample

OR the number of molecules present

(iii) No molecules have no energy

OR all molecules have some energy

Do not allow "if there are no molecules there is no energy"

4

(b) (i) The minimum energy required **(1)**

for a reaction to occur **(1)**

OR to start reaction or for a successful collision

(ii) Changes: Catalyst **(1)**

Explanation: Alternative route **(1),** with a lower activation energy **(1)**

OR a lower activation energy (1)
so more molecules can react (1)/more molecules have this energy

If change incorrect CE = 0

Allow answers anywhere in b (ii)

5

[9]