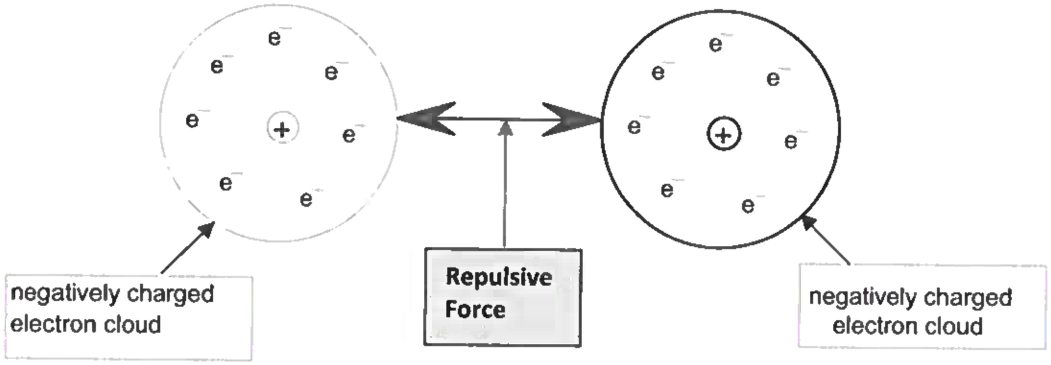
Name: Date:

Chemistry 12 – Lesson 6 - Activation energies

Potential and Kinetic energy during a collision



As colliding molecules approach the repulsion **slows** them down so **kinetic energy** decreases.
As they push against the **repulsive** force **potential energy** increases.

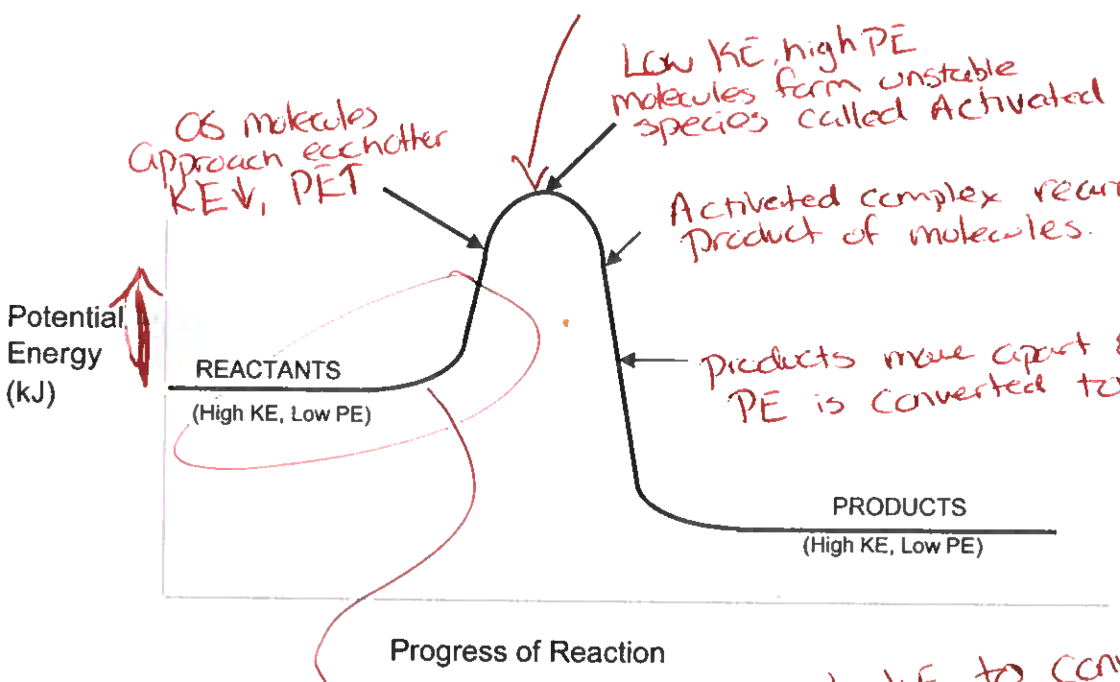
so: **Kinetic Energy** $\xrightarrow{\text{is converted to}}$ **Potential Energy**

KE + PE = Total E ← stays constant

If KE↓, PE↑
If KE↑, PE↓

Potential Energy Diagrams

Activation energy



Low KE, high PE molecules form unstable species called Activated complex

as molecules approach eachother KE↓, PE↑

Activated complex rearranges to form product of molecules.

products move apart & speed up. PE is converted to KE

reactants without enough KE to convert to PE never make it ~~to~~ up "the wall"

ACTIVATION ENERGY (E_a)

- The minimum energy required for a successful collision. (or)

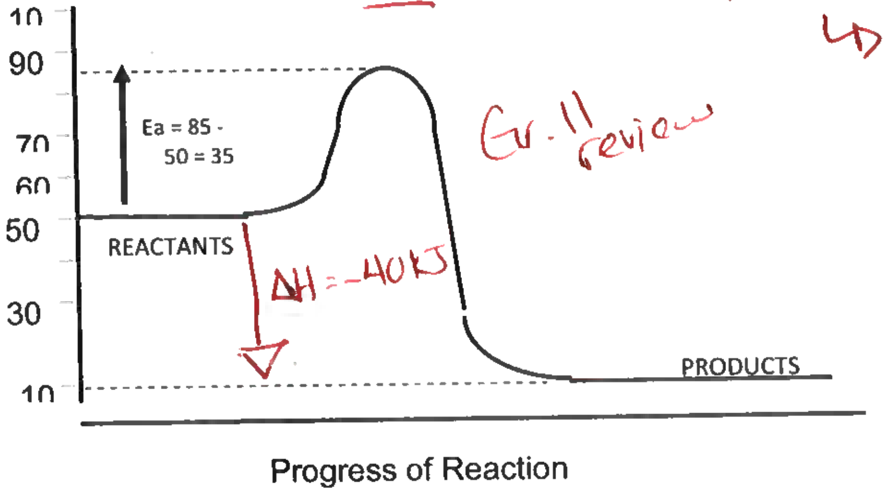
The minimum energy reacting molecules must have in order to form the activated complex.

The **Activated Complex** can be defined as a very unstable, short-lived combination of reactant atoms that exists before products are formed.

NOTE: The Activation Energy (E_a) is fixed by the nature of reactants (#'s and strengths of bonds in reactants.)

Ea is NOT affected by Δtemp or Δconc.

↳ but the # of molecules that ~~can~~ have enough energy are affected by these.

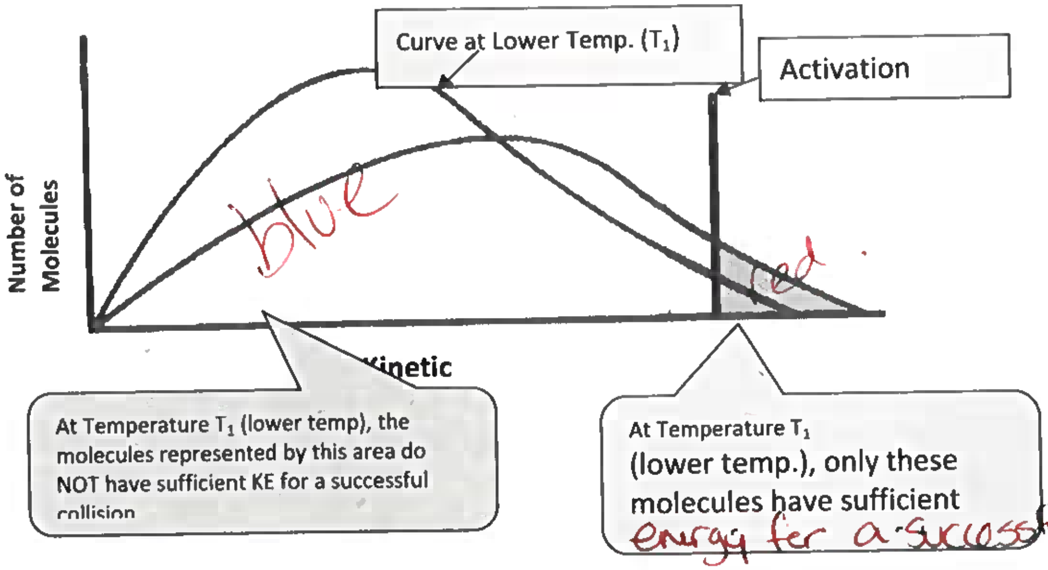


Gr. 11 review

Temperature's role

- the temperature determines how many (or what fraction of the) molecules will have energy ≥ Ea (to make it over the barrier & have a successful collision)

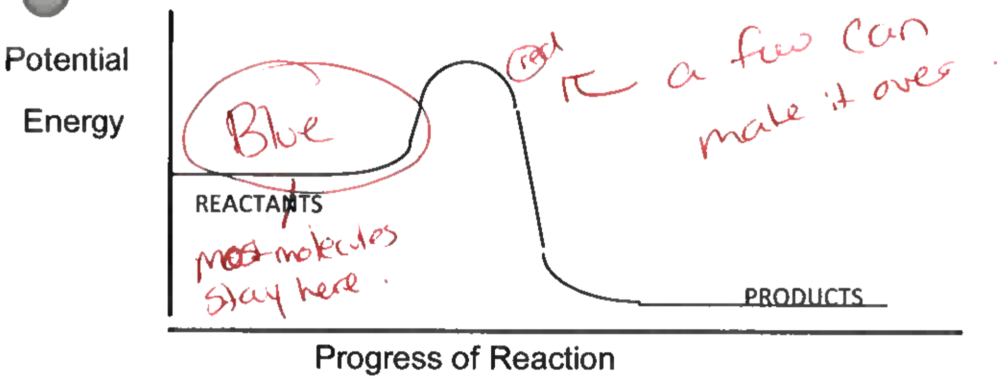
Recall KE distributions: eg.) At a **LOW** temperature:



At Temperature T_1 (lower temp), the molecules represented by this area do NOT have sufficient KE for a successful collision

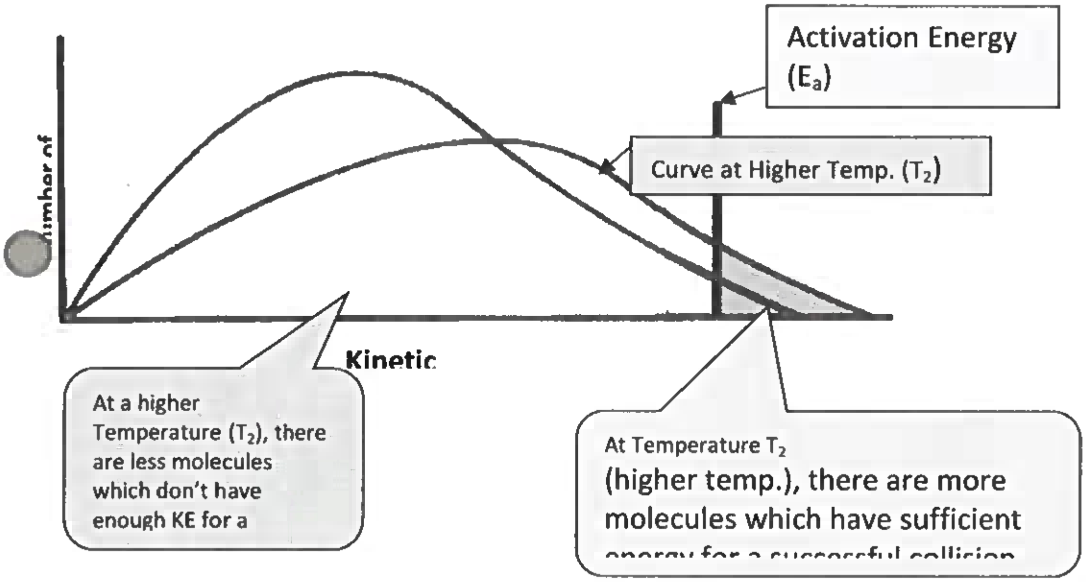
At Temperature T_1 (lower temp.), only these molecules have sufficient energy for a successful collision

Translated on to a POTETIAL ENERGY graph…



Notice in the diagrams on the previous page and above, that only a **small fraction** of the molecules had enough energy to overcome the **Activation Energy barrier**.

Now, at a Higher Temperature:



At a higher Temperature (T_2), there are less molecules which don't have enough KE for a

At Temperature T_2 (higher temp.), there are more molecules which have sufficient energy for a successful collision

How does this affect the PE diagram above? More would make it over 'the wall'

At the higher temperature, a **greater fraction** of the molecules have sufficient energy to "make it over" the **Activation Energy barrier**. (ie. a greater fraction of the molecules posses enough energy to form the **Activated Complex**):

Looking at the diagram above, you can see that at a higher temperature, a **greater fraction** of the molecules have **sufficient energy** to make it over the barrier. Therefore the reaction is **faster**.

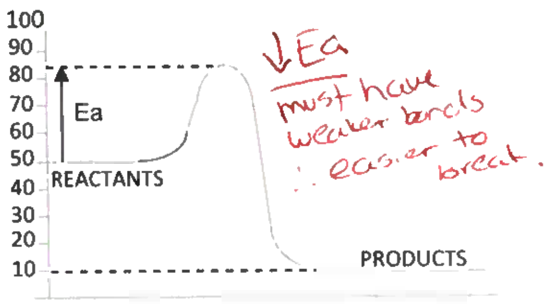
So if you study the graphs on the previous pages, you will see that:

Increasing temp increases the fraction of molecules which have sufficient energy to form the activated complex.

This is **one** reason that increasing the temperature will INCREASE the rate of reaction.

Also, NOTICE that a change in temperature does NOT change the Potential Energy diagram at all. Temperature does NOT affect the Activation energy or the ΔH !!

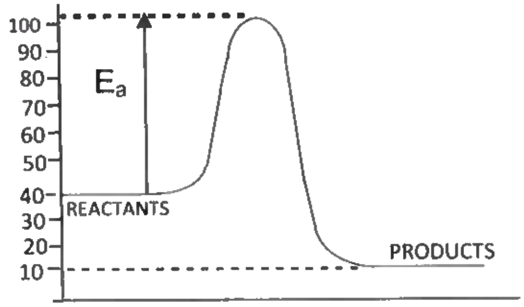
Consider two reactions **AT THE SAME TEMPERATURE**:



↓Ea
must have weaker bonds
∴ easier to break.

Progress of Reaction

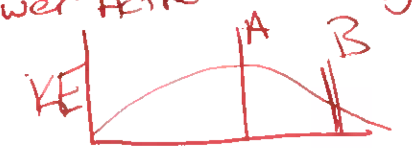
Reaction A



Progress of Reaction

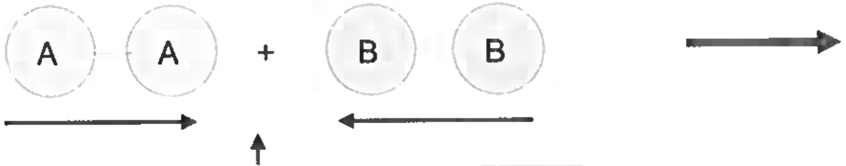
Reaction B

Which reaction is faster? A. Explain why. Lower Activation energy

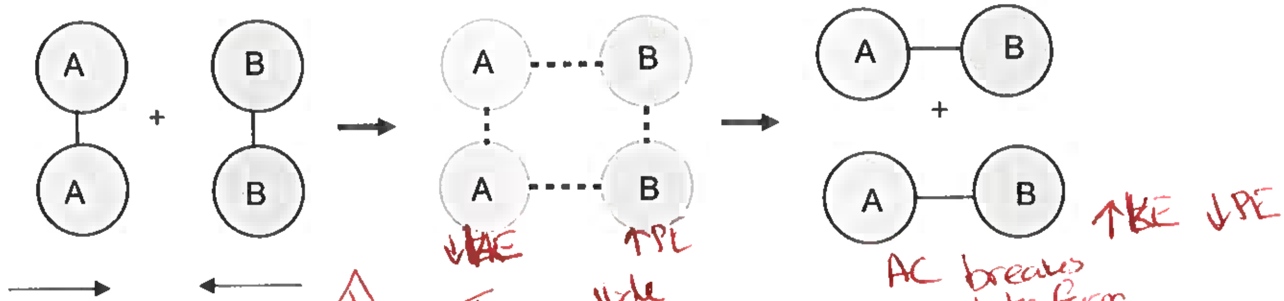


Collision Geometry

eg. for the rxn. $A_2 + B_2 \rightarrow 2AB$:



the above collision has **unfavourable alignment**
(need higher energy for collision to be effective)



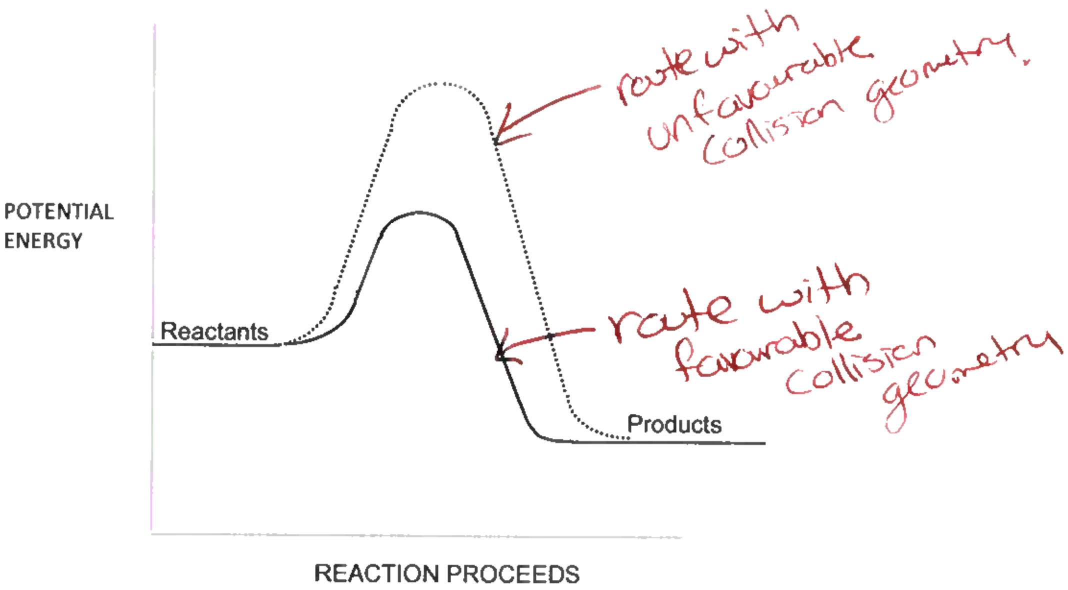
reactant molecules approach eachother

They collide to form activated complex

AC breaks apart to form products.

Favourable alignment.

Potential energy diagram



To Summarize Collision Theory so far:

For any **successful collision** (one resulting in a reaction):

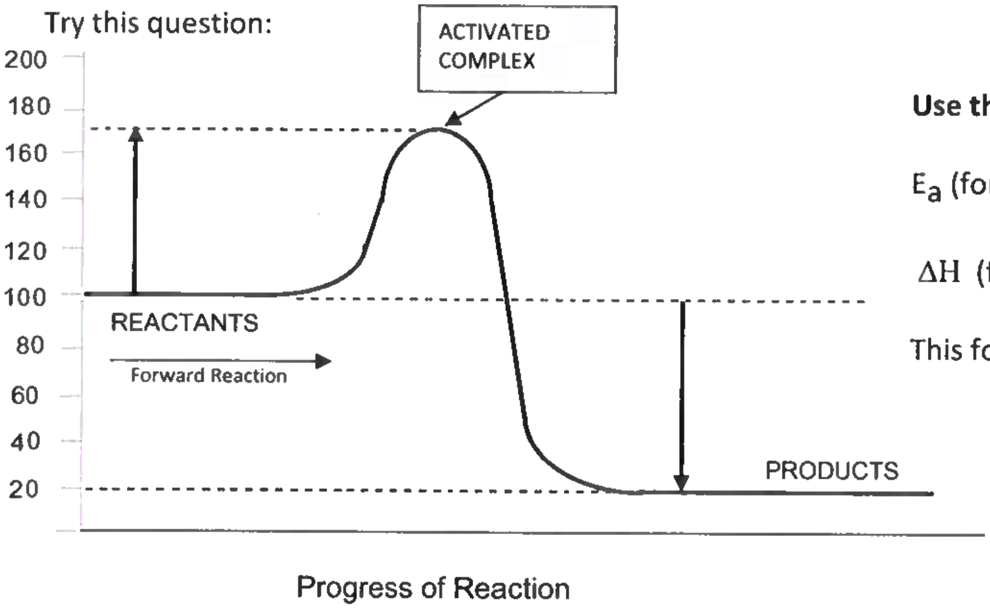
3 Requirements:

1.) - particles must collide

2.) - they must collide with sufficient Energy (>Ea)

3.) - they need to have correct alignment (collision geometry)
(to keep Ea as low as possible)

Try this question:



Use the graph, find:

E_a (forward rx.) = +70 kJ

ΔH (forward rx.) = -80 kJ

This forward reaction is exo thermic

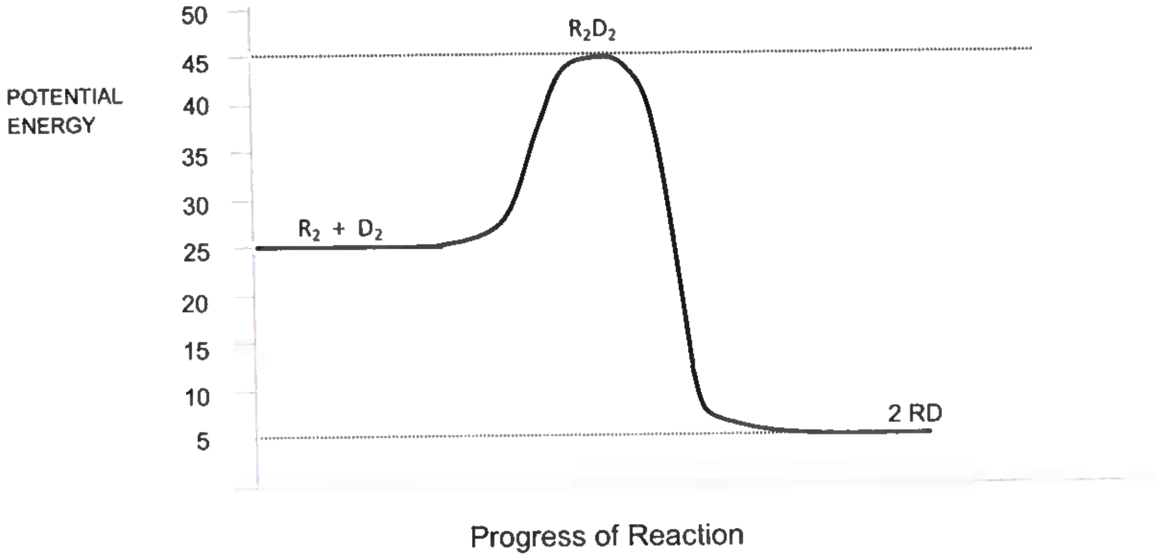
Considering reverse rx.

E_a (reverse rx.) = 150 kJ ΔH (reverse rx.) = +80 kJ

This reverse reaction is endo thermic

Given the following Potential Energy Diagram for the Reaction:

$$R_2 + D_2 \rightarrow 2RD$$



a) Ea (forward) = +20 KJ

b) Energy needed to break bonds in R_2 & D_2 R-R D-D ~~45~~20 KJ

c) Ea (reverse) = 40 KJ

d) Energy needed to break bonds in RD (R-D) 40 KJ

e) Which has the stronger bonds R_2 & D_2 or [✓ 2RD?]

f) On a PE diagram, species with stronger bonds (more stable) are

(low / high) low er on the graph

g) Which set of species (R_2 & D_2, [✓ R_2D_2], or 2RD) have the weakest bonds?

________. This species is the most Un stable. It is called the

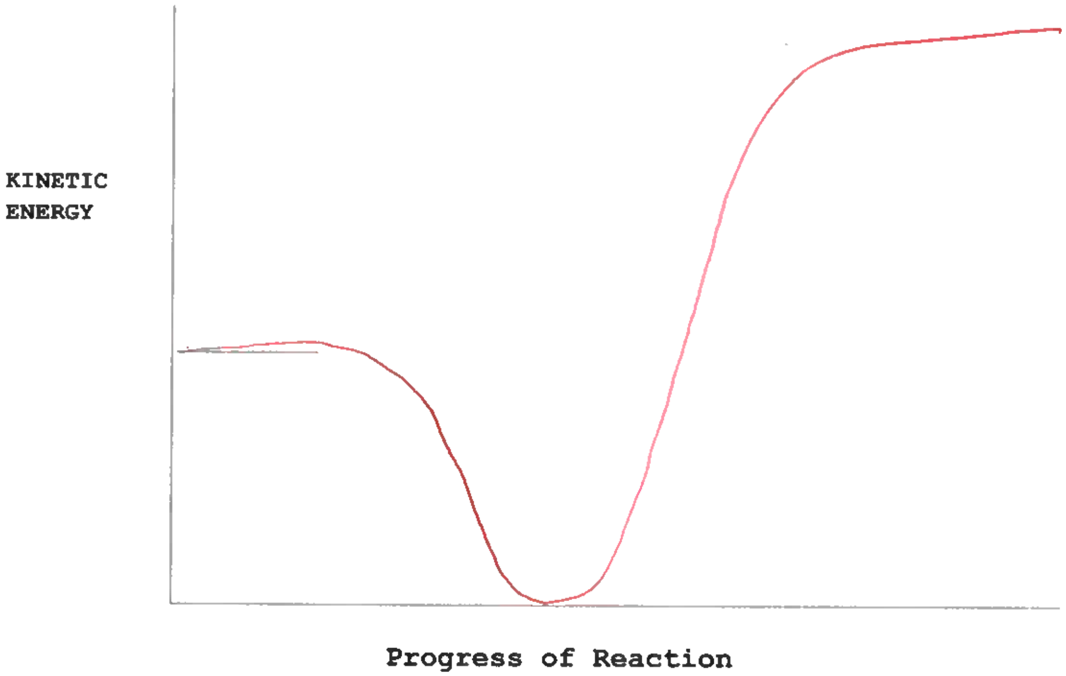
activated complex

h) Which set of species has the highest PE? R_2D_2

i) Which set of species has the highest KE? 2RD.

↓PE

j) Draw a graph of **KE** vs. reaction proceeds for the same forward rxn. ~~Pg 22~~



Read pages 20-22 and 24-25 in SW
Do Ex. 33-45 on pages 23 - 25 of SW