

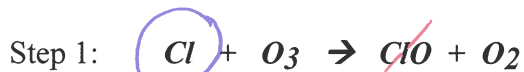
Chemistry 12
REACTION MECHANISMS

KEY

1. It is known that compounds called *chlorofluorocarbons* (C.F.C.s) (eg. CFCl_3) will break up in the presence of ultraviolet radiation, such as found in the upper atmosphere, forming single chlorine atoms:



The Cl atoms then react with Ozone (O_3) as outlined in the following mechanism.



Step 2: $\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2$ (single "O" atoms occur naturally in the atmosphere.)

- a) Write the equation for the *overall reaction*. (Using steps 1 and 2)



- b) What is the *catalyst* in this reaction?

Cl

- c) Identify an *intermediate* in this reaction

ClO

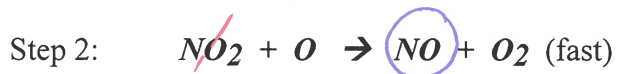
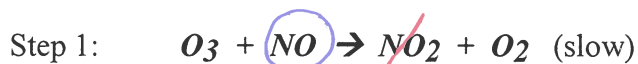
- d) Explain how a *small* amount of chlorofluorocarbons can destroy a *large* amount of ozone.

Cl destroys O_3 in step 1 but then is regenerated so it can destroy more

- e) What breaks the bond in the CFCl_3 and releases the free Cl atom?

a photon of ultraviolet radiation

2. Given the following mechanism, answer the questions below:



- a) Give the equation for the *overall reaction*.



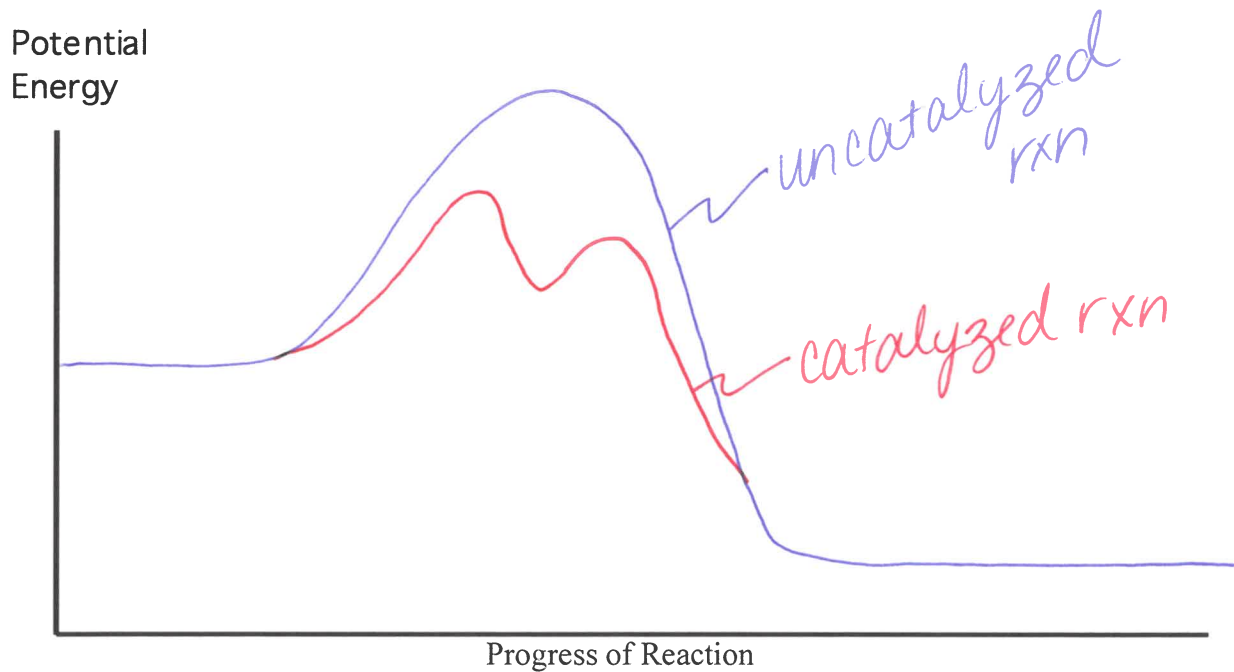
- b) What could the *catalyst* be in this mechanism?

NO

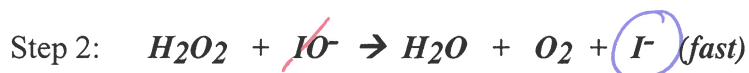
- c) What is an *intermediate* in this mechanism?

NO₂

- d) Given that the **uncatalyzed** overall reaction is a **slow exothermic** reaction, draw a *potential energy graph* which shows the possible shape of the curve for the **uncatalyzed** reaction. On the same graph, show a possible curve for the **catalyzed** reaction.



3. Consider the following mechanism:



- a) Give the equation for the overall reaction.



- b) What acts as a **catalyst** in this mechanism?



- c) What acts as an **intermediate** in this mechanism?



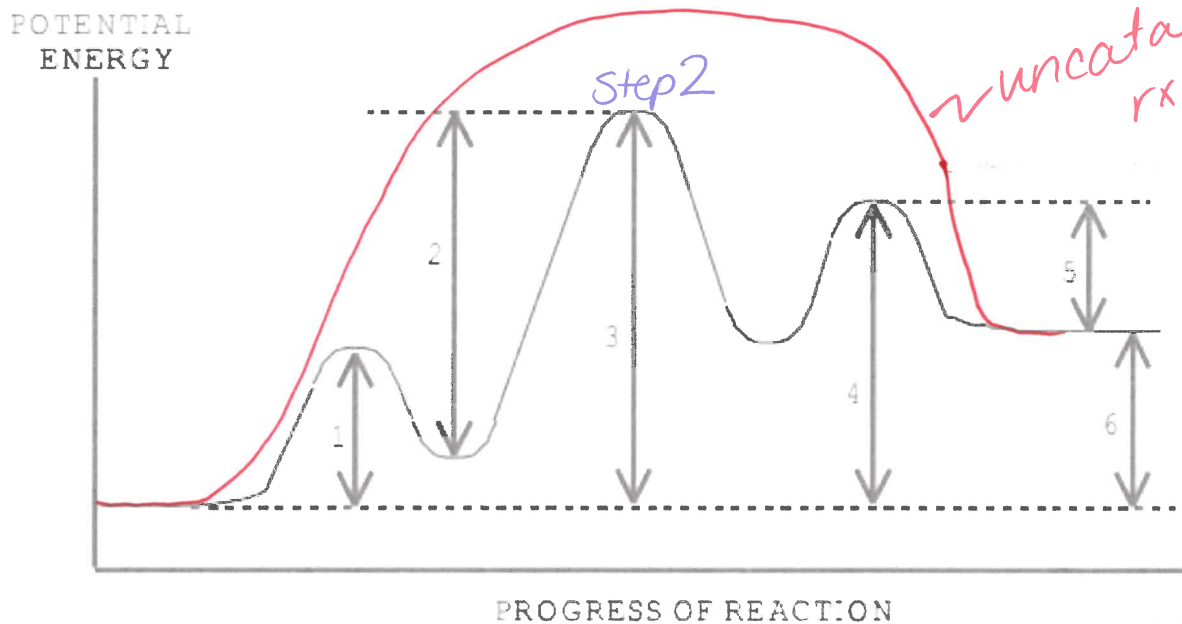
4. What is meant by the **rate determining step** in a reaction mechanism?

slowest step - determines rate of overall rxn

5. What is meant by a **reaction mechanism**?

series of steps by which a rxn takes place

6. Given the following *Potential Energy Diagram* for a 3 step reaction, answer the questions below it:



- a) Which arrow indicates the *activation energy* for the *first* step of the reverse reaction? 5
- b) Which arrow indicates the *activation energy* for the *first* step of the forward reaction? 1
- c) Which arrow indicates the *activation energy* for the *second* step of the forward reaction? 2
- d) Which arrow indicates the *enthalpy change* (ΔH) or "*enthalpy change*" for the **overall forward** reaction? 6
- e) Which arrow indicates the *enthalpy change* (ΔH) or "*enthalpy change*" for the **overall reverse** reaction? 6
- f) Which arrow indicates the *activation energy* for the **overall** forward reaction? 3
- g) Which step would be the **rate determining step** in the forward reaction? Step 2
- h) In a dashed line or another colour sketch a possible curve that would represent the route for the **uncatalyzed overall reaction**. Label this on the graph.

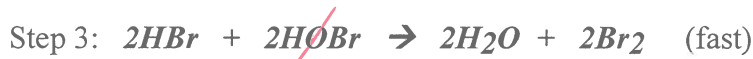
7. Given the reaction:



a) Would you expect this reaction to take place in a single step? no

Why or why not? unlikely for 5 particles to simultaneously collide

b) This reaction is thought to take place by means of the following mechanism:



c) Identify the two *intermediates* HOBr, HOBr

d) A catalyst is discovered which increases the rate of *Step 3*. How will this affect the rate of the *overall reaction*? no effect

Explain your answer. *must speed up slowest step (RDS) to make a difference

e) A catalyst is discovered which increases the rate of *Step 1*. How will this affect the rate of the *overall reaction*? ↑ rate

Explain your answer. speed up slowest step → speed up overall rxn

f) Which step has the greatest *activation energy*? step 1

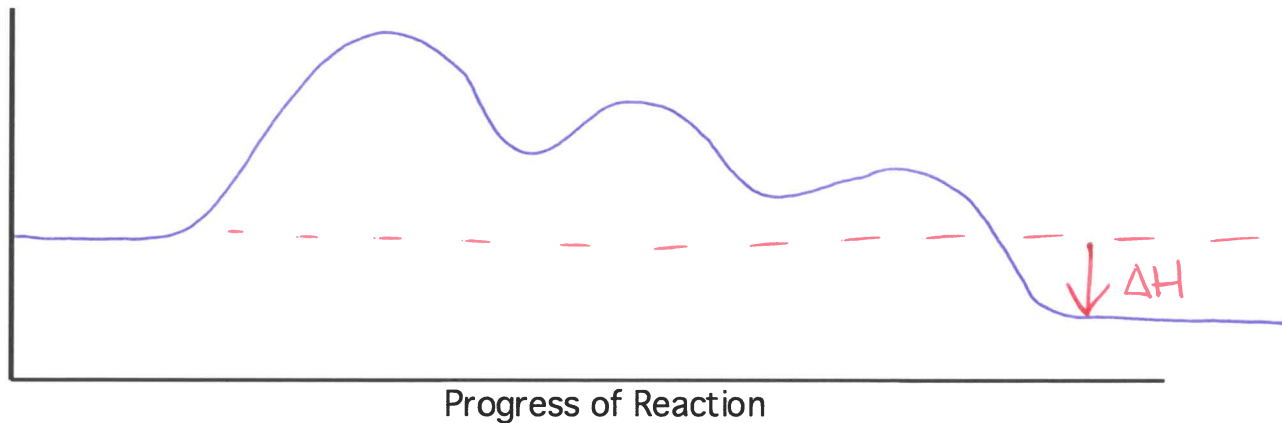
g) How many "bumps" will the potential energy diagram for the reaction mechanism have? 3

h) Which step is called the *rate determining step* in this mechanism? step 1

i) In order to have successful collisions, the colliding particles must have **both** the proper amount of *energy* and the proper orientation/collision geometry

- j) On the set of axes below, draw the shape of the curve you might expect for the reaction in this question. The overall reaction is *exothermic*! Make sure you get the "bumps" the correct relative sizes.

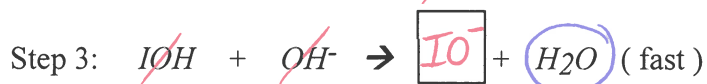
Potential Energy



8. The equation for an *overall* reaction is:

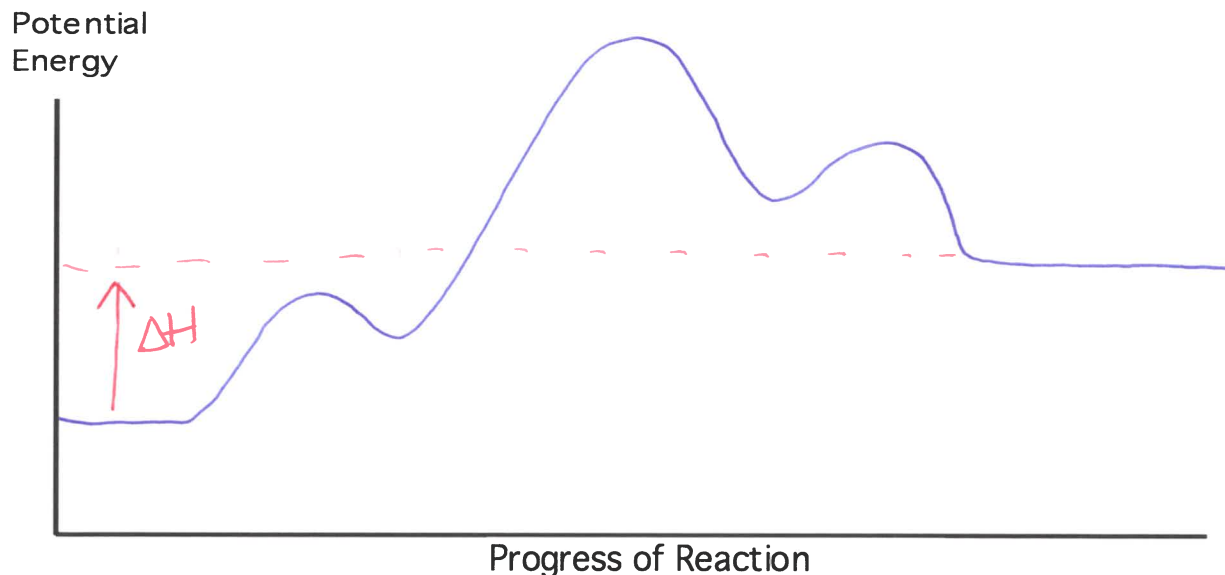


- a) The following is a proposed *mechanism* for this reaction. One of the species has been left out. **Determine what that species is and write it in the box.** Make sure the *charge* is correct if it has one!



- b) Which species in the mechanism above acts as a *catalyst*? H₂O
- c) Which three species in the mechanism above are *intermediates*? HOCl, IOH, OH⁻
- d) Step 2 is the *rate determining step*.

- e) On the set of axes below, draw the shape of the curve you might expect for the reaction in this question. The overall reaction is endothermic! Make sure you get the "bumps" the correct relative sizes.



9. Given the following steps for a mechanism:



- a) Write the equation for the **overall reaction**.



- b) A substance is added that *decreases* the *activation energy* for step 1. Will this speed

up, slow down, or have no effect on the rate of the overall reaction? no effect

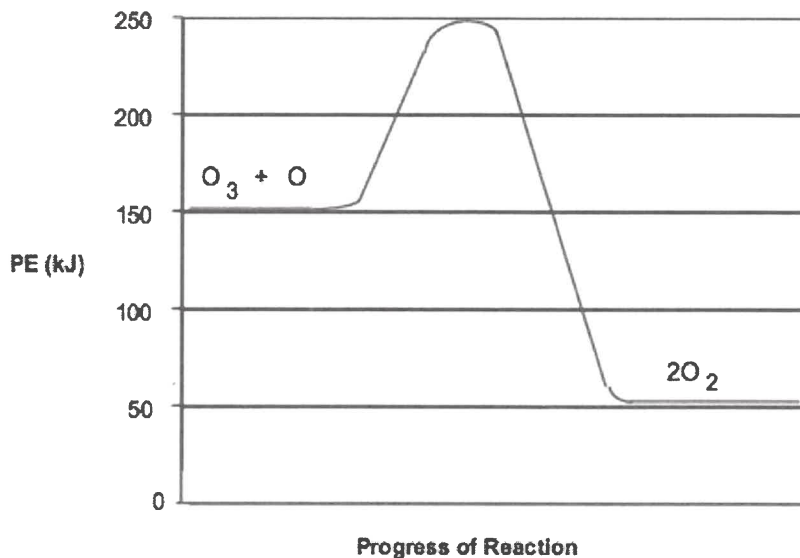
Give a reason for your answer. step 1 not RDS

- c) Is there a catalyst in this mechanism? no. If so, what is it? _____

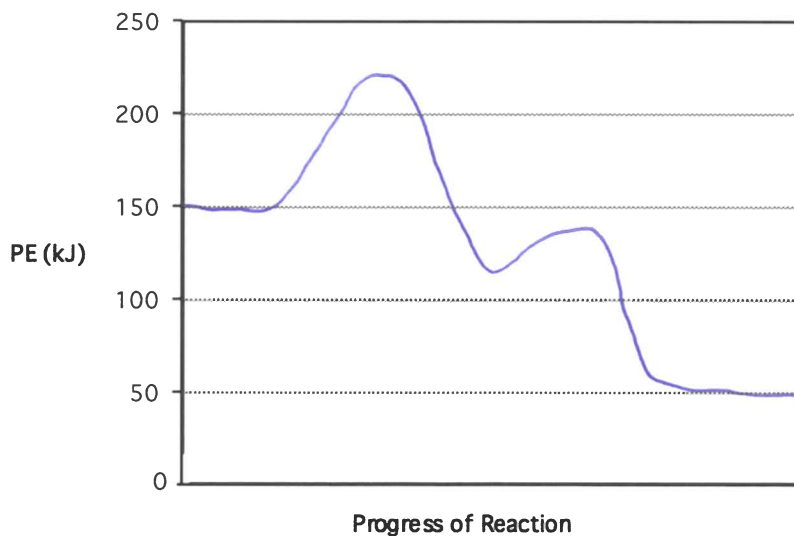
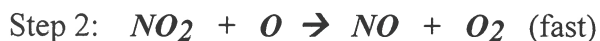
- d) Is there an intermediate in this mechanism? yes. If so, what is it? Br & Cl

- e) Which step is the **rate determining step**? step 2

10. The following **potential energy diagram** refers to a very slow one-step reaction of ozone (O_3) and oxygen atoms in the upper atmosphere.



On the axis below, draw a potential energy diagram which could represent the *catalyzed mechanism* for the reaction:



11. A certain chemical can provide a reaction with an alternate mechanism having a *greater* activation energy. What will happen to the *rate of the reaction* when this chemical is added?

no change
 Explain your answer. rxn will continue to follow original path with lower E_a