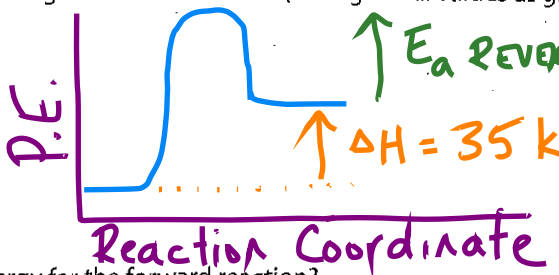
CHEM 12 REACTION KINETICS Unit 1 Review
CHECK YOUR UNDERSTANDING

1. For a hypothetical reaction, $XY(g) \rightleftharpoons X(g) + Y(g)$ $\Delta H = 35$ kJ/mol. For the reverse reaction, $E_a = 25$ kJ/mol.

(a) Sketch a potential energy diagram for this reaction (label general values as given).



E_a REVERSE = 25 kJ/mol

$\Delta H = 35$ kJ/mol (endothermic)

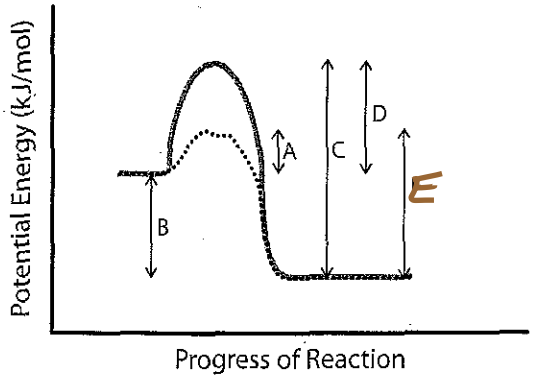
(b) What is the activation energy for the forward reaction?

E_a FORWARD = 25 + 35 = 60 kJ/mol

(c) What is ΔH for the reverse reaction?

$\Delta H = -35$ kJ/mol (exothermic)

2. Study the potential energy diagram shown below.



(a) Indicate what each of the letters (A through E) represents.

A. E_a for catalyzed reaction (they did not label each separate mini curve)

B. ΔH

C. E_a for reverse reaction

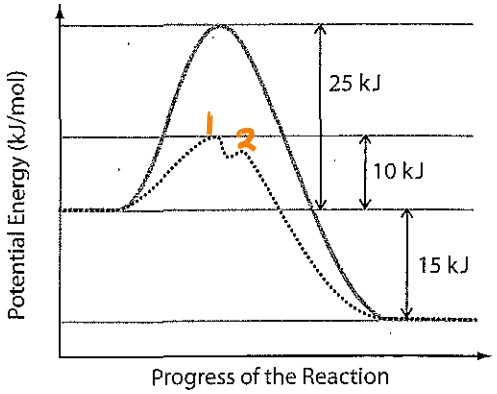
D. E_a for FORWARD reaction (UNcatalyzed)

E. E_a for reverse catalyzed reaction (NOT labeling each mini curve separately because too hard to distinguish)

(b) Is this reaction endothermic or exothermic?

FORWARD reaction is EXOTHERMIC

3. Study the following potential energy diagram.



(a) Is this reaction endothermic or exothermic?

FORWARD: exothermic $\Delta H = -15$ kJ/mol

(b) What is E_a for the catalyzed pathway?

$Ea_1 = 10$ kJ/mol $Ea_2 =$ approx. 1 kJ/mol

(c) What is E_a for the uncatalyzed pathway?

$Ea = 25$ kJ/mol

(d) What is ΔH for this reaction? How does this value change with a catalyst?

ΔH value is NOT affected by catalyst.
$\Delta H = -15$ kJ/mol

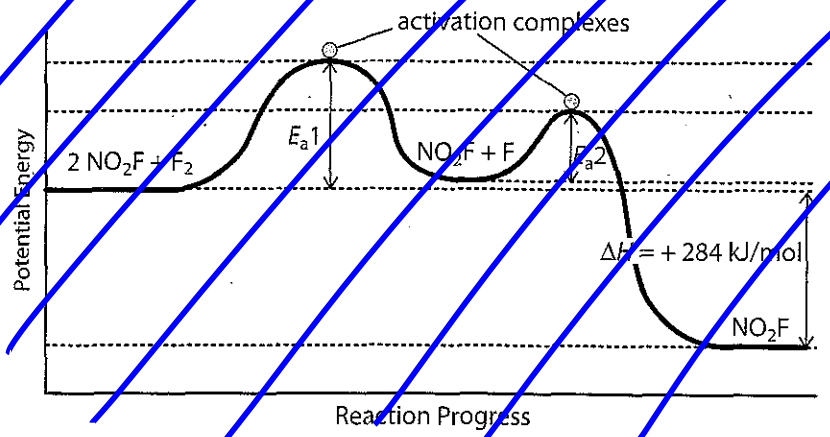
(e) How much lower is the potential energy of the activated complex with a catalyst?

LOOKING AT: Ea UNCAT $= 25$
Ea CAT $= 10$ (ish)
15 kJ more

(f) How does this affect the reaction rate?

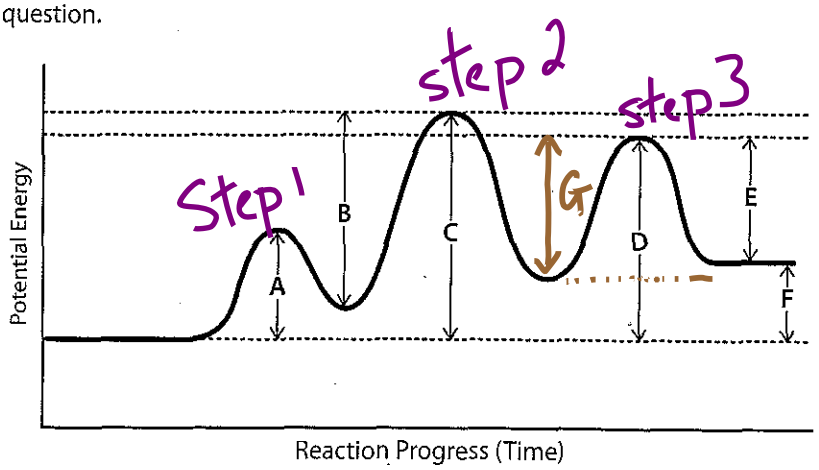
Speeds up reaction since Ea CATALYZED is lower, and therefore more molecules will possess sufficient energy to overcome this lowered activation energy barrier, and successfully collide.

4. Examine the following potential energy diagram and use it to construct a reaction mechanism. Show each step and the overall reaction. Label the rate-determining step.



THIS QUESTION IS FLAWED

5. Look at the PE diagram shown here and answers the questions below. Write your answers at the end of each question.



(a) How many steps are in the reaction represented by this potential energy profile? 3

(b) Which step is rate determining? 2 (highest E_a)

(c) What arrow represents E_a for the forward reaction? 3 answers: A, B, G

(d) What arrow represents E_a for the rate-determining step? B

(e) What arrow represents ΔH for the reaction? F

(f) Is this an endo- or exothermic reaction? endo.

6. The reaction, $CO(g) + NO_2(g) \rightarrow CO_2(g) + NO(g)$ may occur by either of the following two mechanisms:

Mechanism 1: Step 1: $2\,NO_2(g) \rightarrow NO_3(g) + NO(g)$ slow

Step 2: $CO + NO_3 \rightarrow CO_2 + NO_2$ fast

Reaction: $CO + NO_2 \rightarrow CO_2 + NO$

Mechanism 2: Step 1: $2\,NO_2(g) \rightarrow N_2O_4(g)$ fast

Step 2: $N_2O_4 + CO \rightarrow CO_2 + NO + NO_2$ slow

Reaction: $CO + NO_2 \rightarrow CO_2 + NO$

(a) Fill the reaction in and use it to discern the missing step 2 for each mechanism.

(b) Experimental data shows that increasing the [CO] has *no effect* on the overall reaction rate. Based on this data, which mechanism must be correct? ∴ [CO] must be in a step that is already fast ∴ MECHANISM 1 must be correct.

7. Consider the reaction: $4\,HBr(g) + O_2(g) \rightarrow 2\,H_2O(g) + 2\,Br_2(g) + heat$

(a) Does this reaction represent an elementary process? Explain

(b) Propose a reaction mechanism for the overall reaction, given the following clues: There are two intermediates in the reaction. The first to form is $HOOBr(g)$ and the second is $HOBr(g)$.

(c) Experimental data shows that a change in [HBr] has the same effect on the rate of the reaction as an identical change in $[O_2]$. What is the rate-determining step?

8. A reaction between ammonium ions and nitrite ions to produce a salt has the following rate law:

$$\text{rate} = k[NH_4^+][NO_2^-]$$

Assume the rate of formation of the salt is 3.10×10^{-3} mol/L/s. Note that the units may also be expressed as *mol/L s. The reaction is performed in aqueous solution at room temperature.*

(a) What rate of reaction would result if the $[NH_4^+]$ was tripled and the $[NO_2^-]$ was halved?

(b) Determine the reaction rate if the $[NH_4^+]$ was unchanged and the $[NO_2^-]$ was increased by a factor of four?

(c) If the $[NH_4^+]$ and the $[NO_2^-]$ were unchanged, but the rate increased to 6.40×10^{-3} mol/L s, what must have happened to the reacting system?

(d) What would the new reaction rate be if enough water were added to double the overall volume?

9. A student reacts ground marble chips, $CaCO_3(s)$, with hydrochloric acid, $HCl(aq)$, in an open beaker at constant temperature. increased surface area = more molecules available to effectively collide

(a) In terms of collision theory, explain what will happen to the rate of the reaction as it proceeds from the beginning to completion.

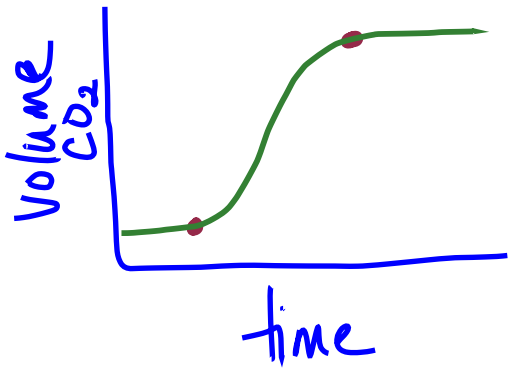
Once molecules start to effectively collide, there will be a measurable rate that will reach a maximum.

(b) Sketch a graph of volume of $CO_2(g)$ vs. time to show the formation of product with time as the reaction proceeds.

(c) Explain, using a diagram, how increasing the temperature (for example, heating the HCl (aq)) would affect the rate, in terms of collision theory.

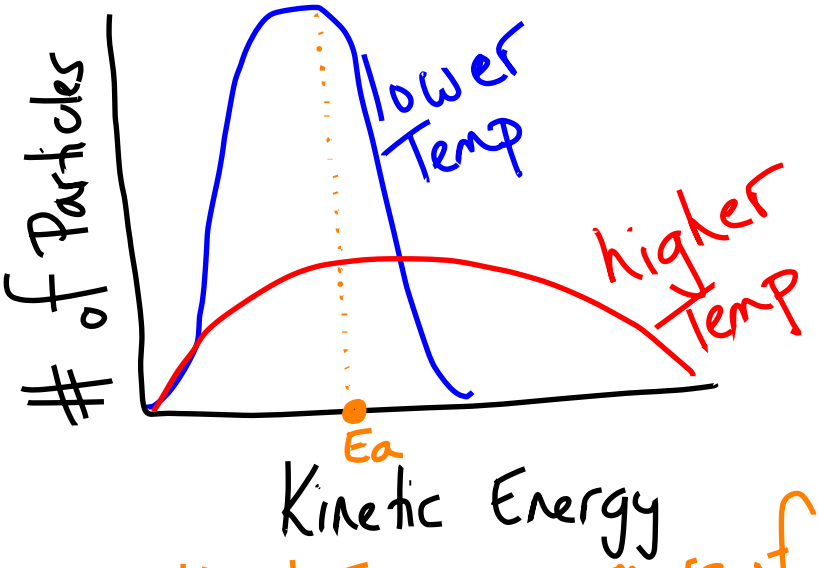
Rate will continue to increase as more frequent successful collisions occur.
Rate will decrease as collisions become less frequent due to lack of energy necessary to overcome the Ea barrier and/or the consumption of one of the reactants, which would reduce the rate to 0.

b)



Some sources would suggest you only need to show the curve between the 2 • points

c)



Increasing the KE means more of the molecules will possess the energy necessary to overcome the activation energy (Ea) barrier and effectively collide to successfully form products.