Chemistry 12 Rates of Reaction Worksheet #1

1. Consider: $N_{2(g)} + 3H_{2(g)} \text{---} > 2NH_{3(g)}$

   If the rate of formation of NH_3 is 9.0×10^{-4} mol/s, then what is the rate of consumption of N_2?

2. Suggest 2 specific changes that would increase the rate of rusting of a piece of iron.

3. Consider:

I	concentration of reactants
II	temperature of reactants
III	surface area of reactants

   Which factor(s) affect the rate of a chemical reaction between 2 gases?

4. Consider: $2NO_{2(g)} \text{---} > 2NO_{(g)} + O_{2(g)}$

   What is the rate of formation of O_2 if, under certain conditions, the rate of decomposition of NO_2 is 3.2×10^{-3} mol/sec?

5. Consider:

I	$N_{2(g)} + O_{2(g)} \text{---} > 2NO_{(g)}$
II	$2Mg_{(s)} + O_{2(g)} \text{---} > 2MgO_{(s)}$
III	$CaCO_{3(s)} + 2H^+_{(aq)} \text{---} > Ca^{2+}_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

   Which reaction rate(s) will increase if the surface area is increased?

6. Consider:

I	frequency of successful collisions
II	volume of reaction vessel
III	pressure of the system
IV	mass of system

   Which condition(s) must increase to increase the rate of the reaction?

7. Consider:

I	pressure per mole
II	energy consumed per mole
III	volume of gas per unit time
IV	moles formed per litre of solution

   Which is(are) an expression of the rate of a chemical reaction?

8. Give an example of a heterogeneous reaction and list four different factors that affect the rate of this reaction.

9. Consider the reaction:

$C_2H_{4(g)} + 3O_{2(g)} \text{------>} 2CO_{2(g)} + 2H_2O$

At certain conditions, 0.15 mol CO_2 is produced in 2.0 minutes. What is the rate of consumption C_2H_4 of in g/s?

10. Consider the following reaction:

$C_{12}H_{22}O_{11(s)} \text{-----> } 11\ H_2O_{(g)} + 12C_{(s)}$

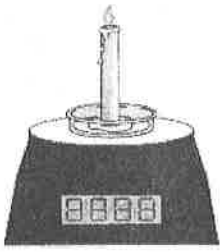
The rate of decomposition of $C_{12}H_{22}O_{11(s)}$ is 0.75 mol/min. What mass of C is produced in 10.0 seconds?

11. The mass of a burning candle is monitored to determine the rate of combustion of paraffin. An accepted reaction for the combustion of paraffin is:

$$2C_{28}H_{58(s)} + 85O_{2(g)} \text{-----> } 58\ H_2O_{(g)} + 56CO_{2(s)}$$

a) Calculate the average rate of consumption of paraffin in g/min for the time interval 12.0 to 24.0 minutes.

b) Calculate to rate of CO_2 production in mol/min for the time interval 12.0 to 24.0 minutes.



The following data is observed:

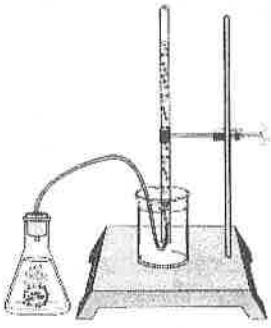
Time (min)	Mass of Candle (g)
0.0	25.6
6.0	25.1
12.0	24.5
18.0	23.9
24.0	23.4
30.0	22.8

12. An Alka-seltzer tablet is added to water to produce carbon dioxide gas. The gas was collected using water displacement.

a) Calculate the average rate of reaction for the formation of CO_2 gas for the times:

i) 0-10 seconds

ii) 10-20 seconds



The following data is recorded:

Time (s)	Volume of CO_2 (mL)
0.0	0
10.0	3.0
20.0	20.0
30.0	33.5
40.0	43.0
50.0	43.0
60.0	43.0

b) Suggest a reason why the rate of reaction from 0-10 seconds is slower than the rate from 10.0-20.0 seconds.

c) The rate of reaction is not constant during the entire interval from 10.0 s to 40.0 s. Describe the change in rate and explain a reason for the change.

Rates of reactions #2

Name _____

Class _____ Date _____

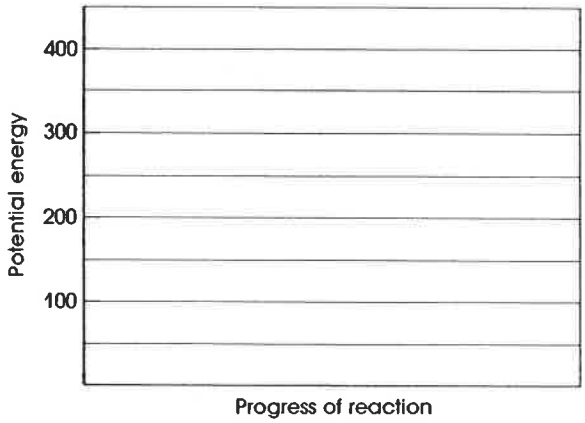
Reaction Rates

A. Potential Energy Diagrams

The potential energy of substances involved in a reaction can be plotted versus the progress of the reaction, as the process moves from initial reactants, through activated complex, to final products.

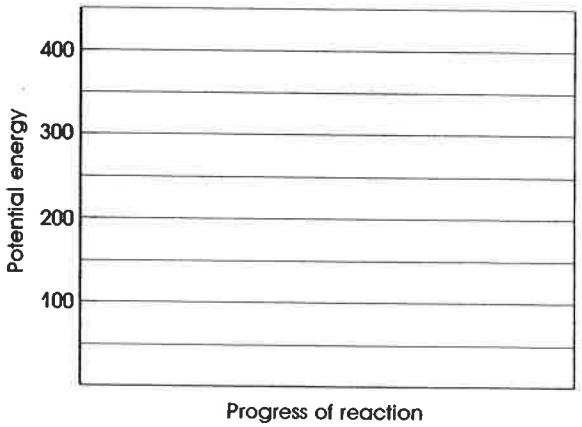
On the grids below, plot energy diagrams for 1-3 below, given the following information, and answer the questions. For number 4, study the energy diagram and answer the questions.

1. Potential energy of reactants: 250
   Potential energy of activated complex: 350
   Potential energy of products: 300
   Is the reaction exothermic or endothermic? How can you tell?
   What is the value of ΔH?



If a catalyst were added, what would happen to the diagram? What would happen to the energies of reactants, products, and activated complex, and to the rate? Explain the effect on the rate.

2. Potential energy of reactants: 350
   Activation energy (energy needed to form activated complex from reactants): 100
   Potential energy of products: 250
   Is this reaction exothermic or endothermic? Why? What is the value of ΔH?



What is the potential energy of the activated complex? _____

If the concentration of the reactants were increased, what would happen to the diagram? What would happen to the energies of reactants, products, and activated complex, and to the rate?

Explain the effect on the rate. _____

_____

_____

_____

3. Potential energy of reactants: 200
   Potential energy of activated complex: 400
   ΔH = +150
   Is this reaction exothermic or endothermic? Why?

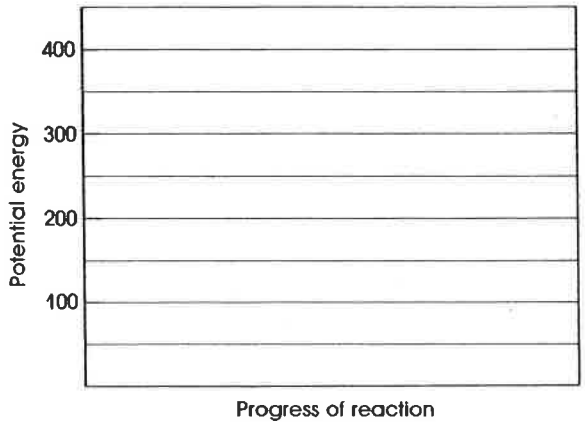
   _____

   _____

   _____

   What is the potential energy of the products? _____

   _____



What is the activation energy? _____

If temperature were increased, what would happen to the diagram? What would happen to the energies of reactants, products, and activated complex, and to the rate? Explain the effect on the rate.

_____

_____

_____

_____

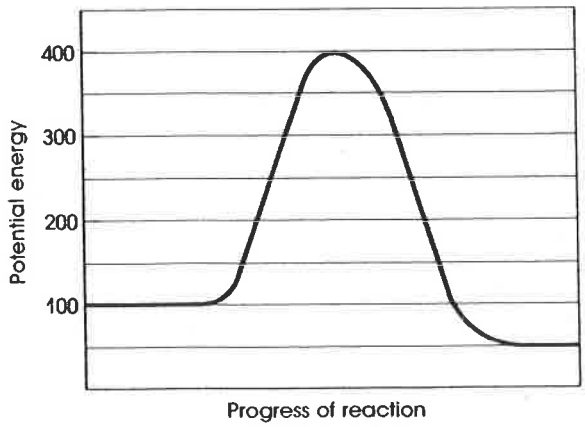
4. Potential energy of reactants: _____

   Potential energy of activated complex: _____

   Activation energy: _____

   Potential energy of products: _____

   ΔH: _____



Is the reaction exothermic or endothermic? Why? _____

_____

If an inhibitor were added, what would happen to the energies of reactants, products, and activated complex, and to the rate? Explain the effect on the rate. _____

B. Factors Affecting Rate

The rates of chemical reactions depend upon a number of factors. These factors can be controlled by scientists in order to cause processes to proceed at desired rates. For each of the following factors, write its probable effect (increase, decrease, no effect) on rate, and then explain the effect on the basis of collision theory.

FACTOR	EFFECT ON RATE	EXPLANATION
decreased concentration	_____	_____
increased gas pressure	_____	_____
decreased temperature	_____	_____
decreased surface area	_____	_____
addition of catalyst	_____	_____
addition of inhibitor	_____	_____

C. Rate Equations

A rate equation expresses the rate of a reaction in terms of a proportionality constant, k, multiplied by the concentrations of various reactants raised to certain powers. Given the following information, write a rate equation for each of the following.

1. The reaction between substances A and B, for which it is found that rate depends upon the concentration of A and the square of the concentration of B _____

2. The reaction between C and D, for which it is found that rate depends only upon the square of the concentration of C _____

3. The reaction between E, F, and G, for which it is found that rate depends upon the squares of the concentrations of E and F, and upon the concentration of G _____

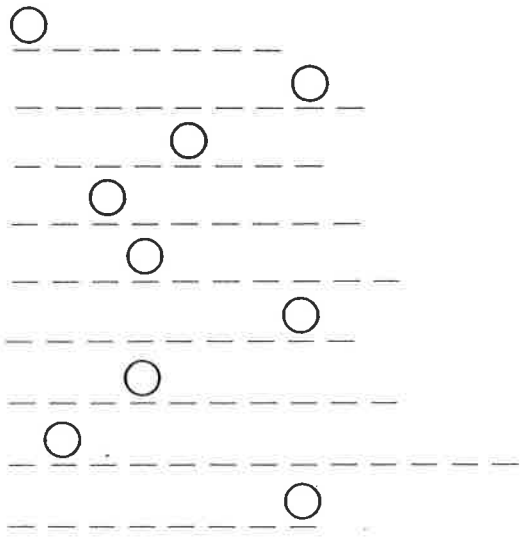
D. Reaction Rate Word Scramble

Use the clues provided to help you unscramble the letters below to form words related to Chapter 18. The letters in the circles will then spell out an important word.

CLUES

1. Activated molecule
2. Slows down a reaction
3. Speeds up a reaction
4. Particles
5. Energy important in determining rate
6. Sequence of steps
7. Percent of effective collisions
8. Moles per liter, for example
9. Chemical change

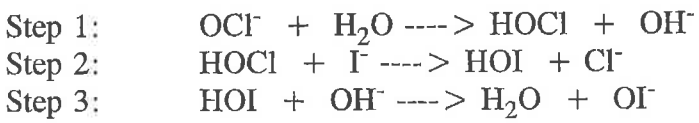
1. X O C E P M L
2. R T I I O N B I H
3. C Y T L S T A A
4. S L C L M U E O E
5. T V A A T O I N I C
6. E M A M S C N I H
7. Y I C N E F C E I F
8. T E C C N N R O O I T A N
9. A E R N O T C I



Word: _____

Rates of Reaction #3

1. Examine the following reaction mechanism:

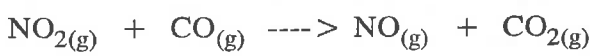


(a) Identify the catalyst in the mechanism and explain how you were able to make your identification.

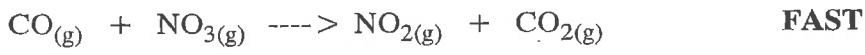
(b) Explain why OH^- would be called a reaction intermediate.

(c) List any additional reaction intermediates.

2. The reaction between NO_2 and CO is slow and has the overall equation:



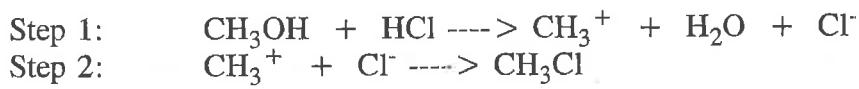
One step in the two-step mechanism of this reaction is:



(a) Write the equation for the other step in the mechanism.

(b) State whether your proposed step is slow or fast and explain your choice.

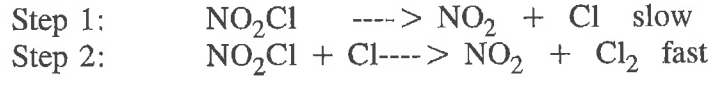
3. The proposed mechanism for a reaction is:



(a) What is the overall reaction being studied?

(b) List any reaction intermediates.

4. The proposed mechanism for a reaction is:



Describe the overall reaction.

5. Consider the following reaction:

$$H^+ + I^- + H_2O_2 \text{ ----> } H_2O + HOI$$

A student proposes the following two-step mechanism for the above **fast** reaction:

Step 1: $H^+ + H^+ + H_2O_2 \text{ ----> } H_4O_2^{2+}$
Step 2: $H_4O_2^{2+} + I^- \text{ ----> } H_2O + HOI + H^+$

Would you agree or disagree with the proposed mechanism? Explain.

6. Consider the following reaction:

$$CO + NO_2 \text{ ----> } CO_2 + NO$$

(a) The first step in each of two proposed reaction mechanisms for the above reaction is listed below. If each proposed reaction mechanism consists of only two steps, determine the second step for each mechanism.

Proposed Mechanism One:

Step 1:	$2NO_2 \text{ ----> } NO_3 + NO$	slow
Step 2:		fast

Proposed Mechanism Two:

Step 1:	$2NO_2 \text{ ----> } N_2O_4$	fast
Step 2:		slow

(b) Experimental data shows that the rate of the reaction is not affected by a change in the CO concentration. Which of the two proposed reaction mechanisms would be consistent with these data? Explain.

7. Consider the following reaction mechanism:

Step 1: $NO_2 + Mn \text{ ----> } NO_2Mn$
Step 2: $NO_2Mn + NO_2 \text{ -----> } NO_3 + NO + Mn$
Step 3: $NO_3 + CO \text{ ----> } NO_2 + CO_2$

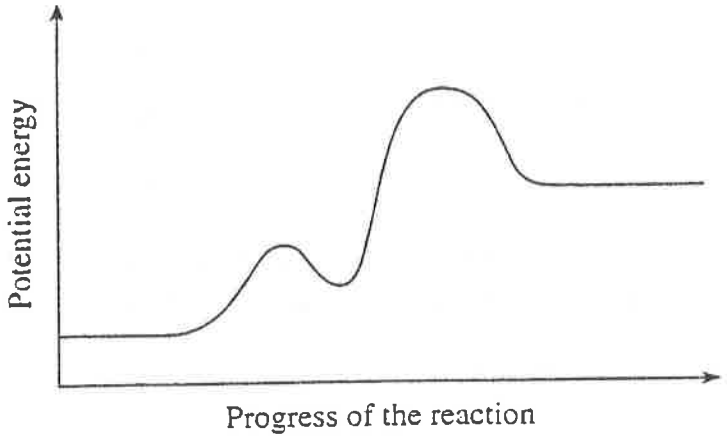
(a) Identify the catalyst.

(b) Identify a reaction intermediate.

(c) Identify the products of the overall reaction.

Rates of Reaction #4

1. On the following diagram, clearly label the:
   (a) activation energy for the forward reaction
   (b) heat of reaction
   (c) energy of the activated complex in the rate determining step



2. The following series of steps describes a reaction mechanism for a chemical reaction:

step 1:	$H_2O_2 + H^+ \text{----} > H_3O_2^+$	fast
step 2:	$H_3O_2^+ + I^- \text{----} > H_2O + HOI$	slow
step 3:	$HOI + I^- \text{----} > OH^- + I_2$	fast
step 4:	$OH^- + H^+ \text{----} > H_2O$	fast
step 5:	$I_2 + I^- \text{----} > I_3^-$	fast

Write the equation for the overall reaction and identify all reaction intermediates. Increasing the concentration of which reactant will greatly increase the rate of the reaction? Explain.

3. Describe two ways, other than the use of a catalyst, to increase the rate of the following reaction:

$$Zn_{(s)} + 2HCl_{(aq)} \text{----} > ZnCl_{2(aq)} + H_{2(g)}$$

4. Consider the following uncatalyzed reaction which is a one-step process:

$$2Ce^{4+} + Tl^{+} \text{ ----> } 2Ce^{3+} + Tl^{3+}$$

When a catalyst is added to the above reaction, the following three-step reaction mechanism takes place:

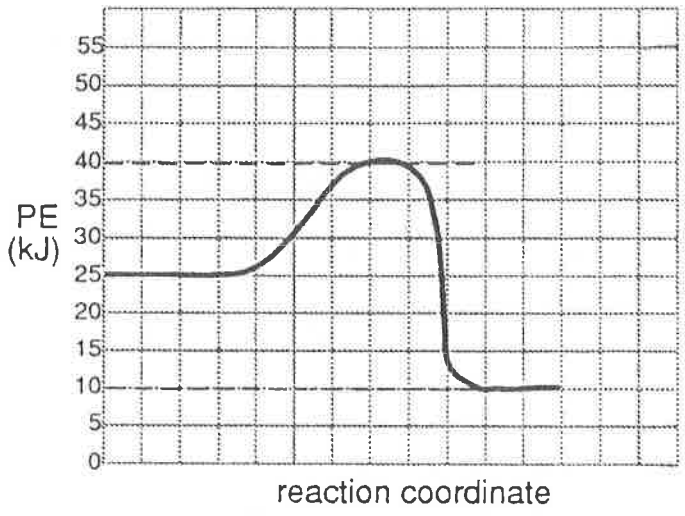
step 1: $Ce^{4+} + Mn^{2+} \text{ ----> } Ce^{3+} + Mn^{3+}$

step 2: $Ce^{4+} + Mn^{3+} \text{ ----> } Ce^{3+} + Mn^{4+}$

step 3: $Mn^{4+} + Tl^{+} \text{ ----> } Tl^{3+} + Mn^{2+}$

With reference to the above equation, use collision theory to explain why the catalyzed reaction mechanism is faster than the uncatalyzed reaction.

5. Consider the following diagram:



(a) On the diagram, label the change in enthalpy and the activation energy for the reverse reaction.

(b) Give the values for the energy of the activated complex and the ▲H for the forward reaction.

6. Consider the following reaction:

$$CO_{(g)} + NO_{2(g)} \text{ ----> } CO_{2(g)} + NO_{(g)}$$

Using collision theory, explain why the rate of the reaction decreases as the reaction proceeds.

7. Consider the following mechanism for an exothermic reaction:

step 1:	$NO_{(g)} + NO_{(g)} \text{ ----> } N_2O_{2(g)}$	fast
step 2:	$N_2O_{2(g)} + O_{2(g)} \text{ ----> } 2NO_{2(g)}$	slow

Draw a PE diagram to represent the above two step reaction mechanism and write the net equation to represent the overall reaction.

8. The uncatalyzed decomposition of methanoic acid, HCOOH, has a $\Delta H = 13$ kJ and the activation energy = 88 kJ.
The reaction mechanism for the catalyzed decomposition of methanoic acid is:

step 1:	$HCOOH + H^+ \text{ ----> } HCOOH_2^+$	fast
step 2:	$HCOOH_2^+ \text{ ----> } HCO^- + H_2O$	slow
step 3:	$HCO^- \text{ ----> } H^+ + CO$	fast

On a graph draw a PE diagram for the catalyzed decomposition of methanoic acid.
Label the ΔH and the activation energy for the reaction.

9. The following equations represent a proposed mechanism for the decomposition of ozone:

step 1:	$Cl + O_3 \text{ ----> } ClO + O_2$
step 2:	$ClO + O \text{ ----> } Cl + O_2$

Write the equation for the overall reaction.
Identify the catalyst.
Explain how the catalyst increases the rate of this reaction.