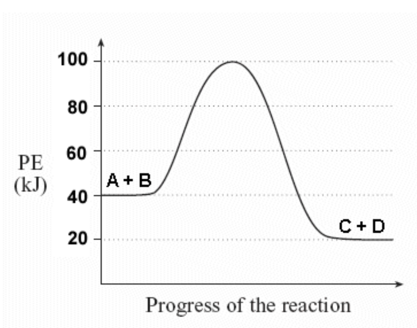
Factors that Affect Rates

Describe how each of the factors below affects the reaction rate and explain why based on Collision Theory.

Factor affecting Reaction Rate	Relationship with reaction rate	Explanation of effect on reaction rate
Temperature	↑ temp = ↑ rate	Molecules moving around faster with more energy means for collisions with enough energy to lead to a reaction.
Concentration	↑ concentration = ↑ rate	More crowded so there will be more collisions.
Surface Area	↑ surface area = ↑ rate	More surface area on which reactions can occur.
Catalyst	Presence of a catalyst = ↑ rate	Lowers activation energy

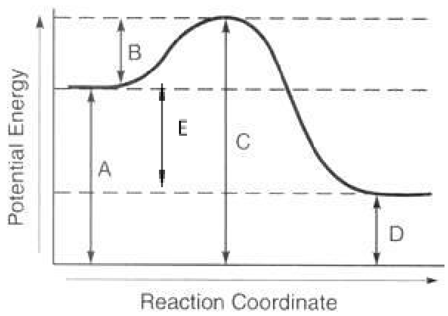
1. Use the graph below to answer the question to the right.

Potential E Changes for Reaction



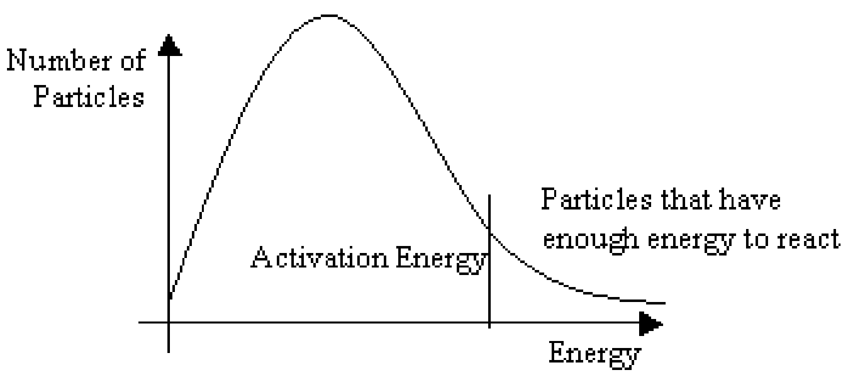
- Does the graph represent an endothermic or exothermic reaction? Explain.
- Determine the ΔH for the reaction represented.
- Determine the ΔH for the reverse reaction.
- Determine the activation energy (Ea) for the reaction represented.
- Show how a catalyst would affect the changes in potential energy for the reaction represented by drawing a line on the graph. Label it.

2. Use the graph below to answer the questions to the right.



- Which arrow represents the potential energy of the reactants?
- Which arrow represents the activation energy (Ea)?
- Which arrow represents the heat of reaction, ΔH?
- Which arrows would be affected by adding a catalyst? How would they change?

3. Use the graph below to explain how various factors impact collisions and rate of reaction.



a. Draw and label a line on the graph to show the average kinetic energy.

b. Estimate the percent of particles that have enough energy to react. (Use area under the curve) about 15%

c. Draw and label a new activation energy (Ea) line when a catalyst is added. How does this affect the percent of particles with enough energy to react. Explain why. More molecules have enough energy to react

d. Draw and label a new curve on the graph showing the particles at a higher temperature. How does a higher temperature affect the percent of particles with enough energy to react? Explain why. The average kinetic energy moves up so a higher percentage of molecules have enough energy to react.

e. How do you think the curve would change if the concentration was increased? Explain your answer.

There would be more molecules, the percentage wouldn't change.

Potential Energy Diagrams

The potential energies of the substances involved in a chemical reaction can be plotted versus the progress of the reaction. From left to right the reaction progresses from reactants, through the activated complex, to final products.

On the grids below, graph the potential energy graph for the chemical reaction data provided. Answer all of the questions in the spaces provided.

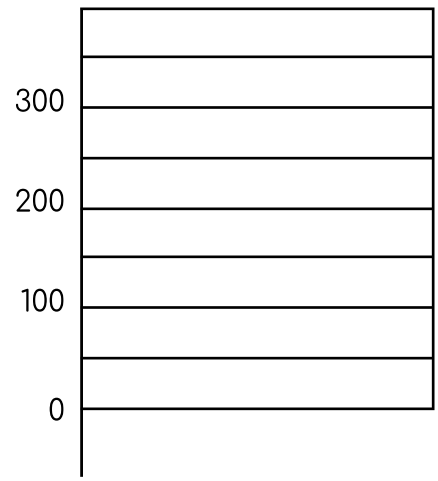
Graph #1:

Reactants = 250 kJ
Activated Complex = 350 kJ
Products = 300

What is the Activation Energy? 100

What is the ΔH of the reaction? +50

Is the reaction **Endothermic** or Exothermic? (circle one)



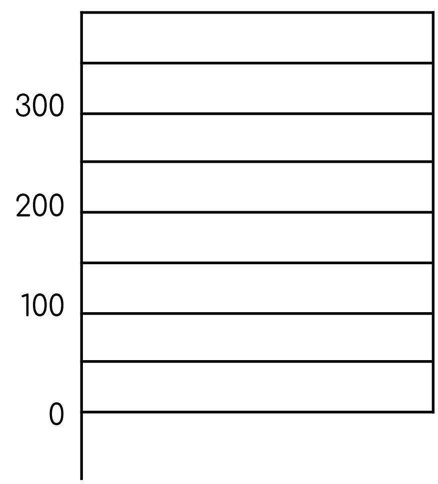
Graph #2:

Reactants = 250 kJ
Activation Energy = 100 kJ
Products = 150

What is the Activated Complex Energy? 350

What is the ΔH of the reaction? -100

Is the reaction Endothermic or **Exothermic**? (circle one)

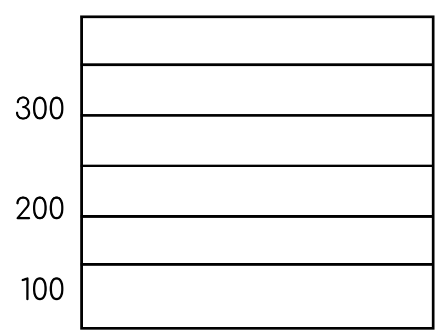


Graph #3:

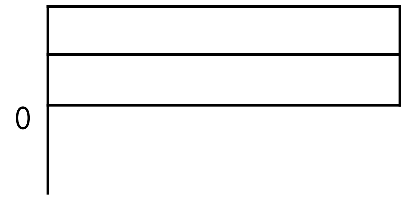
Reactants = 200 kJ
Activated Complex = 400 kJ
ΔH = +100 kJ

What is the Activation Energy? 200

What is the Product Potential Energy? 300



Is the reaction **Endothermic** or Exothermic? (circle one)



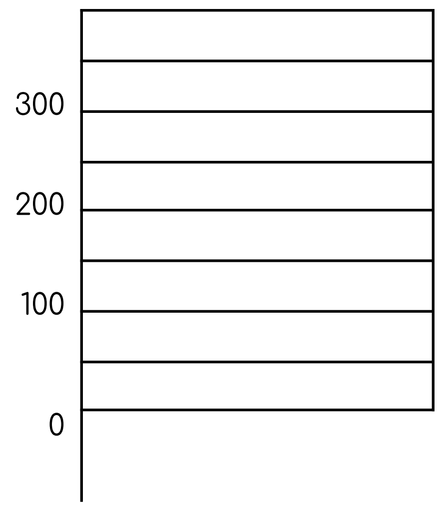
Graph #4:

A catalyst is added to the reaction in Graph #3 which lowers the activation energy by 50 kJ. Redraw the graph.

Energy of the Activated Complex? 350

What is the ΔH of the reaction?100

Is the reaction rate likely **faster** or slower? (circle one)



Extensions – Use the reaction plotted in Graph #4 above to answer the following questions

A) If the concentration of the reactants were increased, what would happen to the diagram? Nothing, Concentration doesn't change the energy diagram.

B) If the concentration of the reactants were increased, what would happen to the reaction rate? Reaction rate would increase. The graph would be compressed.

C) If the temperature of the reactants was increased, what would happen to the diagram AND reaction rate? Nothing much would happen to the diagram, but the reaction rate would increase, so it would be compressed to the left.

An Equilibrium Experiment

Introduction

The purpose of this experiment is to study the rates of forward and reverse reactions and the establishment of equilibrium.

Materials

2 graduated cylinders (same size) | water
2 straws of different diameters | labels

Procedure

1. Label one graduated cylinder "A" and one "B"
2. Fill cylinder A with water to the maximum volume mark (25mL for a 25mL cylinder)
3. Label one straw "A" and one "B"
4. Put straw A into cylinder A and straw B into cylinder B so that the straws touch the bottom of their cylinder.
5. Place a finger over each straw opening, simultaneously withdraw the straws and empty the contents of each straw into the opposite cylinder.

Note: Straw A will always be used to transfer water from cylinder A to B
Straw B will always be used to transfer water from cylinder B to A

6. Record the new volume of the cylinders in the data table.
7. Repeat steps 4 through 6 until you think you have reached equilibrium.
8. Verify that you have reached equilibrium with your instructor and apply a 5mL stress

Transfer #	Volume in A (mL)	Volume in B (mL)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Transfer #	Volume in A (mL)	Volume in B (mL)
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		

13		
14		

27		
28		

Follow-Up Questions

1. Which cylinder represented your “reactants”? How do you know?

A, the one that starts with all the water in it.

2. What is the Wikipedia definition of dynamic equilibrium?

In chemistry, and in physics, a dynamic equilibrium exists once a reversible reaction occurs. The ratio of reactants/products changes, but substances move between the chemicals at an equal rate, meaning there is no net change. Reactants and products are formed at such a rate that the concentration of neither changes.

3. How could you have reached equilibrium but have different volumes of water in each cylinder?
   Equilibrium doesn’t mean the same thing as equal. Equilibrium is when the amount of reactants to products is constant.

4. Describe what dynamic equilibrium looks like macroscopically?

There is a consistant amount of water in tube A and B from trial to trial.

5. Describe what dynamic equilibrium looks like sub-microscopically (atoms and molecules)?

   The same number of water molecules is transferred from trial to trial.

6. Graph your data such that: x-axis = transfer #, y-axis = volume, Trial A and Trial

B are two separate lines (smooth curve except for 5mL stress after 1st equilibrium)

Equilibrium and Le Chatelier's Principle

Reactant:
Increase (↑) causes the equilibrium to shift to the right (→)
Decrease (↓) causes the equilibrium to shift to the left (←)

Product:
Increase (↑) causes the equilibrium to shift to the left (→)
Decrease (↓) causes the equilibrium to shift to the right (←)

Temperature:
A change in temperature corresponds to a change in energy therefore by using the 'energy' term in the equation itself, it can be treated like a reactant or product (see above).

Pressure:
An increase (↑) in pressure causes the equilibrium to shift towards the "smaller number of moles of gas" side. A decrease (↓) in pressure causes the equilibrium to shift towards the "larger number of moles of gas" side.
Note: If the number of moles of gas is the same on both sides, then a change in pressure has no effect in the equilibrium.

The following equation describes a system that is at equilibrium:

$$2H_2(g) + O_2\,(g) \leftrightarrow 2H_2O\,(g) + \text{energy (heat)}$$

In Table 1 apply Le Chatelier's Principle and indicate the direction of the shift in equilibrium if the indicated stress is applied to the reaction system. (The first one is completed for you.).

1. Complete the following table:

Stress	Shift Direction
Concentration H_2 increases	→ shifts to the right
Concentration H_2 decreases	left
Concentration of O_2 increases	right
Concentration of O_2 decreases	left
Concentration of H_2O increases	left

Concentration of H_2O decreases	
Temperature increases	
Temperature decreases	
Pressure increases	
Pressure decreases	

The following questions are based on the table in Question #1

1. In general terms, describe the direction of the equilibrium shift when the concentration of a reactant is increased.
2. If an equilibrium shifts to the right, which reaction speeds up, the forward or the reverse?
3. What happens to the concentrations of the reactants H_2 and O_2 when the reaction in Model 2 shifts to the right?
4. What happens to the concentration of the product H_2O when the reaction in Model 2 shifts to the right?
5. If an equilibrium shifts to the left, which reaction speeds up, the forward or the reverse?
6. What happens to the concentrations of the reactants H_2 and O_2 when the reaction in Model 2 shifts to the left?
7. What happens to the concentration of the product H_2O when the reaction in Model 2 shifts to the left?
8. What is true of the reaction rates for the forward and reverse reactions when a new equilibrium is established?

Got *It!* Write a general description based on the information in Table 1 that describes what happens to an equilibrium system when conditions change.

LeChatelier's Principle

Identify three ways of stressing or changing the equilibrium of a gaseous system.

1. concentration
2. pressure
3. temperature

In each reaction below, **circle the arrow** that shows which way the reaction will shift to return to equilibrium <u>after</u> the given "stresses" are applied to the system. On the lines below the equation, **draw an up or down arrow or a dash** (no change) indicating the change on the equilibrium concentrations after the reaction shifts back to equilibrium.

Reaction:							**Stress Applied:**
$2H_{2(g)}$	+	$2NO_{(g)}$	← →	$N_{2(g)}$	+	$2H_2O_{(g)}$	increase [NO]
Down		(up)down	right	up		up	
$2H_{2(g)}$	+	$2NO_{(g)}$	← →	$N_{2(g)}$	+	$2H_2O_{(g)}$	decrease [H_2O]
Down		down	right	up		(down) up	
$2H_{2(g)}$	+	$2NO_{(g)}$	← →	$N_{2(g)}$	+	$2H_2O_{(g)}$	increase pressure
Down		down	right	up		up	
$N_{2(g)}$	+	$3H_{2(g)}$	← →	$2NH_{3(g)}$	+	energy	decrease pressure
Up		up	left	down		down	
$N_{2(g)}$	+	$3H_{2(g)}$	← →	$2NH_{3(g)}$	+	energy	increase temp
Up		up	left	down		down	
$N_{2(g)}$	+	$3H_{2(g)}$	← →	$2NH_{3(g)}$	+	energy	decrease [$N_{2(g)}$]
up(down)		up	left	down			
$N_{2(g)}$	+	$3H_{2(g)}$	← →	$2NH_{3(g)}$	+	energy	increase [$H_{2(g)}$]
Down		(up)down	right	up			
$PCl_{5(g)}$	+	137 kJ	← →	$PCl_{3(g)}$	+	$Cl_{2(g)}$	increase [$Cl_{2(g)}$]
Up			left	down		(up)down	
$PCl_{5(g)}$	+	137 kJ	← →	$PCl_{3(g)}$	+	$Cl_{2(g)}$	decrease temp
Up		(down)	left	down		down	

$PCl_{5(g)}$ + 137 kJ ← → $PCl_{3(g)}$ + $Cl_{2(g)}$ increase pressure

Up left down down

$PCl_{5(g)}$ + 137 kJ ← → $PCl_{3(g)}$ + $Cl_{2(g)}$ increase $[PCl_{5(g)}]$

(up)down right up up

$SO_{2(g)}$ + $NO_{2(g)}$ ← → $SO_{3(g)}$ + $NO_{(g)}$ decrease pressure

Same number of moles of gas on each side, so no shift

$SO_{2(g)}$ + $NO_{2(g)}$ ← → $SO_{3(g)}$ + $NO_{(g)}$ add a catalyst

Adding a catalyst does not cause a shift left or right

$SO_{2(g)}$ + $NO_{2(g)}$ ← → $SO_{3(g)}$ + $NO_{(g)}$ decrease $[SO_{3(g)}]$

Down down right (down)up up

$Zn_{(s)}$ + $2Ag^{+}_{(aq)}$ ← → $Zn^{+2}_{(aq)}$ + $2Ag_{(s)}$ add solid Zn

(up) down down right up up

$Zn_{(s)}$ + $2Ag^{+}_{(aq)}$ ← → $Zn^{+2}_{(aq)}$ + $2Ag_{(s)}$ add $AgNO_{3(aq)}$

Down (up) down right up up

$Zn_{(s)}$ + $2Ag^{+}_{(aq)}$ ← → $Zn^{+2}_{(aq)}$ + $2Ag_{(s)}$ increase pressure

Changes in pressure only cause shifts in gaseous systems

$Zn_{(s)}$ + $2Ag^{+}_{(aq)}$ ← → $Zn^{+2}_{(aq)}$ + $2Ag_{(s)}$ precipitate Zn^{2+} with CO_3^{2-}

Down down right (down)up up

To **increase** the amount of **products** in the equilibrium system,

$$CH_4(g) + 2\ O_2(g) \leftrightarrow CO_2(g) + 2\ H_2O(g) + \text{heat}$$

how would you change the:

a. temperature decreasing the temp would cause a right shift

b. concentration of CO_2 removing CO_2 as it is produced would cause a right shift

c. Pressure There are equal number of moles of gas on each side, so you can not cause a shift by changing the pressure.

Consider the system: **$2\ CO(g)$ + heat ↔ $2\ C(s)$ + $O_2(g)$**

Would the concentration of CO(g) **increase or decrease** if you:

a. Increase the temperature this would cause a right shift and a decrese in CO concentration

b. Add $O_2(g)$ this would cause a shift to the left shift and an increase in th CO concentration.

c. Increase pressure This would cause a shift to the side with fewer moles of gas which is the right side. The effect would be to decrease the concentration of CO.

Stress Management Application

Problem

How can LeChatlier's Principle be used to predict the direction in which a system at equilibrium will shift when a stress is applied?

Materials

1.0 M Copper Chloride Solution	NaCl crystals	Ice
0.1 M $AgNO_3$	Common Lab Glassware	Hot Plate

Safety

Goggles must be worn at all times. $AgNO_3$ is photoreactive and will stain skin and clothing. $AgNO_3$ and $CuCl_2$ are possible skin irritants. Wash hands after handling chemicals.

Background

Equilibrium can exist only under conditions of constant temperature, pressure, and volume. If one of these factors is changed, the equilibrium will be disturbed and will shift to offset the stress. The equilibrium we will investigate is:

$$\underset{\text{green}}{CuCl_4^{2-}(aq)} \leftrightarrow \underset{\text{blue}}{Cu^{2+}(aq)} + 4\,Cl^-(aq) + \text{heat}$$

Procedure

1) Place 5.0 mL of $CuCl_2$ (aq) into 3 separate test tubes.

2) Study the table below and the equilibrium equation above. Complete the column in which you are asked to predict the change. Consider the predicted shift and predict what you will see (example: more blue, more green, no change, etc...)

Stress	Predicted Change	Observed Change
Control	Record the initial color:	
Heating		
Adding Ag^+ and NO_3^- to the heated solution		
Cooling		
Adding Na^+ and Cl^- to the cooled solution		

3) Once you have predicted the change you can begin your experimentation. You will use the following:
   a) Hot water bath
   b) Cold water bath
   c) 0.1M $AgNO_3$

d) NaCl crystals

3) Devise your own experiment for testing each of the stresses listed in the above table. Record the actual changes observed in the table above.

Conclusion

1) What effect does heating the solution have on the color?

   a) What does this tell you about the concentration of $CuCl_4^{2-}$?

   b) Indicate the direction the reaction is "shifting" when heated (left or right).

   c) When silver nitrate was added, what precipitate was formed? Explain why the observed change occurred.

2) Use LeChatlier's Principle to explain the color change observed when cooling the solution.

   a) Indicate the direction the reaction is "shifting" when cooled (left or right).

   b) When adding sodium chloride to the equilibrium system, which ion was affecting the equilibrium... Na^+ or Cl^-?

Equilibrium Constant Expressions

Example: Dinitrogen tetroxide (N_2O_4), a colorless gas, and nitrogen dioxide (NO_2), a colorless gas, exist in equilibrium with each other according to the equation:

$$N_2O_4\ (g) \leftrightarrow 2\ NO_2\ (g)$$

A liter of the gas mixture at 10°C at equilibrium contains 0.0045 mol N_2O_4 and 0.030 mol NO_2. Write the expression for the equilibrium constant (K_{eq}) and calculate the equilibrium constant for the reaction.

$$Keq = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(0.03)^2}{(0.0045)} = 0.2$$

1) Analysis of an equilibrium mixture of nitrogen, hydrogen, and ammonia contained in a 1 Liter flask at 300°C gives the following results: 0.15 moles of hydrogen, 0.25 moles of nitrogen, and 0.10 moles of ammonia. Calculate the K_{eq} for the reaction.

$$N_2\ (g) + 3\ H_2\ (g) \leftrightarrow 2\ NH_3\ (g)$$

K_{eq}= 12, products are favored

2) Analysis of an equilibrium system mixture of nitrogen, oxygen, and nitrogen monoxide give the following results: 0.50 moles of nitrogen, 0.50 moles of oxygen, and 0.020 moles of nitrogen monoxide. Calculate the K_{eq} for the reaction.

$$N_2\ (g) + O_2\ (g) \leftrightarrow 2\ NO\ (g)$$

K_{eq} = 0.0016, reactants are favored

3) Bromine chloride decomposes to form chlorine and bromine. At a certain temperature, the equilibrium constant for the reaction is 11.1, and the equilibrium mixture contains 4.00 moles of chlorine gas. How many moles of Br_2 and BrCl are present in the equilibrium mixture? Assume that initially only pure BrCl existed and that the container has a volume of 1.00 liters.

$$2\ BrCl\ (g) \leftrightarrow Cl_2\ (g) + Br_2\ (g)$$

$K_{eq} = \frac{[Cl_2][Br_2]}{[BrCl]^2}$ $\quad$ $11.1 = \frac{[4][4]}{x^2}$ $\quad$ x=1.2

4) The decomposition of hydrogen iodide at 450°C in a 1.00 liter container produces an equilibrium mixture that contains 0.50 moles of hydrogen. The equilibrium constant for the reaction is 0.020. How many moles of iodine and hydrogen iodide are present in the equilibrium mixture?

$$2\ HI\ (g) \leftrightarrow H_2\ (g) + I_2\ (g)$$

x=3.5

5) The following reaction has a K_{eq} of 0.48. What is the equilibrium concentration of PCl_5 if the equilibrium concentration of PCl_3 and Cl_2 is 0.74 M?

$$PCl_3\ (g) + Cl_2\ (g) \leftrightarrow PCl_5\ (g)$$

x=0.26M

Equilibrium ICE Charts

Example: Initially 1.00 moles of A and 1.00 moles of B are placed in a 1.00 liter container and allowed to reach equilibrium. The final concentration of B is 0.50 M. Find K_{eq}.

A + B ↔ C + 3 D

	A	B	C	3D
Initial	1.0 M	1.0 M	0	0
Change	-x	-x	+x	+3x
Equilibrium	0.5 M	0.5 M	0.5 M	1.5 M

1.0 – x = 0.5 so x must equal 0.5

$$Keq = \frac{[C][D]^3}{[A][B]} = \frac{(0.5)(1.5)^2}{(0.5)(0.5)} = 6.8$$

1) Initially 1.0M A and 1.0M B are placed into a container and allowed to reach equilibrium. At equilibrium [C] = 0.70M. Find K_{eq}.

A (g) + B (g) ↔ C (g) + D (g)

$K_{eq} = \frac{(.7)(.7)}{(.3)(.3)} = 5.4$

2) 0.50M A and 0.30M B are placed in a container where they react until reaching equilibrium. At equilibrium [C] = 0.20M. Find K_{eq}.

3 A (g) + B (g) ↔ 2 C (g) + D (g)

$K_{eq} = \frac{(.2)^2(.10)}{(.2)^3(.2)} = 2.5$

3) Initially 0.400 moles of HI gas is placed in a 1.50 liter container and allowed to come to equilibrium. Hydrogen gas and iodine gas are produced in the reaction. At equilibrium the concentration of iodine gas is found to be 0.100M. Find K_{eq}.

___ HI (g) ↔ ___ H_2 (g) + ___ I_2 (g)

$K_{eq} = \frac{(.100)(.100)}{(.067)^2} = 2.2$

4) 9.2 grams of ammonia gas are placed in an empty 1.8 liter container and

allowed to reach equilibrium. At equilibrium the concentration of the N_2 gas is found to be 0.060 M. What is the equilibrium constant (K_{eq})?

___ NH_3 (g) ↔ ___ N_2 (g) + ___ H_2 (g)

$$K_{eq} = \frac{(0.6)(.18)^3}{(.18)^2} = 0.0108$$

Rates and Equilibrium Review

1. Complete the table below comparing the factors affecting the rate and equilibrium.

List 4 factors that affect the *reaction rate*	Explain using the Collision Theory

2. Draw a double arrow to show which direction the reaction will shift to return to equilibrium after the initial stress is applied. Draw arrows in each blank below to show whether the concentration of the substances are increasing or decreasing.

<u>Stress Applied</u>

a. $SO_{2(g)}$ + $NO_{2(g)}$ ⟷ $SO_{3(g)}$ + $NO_{(g)}$

____ ____ ____ ____ Decrease $[SO_3]$

____ ____ ____ ____ Increase pressure

b. $CO_{(g)} + 2H_{2(g)}$ ⟷ $CH_3OH_{(g)}$ + energy

____ ____ ____ Decrease temperature

____ ____ ____ Increase $[CH_3OH]$

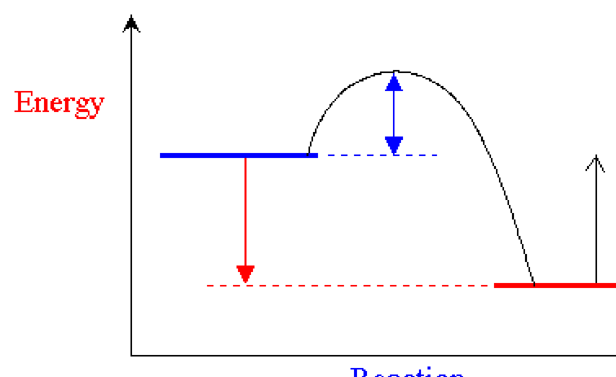
c. $CuCl_4^{-2}{}_{(aq)}$ ⟷ $Cu^{+2}{}_{(aq)} + 4Cl^{-}{}_{(aq)}$ + heat

____ ____ ____ Add NaCl

____ ____ ____ Add $AgNO_3$

(Ag^+ combines with Cl^- to produce a ppt of AgCl)

3. Label the following on the graph:
   - Reactants
   - Products
   - Activation Energy of the forward reaction
   - Activation Energy of reverse reaction



- Enthalpy (ΔH) of the forward reaction
- Enthalpy (ΔH) of the reverse reaction

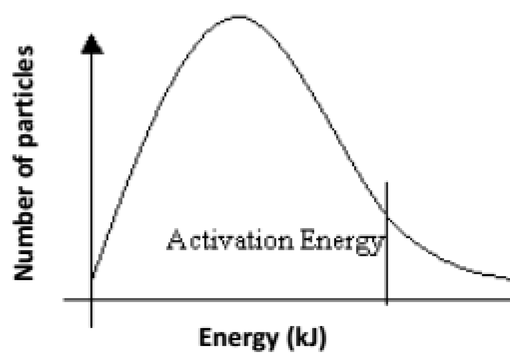
a. Make a dotted line and label it to represent the effect on this reaction if a catalyst was used

b. Is the forward reaction endothermic or exothermic?

4. Sketch a graph that shows the change in concentration of reactants and products as a reaction reaches equilibrium. Concentration should be on the y-axis and time is on the x-axis.

5. Use the graph below to explain how various factors impact collisions and rate of reaction.

- Shade in the portion of the graph that shows the number of particles that have enough energy to react.



- Draw and label a new activation energy line when a catalyst is added. How does this affect the percent of particles with enough energy to react. Explain why.

- How does a higher temperature affect the percent of particles with enough energy to react? Explain why.

- Sketch a new graph to show how the initial curve would change if the reaction occurs at a higher temperature.

e. Sketch a new graph to show how the initial curve would change if the concentration was increased? Explain your answer.

Calculations: *In #6-8, write the equilibrium expression AND calculate for the unknown.*

6. The following system reaches equilibrium: $N_{2(g)} + O_{2(g)} \longleftrightarrow 2NO_{(g)}$. An analysis of the equilibrium mixture in a 1.0 L flask gives the following results: nitrogen, 0.50 mol; oxygen, 0.50 mol; nitrogen monoxide, 0.020 moles.
    a. Write the equilibrium constant expression for this reaction.

    b. Calculate the K_{eq} for this system.

    c. Based on the K_{eq} are reactants or products favored?
7. The decomposition of hydrogen iodide at 450°C in a 1.0 L container produces an equilibrium mixture that contains 0.50 moles of hydrogen. The equilibrium constant (K_{eq}) is 0.020 for the reaction. $2HI_{(g)} \longleftrightarrow H_{2(g)} + I_{2(g)}$
    a. Write the equilibrium constant expression for this reaction

    b. Based on the K_{eq} are reactants or products favored?

    c. Calculate how many moles of iodine and hydrogen iodide are present in the equilibrium mixture?

8. Initially 0.15 mole of A is placed in a 1.0 L container. It reacts as follows: $A_{(g)} \longleftrightarrow B_{(g)} + 2C_{(g)}$. At equilibrium, [C] = 0.060 M.
    a. Write the equilibrium constant expression, calculate the equilibrium concentrations of A and B <u>and</u> calculate the K_{eq}.

    b. State whether the reactants or products are favored based on the K_{eq} value.

9. A student carries out an experiment by varying the temperature of the iodine clock reaction in an effort to understand rates of reactions. The results are recorded in the following table:

Trial	Temperature (°C)	Time (sec)	Rate (1/sec)
1	8.0	33	
2	21.0	22	
3	28.0	17	
4	31.0	11	

a. Which trial do you expect would give you the <u>fastest rate</u>? Explain why using the Collision Theory.

b. Calculate the rate of the reaction and record your values in the data table.

c. What is the relationship between Temperature and time? Use a complete sentence.

d. What is the relationship between Temperature and rate? Use a complete sentence.

10. The iodine clock lab also tested the concentration (molarity) of solution A. Without having data, predict the following relationships using the collision theory.
    a. What is the relationship between Molarity and time? Use a complete

sentence.

b. What is the relationship between Molarity and rate? Use a complete sentence.

c. **<u>Sketch</u>** 2 graphs to show these relationships from part a and b. Be sure to label the axis and provide a title.