Name:_____**Period:**_____
Ms. Randall
Unit 9: Kinetics and Equilibrium Workbook

The **bold, underlined** words are **important vocabulary words** that you should be able to define and use properly in explanations. This is a study guide for what you will be tested on throughout the year. The objectives are divided into categories of "**Knowledge**" (**what you have to *know***) and "**Application**" (**what you have to be able to *do***).

KINETICS AND EQUILIBRIUM	
Knowledge	**Application**
○ The **Collision Theory** states that a chemical reaction is most likely to occur if **reactant particles** collide with the proper energy and orientation.	
○ The **rate** (speed) of a chemical reaction depends on several factors: temperature, concentration, nature of reactants, surface area, and the presence of a **catalyst**. ○ Ionic compounds generally react faster than covalent (molecular) compounds ○ A catalyst provides an alternate reaction pathway, which has lower **activation energy** than an uncatalyzed reaction.	○ Use the Collision Theory to explain how factors such as temperature, surface area, and concentration influence the rate of reaction *Ex: Increasing the temperature, surface area, or concentration all lead to an increase in the rate of a reaction because they all increase the* ***number of effective collisions between reactant particles****.* ○ Explain, in terms of the number of bonds broken, why ionic compounds generally react faster than covalent compounds ○ Explain how a catalyst speeds up a reaction
○ Energy released or absorbed during a chemical reaction can be represented by a **potential energy diagram**. ○ The difference in PE of the products and reactants is called the **heat of reaction (ΔH)** ΔH = PE products – PE reactants ○ ΔH values for many chemical reactions are listed in Table I	○ Read and interpret a potential energy diagram ○ Draw and label the following parts of a potential energy diagram for both an endothermic and exothermic reaction □ PE of reactants and PE of products □ heat of reaction (ΔH) □ activation energy (for both the **forward and reverse reactions**) □ activation energy with a catalyst present
○ Chemical and physical changes can reach **equilibrium** ○ **Saturated solutions** are examples of systems in physical equilibria (aq ↔ s)	○ Distinguish between examples of physical equilibria and chemical equilibria
○ At equilibrium, the rate of the **forward reaction** equals the rate of the **reverse reaction** and the measurable quantities of reactants and products remain constant at equilibrium*CARE*	○ Describe what is happening to the concentrations or amounts of reactants and products in a system at equilibrium ○ Describe the rates of opposing reactions in a system at equilibrium
○ **LeChatelier's principle** can be used to predict the effect of a **stress** (such as a change in pressure, volume, concentration, or temperature) on a system at equilibrium. ○ According to LeChatelier's principle, a system at equilibrium will "**shift**" to reduce the effects of a stress placed on the system. It will "shift" AWAY from an INCREASE and will "shift" *toward* a *decrease* in concentration or temperature ("shift" means that either	○ Describe, in terms of LeChatelier's principle, the effects of stress on a given system at equilibrium, including: □ Changing the temperature/heating/cooling □ Changing the concentration of a reactant or product □ Changing the pressure or volume (this affects systems involving gases)

the forward or the reverse reaction will be "**favored**" (go *faster*) until the rates are again equal and equilibrium is re-established). ○ Changing the pressure or volume only affects systems that contain gases	○ Also be able to explain why any shifting occurs in terms of Collision Theory
○ **Systems in nature tend to undergo changes toward lower energy and higher entropy.**	

Goal setting: Based upon your learning style results and the information above list at least two techniques you plan to use to study during this unit.

1.
2.

What grade would you like to achieve on this unit based on your efforts? _____%

Lesson 1: <u>Chapter Diary 14</u>

Objective: To summarize unit concepts

Directions: After reading the Chapter diary answer the following questions.

<u>1. Describe the Collision theory.</u>

<u>2. Factors affecting reaction rate:</u>

a. Concentration- a measure of the amount of solute that is dissolved in a given quantity of solvent.

- As concentration increases the frequency of collisions _____.
(decrease/increase)
- Reaction rate increases with a(n) _____ in concentration.
(decrease/increase)

b. Temperature- a measure of the average kinetic energy of particles.

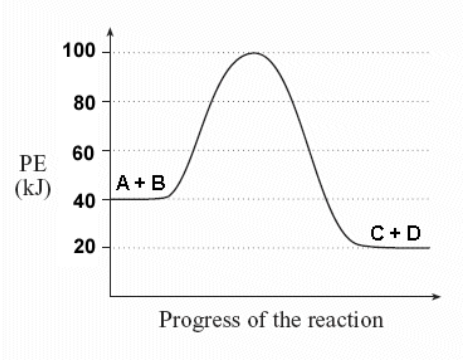
- As temperature increases molecules have greater KE (moving faster) and therefore _____collisions occur.
(more/less)
- Reaction rate increases with a(n) _____ in temperature.

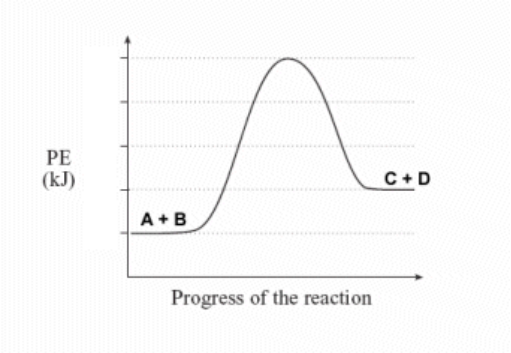
c. Surface Area- a measure of how much exposed area an object has.

- As surface area increases the particles have a greater area for collisions to occur and therefore, more effective collisions take place.
Reaction rate increases with a(n) _____ *(decrease/increase)* in surface area.

d. Adding a **Catalyst**- a substance that _____(slows down/speeds up) the reaction and allows an alternate path for the reaction with lower activation energy (energy needed for the reaction to occur).

3.





REACTION #1 **REACTION #2**

1. Which reaction (#1 or #2) is exothermic? Explain.

2. Which reaction (#1 or #2) is endothermic? Explain.

List 10 facts from the reading

List any questions you may have from your reading:

Lesson 2: Reaction Rates Date:_____

Objective: To compare and contrast factors that may affect the rate of a chemical reaction

Check your understanding: Fill-in-the-Blanks

Word Bank: ***attractions, collide, chemical change, alignment, high, effective***

If particles are going to react with each other, they have to actually _____ with each other. When particles hit each other, they may just bounce off each other. In this case, no _____, or "reaction" will take place. Chemists call collisions between particles that result in a reaction (chemical change) "_____" collisions. The collision will more likely be effective if it happens at _____ speed and proper

_____.

Practice: Factors Affecting Reaction Rates

Directions: Read the following passage and answer the questions suing complete sentences

Kinetics

Kinetics is a branch of Chemistry that studies the rate or speed of chemical reactions. There are many factors that determine the rate of reactions including temperature, the nature of reactants, concentration of reactants, pressure, surface area, and the presence of a catalyst. To understand how each of these factors affects the rate of a chemical reaction you must first understand the collision theory. The collision theory is one of the basic concepts of kinetics and it states that in order for a reaction to occur, reactant particles *must* collide. Collisions between particles will result in a chemical reaction if they collide with the proper alignment and amount of energy. The following discusses the various factors what will alter the rate of a chemical reaction. All of these factors affect the rate of a reaction by affecting the rate of collisions that take place between particles.

Nature of Reactants

All reactions involve the breaking of existing bonds and the formation of new bonds. As a general rule covalent compounds take more time to break down than ionic compounds. This is due to the fact that in covalent compounds more bonds must be broken than in ionic compounds. Relating the nature of reactants to the collision theory, the breaking of more bonds requires that particles have more energy when they collide, thus covalent compounds take more time to react.

Concentration of Reactants

The collision theory states that particles must collide with proper alignment and energy. Therefore, it is logical that the more particles that are present in a given area (which happens when you increase concentration) the more likely particles are to collide with one another. Therefore, as a general rule chemical reactions will proceed faster if the concentration of one or more of the reactants are increased.

Pressure

Pressure has little to no effect on the rate of reactions between solids and liquids. However, pressure does play a role in the rate of reaction among gases. As pressure is increased gases are compressed making gas particles closer together and more likely to collide. Therefore, an increase of pressure will increase the rate of reaction *for gases only.*

Temperature

Recall that temperature measures the average kinetic energy of particles. Therefore, the higher the temperature the faster the particles are moving. If particles are moving faster, they are much more likely to collide. We can relate this to the collision theory (which says that particles MUST collide) by reasoning that a higher temperature will result in more collisions and a faster rate of a chemical reaction. Additionally, at a higher temperature particles are not just moving faster they also have a greater energy. Therefore, not only will more collisions occur, but the reacting particles will collide with more energy, making the collisions more effective! For example, milk will sour faster at room temperature than it does in the refrigerator.

Surface Area

When more surface area of a reactant is exposed to the air there are more chances for reactant particles to collide, therefore increasing the reaction rate. Given this, a finely divided powder will react more rapidly than a single lump of the same mass. Think about which will dissolve faster – a cube of sugar or individual granules of sugar? The granules of sugar will dissolve faster because they have more surface area exposed to the air or the solvent that it is being dissolved in.

Catalyst

A catalyst is a substance that is neither a reactant nor a product, but functions to speed up the rate of a chemical reaction by lowering activation energy. Another way of saying this is that the catalyst "provides a shorter or alternate

pathway" for a reaction to occur. It is important to note that the catalyst does take part in a reaction, but remains unchanged when the reaction is complete. Your body is loaded with enzymes, which are natural catalysts that perform several important jobs like breaking down carbohydrates and proteins in your stomach and small intestine.

Questions:

1) As the number of effective collisions between reacting particles increases what will happen to the rate of the reaction? Explain.

_____

2) Which of the following pairs of reactants will react most quickly? Be sure to give an explanation for your answer.

a. sodium chloride and silver nitrate
b. ethane (C_2H_6) and oxygen (O_2)

Reason: _____

3) Given the reaction: $2\ Mg_{(s)} + O_{2(g)} \rightarrow 2\ MgO_{(s)}$
List four ways that you could speed up the rate of the reaction:

1. _____ 3. _____
2. _____ 4. _____

4) Why does raising the temperature speed up the rate of reaction?

_____

5) Factors that affect the rate of reaction are:

a) _____, or the substances used
b) _____, or the average kinetic energy of the molecules
c) _____, or the amount of contact between reactants
d) _____, which determines how close particles are to one another.
e) _____, which lowers the activation energy for a reaction.

6) Explain how rate determining step and reaction rate are related.

_____

7) What is the area of chemistry concerned with the speed of reactions? _____

8) Do all chemical reactions take place at the same speed? Why or why not?

_____

9) Which statement most correctly describes the collision theory?

a) if molecules collide with either proper alignment or enough energy, then a reaction will occur
b) when molecules collide a reaction always occurs
c) collisions between particles often result in a reaction

Lesson 3: Energy in reactions Date:_____

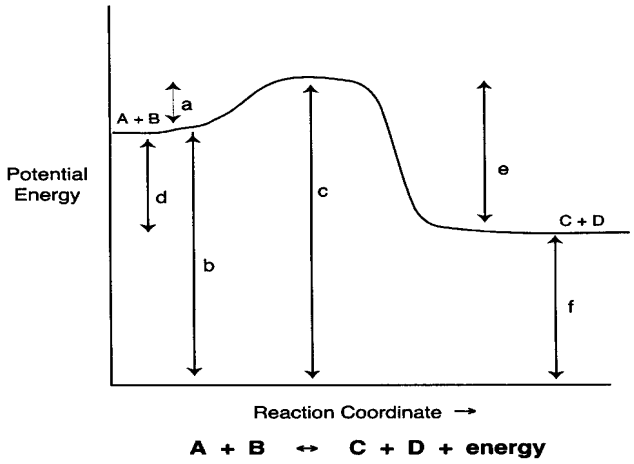
Objective: To apply changes during a reaction in energy to a PE diagram

Check your understanding:

1. Fill in the table

Reaction	ΔH (kJ)	Endothermic or Exothermic
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\mathbf{l})$		
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$		
$C_2H_5OH(\mathbf{l}) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\mathbf{l})$		

2. Potential energy released or absorbed by a chemical reaction can be represented by a potential energy diagram.



Answer Questions #1-7 below based on the diagram above.

1. What letter represents the energy of the reactants? _____

2. What letter represents the energy of activation of the forward reaction? _____

3. What letter represents the change in energy (Δ H) for the reaction)? _____

4. Would the Δ H value be (+) or (-)? Explain your choice.

5. Is the forward reaction exothermic or endothermic? How do you know?

6. Sketch a dotted line to the curve to indicate what happens when a catalyst is added.

7. Explain why a catalyst makes the reaction go faster.

Practice: Table I Worksheet

Reaction	ΔH (kJ)	Endothermic or Exothermic
$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$		
$4H_2O(l) + 3CO_2(g) \rightarrow C_3H_8(g) + 5O_2(g)$		
$2Al_2O_3(s) \rightarrow 4Al(s) + 3O_2(g)$		
$*CO(g) + ½O_2(g) \rightarrow CO_2(g)$		
$*4NO(g) \rightarrow 2N_2(g) + 2O_2(g)$		

1. If you reverse a reaction, what happens to the magnitude of ΔH? What happens to the sign?

2. If you double the concentration of the reactants and the products, what happens to the magnitude of ΔH? What happens to the sign?

3. If the ΔH for a given forward reaction is positive, will the reverse reaction be endothermic or exothermic?

4. If a given reaction is exothermic, will heat be found on the reactants side of the equation or the products side?

5. If a given reaction is endothermic, what will be the sign for ΔH for the reverse reaction?

6. Using the graph below please draw a reaction potential energy diagram for a reaction with the following characteristics:

Potential Energy of Reactants = 350 kJ/mole
Activation Energy of Forward Reaction = 100 kJ/mole
Potential Energy of Products = 150 kJ/mole

7. Is the reaction from question #6 an endothermic or exothermic reaction? _____

8. Please identify the following on the diagram you created in question #6. Place this letter above its corresponding line segment on the graph and the value in the adjacent column.

Component of Potential Energy Diagram	**Symbol**	**Value**
Potential Energy of Reactants	A	
Potential Energy of Products	B	
Potential Energy of Activated Complex	C	
Heat of Reaction	D	
Activation Energy of Forward Reaction	E	
Activation Energy of Reverse Reaction	F	

9. Using a dotted line, show how the reaction potential energy diagram would be altered upon the addition of a catalyst to the reaction in the graph above.

10. If a catalyst were added, which lettered quantities, if any would change?

11. How would the addition of a catalyst affect the heat of reaction?

Lesson 4: Equilibrium **Date:_____**

Objective: To compare and contrast the different types of system equilibriums

Check your understanding:

Define *equilibrium* in terms of reactant and product concentrations:

Define *equilibrium* in terms of forward and reverse reaction rates:

Practice:

Equilibrium: Most reactions are reversible. Equilibrium is a state of balance between two opposing reactions (physical or chemical) occurring at the same rate. Equilibrium is dynamic and only describes the overall appearance of the system. It does not describe the activity of individual particles. The word dynamic implies motion, and dynamic equilibrium is that condition in which the interaction of the particles of the reactants in direction is balanced by the interaction of the particles of the products in the opposite direction. Although the reaction rates for the opposing reactions are equal, a state of equilibrium may exist in which the quantities of reactants and products are not equal. Thus equilibrium may be reached when only a small quantity of the products has been formed or when only a small amount of the reactants remains. For a system in equilibrium, a change in conditions (such as temperature, concentration, or pressure) may result in a change in the equilibrium point. Because reactions in an equilibrium are reversible, it follows that equilibrium may be attained either from the forward or the reverse reaction.

Phase Equilibrium: In general, phase changes (solid to liquid, or liquid to gas) are reversible and, in a closed system, equilibrium may be attained. In general, if a solid or a liquid is confined in a closed container, eventually there will be enough particles in the vapor phase so that the rate of return is equal to the rate of escape. Thus, a dynamic equilibrium results in which there is an equilibrium vapor pressure characteristic of the solid or the liquid.

Solution Equilibrium: Gases in Liquids: In a closed system, equilibrium may exist between a gas dissolved in a liquid and the undissolved gas above the liquid. The equilibrium between dissolved and undissolved gas is affected by temperature and pressure.
Solids in Liquids: A solution equilibrium exists when the opposing processes of dissolving and crystallizing of a solute occur at equal rates. A solution exhibiting equilibrium between the dissolved and undissolved solute must be a saturated solution.
Solubility: The solubility of a solute is defined as the maximum mass of that solute dissolved in a given volume of solvent under specified conditions. Solubility may be defined as the concentration of solute in a saturated solution.

Chemical Equilibrium: Chemical equilibrium is attained when the concentration of the reactants and products remains constant. When observable changes (such as color, pressure, and temperature) no longer occur in a reacting chemical system. The system has reached a state of equilibrium. At this point the forward reaction and the reverse reaction are occurring at equal rates.

Questions:

The following conditions **must** exist for a change (physical or chemical) to reach equilibrium:

1. **The reaction (change) must be able to go _____ and backward.**
   (For example: burning wood can never be at equilibrium, because the products can't go back to be the wood again.)

2. **The system must be _____.**
   (For example: if a gas is produced and flies away, it's not around to go back to being the reactants.)

3. **The amounts of products and reactants do not change.**
   Since the rate at which product is being made in the forward is equal to the rate at which the product is being "unmade" in the _____ reaction, the amounts of products and reactants has stopped changing, and the system has achieved "_____". This does NOT imply that there are the _____(same/different) amounts of products and reactants.

4. **Chemical equilibrium is attained when…**

Lesson 5: Le Chatelier's Principle **Date:_____**

Objective: To apply Le Chatelier's principle to a system at equilibrium and predict the changes on the system

Check your understanding:

Match the change to the equilibrium system below with the letter of the appropriate response.
Each letter can be used once, more than once, or not at all.

$$2SO_{2(g)} + O_{2(g)} \leftrightarrows 2SO_{3(g)}$$

_____ 1) O_2 is added to the reaction
_____ 2) SO_3 is removed from the reaction
_____ 3) SO_3 is added to the reaction
_____ 4) The pressure is increased

a) The equilibrium shifts to the right
b) The equilibrium shifts to the left
c) there is no change in the equilibrium

Practice:

If the statement is true, write "true." If it is false, change the underlined word or words to make the statement true. Write your answer on the line provided.

$$NH_4Cl_{(s)} + \text{heat} \leftrightarrows NH_{3(g)} + HCl_{(g)}$$

_____ 1) The above reaction is <u>exothermic.</u>

_____ 2) The production of ammonia from ammonium chloride will <u>increase</u> at higher temperature.

_____ 3) For the above reaction at equilibrium, an increase in pressure on the system causes a <u>decrease</u> in gaseous ammonia concentration.

4) Describe Le Chatelier's Principle.

5) How is changing the concentration of a reactant in a reaction related to a shift in equilibrium?

6) For the following reaction, what will occur if pressure is increased? Why?

$$2NO_{2(g)} \leftrightarrows N_2O_{4(g)}$$

7) Given the reaction at equilibrium $A_{(g)} + B_{(g)} \leftrightarrows C_{(g)} + D_{(g)}$

The addition of a catalyst will:

a) shift equilibrium to the right
b) shift equilibrium to the left
c) increase the rate of the forward and reverse reactions
d) have no effect on the rate of the forward and reverse reactions

8) Consider the equation of the following reaction at equilibrium:

$$X + Y \leftrightarrows 2Z + \text{heat}$$

The concentration of the product can be increased by

a) adding a catalyst
b) adding more heat to the system
c) increasing the concentration of Y
d) decreasing the concentration of Z

9) Consider the following equation: $H_{2(g)} + Cl_{2(g)} \leftrightarrows 2HCl_{(g)}$

Which change will result in an increase in the concentration of chloride gas?

a) decreasing the pressure on the system
b) decreasing the concentration of HCl
c) increasing the concentration of H_2
d) increasing the concentration of HCl

10) Consider the following equation:

$$N_{2(g)} + O_{2(g)} \leftrightarrows 2NO_{(g)}$$

As the concentration of $N_{2(g)}$ increases, the concentration of $O_{2(g)}$ will

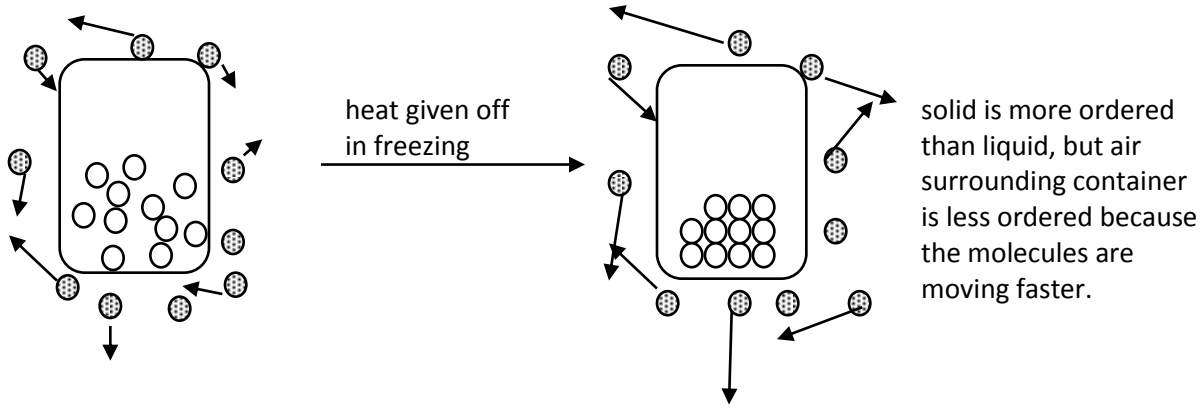
a) decrease b) increase c) remain the same d) vary directly

Lesson 6: Entropy/Enthalpy **Date:_____**

Objective: To define the conditions necessary for a spontaneous reaction to occur

Check your understanding:

An increase in entropy is an increase in **dis**order or increase in energy dispersal.
Everything you do increases the entropy of the universe.
If the system you are looking at decreases in entropy, the environment outside the "system" must increase in entropy.



1. Does the entropy (disorder) increase, decrease or stay the same in the following systems?

a.) CO_2 (s) → CO_2 (g)

b.) H_2O (g) → H_2O (l)

c.) H_2O at 40°C → H_2O at 60°C

d.) C (s) + O_2 (g) → CO_2 (g)

e.) 2 Mg (s) + O_2 (g) → 2 MgO (s)

f.) ice → liquid water

g.) NaCl (s) → Na^+ (aq) + Cl^- (aq)

h.) $Na_2(SO_4)$ (s) → 2 Na^+ (aq) + SO_4^{2-} (aq)

2. As the temperature of a system increases, the entropy of the system:

a.) increases
b.) decreases
c.) remains the same

3. Which two tendencies favor a chemical reaction happening spontaneously?

a.) toward higher energy and less entropy
b.) toward higher energy and more entropy
c.) toward lower energy and less entropy
d.) toward lower energy and more entropy

Practice:

Entropy is the degree of randomness in a substance. The symbol for change in entropy is ΔS. Solids are very ordered and have low entropy. Liquids and aqueous ions have more entropy than solids because they move about more freely. Gases have an even larger amount of entropy because their particles are spread out and are extremely free to move about. Nature *always* proceeds to a state of higher entropy (or randomness).

Determine whether the following reactions show an increase or decrease in entropy based on the individual states [(s), (l), (aq), (g)] within the reaction.

1) $2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$ _____

2) $H_2O_{(l)} \rightarrow H_2O_{(s)}$ _____

3) $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ _____

4) $NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$ _____

5) $KCl_{(s)} \rightarrow KCl_{(l)}$ _____

6) $CO_{2(s)} \rightarrow CO_{2(g)}$ _____

7) $H^+_{(aq)} + C_2H_3O_2^-{}_{(aq)} \rightarrow HC_2H_3O_{2(l)}$ _____

8) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ _____

9) $Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$ _____

10) $2N_2O_{5(g)} \rightarrow 4NO_{2(g)} + O_{2(g)}$ _____

11) $2Al_{(s)} + 3I_{2(s)} \rightarrow 2AlI_{3(s)}$ _____

12) $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$ _____

13) $H_2O_{(g)} \rightarrow H_2O_{(l)}$ _____

Review: Fill in the blanks using the word bank provided below.

activated complex	Le Chatelier's Principle	entropy
heterogeneous reaction	double arrow	reaction mechanism
activation energy	potential energy	exothermic reaction
homogeneous reaction	endothermic reaction	shift
catalyst	rate	heat of reaction***(used
kinetics	enthalpy	twice)
chemical equilibrium	rate-determining step	stress

The branch of chemistry concerned with the rates of chemical changes is called _____. A chemical change in which all the reactants are in the same phase is called a(n) _____. One in which the reactants are in different phases is called a(n) _____. A substance that speeds up a chemical change without being permanently altered or affecting the nature of the reaction is called a(n) _____.

The series of steps by which reacting particles rearrange themselves to form products is called the _____. The slowest step in such a series is the _____. A short-lived, high-energy arrangement of particles that is formed when reacting particles collide at the proper angle with the proper amount of energy is a(n) _____. The minimum amount of energy needed to form this arrangement is called the _____. Because this energy is stored inside the particles, it is an example of _____. The reactants and the products of any reaction have different amounts of this kind of stored energy. The difference between these two amounts of energy is the _____.

The heat content of a substance is called its _____. The change in this quantity that occurs during a chemical reaction is called the _____, ΔH. The sign of the quantity ΔH is positive in the case of a(n) _____. It is negative in the case of a(n) _____. When forward and backward reactions occur at the same _____, a state of _____ exists. A(n) _____is used in an equation to symbolize this state. When conditions such as temperature are changed, a chemical reaction is said to be placed under a(n) _____. Under such changing conditions, equilibrium can undergo a(n) _____ in direction that tends to counteract the imposed changes. This generalization is known as _____.

The measure of the randomness of a system is its _____.

Law, Theories, BIG ideas	**Equations, Calculations, Reference Tables**
Laws:	Equation: (When to use & units)
Theories:	Calculations (When to use)
BIG ideas:	Reference Table (Hints & tricks)

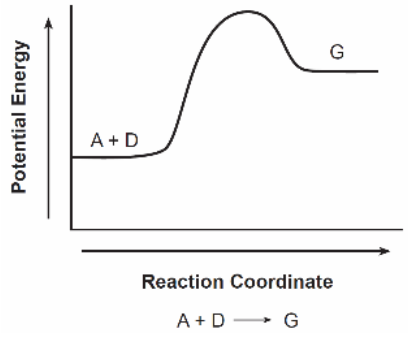
Helpful tips, sayings, shortcuts

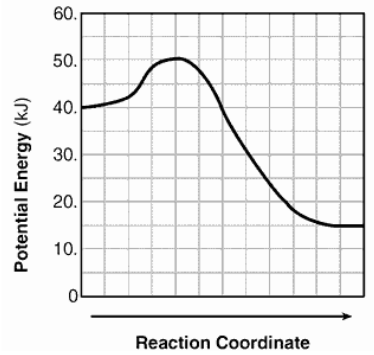
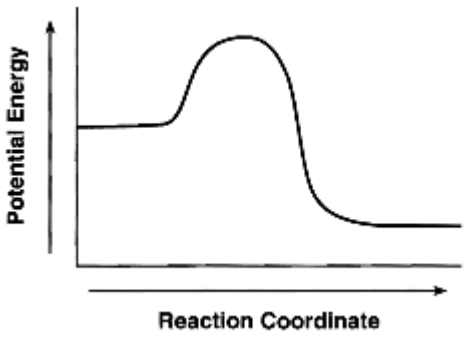
Things I always forget…

Place a checkmark next to each item that you can do! If a sample problem is given, complete it as evidence.

_____1. I can still do everything from Unit 1.	
_____2. I can still do everything from Unit 2.	
_____3. I can still do everything from Unit 3.	
_____4. I can still do everything from Unit 4.	
_____5. I can still do everything from Unit 5.	
_____6. I can still do everything from Unit 6.	
_____7. I can still do everything from Unit 7.	
_____8. I can still do everything from Unit 8.	
_____9. I can define effective collision and collision theory	**<u>Definition:</u>** effective collision collision theory
_____10. I can state and apply the relationship between temperature and reaction rate in terms of collision theory.	As the temperature ________________________, the reaction rate for most chemical reactions _________________________ because there are _______ effective collisions between particles. - Given the reaction: $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ At which temperature would the reaction occur at the greatest rate? A) 0^oC B) 15^oC C) 95^oC D) 273K
_____11. I can state and apply	

the relationship between surface area and reaction rate in terms of collision theory.	As the surface area _____, the reaction rate _____ because there are _____ effective collisions between particles. At STP, which 4.0 g sample of Zn(s) will react most quickly with dilute hydrochloric acid? A) lump B) bar C) powdered D) sheet metal
_____12. I can state and apply the relationship between concentration and reaction rate in terms of collision theory.	As the concentration _____, the reaction rate _____ because there are _____ effective collisions between particles. At 20^{o}C, a reaction between powdered Zn(s) and hydrochloric acid will occur most quickly if the concentration of the HCl is A) 1.0 M B) 1.5 M C) 2.5 M D) 2.8 M
_____13. I can state the unit used to measure energy.	Energy is measured in _____.
_____14. Based on the location of the energy term, I can determine if the reaction is exothermic or endothermic.	Given the following balanced equation: $I + I \text{ -----> } I_2 + 146.3\ kJ$ Is this reaction exothermic or endothermic? Justify your answer.
_____15. I can use Table I to determine if a reaction is exothermic or endothermic.	Which balanced equation represents an endothermic reaction? A) $C(s) + O_2(g) \rightarrow CO_2(g)$ B) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell)$ C) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ D) $N_2(g) + O_2(g) \rightarrow 2NO(g)$

_____16. I can define potential energy diagram, reaction coordinate, $PE_{reactant}$, $PE_{product}$, heat of reaction (ΔH), activation energy, catalyst.	**<u>Definitions:</u>** potential energy diagram reaction coordinate $PE_{reactant}$ $PE_{product}$ heat of reaction (ΔH) activation energy catalyst entropy
_____17. Given a potential energy diagram, I can determine if the reaction is exothermic or endothermic.	Give the potential energy diagram below, determine if the reaction is exothermic or endothermic. Justify your answer. 

_____18. Given a potential energy diagram, I can determine the $PE_{reactant}$, $PE_{product}$, ΔH, and activation energy.	Given the potential energy diagram below, determine the $PE_{reactant}$, $PE_{product}$, ΔH, and the activation energy.  $PE_{reactant}$ = $PE_{product}$ = ΔH = activation energy =
_____19. Given a potential energy diagram for an uncatalyzed reaction diagram, I can how the diagram will change when a catalyst is been added.	Draw a dotted line on the potential energy diagram shown below to indicate how it will change if a catalyst is added. 
_____20. I can rank the three phases of matter from least entropy to most entropy.	Least entropy Most entropy _____<_____<_____
_____21. I can state the trends in nature for entropy and energy.	In nature most systems in nature tend to undergo reactions that have a(n) _____ in entropy and a(n) _____ in energy. As Mrs. S says, nature is like a teenager ---- lazy and messy!

_____22. Given a balanced equation, I can determine if the reaction results in an overall increase or decrease in entropy.	Which reaction results in an increase in entropy? A) $CO_2(g) \rightarrow CO_2(s)$ B) $H_2O(\ell) \rightarrow H_2O(s)$ C) $Ca(s) + 2\ H_2O(\ell) \rightarrow Ca(OH)_2(aq) + H_2(g)$ D) $NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$ --- Which equation shows an increase in entropy? A) $CO_2(g) \rightarrow CO_2(s)$ B) $CO_2(\ell) \rightarrow CO_2(g)$ C) $CH_3OH(\ell) \rightarrow CH_3OH(s)$ D) $CH_3OH(g) \rightarrow CH_3OH(\ell)$ --- Which reaction has the greatest increase in entropy? A) $2\ H_2O(\ell) \rightarrow 2\ H_2(g) + O_2(g)$ B) $2\ H_2O(g) \rightarrow 2\ H_2(g) + O_2(g)$ C) $H_2O(g) \rightarrow H_2O(\ell)$ D) $H_2O(\ell) \rightarrow H_2O(s)$
_____23. I can define forward reaction, reverse reaction, reversible reaction, and closed system	**<u>Definitions:</u>** forward reaction reverse reaction reversible reaction closed system
_____24. I can state the three types of equilibrium.	The three types of equilibrium are: _____ equilibrium _____ equilibrium and _____ equilibrium

_____25. I can state two conditions that apply to all systems at equilibrium.	In a system at equilibrium the _____ of the forward and reverse reaction must be _____ and the _____ of the reactants and products must be _____.
_____26. Given a list of reactions, I can identify reactions that show equilibrium (chemical, phase, or solution).	Which balanced equation represents phase equilibrium? A) $H_2(g) + I_2(s) \text{ <-----> } 2HI(g)$ B) $I_2(s) \text{ <-----> } I_2(g)$ C) $KCl(s) \overset{H_2O}{\text{<-----> }} KCl(aq)$ D) $2KCl(s) + 3O_2(g) \text{ -----> } 2KClO_3$ Which balanced equation represents solution equilibrium? A) $H_2(g) + I_2(s) \text{ <-----> } 2HI(g)$ B) $I_2(s) \text{ <-----> } I_2(g)$ C) $KCl(s) \overset{H_2O}{\text{<-----> }} KCl(aq)$ D) $2KCl(s) + 3O_2(g) \text{ -----> } 2KClO_3$ Which balanced equation represents chemical equilibrium? A) $H_2(g) + I_2(s) \text{ <-----> } 2HI(g)$ B) $I_2(s) \text{ <-----> } I_2(g)$ C) $KCl(s) \overset{H_2O}{\text{<-----> }} KCl(aq)$ D) $2KCl(s) + 3O_2(g) \text{ -----> } 2KClO_3$
_____27. In terms of saturation, I can describe a solution that is at equilibrium.	In terms of saturation, a solution that is at equilibrium must be _____.
_____28. I can state LeChatelier's Principle.	LeChatelier's Principle states

_____29. Given a balanced equation at equilibrium, I can predict the direction of shift in the equilibrium when the temperature, concentration, or pressure is changed or if a catalyst is added.

Given the reaction at equilibrium:

$2SO_2(g) + O_2(g) \text{ <-----> } 2SO_3(g) + 392kJ$

Predict the direction of shift in the equilibrium (right, left, no shift) when the following changes are made to the system.

Change	Direction of Shift
Increase concentration of SO_2	
Increase concentration of SO_3	
Increase temperature	
Increase pressure	
Add a catalyst	