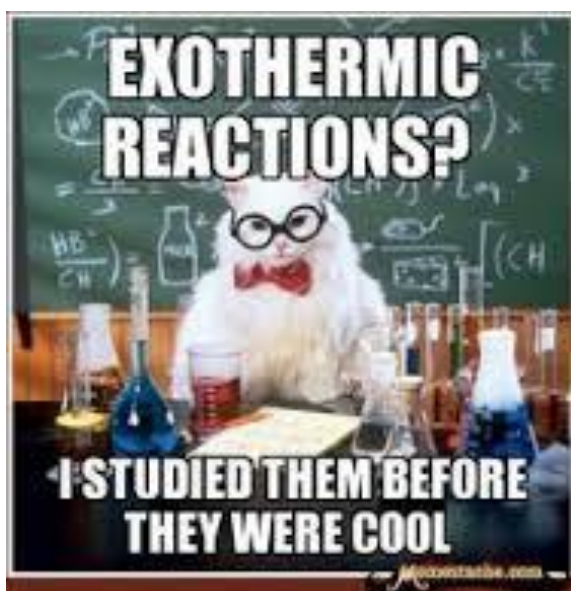


Practice Packet Unit 11: Kinetics and Equilibrium



Vocabulary

Reaction Rate: _____

Entropy: _____

Potential Energy: _____

Activation energy: _____

Le Chatelier's Principle: _____

Activated complex: _____

Spontaneous reaction: _____

catalyst: _____

heat of the reaction ΔH : _____

Heat of the reactants: _____

Heat of the products: _____

Collision Theory: _____

Effective Collision: _____

Le Chatelier's Principal



Drawn by John Beckwith on June 9, 2011 for Dr. Robert's Inorganic Chemistry II

LESSON 1: Energy Changes in Chemical Reactions (Review)

Objective:

- Distinguish between endothermic and exothermic reactions.
- Use Table I (ΔH) to determine the type of reaction.

Key Ideas:

WORD BANK: (not all words may be used)

Absorbed	Heat of Reaction	I	Minus	Reactant
Conserved	Heat of Products	Kinetic	Potential	Released
Gained	Heat of Reactants	Lost	Product	T

- In chemical reactions, _____ energy (stored in bonds) and _____ energy (heat) can be converted, however total energy is _____.
- In endothermic reactions, heat is _____. In a reaction equation, heat would be a _____.
- In exothermic reactions, heat is _____. In a reaction equation, heat would be a _____.
- All exothermic reactions are given a _____ value on Table I.

_____ of a reaction is measured by subtracting: _____ minus _____ . These values can be found on table _____ .

PRACTICE USING TABLE I:

1. How much heat is required to produce 1 mole of C_2H_2 ? _____
2. How much heat is required to produce 2 moles of C_2H_2 ? _____
3. If you reverse a reaction what happens to the magnitude of ΔH ? What happens to the sign?
4. If the ΔH for a given forward reaction is positive, will the reverse reaction be endothermic or exothermic?
5. Is the decomposition of C_2H_6 endothermic or exothermic? _____

Complete the following chart using Table I. The first one is shown as an example.

Reaction	ΔH (kJ)	Endo or Exo-thermic	Reaction Equation (with heat as either a reactant or product)
$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$	-890.4	EXO	$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 890.4\text{kJ}$
$2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$			
$\text{C}_2\text{H}_5\text{OH}(\text{l}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$			
$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$			
$2\text{Al}_2\text{O}_3(\text{s}) \rightarrow 4\text{Al}(\text{s}) + 3\text{O}_2(\text{g})$			
$*4\text{NO}(\text{g}) \rightarrow 2\text{N}_2(\text{g}) + 2\text{O}_2(\text{g})$			
Potassium nitrate dissociating into a positive potassium ion and a negative nitrate ion			

Regents Practice:

- Given the equation representing a reaction:
 $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g}) + \text{CO}_2(\text{g}) + \text{heat}$
 Which statement is true about energy?
 A) The reaction is exothermic because it releases heat.
 B) The reaction is exothermic because it absorbs heat.
 C) The reaction is endothermic because it releases heat.
 D) The reaction is endothermic because it absorbs heat.
- Which balanced equation represents an endothermic reaction?
 A) $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$
 B) $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
 C) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
 D) $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}(\text{g})$
- According to Table I, which salt releases energy as it dissolves?
 A) KNO_3 B) LiBr C) NH_4NO_3 D) NaCl
- Given the balanced equation representing a reaction at 101.3 kPa and 298 K:
 $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g}) + 91.8 \text{ kJ}$
 Which statement is true about this reaction?
 A) It is exothermic and ΔH equals -91.8 kJ .
 B) It is exothermic and ΔH equals $+91.8 \text{ kJ}$.
 C) It is endothermic and ΔH equals -91.8 kJ .
 D) It is endothermic and ΔH equals $+91.8 \text{ kJ}$.
- Which expression represents the ΔH for a chemical reaction in terms of the potential energy, PE, of its products and reactants?
 A) PE of products + PE of reactants
 B) PE of products – PE of reactants
 C) PE of products \times PE of reactants
 D) PE of products / PE of reactants
- According to Table I, which equation represents a change with the greatest quantity of energy released?
 A) $2\text{C}(\text{s}) + 3\text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_6(\text{g})$
 B) $2\text{C}(\text{s}) + 2\text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_4(\text{g})$
 C) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
 D) $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}(\text{g})$

37. Base your answers to the following questions on the information below.

A hot pack contains chemicals that can be activated to produce heat. A cold pack contains chemicals that feel cold when activated.

a Based on energy flow, state the type of chemical change that occurs in a hot pack.

b A cold pack is placed on an injured leg. Indicate the direction of the flow of energy between the leg and the cold pack.

c What is the Law of Conservation of Energy? Describe how the Law of Conservation of Energy applies to the chemical reaction that occurs in the hot pack.

ADDITIONAL PRACTICE LESSON 1:

Reaction	ΔH (kJ)	Endo or Exo	Reaction Equation with Heat as Reactant or Product
$\text{CO}_2(\text{g}) \rightarrow \text{C}(\text{s}) + \text{O}_2(\text{g})$			
$\text{NH}_4\text{Cl}(\text{s}) \rightarrow \text{NH}_4^+(\text{aq}) + \text{Cl}^-(\text{aq})$			
$2\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{CH}_3\text{OH}(\text{l}) + 3\text{O}_2(\text{g})$			
Sodium hydroxide dissociating into a positive sodium ion and a negative hydroxide ion			

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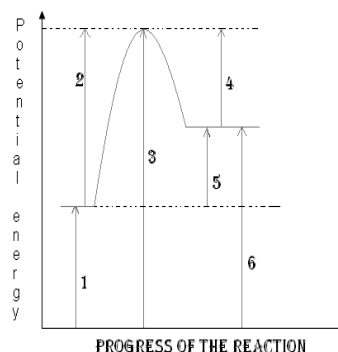
LESSON 2: POTENTIAL ENERGY DIAGRAMS

Objective:

- Label potential energy diagrams and determine the type of diagram represented

Key Ideas:

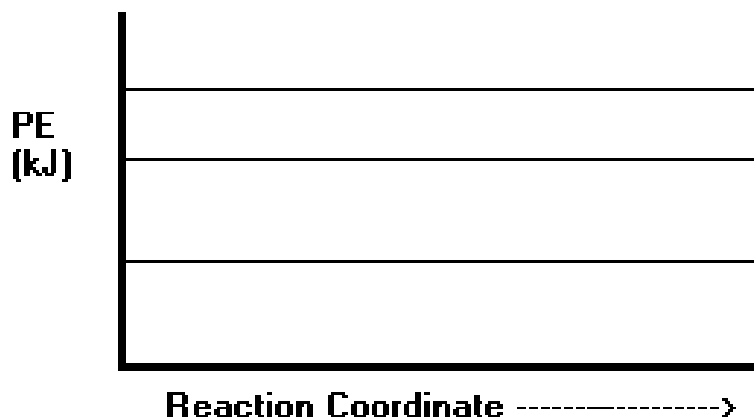
- The _____ energy is the energy needed to start a reaction. It is labeled on the diagram with ____.
- The activated complex is the point with the _____ energy on the graph. It is labeled on the diagram with the number ____.
- The _____ are always at the beginning of a reaction and is labeled here with the number ____.
- The _____ are always at the end of a reaction and is labeled here with the number ____.
- The heat of the reaction is the _____ between the products and the reactants and is labeled here with the number ____.
- Reactions that have products with higher energy than reactants, such as the one in the diagram, are _____ thermic reactions.



For the reaction on table I that creates Aluminum oxide, write the reaction equation and the ΔH then sketch the PE curves:

RXN: _____ \rightarrow _____

$\Delta H =$ _____



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REGENTS PRACTICE:

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LESSON 3: Collision Theory and Factors that Affect Reaction Rate

Objective:

- *Determine what factors affect the rate of reaction*

1. In order for a reaction to occur the particles must _____ with proper _____ and _____. Therefore, the more collisions the reactant particle have, the faster the rate of the reaction.

2. Recall 5 ways to *increase* the rate of reaction. Be specific.

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

3. Matches have the potential to burn on fire. But they will not without sufficient activation energy. Explain what activation energy means and what type of activation energy the matches need.

4. Explain in terms of collision theory why increasing the temperature increases the rate of a reaction/

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Regents Practice:

5. Which event must *always* occur for a chemical reaction to take place?
- formation of a precipitate
 - formation of a gas
 - effective collisions between reacting particles
 - addition of a catalyst to the reaction system
6. Increasing the temperature increases the rate of a reaction by
- lowering the activation energy
 - increasing the activation energy
 - lowering the frequency of effective collisions between reacting molecules
 - increasing the frequency of effective collisions between reacting molecules
7. After being ignited in a Bunsen burner flame, a piece of magnesium ribbon burns brightly, giving off heat and light. In this situation, the Bunsen burner flame provides
- ionization energy
 - activation energy
 - heat of reaction
 - heat of vaporization
8. As the number of effective collisions between reacting particles increases, the rate of reaction
- Decreases
 - increases
 - remains the same
9. In most aqueous reactions as temperature increases, the effectiveness of collisions between reacting particles
- Decreases
 - increases
 - remains the same
10. Given the reaction: $\text{Mg} + 2\text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2 + \text{H}_2$
At which temperature will the reaction occur at the greatest rate?
- | | |
|---------|----------|
| A) 25°C | B) 50°C |
| C) 75°C | D) 100°C |
11. A 5.0-gram sample of zinc and a 50.-milliliter sample of hydrochloric acid are used in a chemical reaction. Which combination of these samples has the fastest reaction rate?
- a zinc strip and 1.0 M HCl(aq)
 - a zinc strip and 3.0 M HCl(aq)
 - zinc powder and 1.0 M HCl(aq)
 - zinc powder and 3.0 M HCl(aq)

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12. A 1.0-gram piece of zinc reacts with 5 milliliters of HCl(aq). Which of these conditions of concentration and temperature would produce the greatest rate of reaction?
- 1.0 M HCl(aq) at 20.°C
 - 1.0 M HCl(aq) at 40.°C
 - 2.0 M HCl(aq) at 20.°C
 - 2.0 M HCl(aq) at 40.°C
13. At STP, which 4.0-gram zinc sample will react fastest with dilute hydrochloric acid?
- lump
 - powdered
 - bar
 - sheet metal
14. Given the reaction:
- $$\text{Fe(s)} + 2 \text{HCl(aq)} \rightarrow \text{FeCl}_2\text{(aq)} + \text{H}_2\text{(g)}$$
- In this reaction, 5 grams of powdered iron will react faster than a 1-gram piece of solid iron because the powdered iron
- has less surface area
 - has more surface area
 - is less dense
 - is more dense
15. Which statement best explains the role of a catalyst in a chemical reaction?
- A catalyst is added as an additional reactant and is consumed but not regenerated.
 - A catalyst limits the amount of reactants used.
 - A catalyst changes the kinds of products produced.
 - A catalyst provides an alternate reaction pathway that requires less activation energy.
16. Which change would most likely increase the rate of a chemical reaction?
- decreasing a reactant's concentration
 - decreasing a reactant's surface area
 - cooling the reaction mixture
 - adding a catalyst to the reaction mixture
17. In terms of collisions, why does an increase in concentration lead to an increase in the rate of the reaction?

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LESSON 4: SPONTANEOUS REACTIONS

Objective:

- Determine if a reaction is spontaneous
- Determine if entropy increases or decreases in a reaction

Key Ideas - Entropy:

- Entropy measures the _____ in a system.
- The _____ phase has the most entropy because its particles move the most.
- Nature favors reactions which result in _____ (*higher or lower*) entropy and _____ (*higher or lower*) energy, i.e., _____ thermic where the PE of the products is _____ (greater or less than) the PE of the reactants.

Rank order the following states of matter (solid, liquid, gas, aqueous) in terms of entropy from lowest to highest:

Least entropy: _____

Most entropy: _____

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



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11. Fill in the table below.

Reaction	Change in Energy (endo /exothermic)	Entropy (Increases or decreases)	BONUS!! NAME THAT PROCESS!
a.) $\text{CO}_2(\text{s}) \rightarrow \text{CO}_2(\text{g})$			
b.) $\text{I}_2(\text{g}) \rightarrow \text{I}_2(\text{s})$			
c.) $\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{l})$			
c.) $\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{aq})$			
c.) $\text{NH}_4^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{NH}_4\text{Cl}(\text{s})$			
d.) $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$			

Questions:

- Which substance has the highest entropy?
a. $\text{Xe}_{(\text{g})}$ b. $\text{S}_{(\text{s})}$ c. $\text{Hg}_{(\text{s})}$
- Which substance has the lowest entropy?
a. H_2O at -120°C b. H_2O at 0°C c. H_2O at 100°C
- When a system becomes less random the entropy
a. Increases b. decreases c. remains the same
- Which shows an increase in entropy?
a. $\text{H}_2\text{O}_{(\text{s})} \rightarrow \text{H}_2\text{O}_{(\text{l})}$ b. $\text{H}_2\text{O}_{(\text{g})} \rightarrow \text{H}_2\text{O}_{(\text{l})}$ c. $\text{H}_2\text{O}_{(\text{l})} \rightarrow \text{H}_2\text{O}_{(\text{s})}$
- In the following reaction, the entropy is $\text{CaCO}_{3(\text{s})} \rightarrow \text{CaO}_{(\text{s})} + \text{CO}_{2(\text{g})}$
a. Increasing b. decreasing c. remaining the same
- A chemical reaction is spontaneous if
a. There is a gain of energy and entropy increases
b. There is a gain of energy and entropy decreases
c. There is a loss of energy and entropy increases
d. There is a loss of energy and entropy decreases

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LESSON 5: EQUILIBRIUM

Objective:

- Describe the types of physical equilibrium.
- Describe the concentration of particles and rates of opposing reactions in a system at equilibrium.

Key Ideas - Equilibrium:

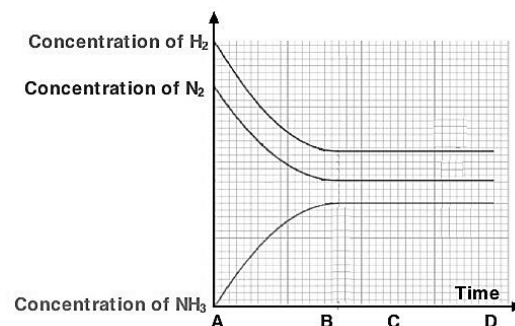
WORD BANK (Not all words will be used:

Boiling	Dissolving	Less than	Phases	Saturated
Closed	Equal to	Melting	Precipitating	Super saturated
Concentrations	Greater than	Open	Rates	Unsaturated

-
- Equilibrium requires the rate that the reaction forms products must be _____ the rate that the reaction forms reactants.
- Equilibrium states that a reversible reaction has equal _____ not necessarily equal amounts.
- Equilibrium can be between _____, e.g. the rate of freezing = rate of melting, which can only occur at the _____ point of the substance.
- In solution equilibrium, rate of _____ = rate of _____. The solution must be _____ to be at equilibrium.
- Equilibrium can only be achieved in a _____ (*closed or open*) system.

Consider the diagram on the right:

1. What condition(s) describe a system at equilibrium?
Equal _____; Constant _____
2. For the diagram to the right
 - a. Write the reaction equation for the system at equilibrium
 - b. At what time is equilibrium is achieved in the system.
3. Why is this described as “dynamic” equilibrium



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Regents Practice:

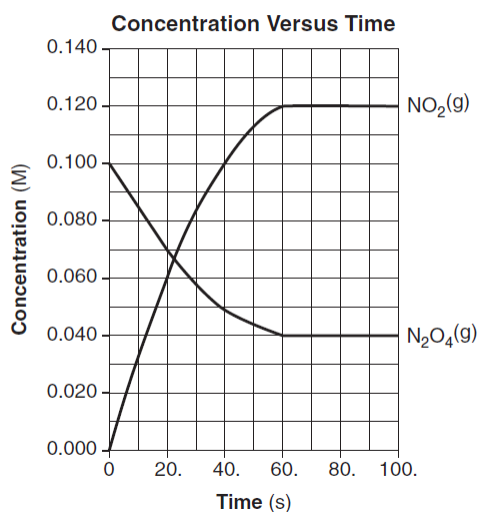
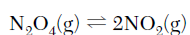
1. What occurs when a reaction reaches equilibrium?
 - A) The concentration of the reactants increases.
 - B) The concentration of the products increases.
 - C) The rate of the forward reaction is equal to the rate of the reverse reaction.
 - D) The rate of the forward reaction is slower than the rate of the reverse reaction.
2. Which changes can reach dynamic equilibrium?
 - A) nuclear changes, only
 - B) chemical changes, only
 - C) nuclear and physical changes
 - D) chemical and physical changes

3. Given the equation representing a system at equilibrium:



Which statement describes this system:

- A) The concentration of $\text{PCl}_5(\text{g})$ is increasing.
 - B) The concentration of $\text{PCl}_5(\text{g})$ is decreasing.
 - C) The concentrations of $\text{PCl}_5(\text{g})$ and $\text{PCl}_3(\text{g})$ are equal.
 - D) The concentrations of $\text{PCl}_5(\text{g})$ and $\text{PCl}_3(\text{g})$ are constant.
4. A reaction reaches equilibrium at 100 °C. The equation and graph representing this reaction are shown below:



The graph shows that the reaction is at equilibrium after 60 seconds because the concentration of both $\text{NO}_2(\text{g})$ and $\text{N}_2\text{O}_4(\text{g})$ are

- A) increasing
- B) decreasing
- C) constant
- D) zero

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LESSON 6: STRESSES ON EQUILIBRIUM (Le Chatelier's Principle)

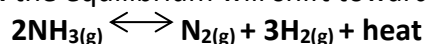
Objective:

- Determine the shift in equilibrium when a stress is placed on a system
- Determine the change in concentration when a stress is placed on a system

Key Ideas:

- When changes are made to a system at equilibrium the system will react to reduce the stress as follows:
- When a reactant is added the reaction shifts away from the reactant to make more _____.
- When a product is added the reaction shifts away from the product to make more _____.
- When a reactant is taken the reaction shifts _____ the reactant to restore it.
- When a product is taken the reaction shifts _____ the product to restore it.
- When heat is added to a reaction the reaction shifts _____ from the heat, much like a reactant or product. Therefore if heat is removed (or taken) the reaction shifts _____ heat.
- When a gaseous system increases in pressure or decreases in volume the system can hold fewer moles. Therefore the reaction shifts towards the side with _____ moles.
- Catalysts affect both forward and reverse reaction rates _____, therefore have _____ on equilibrium.

1. Circle which **direction** the equilibrium will shift towards to relieve the stress:



- | | | | |
|--------------------------|------|-------|-----------|
| a. Ammonia is added | left | right | no effect |
| b. Nitrogen is added | left | right | no effect |
| c. Heat is added | left | right | no effect |
| d. Ammonia is removed | left | right | no effect |
| e. Hydrogen is removed | left | right | no effect |
| f. Pressure is increased | left | right | no effect |
| g. A catalyst is added | left | right | no effect |

2. Circle what will happen to the concentration of **Nitrogen** to relieve the stress:



- | | | | |
|--------------------------|----------|----------|-----------------|
| a. Heat is added | increase | decrease | remain the same |
| b. Ammonia is added | increase | decrease | remain the same |
| c. Hydrogen is added | increase | decrease | remain the same |
| d. A catalyst is used | increase | decrease | remain the same |
| e. Pressure is decreased | increase | decrease | remain the same |

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3. List four changes you could make to the system in order to produce more phosphorous pentachloride:



_____	_____
_____	_____

REGENTS PRACTICE

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TICKET TO THE TEST

Unit 11 Kinetics

Directions: Answer all questions and show all work. Use your notebook, homework, and videos to help you review all the concepts. I might ask you to come up with your own examples. Come after school if you have questions. You should be supplying me with anything you think may be tested. Then, use this as a study sheet. It is due BEFORE the test. No late tickets will be accepted. This could be worth up to 5 points on the test. The more you show, the more points you get, the more you might actually remember!

1. Explain what two parameters are needed in order for a reaction to be considered effective. Draw examples of reactions and give analogies.

Effective collisions need proper _____ and _____



Analogy:

2. List and explain the five factors that affect the rate of reaction and how they do it:
 - a. _____
 - b. _____
 - c. _____
 - d. _____
 - e. _____
3. Go back into your homework and class packets and find a question about reaction rates that you got wrong the first time. Give the question and explain the correct answer:
4. Pretend you are the teacher. Create a question that you could ask in order to judge if your students know what factors affect reaction rates and why. Create the question and answer.

Question:

Answer:

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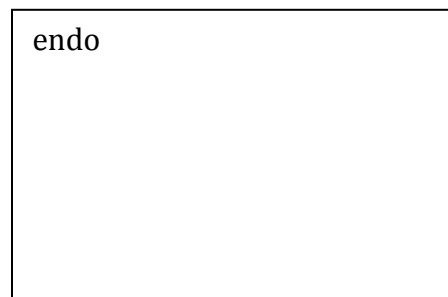
5. Using table I give examples for the following:

- Endothermic reaction: _____
- Exothermic reaction: _____
- Doubling a reaction and finding the heat of reaction:
- Reversing a reaction and finding the heat of reaction:

POTENTIAL ENERGY DIAGRAMS:

6. Draw an exothermic and an endothermic potential energy diagram and label the following with a-e:

- Reactants
- Products
- Activated complex
- Activation energy
- Heat of reaction



7. Compare and contrast your two drawings.

8. If values were given, how could you calculate the heat of reaction?

HEAT OF REACTION =

9. What factors (a-e) change when a catalyst is added? Why? What does a catalyst do?

Factors that change with a catalyst: _____

Role of a catalyst: _____

10. Why do these PE diagrams have a “bump” even though energy is sometimes exothermic and releasing?

11. Give examples of **ACTIVATION ENERGY:** _____

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12. If you were the teacher, what additional question would you ask to measure a student's understanding of PE diagrams?

Question:

Answer:

13. Define entropy:

ENTROPY: _____

14. Give examples of:

a. A phase change where entropy increases:

b. A phase change where entropy decreases:

15. How do changes in temperature affect entropy?

16. What two factors make reactions spontaneous?

SPONTANEOUS REACTIONS _____

Example:

17. **What is equal about equilibrium?** _____

18. What special sign do equilibrium reactions get?



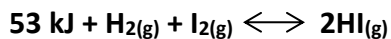
19. At equilibrium, what happens to the quantities of reactants and products?

20. Give a word that describes a solution at equilibrium:

Only a _____ solution can be at equilibrium.

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21. Using the following reaction, construct questions about concentration, pressure, volume, catalyst, and temperature changes on the system and then answer them.



<u>Question</u>	<u>Answer</u>
a. _____	_____
b. _____	_____
c. _____	_____
d. _____	_____
e. _____	_____

22. What topics do you still need to study after completing this packet? Show me work for additional examples you have done:

What is your goal grade on this kinetics test? Be reasonable. _____
Do you really feel you did enough to achieve that goal? Why or why not?