Name: ____ Period: ____________

Equilibrium and Rates- Guided Notes Part 1

What is a Chemical Reaction and how do they occur?

- A chemical reaction is a process that involves ________________________ of atoms
- Law of Conservation of ______________________: Mass is neither created or destroyed
- Balance and model the following reaction: ____H_2 + ____O_2 $\leftrightarrow$ ____H_2O

- Explain how the atoms are rearranged

- Why are there double arrows in the reaction?

Equilibrium

- __________________________ reaction: reaction involving reactants and products in the same state
- __________________________ reaction: reaction involving reactants and products in different states
- ________________________: the exact balance of two processes, one of which is the opposite of the other
- ___________________________ _________________________: is when the **rate** of the forward reaction is the same as the **rate** of the reverse reaction
- At equilibrium concentrations of all reactants and products remain _________________________________
- Chemical Equilibrium is _______________________ equilibrium (constantly changing)
- Does NOT mean same _________________________ of reactants and products
- H_2O + CO $\leftrightarrow$ H_2 + CO_2
  - Equilibrium will occur when…
    - _______________________ of the forward rxn= _______________ of reverse rxn
    - When concentration of all reactants and products remain______________________
    - Does NOT mean concentration of reactants and products are ______________________
    - It is a *dynamic state* (reactants constantly _________________________ to products and products constantly _____________________ to reactants)

Equilibrium Expression

- Reactions are given the following general format: aA + bB $\leftrightarrow$ cC + dD
- Where A, B, C, D are chemical ______________________________________
- a, b, c, d are __________________________________
- Equilibrium expression: $K = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ (Products over reactants)
- Remember [ ] indicate _______________________________________ in M
- ________ is a constant called the equilibrium constant
- Used to ___________________________________ the equilibrium of a reaction

- Solids and Liquids are ___________________ included in the equilibrium expression
  - The concentration of solids and liquids cannot change, so we ignore them
- Practice: Write the equilibrium expression for the following reactions:
  1) NH_4NO_3 (aq) + ←→ N_2O (g) + $2H_2O$ (g)

  2) $2KClO_3$ (s) ←→ 2KCl (s) + $3O_2$(g)

  3) CO_2 (g) + MgO (s) ←→ $MgCO_3$ (s)
  4) Suppose that for the reaction below it is determined that the equilibrium concentrations are [N_2] = 0.000104 M, [Cl_2] = 0.000201 M, and [NCl_3]= 0.141M. Write the equilibrium expression and solve for the equilibrium constant. N_2 (g) + $3Cl_2$ (g) ←→ $2NCl_3$ (g)

Conditions that Affect Reaction Rates

1) **Nature of Reactants**- Substances vary greatly in their tendency to react depending on their _____________________ strengths and structure. Only effect ________________, but not ____________________
2) **Catalysts and Inhibitors-** Only effect _____________________, but not _______________________ because they effect the rate of both the forward and reverse reaction
3) **Pressure-** Increase in pressure means increases _______________________________. This _____________________ the rate of reaction.
4) **Concentration-** More molecules means more collisions. This _____________________ the rate of reaction.
5) **Temperature-** Higher temp means higher speeds which means more collisions. This _____________________ the rate of reaction.

Le Chatelier's Principle

- LeChatelier's Principle (also called _______________________________ ____________)- when stress is applied to a system the system will shift in an effort to offset that stress and establish a new ___________________________
- A stress is a change in _______________________, _____________________________, or _____________________
  - Pure ______________________ and _________________________, along with catalysts and inhibitors do NOT effect equilibrium
- These stressors will cause the forward or the reverse reaction __________________ to change, shifting equilibrium
- The shift will be
  - towards _________________/ ___________________ are favored/ to the _________________

    OR
  - towards _________________/ ___________________ are favored/ to the _________________

- Change in Concentration
  - If concentration is increased, the equilibrium will shift ______________________ from the increase
    - If more of a substance is _________________________, the system will shift in a way that will use up the substance added
  - If concentration is decreased, the equilibrium will shift ________________________ the decrease
    - If substance is _________________________, the system will shift in a way that will produce more of that substance
  - Practice: $N_{2\,(g)} + 3\,H_{2\,(g)} \leftrightarrow 2\,NH_{3\,(g)}$
    1) What happens if I increase concentration of N_2?

    2) What happens if I decrease concentration of H_2?

- Change in Temperature
  - First you have to determine if reaction is endothermic or exothermic.
  - Exothermic reaction- heat is _____________________; heat is treated as a _____________________
  - Endothermic reaction- heat is _____________________; heat is treated as a _____________________
  - Think of heat as a reactant or product (but it's not).
  - Example: $N_{2\,(g)} + 3\,H_{2\,(g)} \leftrightarrow 2\,NH_{3\,(g)} + 92\text{ KJ}$
    1) Is this reaction endothermic or exothermic?
    2) What happens if reaction is heated?

- Change in Pressure
  - A change in pressure will only effect a reaction with ____
  - If the pressure is ___________________________the reaction will shift to the side with ___________________ moles of gas
  - ___________________ are used to determine # of moles
    - _____________________ pressure allows more space for gas
  - If the pressure is __________________________the reaction will shift to the side with ______________________ moles of gas
    - _____________________ pressure, allows less space for gas
  - Example: $N_{2\,(g)} + 3\,H_{2\,(g)} \leftrightarrow 2\,NH_{3\,(g)}$
    1) What happens if I increase the pressure?

    2) What happens if I decrease the pressure?

- Practice:
  1) Which way would the reaction shift if the more pure liquid is added to the reactants? _________________
  2) Which way would the reaction shift if a catalyst was added to the reactants? ________________________
  3) Using the reaction below determine which way the reaction will shift with the following stressors:
     $2H_{2(g)} + O_{2(g)} \leftrightarrow 2H_2O_{(g)} + 95kJ$
     a. Add O_2 ________________________________
     b. Remove H_2 ______________________________
     c. Decrease Pressure ______________________
     d. Increase temperature ___________________
  4) Using the reaction below determine which way the reaction will shift with the following stressors: (remember pure solids and liquids do NOT effect equilibrium): $87.6cal + 2KClO_{3(s)} \leftrightarrow 2KCl_{(aq)} + 3O_{2(g)}$
     a. Add $KClO_3$ _____________________________
     b. Remove O_2 _____________________________
     c. Increase pressure _______________________
     d. Increase temperature ___________________
  5) Using the reaction below determine at least 3 ways you could stress the reaction above to cause an increase in the concentration of oxygen gas. $87.6cal + 2KClO_{3(s)} \leftrightarrow 2KCl_{(aq)} + 3O_{2(g)}$
     a. ____
     b. ____
     c. ____

Equilibrium and Rates- Guided Notes Part 2

How Chemical Reactions Occur

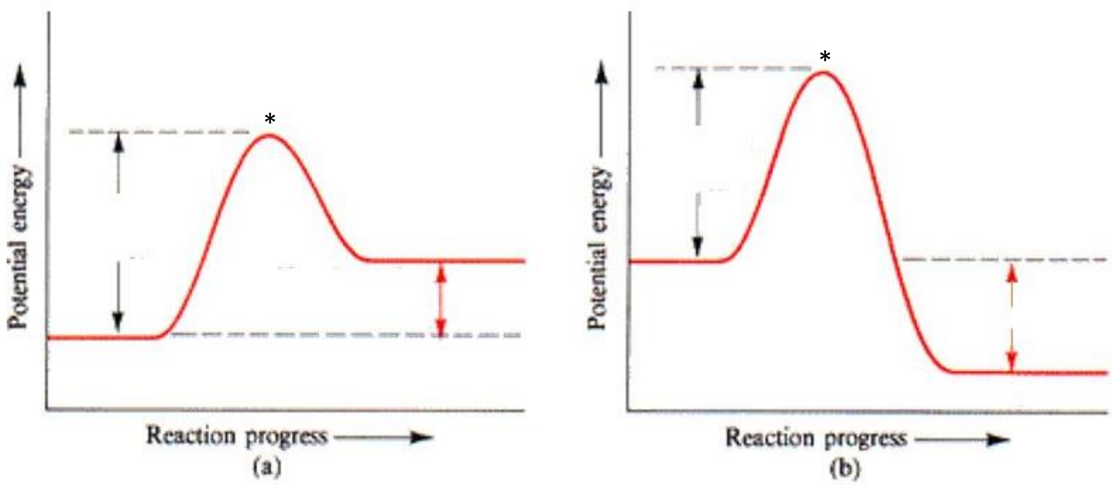
- Collision Theory: molecules must __________________________ with enough ___________________________ and in the proper ____ in order to react
- Do all reactions require energy to occur?

- ______________________________ Energy- The minimum energy required in for a chemical reaction to occur
- What do we call a reaction that absorbs energy? ____
- What do we call a reaction that releases energy? ____

Energy in Reactions

- Once the reactants have gained enough energy (the ________________________________ energy), they are considered to be the __________________________________ _________________________________
  - In other words the activated complex is the reactants with a lot of ________________________________
- After the activated complex state, the reactants ____________________________________ to form the products
- _______________________________________: The change in energy in a reaction
- Represented by __________________________________
- ____ reactions have a +ΔH
- ____ reactions have a -ΔH

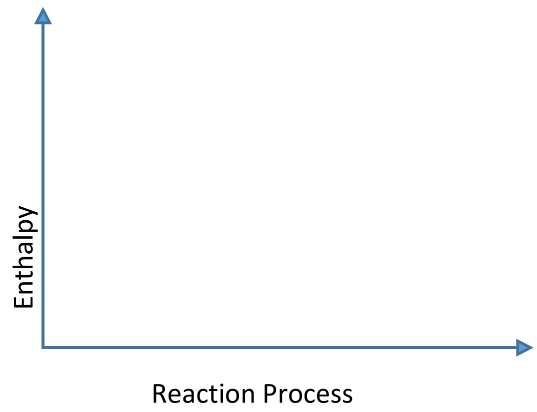
Reaction Coordinate Diagrams



Catalyst and Inhibitors

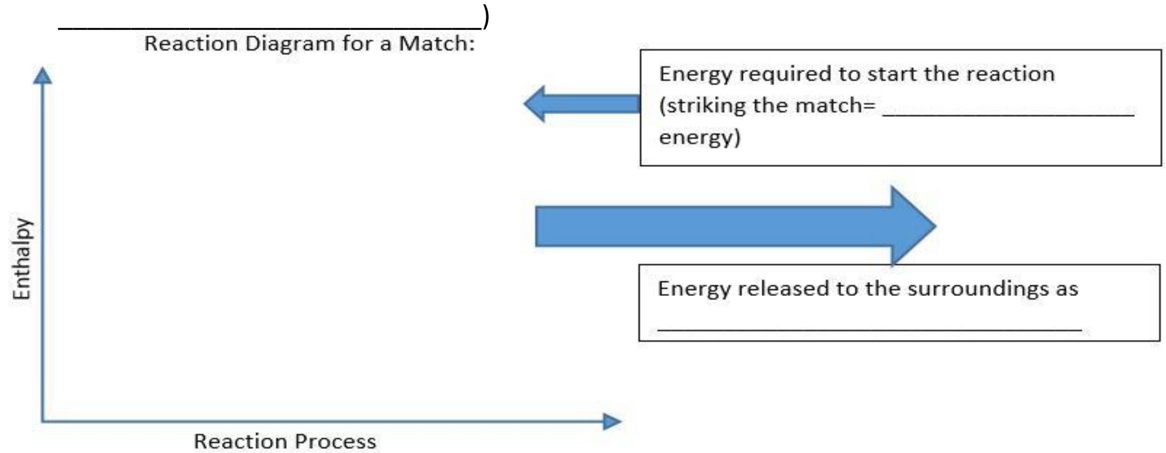
- ______________________________________: a substance that speeds up a reaction without being consumed (____________________ part of the reaction)
- How do catalysts work?
  - They lower the _______________________________________ energy (Now less energy is required for the reaction to take place)
  - They increase the rate of the ________________________AND the ________________________ reaction
- An example of a catalyst is an ____________________________________
  - Enzyme: a large molecule, usually a protein, which catalyzes biological reactions (reactions in your body)
- _____________________________________: a substance that slows down a reaction without being consumed (__________________ part of the reaction)
  - Decreases the rate of the _______________________ AND ______________________reaction

- Draw a Reaction Diagram with and without a catalyst:



Enthalpy

- The amount of energy transferred between the ______________________________________ (the reaction) and the ____
- ΔH = Hproducts - Hreactants
- ΔH = **+** (___________________________)
  - More heat goes from _______________________________________ into system
- ΔH = **-** (______________________________)
  - More heat leaves ____________________________ and goes into surroundings
- Energy is not created or destroyed just transferred between system and surroundings (Law of Conservation of ________________________________)



Hess's Law

- ____________________________________states that the enthalpy of a whole reaction is equivalent to the sum of its steps.
- All reactions have a ________________________
- Most substances have a known __________________________
- ΔH is usually measured in units of ____
- The change in enthalpy is caused by _________________________ breaking and forming
- For example:
  - $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ ΔH = - 967.2 kJ
- What about the reverse reaction?
  - $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$ ΔH = ______________________________kJ

- What if we tripled the amount of water?
  - 3 [$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$]   ΔH = 3 (________________________________kJ)
  - $6H_2O(l) \rightarrow 6H_2(g) + 3O_2(g)$ ΔH = _____________________________kJ
- Hess's Law allows us to add chemical equations to determine potential ΔH of reactions
  - We can ___________________ reactants, products, and ΔH
  - We can simplify, multiply by coefficients, and reverse a reaction
- If a reaction is reversed, ΔH is also reversed
  - $2\ CH_4 + O_2 \rightarrow 2\ CH_3OH$ ΔH_{rxn} = -328 kJ
  - $2\ CH_3OH \rightarrow 2\ CH_4 + O_2$ ΔH_{rxn} = _______________ kJ
- If the coefficients of a reaction are multiplied by an integer, ΔH is multiplied by that same integer
  - $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$ ΔH_{rxn} = -802.5 kJ
  - $2(CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O)$ ΔH_{rxn} = 2(__________________) kJ
  - $2CH_4 + 4\ O_2 \rightarrow 2CO_2 + 4\ H_2O$ ΔH_{rxn} = _____________________ kJ
- Tips for applying Hess's Law:
  - Look at the final equation that you are trying to create first
  - Find a molecule from that equation that is only in one of the given equations
  - Look at each reaction and determine if the products and reactants are on the correct side of the equation- if not reverse the reaction
  - Look to see if each reaction will provide the correct number of reactants and products- if not multiply
  - Next, alter remaining equations to get things to cancel that do not appear in the final equation
- **Hess's Law Example #1:** When methane is burned in oxygen, carbon dioxide and water are produced.
  $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$
- Calculate the change in enthalpy when methane is burned using the following:
  1) $C + 2H_2 \rightarrow CH_4$ ΔH= -74.80 kJ
  2) $C + O_2 \rightarrow CO_2$ ΔH= -393.50 kJ
  3) $H_2 + \frac{1}{2} O_2 \rightarrow H_2O$ ΔH= -285.83 kJ

- **Hess's Law Example #2:** Methanol-powered cars are an idea for alternative fuel What is the change in enthalpy of the reaction for methanol burning in a car? $2\ CH_3OH_{(l)} + 3\ O_{2(g)} \rightarrow 2\ CO_{2(g)} + 4\ H_2O_{(g)}$ ΔH_{rxn} = ?
  - Given the following information:
    1) $2\ CH_{4(g)} + O_{2(g)} \rightarrow 2\ CH_3OH_{(l)}$ ΔH_{rxn} = -328 kJ
    2) $CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(g)}$ ΔH_{rxn} = -802.5 kJ

- Another way to calculate Hess's Law:
  - $\Delta H = \Sigma\Delta H_{f\,(products)} - \Sigma\Delta H_{f\,(reactants)}$
  - What does this mean?
  - ΔH = (the sum of the enthalpy of formation of the products) - (the sum of the enthalpy of formation of the reactants)
  - Be careful adding and subtracting negative numbers
- **Hess's Law Example #3:** When methane is burned in oxygen, carbon dioxide and water are produced. $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$
- Calculate the ΔH when methane is burned using the following:

Substance	ΔH_f
CH_4	-74.80 kJ
O_2	0 kJ
CO_2	-393.50 kJ
H_2O	-285.83 kJ

- **Hess's Law Example #4:** Use the standard enthalpies of formation table to determine the change in enthalpy for the following: $NaOH + HCl \rightarrow NaCl + H_2O$

Substance	ΔH_f
NaOH	-426.70 kJ
HCl	-92.30 kJ
NaCl	-411.00 kJ
H_2O	-285.83 kJ