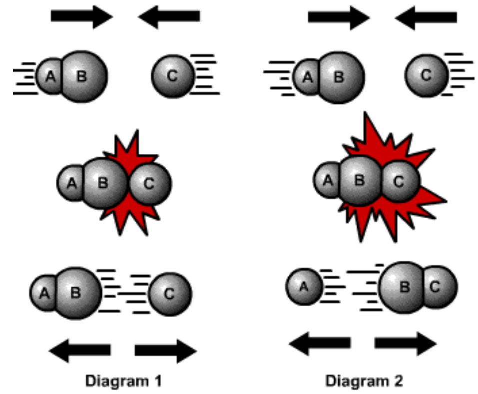
PART 1: CHEMICAL KINETICS



Objective #1: Define Reaction Rates and Effective Collisions

A. Effective Collisions: For a reaction to occur, collisions must occur with sufficient (enough) ______________________ and correct ___________________________.

- Only when particles collide with these two conditions being met will there be a change resulting in a chemical reaction

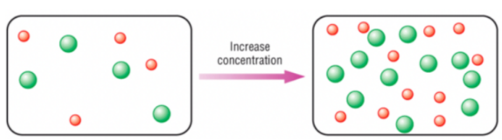
B. Reaction rate: The ____________________ of a reaction
- Measures the rate at which the reactants are consumed and the products are formed

Objective #2: Know the factors that affect the rate of a reaction

SIX factors affect the rate of reaction by changing the number of ______________________ ______________________ that take place between particles.

- The more effective the collisions, the ___________________ the reaction rate!!

1) Concentration

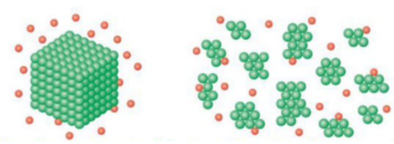


- The ___________________ the concentration, the more likely particles will ____________________, and the reaction rate ___________________

2) Temperature

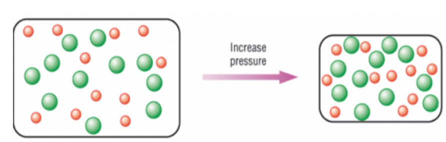
- The ___________________ the temperature, the _________________ the particles move and the more likely they are to____________________, so the reaction rate ____________________.

3) Surface Area



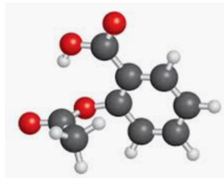
- The ___________________ the surface area, the more exposed the particles are, and the more likely particles will ____________________, and the reaction rate ___________________

4) Pressure



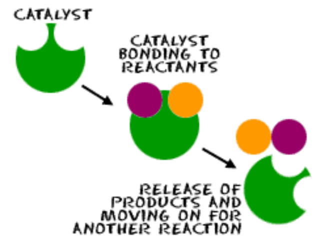
- The ___________________ the pressure, the _________________ the particles are together and the more likely they are to ___________________, so the reaction rate _________________.

5) Nature of Reactant (Ionic vs. Covalent)



- _______________compounds (M + NM) react faster than ____________________ compounds (NM's only) because there are fewer ___________________ to break and the reaction occurs ________________

6) Catalyst



- A <u>catalyst</u> is a substance that speeds up the _____________ of a reaction but is not itself changed or consumed in the reaction
  - provides an _________________ pathway
  - lowers the __________________________ _______________ (aka the "matchmaker")

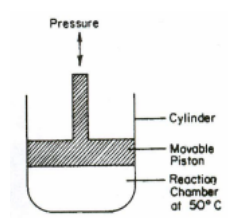
Reaction Rate Practice Questions

1. As the number of effective collisions between reacting particles increases, the rate of the reaction
   (1) decreases (2) increases (3) remains the same

2. Which of the following pairs of reactants will react most quickly?
   (1) sodium chloride and silver nitrate
   (2) water and hydrogen chloride
   (3) hydrogen and propane
   (4) oxygen and carbon VI hydride

3. In the reaction 2 Mg(s) + O_2(g) → 2 MgO(s), as the surface area of the Mg(s) increases, the rate of the reaction
   (1) increases (2) decreases (3) remains the same

4. Consider the following equation: A(g) + B(g) → C(g)
   As the concentration of A(g) increases, the frequency of collisions with B(g)
   (1) increases (2) decreases (3) remains the same



5. The reaction A(g) + B(g) → C(g) is occurring in the apparatus shown to the right.
   The rate of the reaction can be decreased by increasing the
   (1) pressure of the reactants
   (2) temperature of the reactants
   (3) concentration of the reactants
   (4) volume of the reaction chamber

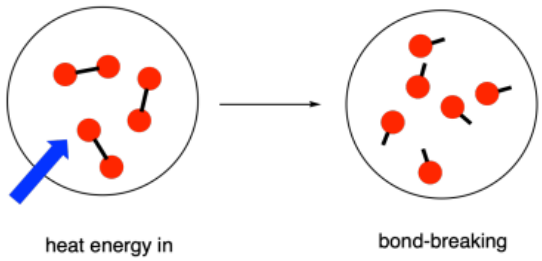
6. Consider the following equation: Mg(s) + H_2O(l) → $Mg(OH)_2$(s) + H_2(g)
   For the reaction to occur at the fastest rate, 1 g of Mg(s) should be added in the form of
   (1) large chunks (2) small chunks (3) a ribbon (4) powder

7. If the pressure on gaseous reactants is increased, the rate of reaction is increased because there is an increase in
   (1) temperature (2) volume (3) concentration (4) heat of reaction

8. Raising the temperature speeds up the rate of chemical reaction by increasing
   (1) the effectiveness of collisions, only
   (2) the frequency of collisions, only
   (3) both the effectiveness and frequency of collisions
   (4) neither the effectiveness nor frequency of collisions

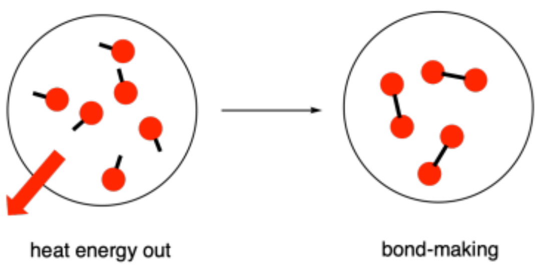
Objective #3: Identifying and labeling Potential Energy diagrams

When a chemical reaction occurs, it can be either an exothermic reaction (____________________ heat) or an endothermic reaction (_____________________ heat). This process can be illustrated with a potential energy diagram, which shows the ___________________ transformation the reactants undergo to form the products.



- If the overall energy to break the bonds is less than the energy released when forming bonds, the reaction is an ____________________________ reaction

Energy is released when new bonds are made.



- If the overall energy to form the bonds is more than the energy to break the bonds, the reaction is an ____________________________ reaction

Exothermic: energy is released (overall) as a product during a chemical reaction

- The products have less energy, so ΔH value is written after the arrow (→) to symbolize heat being released (exiting the system)

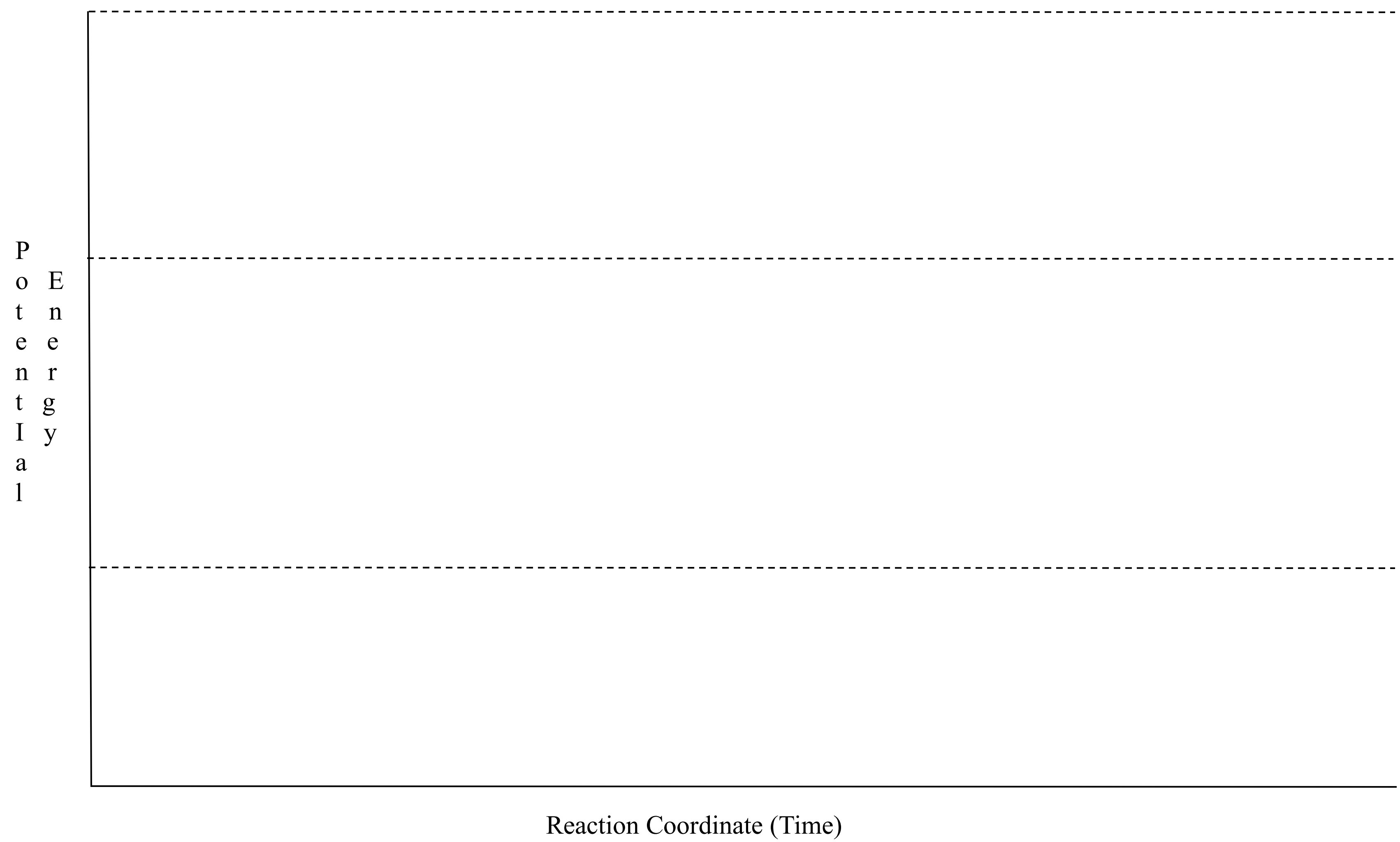
ΔH value will be ___________________

Endothermic: energy is absorbed (overall) as a reactant during a chemical reaction

- The reactants have more energy, so ΔH is written before the arrow (→) to symbolize heat being absorbed (entering the system)

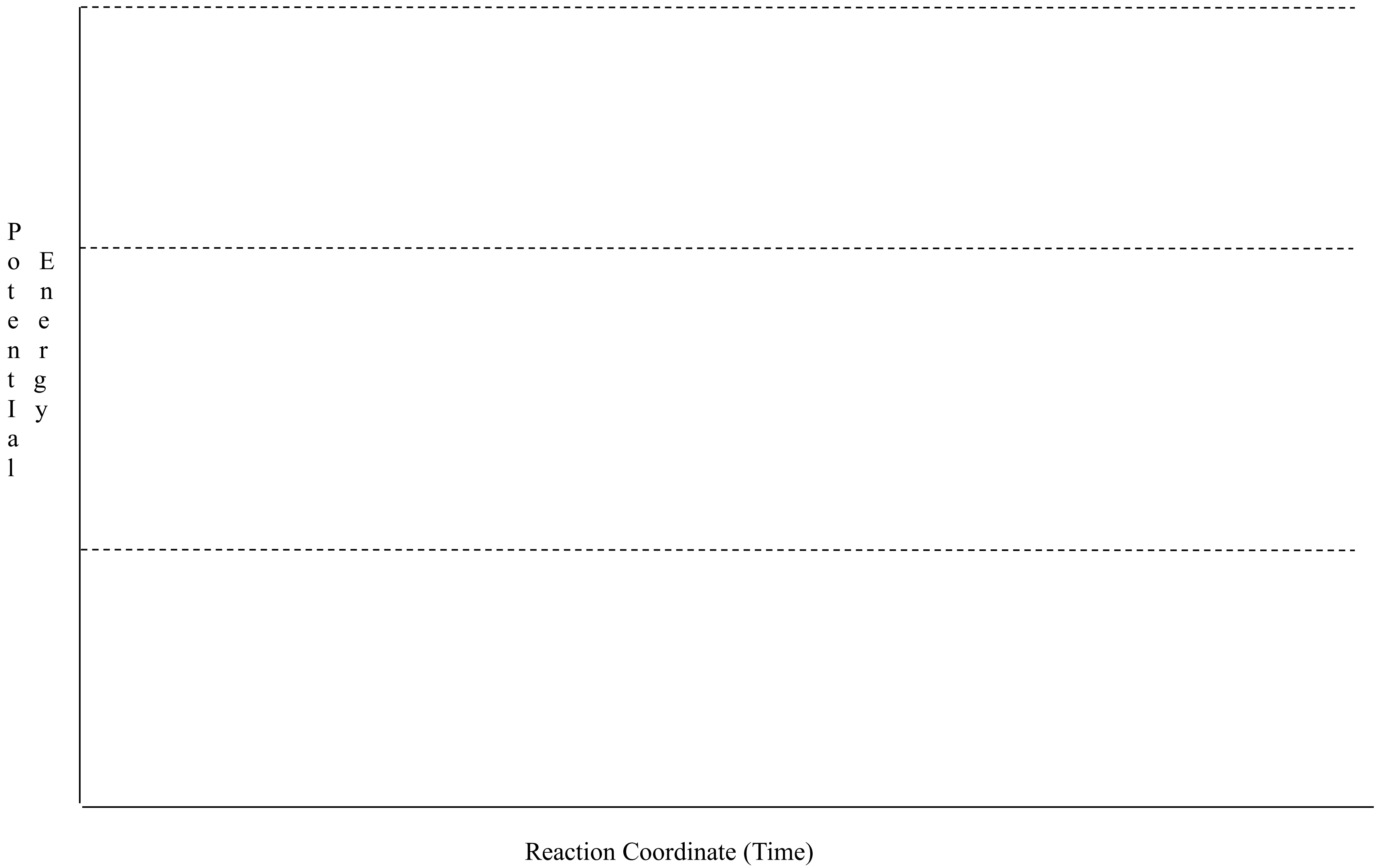
ΔH value will be _______________________

1. Potential Energy (PE) Diagram: EXOTHERMIC reaction



**If a catalyst is added, the reaction pathway will be shorter and hence arrows ______, _______ and ______ change

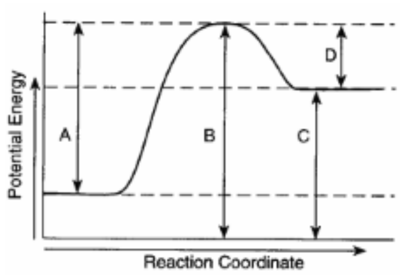
2. Potential Energy (PE) Diagram: ENDOTHERMIC reaction



** If a <u>catalyst</u> is added, the reaction pathway will be shorter and hence arrows ______, _______ and ______ change

PE Diagram Practice Questions

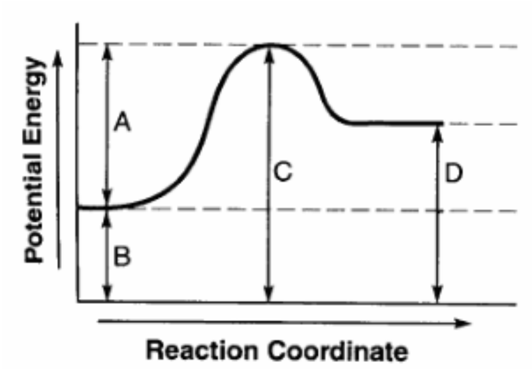
____ 1) Base your answer to the following question on the potential energy diagram of a chemical reaction shown below.



The forward reaction is best described as an

1) exothermic reaction in which energy is released
2) exothermic reaction in which energy is absorbed
3) endothermic reaction in which energy is released
4) endothermic reaction in which energy is absorbed

____ 2) Given the potential energy diagram of a chemical reaction:



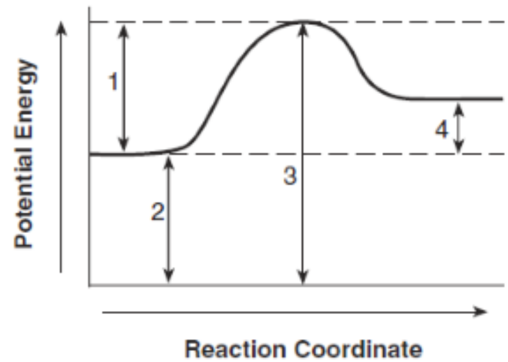
Which arrow represents the potential energy of the reactants?

1) *A* 2) *B* 3) *C* 4) *D*

____ 3) The activation energy required for a chemical reaction can be *decreased* by

1) increasing the surface area of the reactant
2) increasing the temperature of the reactant
3) adding a catalyst to the reaction
4) adding more reactant

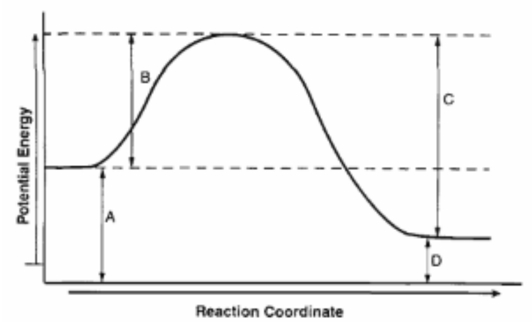
____ 4) Given the potential energy diagram for a reaction:



Which intervals are affected by the addition of a catalyst?

1) 1 and 2
2) 1 and 3
3) 2 and 4
4) 3 and 4

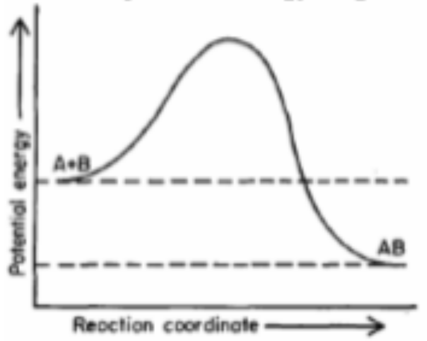
____ 5) A potential energy diagram is shown below.



Which letters represent the activation energy of the forward and reverse reactions, respectively?

1) *A* and *C*
2) *A* and *D*
3) *B* and *C*
4) *B* and *D*

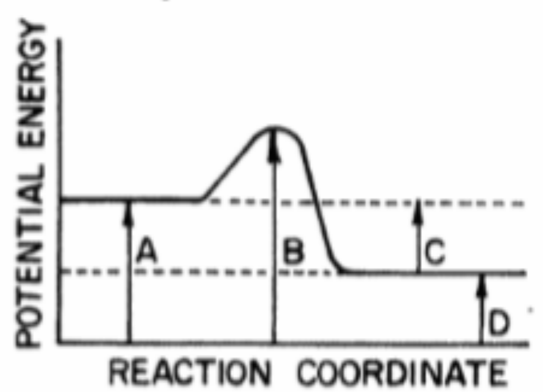
____ 6) Given the potential energy diagram:



With reference to energy, the reaction $A + B \rightarrow AB$ can best be described as

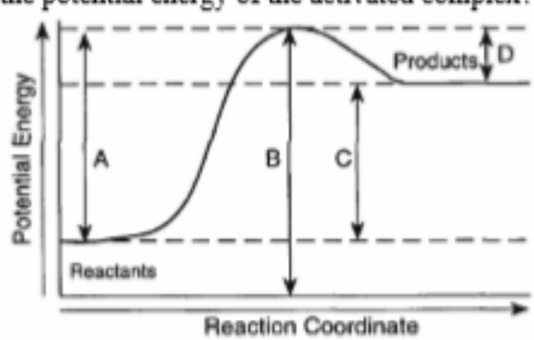
1) endothermic, having a $+\Delta H$
2) endothermic, having a $-\Delta H$
3) exothermic, having a $+\Delta H$
4) exothermic, having a $-\Delta H$

____ 7) In the potential energy diagram below, which letter represents the potential energy of the activated complex?



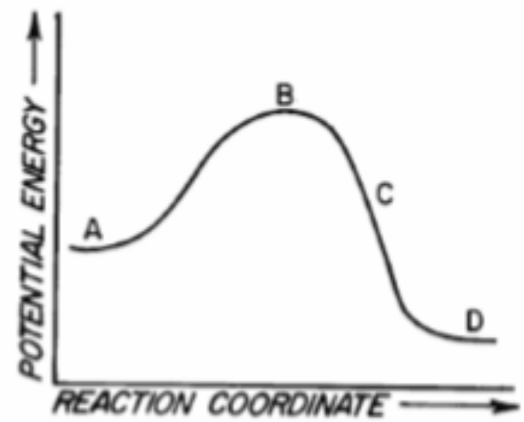
1) *A* 2) *B* 3) *C* 4) *D*

____ 8) In the diagram below, which letter represents the potential energy of the activated complex?



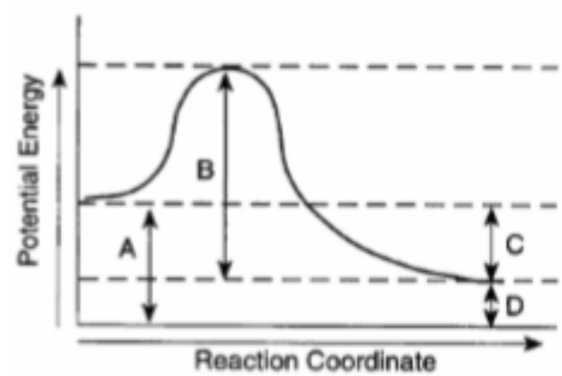
1) *A* 2) *B* 3) *C* 4) *D*

____ 9) The graph below represents the potential energy changes that occur in a chemical reaction. Which letter represents the activated complex?



1) *A* 2) *B* 3) *C* 4) *D*

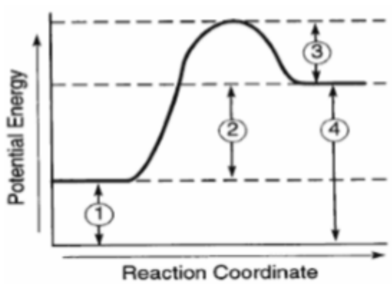
____ 10) The potential energy diagram of a chemical reaction is shown below.



Which arrow represents the potential energy of the products?

1) *A* 2) *B* 3) *C* 4) *D*

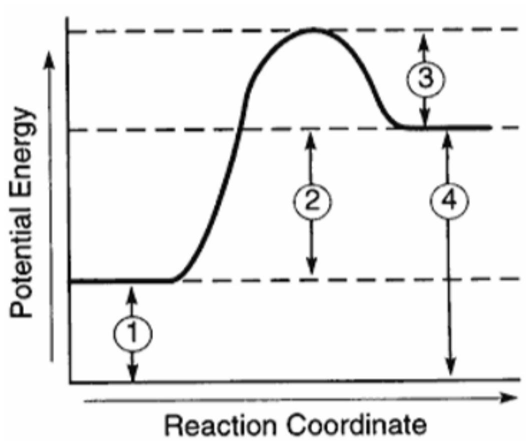
____ 11) Base your answer to the following question on The potential energy diagram of the reaction is shown below.



Which arrow represents the heat of reaction (ΔH) for the reverse reaction?

1) 1 2) 2 3) 3 4) 4

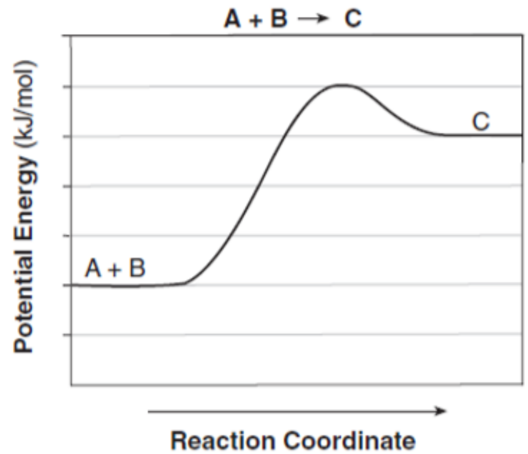
____ 12) The potential energy diagram of the reaction is shown below.



Which arrow represents the activation energy for the reverse reaction?

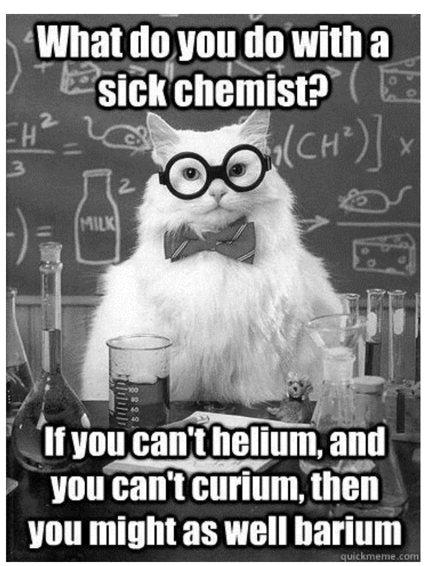
1) 1 2) 2 3) 3 4) 4

____ 13) Given the equation and potential energy diagram representing a reaction:



If each interval on the axis labeled "Potential Energy (kJ/mol)" represents 10. kJ/mol, what is the heat of reaction?

1) +60. kJ/mol 3) +30. kJ/mol
2) +20. kJ/mol 4) +40. kJ/mol

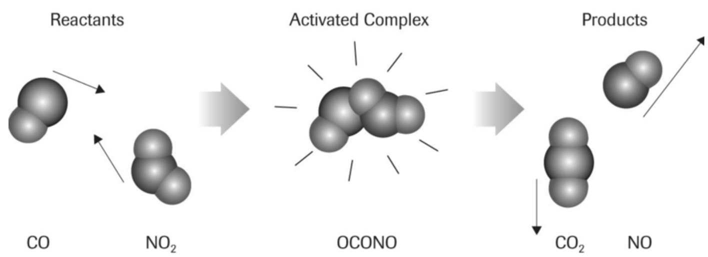


Objective #4: Enthalpy and Heats of a Reaction (ΔH)

A. Enthalpy is the amount of ___________________ (potential energy) a sample of matter has at a certain temperature and pressure.

1. In order for a chemical reaction to begin, a starting amount of energy is required. This comes from the collisions between particles and is called activation energy

- Activation Energy: the _______________________ amount of energy needed to start a chemical reaction
    - o The activation energy will allow the ____ to be formed
        - ▪ This is a temporary intermediate formed as atoms rearrange themselves



2. During a chemical reaction, there is a change in enthalpy (heat energy) as bonds are broken and reformed as new products. This is called the Heat of Reaction, or ΔH
    - o It is recorded as Kilojoules (KJ) or Joules (J)

Formula: ____

B. Using Reference Table I: Heats of Reaction at 101.3 kPa and 298 K
Reference table I provides the overall calculated amount of heat (in kilojoules) absorbed or released during the given chemical reaction. The value assigned for each reaction is called the Heat of Reaction (ΔH)
**** The ΔH values are based on the molar quantities represented in the equations.*

___ 1) Given the reaction:

$CH_4(g) + 2\,O_2(g) \rightarrow 2\,H_2O(g) + CO_2(g)$
What is the overall result when $CH_4(g)$ burns according to this reaction?

1) Energy is absorbed and ΔH is negative.
2) Energy is absorbed and ΔH is positive.
3) Energy is released and ΔH is negative.
4) Energy is released and ΔH is positive.

___ 2) Based on Reference Table I, which reaction is endothermic?

1) $NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$
2) $NH_4Cl(s) \rightarrow NH_4^+(aq) + Cl^-(aq)$
3) $CO(g) + O_2(g) \rightarrow CO_2(g)$
4) $CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(\ell)$

___ 3) According to Reference Table I, which compound released the greatest amount of energy per mole when it is formed from its elements?

1) HI 3) NO
2) CO_2 4) C_2H_4

___ 4) Based on Reference Table I, the formation of 1 mole of which of the following substances releases the greatest amount of energy?

1) C_2H_2 3) CO_2
2) C_2H_4 4) H_2O

If a reaction is re-written with the enthalpy value (ΔH) inserted into the reaction, <u>the kJ value will be placed on the reactant side if it is an endothermic reaction (Endo: **X + kJ** → Y) and on the product side if it is an exothermic reaction. (Exo: X → **Y + kJ**)</u>

___ 1) Given the balanced equation representing a reaction at 101.3 kPa and 298 K:

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) + 91.8$ kJ

Which statement is true about this reaction?

1) It is exothermic and ΔH *equals –91.8 kJ.*
2) It is exothermic and ΔH *equals +91.8 kJ.*
3) It is endothermic and ΔH *equals –91.8 kJ.*
4) It is endothermic and ΔH *equals +91.8 kJ.*

___ 2) Given the balanced equation:

$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s) + 1640$ kJ

Which phrase best describes this reaction?

1) endothermic with $\Delta H = +1640$ kJ
2) endothermic with $\Delta H = -1640$ kJ
3) exothermic with $\Delta H = +1640$ kJ
4) exothermic with $\Delta H = -1640$ kJ

___ 3) Given the reaction:

$H_2O + 286\text{ kJ} \rightarrow H_2 + 0.5\ O_2$

Which statement describes the reverse reaction?

1) It is endothermic and releases 286 kJ.
2) It is endothermic and absorbs 286 kJ.
3) It is exothermic and releases 286 kJ.
4) It is exothermic and absorbs 286 kJ.

___ 4) When one mole of a certain compound is formed from its elements under standard conditions, it absorbs 85 kiloJoules of heat. A correct conclusion from this statement is that the reaction has a

1) ΔH equal to –85 kJ/mole
2) ΔH equal to +85 kJ/mole
3) ΔT equal to –85 kJ/mole
4) ΔT equal to +85 kJ/mole

If the given equation has different molar quantities than what is on Table I, the Heat of Reaction (ΔH) will also have to be adjusted accordingly.

___ 1) Based on Table *I*, what is the ΔH value for the production of 1.00 mole of $NO_2(g)$ from its elements at 101.3 kPa and 298 K?

1) +33.2 kJ
2) –33.2 kJ
3) +132.8 kJ
4) –132.8 kJ

___ 2) Given the reaction:

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(\ell) + 571.6$ kJ

What is the approximate ΔH for the formation of 1 mole of $H_2O(\ell)$?

1) –285.8 kJ
2) +285.8 kJ
3) –571.6 kJ
4) +571.6 kJ

___ 3) Based on Reference Table I, when 2.00 moles of NaOH(s) dissolves in water

1) 44.5 kJ of energy is released and the temperature of the water increases
2) 44.5 kJ of energy is absorbed and the temperature of the water decreases
3) 89 kJ of energy is released and the temperature of the water increases
4) 89 kJ of energy is absorbed and the temperature of the water decreases

___ 4) According to Reference Table I, what happens when two moles of $C_2H_6(g)$ are formed from its elements?

1) 84 kJ are absorbed
2) 84 kJ are released
3) 168 kJ are absorbed
4) 168 kJ are released

C. Calculating the Heat of Reaction

For a chemical reaction, the enthalpy change is known as the heat of reaction (ΔH). To *actually* determine the overall heat of reaction that is listed on Reference Table I, the heats of formations for all reactants and products must be determined and calculated using the Enthalpies of Formation chart

$$\boldsymbol{\Delta H_{rxn} = (\Sigma \text{ of } H_f \text{ of products}) - (\Sigma \text{ of } H_f \text{ of reactants})}$$

* $\Delta H_f = 0$ for any element
* if a reactant or product has a coefficient, multiply its ΔH_f value given on the chart by its coefficient

Ex1: Find the ΔH_{rxn} for the following balanced equation: $2\ Fe(s) + 3\ CO_2(g) \rightarrow Fe_2O_3(s) + 3\ CO(g)$

Ex2: Find the ΔH_{rxn} for the following balanced equation: $4\ NH_3(g) + 7\ O_2(g) \rightarrow 4\ NO_2(g) + 6\ H_2O(g)$

Ex. 3: ΔH_{rxn} for the following balanced equation: $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$

Objective #5: Writing Reaction Mechanisms

A chemical reaction usually does not occur in one step. There are several changes in atom arrangements that occur before the final product(s) are produced.

- Reaction mechanisms show the series of steps that leads from reactants to products
  - Describes the order in which bonds are broken and atoms rearrange during the chemical reaction
    - Rate Determining Step: the ________________________ step in the reaction
    - Temporary Intermediates: part of the reaction as bonds break and atoms rearrange; neither the reactants nor the products

Hess's Law – the _____________________ heat energy change in a chemical reaction is the sum of the changes in its many steps leading to the overall reaction

- The goal when doing Hess Problems is to cancel out intermediates so that all that is left is what reactants and products you started with.
  - To do this, you can manipulate intermediate steps by multiplying, dividing, flipping reaction order, etc…

Ex1: Calculate the enthalpy of the following chemical reaction:

$CS_2(\ell) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$ **ΔH_{rxn} = ? kJ**

Given the following thermochemical equations:

Step 1: $C(s) + O_2(g) \rightarrow CO_2(g)$ ΔH = -393.5 kJ
Step 2: $S(s) + O_2(g) \rightarrow SO_2(g)$ ΔH = -296.8 kJ
Step 3: $C(s) + 2S(s) \rightarrow CS_2(\ell)$ ΔH = +87.9 kJ

Ex 2: Calculate the enthalpy of the following chemical reaction:

$2C(s) + H_2(g) \rightarrow C_2H_2(g)$ **ΔH_{rxn} = ? kJ**

Given the following thermochemical equations:

Step 1: $C_2H_2 + 2.5\ O_2 \rightarrow 2\ CO_2 + H_2O$ ΔH = -1299.5 kJ
Step 2: $C + O_2 \rightarrow CO_2$ ΔH = -393.5 kJ
Step 3: $H_2 + 0.5\ O_2 \rightarrow H_2O$ ΔH = -285.8 kJ

Objective #6: Changes in Entropy (ΔS)

Entropy is a measure of the ______________________ or ____________________________ in a "system" (chemical reaction). As a chemical reaction occurs, the entropy of a system will usually change. The system can become more _____________________ or more _____________________. The change in entropy is designated as ΔS.

- ______________ entropy ($+\Delta S$) is ___________________________ because it requires *less work* of the system
- ______________ entropy ($-\Delta S$) is ___________________________ because it requires more work of the system

A) Physical changes that result in increasing entropy ($+\Delta S$)

1) Phase changes

Changing from ___________________, ___________________ or _____________________ will all increase the entropy (disorder and chaos) of the system

Ex) ____

2) Forming an aqueous solution

Dissolving a substance in water will change it to aqueous and result in more entropy

Ex) ____

B) Chemical changes that result in increasing entropy ($+\Delta S$)

1) Forming more products than are reactants

If the quantity of product species is _____________________ than the number of reactant species, the overall entropy will increase

Ex) ____

2) Changes in state as a result of a reaction

If reactants start as a solid, but as products they change into liquids, aqueous or gases, the entropy will increase

Ex) ____

Do the following situations have an increase in entropy ($\Delta S = +$) or a decrease in entropy ($\Delta S = -$)?

a) $H_2O(g) \rightarrow H_2O(s)$ $\Delta S =$ _______

b) $2\ NaCl(s) \rightarrow 2\ Na(s) + Cl_2(g)$ $\Delta S =$ _______

c) $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$ $\Delta S =$ _______

d) $KCl(s) \rightarrow KCl(aq)$ $\Delta S =$ _______

e) $N_2(g) + 2\ H_2(g) \rightarrow 2\ NH_3(g)$ $\Delta S =$ _______

f) $2\ N_2O_5(g) \rightarrow 2\ NO_2(g) + O_2(g)$ $\Delta S =$ _______

g) $Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$ $\Delta S =$ _______

h) $2\ HCl(g) \rightarrow H_2(g) + Cl_2(g)$ $\Delta S =$ _______

Objective #7: Calculating Gibbs Free Energy (ΔG)
Gibbs Free Energy is a numerical quantity derived from the enthalpy (ΔH), entropy (ΔS) and temperature (T) of a system.

- The value calculated determines if OVERALL a reaction is favorable (spontaneous) or unfavorable (non-spontaneous) based on all three factors together
  - If ΔG is a negative value, the overall reaction is favored (spontaneous)
  - If ΔG is a positive value, the overall reaction is un-favored (non-spontaneous)

Gibbs Free Energy Equation: $\Delta G = \Delta H - T\Delta S$

ΔG = Gibbs Free Energy value | ΔS = Entropy value
ΔH = Enthalpy value | T = Temperature (in Kelvin)

Examples:

1. Calculate ΔG° at 25°C and tell whether or not the reaction will be spontaneous.
   $CH_3COOH_{(l)} + 2\ O_{2\,(g)} \rightarrow 2\ CO_{2\,(g)} + 2\ H_2O_{(g)}$ ΔH = -638.4 kJ/mol ΔS = 0.1569 kJ / mol-K

2. Determine the entropy change for the formation of PbO at 25°C.
   ΔH = -218 kJ/mole ΔG = -188 kJ/mole

3. Determine the enthalpy change for the reaction of $H_2 + F_2 \rightarrow 2\ HF$ at 25°C.
   ΔG = -273 kJ/mol ΔS = 0.173 kJ/mol-K

4. Determine the temperature needed of a system for the reaction of $4\ Al + 3\ O_2 \rightarrow 2\ Al_2O_3$ to occur spontaneously. ΔG = -1582 kJ/mol ΔH = -1675.3 kJ/mol ΔS = -0.626 kJ/mol-K

PART 2: CHEMICAL EQUILIBRIUM

Equilibrium Definition: A state of ______________________________ between opposing forces or influences

Objective #1: Know what it means to be at "equilibrium"

If a "system" is said to be at EQUILIBRIUM, then it means:

1) ________________________ System: nothing new added in, nothing taken out

2) ________________________ System: reaction is reversible ($\leftrightarrow$)

- Reaction can go _____________________________ or _______________________________
- Reactants ________ Products AND Reactants ________ Products

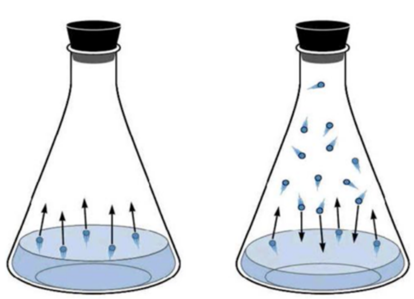
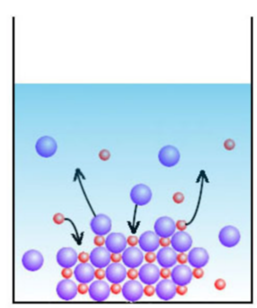
3) Forwards Reaction Rate ____________________ Reverse Reaction Rate

- Amount of reactants and products remains ______________________________ (the same)

Regents Question
Which of the following chemical reactions is at equilibrium? 1) $2\ H_2O \rightarrow 2\ H_2 + O_2$ 3) $CH_4 + H_2O \rightarrow 3\ H_2 + CO$ 2) $2\ NH_3 \rightarrow N_2 + 3\ H_2$ 4) $2\ SO_2 + O_2 \leftrightarrow 2\ SO_3$

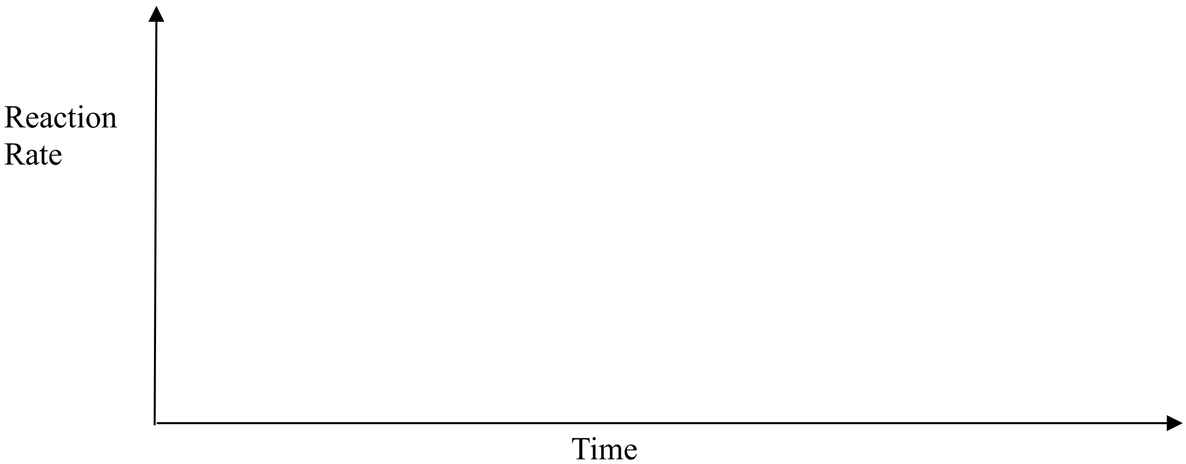
Objective #2: Know the two main types of equilibrium

1. Physical Equilibrium

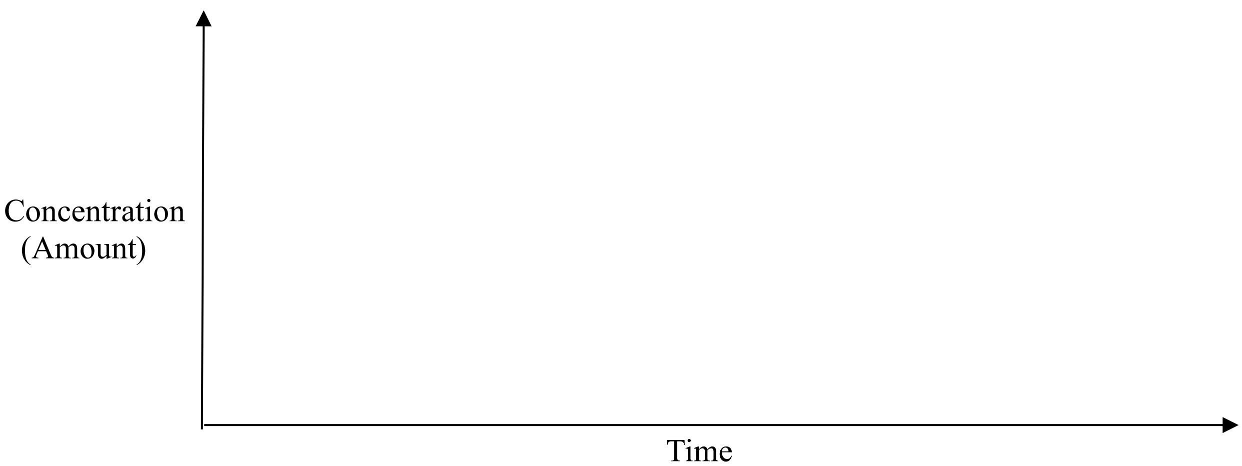
a) Phase Equilibrium	b) Solution Equilibrium
Rate of ______________________________ is the same as the rate of ___________________________________ Example: $H_2O\ (l) \leftrightarrow H_2O(g)$ 	* Occurs only in a _____________________________ solution Rate of ______________________________ is the same as the rate of ______________________________ Ex) $NaCl(s) \leftrightarrow NaCl(aq)$ 

2. Chemical Equilibrium

- The rate of the forwards reaction ____________________ the rate of the reverse reaction
  - Rate of _______________________ bonds = Rate of _______________________ bonds



- The concentration of the reactants and products are __________________________.



Regents Review Questions

______1. Which equation represents a chemical equilibrium?

1) $N_2(l) \leftrightarrow N_2(g)$ 2) $2NO_2(g) \leftrightarrow N_2O_4(g)$ 3) $CO_2(s) \leftrightarrow CO_2(g)$ 4) $NH_3(l) \leftrightarrow NH_3(g)$

______2. What occurs when a reaction reaches equilibrium?

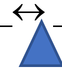
1) Only the forward reaction occurs; the reverse reaction does not occur
2) The rate of the forward reaction is faster than the rate of the reverse reaction.
3) The rate of the forward reaction is equal to the rate of the reverse reaction.
4) The rate of the forward reaction is slower than the rate of the reverse reaction.

______3. When a reversible reaction is at equilibrium, the concentration of products and the concentration of reactants must be

1) decreasing 2) increasing 3) constant 4) equal

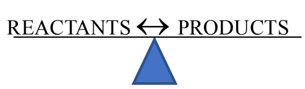
Objective #3: Understand Le Chatelier's Principle

A chemical equilibrium is a balanced state: ____________________ ↔ ____________________

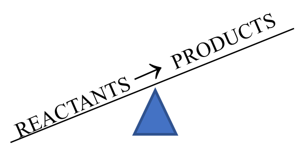


When a chemical reaction at equilibrium is *"STRESSED"* out, the reaction will "*SHIFT*" and respond to relieve the stress by "*CHANGING THE CONCENTRATIONS*" of reactants and products

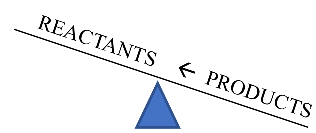
- Le Chatelier's principle explains how a reaction will respond to "*STRESS*", or changes in __________________________, _____________________________ and ______________________
    - When one of these 3 *stresses* occurs, the reaction will shift (change in direction) ___________________________ (   ) or ______________________________ (   )
    - The change in direction depends on how the reaction needs to reduce or remove the stress
        - If the reaction shifts FORWARDS (to the RIGHT) →
            - Reactants ___________________ and Products ___________________
        - If the reaction shifts REVERSE (to the LEFT) ←
            - Reactants ___________________ and Products ___________________



@ equilibrium



shift forwards (right)



shift reverse (left)

1) Concentration and Temperature

- When you "add" a substance or heat to a reaction at equilibrium, the reaction will shift _________________ from the stress to use up the excess.
- When a substance or heat is removed ("taken") from the reaction, the reaction will shift back __________________ the loss to replace what is missing.

For the reaction @ equilibrium $N_2\ (g) + 3\ H_2\ (g) \leftrightarrow 2\ NH_3\ (g) + 91.8\ KJ$

Stress	**Shifts**	**Change In Concentration**
Add N_2 (g)		Reactants : Products:
Add NH_3 (g)		Reactants : Products:
Add H_2 (g)		Reactants : Products:
Remove Heat		Reactants: Products:
Remove H_2 (g)		Reactants: Products:
Remove NH_3 (g)		Reactants: Products:

2) Common Ion Effect
A "common" ion is an ion already present in one solution at equilibrium that also is in a different solution

Ex) $NaCl\ (s) \leftrightarrow \mathbf{Na}^{+1}(aq) + Cl^{-1}(aq)$

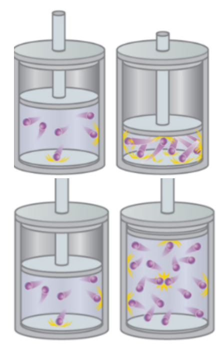
Add LiCl(aq): Common Ion = _______

- When a compound is added that has a "common ion" to the original reaction, the system reacts as if the concentration of that common ion is increases (ADDED)
  - Add a substance, shift __________________ to use up excess

For the solution at equilibrium: $KNO_3\ (s) + 34.89\ kJ \leftrightarrow K^{+1}\ (aq) + NO_3^{-1}\ (aq)$:

Stress	Shifts	Change In Concentration	
Add KBr (aq)		Reactants:	Products:

2) Pressure



- When you increase pressure over a gas, the volume of space gas particles have to move in decreases
  - With less space, the system shifts the reaction in the direction towards less overall _______________
- When you decrease pressure over a gas, the volume of space gas particles have to move in increases
  - With more space, the system shifts the reaction in the direction towards more overall _________________

* If the number of moles is the same on both sides of the reaction, pressure has NO EFFECT!!!

For the reaction @ equilibrium $N_2\ (g) + 3\ H_2\ (g) \leftrightarrow 2\ NH_3\ (g) + 91.8\ KJ$

Stress	Shifts	Change In Concentration	
Increase pressure		Reactants:	Products:
Decrease pressure		Reactants:	Products:

For the reaction @ equilibrium $2\ CO_2\ (g) + 566\ kJ \leftrightarrow 2\ CO(g) + O_2(g)$

Stress	Shifts	Change In Concentration	
Increase pressure		Reactants:	Products:
Decrease pressure		Reactants:	Products:

Le Chatelier Practice Questions

____ 1) Given the equilibrium reaction in a closed system: $H_2(g) + I_2(g) + heat \leftrightarrow 2\ HI(g)$
What will be the result of an increase in temperature?

1) The equilibrium will shift to the left and $[H_2]$ will increase.
2) The equilibrium will shift to the left and $[H_2]$ will decrease.
3) The equilibrium will shift to the right and [HI] will increase.
4) The equilibrium will shift to the right and [HI] will decrease.

____ 2) Given the equation representing a reaction at equilibrium:
$N_2(g) + 3\ H_2(g) \leftrightarrow 2\ HN_3(g) + energy$
Which change causes the equilibrium to shift to the right?

1) decreasing the concentration of $H_2(g)$
2) decreasing the pressure
3) increasing the concentration of $N_2(g)$
4) increasing the temperature

____ 3) Given the system at equilibrium:
$2\ POCl_3(g) + energy \rightleftharpoons 2\ PCl_3(g) + O_2(g)$
Which changes occur when $O_2(g)$ is added to this system?

1) The equilibrium shifts to the right and the concentration of $PCl_3(g)$ increases.
2) The equilibrium shifts to the right and the concentration of $PCl_3(g)$ decreases.
3) The equilibrium shifts to the left and the concentration of $PCl_3(g)$ increases.
4) The equilibrium shifts to the left and the concentration of $PCl_3(g)$ decreases.

____ 4) Given the reaction at equilibrium:
$4\ HCl(g) + O_2(g) \leftrightarrow 2\ Cl_2(g) + 2\ H_2O(g)$
If the pressure on the system is increased, the concentration of $Cl_2(g)$ will

1) decrease
2) increase
3) remain the same

____ 5) Ammonia is produced commercially by the Haber reaction:
$N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g) + heat$
The formation of ammonia is favored by

1) an increase in pressure
2) a decrease in pressure
3) removal of $N_2(g)$
4) removal of $H_2(g)$

____ 6) The addition of a catalyst to a system at equilibrium will increase the rate of

1) the forward reaction, only
2) the reverse reaction, only
3) both the forward and reverse reactions
4) neither the forward nor reverse reaction

____ 7) Given the Haber reaction at equilibrium:

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

Which stress on the system will shift the reaction towards the reactants?

1) increasing the concentration of $N_2(g)$
2) increasing the pressure on the system
3) decreasing the concentration of $H_2(g)$
4) decreasing the temperature on the system

____ 8) Given the equation representing a system at equilibrium:

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

Which changes occur when the temperature of this system is *decreased*?

1) The concentration of $H_2(g)$ increases and the concentration of $N_2(g)$ increases.
2) The concentration of $H_2(g)$ decreases and the concentration of $N_2(g)$ increases.
3) The concentration of $H_2(g)$ decreases and the concentration of $NH_3(g)$ decreases.
4) The concentration of $H_2(g)$ decreases and the concentration of $NH_3(g)$ increases.

___ 9) Given the equilibrium reaction in a closed system:

$H_2(g) + I_2(g) + \text{heat} \leftrightarrow 2\ HI(g)$
What will be the result of an increase in temperature?

1) The equilibrium will shift to the left and $[H_2]$ will increase.
2) The equilibrium will shift to the left and $[H_2]$ will decrease.
3) The equilibrium will shift to the right and [HI] will increase.
4) The equilibrium will shift to the right and [HI] will decrease.

___ 10) For a reaction system at equilibrium, LeChatelier's principle can be used to predict the

1) activation energy for the system
2) type of bonds in the reactants
3) effect of a stress on the system
4) polarity of the product molecules

___ 11) Given the system at equilibrium:

$H_2(g) + F_2(g) \leftrightarrow 2\ HF(g) + \text{heat}$

Which change will *not* shift the point of equilibrium?

1) changing the pressure
2) changing the temperature
3) changing the concentration of $H_2(g)$
4) changing the concentration of HF(g)

___ 12) Given the closed system at equilibrium:

$CO_2(g) \leftrightarrow CO_2(aq)$

As the pressure on the system increases, the solubility of the $CO_2(g)$

1) decreases
2) increases
3) remains the same

___ 13) Which system at equilibrium will be *least* affected by a change in pressure?

1) $3\ H_2(g) + N_2(g) \leftrightarrow 2\ NH_3(g)$
2) $2\ S(s) + 3\ O_2(g) \leftrightarrow 2\ SO_3(g)$
3) $AgCl(s) \leftrightarrow Ag^+(aq) + Cl^-(aq)$
4) $2\ HgO(s) \leftrightarrow 2\ Hg(\ell) + O_2(g)$

___ 14) Given the reaction at equilibrium:
$AgI(s) \leftrightarrow Ag^+(aq) + I^-(aq)$
What happens as KI(s) is added to the solution?

1) The reaction shifts forwards and the concentration of AgI(aq) decreases .
2) The reaction shifts reverse and the concentration of AgI(aq) increases
3) The reaction shifts forwards and the concentration of $Ag^+(aq)$ increases
4) The reaction shifts reverse and the concentration of $Ag^+(aq)$ increases

___ 15) Given the reaction at equilibrium:
$BaCrO_4(s) \leftrightarrow Ba^{2+}(aq) + CrO_4^{2-}(aq)$
Which substance, when added to the mixture will cause an increase in the amount of $BaCrO_4(s)$?

1) K_2CO_3
2) $CaCO_3$
3) $BaCl_2$
4) $CaCl_2$