UNIT 8: Kinetics & Equilibrium STUDY GUIDE Name Key

This is homework and will be collected the day of the Unit 8 Test: Tuesday March 13, 2018 !!

Vocabulary- Match the terms to the correct definitions.

1. K kinetics
2. L collision theory
3. J reaction rate
4. B potential energy
5. Q catalyst
6. A solution equilibrium
7. M phase equilibrium
8. G chemical equilibrium
9. F Le Chatelier's Principle
10. E endothermic reaction
11. N exothermic reaction
12. C activated complex
13. P activation energy
14. D entropy
15. O heat of reaction (ΔH)
16. I concentration of products and reactants
17. H rates of forward and reverse reaction

a) when the process of dissolving and precipitating (crystallizing) are occurring at equal rates; when a solution has reached its saturation point

b) stored energy in chemical bonds

c) an intermediate, temporary structure formed in the conversion of reactants to products; highest energy point on PE diagram

d) a measure of the randomness/disorder associated with a chemical reaction

e) reaction in which energy is consumed/required; energy is a reactant

f) predicts that when a stress is applied to an equilibrium mixture, the equilibrium will shift to relieve the stress

g) when the forward and reverse reactions are occurring at equal rates

h) this is what is **equal** during dynamic equilibrium

i) this is what remains **constant** during dynamic equilibrium

j) the speed at which reactants are converted into products in a chemical reaction

k) the branch of chemistry that deals with rates of reactions

l) in order for a chemical reaction/effective collision to occur, particles must collide with proper energy and orientation

m) when the processes of freezing & melting (or evaporating & condensing) are occurring at equal rates

n) reaction in which energy is released/produced; energy is a product

o) the difference between the potential energy of products minus potential energy of reactants (PEP – PER)

p) the minimum energy required to **start** a chemical reaction

q) a substance that speeds up the rate of a chemical reaction by providing an alternate pathway that lowers the activation energy

Learning Target Checklist – How prepared are you for the Unit 8 test? Check yourself against this unit's learning targets.

I understand that in order for a chemical reaction to occur, particles must collide with the correct amount of energy and orientation, according to the collision theory.

I can explain how various factors affect the rate of a reaction, in terms of collision theory.

Directions: Determine the effect each of these will have on reaction rate, and **explain the effect based on particle behavior and collision theory**.

1. Increase the temperature.

Effect: Rate will ↑ *(↑,↓,or be unaffected)*

Explanation: Increasing temperature increases the Kinetic energy of the particles, so the # of effective collisions ↑

2. Decrease the concentration.

Effect: Rate will ↓ *(↑,↓,or be unaffected)*

Explanation: Decreasing concentration means less solute particles, so less particle collisions will occur.

3. Crush the reactants into powder.

Effect: Rate will ↑ *(↑,↓,or be unaffected)*

Explanation: This will increase the surface area, allowing more particles to be exposed and collide

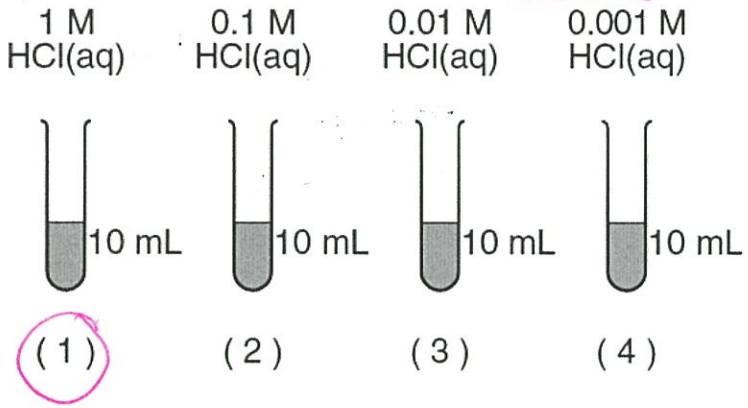
4. Add a catalyst.

Effect: Rate will ↑ *(↑,↓,or be unaffected)*

Explanation: Catalysts provide an alternate pathway with a lower activation energy.

Regents Questions:

1.) Each of four test tubes contains a different concentration of HCl(aq) at 25°C. A 1-gram cube of Zn is added to each test tube. In which test tube is the reaction occurring at the fastest rate?



2.) As the temperature of a chemical reaction in the gas phase is increased, the rate of the reaction increases because

(1) fewer particle collisions occur
(2) more effective particle collisions occur
(3) the required activation energy increases
(4) the concentration of the reactants increases

3.) A chemical reaction between iron atoms and oxygen molecules can only occur if

(1) the particles are heated
(2) the atmospheric pressure decreases
(3) there is a catalyst present
(4) there are effective collisions between the particles

4.) During a laboratory activity to investigate reaction rate, a student reacts 1.0-gram samples of solid zinc with 10.0-milliliter samples of HCl(aq). The table below shows information about the variables in five experiments the student performed.

Reaction of Zn(s) with HCl(aq)

Experiment	Description of Zinc Sample	HCl(aq) Concentration (M)	Temperature (K)
1	lumps	0.10	270.
2	powder	0.10	270.
3	lumps	0.10	290.
4	lumps	1.0	290.
5	powder	1.0	280.

concentration is the only variable that changes

Which two experiments can be used to investigate the effect of the concentration of HCl(aq) on the reaction rate?

(1) 1 and 3
(2) 1 and 5
(3) 4 and 2
(4) 4 and 3

5.) An effective collision between reactant particles requires the particles to have the proper

(1) charge and mass
(2) charge and orientation
(3) energy and mass
(4) energy and orientation

6.) Given the balanced equation representing a reaction:

$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$

This reaction occurs more quickly when powdered iron is used instead of a single piece of iron of the same mass because the powdered iron

(1) acts as a better catalyst than the single piece of iron
(2) absorbs less energy than the single piece of iron
(3) has a greater surface area than the single piece of iron
(4) is more metallic than the single piece of iron

7.) What is required for a chemical reaction to occur?

(1) standard temperature and pressure
(2) a catalyst added to the reaction system
(3) effective collisions between reactant particles
(4) an equal number of moles of reactants and products

Base your answer to question 8 on the information below.

Calcium reacts with water. This reaction is represented by the balanced equation below. The aqueous product of this reaction can be heated to evaporate the water, leaving a white solid, $Ca(OH)_2(s)$.

$$Ca(s) + 2H_2O(\ell) \rightarrow Ca(OH)_2(aq) + H_2(g)$$

8.) State *one* change in reaction conditions that will increase the rate of the reaction.

↑ temp , ↑ surface area , add a catalyst

Base your answer to question 9 on the information below.

A student performed a laboratory activity to observe the reaction between aluminum foil and an aqueous copper(II) chloride solution. The reaction is represented by the balanced equation below.

$$2Al(s) + 3CuCl_2(aq) \rightarrow 3Cu(s) + 2AlCl_3(aq) + \text{energy}$$

9.) Describe *one* change in the procedure that would cause the reaction to occur at a faster rate.

increase concentration of aqueous solution

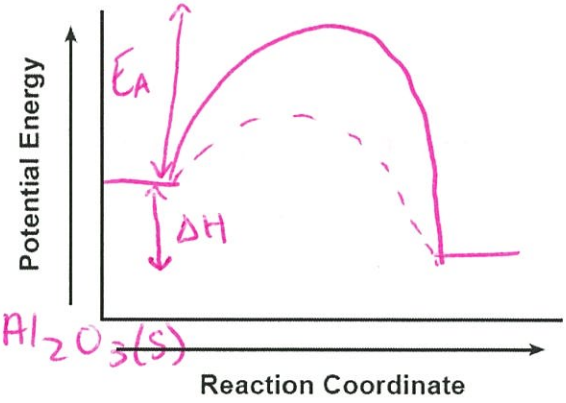
I can draw, label, and identify potential energy diagrams for both endothermic and exothermic reactions. I can demonstrate the effect of a catalyst on a potential energy diagram.

1. Draw a PE diagram for the synthesis of aluminum oxide (HINT: where can you go to *both* find this reaction AND determine if its endothermic or exothermic? If you don't know ask Miss Virga. Or check your mini lesson notes).

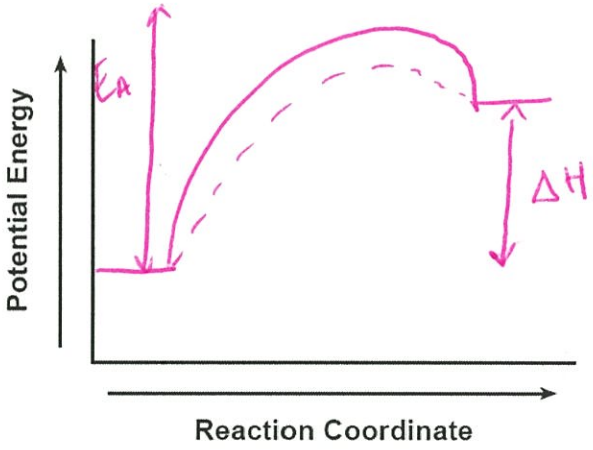
Table I

$4\ Al(s) + 3\ O_2(g) \rightarrow 2\ Al_2O_3(s)$

$\Delta H = -3351$



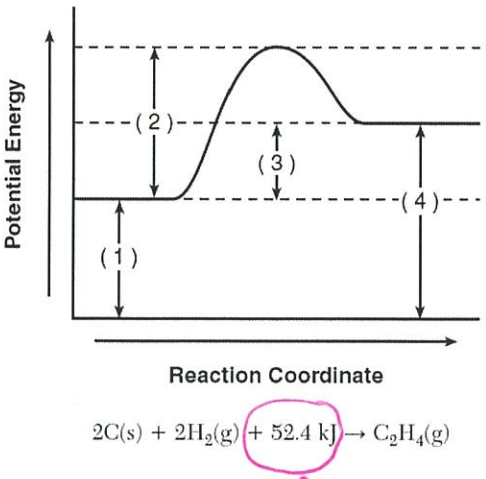
2. Draw a PE diagram for the dissociation of potassium nitrate.



$\Delta H = +34.89$

3. On both diagrams you drew above, label the activation energy and heat of reaction. Also, use a dotted line to show the effects of a catalyst. Place a check here to ensure you've done so: ✓

Base your answers to questions 4 through 5 on the information below.



$2C(s) + 2H_2(g) + 52.4\ kJ \rightarrow C_2H_4(g)$

The potential energy diagram and balanced equation shown below represent a reaction between solid carbon and hydrogen gas to produce 1 mole of $C_2H_4(g)$ at 101.3 kPa and 298 K.

4. State what interval 3 represents.

heat of reaction

5. Is this reaction endothermic or exothermic? Use evidence from the PE diagram **AND** the balanced equation to support your answer.

① products have more PE than reactants

② energy is a reactant

Base your answer to question 6 on the information below.

Ammonium chloride is dissolved in water to form a 0.10 M $NH_4Cl(aq)$ solution. This dissolving process is represented by the equation below.

$$NH_4Cl(s) + \text{heat} \xrightarrow{H_2O} NH_4^+(aq) + Cl^-(aq)$$

6. State evidence that indicates the dissolving of ammonium chloride is an endothermic process.

Heat is a reactant.

Base your answer to questions 7 and 8 on the information below.

At standard pressure, hydrogen peroxide, H_2O_2, melts at -0.4°C, boils at 151°C, and is very soluble in water. A bottle of aqueous hydrogen peroxide, $H_2O_2(aq)$, purchased from a pharmacy has a pressure-releasing cap. Aqueous hydrogen peroxide decomposes at room temperature, as represented by the balanced equation below.

$$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g) + 196.0\ kJ$$

7. State evidence that indicates the decomposition of $H_2O_2(aq)$ is exothermic.

Energy is a product

8. How much energy would be released when 1 mole of hydrogen peroxide decomposes?

$$\frac{196}{2} = 98\ kJ$$

I can identify under which conditions of entropy and energy a reaction is most favorable.

1. Which term is defined as a measure of the randomness of a system?

   A) heat B) entropy
   C) pressure D) temperature

2. Systems in nature tend to undergo changes that result in

   A) lower energy and lower entropy
   B) lower energy and higher entropy
   C) higher energy and lower entropy
   D) higher energy and higher entropy

3. Entropy is a measure of the

   A) acidity of a sample
   B) disorder of a system
   C) concentration of a solution
   D) chemical activity of an element

4. In terms of entropy and energy, systems in nature tend to undergo changes toward

   A) lower entropy and lower energy
   B) lower entropy and higher energy
   C) higher entropy and lower energy
   D) higher entropy and higher energy

5. Systems in nature tend to undergo changes toward

   A) lower energy and higher entropy
   B) lower energy and lower entropy
   C) higher energy and higher entropy
   D) higher energy and lower entropy

6. Which equation represents a change that results in an increase in disorder?

   A) $I_2(s) \rightarrow I_2(g)$ solid → gas
   B) $CO_2(g) \rightarrow CO_2(s)$
   C) $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$
   D) $2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell)$

7. Given the equation:

   $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

   a Name the general type of reaction shown above. decomposition

   b Explain, in terms of particle behavior, why entropy is increasing during this reaction.

   Gases are more disordered than solids

I can describe dynamic equilibrium in terms of rates of forward and reverse reactions and concentration of products and reactants.

KEY IDEA: "EQUAL EXCHANGE, CONSTANT CONCENTRATION"

1. Given the equation representing a system at equilibrium:

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

   Which statement describes this system?

   A) The concentration of $PCl_5(g)$ is increasing.
   B) The concentration of $PCl_5(g)$ is decreasing.
   C) The concentrations of $PCl_5(g)$ and $PCl_3(g)$ are equal.
   D) The concentrations of $PCl_5(g)$ and $PCl_3(g)$ are constant.

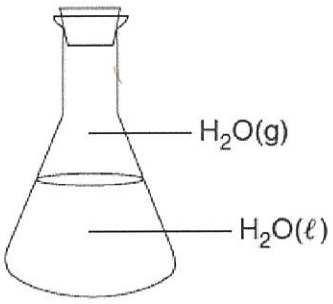
2. What occurs when a reaction reaches equilibrium?

   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.

3. When a chemical reaction is at equilibrium, the concentration of each reactant and the concentration of each product must be

   A) constant B) variable
   C) equal D) zero

4. Given the diagram representing a closed system at constant temperature:



Stoppered Flask

   Which statement describes this system at equilibrium?

   A) The mass of $H_2O(\ell)$ equals the mass of $H_2O(g)$.
   B) The volume of $H_2O(\ell)$ equals the volume of $H_2O(g)$.
   C) The number of moles of $H_2O(\ell)$ equals the number of moles of $H_2O(g)$.
   D) The rate of evaporation of $H_2O(\ell)$ equals the rate of condensation of $H_2O(g)$.

5. Given the equation representing a closed system:

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

   Which statement describes this system at equilibrium?

   A) The volume of the $NO_2(g)$ is greater than the volume of the $N_2O_4(g)$.
   B) The volume of the $NO_2(g)$ is less than the volume of the $N_2O_4(g)$.
   C) The rate of the forward reaction and the rate of the reverse reaction are equal.
   D) The rate of the forward reaction and the rate of the reverse reaction are unequal.

6. Some solid KNO_3 remains at the bottom of a stoppered flask containing a saturated $KNO_3(aq)$ solution at 22°C. Which statement explains why the contents of the flask are at equilibrium?

   A) The rate of dissolving is equal to the rate of crystallization.
   B) The rate of dissolving is greater than the rate of crystallization.
   C) The concentration of the solid is equal to the concentration of the solution.
   D) The concentration of the solid is greater than the concentration of the solution.

7. Which type of equilibrium exists in a sealed flask containing $Br_2(\ell)$ and $Br_2(g)$ at 298 K and 1.0 atm?

   A) static phase equilibrium
   B) static solution equilibrium
   C) dynamic phase equilibrium
   D) dynamic solution equilibrium

8. An open flask is half filled with water at 25°C. Phase equilibrium can be reached after

   A) more water is added to the flask
   B) the flask is stoppered
   C) the temperature is decreased to 15°C
   D) the temperature is increased to 35°C

I can use Le Chatelier's Principle to identify which direction equilibrium will shift when a stress, such as concentration, temperature, or pressure is applied.

KEY IDEAS:

- Keep in mind that you can consider the "concentration" of temperature as the side of the reaction with **energy**
- You can consider the "concentration" of pressure as the side of the reaction with **more moles of gas**
- If you INCREASE the concentration of a substance (or temp/pressure), the equilibrium will shift in the OPPOSITE direction
- If you DECREASE the concentration of a substance (or temp/pressure, the equilibrium will shift towards that substance to replenish what was lost

$$\text{energy} + N_2\,(g) + O_2\,(g) \rightarrow 2\,NO\,(g)$$

Stress	Direction of Shift (right or left)
Increase Temperature	right
Decrease Temperature	left
Increase Pressure	no shift } same # of
Decrease Pressure	no shift } mols of gas on both sides
Increase concentration of O_2	right
Decrease concentration of NO	right
Decrease concentration of N_2	left

pressure $N_2\,(g) + 3\,H_2\,(g) \rightarrow 2\,NH_3\,(g) + \text{energy}$

Stress	Direction of Shift (right or left)
Increase Temperature	left
Decrease Temperature	right
Increase Pressure	right
Decrease Pressure	left
Increase concentration of N_2	right
Decrease concentration of H_2	left
Increase concentration of NH_3	left

I can use the concept of conservation of mass/matter to determine the amount of product or reactant in a given chemical reaction.

CONSERVATION OF MASS: Matter is neither created nor destroyed, only transformed!

A.K.A. NO MASS SHOULD BE LOST OR GAINED

1.) Given the balanced equation representing a reaction:

$2NaCl(\ell) \rightarrow 2Na(\ell) + Cl_2(g)$

A 1170.-gram sample of $NaCl(\ell)$ completely reacts, producing 460. grams of $Na(\ell)$. What is the total mass of $Cl_2(g)$ produced?

(1) 355 g
(2) 710. g
(3) 1420. g
(4) 1630. g

$1170 = 460 + x$

2.) Given the balanced equation representing a reaction:

$CaO(s) + CO_2(g) \rightarrow CaCO_3(s) + heat$

What is the total mass of CaO(s) that reacts completely with 88 grams of $CO_2(g)$ to produce 200. grams of $CaCO_3(s)$?

(1) 56 g
(2) 88 g
(3) 112 g
(4) 288 g

$x + 88 = 200$

3.) Given the balanced equation representing a reaction:

$2H_2 + O_2 \rightarrow 2H_2O$

What is the mass of H_2O produced when 10.0 grams of H_2 reacts completely with 80.0 grams of O_2?

(1) 70.0 g
(2) 90.0 g
(3) 180. g
(4) 800. G

$10 + 80 = x$

Base your answers to questions 4 through 5 on the information below.

The Solvay process is a multistep industrial process used to produce washing soda, $Na_2CO_3(s)$. In the last step of the Solvay process, $NaHCO_3(s)$ is heated to 300°C, producing washing soda, water, and carbon dioxide. This reaction is represented by the balanced equation below.

$$2NaHCO_3(s) + heat \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

4.) Identify the type of chemical reaction represented by the equation.

decomposition

5.) Determine the total mass of washing soda produced if 3360. kilograms of $NaHCO_3$ reacts completely to produce 360. kilograms of H_2O and 880. kilograms of CO_2.

$3360\,kg = x + 360\,kg + 880\,kg$

$x = 2120\,kg$

6.) Besides mass, what else is conserved during chemical changes?

energy & charge !