Chatsworth Charter High School
Mr. West AP Chemistry Summer Assignment rev. 6/2018
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YOU SHOULD BE ABLE TO COMPLETE AT LEAST 80% OF THE QUESTIONS

AP Chemistry is taught as a first year college chemistry course. The College Board recommends that potential AP Chemistry students have completed a first year high school chemistry course (preferably honors level).

You will need to purchase a college student lab notebook with carbonless copy pages (You can find them at Pierce College, Moorpark College, CSUN, Amazon, etc.). Please have your lab notebook with you on the first day of class. Also, I highly recommend that you purchase an AP Chemistry Test Prep Book (I have found that Princeton Review and Barron's are two of the best. You can purchase them through Amazon at a good price, and you can buy used. You may find them at major bookstores too). You will receive 3 points extra credit if you come to class on the first day with the test preparation book.

The AP Chemistry summer assignment is included on the five pages that follow. It includes questions for you to complete as a review of what you already know in preparation for AP Chemistry. Use your notes from Honors Chemistry/Chemistry as needed. **I am available by email during the summer if you need additional help.** *During the course we will build on these topics as well as others, and when applicable, our college-level chemistry studies will focus on connections to Biomedical and Engineering Applications.*

The summer assignment is due in parts. Please email me your answers according to this schedule:

Kinetics and Equilibrium by the last day in June
Composition, Reactions and Stoichiometry by the last day in July
Thermochemistry/Thermodynamics and Electrochemistry by the first day of school

The following subject areas are emphasized in the summer assignment:

1. **Kinetics**
   - **rates of reaction**
   - **rate laws**
   - **potential energy diagrams**
2. **Equilibrium**
   - **Keq expressions**
   - **solving for Keq**
   - **solving for Q; comparing to Keq**
   - **Le Chatlier's principle**
3. **Thermochemistry/Thermodynamics**
   - **styrofoam cup calorimetry**
   - **enthalpy for a reaction**
   - **entropy and free energy**
   - **relating free energy to Keq**
4. **Electrochemistry**
   - **galvanic cells**
   - **relating voltage to free energy and Q**
   - **electrolytic cells**
5. **Composition, Reactions and Stoichiometry**
   - **molar mass; percent composition**
   - **empirical formula**
   - **balancing equations/identifying types of reactions**
   - **writing net ionic equations**

Kinetics

1. Describe reaction rate in your words including appropriate units.

2. Explain at the molecular level how each of these speeds up reaction rate: increasing concentration, increasing temperature, adding a catalyst.

3. The decomposition of CH_3NC was studied and the following data were obtained.

Time (s)	0	2000	5000	8000	12000	15000
$[CH_3NC]$ M	0.0165	0.0110	0.00591	0.00314	0.00137	0.00074

   a. Graph the data.
   b. Calculate the average rate of reaction, in M/s, from time 0 seconds to 5000 seconds. Calculate the average rate from time 5000 seconds to 12000 seconds.
   c. Explain why the average rate from 5000 to 12000 seconds was slower than that from 0 to 5000 seconds.

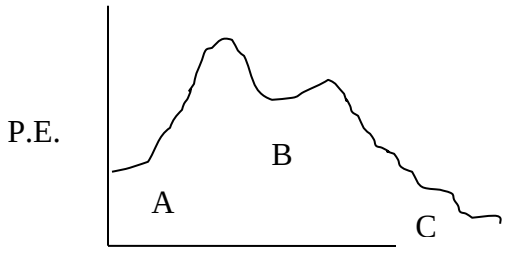
4. A reaction $A + B \rightarrow C$ obeys the following rate law: Rate = $k\,[A]^2[B]$.
   a. If [A] is doubled, how will the rate change? If [B] is doubled, how will the rate change?
   b. What are the reaction orders for A and B? What is the overall order of the reaction?

5. The reaction $2\,ClO_2 + 2OH^- \rightarrow ClO_3^- + ClO_2^- + H_2O$ was studied and the following initial rate data were obtained:

Experiment	Initial $[ClO_2]$ M	Initial [OH-] M	Initial Rate M/s
1	6.0	3.0	9.0
2	2.0	3.0	1.0
3	2.0	6.0	2.0

   a. Determine the rate law for the reaction.
   b. Is it likely that this reaction occurs in only one step? Justify your answer.

6. The following reaction profile (potential energy diagram) was obtained for the reaction $A \rightarrow C$.



   a. Based on the graph, the reaction appears to have two steps. Which step is the faster step: "$A \rightarrow B$" or "$B \rightarrow C$?" Justify your answer.
   b. How would a catalyst for step "$A \rightarrow B$" change the appearance of the graph?
   c. Is the overall reaction endothermic or exothermic? Justify your answer.

Equilibrium

1. Describe in your words what it means for a chemical reaction system to be at equilibrium.

2. Write Keq expressions for the following reactions. Remember that Keq expressions do not include solids and liquids.

    a. $3\ NO(g) \leftrightarrow N_2O\ (g) + NO_2\ (g)$
    b. $HF\ (aq) \leftrightarrow H^+\ (aq) + F^-\ (aq)$
    c. $H_2O\ (l) \leftrightarrow H^+\ (aq) + OH^-\ (aq)$
    d. $2\ Ag\ (s) + Zn^{2+}\ (aq) \leftrightarrow 2\ Ag^+\ (aq) + Zn\ (s)$

3. At 900 K the following equilibrium is established:

$$2\ NO\ (g) + Cl_2\ (g) \leftrightarrow 2\ NOCl\ (g)$$

An equilibrium mixture of the three gases has concentrations of 1.00 M NO, 2.50 M Cl_2, and 3.00 M NOCl.

    a. Write an equilibrium expression and calculate Keq for this reaction at 900 K
    b. How does a reaction quotient "Q" differ from the equilibrium constant "Keq?"
    c. If Q for the reaction above is less than Keq, in which direction will the reaction proceed in order to re-establish equilibrium?
    d. The concentration of NOCl is increased to 5.00 M.
        i. Calculate "Q."
        ii. Compare "Q" to "Keq." Based on this comparison, which direction should the reaction shift to re-establish equilibrium?
        iii. Is your answer above consistent with that which you expect based on Le Chatlier's principle? Explain.

4. Consider the following equilibrium:

$$2\ SO_2\ (g) + O_2\ (g) \leftrightarrow 2\ SO_3\ (g) + Heat$$

    a. Is the reaction endothermic or exothermic?
    b. Are there more moles of gaseous reactants or gaseous products?
    c. For each of the following stresses to this equilibrium system, identify the direction the reaction will shift to re-establish equilibrium and explain your answer:
        i. O_2 (g) is added.
        ii. The reaction mixture is heated (remember it is the surroundings that increase in temperature).
        iii. The volume of the reaction vessel is doubled.
        iv. SO_3 (g) is removed from the system.

Thermochemistry/Thermodynamics (2018-19 students, you do not need to complete questions 3d through 3h, but research those concepts just to provide you an introduction to them)

1. Assume you are carrying out a Styrofoam calorimetry experiment involving a chemical reaction and the temperature of the solution increases.
    a. Did the solution absorb or release heat? Did the reaction absorb or release heat?
    b. Based on your answer to "a" above, is the reaction endothermic or exothermic?

2. Magnesium metal reacts with hydrochloric acid solution according to the following equation:

$$Mg\ (s) \ + \ 2\ HCl\ (aq) \ \rightarrow \ MgCl_2\ (aq) \ + \ H_2\ (g)$$

    2.43 grams of Mg (s) reacts with 50.0 mL of 3.00 M HCl in a styrofoam cup calorimeter. Mg is the limiting reactant. The temperature of the solution increases from 20.0°C to 60.0°C. (The specific heat of the solution is 4.18 J/g°C, and the density is 1.00 g/ml).
    a. Calculate the heat (q) for the solution. How does this value compare to (q) for the reaction? What is the value of ΔH for the reaction?
    b. Based on your answer above and the data given in the problem, calculate the ΔH per mole Mg.

3. Liquid ethanol is burned in air (combustion reaction) according to the following equation:

$$1\ C_2H_5OH\ (l) \ + \ 3\ O_2\ (g) \ \rightarrow \ 3\ H_2O\ (g) \ + \ 2\ CO_2\ (g) \qquad \Delta H = 871.1\ kJ$$

    a. Based on the description above, is the reaction endothermic or exothermic?
    b. Based on your answer above, write a potential energy diagram for the reaction, which is also known to be a **fast** reaction.
    c. Calculate the amount of heat when 0.50 moles of C_2H_5OH (l) reacts.
    d. Based on the moles of reactants and products in the balanced equation, and the states of matter for each, does this system increase or decrease in entropy, disorder, (ΔS) as reactants become products? Is ΔS positive or negative?
    e. Explain in your words the difference between a thermodynamically favorable and non-thermodynamically favorable reaction.
    f. One of the most useful thermodynamic equations is $\Delta G = \Delta H - T\Delta S$. Based on this thermodynamic equation and your responses to the previous questions, is the free energy (ΔG) positive or negative? Is the reaction thermodynamically favorable or not?
    g. Free energy (ΔG) is related to equilibrium through the equation: $\Delta G \approx -\ln K_{eq}$. Based on the sign of your answer above, should Keq be greater than 1 or less than 1? Explain.
    h. Is your answer for Keq above consistent with your answer to "f" regarding the reaction's thermodynamic favorability? Explain.

Electrochemistry (2018-19 students, you do not need to complete this electrochemistry section; however, research the topics covered here just to provide you an introduction to those concepts)

1. Explain in your words the terms oxidation and reduction.

2. Explain in your words what a voltaic (galvanic) electrochemical cell is and how it operates.

3. The following two reduction half reactions are taken from a table of standard reduction potentials:

$$Ag^{+1}\ (aq) + 1e^- \rightarrow Ag\ (s) \qquad E^o = +0.80 \text{ volts}$$
$$Ba^{+2}\ (aq) + 2e^- \rightarrow Ba\ (s) \qquad E^0 = -2.90 \text{ volts}$$

   a. Which species, silver or barium, is more likely to be reduced when these two metals come into contact? Explain your reasoning.
   b. Sketch a diagram of a galvanic cell based on these two and label all the features of the cell, including the direction of electron flow through the wires.
   c. Write a balanced overall net ionic equation for the reaction between these two. Calculate the cell voltage.
   d. Is the sign for the voltage you obtained consistent with a spontaneous reaction? Explain.
   e. What should happen to the size of each of the electrodes (the barium and the silver) as the cell reaction proceeds? Explain.
   f. Free energy (ΔG) is related to electrochemistry through the equation: $\Delta G \approx -E$.
      i. Is the sign for ΔG positive or negative for your galvanic cell?
      ii. Is your answer for ΔG above consistent with the reaction being spontaneous?
   g. Voltage (E) is related to equilibrium through the equation: $E \approx E^o - \ln Q$. (Note that E^o is positive for galvanic cells).
      i. Recall that Q = [Products]/[Reactants]. Write a "Q" expression for the galvanic cell reaction described in this problem (silver and copper). Remember that solids are not included in "Keq" or "Q" expressions. In this case, only the aqueous ions will appear in your expression.
      ii. As [Products] increases, what happens to the value of Q? What happens to the value of E? Explain this in terms of Le Chatlier's principle.

4. Explain in your words what an electrolytic cell is and how it operates.

5. Explain in your words the process of metal electroplating.

6. Refer back to the two half reactions in question #3. You should have discovered that silver ions were reduced while barium metal was oxidized leading to a spontaneous process with a positive voltage.
   a. Since the voltage is positive, is free energy released?
   b. Explain how it is possible to go against the natural tendency of reducing silver in the presence of barium and electroplating barium metal onto a silver electrode?

Composition, Reactions and Stoichiometry

1. The following questions refer to sodium carbonate (Na_2CO_3)
    a. Calculate the molar mass of sodium carbonate.
    b. Calculate the percent composition of each of the elements in sodium carbonate.

2. The following question requires you to determine an empirical and molecular formulas based on experimental data. Ascorbic acid (vitamin C) contains the following % composition by mass: 41 % C, 4.5 % H, and 54.5 % O.
    a. Calculate the number of moles for each element in the compound, and carryout the necessary calculations to determine the empirical formula.
    b. The experimentally determined molar mass of ascorbic acid is 176 g/mole. Use this information along with your results above to determine the molecular formula.

3. The following question refers to analyzing lab data for determining the empirical formula of a hydrated salt. A student measures out a **25 gram** sample of the blue colored *copper sulfate hydrate* salt. After heating the salt for some time, the student observes that water has condensed near the top of the tube and the salt has lost most of its blue color. After additional heating, the salt has turned completely white. The final mass of the now dehydrated salt is **16 grams**. Use the data from the experiment described above to do the following:
    a. Calculate the mass of water lost and moles of water lost.
    b. Calculate the mass of $CuSO_4$ (dehydrated salt) and moles of $CuSO_4$.
    c. Calculate the mole ratio of water to $CuSO_4$.
    d. Use your answer above to write a correct formula for the hydrated salt in the form of $CuSO_4 \bullet \chi\ H_2O$ replacing the χ with the correct value you obtained above.
    e. Describe the expected observations if the student were to add a small amount of water back to the test tube.

4. Carryout the following for each of the equations below:
    - Balance the equation.
    - Identify the type of reaction (synthesis, decomposition, combustion, acid-carbonate, precipitation, acid-base neutralization, oxidation of a metal by a metal ion, oxidation of a metal by hydrogen ion, oxidation of a halide by a halogen)
    - Dissociate only those reactions that occur in aqueous solution and write balanced net ionic equations.
        a. $HCl\ (aq) + Na_2CO_3\ (s) \rightarrow NaCl\ (aq) + H_2O\ (l) + CO_2\ (g)$
        b. $Na_2CO_3\ (aq) + Ba(NO_3)_2\ (aq) \rightarrow NaNO_3\ (aq) + BaCO_3\ (s)$
        c. $Al\ (s) + HCl\ (aq) \rightarrow AlCl_3\ (aq) + H_2\ (g)$
        d. $Na\ (s) + Al(NO_3)_3\ (aq) \rightarrow NaNO_3\ (aq) + Al\ (s)$
        e. $F_2\ (g) + NaCl\ (aq) \rightarrow Cl_2\ (g) + NaF\ (aq)$
        f. $N_2\ (g) + H_2\ (g) \rightarrow NH_3\ (g)$
        g. $KClO_3\ (s) \rightarrow K\ (s) + Cl_2\ (g) + O_2\ (g)$