Dougherty Valley • AP Chemistry

Name______________________________

AP Test Review

Period ________ Date _____________

B I G I D E A 3 : R E A C T I O N S

1 – Review the Content

- Honors Chemistry: Lesson 3.3; Unit 5
- AP Chemistry: 1.4, 1.5; Unit 7
- Textbook: Chapters 5, 21
- D&S Review: Ch 11, 12
- 5 Steps to a 5: Ch 6, 7, 16, Ch 19: #7-9
- Princeton Review: Ch 5
- Crash Course: Ch 11-13

2 – Review the Essential Knowledge and Learning Objectives

Read through and annotate the Essential Knowledge and Learning Objectives for this Big Idea. Then make a list of the ideas and topics here.

3 – Multiple Choice Review

List items that you missed. Make notes for why you missed them and what you learn from it.

Packet Q# Reason for Mistake Takeaways

4 – Free Response Practice

Reflect on your responses for FR questions. Make notes about how to craft stronger responses.

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BIG IDEA 3: REACTIONS

Essential Knowledge

3. Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.

When chemical changes occur, the new substances formed have properties that are distinguishable from the initial substance or substances. Such chemical processes may be observed in a variety of ways, and often involve changes in energy as well. Chemical change is depicted in several ways, with the most important and informative one being the balanced chemical equation for the reaction. Because there is a large diversity of possible chemical reactions, it is useful to categorize reactions and be able to recognize the category into which a given reaction falls.

3.A. Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form.

Chemical reactions are the primary means by which transformations in matter occur. Chemical equations for reactions efficiently communicate the rearrangements of atoms that occur during a chemical reaction. Describing a chemical change can include different forms of the equation, such as molecular, ionic, and net ionic. The equation provides information about atoms, ions and/or molecules reacting (not how they react) at the particulate level, as well as quantitative information about stoichiometry at the macroscopic level. Many chemical reactions involve small whole number ratios of reactants and products as expressed by the stoichiometric coefficients of the balanced equation. Many modern materials are composed of non-stoichiometric combinations of the constituent elements.

3.A.1. A chemical change may be represented by a molecular, ionic, or net ionic equation.

a. Chemical equations represent chemical changes, and therefore must contain equal numbers of atoms of every element on each side to be "balanced."
b. Depending on the context in which it is used, there are different forms of the balanced chemical equations that are used by chemists. It is important not only to write a balanced molecular, ionic, or net ionic reaction equation, but also to have an understanding of the circumstances under which any of them might be the most useful form.
c. The balanced chemical equation for a reaction is capable of representing chemistry at any level, and thus it is important that it can be translated into a symbolic depiction at the particulate level, where much of the reasoning of chemistry occurs.
d. Because chemistry is ultimately an experimental science, it is important that students be able to describe chemical reactions observed in a variety of laboratory contexts.

3.A.2. Quantitative information can be derived from stoichiometric calculations that utilize the mole ratios from the balanced chemical equations. The role of stoichiometry in real-world applications is important to note, so that it does not seem to be simply an exercise done only by chemists.

a. Coefficients of balanced chemical equations contain information regarding the proportionality of the amounts of substances involved in the reaction. These values can be used in chemical calculations that apply the mole concept; the most important place for this type of quantitative exercise is the laboratory.
   1. Calculate amount of product expected to be produced in a laboratory experiment.
   2. Identify limiting and excess reactant; calculate percent and theoretical yield for a given laboratory experiment.
b. The use of stoichiometry with gases also has the potential for laboratory experimentation, particularly with respect to the experimental determination of molar mass of a gas.

c. Solution chemistry provides an additional avenue for laboratory calculations of stoichiometry, including titrations.

3.B. Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions.

There are a vast number of possible chemical reactions. In order to study and make predictions and comparisons concerning such a wide array of reactions, chemists have devised ways to classify them. Because of their prevalence in the laboratory and in real-world applications, two categories of reactions that are of particular importance are acid-base reactions and oxidation-reduction reactions. Also, a key contribution of chemistry to society is the creation of new materials or compounds that benefit the health and welfare of people in the community. Most often the creation of new materials or compounds can be considered as synthesis reactions, another important reaction category.

3.B.1. Synthesis reactions are those in which atoms and/or molecules combine to form a new compound. Decomposition is the reverse of synthesis, a process whereby molecules are decomposed, often by the use of heat.

a. Synthesis or decomposition reactions can be used for acquisition of basic lab techniques and observations that help students deal with the abstractions of atoms and stoichiometric calculations.

3.B.2. In a neutralization reaction, protons are transferred from an acid to a base.

a. The amphoteric nature of water plays an important role in the chemistry of aqueous solutions, since water can both accept protons from and donate protons to dissolved species.

b. Acid-base reactions:

1. Only reactions in aqueous solutions are considered.
2. The Brønsted-Lowry concept of acids and bases is the focus of the course.
3. When an acid or base ionizes in water, the conjugate acid-base pairs can be identified and their relative strengths compared.

3.B.3. In oxidation-reduction (redox) reactions, there is a net transfer of electrons. The species that loses electrons is oxidized, and the species that gains electrons is reduced.

a. In a redox reaction, electrons are transferred from the species that is oxidized to the species that is reduced.

b. Oxidation numbers may be assigned to each of the atoms in the reactant and products; this is often an effective way to identify the oxidized and reduced species in a redox reaction.

c. Balanced chemical equations for redox reactions can be constructed from tabulated half-reactions.

d. Recognizing that a reaction is a redox reaction is an important skill; an apt application of this type of reaction is a laboratory exercise where students perform redox titrations.

e. There are a number of important redox reactions in energy production processes (combustion of hydrocarbons and metabolism of sugars, fats, and proteins).

3.C. Chemical and physical transformations may be observed in several ways and typically involve a change in energy.

An important component of a full understanding of chemical change involves direct observation of that change; thus, laboratory experiences are essential for the AP Chemistry student to develop an appreciation of the discipline. At the AP course level, observations are made on macroscopically large samples of chemicals; these observations must be used to infer what is occurring at the particulate level. This ability to reason about observations at one level (macroscopic) using models at another level (particulate) provides an important demonstration of conceptual understanding and requires extensive laboratory experience. The difference between physical and chemical change is best explained at the particulate level. Laboratory observations of temperature change accompanying physical and chemical transformations are manifestations of the energy changes occurring at the particulate level. This has practical applications, such as energy production via combustion of fuels (chemical energy conversion to thermal energy) and/ or batteries (chemical energy conversion to electrical energy).

3.C.1. Production of heat or light, formation of a gas, and formation of a precipitate and/or a color change are possible evidences that a chemical change has occurred.

a. Laboratory observations are made at the macroscopic level, so students must be able to characterize changes in matter using visual clues and then make representations or written descriptions.
b. Distinguishing the difference between chemical and physical changes at the macroscopic level is a challenge; therefore, the ability to investigate chemical properties is important.
c. In order to develop the ability to distinguish experimentally between chemical and physical changes, students must make observations and collect data from a variety of reactions and physical changes within the laboratory setting.
d. Classification of reactions provides important organizational clarity for chemistry; therefore, students need to identify precipitation, acid-base, and redox reactions.

3.C.2. Net changes in energy for a chemical reaction can be endothermic or exothermic.

a. Macroscopic observations of energy changes when chemicals react are made possible by measuring temperature changes.
b. These observations should be placed within the context of the language of exothermic and endothermic change.
c. The ability to translate observations made at the macroscopic level in the laboratory to a conceptual framework is aided by a graphical depiction of the process called an energy diagram, which provides a visual representation of the exothermic or endothermic nature of a reaction.
d. It is important to be able to use an understanding of energy changes in chemical reactions to identify the role of endothermic and exothermic reactions in real-world processes.

3.C.3. Electrochemistry shows the inter-conversion between chemical and electrical energy in galvanic and electrolytic cells.

a. Electrochemistry encompasses the study of redox reactions that occur within electrochemical cells. The reactions either generate electrical current in galvanic cells, or are driven by an externally applied electrical potential in electrolytic cells. Visual representations of galvanic and electrolytic cells are tools of analysis to identify where half-reactions occur and the direction of current flow.
b. Oxidation occurs at the anode, and reduction occurs at the cathode for all electrochemical cells.
c. The overall electrical potential of galvanic cells can be calculated by identifying the oxidation half-reaction and reduction half-reaction, and using a table of Standard Reduction Potentials.
d. Many real systems do not operate at standard conditions and the electrical potential determination must account for the effect of concentrations. The qualitative effects of concentration on the cell potential can be understood by considering the cell potential as a driving force toward equilibrium, in that the farther the reaction is from equilibrium, the greater the magnitude of the cell potential. The standard cell potential, $E°$, corresponds to the standard conditions of $Q = 1$. As the system approaches equilibrium, the magnitude (i.e., absolute value) of the cell potential decreases, reaching zero at equilibrium (where $Q = K$). Deviations from standard conditions that take the cell further from equilibrium than $Q = 1$ will increase the magnitude of the cell potential relative to $E°$. Deviations from standard conditions that take the cell closer to equilibrium than $Q = 1$ will decrease the magnitude of the cell potential relative to $E°$. In concentration cells, the direction of spontaneous electron flow can be determined by considering the direction needed to reach equilibrium.

e. $\Delta G°$ (standard Gibbs free energy) is proportional to the negative of the cell potential for the redox reaction from which it is constructed.
f. Faraday's laws can be used to determine the stoichiometry of the redox reactions occurring in an electrochemical cell with respect to the following:
   1. Number of electrons transferred
   2. Mass of material deposited or removed from an electrode
   3. Current
   4. Time elapsed
   5. Charge of ionic species

Learning Objectives

3.1	Students can translate among macroscopic observations of change, chemical equations, and particle views.	Big Idea 3
3.2	The student can translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances.	EK 3.A.1
3.3	The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results.	EK 3.A.2
3.4	The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.	EK 3.A.2
3.5	The student is able to design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.	EK 3.B.1
3.6	The student is able to use data from synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.	EK 3.B.1
3.7	The student is able to identify compounds as Brønsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification.	EK 3.B.2
3.8	The student is able to identify redox reactions and justify the identification in terms of electron transfer.	EK 3.B.3
3.9	The student is able to design and/or interpret the results of an experiment involving a redox titration.	EK 3.B.3
3.10	The student is able to evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and non-covalent interactions.	EK 3.C.1
3.11	The student is able to interpret observations regarding macroscopic energy changes associated with a reaction or process to generate a relevant symbolic and/or graphical representation of the energy changes.	EK 3.C.2
3.12	The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/ or Faraday's laws.	EK 3.C.3
3.13	The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions.	EK 3.C.3

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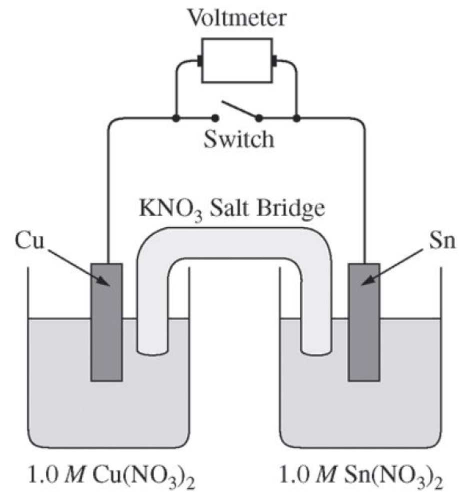
FREE RESPONSE PRACTICE

Abide by the time guidelines. Use only (1) a black or blue pen or No. 2 pencil, (2) a scientific or graphing calculator, and (3) the provided Periodic Table and list of Equations and Constants.

Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved at arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.

Write clearly and legibly. Cross out any errors you make; erased or crossed-out work will not be scored.

2014 AP Chemistry #3 (23 minutes)

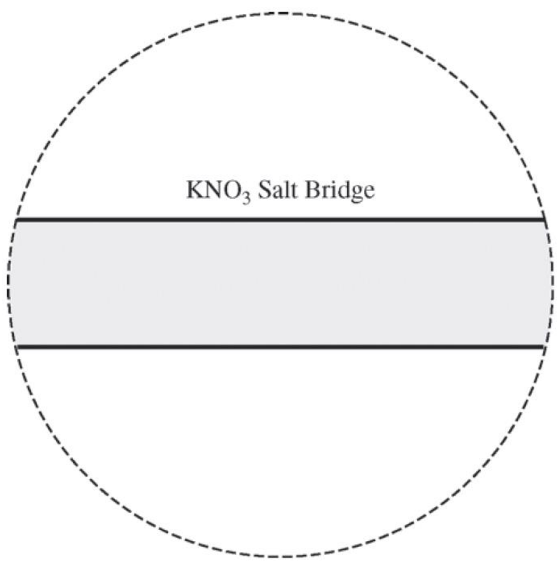


A student is given a standard galvanic cell, represented above, that has a Cu electrode and a Sn electrode. As current flows through the cell, the student determines that the Cu electrode increases in mass and the Sn electrode decreases in mass.

(a) Identify the electrode at which oxidation is occurring. Explain your reasoning based on the student's observations.

(b) As the mass of the Sn electrode decreases, where does the mass go?

(c) In the expanded view of the center portion of the salt bridge shown in the diagram below, draw and label a particle view of what occurs in the salt bridge as the cell begins to operate. Omit solvent molecules and use arrows to show the movement of particles.



(d) A nonstandard cell is made by replacing the 1.0 *M* solutions of $Cu(NO_3)_2$ and $Sn(NO_3)_2$ in the standard cell with 0.50 *M* solutions of $Cu(NO_3)_2$ and $Sn(NO_3)_2$. The volumes of solutions in the nonstandard cell are identical to those in the standard cell.

(i) Is the cell potential of the nonstandard cell greater than, less than, or equal to the cell potential of the standard cell? Justify your answer.

(ii) Both the standard and nonstandard cells can be used to power an electronic device. Would the nonstandard cell power the device for the same time, a longer time, or a shorter time as compared with the standard cell? Justify your answer.

(e) In another experiment, the student places a new Sn electrode into a fresh solution of 1.0 M $Cu(NO_3)_2$.

Half-Reaction	$E°$ (V)
$Cu^{+} + e^{-} \rightarrow Cu(s)$	0.52
$Cu^{2+} + 2\,e^{-} \rightarrow Cu(s)$	0.34
$Sn^{4+} + 2\,e^{-} \rightarrow Sn^{2+}$	0.15
$Sn^{2+} + 2\,e^{-} \rightarrow Sn(s)$	−0.14

(i) Using information from the table above, write a net-ionic equation for the reaction between the Sn electrode and the $Cu(NO_3)_2$ solution that would be thermodynamically favorable. Justify that the reaction is thermodynamically favorable.

(ii) Calculate the value of $\Delta G°$ for the reaction. Include units with your answer.

ADDITIONAL PAGE FOR ANSWERING QUESTION #3

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ADDITIONAL PAGE FOR ANSWERING QUESTION #3

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2017 AP Chemistry #7 (9 minutes)

A student wants to determine the concentration of H_2O_2 in a solution of $H_2O_2(aq)$. The student can use one of two titrants, either dichromate ion, $Cr_2O_7^{2-}(aq)$, or cobalt(II) ion, $Co^{2+}(aq)$. The balanced chemical equations for the two titration reactions are shown below.

Dichromate as titrant: $Cr_2O_7^{2-}(aq) + 3\ H_2O_2(aq) + 8\ H^+(aq) \rightarrow 2\ Cr^{3+}(aq) + 3\ O_2(g) + 7\ H_2O(l)$

Cobalt(II) as titrant: $2\ Co^{2+}(aq) + H_2O_2(aq) + 2\ H^+(aq) \rightarrow 2\ Co^{3+}(aq) + 2\ H_2O(l)$

The half-reactions and the $E°$ values for the systems related to the titrations above are given in the following table.

Half-Reaction	E° (V) at 298 K
$Co^{3+}(aq) + 3\ e^- \rightarrow Co^{2+}(aq)$	1.84
$H_2O_2(aq) + 2\ H^+(aq) + 2\ e^- \rightarrow 2\ H_2O(l)$	1.77
$Cr_2O_7^{2-}(aq) + 14\ H^+(aq) + 6\ e^- \rightarrow 2\ Cr^{3+}(aq) + 7\ H_2O(l)$	1.33
$O_2(g) + 2\ H^+(aq) + 2\ e^- \rightarrow H_2O_2(aq)$	0.70

(a) Use the information in the table to calculate the following.

(i) $E°$ for the reaction between $Cr_2O_7^{2-}(aq)$ and $H_2O_2(aq)$ at 298K

(ii) $E°$ for the reaction between $Co^{2+}(aq)$ and $H_2O_2(aq)$ at 298K

(b) Based on the calculated values of $E°$, the student must choose the titrant for which the titration reaction is thermodynamically favorable at 298 K.

(i) Which titrant should the student choose? Explain your reasoning.

(ii) Calculate the value of $\Delta G°$, in kJ/mol_{rxn}, for the reaction between the chosen titrant and $H_2O_2(aq)$.

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ADDITIONAL PAGE FOR ANSWERING QUESTION #7

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