**AP Chemistry Unit 13 Tentative Agenda** Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Electrochemistry

| **Date** | **Agenda** |
| --- | --- |
| Tues 4/10 | * Go over Unit 12 Test * Begin electrochemistry notes * Homework:   + Read Chapter 20 |
| Wed 4/11 | * Finish electrochemistry notes * Work sample problems * Homework:   + Mastering   + Prelab |
| Thurs 4/12 | * Finish working sample problems * Homework:   + Mastering |
| Fri 4/13 | * Begin Electrochemistry Lab * Homework:   + Mastering |
| Mon 4/16 | * Electrochemistry Lab * Homework:   + Mastering |
| Tues 4/17 | * Electrochemistry Lab Due * Review/Mastering * Homework:   + Mastering |
| Wed 4/18 | * Electrochemistry Quiz * Mastering Day * Homework   + Mastering |
| Thurs 4/19 | * Review/Mastering * Mastering Due 11:59 PM |
| Fri 4/20 | * Unit 13 Test |
| Mon 4/23 | * Go over Unit 13 Test * Begin AP Exam Review * AP Chemistry Exam   + 8:00 AM Monday, May 7, 2018 |

**Learning Objectives:**

Essential knowledge 3.C.3: Electrochemistry shows the interconversion 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.

✘✘ Labeling an electrode as positive or negative is beyond the scope of this course and the AP Exam.

Rationale: The sign on the electrode is different for electrochemical and electrolytic cells, but the most important concept is that oxidation always takes place at the anode in either cell type. Labeling electrodes does not provide a deeper understanding of electrochemistry.

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, Eo, 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 (when 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.

✘✘The Nernst equation is beyond the scope of this course and the AP Exam.

Rationale: Qualitative reasoning about the effects of concentration on cell potential is part of the course. However, inclusion of algorithmic calculations was not viewed as the best way to deepen understanding of the big ideas. e. ΔG° (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:

i. Number of electrons transferred

ii. Mass of material deposited or removed from an electrode

iii. Current

iv. Time elapsed

v. Charge of ionic species

**LO 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. [See SP 2.2, 2.3, 6.4]**

**LO 3.13 The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions. [See SP 5.1]**

Essential knowledge 5.E.3: If a chemical or physical process is not driven by both entropy and enthalpy changes, then the Gibbs free energy change can be used to determine whether the process is thermodynamically favored.

a. Some exothermic reactions involve decreases in entropy.

b. When ΔG° > 0, the process is not thermodynamically favorable. When ΔG° < 0, the process is thermodynamically favorable.

c. In some reactions, it is necessary to consider both enthalpy and entropy to determine if a reaction will be thermodynamically favorable. The freezing of water and the dissolution of sodium nitrate in water provide good examples of such situations.

**LO 5.14 The student is able to determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy. [See SP 2.2, connects to 5.E.2]**

Essential knowledge 5.E.4: External sources of energy can be used to drive change in cases where the Gibbs free energy change is positive.

a. Electricity may be used to cause a process to occur that is not thermodynamically favored. Useful examples are charging of a battery and the process of electrolysis.

b. Light may also be a source of energy for driving a process that in isolation is not thermodynamically favored. Useful examples are as follows:

1. The photoionization of an atom, because although the separation of a negatively charged electron from the remaining positively charged ion is highly endothermic, ionization is observed to occur in conjunction with the absorption of a photon.

2. The overall conversion of carbon dioxide to glucose through photosynthesis, for which 6 CO2(g) + 6 H2O(l) → C6H12O6(aq) + 6 O2(g) has ΔG° = +2880 kJ/ molrxn, yet is observed to occur through a multistep process that is initiated by the absorption of several photons in the range of 400–700 nm.

c. A thermodynamically unfavorable reaction may be made favorable by coupling it to a favorable reaction, such as the conversion of ATP to ADP in biological systems. In this context, coupling means the process involves a series of reactions with common intermediates, such that the reactions add up to produce an overall reaction with a negative ΔG°.

**LO 5.15 The student is able to explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable. [See SP 6.2]**

Essential knowledge 6.D.1: When the difference in Gibbs free energy between reactants and products (ΔG°) is much larger than the thermal energy (RT), the equilibrium constant is either very small (for ΔG° > 0) or very large (for ΔG° < 0). When ΔG° is comparable to the thermal energy (RT), the equilibrium constant is near 1.

a. The free energy change for a chemical process in which all of the reactants and products are present in a standard state (as pure substances, as solutions of 1 molar concentration, or as gases at a pressure of 1 bar, or 1 atm) is given a particular symbol, ΔG°.

b. The equilibrium constant is related to free energy by K = e –ΔG°/RT. This relation may be used to connect thermodynamic reasoning about a chemical process to equilibrium reasoning about this process. This reasoning can be done quantitatively through numerical examples or qualitatively through estimation. For example, the thermal energy (RT) at room temperature is 2.4 kJ/mol. This sets the energy scale for relating the enthalpy and entropy changes to the magnitude of K, since when the magnitude of ΔG° is large compared to the thermal energy, then K deviates strongly from 1.

c. The relation K = e –ΔG°/RT provides a refinement of the statement in 5.E that processes with ΔG° < 0 favor products, while those with ΔG° > 0 favor reactants. If ΔG° < 0, then K > 1, while if ΔG° > 0, then K < 1. The phrase “favors products” in 5.E is therefore more precisely stated as K > 1, while “favors reactants” in 5.E is more precisely stated as K < 1.

d. Since K is directly related to free energy, when the magnitude of K is of primary interest, it is useful to consider whether a reaction is exergonic (ΔG° < 0) or endergonic (ΔG° > 0). (Exothermic versus endothermic is the useful distinction when the issue of interest is whether a reaction releases or consumes energy.) In many biological applications, the magnitude of K is of central importance, and so the exergonic/endergonic distinction is useful.

**LO 6.25 The student is able to express the equilibrium constant in terms of ΔG° and RT and use this relationship to estimate the magnitude of K and, consequently, the thermodynamic favorability of the process. [See SP 2.3]**

**Mastering Chemistry Assignment Breakdown**

| [**#**](http://session.masteringchemistry.com/myct/yui-dt0-href-ordinal) | [**TITLEShow Descriptions**](http://session.masteringchemistry.com/myct/yui-dt0-href-title) | | | | **DIFFICULTY** | | **MEDIAN TIME** | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [**System**](http://session.masteringchemistry.com/myct/yui-dt0-href-systemDifficulty) | | [**System**](http://session.masteringchemistry.com/myct/yui-dt0-href-formattedSystemTime) | |
| **1** | [**Problem 20.3**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528104) | | | | **1** | | **4m** | |
| **2** | [**Problem 20.4**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528086) | | | | **1** | | **4m** | |
| **3** | [**Problem 20.6**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528091) | | | | **1** | | **2m** | |
| **4** | [**Problem 20.9**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528362) | | | | **1** | | **2m** | |
| **5** | [**Identifying Oxidizing and Reducing Agents**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528409) | | | | **3** | | **6m** | |
| **6** | [**Problem 20.13**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528410) | | | | **1** | | **2m** | |
| **7** | [**Problem 20.14**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528411) | | | | **1** | | **1m** | |
| **8** | [**Problem 20.15**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528387) | | | | **1** | | **1m** | |
| **9** | [**Chapter 20 Question 1 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528388) | | | | **1** | | **<1m** | |
| **10** | [**Chapter 20 Question 2 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528415) | | | | **1** | | **1m** | |
| **11** | [**Chapter 20 Question 2 - Multiple-Choice**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528416) | | | | **1** | | **<1m** | |
| **12** | [**Chapter 20 Question 3 - Multiple-Choice**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528429) | | | | **1** | | **<1m** | |
| **13** | [**Chapter 20 Question 5 - Multiple-Choice**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528377) | | | | **1** | | **1m** | |
| **14** | [**Balancing Redox Equations and Stoichiometry**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528546) | | | | **4** | | **14m** | |
| **15** | [**Problem 20.20**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528514) | | | | **1** | | **5m** | |
| **16** | [**Problem 20.21**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528547) | | | | **1** | | **30m** | |
| **17** | [**Chapter 20 Question 14 - Multiple-Choice**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528609) | | | | **1** | | **1m** | |
| **18** | [**Chapter 20 Question 15 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528882) | | | | **1** | | **1m** | |
| **19** | [**Chapter 20 Question 16 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528611) | | | | **1** | | **1m** | |
| **20** | [**Chapter 20 Question 16 - Multiple-Choice**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528887) | | | | **1** | | **1m** | |
| **21** | [**Chapter 20 Question 15 - Multiple-Choice**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528874) | | | | **1** | | **1m** | |
| **22** | [**± Introduction to Galvanic Cells**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528615) | | | | **2** | | **4m** | |
| **23** | [**Chapter 20 Question 2 - True/False**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528905) | | | | **1** | | **<1m** | |
| **24** | [**Chapter 20 Question 17 - Multiple-Choice**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528923) | | | | **2** | | **1m** | |
| **25** | [**Chapter 20 Question 18 - Multiple-Choice**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528924) | | | | **2** | | **1m** | |
| **26** | [**Chapter 20 Question 19 - Multiple-Choice**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528896) | | | | **2** | | **2m** | |
| **27** | [**Chapter 20 Question 20 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528925) | | | | **1** | | **<1m** | |
| **28** | [**Chapter 20 Question 21 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528908) | | | | **1** | | **1m** | |
| **29** | [**± A Nickel–Aluminum Galvanic Cell**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528911) | | | | **2** | | **7m** | |
| **30** | [**± Cell Potential**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528962) | | | | **2** | | **2m** | |
| **31** | [**Analyzing a Galvanic Cell**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528953) | | | | **2** | | **4m** | |
| **32** | [**Problem 20.37**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528963) | | | | **1** | | **9m** | |
| **33** | [**Chapter 20 Question 4 - True/False**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528913) | | | | **1** | | **<1m** | |
| **34** | [**Chapter 20 Question 3 - True/False**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528940) | | | | **1** | | **<1m** | |
| **35** | [**Chapter 20 Question 25 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528941) | | | | **1** | | **<1m** | |
| **36** | [**Chapter 20 Question 26 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528966) | | | | **1** | | **<1m** | |
| **37** | [**Chapter 20 Question 28 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528982) | | | | **1** | | **1m** | |
| **38** | [**Cell Potential and Free Energy of a Lithium–Chlorine Cell**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528971) | | | | **2** | | **6m** | |
| **39** | [**± Cell Potential and Free Energy**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528986) | | | | **3** | | **10m** | |
| **40** | [**Problem 20.54**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528977) | | | | **1** | | **5m** | |
| **41** | [**Chapter 20 Reading Quiz Question 7**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529008) | | | | **2** | | **3m** | |
| **42** | [**Chapter 20 Question 31 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529009) | | | | **1** | | **<1m** | |
| **43** | [**Chapter 20 Question 32 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34528978) | | | | **1** | | **1m** | |
| **44** | [**Chapter 20 Question 34 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529527) | | | | **2** | | **2m** | |
| **45** | [**± Introduction to the Nernst Equation**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529528) | | | | **2** | | **12m** | |
| **46** | [**Problem 20.63**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529012) | | | | **1** | | **2m** | |
| **47** | [**Problem 20.64**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529545) | | | | **1** | | **2m** | |
| **48** | [**Chapter 20 Question 27 - Multiple-Choice**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529531) | | | | **3** | | **1m** | |
| **49** | [**Protection of Iron from Corrosion**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529570) | | | | **2** | | **5m** | |
| **50** | [**Go Figure 20.22**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529548) | | | | **1** | | **1m** | |
| **51** | [**Chapter 20 Question 37 - Bimodal**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529573) | | | | **1** | | **<1m** | |
| **52** | [**± Introduction to Electroplating**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529019) | | | | **2** | | **11m** | |
| **53** | [**Electrolysis of Molten Salts**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529537) | | | | **2** | | **8m** | |
| **54** | [**± Gold Electroplating**](http://session.masteringchemistry.com/myct/itemView?showStatsForCourse=1110976&view=solution&showStats=1&assignmentProblemID=34529538) | | | | **3** | | **5m** | |
|  | **Average:** |  | **Total:** |  | |  | |
| **54 items** | **--** | **1.5** | **--** | **186m** | |