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| **Name: Travis Hartberger** | **Contact Info: travis.hartberger@dc.gov** | **Dates: 11/9/15-11/19/15** |

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| **Lesson Title: Introduction to Electrochemistry** | **Unit #:**  **1** | **Lesson #:**  **1** | **Activity #:**  **1** |
| **Activity Title: What is electrochemistry?** |

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| **Estimated Lesson Duration:** | **10 class periods (80 minutes each)** |
| **Estimated Activity Duration:** | **8 class periods (80 minutes each)** |

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| **Setting:** | **Science classroom** |

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| **Activity Objectives:** |

* Recognize reactions as acid-base, precipitation, metathesis or redox
* Calculate moles or grams of substances in solution using molarity
* Understand how to carry a dilution to achieve a desired solution concentration
* Understand how to perform and interpret the results of a redox titration
* Identify oxidation, reduction, oxidizing agent, and reducing agent in a chemical equation
* Complete and balance redox equations using the method of half-reactions
* Sketch a voltaic cell and identify its cathode, anode, and the directions that electrons and ions move
* Calculate standard emfs (cell potentials), Eocell, from standard reduction potentials
* Use reduction potentials to predict whether a redox reaction is spontaneous
* Relate Eocell to ΔGo and equilibrium constants
* Infer emg under nonstandard conditions
* Describe amounts of products and reactants in redox reactions to electrical charge

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| **Activity Guiding Questions:** |

* What kind(s) of reactions require/produce electricity, current, and voltage?
* What chemical species are used in oxidation-reduction reactions?
* How is a redox titration similar and/or different from an acid-base titration?
* How is a redox titration similar and/or different form the operation of a Galvanic cell or battery?
* Can the voltage of the chemical species be predicted?
* What parts are needed for a Galvanic Cell or battery to operate?
* How is a Galvanic cell or battery assembled?
* What factors contribute to the current or potential produced by a redox reaction?
* Do those factors affect current or potential independently, or do they work cooperatively?

| **Next Generation Science Standards (NGSS)** | |
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| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| ☒ Asking questions (for science) and defining problems (for engineering) | ☒ Patterns |
| ☒ Developing and using models | ☒ Cause and effect |
| ☒ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☒ Analyzing and interpreting data | ☒ Systems and system models |
| ☒ Using mathematics and computational thinking | ☒ Energy and matter: Flows, cycles, and conservation |
| ☒ Constructing explanations (for science) and designing solutions (for engineering) | ☒ Structure and function. |
| ☒ Engaging in argument from evidence | ☒ Stability and change. |
| ☒ Obtaining, evaluating, and communicating information |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☐ Demonstrating Science Knowledge **(D)** |
| ☐ Interpreting and Communicating Science Concepts **(C)** |
| ☐ Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):** |

LO = Advanced Placement® Chemistry Learning Objective

SP = Advanced Placement® Science Practice

SEP = NGSS Science and Engineering Practices

LO 3.8 The student is able to identify redox reactions and justify the identification in terms of electron transfer.

SP 6.1 The student can justify claims with evidence.

SEP 7: Engaging in argument from evidence

LO 3.9 The student is able to design and/or interpret the results of an experiment involving a redox titration.

SP 4.2 The student can design a plan for collecting data to answer a particular scientific question.

SEP 3: Planning and carrying out investigations

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.

SP 2.2 The student can apply mathematical routines to quantities that describe natural phenomena.

SP 2.3 The student can estimate numerically quantities that describe natural phenomena.

SP 6.4 The student can make claims and predictions about natural phenomena based on scientific theories and models.

SEP 5: Using mathematics and computational thinking

SEP 6: Constructing explanations and designing solutions

LO 3.13 The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions.

SP 5.1 The student can analyze data to identify patterns or relationships.

SEP 4: Analyzing and interpreting data

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

PowerPoint and handouts for each lesson.

Laboratory Preparation for:

NMSI: **How Can We Determine an Electrochemical Series?**Uses a voltage probe or multimeter to measure the electric potentials of Microvoltaic cells involving five metal samples and their respective 1.0 M salts to establish an electrochemical series.  Labels   for [baggies](http://nmsiteachers.org/library/filelib/rmccormick/05%20Lab/20%20Microvoltaic%20Cells%20Baggie%20Labels.doc) and [pipettes](http://nmsiteachers.org/library/filelib/rmccormick/05%20Lab/20%20Microvoltaic%20Cells%20Pipette%20Labels.doc)

URL: <http://nmsiteachers.org/library/filelib/AP%20Chemistry%20Redesign/Labs/As%20of%20summer%202014/08%20Microvoltaic%20Cells%20TEACHER.pdf>

NMSI: ***How Can We Construct an Electrolytic Cell, Collect Data & Utilize Faraday’s Law  to Determine Avogadro’s Number?***Students construct an electrolytic cell using a power source and current probe or multimeter to collect and analyze data gathered and apply Faraday’s Law to ultimately calculate Avogadro’s Number.

URL: <http://nmsiteachers.org/library/filelib/AP%20Chemistry%20Redesign/Labs/As%20of%20summer%202014/09%20Electrolytic%20Cells%20and%20and%20Electroplating%20to%20Determine%20Avogadros%20Number%20TEACHER.pdf>

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| **Teacher Advance Preparation:** |

PowerPoint and handouts for each lesson.

Student groupings for in-class and laboratory activities based on learning styles assessment.

Laboratory Preparation for:

NMSI: **How Can We Determine an Electrochemical Series?**Uses a voltage probe or multimeter to measure the electric potentials of Microvoltaic cells involving five metal samples and their respective 1.0 M salts to establish an electrochemical series.  Labels   for [baggies](http://nmsiteachers.org/library/filelib/rmccormick/05%20Lab/20%20Microvoltaic%20Cells%20Baggie%20Labels.doc) and [pipettes](http://nmsiteachers.org/library/filelib/rmccormick/05%20Lab/20%20Microvoltaic%20Cells%20Pipette%20Labels.doc)

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| **Activity Procedures:** |

Day 3 Lesson:

We will… Identify oxidation, reduction, oxidizing agent, and reducing agent in a chemical equation

In order to… Complete and balance redox equations using the method of half-reactions

Day 4:

We will… Sketch a voltaic cell and identify its cathode, anode, and the directions that electrons and ions move

In order to… Calculate standard emfs (cell potentials), Eocell, from standard reduction potentials

Day 5:

We will… Calculate standard emfs (cell potentials), Eocell, from standard reduction potentials

In order to… Use reduction potentials to predict whether a redox reaction is spontaneous

Day 6: NMSI: **How Can We Determine an Electrochemical Series?**Uses a voltage probe or multimeter to measure the electric potentials of Microvoltaic cells involving five metal samples and their respective 1.0 M salts to establish an electrochemical series.  Labels   for [baggies](http://nmsiteachers.org/library/filelib/rmccormick/05%20Lab/20%20Microvoltaic%20Cells%20Baggie%20Labels.doc) and [pipettes](http://nmsiteachers.org/library/filelib/rmccormick/05%20Lab/20%20Microvoltaic%20Cells%20Pipette%20Labels.doc)

URL: <http://nmsiteachers.org/library/filelib/AP%20Chemistry%20Redesign/Labs/As%20of%20summer%202014/08%20Microvoltaic%20Cells%20TEACHER.pdf>

Day 7: We will… Relate Eocell to ΔGo and equilibrium constants

In order to… Use reduction potentials to predict whether a redox reaction is spontaneous

Day 8:

We will… Use reduction potentials to predict whether a redox reaction is spontaneous

In order to… Infer emg under nonstandard conditions

Day 9:

We will… Sketch a voltaic cell and identify its cathode, anode, and the directions that electrons and ions move and Calculate standard emfs (cell potentials), Eocell, from standard reduction potentials

In order to… Describe amounts of products and reactants in redox reactions to electrical charge

Day 10: NMSI: ***How Can We Construct an Electrolytic Cell, Collect Data & Utilize Faraday’s Law  to Determine Avogadro’s Number?***Students construct an electrolytic cell using a power source and current probe or multimeter to collect and analyze data gathered and apply Faraday’s Law to ultimately calculate Avogadro’s Number.

URL: <http://nmsiteachers.org/library/filelib/AP%20Chemistry%20Redesign/Labs/As%20of%20summer%202014/09%20Electrolytic%20Cells%20and%20and%20Electroplating%20to%20Determine%20Avogadros%20Number%20TEACHER.pdf>

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

1. Warm-up: Each day will start with a warm up to determine and have students access prior knowledge for each lesson.
2. Exit Slip: Each day will conclude with a exit ticket to determine and have students gauge their mastery for each lesson.
3. Laboratory Journal: Laboratory experience will be assessed during the laboratory via questioning and direct observation.
4. Free Response Questions: Each laboratory activity will be followed by a released free-response question that will be scored using released scoring guidelines and translated into an AP score using peer grading/feedback.

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

Students will have a unit assessment that will include 30 released multiple-choice items and 4 released free response items (2 long form and 2 short form questions). This will serve as a post-test to matching test items in the diagnostic for the course offered at the beginning of the school year.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

Auditory learners will benefit the discussions.

Kinestic/tactile learners will benefit from the hands-on nature of this unit, i.e. constructing/drawing electrochemical cells.

Auditory and visual learners will benefit from the YouTube video used to “flip” instruction.

Students will special needs will be working in cooperative learning groups during established for the unit and utilized in small-group of each lesson.

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

The success of this lesson hinged on students developing their own activity series. Students really enjoyed being able to assemble and test their own microvoltaic cells—it was be both relatively easy to setup and provided instant data/feedback with the Vernier probes. Building content around activities that are both accessible and feedback driven is more palatable for students, especially when the content itself can be rather dreary. In retrospect, students did spend a bit of time fretting over the calculations as well as struggling to see the reversibility of processes (switching probes of a voltmeter and electron flow) as well as connecting their actions/methods to high percent error. In future implementation, the teacher could chunk student exploration time with explicit calculations to ensure students make connections between their actions and data more easily rather than after-the-fact. Additionally, a guided study, or even group debrief could allow for students to uncover or discover what types of procedural actions led to poorer yields, or even a picture inquiry—for example, students video or take pictures of each measurement and the debrief allows the class to see how their voltage outcome (data) could be explained by the setup of each cell.