Socially-based Curriculum Unit : TAKING IT OUTSIDE – Establishing a Cell Phone Recycling Program

Unit Title: TAKING IT OUTSIDE – Establishing a Cell Phone Recycling Program
Time Frame: 4-5 days for Summative, **Lesson 4** (+ 4 optional days for introduction of Electrochemistry)
Unit Developer(s): Bogna Haddad
Developed for Course Name and Course Code: Grade 12 Chemistry – College Preparation, SCH4C

Strand(s) and Curriculum Learning Expectations Addressed:

Scientific Investigation Skills Strand

SIS.01 - demonstrate an understanding of safe laboratory practices by selecting and applying appropriate techniques for handling, storing, and disposing of laboratory materials (e.g., safely disposing of organic solutions; correctly interpreting Workplace Hazardous Materials Information System [WHMIS] symbols), and using appropriate personal protection (e.g., wearing safety goggles);
SIS.03 - demonstrate the skills required to plan and carry out investigations using laboratory equipment safely, effectively, and accurately (e.g., manipulate burettes and other instruments used in an acid/base titration);
SIS.05 - select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate scientific ideas, plans, and experimental results (e.g., represent ionic and molecular compounds by their accepted formulae and names);
SIS.06 - select, integrate, and interpret information derived from experiments and from print and electronic sources, including Internet sites, and, either in writing or using a computer, compile and display the information in various forms, including diagrams, tables, graphs, and laboratory reports (e.g., using both experimental results and information from other sources, compile a table summarizing the physical and chemical properties of some common organic compounds);

Electrochemistry Strand

ELV.01 · demonstrate an understanding of the chemical processes that take place in galvanic and electrolytic cells;
ELV.02 · investigate through experimentation the ease of oxidation of metals, and build electrochemical cells and describe their functioning;
ELV.03 · explain the importance for industry and the consequences for the environment of common electrochemical processes.
EL1.01 – name the components of galvanic and electrolytic cells, describe their role, and explain how they function in terms of oxidation and reduction;
EL2.01 – use appropriate scientific vocabulary to communicate ideas related to electrochemistry (e.g., ionic bonds, oxidation, anode, electrolyte);
EL2.04 – interpret observations from experiments to determine an activity series of some metals;
EL2.05 – predict the spontaneity of displacement reactions between metal elements and metal salts based on the activity series, and verify the predictions through experimentation;
EL2.07 – describe an electrochemical cell in terms of half-cell reactions, location of electrodes, direction of electron flow, and direction of migration of ions;

EL3.01 – describe applications of electrochemical cells, such as batteries;
EL3.02 – explain how electrolytic processes are used in the refining of metals (e.g., Al, Cu, or Ni), and evaluate the impact of such processes on the environment (e.g., production of acid rain, high-energy consumption);
EL3.03 – identify electrochemical processes used in industry (e.g., chrome-plating);

Desired Results

Unit Description:

The ringing of a student's cell phone during class is an occasional nuisance that we have all learned to deal with. In this activity our students' love of instant communication will be turned into a chemistry unit with a socially-based goal: protection of the environment through the establishment of a recycling program for old cellular phones. This program will be established as part of the Electrochemistry strand, but can also be adapted to any other course that deals with bioaccumulation, the digital age, recycling, or batteries. The learning outcomes for this unit follow from the SCH4C curriculum expectations: students will reinforce their understanding of redox reactions as they design and conduct an experiment on the reactivities of different metals; they will be introduced to batteries in the form of galvanic cells; they will develop an understanding of how chemical reactions can be turned into usable electrical energy; and finally students will analyze the impact of our current digital age on the environment. Their culminating task will be to research and educate other students and community members on the dangers of old cell phones and establish a cell phone recycling program at the school. This real-world example of environmentally-sound thinking exemplifies how students can address global concerns at a local level.

Enduring Understandings / Learning:

The key knowledge addressed in the unit will be: activities of metals, electrochemistry of both galvanic and electrolytic cells, and the impact of electrochemistry on the environment. The skills learned include key science investigative skills: planning and carrying out an investigation; selecting, integrating and interpreting information; they will also select and use appropriate modes of representation to communicate scientific ideas, plans, and experimental results their findings.

Assessment Tasks

Performance Tasks and Other Evidence That Will Demonstrate the Knowledge and Skills Acquired:
- Design-A-Lab Assessment, Formal Lab Report Self-Evaluation and Teacher Evaluation, Post-Evaluation Self-Assessment
- Summative Task Teacher Evaluation

Assessment Criteria:
- checkbricks/rubricks based on the Ministry of Education's Achievement Chart for Science (2000)

Unit Planning Notes

Prior Learning Necessary (if any):
- IUPAC nomenclature
- single displacement reactions
- net and total ionic equations, balancing, spectator ions
- electronegativity
- conducting a lab: lab safety
- insulator/conductor
- electrolytes

Preparation Notes (if any):
Specified at the beginning of each lesson

Learning Plan

Lesson 1: ELECTROCHEMISTRY: An Introduction

- *this lesson will take 2-3 periods to complete*
- *photocopy Appendix A (class set)*
- *prepare solutions and thin metal strips (from Materials and Methods of Appendix 1 Design-A-Lab)*
- *ensure that your class has access to a Periodic Table with an Activity Series of Metals*
- *notes for students are provided below, directions for teacher are in italics.*

-electrochemistry deals with the transfer of electrons from one substance to another

ex. $Mg (s) + 2 AgNO_3 (aq) \rightarrow Mg(NO_3)_2 (aq) + 2 Ag (s)$

Looking at this in terms of the ions present:

reactants: $Mg (s) + 2 Ag^+ (aq) + 2 NO_3^- (aq) \rightarrow$

products: $Mg^{2+} (aq) + 2NO_3^- (aq) + 2 Ag (s)$

If we eliminate the spectator ions (nitrate), we get

reactants: $Mg(s) + 2 Ag^+(aq) \rightarrow$

products: $Mg^{2+} (aq) + 2 Ag (s)$

where Mg (s) lost electrons, while Ag^+(aq) gained them!

Recall: oxidation-reduction reactions are based on the loss and gain of electrons

LEO the lion says **GER**:
- **L**oss of **E**lectrons, **O**xidation
- **G**ain of **E**lectrons, **R**eduction

<u>REDOX REACTIONS</u>

- a redox reaction is a reaction where one substance loses electrons while another gains electrons
  - in a redox electrons are lost AND gained within the same reaction, i.e. the same number of electrons is gained as lost

ex. $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4 (aq)$

look at the ions involved:

lost electrons: oxidation

$Zn(s) + Cu^{2+}(aq) \rightarrow Cu (s) + Zn^{2+} (aq)$

gained electrons: reduction

In-Class Examples

Have students complete in class and post solutions on board.

Identify the reactant oxidized and the reactant reduced in the following

a) $Zn\ (s) + FeCl_2\ (aq) \rightarrow Fe\ (s) + ZnCl_2\ (aq)$

total ionic:
net ionic:
oxidation half-reaction:
reduction half-reaction:

b) magnesium and aqueous aluminum sulfate
$Mg\ (s) + Al_2(SO_4)_3\ (aq) \rightarrow Al\ (s) + MgSO_4\ (aq)$

RECALL: HOW DO WE KNOW THAT A REACTION IS TAKING PLACE?
- have students brainstorm and randomly write down the typical signs of a the formation of a new substance (ex. colour change, bubbling, precipitate formation, etc.)

- will a reaction always take place? NO

- in a single displacement reaction what would cause a reaction to take place?
ex. $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4\ (aq)$

look at the ions involved:
Zn(s) + Cu2+(aq) → Cu (s) + Zn 2+ (aq)

Since the electronegativity of positive copper is stronger than neutral Zn, the copper ion pulls off zinc's electrons!

ex. $Cu(s) + Mg(NO_3)_2(aq) \rightarrow$ NO REACTION

How can we determine which metals will/will not react?
- experimental data!

Lesson 1 cont…

Hand out the Appendix A: "Activity Series of Metals Design-A-Lab"

If needed, give real-life applications for the metals: copper roofs of Parliament Hill, silver jewelry, lead plumbing, etc.

Collect experimental designs, one per group. Once you have gone through them for safety/major issues hand the protocols back to the groups, along with Appendix A: "Presenting a Formal Lab Report" *and the attached marking scheme. Go through both. Prior to students handing in the reports have them mark themselves (in pencil) using the provided marking scheme and remind them to attach the marking scheme with the lab report. Once the reports have been marked and returned have them complete the included* Appendix A: "Post-Evaluation Self-Assessment."

Lesson 2: GALVANIC CELLS

- *this lesson will take 1-2 periods to complete*
- *photocopy Appendix B (class set)*
- *set up a demonstration of a galvanic cell (illustrated below, can be `dry`, to provide a visual)*
- *notes for students are provided below, directions for teacher are in italics.*

GALVANIC CELLS: CONVERTING CHEMICAL ENERGY TO ELECTRICAL ENERGY

Recall from last class:
electrochemistry

- the study of processes involved in converting chemical energy to electrical energy, involves the transfer of electrons from one substance to another (through oxidation-reduction reactions)

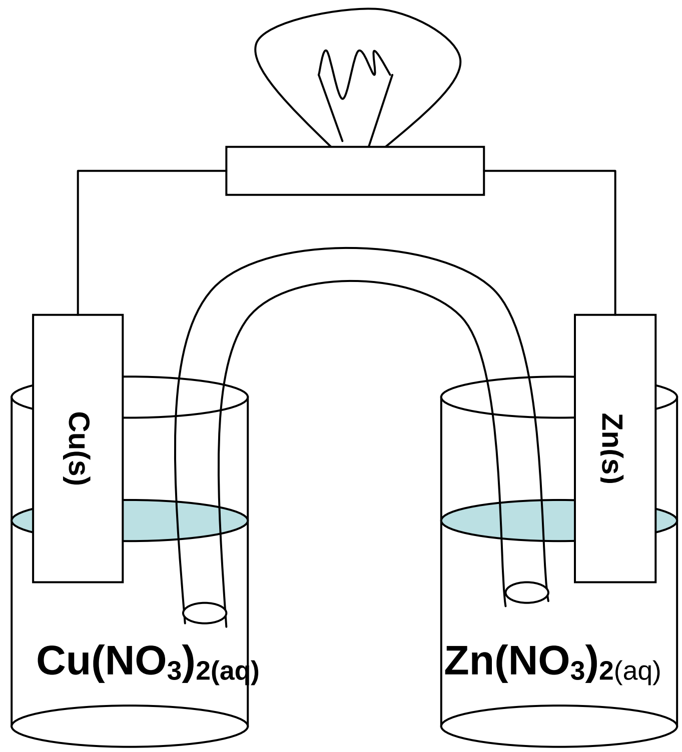
SO:
$Zn (s) + Cu^{2+} (aq) \rightarrow Cu (s) + Zn^{2+} (aq)$

Zn becomes Zn^{2+}, loses 2 electrons (LEO: oxidized)
Cu^{2+} becomes Cu, gains 2 electrons (GER: reduced)
- if we separate the zinc metal from the Cu^{2+} solution and place a **conductor** (ex. metal wire that allows for electron transfer) between them the electrons will be forced to travel to reach the copper ions

a galvanic/voltaic cell

- converts chemical energy to electrical energy: the two reactants are separated and electrons flow through an external circuit (a circuit outside the reaction vessel)
- reactions in a galvanic cell are spontaneous (proceed on their own, without outside assistance)
- a galvanic cell has four main components:

ex. a zinc/copper galvanic cell



1. Anode

- the half-cell where **oxidation** occurs

Zn electrode is oxidized at the anode (loses electrons), submerged in zinc nitrate solution

- recall: in the Activity Series of Metals, the metal most likely to be oxidized is closer to the top, since zinc is higher than copper zinc is oxidized, copper is reduced

2. Cathode

- the half-cell where reduction occurs

Cu electrode is reduced at the cathode (gains electrons), submerged in a copper (II) nitrate solution

3. A conductor
- a wire between the half-cells allows for electron flow.

draw the cell without the salt bridge, have students put up the cathode/anode signs and the half-reactions, as well as direction of electron flow

- zinc is higher than copper in the activity series so zinc is oxidized, copper is reduced

anode half-reaction: $Zn(s) \rightarrow Zn^{2+}(aq)$ + 2 electrons (oxidation)
cathode half-reaction: $Cu^{2+}(aq)$ + 2 electrons $\rightarrow Cu(s)$ (reduction)

- as cell operates mass of Zn electrode decreases, mass of copper electrode increases, while blue colour of copper solution fades

Overall reaction for zinc/copper cell
$Cu^{2+}(aq) + Zn(s) \rightarrow Cu(s) + Zn^{2+}(aq)$
So it's a redox: electrons lost by one reactant are gained by another!

ask which ions will form in which half-cell and what do they think will happen as those ions accumulate? (ie. the reaction will stop), introduce the salt bridge

4. The salt bridge
- an electrolyte solution that does not interfere with the reaction (ex. sodium nitrate), provides ions to prevent charge build-up: neutralize the charges in the solutions of each half-cell
  - as Cu^{2+} ions are removed (made into Cu(s)), Na^{+} ions move into the cathode half-cell
  - as Zn is changed into Zn^{2+} (aq), nitrate ions NO_3^- flow into the anode half-cell
- if too many charges build up the electron flow will stop, *WHY?*

Thus…
- cations migrate to cathode
- anions migrate to anode
draw the salt bridge and have students indicate the flow of ions

Writing Chemical Equations for Cell Reactions

ex. Write the anode, cathode, and overall cell reactions that occur when each pair of half-cells is combined to form a galvanic cell.

a) a tin strip in a solution to tin (II) chloride, and a copper strip in a solution of copper (II) nitrate

what is oxidized and reduced ?

- tin is higher than copper in the activity series, so tin is oxidized

anode half-reaction: $Sn(s) \rightarrow Sn^{2+}(aq)$ + 2electrons

cathode half-reaction: $Cu^{2+}(aq)$ + 2 electrons $\rightarrow Cu(s)$

overall cell reaction: $Sn(s) + Cu^{2+}(aq) \rightarrow Sn^{2+}(aq) + Cu(s)$

b) a silver strip in a solution of silver nitrate, and a copper strip in a solution of copper (II) nitrate

Have students practice the writing and balancing of cell reactions individually. Have them design a cell (Appendix B) *based on the activity series (I suggest think-pair-square) and submit it individually. Check for understanding – especially the concept of a salt bridge!*

Lesson 3: THE ELECTROLYTIC CELL

- *this lesson will take 1 period to complete*
- *photocopy Appendix C (class set)*
- *notes for students are provided below, directions for teacher are in italics.*

THE ELECTROLYTIC CELL

- in a galvanic cell, spontaneous redox reactions are used to produce electrical energy through the transfer of electrons from the anode to the cathode

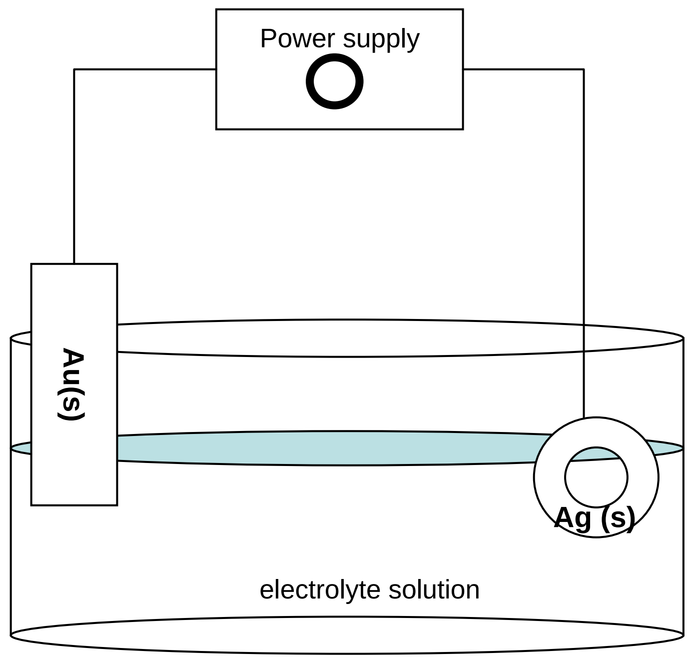
- the opposite is also possible: in an electrolytic cell electrical energy (a power supply) is used to cause a non-spontaneous redox reaction in a process called **electrolysis**, thus electrical energy is converted to chemical energy
    - electricity is used to strip electrons from the anode and push them to the cathode

    Why Would This Be Useful?

Example 1. electroplating

- gold at the anode, silver ring at the cathode, what will happen? (Au will oxidize to Au^{3+})
- used in jewelry, the making of coins (ex. a loonie is 91.5% nickel, with 8.5% bronze plating (mix. of tin and copper)), gold- or silver-plated forks etc.

Have students label anode, cathode, electron flow



Example 2. electrorefining

- purification of metals using electrolysis: the anode is made of impure metal (ex. copper), cathode is made of pure copper, with copper (II) sulphate as the electrolyte
  - impure anode will be oxidized into ions, with copper ions traveling to the cathode where they will be reduced to copper (s) and will attach to the cathode

Example 3. rechargeable batteries

Battery

- two or more galvanic cells connected in series, ie. the positive electrode of one cell is connected to the negative electrode of the next cell

There are two types of batteries:

1) Primary cells

- single-use batteries, once used up have to be disposed of
- use the principles of a galvanic cell, with a thickened paste as the electrolyte

2) Secondary cells

- multiple-use or rechargeable batteries
- spend some of their time as a galvanic cell (when in use) and some as an electrolytic cell (when being charged): in a rechargeable battery redox chemical reaction can be forced to proceed in the opposite direction by applying an external voltage to the battery (like in an electrolytic cell), thus allowing it to reverse the chemical reaction and make it available to once again go through a spontaneous redox reaction

Hand Out Appendix C: COMPARING GALVANIC AND ELECTROLYTIC CELLS

Lesson 4: *TAKING IT OUTSIDE: Establishing a Cell Phone Recycling Program*

- this lesson will take 4-5 periods to complete
- photocopy Appendix D (class set)
- discuss the project with your school's EarthCare (or equivalent) group
- ask your teacher-librarian for available in-school print resources and databases
flip charts and markers
- actual needs to carry out assignment will vary from group to group, some general suggestions include: random magazines and cell phone advertisements, scissors, glue, Bristol board, markers, etc.
- computer with internet and printer access
- notes for students are provided below, directions for teacher are in italics

TAKING IT OUTSIDE: Establishing a Cell Phone Recycling Program

Introducing the topic
- brainstorm with the students everyday sources of pollution, ie. household hazardous wastes, too much packaging, private transport, etc.
- draw their attention to the digital age and ask what wastes are specific to our time right now: batteries, fumes, toxic display monitors, etc.
- ask for a show of hands to see how many of them have old cell phones at home
- ask what could be done to minimize their impact on the environment, the idea of collecting cell phones should come up

Developing the Concept
- ask the students to think-pair-square what they think would be essential to conducting a successful collection and use flip charts to share their information with the rest of the class, using the format below (hints are in italics):

1. Define your goals
- what do you hope to accomplish?

2. Identify potential participants
- whom could you involve in this project?
    - *other students, local community associations, environmental associations, your municipality*

- how can you involve them?
    Publicize through: library, local environmental groups, community centre, neighborhood associations, YM/YWCA, health food stores

3. Prepare your budget
- include both expenses and sources of income

Developing an action plan
As a class develop an action plan. Identify a start date for your project and an end date, what needs to be in place for it, what the necessary roles will be, how the project will be maintained, what do you need in terms of equipment and materials?

Bringing out the assignment
- hand out the assignment (Appendix D)
- discuss it with the students

In-class research time and assembly
- allocate in-class time to begin the research and to assemble materials

Post-assignment
- a good way to bring it all together is to (as a class) evaluate what you have accomplished, what you could do better next time, and write thank-you's to those in the community who were involved!

Attachments

Appendix A
- Metal Reactivities Design-A-Lab
- Presenting a Formal Lab Report
- Formal Lab Report Rubric
- Post-Evaluation Self-Assessment

Appendix B
- Designing a Galvanic/Voltaic Cell

Appendix C
- Comparing Galvanic and Electrolytic Cells

Appendix D
- Taking It Outside: Establishing a Cell Phone Recycling Program
- The Student's Guide to Using Google

Other Possible Course Applications

- Lesson 4: **Taking It Outside: Establishing a Cell Phone Recycling Program** can be used (as is) in any course that deals with biotoxicity, bioaccumulation, electrochemistry and environmental protection. It can also be modified through adapting the questions to cover course-specific expectations. The courses where it can be used include but are not limited to:

Course Code	Course Name	Strand*
SNC1D	Science, Grade 9 Academic	Chemistry: Atoms and Elements
SNC2D	Science, Grade 10 Academic	Biology: The Sustainability of Ecosystems
SNC2P	Science, Grade 10 Applied	Chemistry: Chemical Reactions and Their Practical Applications
SNC3M	Science, Grade 11 University/College Preparation	Waste Management
SNC3E	Science, Grade 11 Workplace Preparation	Electrical Circuits Or Human Impact on the Environment

SNC4M	Science, Grade 12 University/College Preparation	Communication Systems
SNC4E	Science, Grade 12 Workplace Preparation	Communications: Sounds and Pictures
SBI4U	Biology, Grade 12 University Preparation	Population Dynamics
SCH4U	Chemistry, Grade 12 University Preparation	Electrochemistry
SPH4C	Physics, Grade 12 College Preparation	Electricity and Electronics

* Based on The Ontario Curriculum, Grades 9 and 10: Science, 1999 and The Ontario Curriculum, Grades 11 and 12: Science, 2000