LABORATORY EXERCISE #9
METAL CORROSION PROCESSES

OBJECTIVES

- Create a galvanic series relative to graphite for the voltages developed by aluminum, copper, iron and zinc, using 3% NaCl brine as an electrolyte.

- Measure the voltages developed by galvanic cells consisting of all possible combinations of aluminum, copper, iron and zinc, taken in pairs, and using 3% NaCl brine as an electrolyte. Compare these voltages with the values that one would predict from the initial galvanic series.

- Determine the corrosion penetration rate, in mmpy, for the anode in the galvanic cell consisting of graphite and the most anodic metal in your galvanic series.

PROCEDURES

Galvanic Series

- Set the multimeter to DC volts, manual range control, X.XXX volt scale.

- Clean samples of aluminum, copper, iron and zinc with sandpaper and / or steelwool.

- Immerse each metal sample, together with a graphite sample (pencil "lead"), into a beaker of 3% NaCl brine. If necessary, clamp them to the side of the beaker to keep them from touching, but be careful not to snap the graphite or the beaker. Try to keep the separation between the metal sample and the graphite more or less constant throughout the sequence of voltage measurements. Immediately upon immersion of the samples use the voltmeter probes to measure the open circuit DC voltage developed by the cell. Do not let the probes touch the saltwater. All of these metals are anodic with respect to graphite, and therefore all voltages should be recorded as negative values relative to graphite, regardless of which way the meter probes are touched on the samples.

- Based on the four voltages you have measured, create a table showing the galvanic series relative to graphite (0.000 volts) with the four metals sorted into the proper sequence from least anodic (smallest voltage magnitude) to most anodic (largest voltage magnitude).

Galvanic Cells

- Create galvanic cells by using all possible combinations of the aluminum, copper, iron and zinc samples, taken in pairs. Immerse each pair in the 3% NaCl brine and immediately measure the voltage developed, as described above. For each pair, the cathode will be the metal that produces a positive voltage when connected to the positive input terminal of the voltmeter. Create a table comparing these measured (positive) values with the voltages you would predict by subtracting the anode voltage from the cathode voltage in your galvanic series.

Corrosion Penetration Rate

- Reset the multimeter to read current in milliamps.
- Identify the metal that is most anodic with respect to graphite. Measure the dimensions of this sample such that you can estimate the surface area that will make contact with the electrolyte when immersed in the saltwater.
- Immerse the graphite and the sample into the saltwater and immediately measure the magnitude of the short circuit current, in microamps, with the ammeter.
- Rinse all of your samples in fresh water and dry them. Discard the saltwater into the sink, rinse and dry your beaker.

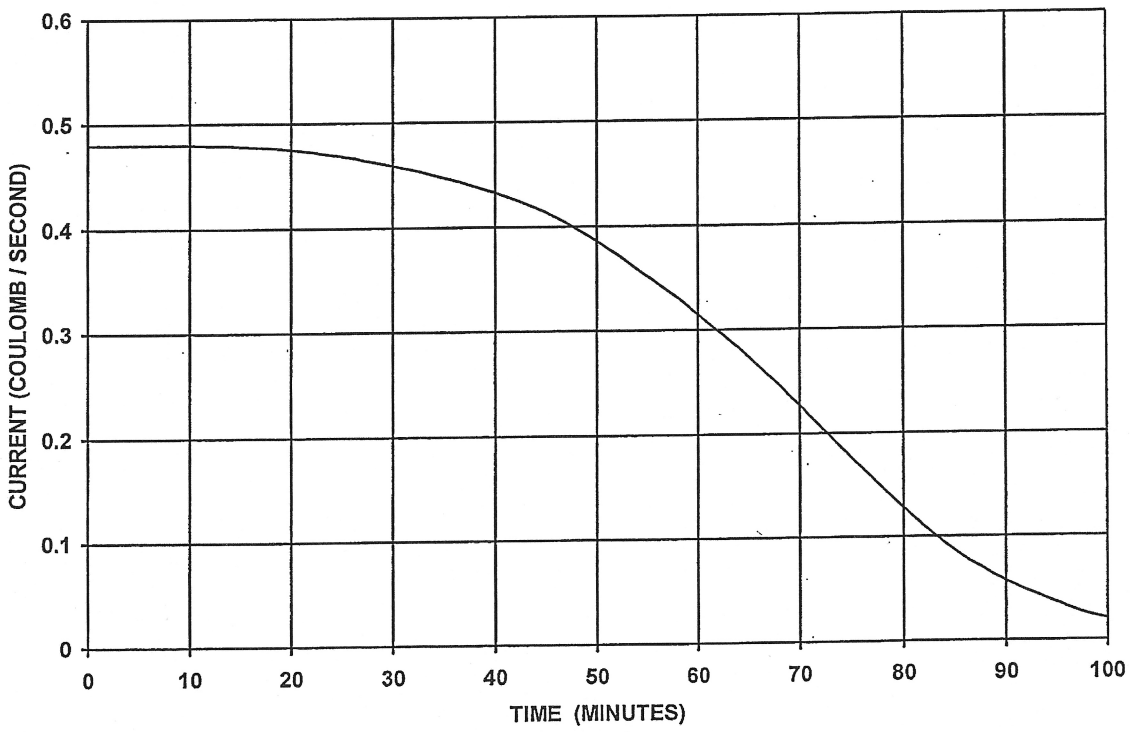
DATA ANALYSES

- Create a table for your galvanic series with graphite at the top and the other metals and their voltages relative to graphite in the proper order, with the most anodic at the bottom.

- Create a table containing each of your six galvanic cells. Identify the anode, the cathode, the measured cell voltage and the voltage predicted from your galvanic series.

- Based on the measured current, the estimated surface area and the type of metal, calculate the corrosion penetration rate in millimeters per year (mmpy) for the most anodic metal.

- Solve the following problem. Suppose that the current for a galvanic cell with a cadmium anode and a surface area of 25 cm^2 is given by the graph shown below. The original thickness of the cadmium is 0.350 mm. Use Simpson's Rule to numerically integrate the graph from zero to 100 minutes (6000 seconds) to obtain the total charge, in coulombs, removed from the cadmium. Use a maximum time interval of ten minutes and remember that the total number of time intervals must be an even number for Simpson's Rule to work correctly. Based on this electric charge, calculate the final thickness of the cadmium after 100 minutes.



REPORT

Write a short format lab report that includes the following elements:

- A brief summary of the objectives of this exercise.
- A brief summary of the procedures used to measure the voltages and currents for galvanic cells.
- The table containing the galvanic series.
- The table containing the six galvanic cell voltages.
- A summary of the results of your corrosion penetration rate calculations.
- A summary of the results of your solution for the cadmium corrosion problem. Describe the problem before presenting the solution.
- An appendix containing the corrosion penetration rate calculations.
- An appendix containing the calculations for the cadmium corrosion problem, including the Simpson's Rule calculations.

Voltage

Copper	0.1 V
Zinc	0.9 V
Aluminum	0.8 V
Iron	0.5 V

Copper vs. Iron	0.4 V
Zinc vs. Iron	0.4 V
Aluminum vs. Iron	0.2 V
Aluminum vs. Zinc	0.2 V
Aluminum vs. Copper	0.6 V
Copper vs. Zinc	0.8 V

Amperage

Aluminum	.828 mA
Copper	.47 mA
Zinc	1.146 mA
Iron	.724 mA