Gr12 Electrochemistry: 2016 Name Instructions & MEMO

Reduction Potentials of different metals

**AIM:**

1) To investigate various metals and their salts and measure the potential difference of various cell combinations

2) To use the measure values to rank the half cells in order of reactivity

3) To compare our results with those of the accepted Redox Table.

**METHOD:**

1. Various metals and their salts are arranged on a piece of filter paper as shown in the diagram below.

## Fig. 1: Experimental Set-up



M

M

M

M

M

1

2

3

4

5

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

|  |  |  |
| --- | --- | --- |
|  | Metal | Solution |
| M1 | Cu | CuSO4 |
| M2 | Zn | ZnSO4 |
| M3 | Pb | Pb Acetate |
| M4 | Mg | MgSO4 |
| M5 | Fe | FeSO4 |

**Procedure**

* Cut 5 wedges out of filter paper to make the shape alongside.

M5

M1

* 2-3 drops of various salt solutions are carefully dripped onto the circles  – & KNO3 is dripped onto the dotted lines (acts as the salt bridge). All solutions have a concentration of 1 mol.dm3
* The appropriate metal pieces are then laid on top of the solutions.
* The electrodes of the multi-meter (set on DC Voltage 20) then link different combinations of the metals and their salts thus determining their relative reduction potentials

1. Use metal M1= Cu as the reference metal. Determine the potential of four cells by connecting M1 to M2; M1 to M3; M1 to M4 and M1 to M5.

This is done by bringing the (+) lead in contact with M1 (Cu) and the (–) lead in contact with the other. **Record** the value in Data **Table 1**.

1. **Analysis so far -** Rank the five metals from the highest reduction potential at the top to the lowest at the bottom.

* Metal M1, (Cu), the standard reference, will be given an arbitrary value of 0.00 V.
* If the other metal was correctly connected to the *negative* terminal, it will be placed *above* M1 in the chart (with a negative E° value).
* If it was connected to the positive terminal, it will be placed below M1 in the chart (with a positive E° value).
* The numerical value of the potential relative to M1 will simply be the value that you measured on the multimeter.

1. **Prediction -** Calculate the predicted potential of each of the remaining cell combinations shown in Data **Table 3**, using the reduction potentials you just determined (in Data Table 2).
2. **Measure** the potential of the six remaining half-cell combinations. If the KNO3 salt bridge solution has dried, you may have to re-moisten it. Record each measured potential in Data **Table 3.**
3. **Compare** these to your predicted values and calculate the **percentage error** in each prediction.
4. **Clean up:** use forceps to remove each of the pieces of metal from the filter paper. Rinse each piece of metal with tap water. Dry it and return it to the correct container. Remove the filter paper from the glass plate using the forceps, and discard it as directed by your teacher. Rinse the glass plate with tap water, making sure that your hands do not come in contact with wet spots on the glass.

**Table 2 Ranking of the metals (most negative on top)**

# RESULTS/DATA

|  |  |
| --- | --- |
| Metal  (Mi) | Highest Reduction Potential, E°  (V) |
| Mg | - 1.84 |
| Zn | - 1.10 |
| Fe | - 0.59 |
| Pb | - 0.49 |
| Cu | 0.00 |
|  | Lowest Reduction Potential, E° |

# Table 1 Potentials of 1st combinations

|  |  |  |  |
| --- | --- | --- | --- |
| Voltaic Cell  (metals used) | | Measured Potential  (V)  At least one calc. must be shown                      Tick per column correct | E0 = E0cathode - E0anode  (using STD Values) |
| M1 // M2 | Cu // Zn | 1.10 ✓ | +0.34 – (-0.76) = 1.10 |
| M1 // M3 | Cu // Pb | 0.49  | +0.34 – (-0.13) = 0.47 |
| M1 // M4 | Cu // Mg | 1.84 much less than redox table | +0.34 – (- 2.36) = 2.70 |
| M1 // M5  **Table 3 Potential of other Combinations** | Cu // Fe | 0.59  | +0.34 – (-0.44) = 0.78 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Voltaic Cell  (metals used) | | Predicted Potential  (V) | Measured Potential  (V) | Error  (%) | E0 = E0cathode - E0anode  (using STD Values) |
| M2 // M3 | Zn // Pb | 0.61 | 0.59 |  | -0.13 –(0.76) = 0.63 |
| M2 // M4 | Zn // Mg | 0.74 |  |  | -0.76 – (-2.36) = 1.6 |
| M2 // M5 | Zn // Fe | 0.51 |  |  | -0.44 –(-0.76) = 0.32 |
|  | | | | | |
| M3 // M4 | Pb // Mg | 1.35 |  |  | -0.13 – (-2.36) = 2.23 |
| M3 // M5 | Pb // Fe | 0.10 |  |  | -0.13 – (-0.44) = 0.31 |
|  | | | | | |
| M4 // M5 | Mg // Fe | 1.25 |  |  | -0.44 – (-2.36) = 1.92 |

**DISCUSSION QUESTION**

1. Compare your ranking and reduction potential to those of the accepted Redox table provided.

Ranking is same  as the Redox Table. The values Zn/Cu, Zn/Pb are similar but the Values for Zn/Mg is much less than the Redox Table. This probably due to the lack of mobility of ions in the filter paper compare to in standard conditions. The Fe values also a bit lower. Fe2+ ions in solution oxidize further to Fe3+ which has a lower E0 value on the Redox table. This is why the Fe2+ solution must be freshly prepared. Our salt is old and it’s uncertain how much has changed. [total /15]

# Practical Examples

1. Chemical Cells - all cells are redox reactions. Rechargeable cells have reversible reactions. When supplied with voltage they react backwards.
2. Electroplating – electrolysis is a redox reaction caused by electricity. Sometimes this is called an electrolytic cell as opposed to the voltage cells above.
3. Preferential rusting - the hull of a large ship is normally made out of steel. To prevent its corrosion a piece zinc is connected to the hull, under the waterline. Because zinc is more reactive than steel (i.e. oxidizes more easily OR has a lower reduction potential), it is oxidized and corrodes away instead of the steel. In fact all galvanizing works on this principle.

Instructions for preparation of the solutions:

1. Prepare the filter paper, salt solutions and pieces of metal:

* Approximately 0.25 ml of each of the following solutions is necessary to prepare the micro-voltaic cells. Solutions are prepared using the quantities shown below. Use distilled water for all solutions.
* 1 M CuSO4 =(M12+) [24.96 g solid CuSO4.5H2O per 100 ml] & M1 = Cu
* 1 M ZnSO4 =(M22+) [28.76 g solid ZnSO4.7H2O per 100 ml] & M2 = Zn
* 1 M Pb(NO3)2 =(M32+) [33.10 g solid Pb(NO3)2 per 100 ml] & M3 = Pb
* 1 M MgSO4 or 1 M MgCl2 =(M42+) & M4 = Mg
* 1 M FeSO4 =(M52+) [27.80 g solid FeSO4.7H2O per 100 ml], freshly prepared. & M5 = Fe
* 1 M NaNO3 [8.50 g solid CuSO4.5H2O per 100 ml]