K_{sp} of Copper(II) Iodate(V) by E.M.F. Measurement

Student Handout

Purpose

To determine the solubility product of copper(II) iodate(V) at room temperature and pressure by e.m.f. measurement.

Introduction

Copper(II) iodate(V) ionises weakly in water:

$$Cu(IO_3)_2(s) + aq \rightleftharpoons Cu^{2+}(aq) + 2IO_3^-(aq)$$

For a saturated solution of copper(II) iodate(V), concentration of $IO_3^-(aq)$ ions doubles that of the $Cu^{2+}(aq)$ ions, and K_{sp} of $Cu(IO_3)_2(s)$ can be calculated by determining the concentration of $Cu^{2+}(aq)$ ions of a saturated $Cu(IO_3)_2(aq)$.

The e.m.f. of a galvanic cell consisting of a $Zn(s)/Zn^{2+}(aq)$ half-cell and another half-cell containing a copper strip in contact with a saturated solution of $Cu(IO_3)_2(aq)$ is measured by a digital multimeter. The concentration of $Cu^{2+}(aq)$ is determined with reference to the E^θ values of the $Zn(s)/Zn^{2+}(aq)$ and the $Cu(s)/Cu^{2+}(aq)$ couples using the Nernst equation for a metal-metal ion half-cell:

$$E = E^\theta + \frac{0.059}{n}\log[ion]$$

where n is the number of electrons transferred in the reduction process.

For the $Zn(s)/Zn^{2+}(aq)$ half-cell, $E_L = (-0.76) + \frac{0.059}{2}\log[1] = -0.76V$

For the $Cu(s)/Cu^{2+}(aq)$ half-cell, $E_R = (+0.34) + \frac{0.059}{2}\log[Cu^{2+}(aq)]$

$$E_{cell} = E_R - E_L$$
$$= \{(+0.34) + 0.0295 \log[Cu^{2+}(aq)]\} - \{(-0.76)\}$$
$$= 1.10 + 0.0295 \log[Cu^{2+}(aq)]$$

Safety

Avoid skin contact with the chemicals.


EYE PROTECTION MUST BE WORN

Materials and Apparatus

1 M $ZnSO_4(aq)$, 0.3 M $KIO_3(aq)$ 
IRRITANT

0.15 M $CuSO_4(aq)$ 
HARMFUL

Saturated $KNO_3(aq)$, copper wire electrode, zinc plate electrode, well-plate, digital multimeter (DMM), connecting wire with crocodile clips, plastic pipette, filter paper strip, sand paper.

Experimental Procedures

1. Place 50 drops of 1 M $ZnSO_4(aq)$ into a well of the well-plate.
2. Using a clean plastic pipette, add 25 drops of 0.3 M $KIO_3(aq)$ into an empty well next to the well containing the 1 M $ZnSO_4(aq)$.

3. Clean the plastic pipette used in step (2). Using the ***same*** plastic pipette, add 25 drops of 0.15 M $CuSO_4$(aq) and stir well with a microspatula. Wait for 5 minutes to attain equilibrium.
4. Connect the two wells by a strip of filter paper moistened with saturated KNO_3(aq).
5. Place a clean copper wire electrode and a clean zinc plate electrode (Fig. 1) into the well containing the pale blue suspension and the well containing the 1 M $ZnSO_4$(aq) respectively.
6. Connect the constructed galvanic cell to a DMM. Record the steady voltage developed (Fig. 2).

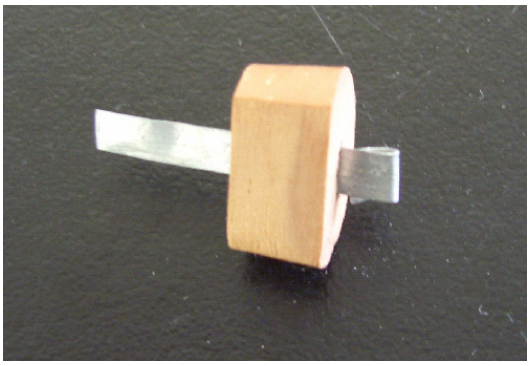

Fig. 1: Home made zinc electrode

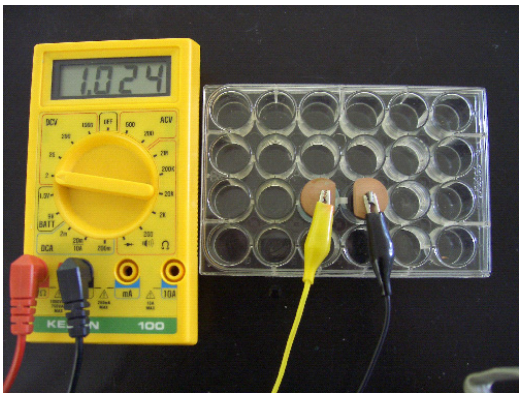

Fig. 2

Results

Temperature = _____^oC

E.m.f. of the cell formed by Zn(s)/Zn^{2+}(aq, 1 M) and Cu(s)/Cu^{2+}(aq, saturated)

= _____ V

Discussion Questions

1. Write down the expression for the K_{sp} of copper(II) iodate(V).
2. Determine the concentration of Cu^{2+}(aq) ions in the saturated pale blue solution.
3. Calculate the concentration of IO_3^-(aq) ions in the saturated pale blue solution.
4. Calculate a value for the K_{sp} of $Cu(IO_3)_2$(s).
5. Look up the literature value of K_{sp} of $Cu(IO_3)_2$(s) from a data book. Compare it with your experimental result. Comment on the discrepancy, if any.