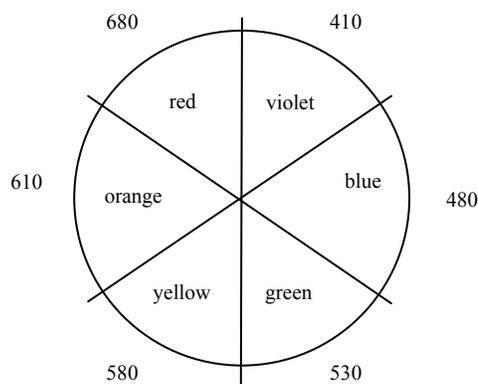


## Experiment 9: The Widely Varying Colors of *d*-Block Metal Complexes<sup>1</sup>

Not only are the *d*-block hydrated metal ions of widely different colors, but the colors of the metal ions can be changed by replacing the coordinated water with other ligands. As you do this experiment you will be looking for regularities in the color changes induced by the ligands. But also enjoy the beautiful colors produced: The gorgeous colors are what persuaded the instructor of this course to become an inorganic chemist!

### A. Preparation of Complexes and Their Ordering by Visual Inspection

1. Different students will be assigned different metal ions, and will prepare separate complexes of that ion with seven different ligands. Some students will be assigned the  $\text{Ni}^{2+}$  ion, some the  $\text{Co}^{2+}$  ion, and some will be assigned the  $\text{Cu}^{2+}$  ion.
2. Take a series of seven test tubes in a rack. To each test tube add 2 mL of a 0.1 M solution of your metal ion (the sulfate form). In turn, add 2 mL of one of the following solutions to each of the test tubes: (1)  $\text{H}_2\text{O}$  (pure); (2) 1.0 M sodium glycinate,  $\text{Na}^+\text{NH}_2\text{CH}_2\text{CO}_2^-$ ; (3)  $\text{K}_2\text{C}_2\text{O}_4$  (saturated); (4) 1.0 M  $\text{NH}_3$ ; (5) 1.0 M pyridine; (6) 1.0 M sodium ethylenediaminetetraacetate,  $(\text{Na}^+)_4[(\text{O}_2\text{CCH}_2)_2\text{NCH}_2\text{CH}_2\text{N}(\text{CH}_2\text{CO}_2^-)_2]$  or just EDTA for short; and (7) 1.0 M ethylenediamine,  $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ . Stopper each test tube and mix its contents. Note: The  $\text{Co}^{2+}$  complexes should be run as soon as possible after they are prepared, since many of them undergo air oxidation.
3. Does the color of a transition metal complex depend on the ligand present? Arrange the seven test tubes in "rainbow" order, such that the colors lead naturally from one test tube to the next. List the ligands in order from yellow to green (why did I choose these colors?).



Color Absorbed

4. Is the ligand ordering for  $\text{Ni}^{2+}$  complexes reasonably consistent with the ordering of the ligands for complexes of the  $\text{Co}^{2+}$  ion, and of the  $\text{Cu}^{2+}$  ion? As a group, check the possibility that making slight rearrangements would make a more nearly metal-independent listing of ligands in order. Your final group list is a qualitative *spectrochemical series of ligands*.
5. Such a listing has uncertainties due to the limited ability of our eyes to discriminate similar colors. Hence, we will check our ordering by measuring the spectra of these complexes. The spectra should be measured in the visible and near-IR region on a spectrophotometer.

<sup>1</sup> Adapted from *Inorganic Chemistry*, G. Wulfsberg, University Science Books, Sausalito, CA, 2000.

## **B. Analysis of the Spectra and Contents of the Lab Report**

1. Attach all spectra, with arrows drawn to indicate any peaks. Tabulate the wavelengths of those peaks.
2. Analyze the periodicity of your spectrochemical series: can you note any grouping of nitrogen- and oxygen-donor ligands in the spectrochemical series?