



The appearance of a nickel(II) ion complex depends on the ligands; at left is  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$  and at right is  $[\text{Ni}(\text{NH}_3)_6]^{2+}$ .

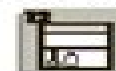
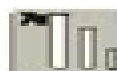
# Experiment 36

## Transition Metal Complexes

- To observe the various colors associated with transition metal ions.
- To determine the relative strengths of ligands.
- To compare the stability of complexes.
- To synthesize a coordination compound.

### OBJECTIVES

The following techniques are used in the Experimental Procedure:



### TECHNIQUES

One of the most intriguing features of the transition metal ions is their vast array of colors. The blues, greens, and reds that we associate with chemicals are oftentimes due to the presence of transition metal ions. We observed these colors in *Experiments 6, 27, 28, 34 and 35*, where it was noted that some colors are characteristic of certain hydrated transition metal ions; for example, hydrated  $\text{Cu}^{2+}$  salts are blue,  $\text{Ni}^{2+}$  salts are green, and  $\text{Fe}^{3+}$  salts are rust-colored.

A second interesting feature of the transition metal ions is that subtle, and on occasion very significant, color changes occur when molecules or ions other than water bond to the metal ion to form a **complex**. These molecules or ions including water, called **ligands**, are Lewis bases (electron pair donors) that bond directly to the metal ion, producing a change in the electronic energy levels of the metal ion. As a result, the energy (and also the wavelengths) of light absorbed by the electrons in the transition metal ion and, consequently, the energy (and wavelengths) of light transmitted change.<sup>1</sup> The solution has a new color.

The complex has a number of ligands bonded to the transition metal ion that form a **coordination sphere**. The complex, along with its neutralizing ion is called a **coordination compound**. For example,  $\text{K}_4[\text{Fe}(\text{CN})_6]$  is a coordination compound; the six  $\text{CN}^-$  ions are the ligands,  $[\text{Fe}(\text{CN})_6]$  is the coordination sphere, and  $[\text{Fe}(\text{CN})_6]^{4-}$  is the complex.

### INTRODUCTION

**Complex:** an ion or molecule formed between a metal ion (a Lewis acid) and a number of anions or molecules (Lewis bases)

**Ligand:** a Lewis base (an electron-pair donor) that combines with a metal ion to form a complex

**Coordination sphere:** the metal ion and all ligands of the complex

**Coordination compound:** a neutral compound which has a cationic and/or an anionic complex ion

<sup>1</sup>See *Dry Lab 3* for a discussion of the theory of the origin of color in substances.

# Do Section D In Beran Lab Manual

**Jo Allan Beran**



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