ACTIVITY 3.4.2 *continued*

Materials

Nelson Chemistry 12 CD, PC

(a) Using **Figure 3**, estimate the wavelength of each of the four lines in the visible region of the hydrogen spectrum. These visible lines belong to the group of lines known as the Balmer series.

- Start the "Bohr" simulation from the Nelson Chemistry 12 CD on your computer. Under the "Series" menu, select "Balmer."
- Set the "New State" at 3 and click the "Photon" button.
- With the electron now in $n_i = 3$, set the "New State" to 2.

(b) Note and record the wavelength of the light to the nearest nanometre. Click the "Photon" button.

(c) Is some light (a photon) absorbed or released in this transition?

(d) To which line in the Balmer series does this transition correspond?

- Repeat the simulation using the following settings:
  $n_i = 4$, $n_f = 2$
  $n_i = 5$, $n_f = 2$
  $n_i = 6$, $n_f = 2$
- Answer questions (b) to (d) for each of these transitions.

(e) How do your answers from (a) using **Figure 3** compare with your answers to (d) using the computer simulation? Is this surprising? Explain briefly.

(f) If some light (a photon) is absorbed by an electron, what happens to the electron? Try this with the simulation program.

(g) How does the wavelength of light corresponding to the transition from $n_i = 3$ to $n_f = 2$ compare with $n_i = 2$ to $n_f = 3$? Explain briefly why this is necessary, according to the Bohr theory.

(h) An electron cannot undergo a transition from $n_i = 1$, to $n_f = 2.5$. According to the Bohr theory, why is this not possible?

INVESTIGATION 3.5.1

Paramagnetism

Inquiry Skills

○ Questioning	● Planning	● Analyzing
○ Hypothesizing	● Conducting	● Evaluating
○ Predicting	● Recording	● Communicating

Paramagnetism was first investigated and named by Michael Faraday in the mid-1800s. At this time, before the discovery of the electron, there was no theoretical explanation of the cause of paramagnetism. According to modern atomic theory, paramagnetism is believed to be caused by the presence of unpaired electrons in an atom or ion.

Purpose

The scientific purpose of this investigation is to determine experimentally which substances are paramagnetic.

Question

Which substances containing calcium, zinc, copper(II), and manganese(II) ions are paramagnetic?

Experimental Design

Test tubes containing the sulfates of each of the ions are suspended by threads from a support. Evidence for any attraction of each test tube toward a strong magnet is observed.

(a) Identify the independent, dependent, and controlled variables.

Materials

eye protection
4 small test tubes
stirring rod
thread
laboratory stand
clamp
horizontal bar
strong magnet (e.g., neodymium
a few grams of the solids:
calcium sulfate
zinc sulfate
copper(II) sulfate
manganese(II) sulfate

Procedure

(b) Write a complete procedure for this experiment. Include safety precautions with respect to handling and disposal of the chemicals used. Have the procedure checked by your teacher before you proceed.

Analysis

(c) Answer the Question based on the evidence collected.

INVESTIGATION 3.5.1 *continued*

Evaluation

(d) Are there any flaws or possible improvements in the Experimental Design? Describe briefly.

(e) Suggest some improvements to the Materials and Procedure.

(f) How certain are you about the evidence obtained? Include possible sources of error or uncertainty.

LAB EXERCISE 3.6.1

Inquiry Skills

- ○ Questioning
- ○ Hypothesizing
- ○ Predicting
- ○ Planning
- ○ Conducting
- ○ Recording
- ● Analyzing
- ● Evaluating
- ● Communicating

Quantitative Paramagnetism

In Investigation 3.5.1, you obtained some preliminary evidence for a possible connection between unpaired electrons (as determined by the electron configuration) and paramagnetism. The purpose of this lab exercise is to test this hypothesis with a quantitative experiment.

Question

What effect does the number of unpaired electrons have on the strength of the paramagnetism of metal salts?

Prediction/Hypothesis

(a) Write a prediction and provide your reasoning based on electron configurations.

Experimental Design

A sensitive electronic balance is used to measure the attraction between a powerful magnet and a test tube containing a metal salt. The balance is tared (zeroed) before the test tube is lowered (**Figure 4**). The mass reading is taken just before contact of the test tube with the magnet. Several ionic compounds containing different metal ions are individually tested using the same mass of each compound.

(b) Identify the independent, dependent, and controlled variables.

Evidence

Table 1: Change in Mass in a Strong Magnetic Field

Ionic compound	Mass reading, Δm (g)
$CaSO_{4(s)}$	0.00
$Al_2(SO_4)_{3(s)}$	0.00
$CuCl_{(s)}$	0.00
$CuSO_4 \cdot 5H_2O_{(s)}$	−0.09
$NiSO_4 \cdot 7H_2O_{(s)}$	−0.22
$CoCl_2 \cdot 6H_2O_{(s)}$	−0.47
$FeSO_4 \cdot 7H_2O_{(s)}$	−0.51
$MnSO_4 \cdot H_2O_{(s)}$	−1.26
$FeCl_3 \cdot 6H_2O_{(s)}$	−0.95

mass of each compound in test tube = 3.00 g

Analysis

(c) What is the significance of a zero-mass reading for some substances and negative-mass readings for other substances?

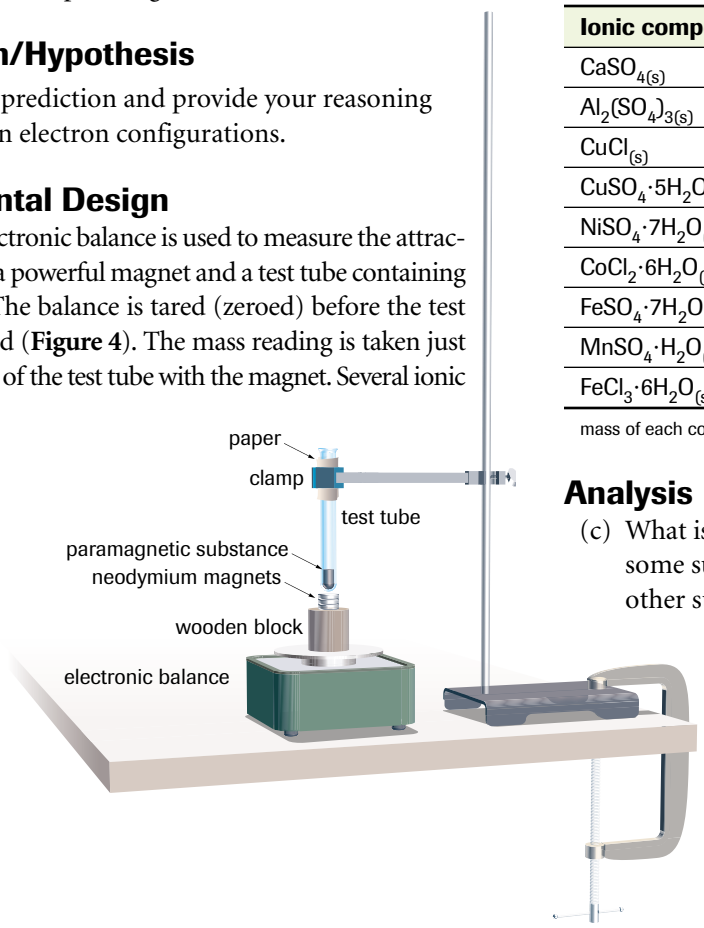

Figure 4
A strong magnet or magnets (such as neodymium magnets) and a paramagnetic substance attract each other. This means that the magnet and block are slightly lifted toward the fixed test tube.