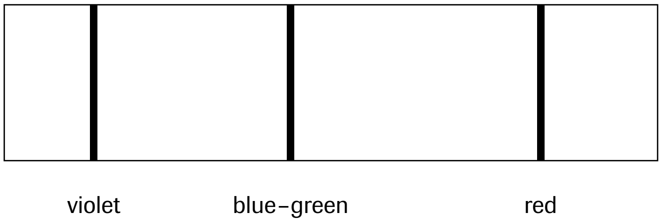
(d) The evidence that some light is being absorbed is the dark lines across the spectrum. Possible gases that might be responsible would include the hydrogen and helium in the Sun and gases such as oxygen in Earth's atmosphere. (Almost all the dark lines in the visible region originate from elements in the Sun.)



(e) Gases produce visible light when they are very hot (or when electricity is passed through them).
(f) In this case (hot gases), the spectrum produced is a bright-line spectrum.
(g) Line spectra are used in chemical analysis to identify substances by the colours (wavelengths or frequencies) of light that they emit or absorb.

ACTIVITY 3.4.2 THE HYDROGEN LINE SPECTRUM AND THE BOHR THEORY

(Page 213)

(a) The wavelengths (shortest to longest) are about 410 nm, 434 nm, 486 nm, and 655 nm.
(b) The wavelength is 656 nm.
(c) A photon is released in this transition.
(d) This transition ($3 \rightarrow 2$) corresponds to the first line in the Balmer series.
- For hydrogen energy-level transition: $n_i = 4$, $n_f = 2$:
  The wavelength is 486 nm.
  A photon is released.
  This transition corresponds to the blue-green line in the spectrum.
- For hydrogen energy-level transition: $n_i = 5$, $n_f = 2$:
  The wavelength is 434 nm.
  A photon is released.
  This transition corresponds to the blue line in the spectrum.
- For hydrogen energy-level transition: $n_i = 6$, $n_f = 2$:
  The wavelength is 410 nm.
  A photon is released.
  This transition corresponds to the violet (very deep blue) line in the spectrum.

(e) Answers from Figure 3 are essentially the same as those from the computer simulation. It seems logical to assume the simulation would be programmed with the correct (accepted) values for these wavelengths.
(f) An electron that absorbs a photon jumps to a higher energy level.
(g) The wavelength of light emitted corresponding to the transition from $n_i = 3$ to $n_f = 2$ is identical to that for the light absorbed in the transition from $n_i = 2$ to $n_f = 3$. The Bohr theory requires that the energy of the levels be fixed, so the energy change, and hence the wavelength of the photons of light involved, must be fixed.
(h) In the Bohr theory, only certain fixed orbits and energies are allowed. These orbits are numbered 1, 2, 3, etc. There are no other orbits in between.

INVESTIGATION 3.5.1 PARAMAGNETISM

(Page 214)

Experimental Design

(a) The independent variable is the metal ion in the compound. The dependent variable is the effect of the strong magnet. A controlled variable is the sulfate anion in each compound.

Procedure

(b)

1. Place about 1 cm of each solid, packed with a stirring rod, into a clean, dry test tube.
2. Tie the end of about 15–20 cm of thread to the top of each test tube.
3. Set up the lab stand with a horizontal bar.
4. Attach the other end of the threads to the horizontal bar for each test tube. (Tie all four test tubes to the bar if possible, or one at a time.)
5. Wait until the test tube is completely at rest and then bring the end of a strong magnet about 1 cm from the solid in the test tube.
6. Observe any deflection of the test tube, testing each solid several times.
7. Dispose of the solids or return the solids (as directed by your teacher).

Evidence

(c)

Paramagnetism of Metal Salts	
Substance	**Effect of magnet**
$CaSO_{4(s)}$	no noticeable effect
$ZnSO_4{\cdot}7H_2O_{(s)}$	no noticeable effect
$CuSO_4{\cdot}5H_2O_{(s)}$	a very slight attraction
$MnSO_4{\cdot}H_2O_{(s)}$	clearly attracted

Analysis

(d) Based on the evidence, manganese(II) ions are obviously paramagnetic and copper(II) ions are likely weakly paramagnetic.

Evaluation

(e) The experimental design should control the amount of the substances used and be more specific about the testing with the magnet, which seems a little vague. Perhaps the metal ions should be tested in solution form.

(f) More substances should be tested and a much stronger magnet should be available. The procedure should include testing the aqueous solution of each substance. Testing with a magnet should be done inside a box so that air currents are not a factor.

(g) The evidence for the manganese(II) compound appears quite certain but the others are less certain. Because the observations were not very precise, it is possible that some substances that had no effect might be weakly affected. Some sources of error or uncertainty are the qualitative judgment of any effect, possible air currents, quantity of the substances used, and the strength of the magnet.

LAB EXERCISE 3.6.1 QUANTITATIVE PARAMAGNETISM

(Page 215)

Prediction/Hypothesis

(a) Based on the hypothesis that unpaired electrons of atoms or ions in a substance are responsible for the paramagnetism of a substance, the greater the number of unpaired electrons per atom, the greater the strength of the paramagnetism.

Experimental Design

(b) The independent variable is the metal ion in the ionic compound tested. The dependent variable is the apparent change in mass as registered on the balance. Some controlled variables are the distance between the test tube and the magnet and the mass of the compound used.

Analysis

(c) A zero mass reading indicates that the substance in the test tube is not paramagnetic because it does not affect the magnet. A negative mass reading on the balance indicates that a paramagnetic substance is attracting the magnet, lifting it slightly from the balance pan.