CHAPTER 19

Quantum Theory and The Atom

CHAPTER CONTENTS

The element helium was discovered on the Sun by Sir Joseph Lockyer in 1868, 27 years before the element was discovered on Earth. When you read the last sentence, did you wonder how anyone could discover helium on the Sun? Obviously, no one went to the sun and brought back a sample. So how was it discovered?

In the late 1800s, scientists knew that each element emitted very specific wavelengths of light, or spectra, although they did not know of any mechanism to explain why. Lockyer was observing spectra from the Sun and discovered a yellow line that was not associated with any known element. He proposed that it represented a new element that had not yet been discovered on Earth. Lockyer named the element helium after the Greek word for Sun, *helios*. In 1895, helium was discovered on Earth and Lockyer's proposal was verified.

Although scientists had been using emission spectra to identify elements for many years, it was not until 1913 when Neils Bohr presented his model of the atom that a mechanism for the production of atomic spectra could be explained. Today, astronomers obtain a wealth of information about stars that are thousands of light years away by observing their spectra and interpreting them according to the modern theory of the atom. In this chapter, you will learn how atomic spectra helped Bohr develop his model of the atom. You will then read about how Erwin Schroedinger extended atomic theory with the new field of quantum mechanics, currently the best model for understanding not only atoms but nuclei, elementary particles, and other phenomena of the submicroscopic world.

INVESTIGATION 19-A

Identifying Elements by Their Emission Spectra

TARGET SKILLS

- Predicting
- Performing and recording
- Analyzing and interpreting
- Communicating results

The emission spectra of atomic hydrogen gas obtained using gas discharge tubes provided Bohr with critical information that helped him to develop his model of the atom. These spectra also gave him experimental data with which to compare predictions based on his model. In this investigation, you will identify gases from observation of their emission spectra.

Problem

Identify gases from observation of their emission spectra.

Equipment

- hand-held spectroscope
- lighted incandescent bulb
- gas discharge tubes

Procedure

1. Practise using the spectroscope by observing a small incandescent light bulb. Point the slit of the spectroscope toward the bulb and move the spectroscope until you can clearly see the spectrum.
2. Record the appearance of the spectrum from the incandescent bulb.
3. Several numbered gas discharge tubes will be assembled and ready to view. Observe each tube with the spectroscope.

CAUTION A very high voltage is required to operate the gas discharge tubes. Do not come into contact with the source while viewing the tubes.

4. Make a sketch of each spectrum. Draw the relative distances between the lines as accurately as possible. Label each of the lines in each sketch with colour and wavelength to two significant figures.
5. Observe a fluorescent bulb with the spectroscope.
6. Record the appearance of the spectrum from the fluorescent bulb.

Analyze and Conclude

1. In a phrase, describe the spectrum of the incandescent bulb. Explain why the incandescent bulb emits the type of spectrum that you described.
2. Your teacher will provide you with spectra of a variety of types of gases. Compare your sketches with the spectra and attempt to identify each gas in the discharge tubes.
3. Compare your observations of the fluorescent bulb with the spectra from both the incandescent bulb and the gas discharge tubes. Which type of spectrum does the spectrum from the fluorescent bulb most resemble?
4. A fluorescent bulb is a type of gas discharge tube. However, the emissions of the gas are absorbed by a coating on the inside of the bulb and the atoms in the coating are excited and emit light. Based on this description, explain the features of the spectrum of the fluorescent bulb.
5. Is it possible to identify the gas in the fluorescent bulb? Explain why or why not.

Apply and Extend

6. Select one of the central lines in the spectrum of atomic hydrogen. Predict which transition (from which energy level to which energy level) created this line.
7. Check your prediction by using Balmer's formula to calculate the wavelength that the transition would have caused. Compare the calculated wavelength with the wavelength of the spectral line that you selected.