(c) Each new generation of scientists builds on the work of previous generations of scientists. For example, Chadwick built on Rutherford's model and proposed the presence of neutrons in the nucleus, in addition to protons.

1.4 THE ELECTROMAGNETIC SPECTRUM

SECTION 1.4 QUESTIONS

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Understanding Concepts

1. Radio waves have a longer wavelength than X rays, therefore, they have a lower frequency and less energy. When radio waves strike an object, they do not damage it. X rays have a much shorter wavelength than radio waves, and therefore a higher frequency and much more energy. When X rays strike soft objects like human tissue, they can cause damage.
2. The human eye can detect wavelengths in the visible range (400–700 nm).
3. When white light is directed through a prism, it separates into different colours. If white light did not consist of different colours, it would remain white when passed through a prism.
4. A continuous spectrum is an uninterrupted pattern of colours observed when a beam of white light is passed through a prism. An example of a continuous spectrum is a rainbow. A line spectrum is discontinuous. The lines, produced when light emitted by an element is directed through a prism, are separated by space with no colour. Hydrogen gas has a line spectrum.

Making Connections

5. (a) It is not safe for the technician to be in the same room during an X ray because the technician would be exposed to X rays each time an X-ray scan is taken: as many as several hundred scans per year. This amount of exposure exceeds the recommended levels of X-ray exposure for an individual. Patients are only exposed during their X-ray scan, therefore the risks are minimal.
   (b) Only the desired area to be X-rayed is exposed; the rest of the patient's body is covered with a lead apron, which X rays cannot penetrate. Technicians wear badges that measure radiation levels in the radiation area, and keep detailed records of their cumulative lifetime dose.

1.5 ACTIVITY: IDENTIFYING GASES USING LINE SPECTRA

(Pages 19–20)

Observations

(a) The spectrum of sunlight is continuous.
(b) The spectrum of fluorescent light contains dark bands alternating with bands of coloured light.
(c) The spectrum of incandescent light consists of more red lines but fewer green-blue lines than the spectrum of fluorescent light.
(d) The line spectrum of hydrogen consists of four lines: red, green, blue, and indigo.
(e) Student drawings will vary depending on the elements they observe.

Analysis

(f) Student responses will depend on the spectra used.

Synthesis

(g) The spectrum of sunlight is a continuous spectrum. The spectra of some incandescent lights contain dark bands and more red lines than the spectrum of fluorescent light. The spectrum of fluorescent light also contains dark bands but is less green-blue than some incandescent spectra. Since sunlight, fluorescent light, and incandescent light all produce different spectra, the light energy they radiate is composed of different wavelengths.
(h) Student answers will vary depending on the gases that they observe. Neon and barium have a large number of spectral lines.

(i) Light spectroscopy may be used as a qualitative analysis technique because the spectrum of each element is unique. Light spectroscopy is used to identify the composition of stars as well as trace elements in food and building materials.

(j) Even though helium is the second most abundant element in the universe, it was only discovered about 140 years ago. It is the only element that was first discovered on the Sun and only later on Earth. In 1869, J. Norman Lockyer, a civil servant, examined the light coming from the Sun using a spectroscope and observed a yellow line that had not been seen before. That same year, Pierre Jules Cesar Janssen, a French astronomer, observed the same yellow line while working in India. Both astronomers tried to recreate their results in a laboratory, but failed. Lockyer proposed that the spectrum belonged to a new element but was ignored. It was not until 1895 that the element helium was discovered on Earth. William Ramsay, a Scottish chemist, was looking at the spectrum of gases emitted by the mineral cleveite. Ramsay observed a yellow line. He sent samples to Lockyer and William Crookes (cathode ray tubes), who confirmed that the yellow line produced by the gases from cleveite was the same line that Lockyer had seen years before. Given that helium is odourless, tasteless, generally nontoxic, and colourless, it is not surprising that it took so long for it to be discovered!

1.6 THE BOHR MODEL OF THE HYDROGEN ATOM

SECTION 1.6 QUESTIONS

(Page 22)

Understanding Concepts

1. According to classical physics, the orbiting negatively charged electron should eventually run out of energy and collapse into the positively charged nucleus. From observation, we see that matter is very stable. We therefore infer that electrons do not collapse into the nuclei of atoms. Rutherford's model of the atom could not explain why.
2. In Bohr's and Rutherford's models, the atom consists of a nucleus, with protons having a positive charge and neutrons carrying zero charge, surrounded by empty space. In Rutherford's model, the electrons orbit the nucleus like planets around the Sun. In Bohr's model, the electrons are found in fixed energy levels around the nucleus. The first energy level holds a maximum of two electrons, while the second energy level holds a maximum of eight electrons. The amount of potential energy an electron has depends on the energy level in which it is located.
3. Spectroscopy revealed that all the elements have characteristic line spectra. Bohr came up with his model of the atom to explain these observations. Spectroscopy provided the empirical evidence on which Bohr's theory is based.
4. An electron in its ground state is in the lowest possible energy level, where it is most stable. At this level, the electron does not emit any electromagnetic radiation because it cannot drop to a lower energy level. When an electron is in the excited state, it has absorbed energy and is in a higher energy level. An electron in the excited state can drop to a lower energy level and release a fixed amount of energy as electromagnetic radiation that appears in a line spectrum.
5. Bohr's atomic model could only explain the line spectrum of hydrogen. It could not accurately predict the line spectra of more complex elements.
6. An electron in a lower energy level has less energy than an electron in a higher energy level. Therefore, when an electron drops from a higher energy level to a lower energy level, it emits the excess energy in the form of light.
7. Energy levels have a specific energy value. Electrons in the same energy level have the same amount of energy. To jump to a higher energy level, they must absorb a specific amount of energy. To drop to a lower energy level, they must release a specific amount of energy. Electrons cannot be found between energy levels.

Applying Inquiry Skills

8. Plug one of the discharge tubes into an electrical source. Observe the gas discharge tube through a spectroscope and record the line spectrum of the gas. To determine the identity of the gas, compare its line spectrum to the line spectra of identified gases in a resource. Repeat for the second discharge tube.

Making Connections

9. In Bohr's atomic model, electrons can only possess specific amounts of energy, depending on the energy level in which they are found. When electrons of an element are excited, they always jump to specific higher energy levels. When the electrons drop to lower energy levels, they always release specific amounts of energy, equal to the difference between the higher and lower energy levels. Since each element has a unique electron configuration, it has a characteristic line spectrum.