(ii) Observation: The back wall of the bedroom is completely burned.
Inference: The fire started in the mattress from careless smoking.
(iii) Observation: The soup is very spicy.
Inference: Chili peppers must be one of the ingredients in the soup.

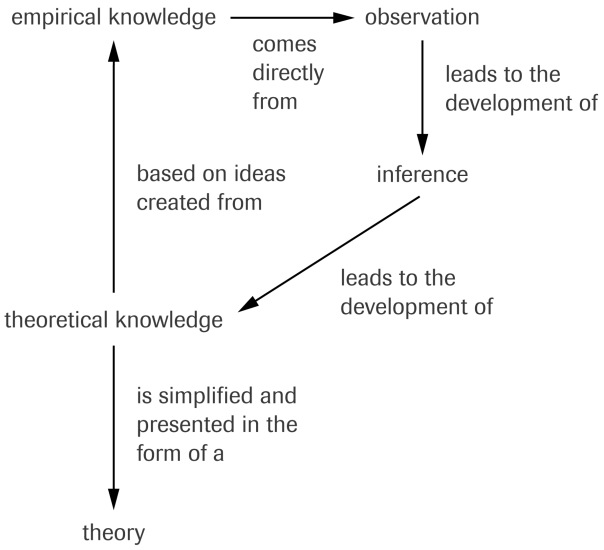
SECTION 1.2 QUESTIONS

(Page 12)

Understanding Concepts

1. (a) inference
   (b) observation
   (c) observation
   (d) inference
   (e) observation
2. A theory is an explanation of a large number of related observations. To come up with a theory, scientists must use their imaginations as well as empirical evidence collected from experiments. Even though a theory is grounded in observation, since it is an idea, it cannot be proven. Many theories are accepted as true, however, since a large amount of experimental evidence supports them. The more experimental testing a theory can withstand, the more credible it becomes.
3. Models can help convey an idea or a concept. A model is a visualization of a theory. Scientists use models to help describe and explore their ideas.

Making Connections

4. 

5. In a court of law, the prosecution and the defence are both interested in only the presentation of facts. If witnesses make inferences, they are considered to be offering an opinion, which could sway a judge or jury. Also, the opinion may be invalid because witnesses may be misinterpreting what they observed. Unless the witness is an "expert," then opinions are struck from court records.
6. Qualitative analysis is empirical because it is based on the physical and chemical properties of substances. Scientists compare the physical and chemical properties of an unidentified sample of matter to those of already identified substances in order to identify the unknown.

1.3 EARLY MODELS OF THE ATOM

TRY THIS ACTIVITY: AN ANALOGY TO PROBING THE ATOM

(Page 14)

(a) Student answers will vary depending on the object encased in the Plasticine. Student descriptions will focus on physical properties, such as the object's size and shape. Students may also speculate on what the object is made of,

for example, metal. Students may also mention where within the Plasticine the object is placed (that is, near the edge or in the middle).

(b) Descriptions could be improved with the aid of other probing tools besides a pin. For example, a magnet could be inserted into the Plasticine. If a magnetic force is felt, then the type of material out of which the object is made could be narrowed down.

(c) Investigating the contents of a black box is similar to investigating the contents of an atom because in both cases, you cannot directly observe the contents. Instead, you must conduct tests or experiments that will help you to describe the contents. Your description is theoretical knowledge because it is not based on direct observation. Similarily, subatomic particles cannot be observed directly. Instead, through indirect experimental evidence, scientists gain theoretical knowledge about the contents and structure of the atom. An atom is different from a black box because it is much less tangible. Also, the contents of a black box can be eventually revealed by removing the Plasticine, whereas an understanding of the contents of an atom depends on theoretical knowledge.

(d) The pin represents the tools that scientists use to probe the atom.

(e) Student answers will vary. Possible answers include computers and elevators (how they work, and what parts they consist of).

SECTION 1.3 QUESTIONS

(Page 15)

Understanding Concepts

1. Empedocles' and Democritus' atomic models are not scientific models because they were not based on observation obtained through experimentation. Rather, their models are based on thought experiments.
2. Dalton's atomic model consists of the following five ideas:
   - Matter consists of definite particles called atoms.
   - Each element is made up of its own type of atom.
   - Atoms of different elements have different properties.
   - Atoms of two or more elements can combine in constant ratios to form new substances.
   - Atoms cannot be created, destroyed, or subdivided in a chemical change.
3. (a) Ernest Rutherford
   (b) Ernest Rutherford
   (c) John Dalton
   (d) Ernest Rutherford
4. (a) The raisins represent the negatively charged electrons in an atom.
   (b) The bun represents the atom's positively charged sphere.
5. (a) Democritus' model was the result of a thought experiment. His model only described the atom as an indivisible particle. Dalton's model is a more detailed description of the atom that includes some of its physical properties. Dalton's model provided empirical support to Democritus' idea.
   (b) The model of the atom was slow to evolve for three reasons. First, the technology available for probing the atom was limited. Second, until several hundred years ago, there were few people of independent means who were also interested in science as a hobby, and even fewer who were specifically interested in probing the atom. Third, it took many years for the scientific method to evolve. The alchemists, who lived during the Middle Ages, were the first group of people to record methodical observations with the purpose of answering a question.
6. (a) nucleus: the positively charged centre of an atom
   (b) proton: a positively charged subatomic particle found in the nucleus of an atom
   (c) electron: a negatively charged subatomic particle
   (d) neutron: an uncharged subatomic particle found in the nucleus of an atom

Making Connections

7. (a) Scientific knowledge is tentative because current models and theories are subject to change as new technology allows us to gather more information. The atomic model is an excellent example of the tentative nature of science. The atom has evolved from Democritus' model of an indivisible particle to the current model of a positively charged centre containing neutrons and protons, with electrons in the space surrounding it. Electron behaviour is currently described using quantum mechanics.
   (b) As new technology is developed, scientists can further probe the atom. Shortly after cathode ray tubes were invented, J.J. Thomson proposed that atoms contain negatively charged particles. Without the cathode ray tube, electrons may not have been discovered.

(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

(Page 18)

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.