

## Knowledge

For each question, select the best answer from the four alternatives.

- Which of the following terms best describes the study of the composition and interaction of matter? (1.1) **K/U**
  - physics
  - science
  - chemistry
  - technology
- Which term applies to the macroscopic world? (1.1) **K/U**
  - experimenting
  - imagining
  - conceptualization
  - theorizing
- Who first theorized that the atom contains a central core called a nucleus? (1.2) **K/U**
  - Dalton
  - Thomson
  - Democritus
  - Rutherford
- Which of the following ions always contain more than one atom? (1.3) **K/U**
  - polyatomic ions
  - cations
  - multivalent ions
  - anions
- Different isotopes of the same element contain different numbers of which of these particles? (1.4) **K/U**
  - electron
  - proton
  - neutron
  - nucleus
- Which statement is true about the elements sulfur, S, and chlorine, Cl? (1.5) **K/U**
  - They are in the same group.
  - They are in the same period.
  - They are both metalloids.
  - They are both halogens.
- Element X is a light, very reactive metal that forms an oxide with the formula XO. This element also reacts with water to release hydrogen. The element belongs to which of the following groups? (1.5) **K/U**
  - alkali metals
  - alkaline earth metals
  - transition metals
  - rare earth metals
- Which scientist is given credit for developing the periodic table that led to the modern version of the periodic table? (1.6) **K/U**
  - Meyer
  - Dobereiner
  - Newlands
  - Mendeleev
- What is the energy change that occurs when an electron is gained by an atom in the gaseous state? (1.7) **K/U**
  - ionization energy
  - electron affinity
  - ionization
  - electronegativity

Indicate whether each statement is true or false. If you think the statement is false, rewrite it to make it true.

- Air is an example of matter. (1.1) **K/U**
- The mass number of an atom is the number of protons it contains. (1.2) **K/U**
- Bohr's work explained why each element has a unique spectrum. (1.2) **K/U**
- The nitrate ion and the sulfate ion are examples of polyatomic cations. (1.3) **K/U**
- You can determine the atomic mass of an element by calculating the weighted average of the masses of all of its ions. (1.4) **K/U**
- A Lewis symbol of an element shows only its symbol and its valence electrons. (1.5) **K/U**
- Newlands arranged groups of three atoms that have similar properties. (1.6) **K/U**
- Atomic radius is generally greater on the left side of the periodic table than on the right side. (1.7) **K/U**
- A metal ion is larger than the atom from which it formed. (1.7) **K/U**

Match each term on the left with the most appropriate description on the right.

- |                |  |
|----------------|--|
| 19. (a) Dalton | (i) discovered the neutron   |
| (b) Rutherford | (ii) discovered the electron   |
| (c) Bohr       | (iii) proposed the nuclear model of the atom   |
| (d) Thomson    | (iv) suggested that electrons exist in energy levels   |
| (e) Chadwick   | (v) proposed the existence of atoms  |
| (f) Democritus | (vi) proposed that atoms are not created or destroyed in chemical reactions (1.2) <b>K/U</b> |

**Write a short answer to each question.**

20. List five different branches of chemistry. (1.1) **K/U**
21. Compare and contrast science and technology. (1.1) **K/U T/I**
22. How do theoretical knowledge and empirical knowledge differ? (1.1) **K/U T/I**
23. What did Thomson observe and conclude about electrons by using a cathode ray tube? (1.2) **T/I**
24. An aluminum atom contains 13 protons and 14 neutrons. (1.2) **K/U T/I**
- (a) What is the atomic number of aluminum?
- (b) What is the mass number of this aluminum atom?
25. Neon, argon, and krypton are used in light fixtures. Helium is used in balloons and in protecting valuable paper documents from damage. These, and other, uses of noble gases are based on the chemical inertness of the gases. What is meant by the term “chemical inertness”? (1.3) **K/U**
26. State two ways in which polyatomic ions are important to human health. (1.3) **K/U**
27. What are three possible ways in which an atom can achieve a complete octet? (1.3) **K/U**
28. What is a polyatomic ion? (1.3) **K/U**
29. How are nitrate ions and nitrite ions similar and how are they different? (1.3) **K/U**
30. (a) What is an isotope?
- (b) How does a radioisotope differ from an isotope that is not radioactive? (1.4) **K/U T/I**
31. Suppose that an isotope with a mass number of 260 u undergoes radioactive decay. The decay produces nuclear radiation and an isotope with a mass number of 256 u. (1.4) **K/U T/I**
- (a) What type of radiation did the isotope emit when it decayed?
- (b) Explain your answer.
32. Draw Bohr–Rutherford diagrams for atoms of the following elements: (1.5) **K/U**
- (a) aluminum-27
- (b) oxygen-16
- (c) hydrogen-1
33. Draw Lewis diagrams for atoms of the following elements: (1.5) **K/U**
- (a) silicon
- (b) chlorine
- (c) potassium
- (d) krypton
34. (a) What is a periodic trend?
- (b) How do periodic trends relate to periodic law? (1.5) **K/U**
35. What is true about the valence electrons within a group on the periodic table? (1.5) **K/U**
36. (a) Which elements are considered to be representative elements?
- (b) Why are these elements called representative elements? (1.5) **K/U**
37. (a) Where are the metals located on the periodic table?
- (b) Where are the non-metals?
- (c) Where are the metalloids? (1.5) **K/U**
38. Some scientists made major contributions to the organization of elements. However, even small contributions added to what was known about the elements. (1.6) **K/U**
- (a) What contribution to the organization of elements was made by Hennig Brand?
- (b) How did Antoine Lavoisier contribute to the knowledge of elements?
39. What unit is usually used when communicating the radius of an atom? (1.7) **K/U**
40. (a) What energy change usually occurs when an atom gains an electron?
- (b) What energy change occurs when an atom loses an electron? (1.7) **K/U**
41. In your own words, describe what is meant by electron affinity. (1.7) **K/U**

**Understanding**

42. Many of the central ideas in chemistry come from the atomic theory. (1.1, 1.2) **T/I**
- (a) Why is knowledge of the atom considered to be theoretical knowledge?
- (b) Predict how atomic theory 30 years from now might compare to current atomic theory.
43. Mass is usually measured in grams or kilograms. (1.2) **K/U T/I**
- (a) Instead of grams or kilograms, what unit is most commonly used to measure the mass of an individual atom?
- (b) Explain why this unit is used instead of grams or kilograms.
44. (a) What did Rutherford observe in his gold foil experiment?
- (b) Why did his observations lead him to theorize that atoms have a positively charged nucleus? (1.2) **K/U T/I**
45. Many elements form more than one polyatomic ion with oxygen. (1.3) **K/U T/I**
- (a) Give an example of two or more polyatomic ions that contain the same element and oxygen.
- (b) Explain why you think this element forms more than one polyatomic ion with oxygen.

46. Nitrites in meat slow down the growth of bacteria and give the meat a desirable red colour. However, nitrites can form compounds that are carcinogenic. Even if no nitrites are added to meat, they might be present. How can nitrites be present in meat if only nitrates were added to the meat? (1.3) **K/U**
47. Create a table and complete it with the following information for the elements listed below:
- the number of electrons in the atom
  - the number of valence electrons
  - whether it will gain or lose electrons (or neither gain nor lose) to become stable
  - whether it will form an anion or a cation, or neither
  - the symbols of the ion it forms (1.3) **K/U T/I**
- (a) neon, Ne  
(b) oxygen, O  
(c) magnesium, Mg
48. (a) List the three main parts of a mass spectrometer.  
(b) Describe what happens in each part during the analysis of a sample. (1.4) **K/U**
49. There are three forms of nuclear radiation. Gamma rays are used in radiation therapy to kill certain kinds of cancer cells. Why do you think this form of radiation is chosen, rather than either of the other forms? (1.4) **T/I A**
50. A radioisotope is sometimes called “parent material.” As the parent material decays and emits nuclear radiation, it forms a new substance that is often referred to as “daughter material.” If the parent material emits alpha rays as it decays, predict how atomic number and mass number of the daughter material will be different from those of the parent material. Explain your answer. (1.4) **T/I**
51. Examine the Lewis symbols in Figure 4 of Section 1.5. The elements in Groups 1 and 2 tend to lose electrons to another atom to become stable. Those in Groups 16 and 17 tend to gain electrons from other atoms. (1.3, 1.5) **K/U T/I A**
- (a) Name one element that might gain the one valence electron from a sodium atom and become stable.  
(b) Name one element that might gain the two valence electrons from a calcium atom and become stable.
52. Early periodic tables listed elements by increasing atomic mass from left to right, arranging elements with similar properties in the same column. How does this periodic table compare to the one we currently use? (1.5) **K/U T/I**
53. (a) Describe how you would write the Lewis symbol for sulfur.  
(b) How does the Lewis symbol for sulfur differ from the Bohr–Rutherford diagram for sulfur? (1.5) **K/U T/I C**
54. The periodic table currently in use is the result of scientists studying the elements for hundreds of years. Summarize the contributions the following scientists made in developing a system of organizing elements. (1.5, 1.6) **K/U T/I C**
- (a) Dmitri Mendeleev  
(b) Johann Dobereiner  
(c) John Newlands
55. The radius of an individual chlorine atom, Cl, is likely to be different from the radius of a chlorine atom in a chlorine molecule, Cl<sub>2</sub>. Explain why these radii are different. (1.7) **K/U**
56. (a) In general, how does atomic radius change from top to bottom in a group on the periodic table?  
(b) Explain why this pattern in atomic radius occurs. (1.7) **K/U T/I**
57. (a) As you move from top to bottom in a group on the periodic table, how does the ionization energy change?  
(b) Why does ionization energy follow this pattern in a group?  
(c) As you move from left to right across a period, how does the ionization energy change?  
(d) Explain why ionization energy follows this pattern in a period. (1.7) **K/U**

## Analysis and Application

58. A student performed an experiment in which she warmed three different liquids to 80 °C, and then measured their temperatures every 5 minutes as they cooled. She discovered that the liquids cooled at different rates. Was the knowledge from this experiment theoretical knowledge or empirical knowledge? Explain your answer. (1.1) **T/I A**
59. Classify each of the following as either “matter” or “not matter.” Explain each classification. (1.1) **K/U T/I A**
- (a) thoughts  
(b) water  
(c) air  
(d) bricks  
(e) ideas
60. Alchemists did not discover any parts of the atom or otherwise develop any part of the atomic theory as it currently exists. Why do you think the work of alchemists was important to atomic theory? (1.2) **K/U T/I**

61. Magnesium is a strong, light metal that is primarily used in strong, low-density alloys. A magnesium atom contains 12 protons, 12 electrons, and 12 neutrons. (1.2) **K/U T/I C**
- How many valence electrons does a magnesium atom have?
  - Explain how you determined the number of valence electrons in a magnesium atom.
62. Too much table salt, sodium chloride, NaCl, is bad for our health. From the effect each of these ions has on the human body, infer why too much salt can cause a person to have high blood pressure. (1.3) **K/U T/I A**
63. When iron metal reacts with oxygen, each iron atom first loses 2 electrons to an oxygen atom. The iron ion formed then loses another electron, forming a different ion. (1.3) **K/U T/I A**
- Write the formula for the first iron ion formed. Name the ion, using both its classical and its IUPAC name.
  - Write the formula for the second iron ion formed. Name the ion, using both its classical and its IUPAC name.
64. Examine the system used for naming the polyatomic ions formed from chlorine and oxygen and those formed from nitrogen and oxygen, as shown in Table 2 in Section 1.3. (1.3) **K/U T/I A**
- What is the difference between an *-ate* ion and an *-ite* ion?
  - What is the difference between the chlorate ion and the perchlorate ion?
  - What would be the formula for the periodate ion? Explain.
65. During nuclear decay, emission of alpha particles changes both the identity and the mass of the atom. Beta emission changes the identity of the atom but not its mass. Gamma emission changes neither the identity of the atom nor its mass. When a C-14 atom undergoes radioactive decay, an N-14 atom forms, along with a particle of radiation. (1.4) **K/U T/I A**
- What particle of radiation forms during this radioactive decay?
  - Explain your answer.
66. A beam of radiation is emitted by a radioisotope. (1.4) **K/U T/I A**
- How might passing the beam between electrically charged plates help you to identify what type of radiation was emitted?
  - How might you identify what type of radiation was emitted by focusing the beam on sheets of different materials?

67. Chromium is found in small quantities in the environment throughout Canada. This element occurs naturally as four different isotopes, as shown in **Table 1**.

**Table 1** Isotopes of Chromium

Isotope	Abundance (%)
Cr-50	4.35
Cr-52	83.79
Cr-53	9.50
Cr-54	2.36

What is the atomic mass of chromium? (1.4) **T/I**

68. Potassium has 21 isotopes. However, almost all of the potassium in a sample consists of the isotopes K-39, K-40, and K-41. The atomic mass of potassium is 39.1. (1.4) **T/I A**
- Which isotope of potassium is present in greatest abundance?
  - Explain your answer.
69. Small quantities of boron do not negatively affect human health, but large quantities are dangerous. For this reason, Health Canada has set a maximum level of 5 mg/L of boron in drinking water. The two naturally occurring isotopes of boron are boron-10 and boron-11. The abundance of B-10 is 19.8%. The remainder of the atoms are B-11. What is the atomic mass of boron? (1.4) **K/U T/I A**
70. Cobalt, Co, was once mined along with silver near Sudbury, Ontario. Cobalt is now mostly a by-product of copper and nickel mining. The element fluorine, F, has also been found in coal deposits in Western Canada. (1.5) **K/U A**
- Look at the position of these two elements on the periodic table. Which of the elements is a representative element?
  - Based on your answer to (a), predict which element most closely follows the periodic law.
71. Most naturally occurring elements were discovered before the existence of the noble gases was known. Why do you think the noble gases were discovered so late? (1.5, 1.6) **T/I**
72. (a) Julius Lothar Meyer proposed a periodic arrangement of known elements. How did he arrange the elements in his table?
- Suggest a drawback of Lothar Meyer's periodic table. (1.6) **K/U T/I C**

73. (a) Use what you know about effective nuclear charge to explain why the radius of rubidium, Rb, is larger than the radius of silver, Ag.  
 (b) Explain the atomic radius of iodine compared to the atomic radii of rubidium and silver. (1.7) K/U T/I A
74. An atom of magnesium, Mg, loses 2 electrons to achieve a stable octet. The first ionization energy for magnesium is 738 kJ/mol, and the second ionization energy for magnesium is 1451 kJ/mol. Why do you think the second ionization energy is greater than the first ionization energy? (1.7) K/U T/I A

## Evaluation

75. Compare and contrast chemistry today to what you think chemistry would be like if the International Union of Pure and Applied Chemistry (IUPAC) had not been established. (1.1) K/U T/I C
76. (a) Briefly describe how the work of Niels Bohr contributed to modern atomic theory.  
 (b) How did the work of Ernest Rutherford contribute to modern atomic theory?  
 (c) How did the experimental results obtained by both Bohr and Rutherford contribute to the Bohr–Rutherford model of the atom? Include a diagram in your explanation. (1.2) K/U T/I C
77. Suppose 48.2 % of an element is an isotope with a mass of 107 u. Another 32.1 % is an isotope with a mass of 105 u. The remaining proportion of the element is an isotope with a mass of 106. (1.4) K/U T/I A
- (a) A student calculates the percentage of the remaining isotope and then calculates the atomic mass as follows:
- $$\frac{107 + 105 + 106}{3} = 106$$
- Is this an appropriate method of determining the atomic mass of the element? Explain your answer.
- (b) Use the procedure outlined in the chapter to calculate the atomic mass of the element.  
 (c) Explain which is the better procedure, and why.
78. From what you know about the periodic table, would you describe this proposed arrangement of all possible elements as a theory or a law? Explain. (1.5, 1.6) T/I
79. Use what you know about valence shells and ion formation to compare the radii of the following pairs of entities. Explain your answers. (1.7) K/U T/I
- (a) a calcium ion, Ca<sup>2+</sup>, and a calcium atom, Ca  
 (b) a sulfide ion, S<sup>2-</sup>, and a sulfur atom, S
80. Locate beryllium, Be, nitrogen, N, and arsenic, As, on the periodic table. For the following pairs of elements, compare the atomic radius, ionic radius, ionization energy, and electron affinity of the two elements. (1.7) T/I
- (a) Be and N  
 (b) N and As

## Reflect on Your Learning

81. The term “theory” describes certain concepts in chemistry, such as the atomic theory. The term “law” describes other concepts, such as the law of conservation of mass. Based on what you have learned in this chapter, what are some differences between theories and laws? K/U T/I
82. As a young child, your concept of education was not the same as your current concept of education. Explain how the development of your current concept of education is similar to the development of the atomic theory. K/U T/I C
83. For each of the following descriptions, write the formula of an ion that meets both requirements: K/U
- (a) a polyatomic ion and an anion  
 (b) a polyatomic ion and a cation  
 (c) an ion with a classical name ending in *-ous* and a valence of +2  
 (d) an ion with a classical name ending in *-ic* and a valence of +4
84. (a) Should everyone be concerned about radon in the home? Explain your answer.  
 (b) Do you ever check your home for radon? If so, how do you check it?  
 (c) Has anything been done to prevent radon from entering your home? If yes, explain what was done. T/I C A
85. We need to know the properties of different elements to determine their uses. Suppose you are designing a building and need to choose metals for structural support in the walls and floors, for electrical wiring, and for plumbing. K/U T/I A
- (a) What category of metals is best suited for use in your construction project?  
 (b) Justify your answer.
86. Element 113 is temporarily named ununtrium, and element 114 is temporarily named ununquadium. The names are derived from the atomic numbers. For example, *un-* stands for “1,” *tri-* stands for “3,” and *quad-* stands for “4.” If *pent-* means “5,” what is the temporary name of element 115? K/U T/I A

87. Imagine that you are clasping a hockey puck in your hands. Anyone who wants to take that puck from you will have to exert energy to do so. **K/U T/I A**
- How is this situation analogous to removing a valence electron from an atom?
  - What is the term applied to the quantity of energy needed to remove a valence electron from an atom?

## Research



88. The different forms, or allotropes, of carbon are important to Canada. **K/U T/I A**
- The Diavik Diamond Mine is located approximately 300 km north of Yellowknife, Northwest Territories. What properties of diamonds make them a desirable form of carbon?
  - Extracting iron from its ore requires elemental carbon. Charcoal was widely used for this process in the nineteenth century and into the twentieth century in Canada. Suggest two reasons why charcoal was chosen for this purpose.
  - Which province in Canada produces graphite in a commercial quantity?
89. (a) The largest natural deposit of fullerenes on Earth is in Canada. Where is this deposit of fullerenes located?
- (b) Jan Cami, an astronomer at Western University in London, Ontario, found buckminsterfullerene in a rather surprising place. Where did he locate this form of carbon? **T/I**
90. As atomic theory has developed, scientists have discovered that particles even smaller than protons, neutrons, and electrons exist. One of these particles is called a quark. **K/U C**
- What is a quark?
  - The different types of quarks are called “flavours.” What names are assigned to the different flavours of quarks?
  - How do quarks relate to protons, neutrons, and electrons?
91. Schools in Canada must control certain compounds used in their laboratories because of safety factors. Investigate each of these compounds. Which ion in each compound might be harmful to students? Why might it be harmful? **T/I A**
- sodium cyanide, NaCN
  - magnesium chromate, MgCrO<sub>4</sub>
92. Radon in the home is hazardous to human health. **T/I C A**
- In a building, what is the maximum concentration of radon that the Canadian government considers to be safe?
  - What type of radiation does radon emit?
  - How can the quantity of radon in a building be limited?
93. One major change between Mendeleev’s periodic table and the modern periodic table is the ordering of elements by increasing atomic number instead of increasing atomic mass. **K/U T/I**
- Who proposed this change to the table?
  - What elements were out of order on a table based on atomic mass?
  - What led scientists to suspect that the change from atomic mass to atomic number needed to be made?