# OBSERVATORY 4

SECOND EDITION

## Activity Book

Marie-Danielle **CYR**

Jean-Sébastien **VERREAULT**

ACCORDING TO PROGRESSION OF LEARNING REQUIREMENTS

Pearson ERPI

# TABLE OF CONTENTS

## THE MATERIAL WORLD









## THE EARTH AND SPACE







## THE LIVING WORLD





## THE TECHNOLOGICAL WORLD





# SIGNIFICANT DIGITS EST

In a number, the significant digits (also called *significant figures*) are the digits that represent values you know to be accurate. To these digits, you may add one more for a value you have estimated. For example, if you measure the mass of an object with a balance that is accurate to one hundredth of a gram and record a mass of 2.10 g, this value contains three significant digits. If you wrote "$m = 2.100$ g" or "$m = 2.1$ g," your data would be incorrect because they would not be consistent with the precision of your measuring instrument.

If the unit of measurement is changed, the number of significant digits in the value must remain the same. For example, to maintain three significant digits in the mass of the 2.10 g object, its mass can also be expressed as 2100 mg or 0.002 10 kg.

## ZEROS

Using scientific notation effectively avoids any confusion about the significance of zeros. If you write $2.10 \times 10^3$ mg, it is clear that this number contains three significant digits. Specifically, note the following:

- The zeros at the end of a whole number are significant only if they contribute to the accuracy of the number. For example, the last zero in 2100 mg is not significant, but the second-last zero is.
- Any zeros at the beginning of a decimal (such as the first three zeros in 0.002 10 kg) are not significant.

## VALUES DETERMINED BY COUNTING OR BY DEFINITION

A value determined by counting can be considered accurate. For example, if you count 16 trucks, the number 16 contains an infinite number of significant digits. The same is true for a number that is part of a definition. For example, molar mass is defined as the mass of exactly 1 mole of matter. In this case, the number 1 also contains an infinite number of significant digits.

## SIGNIFICANT DIGITS IN CALCULATIONS

The result of a calculation can never be more accurate than the numbers involved. In general, avoid rounding numbers as you calculate; take all digits into account even if they are not significant. When you reach the point of presenting a final answer, then you must make sure the number of significant digits is consistent with the accuracy of the given values.

- When adding or subtracting, round off your result so that the last significant digit has the same place value as the final digit in the least precise number given.
  Example: 2.31 cm + 114.4 cm = 116.71 cm → 116.7 cm
  The above answer must be rounded to the nearest tenth to reflect the accuracy of the least precise number (114.4 cm).
- When multiplying or dividing, round off your result so that it contains the same number of significant digits as the value with the fewest.
  Example: 2.31 cm × 114.4 cm = 264.264 $cm^2$ → 264 $cm^2$
  The above answer must be rounded to three significant digits—the same number as in the value with the fewest significant digits (2.31 cm).

# Chapter 1
# ATOMS AND ELEMENTS

The elements that make up the Earth and all things on it, living and non-living, come from stars that exploded.

**"We are all specks of star dust."**

—Hubert Reeves

Diamonds are a form of carbon: the **6th element** of the periodic table.

Atoms are tiny. The number of atoms in a drop of water is roughly equal to the number of stars in the Universe.

**There are $1 \times 10^{23}$ atoms in 1 ml of water.**

Gold is the **79th element** of the periodic table.

There are

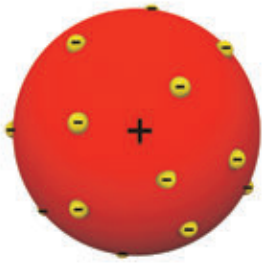
**94**

**elements** that occur naturally on Earth.

# ATOMS AND ATOMIC MODELS

Pages 6 to 17

**1** The following atomic models were developed before the Rutherford-Bohr model. Name each of these models.




a) _____ atomic model

b) _____ atomic model

c) _____ atomic model

**2** Check the characteristics that agree with the Rutherford-Bohr atomic model.

- **A.** A very small, dense nucleus ☐
- **B.** A nucleus containing positively charged protons ☐
- **C.** An atom that resembles a positively charged ball ☐
- **D.** Negatively charged electrons that revolve around the nucleus in specific orbits ☐
- **E.** Negatively charged electrons that revolve randomly around a small, dense nucleus ☐

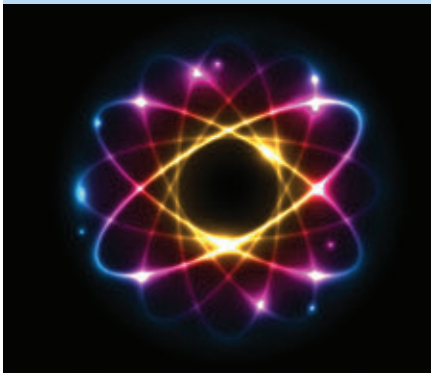
EST **3** Check the characteristics that agree with the simplified atomic model.

- **A.** A very small, dense nucleus made up of positively charged protons and of neutrons that have no electrical charge ☐
- **B.** A nucleus containing only positively charged protons ☐
- **C.** Negatively charged electrons that revolve around the nucleus in electron shells ☐
- **D.** Electrons moving in orbits around a nucleus containing only protons ☐

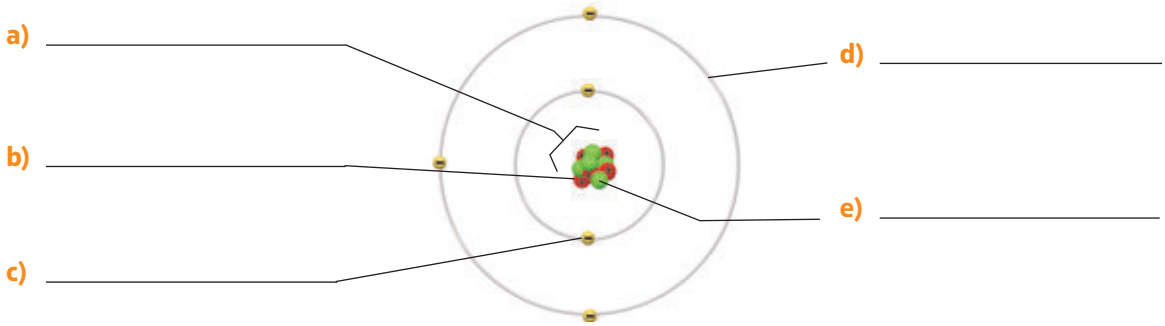
## MYTH OR SCIENCE?

**Matter consists mostly of empty space.**

**SCIENCE.** An atom is about 100 000 times bigger than its nucleus. An atom is therefore 99.9999% empty space. If you could remove the empty space from all of the Earth's atoms, our planet would fit inside a sphere with a radius of 150 m. What gives matter its solidity is the powerful electrical and magnetic fields created by the electrons revolving around the nucleus.



EST **4** Identify each of the labelled parts of the atom in the following representation of the simplified atomic model.




**5** Match each of the statements below to the corresponding atomic model.

| | | |
|---|---|---|
| Dalton's model | Rutherford-Bohr model | Rutherford's model |
| Simplified atomic model | Thomson's model | |

**a)** This atomic model was the first to include a nucleus made up of protons. _____

**b)** This atomic model represents the atom as a positively charged ball with small negative particles, called *electrons*, scattered throughout. _____

**c)** This older model represents the atom as a solid, indivisible ball of variable mass. _____

**d)** This atomic model was the first to include electrons. _____

**e)** In this atomic model, the entire positive charge of the atom lies in a small but dense nucleus, while the negative charge, in the form of electrons, revolves around the nucleus. _____

**f)** This atomic model shows the orbits in which electrons move. _____

EST **g)** This atomic model included a new particle, the neutron, which has no electrical charge. _____

**6** Rutherford's model did not meet with universal approval among the scientists of the day. Why not?

_____

_____

_____

_____

**7** **a)** What experiment led Rutherford to discover important facts about atoms?

**b)** The results of his experiment surprised Rutherford. Why?

**c)** What conclusions did Rutherford draw from his experiment?

**8** In 1913, Niels Bohr published an improved version of Rutherford's model. What new hypothesis about electrons did Bohr formulate?

**9** Why are atoms said to be electrically neutral?

EST **10** What role do neutrons play in the atomic nucleus?

**11** When alpha particles, which are positive, approach the nucleus of an atom, they are deflected. Why?

# THE **PERIODIC TABLE**

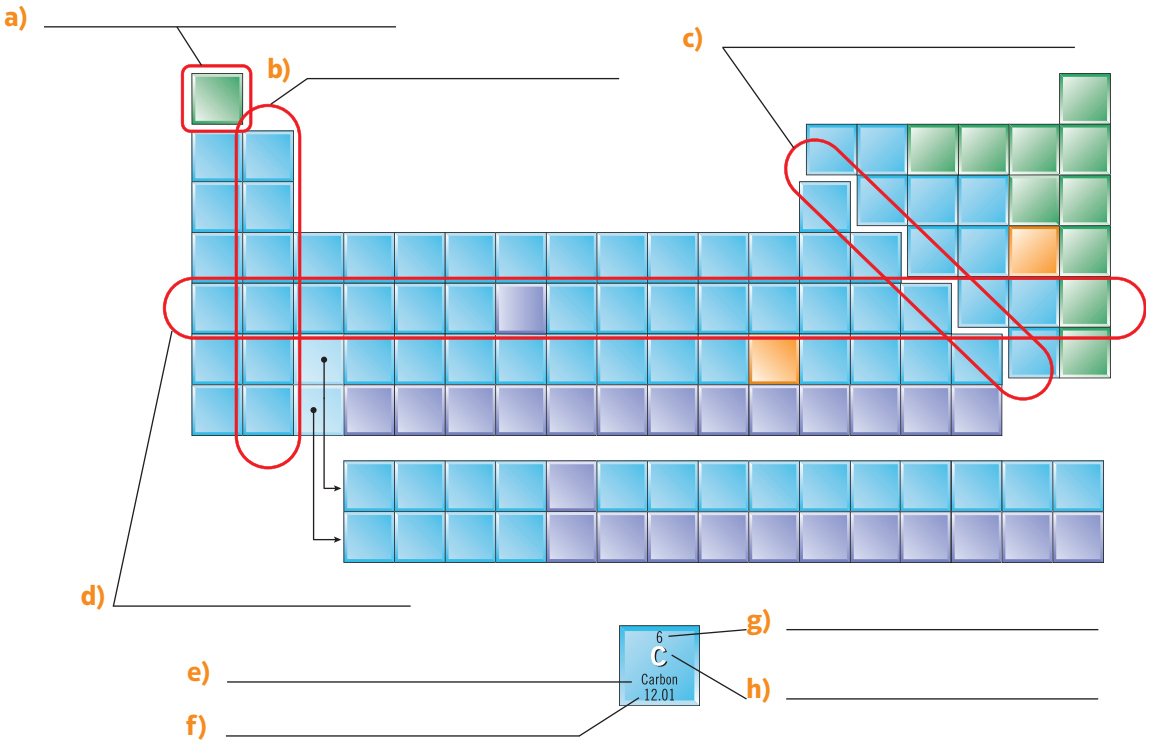
Pages **17** to **26**

**Periodic table** (See the inside front cover.)

**Appendix 1:** Periodic properties, p. 321

**1** Label the illustration below using the following terms.

| | | | |
|---|---|---|---|
| Atomic mass | Atomic number | Chemical symbol | Element |
| Group | Name of the element | Period | Staircase |




**2** Match each of the following descriptions to the corresponding group of elements: alkali metals, alkaline earth metals, halogens or noble gases.

**a)** These elements are nonmetals. They are very stable and react minimally with other elements. They can be found in their elemental state in nature. _____

**b)** These elements are highly malleable and reactive metals that burn easily. They do not react on contact with the open air. They form many compounds found in soil and rocks. _____

**c)** These elements are nonmetals. Several of them are powerful disinfectants. They react easily to form compounds, such as salts. _____

**d)** These elements are soft, highly reactive metals. In their pure state, they must be stored in oil. They are never found in their elemental state in nature. _____

**3** Match each of the following descriptions to the corresponding category of elements: metals, metalloids or nonmetals.

**a)** These elements are good conductors of electricity and heat. They are ductile, malleable and usually shiny. They are also usually solid at room temperature. Many react with acids. _____

**b)** The properties of these elements vary depending on conditions. _____

**c)** These elements are generally poor conductors of electricity and heat. Many of them are gases at room temperature. In solid form, they can easily be reduced to powder. _____

**4** Match each of the definitions below to the corresponding term.

| | | | |
|---|---|---|---|
| Atomic number | Group | Metals | Nonmetals |
| Period | Periodic table | Relative atomic mass | Valence electron |

**a)** Category of elements found to the left of the staircase in the periodic table _____

**b)** Group of elements with similar chemical properties and with the same number of electrons in the outermost shells of their atoms _____

**c)** Presentation of the elements in which they are grouped according to their physical and chemical properties _____

**d)** Group of elements with the same number of electron shells (orbits) _____

**e)** Category of elements found to the right of the staircase in the periodic table _____

**f)** Electron in the outermost shell (orbit) of an atom _____

EST **g)** Number that represents the number of protons in the nucleus of an atom _____

EST **h)** Mass of an atom determined by comparison with the reference element carbon-12 _____

EST **5** What do you call the atoms of an element that have the same number of protons but different numbers of neutrons? _____

EST **6** What do you call the whole number that indicates the sum of the protons and neutrons in an atom? _____

EST **7** Which numerical value from the periodic table can you round off to find the mass number of the most common isotope of an element?

EST **8** What am I? Match each of the statements below to the corresponding term.

| | | |
|---|---|---|
| Atomic radius | Boiling point | Density |
| Electronegativity | First ionization energy | Melting point |

**a)** I am the distance between the centre of an atom and its outermost electron.

**b)** I am the temperature at which a solid becomes a liquid.

**c)** I am the measure of mass per unit of volume.

**d)** I am the degree of attraction that an atom exerts on electrons when forming a chemical bond.

**e)** I am the temperature at which a liquid becomes a gas.

**f)** I represent the amount of energy required to remove the outermost electron from an atom.

EST **9** How do you calculate the number of neutrons in an atom using information from the periodic table?

**10** How many valence electrons does each of the following elements have?

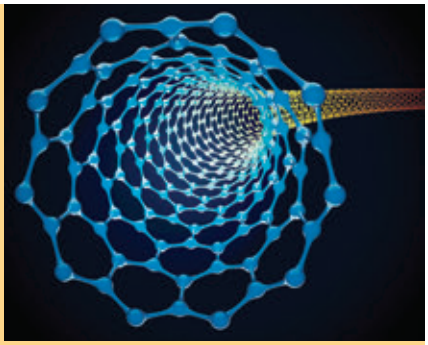
**a)** Antimony: _____ **b)** Fluorine: _____

**c)** Sulphur: _____ **d)** Gallium: _____

**e)** Cesium: _____ **f)** Xenon: _____

## HOW'S THAT **USEFUL?**

By observing atoms under a transmission electron microscope, scientists have learned more about a material that is strong and hard, but light: carbon nanotubes. Carbon nanotubes are an example of a nanotechnology application, in which matter is manipulated at the atomic level. They are used to manufacture sports equipment, among other things. Researchers are currently looking into medical applications for nanotubes, such as carrying medication to target areas of the body, building artificial muscles and helping cells regenerate.



EST **11** How many neutrons does each of the following elements have?

**a)** $^{16}_{8}O$ **b)** $^{39}_{19}K$ **c)** $^{59}_{27}Co$

_____ _____ _____

**12** Fill in the following table.

EST EST

| Element | Chemical symbol | Atomic number | Number of electron shells | Number of valence electrons | Relative atomic mass | Number of neutrons in the most common isotope |
|---|---|---|---|---|---|---|
| Bromine | | | | | | |
| Nitrogen | | | | | | |
| Aluminum | | | | | | |
| Magnesium | | | | | | |
| Potassium | | | | | | |
| Iodine | | | | | | |
| Neon | | | | | | |
| Sodium | | | | | | |
| Calcium | | | | | | |
| Krypton | | | | | | |
| Tin | | | | | | |

**13** Which elements from the table above belong to each of the following groups?

**a)** Alkali metals: _____

**b)** Alkaline earth metals: _____

**c)** Halogens: _____

**d)** Noble gases: _____

**14** Describe each of the following elements based on its place in the periodic table.

**a)** Potassium: _____

_____

_____

**b)** Xenon: _____

_____

_____

**c)** Fluorine: _____

_____

_____

EST **15** An atom has 28 protons and 31 neutrons.

**a)** How many electrons does it have? _____

**b)** What is its mass number? _____

**c)** What is its atomic number? _____

EST **16** An atom has 26 protons and 30 neutrons. Are the following statements about this atom true or false? If a statement is false, correct it.

**a)** The element is iron.

_____

**b)** The atom has 30 electrons.

_____

**c)** Its nucleus contains 30 particles.

_____

EST **17** **a)** What is the difference between carbon-12 and carbon-14?

_____

**b)** Represent these two isotopes in ${}^{A}_{Z}E$ notation.

Carbon-12: _____ Carbon-14: _____

EST **18** Why do the elements in the group of noble gases have no electronegativity?

_____

_____

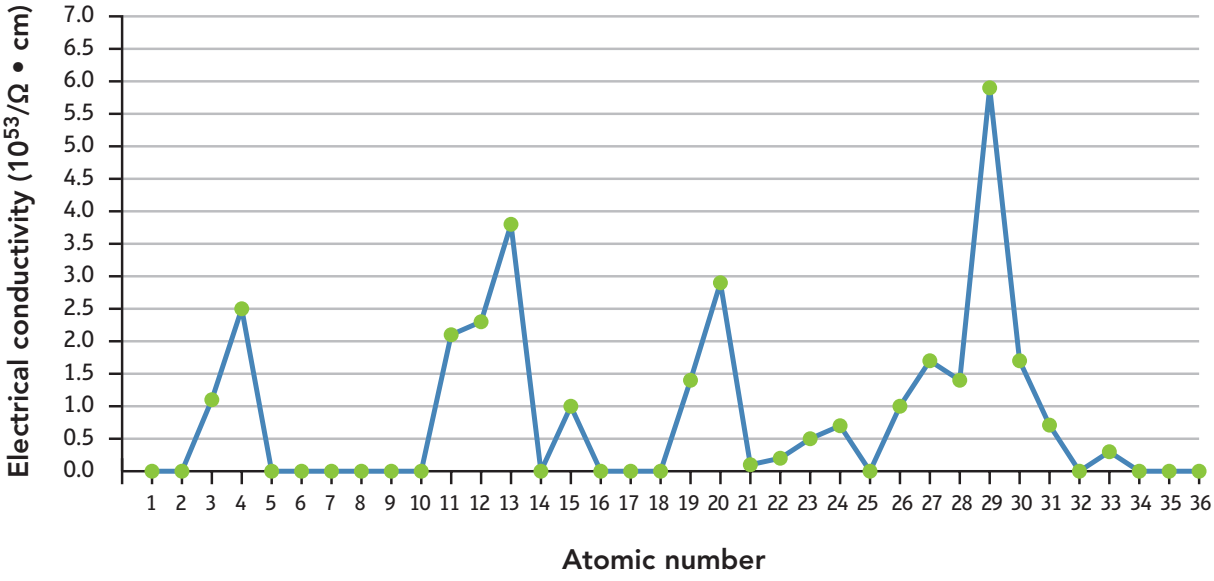
_____

_____

EST 19 Which of the following elements are isotopes of the same element? Explain your answer.

| | | | | |
|---|---|---|---|---|
| $^{123}_{53}A$ | $^{123}_{51}B$ | $^{127}_{53}C$ | $^{53}_{26}D$ | $^{53}_{25}E$ |

EST 20 The following graph shows how electrical conductivity varies with atomic number.




a) How many periods does the graph show? Mark their ranges on the graph and explain your answer.

b) Why is the electrical conductivity of certain elements zero or almost zero?

c) Which of the elements represented in the graph has the greatest electrical conductivity?

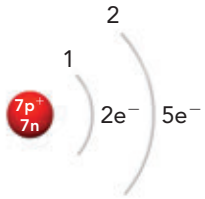
# REPRESENTING ATOMS

Pages **26** to **29**

**Periodic table** (See the inside front cover.)

**1** The following illustrations show different ways to represent a nitrogen (N) atom. Write the name of the corresponding model or notation under each illustration.

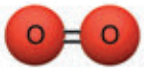




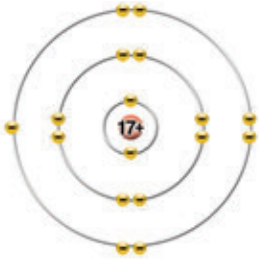

a) _____ b) _____ EST c) _____

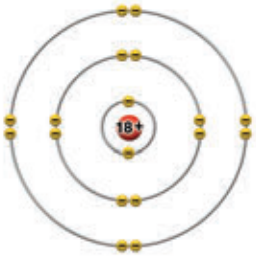
_____ _____ _____

**2** Name each of the following elements.

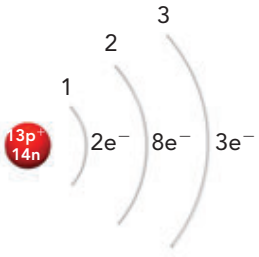



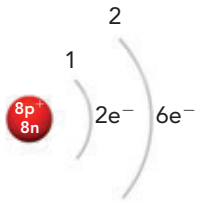

a) _____ b) _____




c) _____ d) _____




EST e) _____ EST f) _____

**3** What is the maximum number of electrons that each of the following electron shells can hold?

a) The first electron shell: _____

b) The second electron shell: _____

EST **4** What information from the periodic table do you need to represent an atom according to the simplified atomic model? Name four values and describe how you would use each of them.

**5** Represent each of the following elements in Lewis notation.

**a)** Cesium

**b)** Phosphorus

**c)** Argon

**6** Represent each of the following elements using the Rutherford-Bohr atomic model.

**a)** Calcium

**b)** Beryllium

**c)** Phosphorus

**d)** Potassium

EST **7** Represent each of the elements from the previous question, using the simplified atomic model instead of the Rutherford-Bohr model.

**a)** Calcium

**b)** Beryllium

**c)** Phosphorus

**d)** Potassium

**8** Fill in the following table. EST

| Element | Number of electron shells | Number of valence electrons | Number of protons | Number of electrons | Number of neutrons |
|---|---|---|---|---|---|
| Sodium | | | | | |
| Neon | | | | | |
| Magnesium | | | | | |
| Hydrogen | | | | | |

EST **9** Represent each of the following elements using the simplified atomic model.

**a)** The element with an atomic number of 14 and a mass number of 30

**b)** $^{20}_{9}F$

# THE **CONCEPT** OF **MOLE**

Pages **30** to **31**

**Periodic table** (See the inside front cover.)

EST **1** **a)** By definition, what amount of matter does a mole equal?

**b)** What is the molar mass of a substance?

**c)** Where can you find the molar mass of an element in the periodic table?

EST **2** **a)** The following formula is used to calculate the molar mass of a substance. Write the meaning of each symbol and identify the corresponding unit of measurement.

$$M = \frac{m}{n}$$

| Symbol | Meaning of the symbol | Unit of measurement (with its symbol) |
|---|---|---|
| *M* | | |
| *m* | | |
| *n* | | |

**b)** How do you calculate the molar mass of a molecule?

EST **3** What does Avogadro's number represent?

EST **4** **a)** What is the molar mass of sulphur (S)?

**b)** What is the mass of 5.00 mol of sulphur (S)?

Answer:

**c)** How many atoms are there in 5.00 mol of sulphur (S)?

Answer: _____

EST **5** **a)** What is the molar mass of water ($H_2O$)?

Answer: _____

**b)** How many moles of water ($H_2O$) are there in 1 L of water (1000 g of water)?

Answer: _____



EST **6** Complete the following table by calculating the missing molar masses. Then name the element of the periodic table that matches each of the molar masses.

| Element (symbol) | Molar mass (g/mol) | Mass (g) | Number of moles (mol) |
|---|---|---|---|
| | | 107.92 | 4 |
| | | 40.12 | 0.2 |
| | | 1.95 | 0.01 |
| | | 2 253 833 | 40 355.11 |

EST **7** A thermometer contains 0.0300 mol of mercury. How many grams of mercury does it contain?

Answer: _____

EST **8** Write the following quantities in terms of moles.

**a)** $2.408 \times 10^{24}$ atoms of oxygen: _____

**b)** $6.02 \times 10^{25}$ atoms of iodine: _____

**c)** $3.01 \times 10^{23}$ atoms of nickel: _____

**d)** $3.8 \times 10^{24}$ steel balls: _____

**e)** $9.39 \times 10^{25}$ candies: _____

**f)** $1.57 \times 10^{23}$ diamonds: _____

EST **9** Complete the following table by filling in the missing information.

| Substance (symbol/formula) | Molar mass (g/mol) | Mass (g) | Number of moles (mol) |
|---|---|---|---|
| Copper (Cu) | | 72 | |
| | 118.71 | | 4.5 |
| Uranium (U) | | | 0.42 |
| | 58.69 | 2000 | |
| Molecular nitrogen ($N_2$) | | 72 | |
| Molecular hydrogen ($H_2$) | | 9.1 | |
| Calcium chloride ($CaCl_2$) | | 15 | |
| Copper sulphate ($CuSO_4$) | | 450 | |

EST 10 An aquarium filled with salt water contains 30.0 g of salt (NaCl) per litre of water. How many moles of salt does the aquarium contain if it has a capacity of 30.0 L?

Answer: _____

EST 11 A hospital patient receives an aqueous solution of glucose ($C_6H_{12}O_6$) at a rate of exactly 0.05 mol of glucose per minute. If the treatment lasts 25 minutes, how many grams of glucose will the patient receive in all?

Answer: _____

EST 12 Valerie bought a gold bracelet. She is convinced it is made of pure gold. If the mass of her bracelet is 30.0 g and it contains 0.165 mol of particles, is she right to think it is made of pure gold? Explain your answer.

Answer: _____

# CHAPTER 1 CONSOLIDATION

**1** When Ernest Rutherford bombarded a thin sheet of gold foil with a beam of alpha particles, he noticed that most of the particles went through the foil without deviating. Which of the following statements describes the conclusion Rutherford drew from this observation of the particles' behaviour?

**A.** An atom consists mostly of empty space. ☐

**B.** An atom contains a very small and very dense nucleus. ☐

**C.** An atom contains a positively charged nucleus. ☐

**D.** An atom contains electrons that revolve around a nucleus. ☐

**2** Identify the two statements that are false and correct them.

**A.** An atomic nucleus is made up of electrons.

**B.** Electrons move in electron shells.

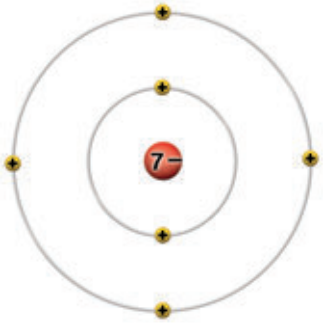
**C.** Protons have a positive charge.

**D.** An atom is either positive or negative.

**E.** An atom cannot be divided chemically.

**F.** All matter is made of atoms.

**3** Identify the two mistakes in the illustration opposite of an atom according to the Rutherford-Bohr model.




**4** Which of the following statements are false?

**A.** Oxygen (O) is a gas that belongs to the second period of the periodic table. ☐

**B.** Sodium (Na) is an alkali metal, containing one valence electron. ☐

**C.** Potassium (K) is a metal that belongs to the third period of the periodic table. ☐

**D.** Beryllium (Be) is an alkali metal, belonging to the second period of the periodic table. ☐

**E.** Iodine (I) is a halogen with five electron shells. ☐

**5** Complete the following table by filling in the missing information on each element.

| Element | Chemical symbol | Atomic number | Number of electron shells | Number of valence electrons | EST Mass number | EST Number of neutrons |
|---|---|---|---|---|---|---|
| Lead | | | | | | 125 |
| Arsenic | | | | | 75 | |
| Xenon | | | | | | 77 |

**6** What am I? Identify the element of the periodic table that fits each of the following descriptions.

**a)** I am a metal. I burn easily when heated. You can find me in rock. I do not need to be stored in oil when I am in a pure state. I have three electron shells. _____

**b)** I am a nonmetal traditionally placed above the alkali metals in the periodic table. _____

**c)** I am a good conductor of electricity, I have six electron shells, and I belong to the same group as zinc. _____

**d)** I am a nonmetal found almost exclusively in compounds. I have two electron shells. _____

EST **7** Fill in the following table with the numbers of each type of particle and the ${}^{A}_{Z}E$ notation for the element. Consider the most common isotope of each element.

| Element | Number of protons | Number of electrons | Number of neutrons | ${}^{A}_{Z}E$ notation |
|---|---|---|---|---|
| Arsenic | | | | |
| Helium | | | | |
| Iodine | | | | |
| Carbon | | | | |
| Radium | | | | |

EST **8** Uranium exists naturally in three forms: uranium 238 (99.28%), uranium 235 (0.71%) and uranium 234 (0.0054%).

**a)** Represent the three isotopes of uranium in ${}^{A}_{Z}E$ notation.

**b)** What is the difference between the three isotopes?

**c)** Given that the atomic masses of the three uranium isotopes (238, 235 and 234) are respectively 238.0508 u, 235.0439 u and 234.0410 u, explain why the relative atomic mass of uranium is 238.03 u in the periodic table.

EST **9** Atomic radius is one of the periodic properties of the elements.

**a)** Explain how the atomic radius varies within a period.

**b)** Why does the radius vary?

EST **10** **a)** If you had to find the number of electron shells and the number of neutrons in an element, would you refer to the periodic table, to the Lewis structure for the element or to its representation according to the Rutherford-Bohr atomic model? Explain your answer.

**b)** Which atomic model can you use to determine the mass number of an element? Explain your answer.

**11** Draw an aluminum atom according to each of the following representations.

**a)** Rutherford-Bohr atomic model

**b)** Lewis structure

EST **c)** Simplified atomic model

EST **12** Which of the representations from the previous question would you use to draw a different isotope of aluminum? Explain your answer.

EST **13** What is the molar mass of each of the following substances?

**a)** Tin (Sn): _____

**b)** Krypton (Kr): _____

**c)** Vitamin C ($C_6H_8O_6$)

Answer: _____

**d)** Calcium carbonate ($CaCO_3$)

Answer: _____

EST 14 What is the mass of each of the following samples?

**a)** 0.25 mol of iron (Fe)

Answer: _____

**b)** 48.5 mol of lithium (Li)

Answer: _____

**c)** 3.50 mol of molecular nitrogen ($N_2$)

Answer: _____

**d)** 5.35 mol of rust ($Fe_2O_3$)

Answer: _____

**e)** $3.01 \times 10^{23}$ atoms of silver (Ag)

Answer: _____

EST **15** Calculate the number of moles in each of the following quantities.

**a)** 32 g of carbon

Answer: _____

**b)** 2500 g of gold

Answer: _____

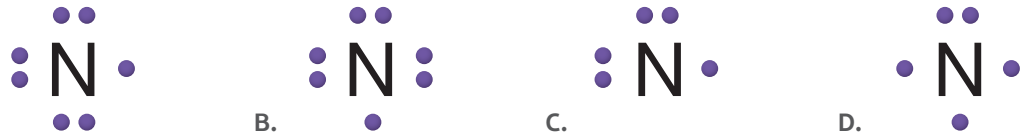
**c)** $1.2 \times 10^{24}$ molecules of water

Answer: _____

**d)** 140 g of copper sulphate ($CuSO_4$)

Answer: _____

**16** Which of the following illustrations is the correct Lewis structure for nitrogen? Circle the correct answer.




A. B. C. D.

EST **17** Julie has to fill her little brother's pool. Her mother, who is a chemist, asks her to put 18 600 mol of water in the pool. Given that 1 L of water has a mass of 1 kg, how many litres of water does Julie have to put in the pool?

Answer: _____

EST 18 Which of the following items of information do you *not* need to represent an atom according to the simplified atomic model?

A. The period number ☐
B. The number of protons ☐
C. The group number ☐
D. The symbol for the element ☐

EST 19 How many atoms are there in 19 mol of water ($H_2O$)?

Answer: _____

EST 20 Which of the following statements describe an isotope of oxygen?

A. It contains 16 protons and 8 neutrons. ☐
B. Its mass number is 32, and it contains 16 protons. ☐
C. Its mass number is 13, and it contains 8 protons. ☐
D. It contains 8 protons and 9 neutrons. ☐

EST 21 Karen and Melissa have both inherited samples of precious metals. Karen received 21 500 mol of silver, and Melissa received 196 mol of gold. Both girls say they could become millionaires by selling their inheritances by the kilogram. Given that gold is worth $25 797.76/kg and silver, $464.90/kg, are the girls right? Explain your answer.

Answer: _____

_____