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UNIT 1

The Matter

The lessons

Lesson one : Structure of the Atom

Lesson two : The Periodic Table of Elements

Lesson three: Matter and Its Properties

Lesson four : Chemical Bonds

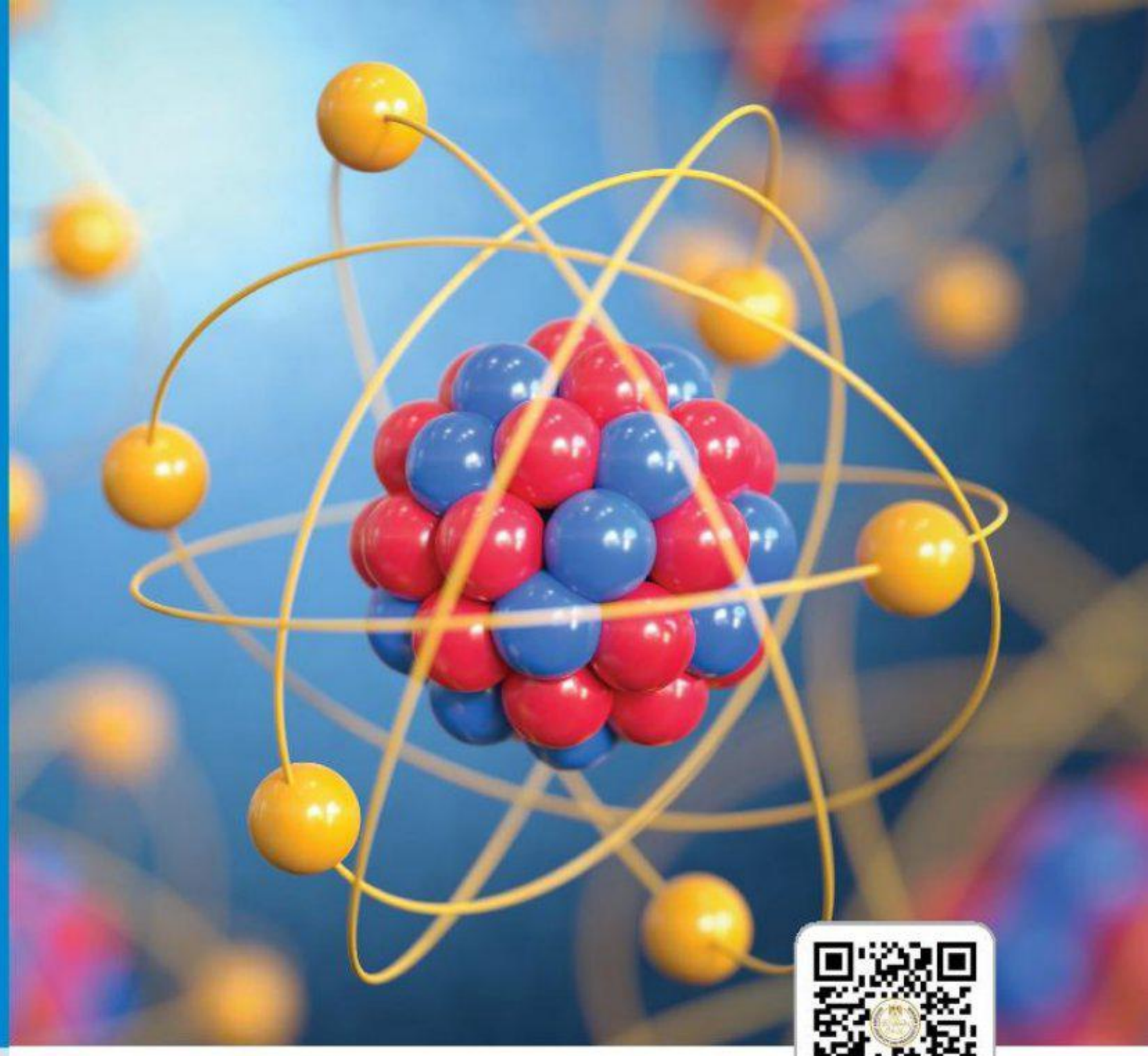
Learning Outcomes :

By the end of this unit, the student should be able to:

1. Conclude that the atom is the building unit of any matter.
2. Appreciate the role of the scientist Ernest Rutherford in the discovering of the nucleus.
3. Understand that the atom consists of subatomic particles called protons, neutrons and electrons, which differ in charge, mass and location within the atom.
4. Recognize that the electrons orbit in different energy levels with different shapes, and each level can carry a definite number of electrons, and any extra electron occupies the next higher energy level.
5. Determine the relationship between the number of subatomic particles that form the atom.
6. Recognize some practical applications and uses of the atom in daily life and its benefits.
7. Outline a brief introduction to the chemist Mendeleev.
8. Realize that the periodic table reflects the atomic structure and properties of the atoms, and that some elements' atoms contain the same number of protons but different numbers of neutrons, known as isotopes.
9. Relate the number of electrons in the outer energy level of an element's atom to its position in the periodic table.
10. Gather information to relate the atomic structure and the properties of matter in the periodic table.
11. Conclude the relationship between an element's location in the periodic table and its chemical activity.
12. Analyze and explain data regarding the composition of different substances.
13. Analyze and explain data to demonstrate that pure substances consist of one type of atoms or molecules, and each substance is characterized by its physical and chemical properties, which can be used to identify it.
14. Realize that molecules are made up of different atoms bonded together in different ways, with the number of atoms in molecules ranging from two to thousands.
15. Describe that the materials differ from each other due to differences in the types of atoms that compose them and the way they are bonded together.
16. Explain a model of water molecule as an example of the bonding of the atoms in the ecosystem (combined with ecology).
17. Connect the atomic structure of carbon to its unique properties in forming simple organic materials like methane.

Lesson **one**

Structure of the Atom



Lesson Terminology :

- Matter.
- Molecule.
- Atom.
- Proton.
- Neutron.
- Electron.
- Nucleus.
- Subatomic Particles.
- Energy level.
- Atomic number.
- Mass number.
- Nucleons.
- Isotopes.

Included Skills, Values, and Issues :

- **Skills** : Prediction - Analysis - Conclusion.
- **Values**: Appreciation of scientists - Collaboration.
- **Issue** : Sustainable development.

Cross-Cutting Concepts :

- Measurement and Proportion.

Lesson Objectives :

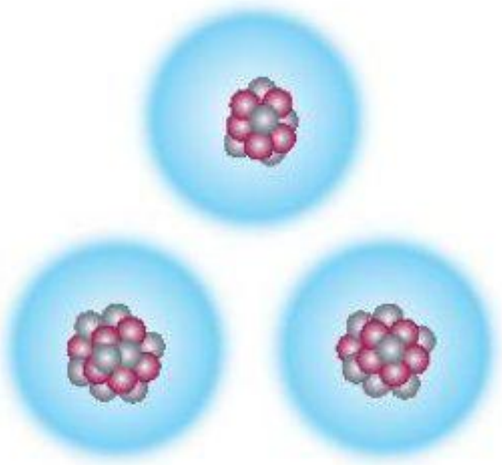
By the end of the lesson, the student should be able to :

1. Conclude that the atom is the building unit of all matter.
2. Find out the role of the scientist Ernest Rutherford in discovering the atomic structure.
3. Identify the subatomic components of the atom.
4. Recognize the charges and masses of the atomic components.
5. Determine the locations of subatomic components within the atom.
6. Recognize that electrons orbit in different shapes at different energy levels.
7. Explain the chemical symbols of some elements.
8. Conclude the number of electrons that occupy energy levels.
9. Determine the relationship between the number of subatomic particles that form the atom.
10. Identify isotopes.

Lesson Preparation :

These are three atomic nuclei. This lesson explores the ideas that will help you answer these questions :

- What are the components that form the nucleus of an element's atom ?
- Why is the nucleus positively charged, while the atom is neutral ?
- Which two nuclei are isotopes ?



The Atom is the Building Unit of Matter

Matter is anything that has mass, volume and occupies space.

Activity 1 Conclude

In Figure (1), which shows the Sphinx statue and the Pyramids of Giza in the background, which is made of limestone rocks, which is composed mainly of calcium carbonate.

- What are the units that form calcium carbonate ?

.....

- What are the smaller units that form molecules ?

.....

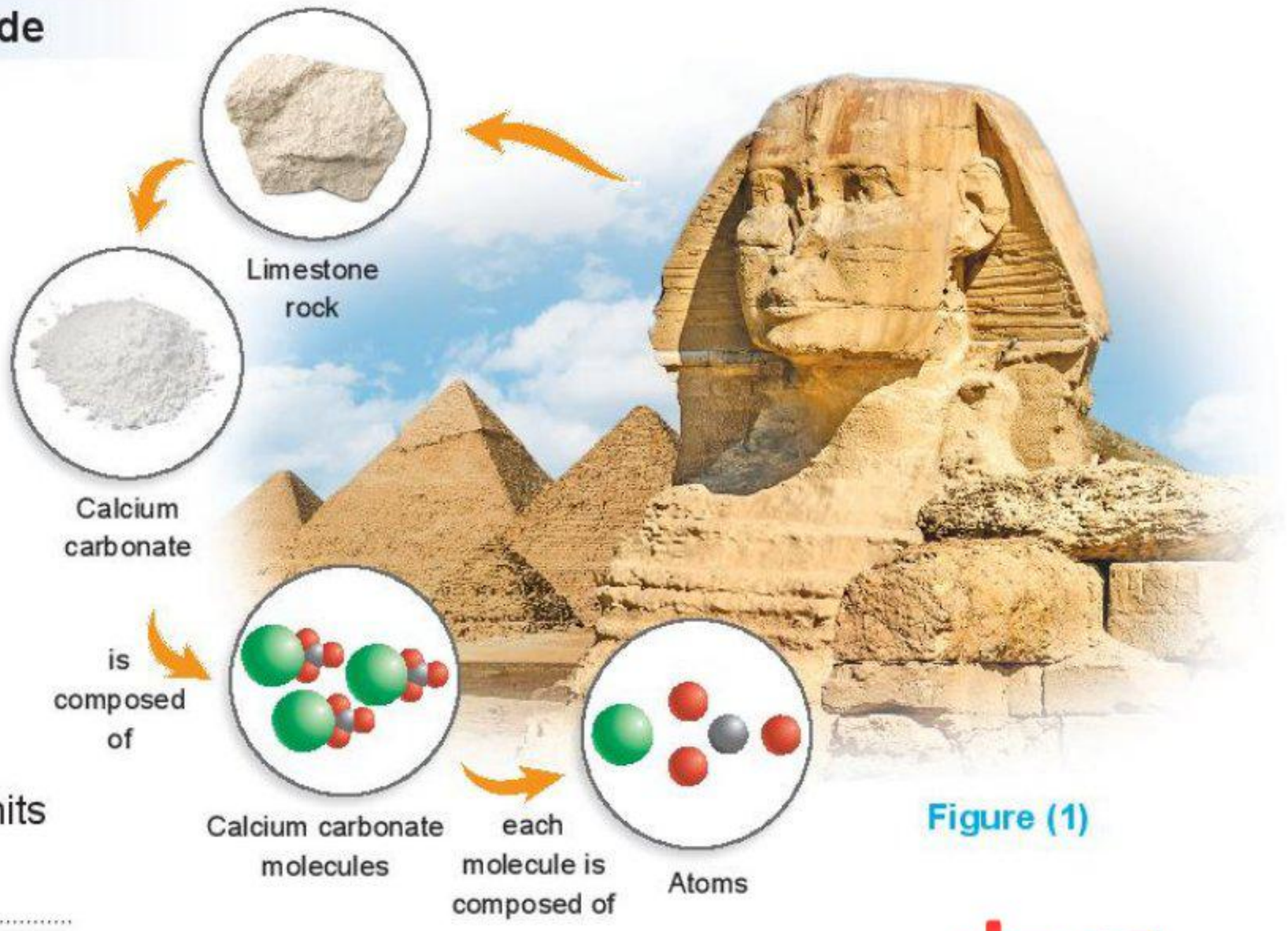


Figure (1)

- **Conclusion :**
  The atom is the building unit of the structure of any matter.

Structure of The Atom

Many attempts were made to discover the structure of the atom. Ancient Greek philosophers believed that matter was composed of small, indivisible parts called atoms.
In the early 19th century, Dalton formulated the first scientific theory about the atom, showing that atoms are indivisible. Rutherford's model of atom (1909) was the first atomic model formulated on experimental basis.
Scientists discovered that there is a very small space in the atom that contains two types of particles: protons and neutrons. This space is called the nucleus, in which electrons revolve around this nucleus at very high speeds in certain energy levels.
Protons, neutrons and electrons are called subatomic particles.

Cross-Cutting Concepts : Measurement and Proportion

If we represent the size of the atom by the size of a baseball field, the nucleus would be represented by the size of a pinhead in the middle of the field (Figure 2).

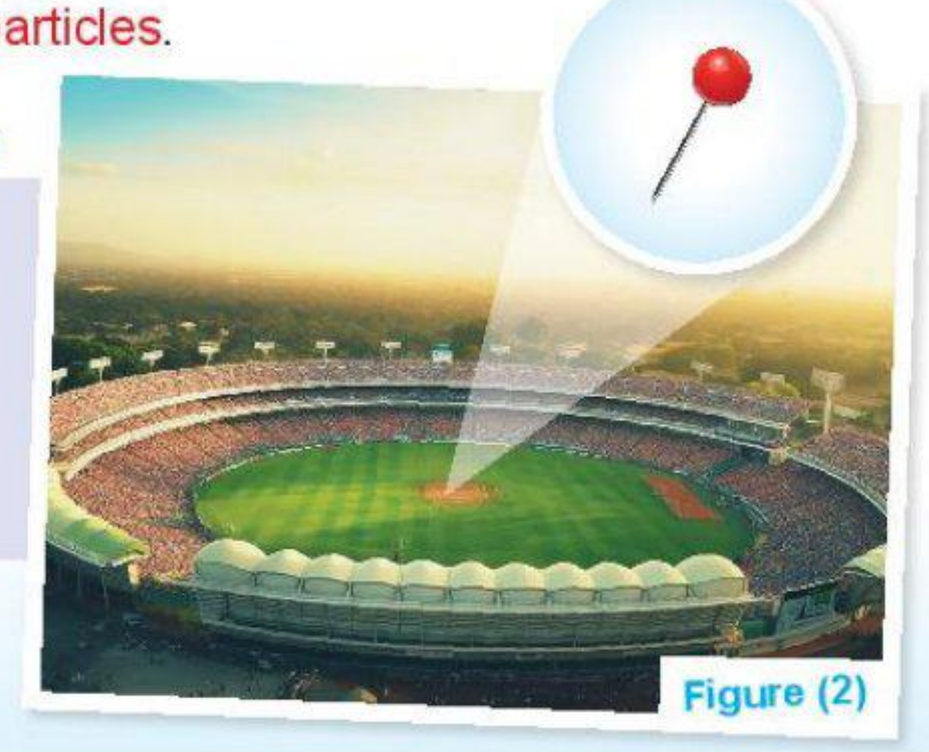


Figure (2)

A profile of the scientist

Ernest Rutherford

Rutherford was a New Zealand physicist, born in 1871, he won the Nobel Prize in Chemistry in 1908, and he died in 1937.

In 1992, New Zealand honored him by placing his image on its one hundred-dollar note (Figure 3), in recognition of his efforts.

(Figure 3)

Activity 2 Explain

Table (1) shows the properties of the subatomic particles that compose the atom.

Particle	Symbol	Relative electric charge	Mass
Proton	p	+1	1 u
Neutron	n	0	1 u
Electron	e^-	–1	$\frac{1}{1836}$ u

Table (1)

① **Why is the nucleus of the atom described as positively charged ?**

.....

.....

② **Why is the mass of the atom concentrated in the nucleus?**

.....

It is concluded from the previous table that :

- The charge of the proton equals the charge of the electron in magnitude but they are opposite in type.
- The masses of the subatomic components are measured in atomic mass units (u).
- The mass of the electrons is neglected in the calculation of the atomic mass due to its smallness compared to the mass of the protons or the neutrons.

The Energy Levels

Electrons revolve around the nucleus at different energy levels according to their energy. There are **7** main energy levels, expressed by the letters **(K, L, M, N, ...)**, the number of each level is represented by the symbol **(n)**.

Activity 3 Analyze

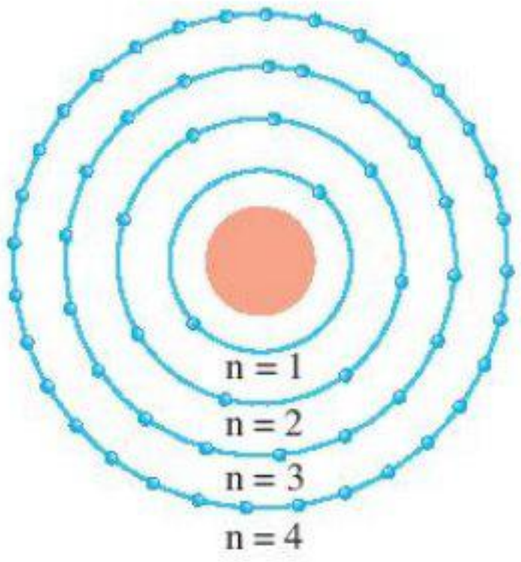


Figure (4) The number of electrons required to saturate the first four energy levels

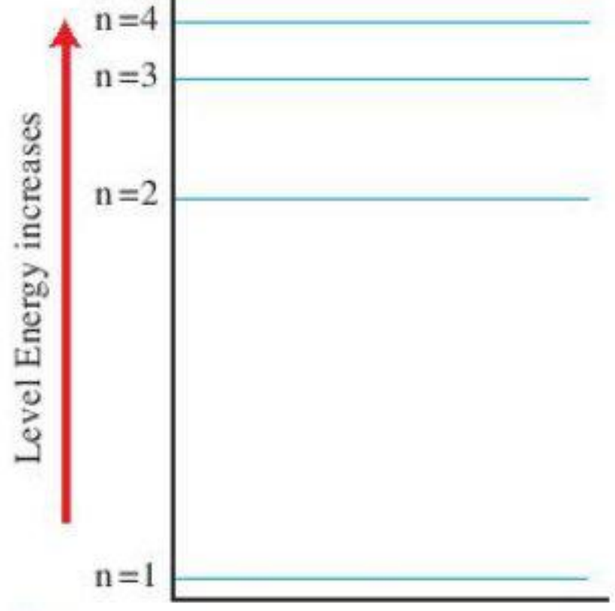


Figure (5) The energy of some levels in which the electrons revolve around the nucleus

Observe : Figures (4),(5) then answer the following questions :

1. **What is the number of the electrons that saturate each of the first four energy levels?**
   - First energy level K (n = 1) : .....
   - Second energy level L (n = 2) : .....
   - Third energy level M (n = 3) : .....
   - Fourth energy level N (n = 4) : .....
2. **What happens to the energy of the electron when it moves farther from the nucleus ?**

.....

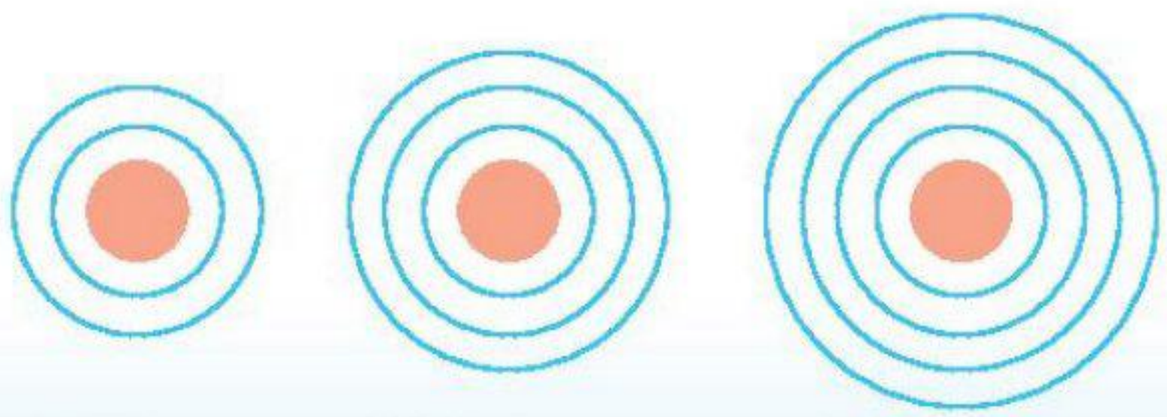
Mathematical Understanding :

- The number of electrons required to saturate the first four energy levels can be determined by the mathematical relationship ($2n^2$), where (n) represents the number of the main energy level.
- Verify the results of Activity (3) by applying the relationship ($2n^2$).

- Scientists have found that each main energy level consists of a number of energy sublevels in which electrons orbit in different shapes, and each main level can be occupied by a specific number of electrons. Any extra electrons occupy the next higher energy level.
- The first energy level is filled with electrons, and then the higher energy levels are filled with electrons successively according to the number of electrons in each atom.
- The outermost energy level of any atom does not contain more than 8 electrons.

Evaluate Your Understanding:

According to your understanding of electronic configuration in the energy levels, place dots (•) to represent the electrons in the energy levels of the atomic models shown in Figure (6).



8 Electrons **12 Electrons** **19 Electrons**

Figure (6)

Symbols of The Elements

Scientists agreed to express the chemical elements are represented by certain symbols to facilitate their expression and writing, especially in chemical equations.
Tables (2) and (3) show the names of some elements in two languages and their chemical symbols.

Element symbol	Element name in	
	English	Latin
C	Carbon	Carbo
N	Nitrogen	Nitrogenium
Cl	Chlorine	Chlorum
Cr	Chromium	Chromium

Table (2)

Element symbol	Element name in	
	English	Latin
Na	Sodium	Natrium
K	Potassium	Kalium
Cu	Copper	Cuprum
Fe	Iron	Ferrum

Table (3)

It is concluded from Tables (2) and (3) that :

The element symbol may be one capital letter or two letters, the first is capital and the second is small. The element symbol usually represents its name in English language.
When the element differs between English and Latin name, its symbol is taken from its Latin name.

Life Application

Fertilizers are chemical compounds used to improve the agricultural crops (Figure 7).
Among the most important types of fertilizers is the fertilizer NPK which is composed of three compounds containing the elements :

- Nitrogen (N) : Necessary for the greening of the plant leaves.
- Phosphorus (P) : Necessary for developing strong roots.
- Potassium (K) : Necessary for the healthy growth of the plant.

Figure (7)
Fertilizer NPK

Issue for Discussion

The impact of excessive fertilizer use in agriculture.

Relation Between The Numbers of The Subatomic Particles

Team up with one of your classmates to discover the relation between the subatomic components by performing Activity (4).

Activity 4 Discover

Figure (8) shows the subatomic particles that form the atoms of some elements.

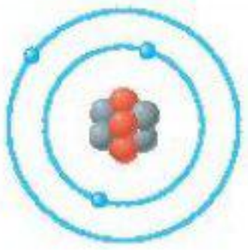
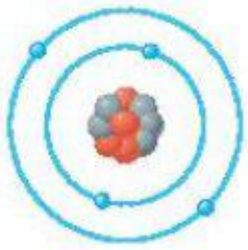
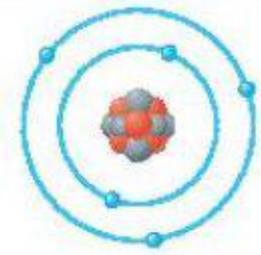
Hydrogen H	Helium He	Lithium Li	Beryllium Be	Boron B
				

Figure (8)

Record the number of the atomic components in Table (4), and choose the appropriate mathematical symbol (> / = / <) to express the relation between :

- The number of protons and electrons.
- The number of protons and neutrons.

Element	H	He	Li	Be	B
Number of protons	1	.....	.....	.....	5
Number of neutrons	0	.....	.....	.....	.....
Number of electrons	.....	2	.....	.....	.....
Relation between number of protons and number of electrons	P ..... e^-	P = e^-	P ..... e^-	P ..... e^-	P ..... e^-
Relation between number of protons and number of neutrons	P > n	P ..... n	P ..... n	P ..... n	P ..... n

Table (4)

From the previous it is concluded that :

Figure (9)

1. The number of positive protons (P) equals the number of negative electrons (e^-) in any atom, so the atom is electrically neutral.
2. The number of protons is called the atomic number, represented by the symbol Z , and is written at the lower left side of the element symbol.
3. The number of protons may equal the number of neutrons in the nuclei of some atoms, or the number of neutrons may exceed the number of protons in the nuclei of other atoms.
4. The sum of the numbers of the protons and the neutrons which compose the nucleus of an atom represents the number of nucleons which is called the mass number, represented by the symbol A, and is written at the upper left side of the element symbol.
5. The difference between the mass number A and the atomic number Z equals the number of neutrons in the nucleus of the atom.

Evaluate Your Understanding

Complete the numbers Z and A for the elements symbols in Table (5) based on the results in Table (4).

$^{1}_{1}H$	$^{.....}_{.....}He$	$^{.....}_{.....}Li$	$^{.....}_{.....}Be$	$^{.....}_{.....}B$

Table (5)

Isotopes

Scientists have observed that the atoms of the same element may exist naturally in different forms that have the same atomic number but differ in mass number, due to the difference in the number of the neutrons in their nuclei. These forms are known as isotopes of the element Figure (10) .

► **What is the only isotope of hydrogen that has no neutrons in its nucleus?**

.....

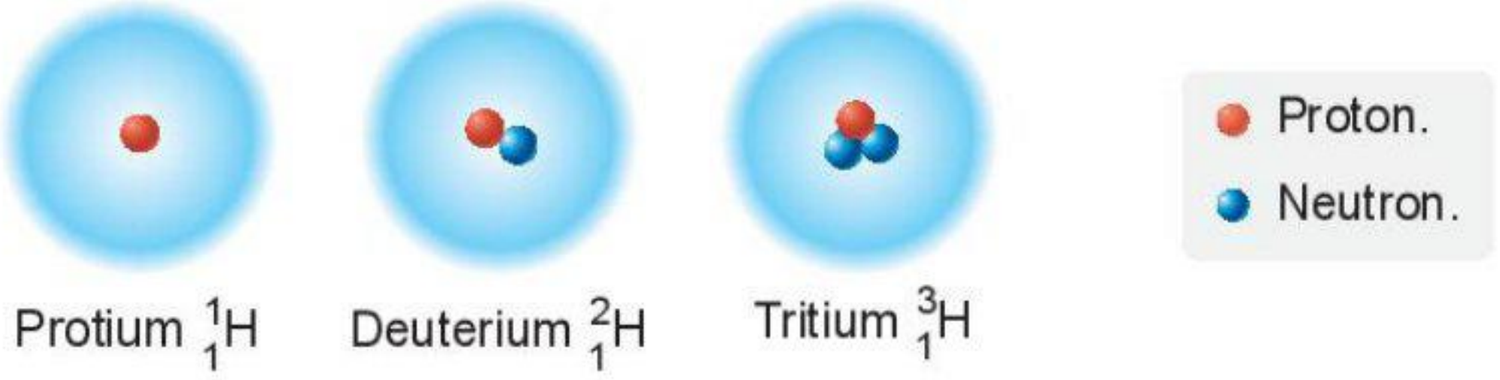


Figure (10) Isotopes of hydrogen

Evaluate Your Understanding

From Table (6), which shows the number of the protons and the neutrons in the atoms of some elements :

Element atom	(1)	(2)	(3)	(4)	(5)
Protons p	20	16	16	7	8
Neutrons n	20	20	18	8	9

Table (6)

Which two atoms are isotopes of the same element ?

(a) (1) , (2) . (b) (2) , (5). (c) (2) , (3). (d) (4) , (5).

Information and Communication Technology

Watch educational videos from reliable digital sources explaining the concept of isotopes.

Research Activity

Search in various knowledge sources, including the internet or the AI applications, about isotopes.

Evaluation Questions on Lesson one

1 Choose the correct answer for the questions from (1) : (8).

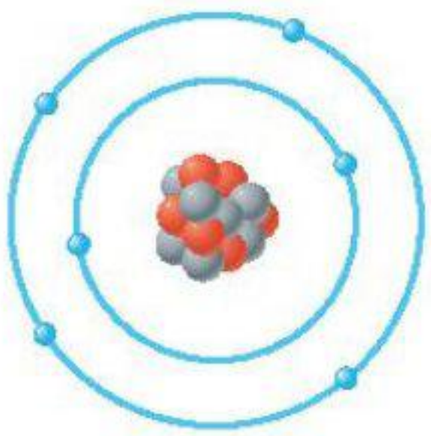
(1) What is the subatomic component that has the smallest mass ?

(a) Proton. (b) Neutron.
(c) Electron. (d) Nucleon.

(2) Which of the following subatomic components has a mass of 1 u ?

(a) Proton only.
(b) Electron only.
(c) Each of neutron and electron.
(d) Each of neutron and proton.

(3) The following figure shows the structure of the atom (X):



What is the symbol that represents this atom?

(a) $^{13}_{7}X$ (b) $^{13}_{6}X$ (c) $^{6}_{7}X$ (d) $^{7}_{6}X$

(4) Which of the following atoms has number of neutrons equals twice the number of protons in its nucleus?

(a) $^{1}_{1}H$ (b) $^{3}_{1}H$ (c) $^{4}_{2}He$ (d) $^{7}_{2}He$

(5) The nucleus of potassium atom contains 19 protons, then the electron with the highest energy in this atom is found in the .....

(a) first energy level.
(b) second energy level.
(c) third energy level.
(d) fourth energy level.

(6) What is the number that is the same in all the atoms of the same element ?

(a) Mass number.
(b) Number of electrons.
(c) Number of neutrons.
(d) Number of nucleons.

(7) Which of the following choices indicates that the atom of the element is neutral?

Choices	Element	Atom components
(a)	Silicon	14 protons, 14 neutrons
(b)	Sodium	11 protons, 23 neutrons
(c)	Chromium	24 protons, 24 electrons
(d)	Iron	26 protons, 30 electrons

(8) The electrons of an atom of an element are distributed in 3 energy levels, and the outermost energy level contains 3 electrons, while its nucleus contains 14 neutrons, its mass number is .....

(a) 3 (b) 13 (c) 14 (d) 27

2 Element (X) has a nucleus that contains 20 neutral particles and 39 nucleons:

(1) What is the number of negatively charged particles in this atom ?

(2) Write the symbol of this element, including the numbers of Z and A

3 In one of the isotopes of oxygen, Oxygen –17

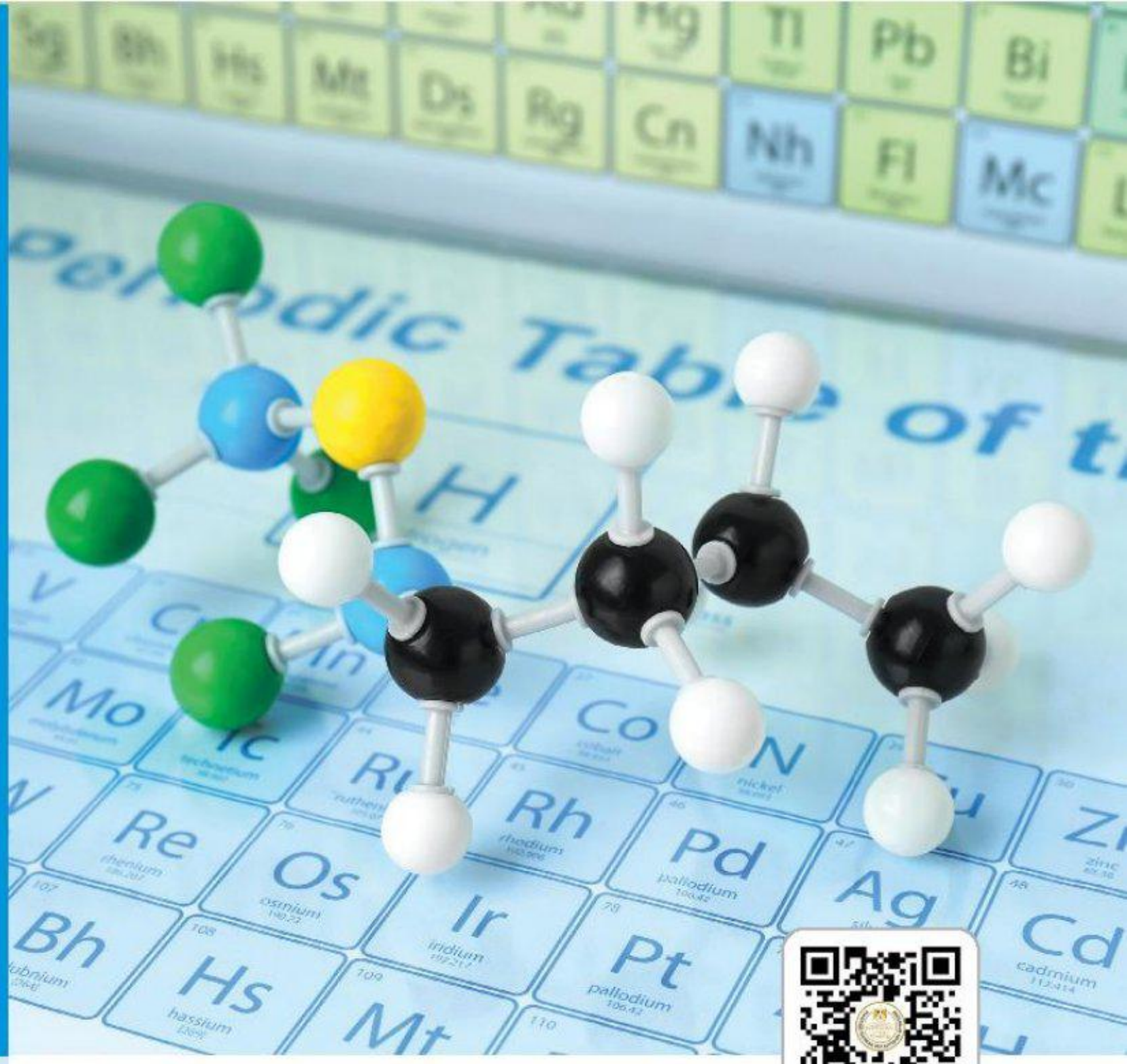
Why is it not possible to determine the number of neutrons in the nucleus of this isotope based only on the number 17 ?

4 The opposite figure represents a model of the atom:

What do the bees and the beehive represent in this model ?

Lesson **Two**

The Periodic Table of elements



Lesson Terminology :

- Periodic Table.
- Block.
- Period.
- Group.
- Metals.
- Nonmetals.
- Metalloids.
- Alkali metals.
- Alkaline earth metals.
- Transition elements.
- Noble gases.
- Halogens.
- Valency.
- Atomic radius.
- Melting point.
- Boiling point.

Included Skills, Values, and Issues :

- **Skills** : Investigation, Prediction, Research.
- **Values** : Collaboration, Appreciation of scientists.
- **Issue** : The relativity of science.

Cross-Cutting Concepts :

- Structure and Function.

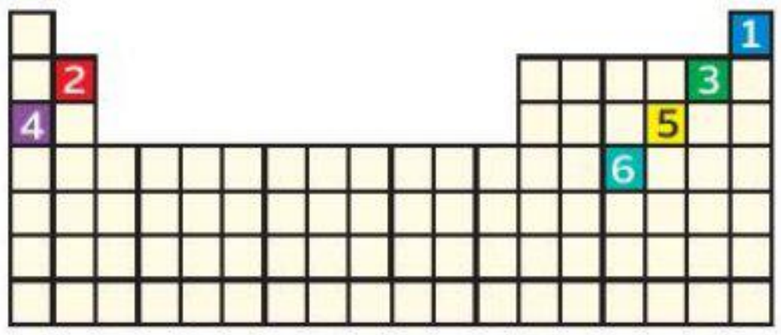
Lesson Objectives :

By the end of the lesson, the student should be able to :

1. Explain the role of the scientist Dmitri Mendeleev in arranging the elements in an ascending order regarding their atomic masses.
2. Confirm that the modern periodic table reflects the electron configurations and properties of atoms.
3. Relate the atomic numbers of group A elements to their locations in the modern periodic table.
4. Identify the electron configurations of the atoms of the elements according to the modern periodic table.
5. Show that chemical properties are similar in some groups of the modern periodic table.
6. Conclude the relation between an element location in the periodic table and its chemical activity.
7. Appreciate the role of the scientists in the evolution of the elements classification attempts.

Lesson Preparation :

Here is a table for classifying elements: This lesson explores the ideas that will help you answer the following questions :



- Can the electron configuration of element 5 be predicted without knowing its atomic number ?
- What are the names of the blocks of the elements 1, 2, 3, and 4 ?
- Can the properties of elements 4 and 5 be compared based on their positions in the periodic table ?
- Is element 6 a metal, nonmetal or something else ?

Attempts of Elements Classification

1 Mendeleev's Table

Scientists have made several attempts to classify elements to facilitate their study and conclude relations between them and their physical and chemical properties. Mendeleev's periodic table is considered the first periodic table for the classification of the elements, where elements were arranged in an ascending order according to their atomic masses without a regular pattern upon moving from the left of the table to the right in horizontal rows. He discovered that their properties repeated periodically at the beginning of each new row.

A profile of the scientist

Dmitri Mendeleev

Dmitri Mendeleev was a Russian chemist who published his periodic table of elements in 1869 and later he modified it,

He was honored 48 years after his death by naming one of the discovered elements after him, which is called Mendelevium (Md)

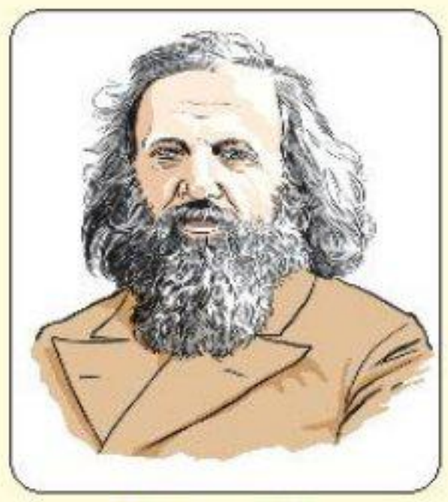


Figure (1)

2 Moseley's Table

After Rutherford discovered the protons, Moseley discovered that the periodicity of elements properties is related to their atomic numbers rather than to their atomic masses. Thus, he modified Mendeleev's table by arranging the elements in an ascending order according to their atomic numbers, so that the atomic number of each element exceeds the atomic number of the preceding element in the same period by **1**.

He also added the noble (inert) gases and other new elements discovered after Mendeleev formulated his table.

Information and Communication Technology

Watch reliable digital sources to learn about the elements of the modern periodic table.

3 The Modern Periodic Table

Some inadequacies in Mendeleev's table prompted the scientists to try to modify it. The elements were rearranged in a regular ascending order according to their atomic numbers and the way to fill the energy sublevels with the electrons in the modern periodic table (Figure 2), which consists of 7 horizontal periods, 18 vertical groups, and contains 118 elements.

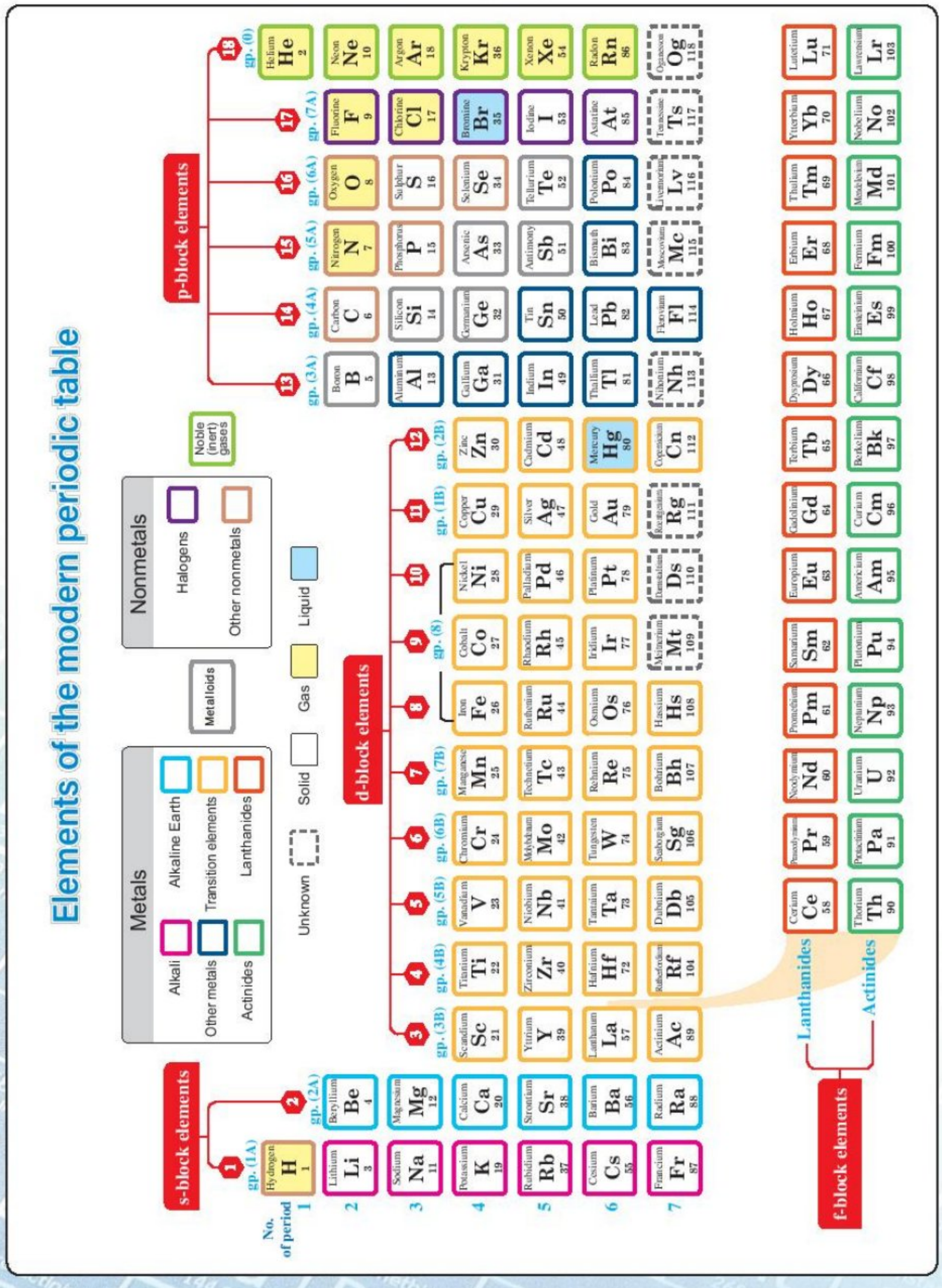


Figure (2) The Modern periodic table

Activity 1 Collaborate and discover

Team up with your classmates to form a collaborative group to study the periodic table (Figure 2), then record your observations about the following questions :

(1) **What are the blocks of the modern periodic table? and what types of elements are found in each block ?**

Location of the block	Left of table	Right of table	Middle of table	Bottom of table
Block	.....	p	.....	f
Types of the block elements	All are metals except	..... in addition to ..... and ..... and other metals	All are metals	All are metals

(2) **What are the two groups of the s-block ? And what are the names given to the metals in each of them?**

Group	1A	2A
Name of metals group	.....	.....

(3) **How many groups are found in the p-block ?** .....

(4) **What are the names and the numbers of the last two groups in the table ?**

Group	Last group	The group before the last (Penultimate group)
Group name	Noble Gases	.....
Group number	.....	.....

(5) **What is the period number in which the d-block starts ? What name is given to most of its elements ?**

• Period number : ..... • Name of their elements : .....

(6) **How many elements are located in each of the first four periods ?**

• Period (1) : ..... • Period (2) : .....

• Period (3) : ..... • Period (4) : .....

(7) **What is the physical state of most elements ?**
Which two elements exist in a liquid state ?

Most of the elements exist in the ..... state.
The two liquid elements are ..... metal,
its symbol is ..... and ..... nonmetal
whose symbol is .....

(8) **Classify the gaseous elements in the periodic table.**

	Inert gases						Other nonmetal gases				
Element symbol	He	.....	Ar	.....	.....	.....	H	.....	.....	.....	Cl
Number	..... elements						..... elements				

A topic for Discussion

Based on your study of the modern periodic table, Does the science stagnant or developing ?
Can the current form of the periodic table be more developed ?

9 **What are the locations of the metalloids in the modern periodic table ?**

Metalloids	Boron B	Silicon Si	Germanium Ge	Arsenic As	Antimony Sb	Tellurium Te
Period number	.....	3	.....	4	.....	5
Group number	3A	.....	4A	.....	5A	.....

Activity 2 Discover

Table (1) : Represents a section of the modern periodic table, showing the electron distributions of elements :

	1A	2A	3A	4A	5A	6A	7A	0
Period 2	Li	Be	B	C	N	O	F	Ne ....
Period 3	Na			Si	P			Ar ....
Period 4	K	Ca						Kr

Table (1)

1 Write the number of energy levels and the number of electrons in the outermost energy level below each element in the first horizontal row of (Table 1).

2 Place dots to indicate the distribution of electrons in the energy levels of the atoms of $_{11}Na$, $_{14}Si$, $_{15}P$, $_{18}Ar$ and determine the number of energy levels and the number of electrons in the last energy level in each atom. What can be concluded ?

.....

3 Conclude the relation between the number of occupied energy levels in the atom of an element and its period number in the modern periodic table.

.....

4 Conclude the relation between the number of electrons in the last energy level of the atoms of the elements in the groups of (p), (s) blocks and the group number of the element in the modern periodic table (except noble gases).

.....

5 Predict the number of electrons in the last energy level in the atoms of :

- Potassium K : ..... - Calcium Ca : ..... - Krypton Kr : .....

According to the two activities (1) and (2), it is clear that :

- The periodic table reflects the electron configuration and properties of atoms.
- The location of an element in the periodic table is determined by the number of occupied energy levels in its atom (period number) and the number of electrons in its last energy level (group number).
- The electron distribution of most metals ends with 1, 2 or 3 electrons, while the electron distribution of most nonmetals ends with 5, 6 or 7 electrons.
- Metalloids cannot be identified by the number of electrons in their outermost energy levels.
- Elements in the same group have similar chemical properties, and the chemical activity increases in alkali metals group and alkaline earth metals group with increasing the atomic number. The chemical activity of alkaline earth metals is less than that of the alkali metals which are highly active, while the chemical activity in the halogens group decreases with increasing the atomic number.

Valency of the element

The electrons in the last energy level are called "valence electrons" and are represented by dots around the element's symbol on four sides individually first, then they are paired up until they are distributed completely, this is known as Lewis structure (Table 2).

Group number	1A	2A	3A	4A	5A	6A	7A	0
Element	Li	Be	B	C	N	O	F	Ne
Valency	Monovalent	Divalent	Trivalent	Tetravalent	Trivalent	Divalent	Monovalent	Zero

Table (2)

The valency of an element can be concluded from the number of the unpaired electrons in its Lewis structure. It is noted from (Table 2) that the valency of elements in groups (1A to 4A) equals the group number, while the valency of elements in groups 5A to group 0 equals (8 minus the number of electrons in the last energy level).

Evaluate Your Understanding

(Figures 3 and 4) illustrate the electron distribution of the atoms of two elements (X) and (Y). Determine the valency and the location of each of them in the periodic table.

- Element (X) : .....
  .....
- Element (Y) : .....
  .....

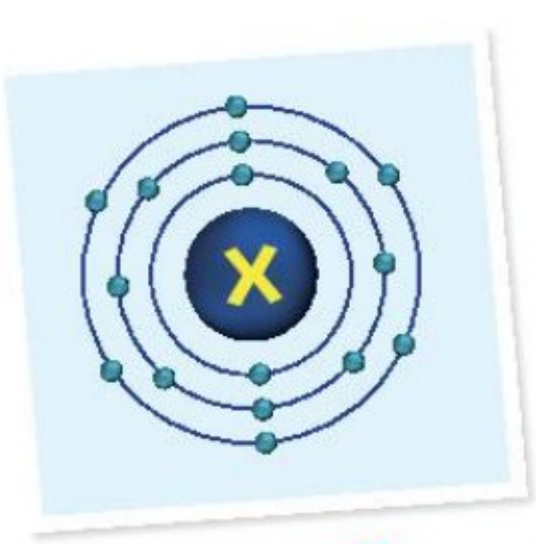


Figure (3)

Figure (4)

► **The electron configuration of elements' atoms reflects its properties.**

Activity 3 Predict

① The following data are the possible values for atomic radius, melting point, and boiling point of some elements :

157 pm	883°C	99 pm	181°C	235 pm	– 34°C

Discuss with your classmate the suitable value for each blank cell in the following tables :

Metals	Atomic radius	Melting point	Boiling point
Lithium $_{3}Li$ 2, 1	157 pm	.....	1347°C
Sodium $_{11}Na$ 2, 8, 1	191 pm	98°C	.....
Potassium $_{19}K$ 2, 8, 8, 1	.....	64°C	774°C

Table (3) Properties of some alkali metals

Halogens	Atomic radius	Melting point	Boiling point
Chlorine $_{17}Cl$ 2, 8, 7	.....	–101°C	.....
Bromine $_{35}Br$ 2, 8, 18, 7	114 pm	– 7°C	59°C
Iodine $_{53}I$ 2, 8, 18, 18, 7	133 pm	114°C	184°C

Table (4) Properties of some halogens

② What happens to the atomic radii in the same group by increasing the atomic number ?

.....

.....

③ Compare between the graduation in the melting and the boiling points in both the alkali metals (Table 3) and the halogens (Table 4) as the atomic number increases.

.....

.....

④ Determine the physical state of elements (Tables 3 and 4) at room temperature (25°C) based on their melting and boiling points.

Element	Lithium	Sodium	Potassium	Chlorine	Bromine	Iodine
Physical state	.....	Solid	.....	.....	.....	.....

From the previous, it is concluded that :

- The atomic radii of elements in the same group increase as the atomic number increases.
- The melting and boiling points of alkali metals decrease as the atomic number increases.
- The melting and boiling points of halogens increase as the atomic number increases.

Cross-Cutting Concepts : Structure and function

The chemical properties of elements depend on the number of electrons in the last energy level of their atoms, while the difference, in the number of neutrons in their nuclei results in different physical properties.

Creative Thinking

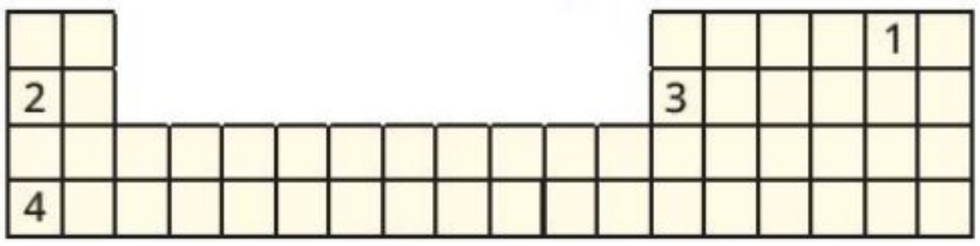
Design a 3D-model for the periodic table where each side of this model includes the elements of each block of the modern periodic table.

Evaluation Questions on Lesson Two

1 Complete the following statement :

The elements in the modern periodic table are arranged according to ..... and in Mendeleev's table according to .....

2 The following figure represents a section in the modern periodic table :



(1) Which two elements are in the same period ?

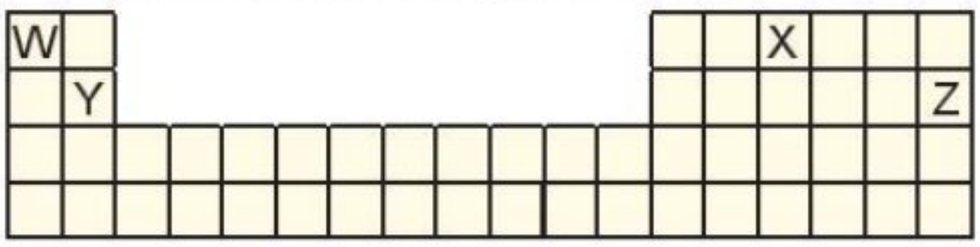
(2) Which two elements are in the same group ?

3 Choose the correct answer for questions (1) : (5).

(1) Which of the following choices represents the two metals lithium and potassium ?

Choices	Metal with higher melting point	More reactive metal with water
a	Lithium	Lithium
b	Lithium	Potassium
c	Potassium	Lithium
d	Potassium	Potassium

(2) The following figure represents a section in the periodic table :



Which of the following represents the correct electron configuration for the mentioned element ?

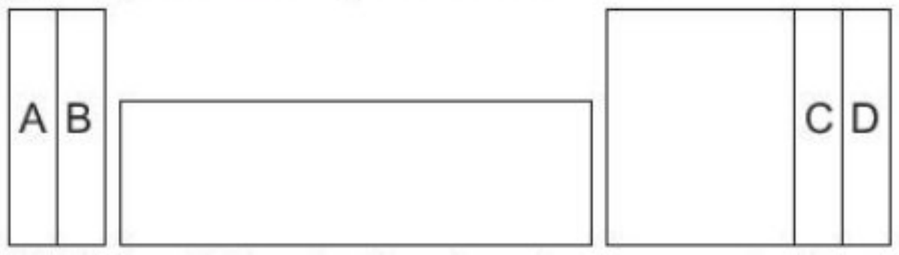
a Element (W) : 2 , 8 , 1

b Element (X) : 2 , 4

c Element (Y) : 2 , 8 , 2

d Element (Z) : 2 , 8

(3) The following figure illustrates some groups of the periodic table :



Which of the following is correct about the elements in these groups ?

a Group (A) : Monovalent nonmetals.

b Group (B) : Their atomic radii decrease with increasing the atomic number.

c Group (C) : The physical states of its elements are not the same.

d Group (D) : Octavalent nonmetals.

(4) Three cubes of materials (1), (2), (3) at room temperature, and the following table shows their melting and boiling points :

	Material (1)	Material (2)	Material (3)
Melting point	16°C	3°C	60°C
Boiling point	117°C	50°C	220°C

After raising the temperature of the three cubes to X°C, their physical states became as follows:

(1) (2) (3)

What is the temperature X°C ?

a 15°C b 45°C c 55°C d 75°C

(5) Two elements (X) and (Y), if element (X) is in period 2 of the periodic table and the number of the protons in the nucleus of element (Y) exceeds that in the nucleus of element (X) by 5, Which of the following is correct ?

a Elements (X) and (Y) are definitely in the same period.

b The number of electrons in the energy level K of both elements (X) and (Y) is equal.

c The number of electrons in the last energy level of element (Y) definitely exceeds that in element (X) by 5.

d The number of nucleons in the nucleus of element (Y) exceeds that in the nucleus of element (X) by 5.

Lesson **Three**

Matter and Its Properties

Lesson Terminology :

- Mixture.
- Homogeneous mixture.
- Heterogeneous mixture.
- Pure substance.
- Element.
- Compound.
- Molecule.
- Organic compound.
- Physical properties.
- Chemical properties.

Lesson Objectives :

By the end of the lesson, the student should be able to :

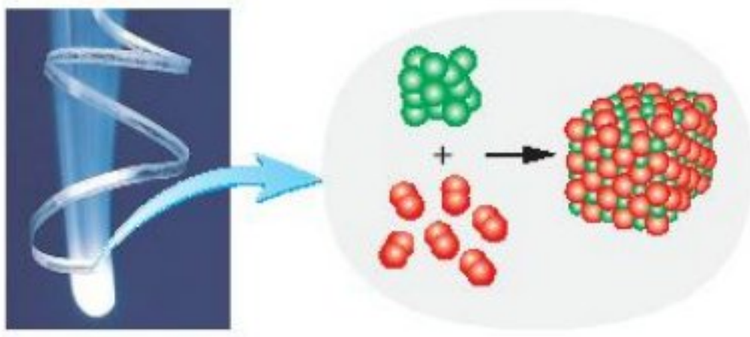
1. Analyze data showing that pure substance consists of one type of atoms or molecules.
2. Explain the difference between the molecules of elements and compounds.
3. Analyze data about the composition of different substances.
4. Explore that the number of the atoms that compose the molecules of compounds ranges between two atoms to several thousands.
5. Differentiate between substances based on their physical and chemical properties.
6. Predict the uses of materials based on their properties.

Included Skills, Values, and Issues :

- **Skills** : Research - Analysis - Interpretation - Conclusion.
- **Values** : Collaboration.
- **Issue** : Preservation of resources.

Lesson Preparation :

You have a strip of magnesium that ignites/burns by the oxygen of the air, glowing brightly and turning into a white powder.



This lesson explores ideas that help you answer these questions :

- What is the difference between the molecules of the reactants and the products ?
- Does the figure represent a physical or chemical change ?
- Can the components of the resulting compound be separated ?

Pure Substances and Mixtures

What is the difference between :

- A mixture of sand in water and a mixture of table salt in water? (Figure 1)
- Red mercury oxide and both mercury and oxygen? (Figure 2)

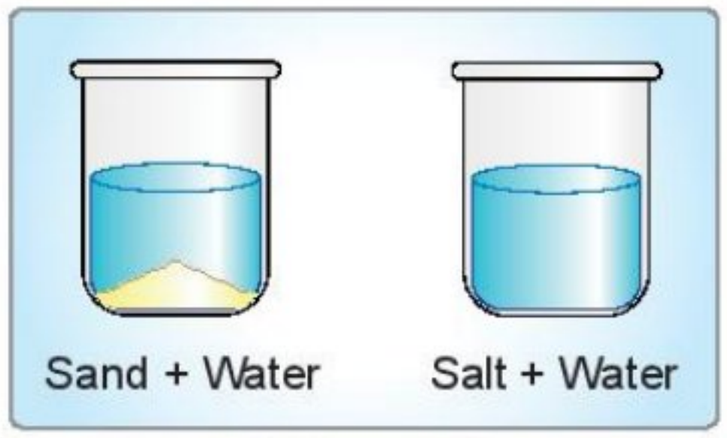


Figure (1)

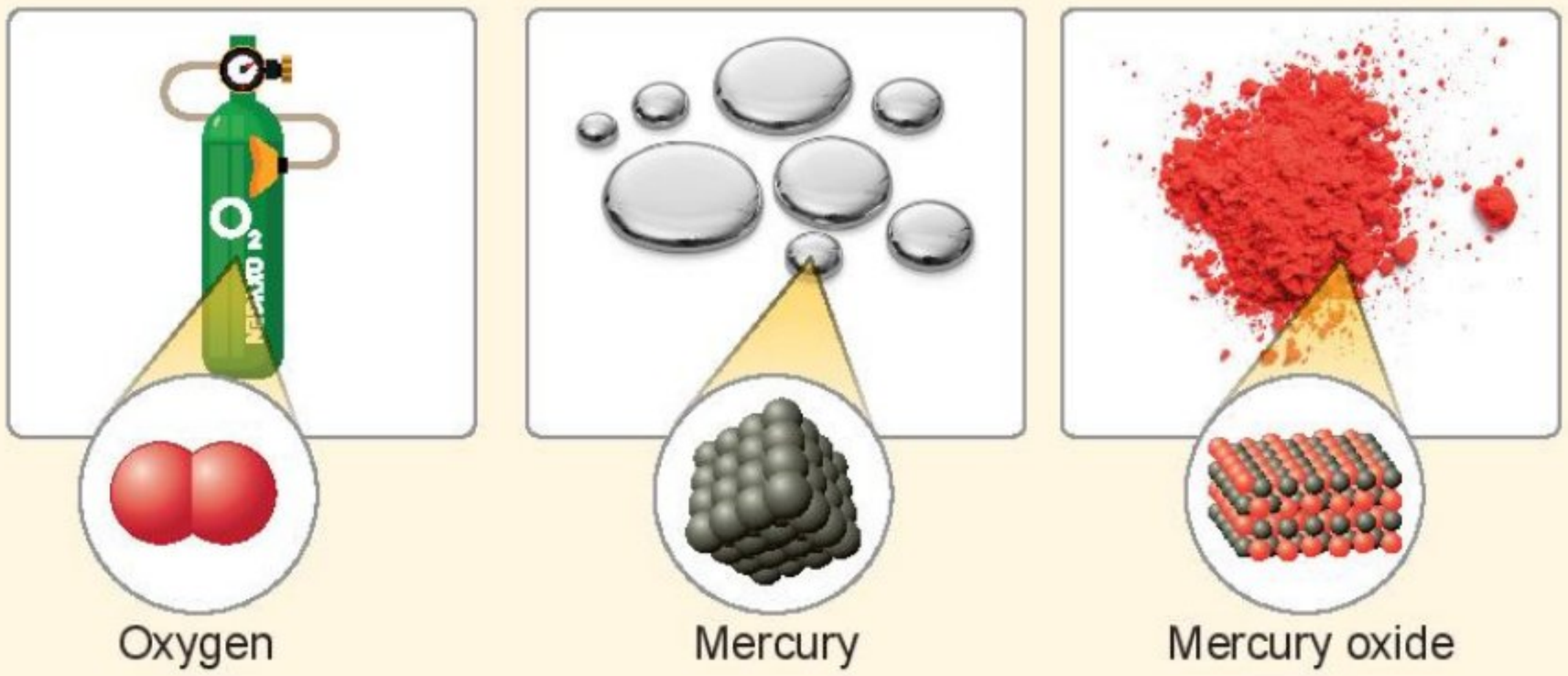


Figure (2)

- **Diagram (1) below shows the classification of some substances :**

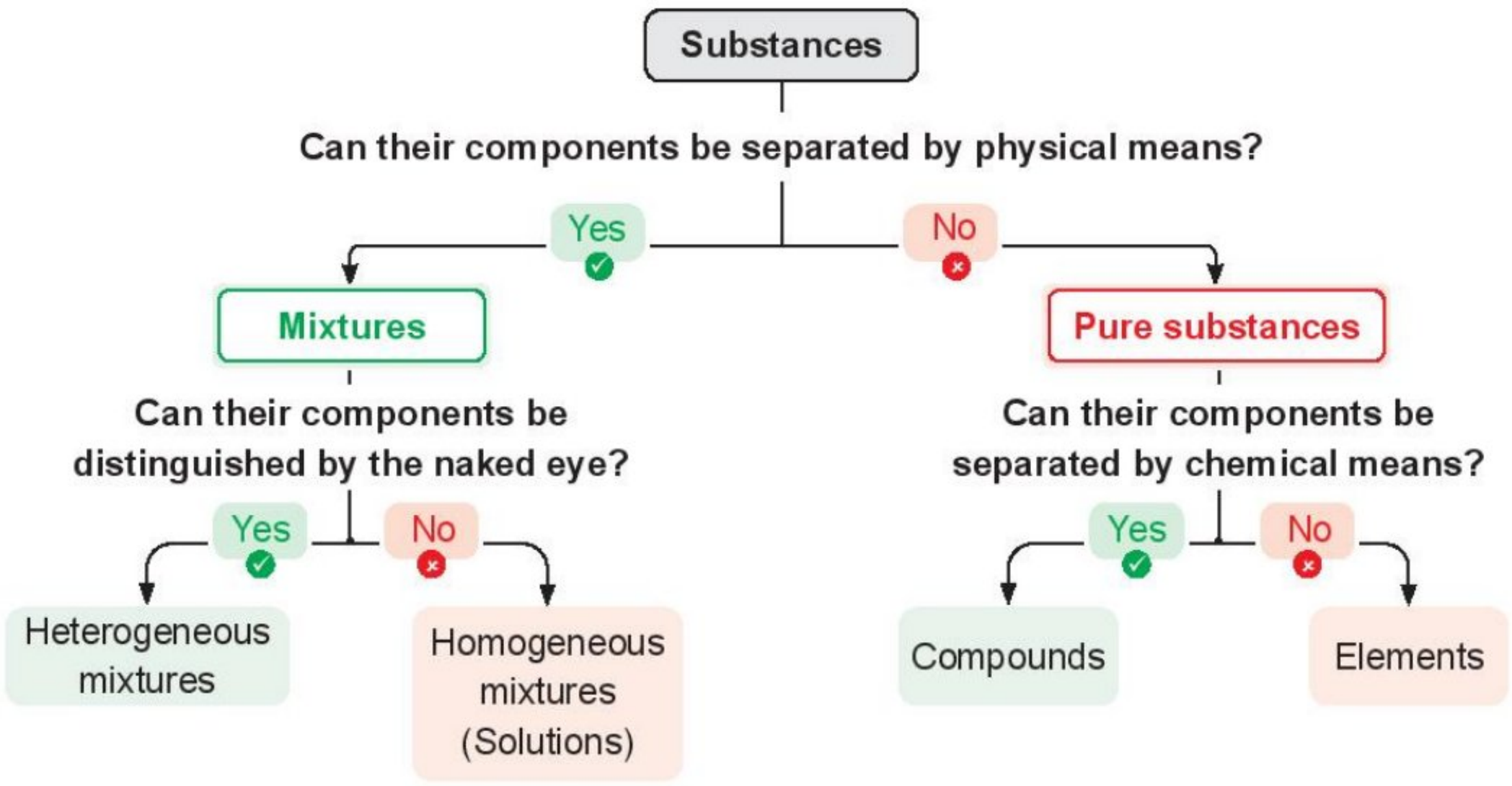


Diagram (1)

- **It is clear from Diagram (1) that :**

- **Mixtures** are substances composed of two or more materials that are not chemically combined. Their components can be separated by physical methods, such as filtration, magnetic separation, evaporation and condensation.
- As shown in Figure (1), the mixture of table salt in water is a homogeneous mixture, its components can be separated by evaporation and condensation, While the mixture of sand in water is a heterogeneous mixture, its components can be separated by filtration .
- Pure substances can be either compounds or elements.
  Compounds are substances formed by the chemical combination of two or more elements in fixed mass ratios, and their components can be separated by chemical methods. For example, mercury oxide (red colour) can be separated into its components (oxygen and mercury) by heating .
- Element, such as mercury and oxygen, is the simplest pure form of matter and cannot be dissociated into simpler forms, either by physical or chemical methods.

Evaluate Your Understanding

The Hoffman voltameter (Figure 3) is used to obtain hydrogen and oxygen gases by the electrolysis of water acidified with sulphuric acid :

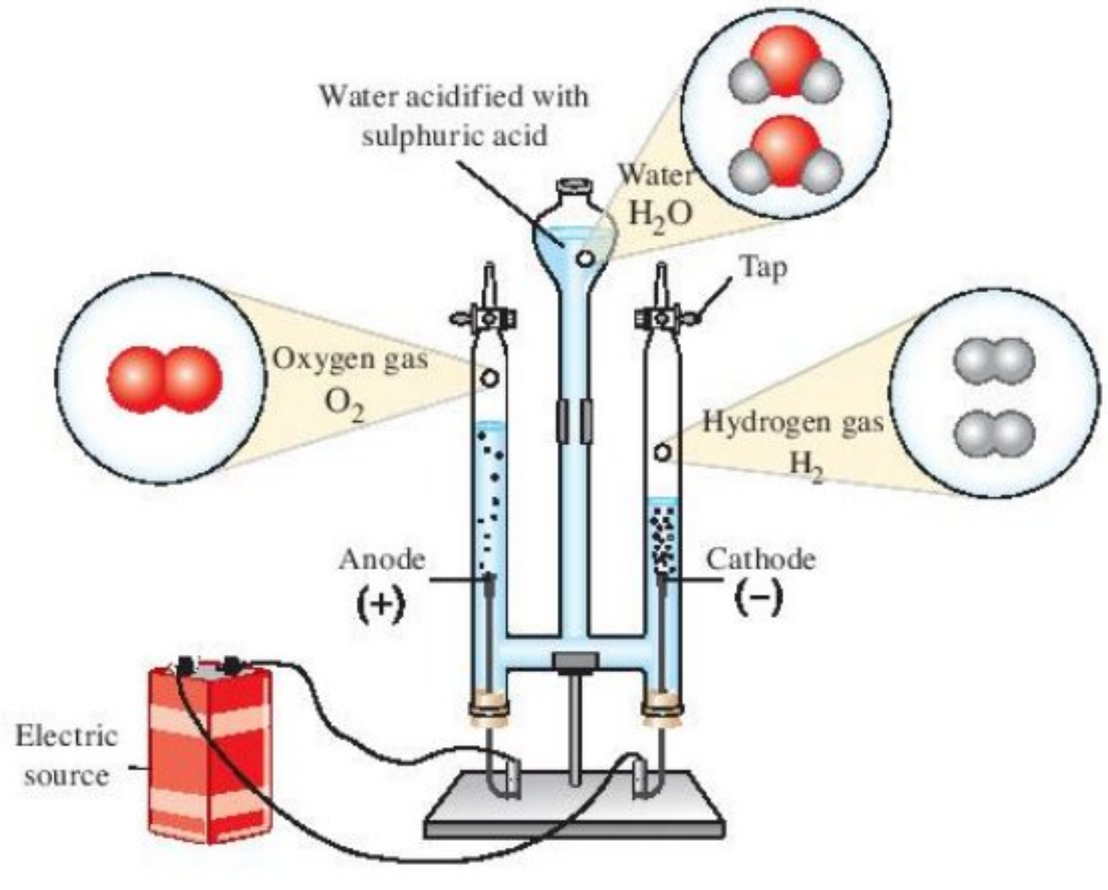


Figure (3) Electrolysis of water

(1) Why is hydrogen classified as an element ?

.....

(2) Why is water classified as a compound ?

.....

Activity 1 Analyze and Explain

First : Fill in the blanks in (Diagram 2) using the following terms :

Diatomic	Organic	Polyatomic	Molecules of compounds	Monatomic

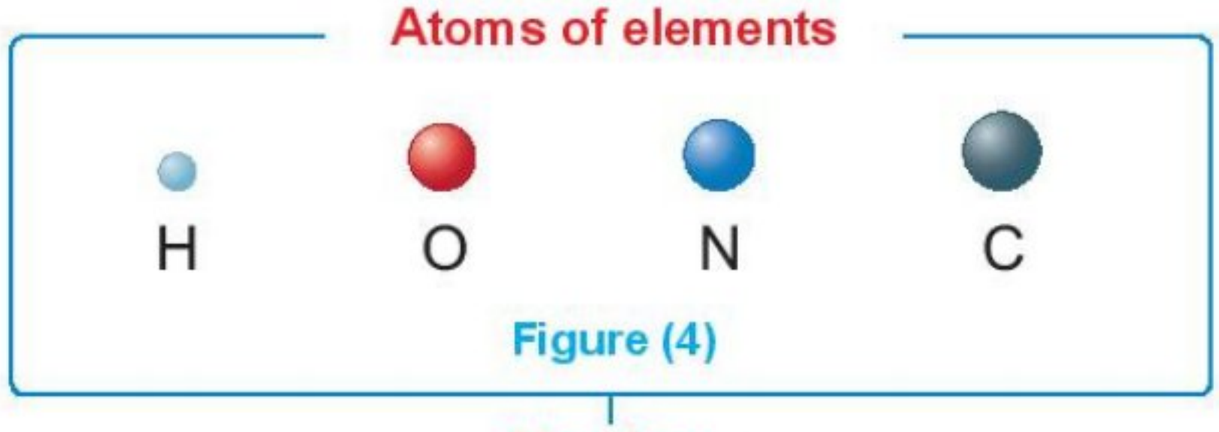


Figure (4)

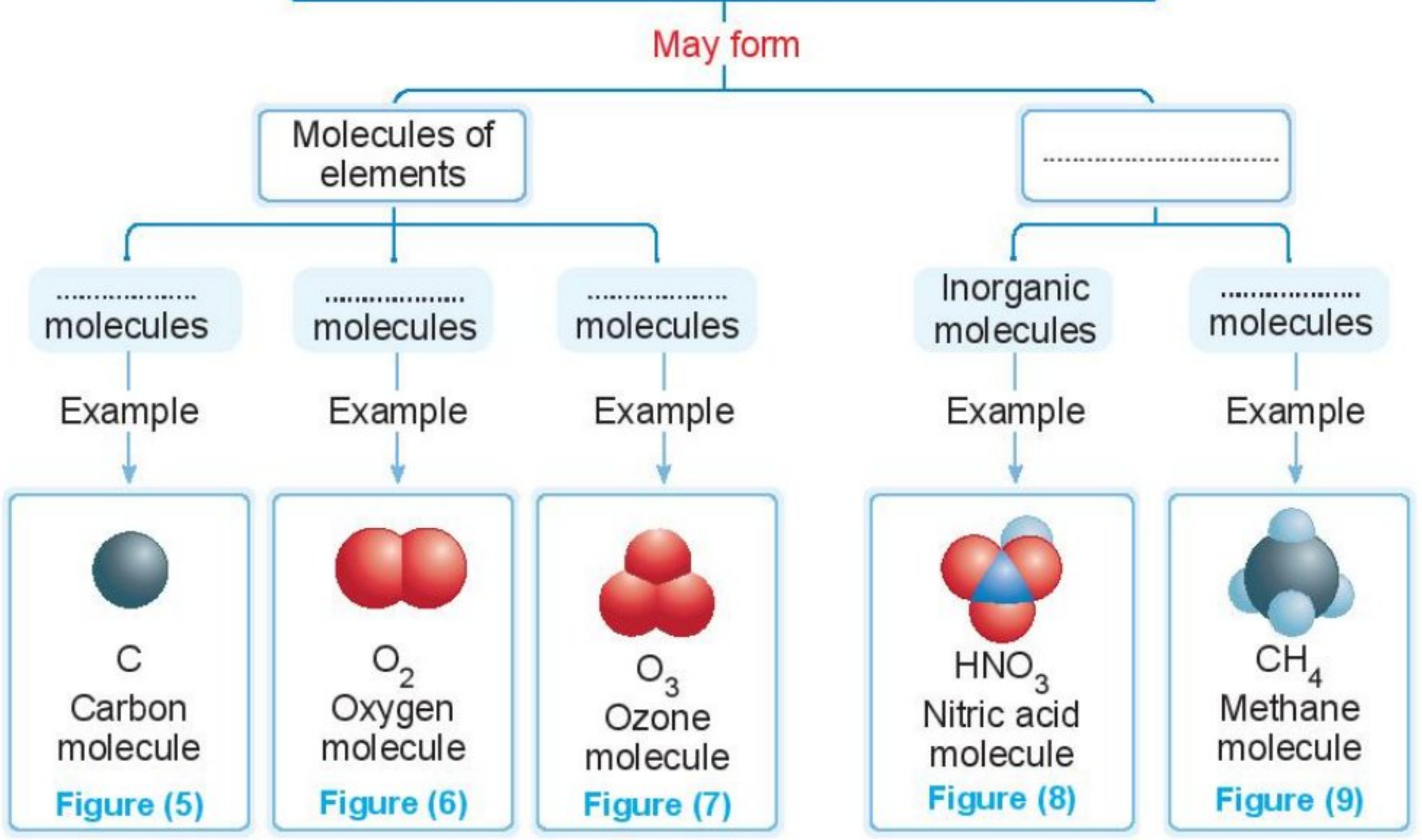


Diagram (2)

Second : Think as a scientist by answering the following questions using (Diagram 2) :

1. Identify the molecules composed of one type of atoms.

   .....

2. What is the difference between oxygen molecule and ozone molecule ?

   .....

- A chemical compound is represented by an abbreviated (shortened) formula known as the molecular formula, which is a symbolic formula that expresses the type and number of atoms of the elements that form the molecule such as HNO_3 , CH_4
  The number of atoms in a single molecule of some organic compounds can reach several thousands, as in plastic polymers, hemoglobin in blood and vitamin (D) that regulates calcium and phosphorus levels in the blood to prevent osteoporosis.

Organic compounds, also known as carbon compounds, are characterized by the presence of carbon element, that are bonded mainly to hydrogen atoms, as in Figure (10).
They may also be bonded to other atoms such as oxygen and nitrogen.

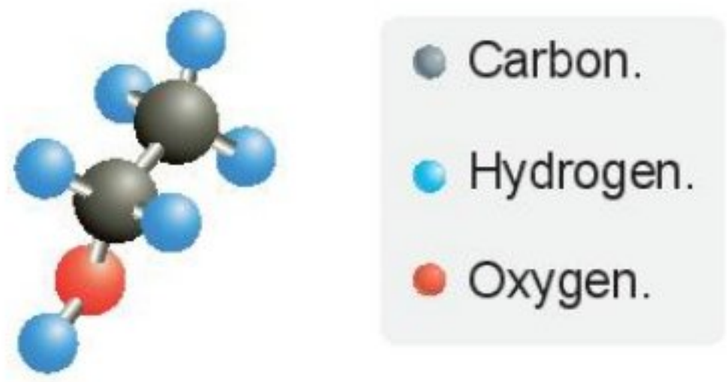


Figure (10)
Organic compound molecule

Evaluate Your Understanding

State, with explanation, what the Figures (11 , 12) represent, using the following concepts :

Molecules | Mixture | Elements

- Figure (11) : .....
- Figure (12) : .....

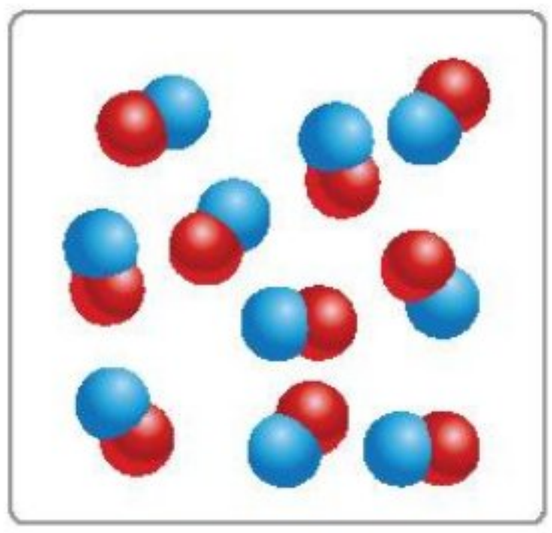


Figure (11)

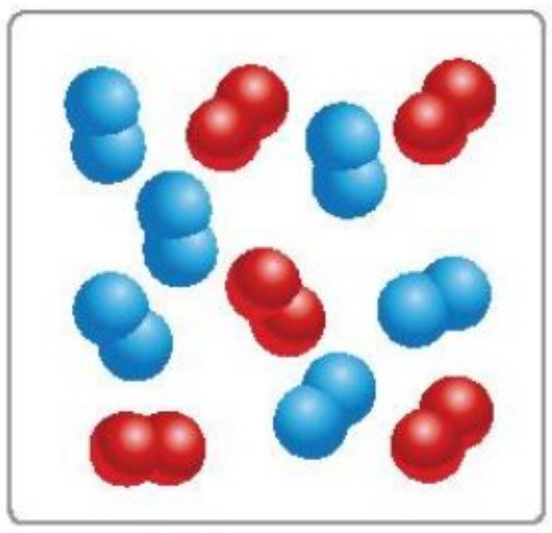


Figure (12)

Life Application

The Egyptian blue dye is a chemical compound. Its molecule is composed of the elements shown in Table (1)
The Ancient Egyptians used Egyptian blue dye (Figure 13) for coloring papyri (Figure 14) and statues.
It is still used up till now to color the facades of houses in Nubian villages, that form a major tourism destination for both domestic and international tourism.

Element	Number of its atoms
Ca	1
Cu	1
S	14
O	10

Table (1)
Components of the Egyptian blue dye molecule

Figure (13)
Egyptian blue dye

Figure (14)
Ancient Egyptian papyrus

Distinguishing Substances by Their Properties

Physical properties of substances can be observed and measured in some cases, while their chemical properties only appear when a chemical reaction occurs, leading to a change in the form and the composition of the substance.

Activity 2 Distinguish

Identify the property used to distinguish between each pair of substances by filling in the blank with the letter P if the property is physical, or C if the property is chemical.

Figure (15)

The difference in viscosity between water and honey is a ..... property

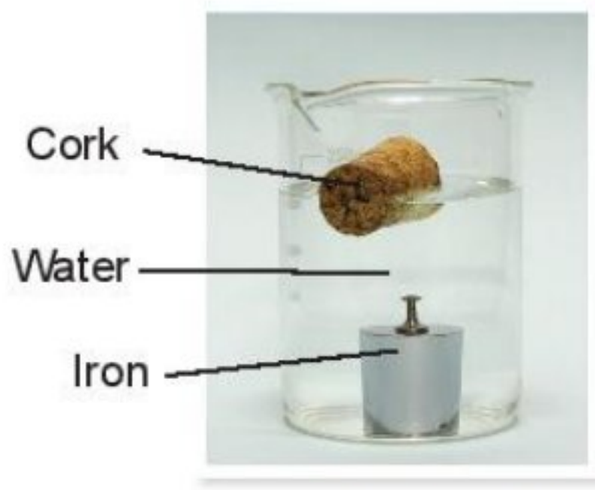


Figure (16)

The difference in density between cork and iron is a ..... property

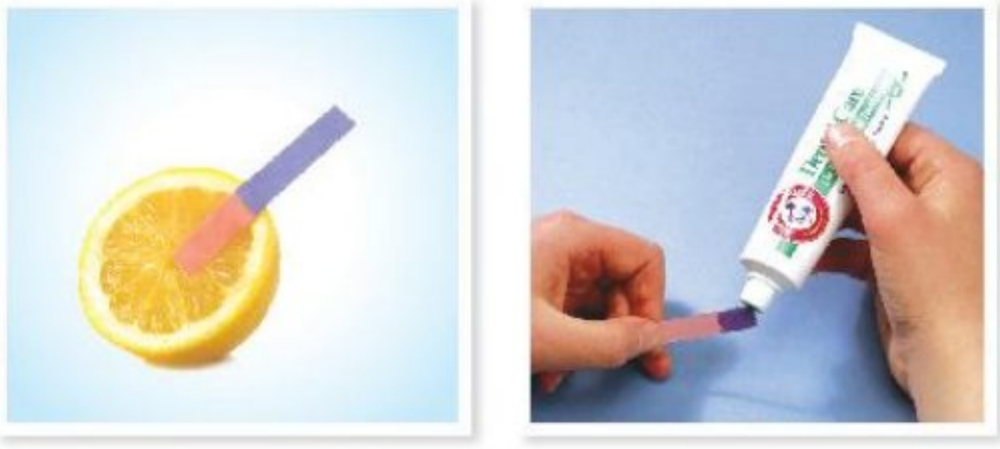


Figure (17)

The difference in the color of a litmus paper in lemon juice from its color in toothpaste is a ..... property

Figure (18)

The difference in the effect of heat on a block of butter and an aerogel sheet is a ..... property

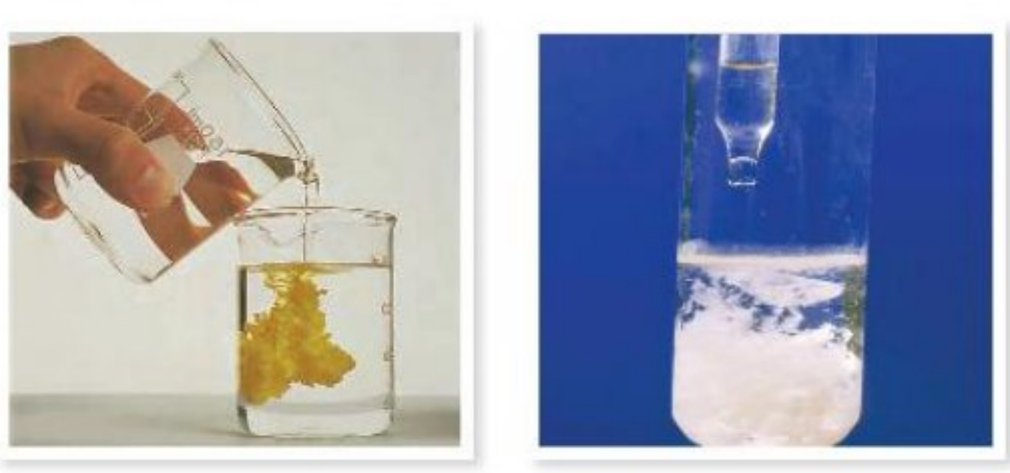


Figure (19)

The difference in the color of the solid precipitate formed by adding a single reagent to two different solutions is a ..... property

Uses of Substances Based on Their Properties

Activity 3 Conclude

According to the properties of the following substances, conclude the appropriate use for four of them by filling in the blanks under Figures (20) : (23).

- **Helium :** An inert gas, less dense than air, and non-flammable.
- **Nitrogen :** A nonmetal gas that is not affected by temperature changes and does not react with rubber.
- **Silicon :** A metalloid that conducts electricity poorer than metals but better than nonmetals.
- **Stainless steel alloy :** Made from iron with added elements, it is resistant to rusting, unlike iron.
- **Aluminum-Titanium alloy :** Lighter than aluminum and retains its strength at high temperatures.

Figure (20)

..... is used in filling car tires instead of air

Figure (21)

..... is used in the construction of military aircraft frames/structure

Figure (22)

..... is used in manufacturing cooking utensils

Figure (23)

..... is used in filling balloons

Technological Application

Aerogel (Figure 24) is a transparent, low-density solid material, where 99.8% of its composition is of air only, so aerogel is the lightest known solid material, with high durability. It has excellent insulating properties, so it is used in making the jackets of the researchers in Antarctica as a substitute for polar bear fur to protect its species from extinction.

Figure (24)

Information and Communication Technology

Watch educational videos that demonstrate the properties and uses of aerogel using reliable digital sources.

Evaluation Questions on Lesson Three

1 Mark (✓) or (×), with correction :

(1) Stirring both table salt and sand in water gives a homogeneous mixture . ( )

(2) NaBr compound is formed by the combination of two metals in a fixed mass ratio. ( )

(3) The melting of ice is a chemical change. ( )

(4) Water in some rivers is covered with ice in winter season, and this means that ice density is greater than water density. ( )

2 Choose the correct answer for questions (1) : (3).

(1) Which of the following describes the properties of copper metal ?

Choices	Melting point	Sinking in water	Conducting electricity
(a)	–40°C	×	✓
(b)	8°C	×	✓
(c)	100°C	✓	×
(d)	1083°C	✓	✓

(2) All the following are physical properties of a piece of calcium carbonate, except that it .....

(a) is solid.

(b) does not dissolve in water.

(c) is white in color.

(d) produces gas bubbles with vinegar.

(3) The following table shows samples of different substances :

Sample	Shiny	Flexible	Conducts electricity
(1)	×	×	✓
(2)	✓	×	×
(3)	×	✓	×
(4)	✓	✓	✓

Which sample its substance can be used in making water hose?

(a) Sample (1). (b) Sample (2).

(c) Sample (3). (d) Sample (4).

3 Classify the following materials into two groups, elements and compounds:

Al	CO_2	N_2	H_2SO_4
SiO_2	Cu	NH_3	O_3

4 Mention one difference between each of the following :

(1) Hydrogen molecule **and** water molecule.

(2) Oxygen molecule **and** ozone molecule.

5 Mention one use of aerogel according to its high ability of insulation.

6 Design a table showing the number of elements and the number of atoms composing one molecule of each of the following :

(1) Nitric oxide NO

(2) Magnesium carbonate $MgCO_3$

(3) Ethanol C_2H_5OH

7 When a white powder in a test tube is heated, nitrogen dioxide gas and oxygen gas evolve and a red substance remains in the tube :

(1) Is the white powder an element or a compound ? Explain.

(2) What are the elements that are certainly found in the white powder ?

(3) Heating the red substance leads to the formation of mercury and oxygen. What are the elements that compose the white powder ?

Lesson **Four**

Chemical Bonds

Lesson Terminology :

- Chemical bonding.
- Ionic bonding.
- Covalent bonding.
- Ionic compound.
- Covalent compound.
- Single bond.
- Double bond.
- Triple bond.

Included Skills, Values, and Issues :

- **Skills** : Inquiry - Conclusion.
- **Values:** Collaboration.
- **Issue** : Protecting the environment from pollution.

Cross-Cutting Concepts :

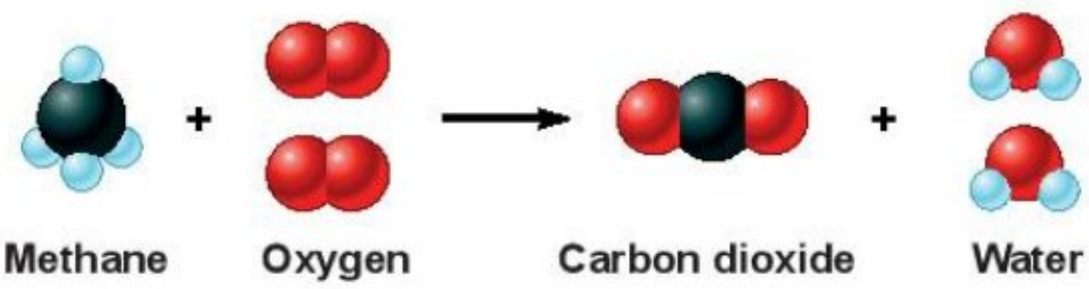
- Cause and effect.

Lesson Objectives :

By the end of the lesson, the student should be able to :

1. Differentiate between ionic and covalent bonding.
2. Express covalent bonding with single valence electrons.
3. Relate the atomic structure of carbon to its distinctive properties in forming organic materials.
4. Explain the bonding in a methane molecule as the simplest organic compound.

Lesson Preparation :



The figure in above shows the reaction of methane with oxygen to form carbon dioxide and water vapor.

This lesson explores ideas that help you to answer these questions :

- What is the similarity between methane molecule and water vapor molecule ?
- What is the overall charge of the compound ?
- How do atoms bond to each other in each of oxygen and methane molecules ?

Chemical Bonding

The molecules of substances around us differ in the type, number of atoms, and how they are bonded together. (Table 1) shows some properties of sodium chloride (NaCl) and hydrogen chloride (HCl).

Think : Why do the properties of the two compounds differ from each other despite both containing chlorine ?

Compound	Sodium chloride	Hydrogen chloride
Physical state	Solid	Gas
Ability to react with caustic soda solution	Doesn't react	Reacts

Table (1)

The difference in how atoms are bonded leads to differences in the physical and chemical properties of the resulting compounds' molecules.

Types of chemical bonding include : Ionic bonding and covalent bonding.

Ionic Bonding

Atoms become positive or negative ions by losing or gaining electrons to reach the stable electronic configuration of the nearest noble gas in atomic number on the periodic table.

Activity 1 Discover

(Table 2) shows the electronic configuration of four elements' atoms:

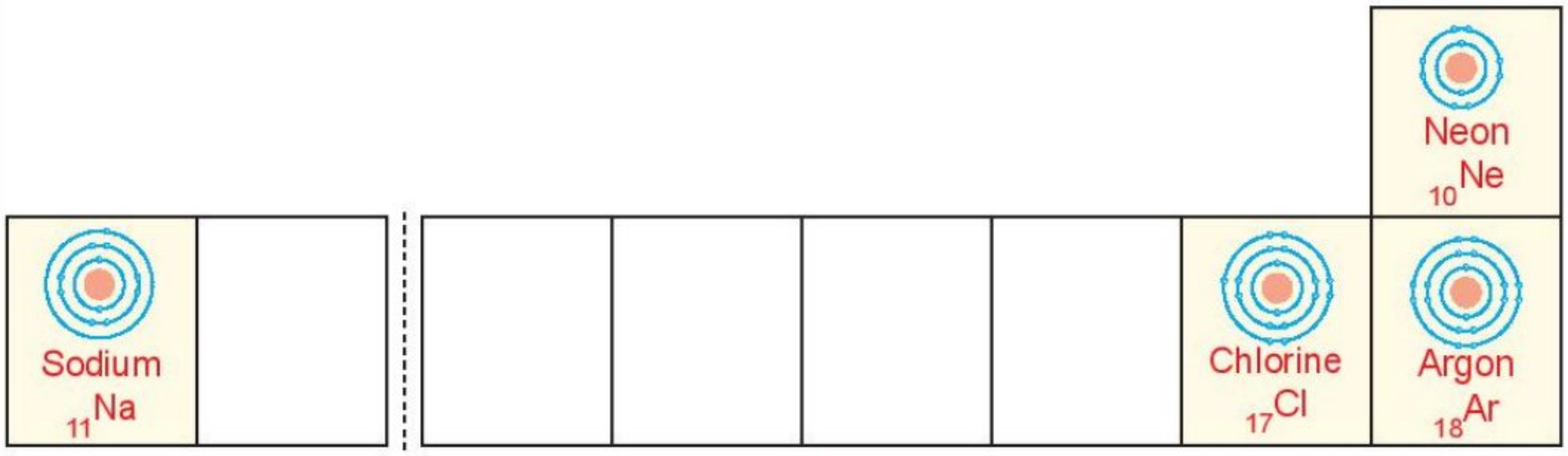


Table (2)

1. **Explain : The stability of the atoms of a noble gas according to their electron configuration.**

.....

2. **What is the nearest noble gas to each of sodium and chlorine ?**
   - Sodium : .....
   - Chlorine : .....

3. **Fill in blanks in (Tables 3 and 4) :**

	Sodium atom	Sodium ion
Number of protons	.....	.....
Number of electrons	.....	.....
Electric charge	.....	.....

Table (3)

	Chlorine atom	Chloride ion
Number of protons	.....	.....
Number of electrons	.....	.....
Electric charge	.....	.....

Table (4)

4 **What is the change that occurs in each of sodium atom to form sodium ion, and chlorine atom to form chloride ion ?**

- Sodium : .....
- Chlorine : .....

5 **Conclude the definitions of positive and negative ions.**

- Positive ion : .....
- Negative ion: .....

6 **What happens when a positive ion approaches a negative ion ?**

.....

The ionic bonding in a sodium chloride molecule is represented as follows:

Figure (1)

Ionic bonding using Lewis dot structures

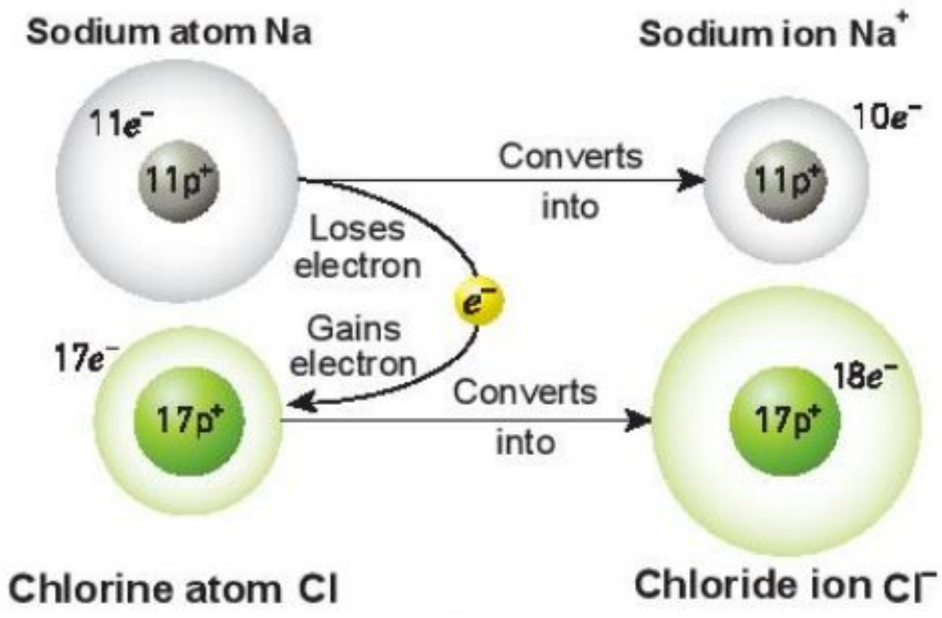


Figure (2)

Ionic bonding in sodium chloride molecule

Cross-Cutting Concepts : Cause and Effect

- When most metals react with nonmetals, the metal atom (M) tends to lose its valence electrons, forming a positive ion (cation) with a number of positive charges equal to the number of the lost electrons. The nonmetal atom (X) gains one or more electrons according to its valence, forming a negative ion (anion) with a number of negative charges equal to the number of the gained electrons.
- The electron configuration of each of the cation and the anion is similar to that of the nearest noble gas.
- The electrostatic attraction between the cation and the anion is called an ionic bond, and the compound formed by them is called an ionic compound. The compound is electrically neutral due to the equal number of positive and negative charges.

Evaluate Your Understanding

Figure (3) illustrates the formation of an ionic bond between the metal A from the alkaline earth metals group and the nonmetal B from group (6A).

(1) **Determine the Charges number of each of the cation and the anion.**

Cation charge : .....

Anion charge : .....

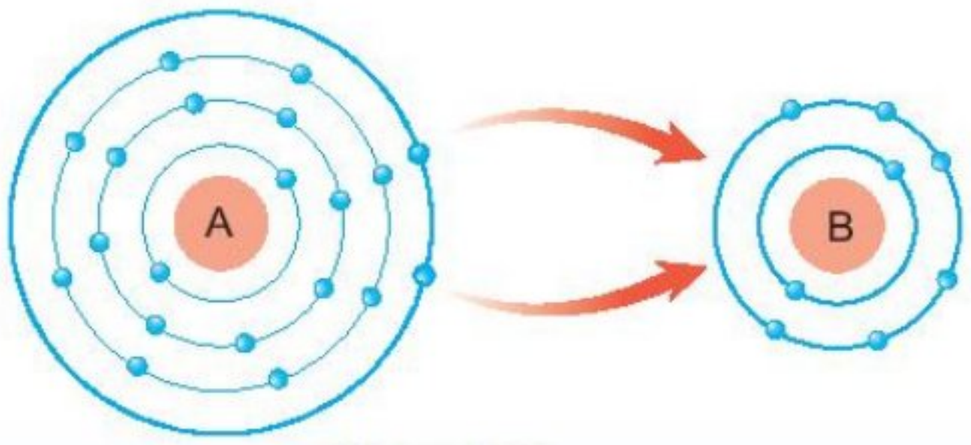


Figure (3)

(2) **What is the molecular formula of the resulting ionic compound ?**

.....

Covalent Bonding

If chlorine is bonded to sodium with an ionic bond, so why doesn't it bind to hydrogen in the same way ?

Figure (4) shows that hydrogen atom needs one electron to reach the same electron configuration as helium, and chlorine atom also needs one electron to reach the same electronic configuration as argon. How can this be achieved?

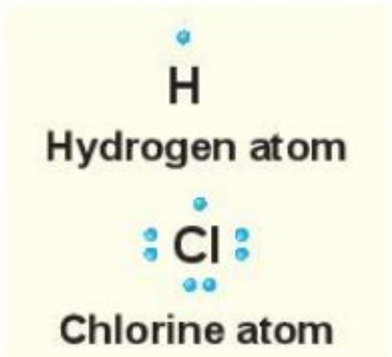


Figure (4)
Lewis structures of hydrogen and chlorine atoms

- Each atom shares a single valence electron to form together a single covalent bond, and the pair of electrons which forms the bond rotates around the two atoms in the covalent compound molecule of hydrogen chloride (HCl).

The covalent bond in hydrogen chloride molecule is represented in (Figure 5), where the dash (–) between the two atoms represents the single covalent bond in the molecule.

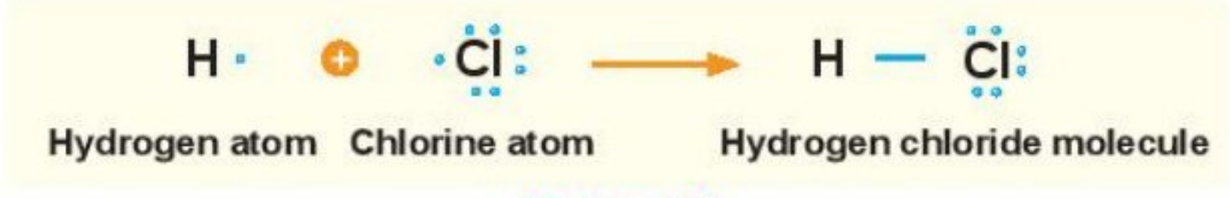


Figure (5)
The formation of covalent bond in hydrogen chloride molecule

Activity 2 Conclude

Illustrate by drawing the bond formation in the following molecules using Lewis dot structures :

- Hydrogen molecule : H • + ... ⟶ .....
- Oxygen molecule : ..... + ... ⟶ O = O
- Nitrogen molecule : ..... + • N • ⟶ .....

It is clear from the previous that covalent bonds are formed between two atoms of the same nonmetal element or between atoms of two different nonmetal elements, and the covalent bond may be single (–), double (=), or triple (≡) bond.

Evaluate Your Understanding

Use dots (•) and dashes (–) to represent valence electrons and covalent bonds in water molecule H_2O as shown in (Figure 6) using Lewis dot structure:

H + O + H ⟶ H O H

Figure (6)

Properties of Ionic and Covalent Compounds

Most ionic compounds dissolve in water; both their aqueous solutions and their moltens conduct electricity; their melting and boiling points are high.
On the other hand, most covalent compounds do not dissolve in water and mostly do not conduct electricity, and they have low melting and boiling points.

Unique properties of carbon as the main element in organic compounds

The outermost energy level of carbon atom contains 4 single electrons, and carbon atoms have very unique properties because of their ability to bind to each other in organic compounds in the form of straight chains (Figure 7), branched chains (Figure 8) or cyclic structures (cycles or rings) (Figure 9).

Figure (7)
Straight chain

Figure (8)
Branched chain

Figure (9)
Cyclic structure

Methane CH_4 (Figure 10) is the simplest organic molecule, in which a carbon atom binds to four hydrogen atoms through single covalent bonds. .

► Represent the covalent bonding in methane molecule using Lewis structure.

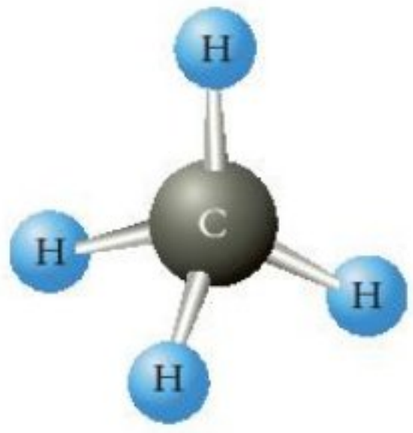


Figure (10)
Structure of methane molecule CH_4

Information and Communication Technology

You can design images of molecular shapes using modelling software like **Chemsketch chem draw**.

Evaluation Questions on Lesson four

1 Choose the correct answer for the questions (1) : (3).

(1) Which of the following represents an ionic bonding ?

ⓐ $[\cdot\dot{K}\cdot]^{+}[\ F\ ]^{-}$ ⓑ $H\cdot\cdot\dot{O}\cdot\cdot H$

ⓒ $[\ Li\ ]^{+}[\cdot\dot{Br}\cdot]^{-}$ ⓓ $\dot{O}::C::\dot{O}$

(2) What is the molecular formula of the compound formed through the bonding of an alkali metal A with an element B from group 6A ?

ⓐ A_2B_2 ⓑ A_2B ⓒ AB_2 ⓓ AB

(3) An atom of element X binds to two hydrogen atoms as shown in the following figure:

$H\cdot\cdot\dot{X}\cdot\cdot H$

What is the type of bonding in this molecule? And what is the group number of element X in the periodic table?

ⓐ Ionic / Group 6A

ⓑ Ionic / Group 2A

ⓒ Covalent / Group 6A

ⓓ Covalent / Group 2A

2 Water and methane are two well known compounds:

(1) Which of them is an organic compound ?

(2) Explain how the atoms bind together in the inorganic compound molecule using Lewis structure.

3 The following table shows the electron configuration of the atoms of 4 elements :

(A)	(B)	(C)	(D)
2, 2	2, 8, 8	2, 8, 1	2, 8, 7

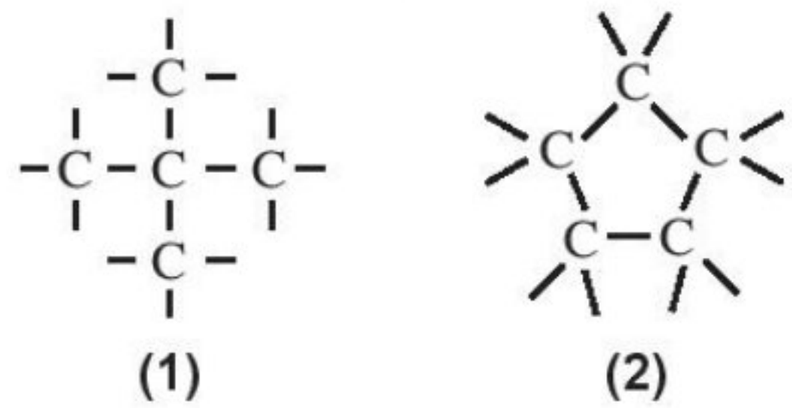
(1) Which element its molecule is diatomic ?

(2) Write the molecular formulas of the compounds, which can be formed from these elements.

4 Complete the following table with the suitable ion charges and their atomic components:

Number of \ Ion	$^{37}R^{-}$	..... X	..... Y	..... Z .....
Protons	17	11	.....	20
Neutrons	.....	12	10	.....
Electrons	.....	10	10	18
Nucleons	.....	.....	19	40

5 The following figures show the carbon structure of two organic compounds:



(1) (2)

What is the form of the carbon structure in each compound?

6 Among the elements in the periodic table are :

- $_{7}N$
- $_{12}Mg$
- $_{13}Al$
- $_{16}S$
- $_{15}P$
- $_{19}K$

(1) What are the two elements which can combine together to form a compound whose molecule is diatomic ?

(2) Conclude the relation between the number of electrons in the outermost energy level in the atoms of these elements and their type.

7 Compare in a table between:

Properties of covalent compounds **and** ionic compounds. **"Only two points are enough"**