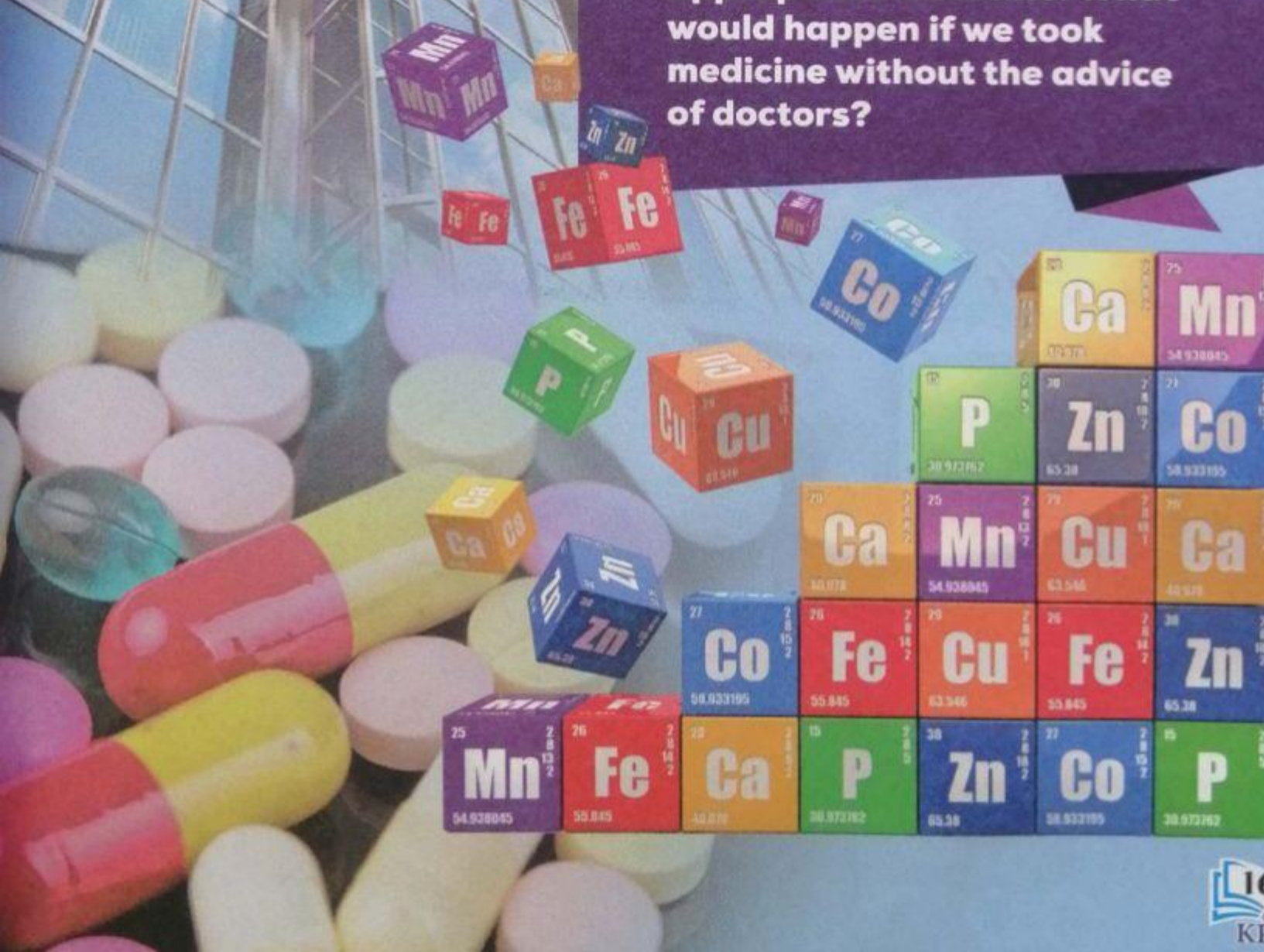
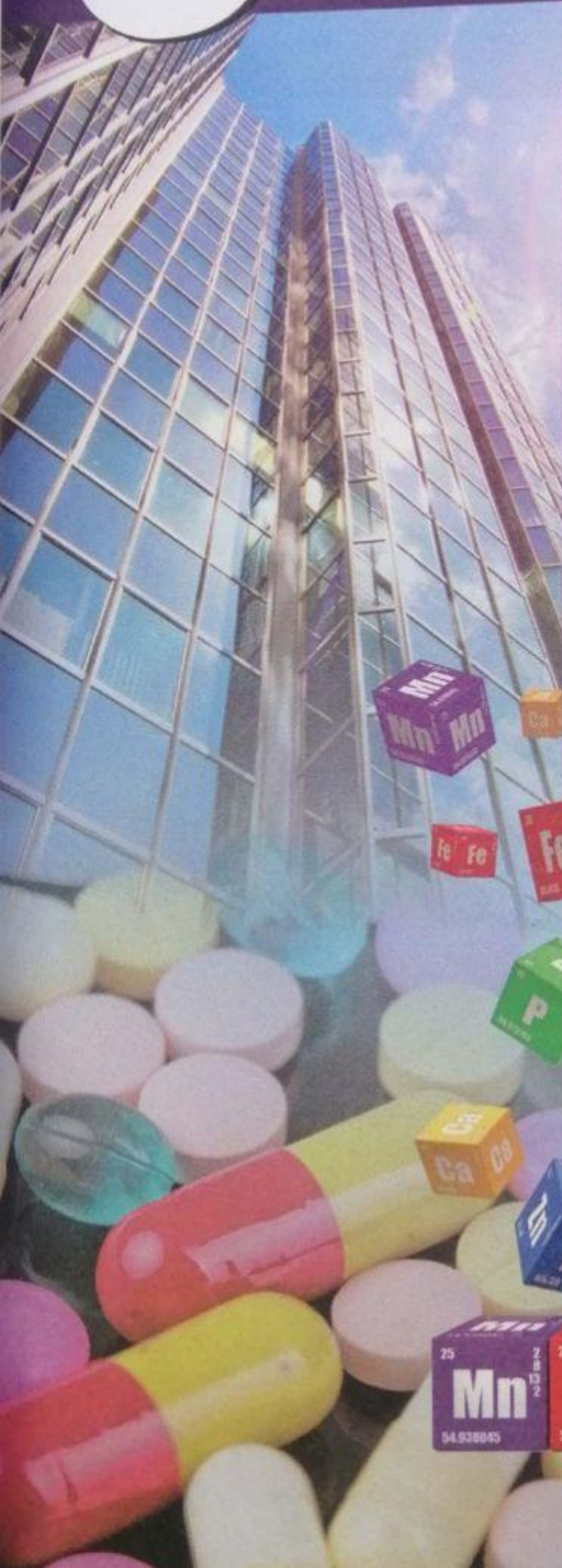


# 3 Exploration of Elements in Nature

- There are 118 elements that have been discovered. Do you know the position of carbon in the Modern Periodic Table of Elements?
- The windows of skyscrapers in Malaysia are usually made of glass. What are the other uses of glass?
- If you were sick, the doctor would treat and give you the appropriate medicine. What would happen if we took medicine without the advice of doctors?



25 Mn 54.938045	26 Fe 55.845	28 Ca 40.078	15 P 30.973762	38 Zn 65.38	27 Co 58.933195	16 S 32.06
20 Ca 40.078	25 Mn 54.938045	29 Cu 63.546	28 Ni 58.6934	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934
20 Ca 40.078	25 Mn 54.938045	29 Cu 63.546	28 Ni 58.6934	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934
20 Ca 40.078	25 Mn 54.938045	29 Cu 63.546	28 Ni 58.6934	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934
20 Ca 40.078	25 Mn 54.938045	29 Cu 63.546	28 Ni 58.6934	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934
20 Ca 40.078	25 Mn 54.938045	29 Cu 63.546	28 Ni 58.6934	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934
20 Ca 40.078	25 Mn 54.938045	29 Cu 63.546	28 Ni 58.6934	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934
20 Ca 40.078	25 Mn 54.938045	29 Cu 63.546	28 Ni 58.6934	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934
20 Ca 40.078	25 Mn 54.938045	29 Cu 63.546	28 Ni 58.6934	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934
20 Ca 40.078	25 Mn 54.938045	29 Cu 63.546	28 Ni 58.6934	26 Fe 55.845	27 Co 58.933195	28 Ni 58.6934

# 8

## Elements and Substances

### Keywords

- ◆ Atomic substances
- ◆ Molecular substances
- ◆ Ionic substances
- ◆ Modern Periodic Table of Elements
- ◆ Positive ions
- ◆ Negative ions
- ◆ Isotopes



What type of particles are found in gold?

How are the elements arranged in the Modern Periodic Table of Elements?

How are the positive and negative ions formed from atoms?

What is an isotope?



## Science Digest

### Elements in the Universe and Earth

Hydrogen and helium are the most abundant elements in the Universe. The stars including the Sun consist of hydrogen and helium. On Earth, there are elements such as oxygen, silicon and gold. Oxygen allows all living things to exist on Earth.

### You will learn about:

- matter
- Modern Periodic Table of Elements
- isotope

## 8.1 Matter

### Atomic Substances, Molecular Substances and Ionic Substances

You learned that matter consists of tiny and discrete particles in Form 1. Matter is formed by three types of particles namely **atoms**, **molecules** or **ions**.

#### Atom

The atom is the smallest particle of an element. It is the most basic unit in an element.

#### Molecule

A molecule consists of two or more atoms which are chemically combined. Molecules can be the combination of the same or different types of atoms.

#### Ion

An ion is a charged particle, either positively-charged or negatively-charged. An ion is formed when an atom loses or gains electrons.

All the substances around us are matter. The substances can be classified into three groups based on the type of particles they contain.

### Atomic Substances

These substances contain only atoms. All metals and inert gases are made up of atoms. Atoms in metals are arranged in a neat and orderly manner, while atoms in inert gases are spread far apart with no regular arrangement.

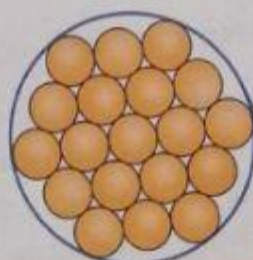


#### Flashback

An atom consists of subatomic particles, which are protons, neutrons and electrons.



- Electron
- Proton
- Neutron



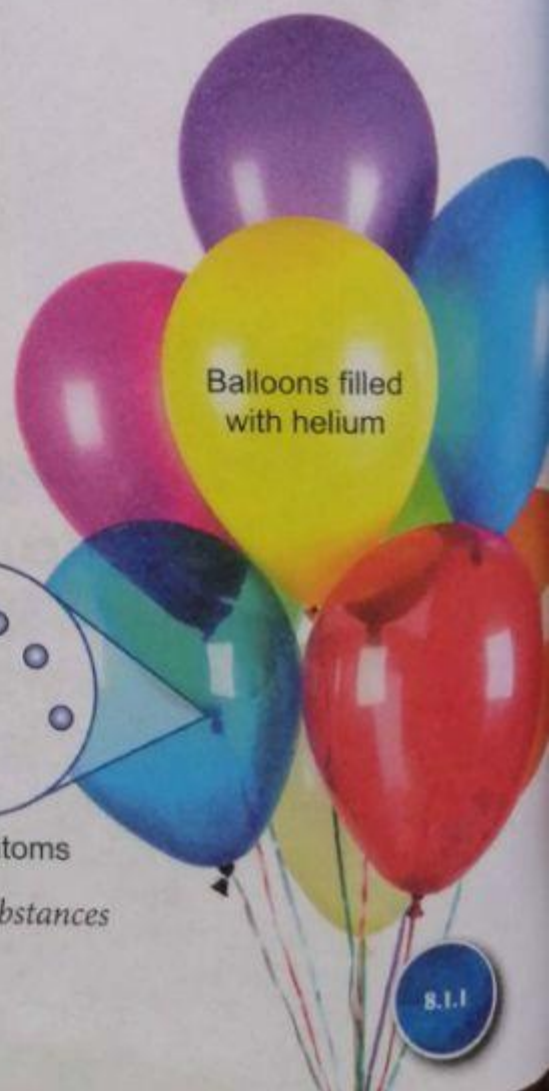
Gold atoms



Gold metal



Helium atoms

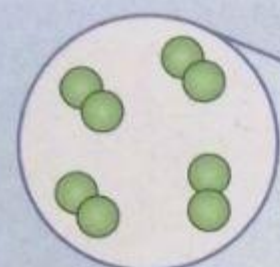


Balloons filled with helium

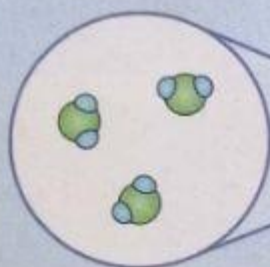
Figure 8.1 Atomic substances

## Molecular Substances

These substances contain molecules made up of two or more atoms that combined chemically. The atoms can either be the same or different. Most of the non-metal substances exists in the form of molecules. The reaction between the non-metallic elements forms a compound which exists in the form of molecules.



Oxygen molecules



Water molecules

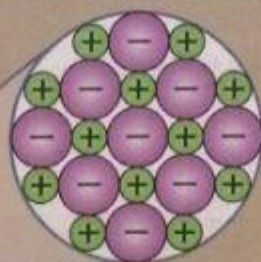


Figure 8.2 Molecular substances

## Ionic Substances



Common salt



Sodium ions and chloride ions

The ionic substances are formed by the reaction between the metal elements and non-metal elements. These substances contain positive ions and negative ions. An example of ionic substance is sodium chloride.

Figure 8.3 Ionic substances

### Activity 8.1

Result Showcase

**Aim:** To create a multimedia presentation on materials that are made of atoms, molecules and ions in daily life.

**Instructions:**

1. Gather information from various sources on the materials around you that are made up of atoms, molecules and ions.
2. Present the information gathered in the form of multimedia presentation.

21<sup>st</sup> Century Skills

## Existence of Elements in Various Forms

Do you still remember the elements in the Modern Periodic Table of Elements that you studied in Form 1? Elements can exist in the form of atoms, molecules or ions. Can the same elements exist in different forms? Take a look at the photograph below.

### Element: Iron



Photograph 8.1 Rusty hammer and non-rusty hammer

### Element: Hydrogen



Photograph 8.2 Lime juice and air



## FORMATIVE PRACTICE

### 8.1

1. Give three types of particles that make up a substance.
2. State an example of a substance that is made up of iron in the form of ions.
3. Classify the following substances according to the type of particles that they are made up of either atoms, molecules or ions.

Iron sheets, ice cubes, common salt, sugar cubes, marbles, copper wire, limewater, oxygen gas, helium gas

4. Give two examples of elements that exist in the form of molecules and atoms.

## 8.2 Modern Periodic Table of Elements

In Form 1, you learned about 118 types of elements listed in the Modern Periodic Table of Elements. Now, let us study the Modern Periodic Table of Elements shown in Figure 8.4 carefully and identify several important features about it.

Each of the vertical columns in the Modern Periodic Table of Elements is called a **group**. There are 18 groups in the Modern Periodic Table of Elements.

**GROUP**

1   2   3   4   5   6   7   8   9   10   11   12   13   14   15   16   17   18

Alkali metals      Alkaline earth metals      Halogens      Inert gases

**Key:**

- Metal
- Semi-metal
- Non-metal
- C Solid
- Br Liquid
- H Gas

**1** — Proton number  
**H** — Symbol of element  
 Hydrogen — Name of element  
**1** — Relative atomic mass

Transition metals

Lanthanoids

Actinoids

1	2																	18
3	4																	10
11	12																	18
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	18
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	18
55	56	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	18
87	88	89-103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	18
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71				
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103				

Each of the horizontal rows of element is called a **period**. There are 7 periods in the Modern Periodic Table of Elements.

There are two series of elements with the proton numbers of 57 to 71 and 89 to 103 placed separately at the bottom of the Modern Periodic Table of Elements. These two series are known as **lanthanoids** and **actinoids**.

Figure 8.4 The Modern Periodic Table of Elements

Moving from left to right across a period, there is a gradual change in chemical and physical properties, such as:

- (a) a decrease in metallic properties and an increase in non-metallic properties
- (b) a change of the properties of oxides from basic to acidic
- (c) a decrease in electrical conductivity of the element

### The Principle for the Arrangement of the Elements in the Modern Periodic Table of Elements

In the Modern Periodic Table of Elements, the elements are arranged from left to right and top to bottom, in the order of their increasing proton number. **Proton number** is defined as the number of protons in the nucleus of an atom. Study the Modern Periodic Table of Elements again.



## Activity 8.2

Round Table

**Aim:** To relate the arrangement of the elements with their proton number in the Modern Periodic Table of Elements.

21<sup>st</sup> Century Skills

### Instructions:

1. Carry out this activity in groups.
2. Each group is given an incomplete Modern Periodic Table of Elements and several cards with the symbol and proton number of the element.
3. Use the cards to fill in the blank space in the Modern Periodic Table of Elements given.
4. Present the completed Modern Periodic Table of Elements in front of the class.



## Activity 8.3

Round Table

**Aim:** To identify the position of the element in the Modern Periodic Table of Elements.

21<sup>st</sup> Century Skills

### Instructions:

1. Carry out this activity in groups.
2. Refer to the Modern Periodic Table of Elements and determine the exact symbol of the element below and their position in the Modern Periodic Table of Elements.



3. Present the results in front of the class.

## Electron Arrangements of the Elements

Now, you know that every element in the Modern Periodic Table of Elements has a specific proton number. For example, the proton number of oxygen is 8 and the proton number of magnesium is 12. For a neutral atom, the number of protons is **equal** to the number of electrons. How are the electrons arranged around the nucleus? The electrons are arranged in **shells** around the nucleus. The electrons occupy the shells closest to the nucleus first. The electrons can only start occupying a new shell when the previous one has been occupied.

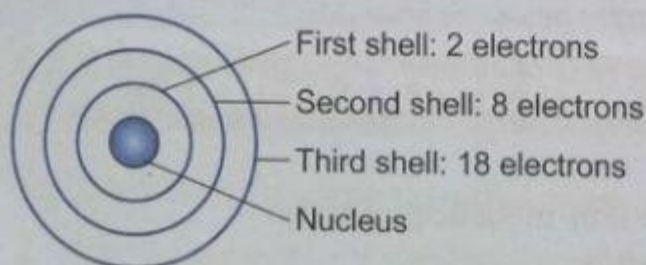


Figure 8.5 The electron arrangement around the nucleus

For atoms with proton numbers 1 to 20, the first shell can accommodate up to two electrons, the second shell can accommodate up to eight electrons, and the third shell can accommodate up to eight electrons.

Example:

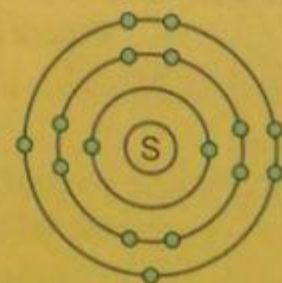


Figure 8.6 The electron arrangement of sulphur atom

Sulphur has a proton number of 16. Hence, a sulphur atom has 16 electrons. These electrons are arranged as two in the first shell, eight in the second shell and the remaining six in the third shell. The electron arrangement of the sulphur atom can be written as 2.8.6.





## Activity 8.4

Gallery Walk

**Aim:** To draw the electron arrangement of the first 20 elements in the Modern Periodic Table of Elements.

**Materials:** Marker pen, A4 paper

**Instructions:**

1. Carry out this activity in groups.
2. Determine the proton number of five different elements and relate it with the number of electrons.
3. Draw the electron arrangement for each element on a piece of A4 paper and paste it at the back of the classroom.

21<sup>st</sup> Century Skills

## Formation of Positive and Negative Ions

You learned about the formation of positive and negative ions in Form 3. Most of the atoms have unstable electron arrangement. Therefore, these atoms will tend to form a **stable** electron arrangement.

Neutral atoms form ions by donating the outermost electrons to other atoms or by accepting the outermost electrons of the other atoms. This is to achieve a stable **duplet** or **octet** electron arrangement.

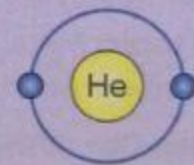
When an atom donates or accepts an electron, the atom becomes a charged particle called an **ion**.

- **Positive ions** are formed when the atoms of metal elements donate electrons.
- **Negative ions** are formed when the atoms of non-metallic elements accept electrons.

As an example, a magnesium atom has 12 electrons. Its electron arrangement is 2.8.2. How does this atom achieve a stable octet electron arrangement? Would it be easier for the atom to donate two electrons or accept six electrons? Let us study Figure 8.7.

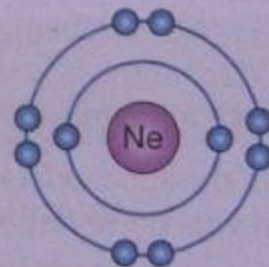
### Science Gallery

**Duplet electron arrangement** is the stable electron arrangement with 2 electrons in the first shell.

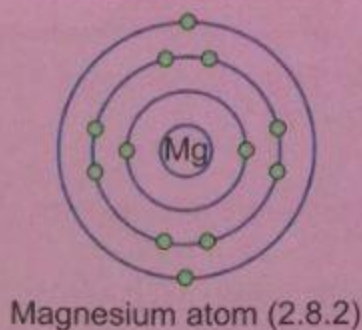


Duplet electron arrangement

**Octet electron arrangement** is the stable electron arrangement with 8 electrons in the outermost shell.



Octet electron arrangement



Donates two electrons

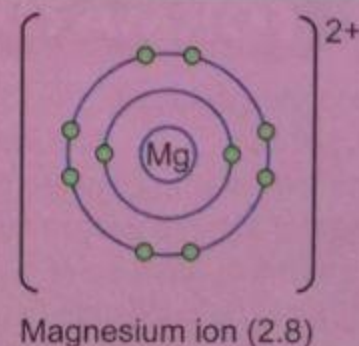


Figure 8.7 Formation of positive ion,  $Mg^{2+}$

A chlorine atom has 17 electrons. Figure 8.8 shows the chlorine atom with an electron arrangement of 2.8.7. This atom accepts one electron to achieve a stable octet electron arrangement.

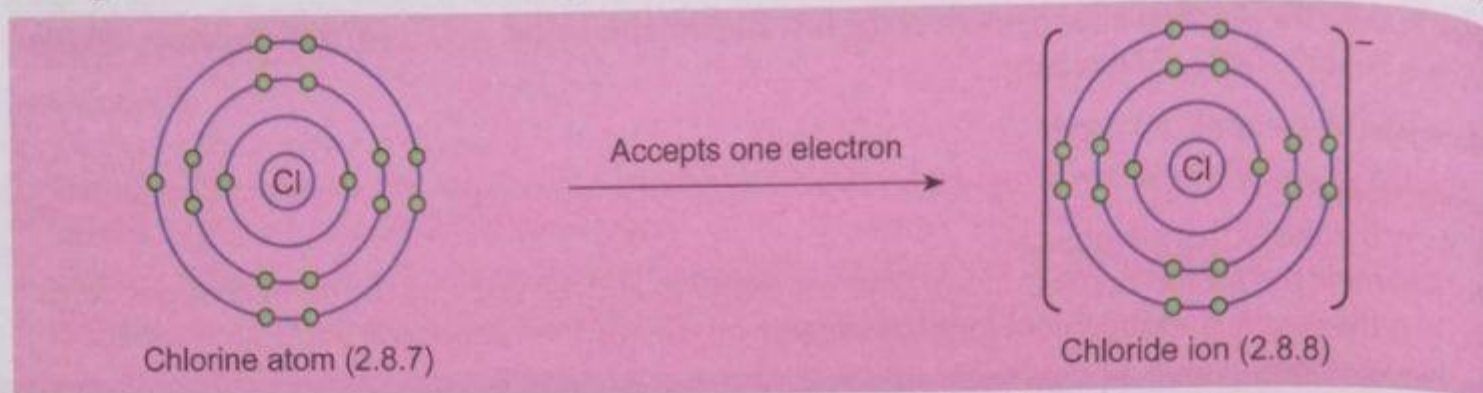


Figure 8.8 Formation of negative ion,  $\text{Cl}^-$

The atom will tend to achieve stable electron arrangement by donating or accepting electrons from other atoms. Carry out Activity 8.5 to show the effect on a substance when ions are formed.



## Activity 8.5

Problem-based Learning

**Title:** Controlling Metal Corrosion

21<sup>st</sup> Century Skills

**Related topic:** Metal corrosion occurs when the metal atoms form positive ions.

**Suggested duration:** 1 week

**Problem:** One of the main problems faced by vehicles and bridges is rust. Therefore, the maintenance of bridges and vehicles is a challenge to a country's economy. The surface of an atomic substance (for example iron) must be kept in good condition.

Based on the problem above, discuss how maintenance work can be carried out on bridges and vehicles.

**Sources:**

- Science textbook (content related to the formation of ion, rusting)
- Websites
- Other reference materials such as scientific magazines related to ion formation and rusting

Explain the appropriate methods or ways to control metal corrosion. Presentations can be in the form of multimedia presentation.



## FORMATIVE PRACTICE

### 8.2

1. State the position of the following elements in the Modern Periodic Table of Elements.  
(a) Lithium      (b) Silver      (c) Helium      (d) Gold
2. Give two examples of elements in Group 17.
3. Element  $M$  has a proton number of 19. Based on the Modern Periodic Table of Elements, state the name of element  $M$ .
4. Element  $N$  is located in Group 15 and Period 3 in the Modern Periodic Table of Elements. What is the electron arrangement for the atom of element  $N$ ?
5. Using suitable examples, state the formation of positive and negative ions from the atoms of their element.

## 8.3 Isotope

All atoms of an element have the same number of protons and neutrons. However, some elements have atoms with the same number of protons but different number of neutrons. These atoms are known as **isotopes**. Table 8.1 shows some examples of isotopes.

Table 8.1 Examples of isotopes

Isotope	Number of protons	Number of electrons	Number of neutrons
Hydrogen-1	1	1	0
Hydrogen-2	1	1	1
Hydrogen-3	1	1	2
Carbon-12	6	6	6
Carbon-13	6	6	7
Carbon-14	6	6	8
Oxygen-16	8	8	8
Oxygen-18	8	8	10

Isotopes are usually written only by their nucleon number. The **nucleon number** is the total number of protons and neutrons in the nucleus of that atom. For example, the isotope for hydrogen has 1 proton and 2 neutrons, written as hydrogen-3. Carry out Activity 8.6 to determine the number of protons, neutrons and nucleon number in other isotopes.

### History Corner

The word isotope originates from the Greek word 'isos' which means same and 'topos' means place. This word means isotope for an element that has the same position in the Modern Periodic Table of Elements.



Isotopes

<http://bukutekskssm.my/Science/F4/Isotope.mp4>

VIDEO

## Activity 8.6

**Aim:** To determine the number of protons, neutrons and the nucleon number of isotopes.

**Instructions:** Complete the table below with the number of protons, neutrons and the nucleon number for the given isotopes.

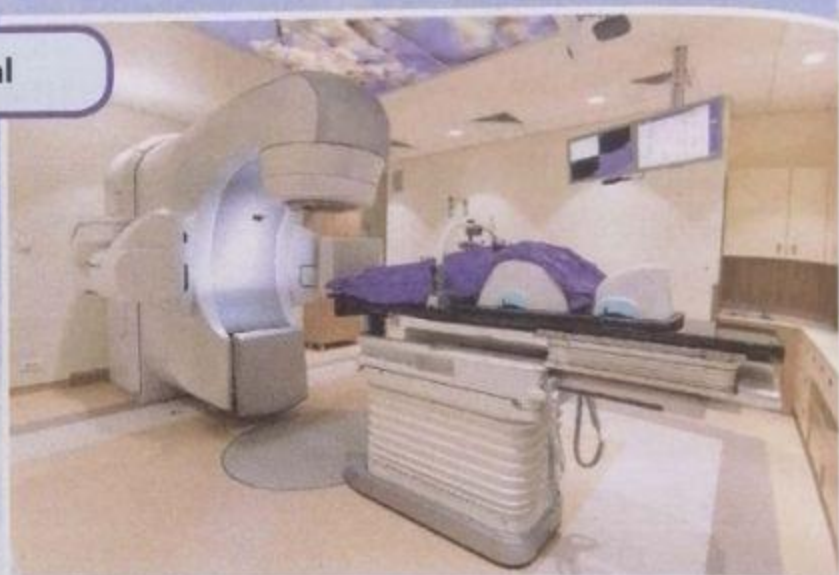
Isotope	Number of protons	Number of neutrons	Nucleon number
Chlorine-35		18	
Chlorine-37			37
Sodium-23	11		
Sodium-24		13	
Bromine-79			79
Bromine-81	35		

## The Use of Isotopes in Various Fields

Technological advances have led to the widespread use of isotopes. Without realising, isotopes in the form of radioisotopes are actually widely used around us. **Radioisotopes** are unstable isotopes that emit radioactive radiation. Even though radioisotopes emit harmful radiation, it has important uses if handled correctly. Radioisotopes are used in medical field, agriculture, industry, power generation and research. Recall the use of radioactive radiation that you learned in Form 3 as shown below.

### Medical

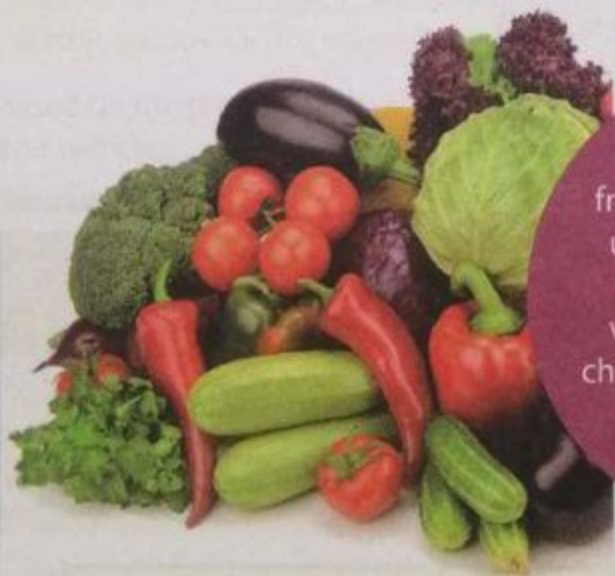
Gamma radiation from cobalt-60 is used to kill cancer cells.



Photograph 8.3 Radiotherapy machine

### Food technology

Gamma radiation from cobalt-60 is also used to destroy the microorganism on vegetables without changing the quality of the food.



Photograph 8.4 Vegetables that are free of germs

### Agriculture

Phosphorus-32 is injected into the root of plants to study the rate of absorption of phosphorus fertiliser in plants.

Photograph 8.5 Plant roots

Do you know the use of other isotopes? Let us carry out Activity 8.7.



## Activity 8.7

Think-Pair-Share

**Aim:** To search information on the use of the isotopes in various fields.

21<sup>st</sup> Century Skills

**Instructions:**

1. Carry out this activity in pairs.
2. Search for information from various sources on the use of isotopes in various fields for 20 minutes.
3. Share and discuss the results obtained with a partner.
4. Present the information obtained in the table as follows.

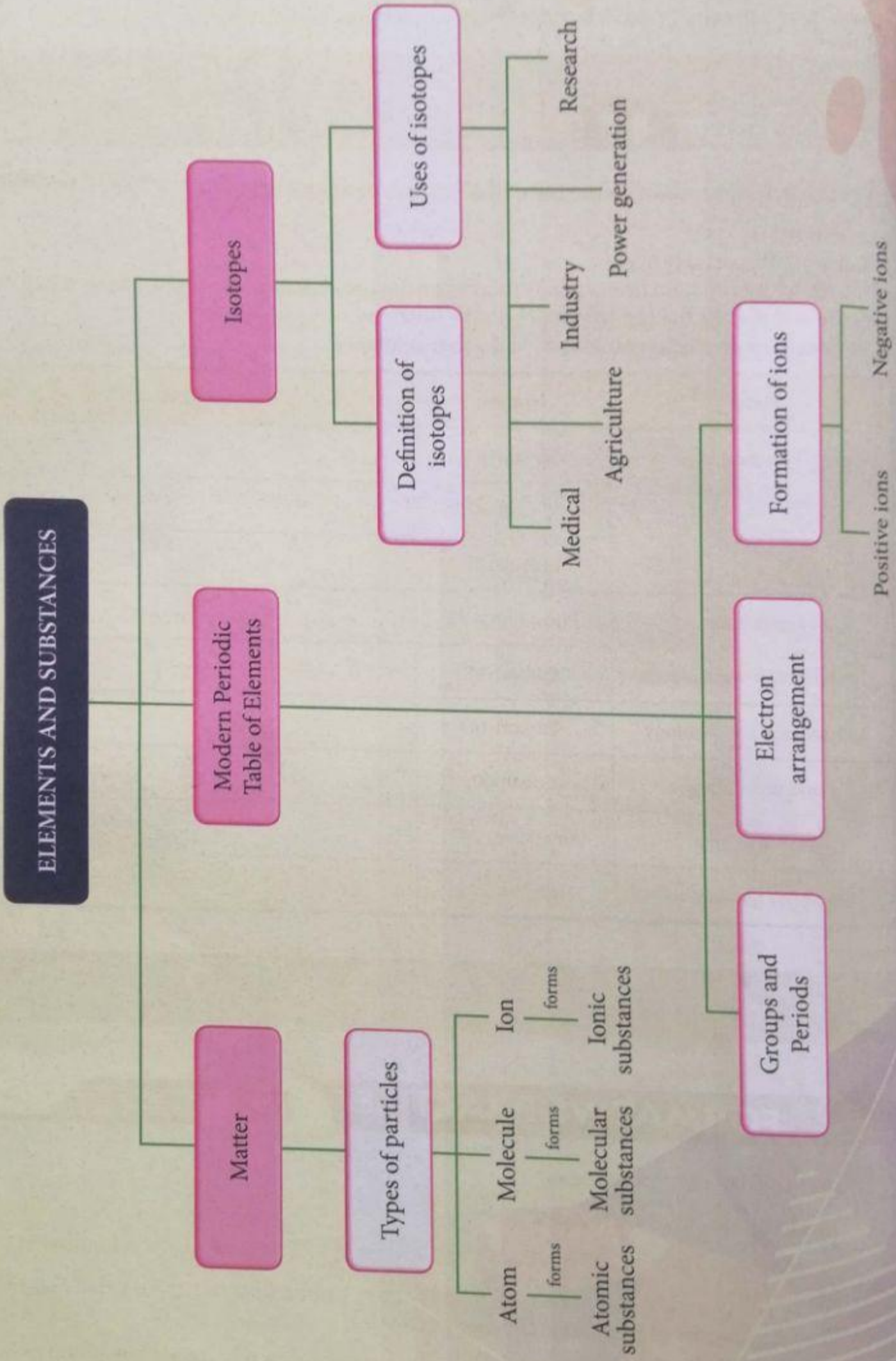
Field	Isotope	Uses
Medical	Sodium-24	
	Cobalt-60	
	Iodine-131	
Agriculture	Phosphorus-32	
	Carbon-14	
Archaeology and Geology	Carbon-14	
Food technology	Cobalt-60	
Paper industry	Americium-241	
Electricity generation	Uranium-235	



## FORMATIVE PRACTICE

### 8.3

1. State the definition of isotopes.
2. Give three examples of isotopes.
3. An atom has 10 protons, 10 neutrons and 10 electrons. What is the nucleon number of that atom?
4. What are the uses of isotopes in the medical field?



## Self-reflection

After studying this chapter, you are able to:

### 8.1 Matter

- Explain the atomic substances, molecular substances and ionic substances with examples.
- Explain the existence of elements in various forms.

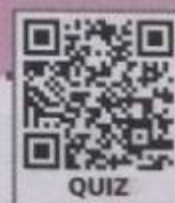
### 8.2 Modern Periodic Table of Elements

- Analyse the Modern Periodic Table of Elements.
- Deduce the principle of the arrangement of the elements in the Modern Periodic Table of Elements.
- Draw and write the electron arrangement of elements in its group.
- Explain the formation of positive ions and negative ions.
- Justify the loss and gain of electrons to achieve the stable electron arrangement.

### 8.3 Isotope

- Explain isotopes with examples.
- Determine the number of proton, number of neutron and nucleon number in isotopes.
- Communicate the use of isotopes in various fields.

## Summative Practice 8




Objective Questions  
[http://bukutekskssm.  
 my/Science/F4/Q8](http://bukutekskssm.my/Science/F4/Q8)

1. Photograph 1 shows two types of substances.



Photograph 1

- (a) State the type of particles that form: 
- (i) salt
  - (ii) sugar
- (b) Give two other examples of substances that are formed from the same type of particles as salt and sugar.
- (c) Give two examples of substances that contain the oxygen that exists in the form of molecules and ions.

2. Figure 1 shows part of the Modern Periodic Table of Elements.

	P																			
	U						S													

Figure 1

P, Q, R, S, T and U are the letters used to represent the elements in the Modern Periodic Table of Elements which is not the correct symbol of that element.

- How are these elements arranged in the Modern Periodic Table of Elements?
- Which elements belong to the same group?
- Which element exists as a stable atom? Explain your answer.
- An element has a nucleon number of 32 and a proton number of 16. Where is the element located in the Modern Periodic Table of Elements?
- State the electron arrangement of the following elements:
  - P
  - Q
  - T

3. Table 1 shows several elements with their proton numbers and nucleon numbers respectively.

Table 1

Element	Proton number	Nucleon number
X	13	27
Y	17	35
Z	20	40



- Determine the number of neutrons for the atomic elements X, Y and Z.
- Draw the electron arrangement for the atomic element X, Y and Z.
- In your opinion, where are the elements X, Y and Z located in the Modern Periodic Table of Elements?
- How do atoms of the following elements achieve a stable electron arrangement?
  - Element X
  - Element Y



4. Table 2 shows the elements *P*, *Q*, *R* and *S* with their respective proton and nucleon numbers.

Table 2

Element	Proton number	Nucleon number
<i>P</i>	15	32
<i>Q</i>	11	24
<i>R</i>	11	23
<i>S</i>	6	14

- (a) Which element is a pair of isotope? Explain your answer. 
- (b) State the uses of the isotopes you mentioned in question 4(a) in medicine and in the field of industry.
- (c) State element *P* and its uses in agriculture.
- (d) Name element *S* and state its uses in agriculture and archaeology. 


## Mind Challenge

5.

Akmal received a complaint about the cracked road condition even after repairing it many times. It was found that the soil beneath the road suddenly became soft due to leakage of the underground pipeline.

How did Akmal solve the problem?

The problem should be solved by following the steps below:

- identifying the problem
- clarifying the problem 
- stating the steps in solving the problem 