TOPIC 15 Periodic Table

Objectives

Candidates should be able to:

(a) describe the Periodic Table as an arrangement of the elements in the order of increasing proton (atomic) number
(b) describe how the position of an element in the Periodic Table is related to proton number and electronic structure
(c) describe the relationship between group number and the ionic charge of an element
(d) explain the similarities between the elements in the same group of the Periodic Table in terms of their electronic structure
(e) describe the change from metallic to non-metallic character from left to right across a period of the Periodic Table
(f) describe the relationship between group number, number of valency electrons and metallic/non-metallic character
(g) predict the properties of elements in Group I and Group VII using the Periodic Table
(h) describe lithium, sodium and potassium in Group I (the alkali metals) as a collection of relatively soft, low density metals showing a trend in melting point and in their reaction with water
(i) describe chlorine, bromine and iodine in Group VII (the halogens) as a collection of diatomic non-metals showing a trend in colour, state and their displacement reactions with solutions of other halide ions
(j) describe the elements in Group 0 (the noble gases) as a collection of monatomic elements that are chemically unreactive and hence important in providing an inert atmosphere
(k) describe the lack of reactivity of the noble gases in terms of their electronic structures
(l) describe the transition elements as metals having high melting points, high density, variable oxidation state and forming coloured compounds
(m) state that the elements and/or their compounds are often able to act as catalysts

1. Features of the Periodic Table

Elements are arranged in order of increasing atomic numbers in the Periodic Table. They are organised into horizontal rows known as periods, and vertical columns known as groups.

2. Metals and Non-metals

Elements can be classified as metals or non-metals. There is also a class of elements known as metalloids, which exhibit both metal and non-metal properties. These elements are found along the diagonal line in the Periodic Table.

3. Variations Across a Period

In a period, metals are found on the left side while the non-metals are found on the right side. The metallic character of elements decreases as we move from left to right of a period.

Elements in the same period have the same number of electron shells. The number of electron shells corresponds with the period number of the element. For example, aluminium belongs to Period 3 and has three electron shells.

4. Variations Down a Group

The metallic character of elements increases as we move down a group. This is due to the increase in size of atoms. Valence electrons are further away from the nucleus of the atom and are not as strongly attracted.

Larger atoms in the group will lose their valence electrons more easily than smaller atoms. Therefore, moving down a group, there is an increase in metallic character.

Elements in the same group have the same number of valence electrons. The number of valence electrons each of the elements has corresponds with the group number. For instance, Group I elements (e.g. lithium, sodium, potassium) each have one valence electron each while Group II elements (e.g. boron, magnesium, calcium) have two valence electrons each.

5. Group I: Alkali Metals

Elements in Group I are also known as alkali metals. The atoms of these elements have one valence electron each. These metals are soft and can be cut easily with a knife. They have relatively low melting and boiling points. Their densities are relatively low. Lithium, sodium and potassium have densities lower than water, enabling them to float.

Moving down the group, the melting and boiling points decrease while the densities increase.

Alkali metals are highly reactive metals. They react easily with oxygen and water.

The reactivity of these metals increases as we move down the group. This is due to an increase in the atom size, which means that the valence electrons are further away from the nucleus and are more easily lost.

Alkali metals react with water to form an alkali and hydrogen gas. The trend in reactivity can be observed from their reactions with water. Lithium reacts quickly with cold water, but potassium reacts very violently with cold water.

As alkali metals easily give away their valence electrons, they are strong reducing agents. These metals react with non-metals to form ionic salts which are soluble in water.

6. Group VII: Halogens

Elements in Group VII are also known as halogens. Atoms of these elements have seven valence electrons each.

These are non-metals that are found as diatomic molecules (e.g. Cl_2, Br_2, I_2). Since they are found as simple covalent molecules, they have low melting and boiling points. They are coloured substances.

Moving down the group, the melting and boiling points increase. At the same time, the colour intensity of these elements increases. This can be observed from their physical properties at room temperature and pressure. Chlorine is a yellow-green gas, bromine is a reddish-brown liquid and iodine is a black solid.

Halogens are highly reactive non-metals as they only need to gain one electron for a noble gas electronic configuration.

The reactivity decreases as we move down the group. As the atoms increase in size, the force of attraction between the valence shell electrons and the nucleus is weaker. As a result, larger halogens do not gain electrons as easily as smaller ones. Out of the three halogens, chlorine is the most reactive while iodine is the least reactive.

Halogens undergo displacement reaction, where a more reactive halogen displaces a less reactive halogen from its salt. For instance, when chlorine gas is bubbled into sodium bromide solution, bromide ions get displaced. The solution changes from colourless to reddish-brown as bromine molecules are produced in the reaction.

$Cl_2(g) + 2NaBr(aq) \rightarrow 2NaCl(aq) + Br_2(aq)$

As halogens accept electrons easily, they are strong oxidising agents.

7. Group VIII: Noble Gases

Elements in Group VIII (or sometimes referred to as Group 0) are known as noble gases. These are inert non-metals which are found as monatomic gases. Their lack of reactivity is due to their complete shell of valence electrons, hence they rarely react to form compounds.

Due to their unreactive nature, noble gases are often used to provide an inert atmosphere. The following table shows some applications of noble gases.

Element	Application
Helium	Weather balloons
Neon	Advertising signs or lights
Argon	Lightbulbs or welding
Krypton	Lasers
Xenon	Photographic flashes or lamps in motion picture projection

8. Transition Elements

Transition elements are a block of metals found between Groups II and III in the Periodic Table. These metals have high melting and boiling points and high densities. Compounds of transition elements are usually coloured.

Transition elements have variable oxidation states. They can form ions of different charges, as opposed to Group I or Group VII elements, which usually form ions of a single charge. For example, iron commonly forms Fe^{2+} and Fe^{3+} ions.

Transition elements and their compounds are good catalysts and are commonly used in industrial processes. For example, nickel is used in the manufacture of margarine (hydrogenation of vegetable oil) and iron is used in the Haber process (manufacture of ammonia).