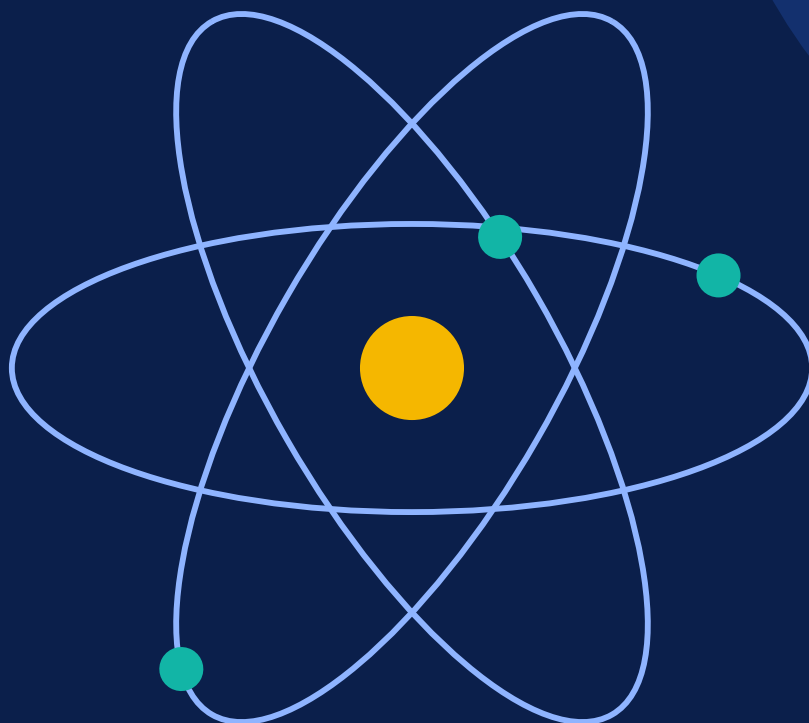


CLASS 9 • CHEMISTRY



CHAPTER 8

PERIODIC TABLE AND PERIODICITY

Complete Exercise Solutions

MCQs • Short • Constructed • Descriptive • Investigative

³ Li	⁴ Be	⁵ B	⁶ C	⁷ N	⁸ O	⁹ F	¹⁰ Ne
---------------------------	---------------------------	--------------------------	--------------------------	--------------------------	--------------------------	--------------------------	----------------------------

scholareye.xyz

1. Tick (✓) the correct answer.

(i) In which period and group will you place the element which is an important part of the solar cell?

✓ (a) Third period and 14th group

(b) Second period and 14th group

(c) Third period and 15th group

(d) Third period and 16th group

✓ **Correct Answer:** (a) Third period and 14th group

Explanation: The most important element used in solar cells is **Silicon (Si)**. Its atomic number is 14 and its electronic configuration is 2, 8, 4. Since its outermost shell is the third shell ($n = 3$), it belongs to the **third period**. It has 4 valence electrons in its outermost shell, which places it in **group 14** of the periodic table.

(ii) Identify the electronic configuration of the outermost shell of a transition metal.

(a) ns^2np^4

✓ **(b) nd^1ns^2**

(c) ns^2np^6

(d) ns^2np^5

✓ **Correct Answer: (b) nd^1ns^2**

Explanation: Transition metals are d-block elements. Their general valence shell configuration involves the filling of the d-subshell of the penultimate shell: $(n-1)d^{1-10} ns^{1-2}$. Option (b) **nd^1ns^2** reflects this typical pattern, where the d-orbital is being filled. Options (a), (c) and (d) represent p-block elements.

(iii) Which is the softest metal?

✓ **(a) Na**

(b) Ca

(c) Al

(d) Zn

✓ **Correct Answer: (a) Na**

Explanation: Sodium (Na) is an alkali metal (Group 1). It has only one valence electron and a large atomic size, so its metallic bond is weak. This makes sodium very soft, and it can be cut easily with a knife. Calcium, aluminium and zinc have more valence electrons and smaller atoms, so their metallic bonds are stronger and they are harder.

(iv) A yellow solid element exists in allotropic forms which is also present in fossil fuels. Indicate the name.

(a) Carbon

(b) Iodine

(c) Aluminium

✓ **(d) Sulphur**

✓ **Correct Answer: (d) Sulphur**

Explanation: Sulphur is a non-metal that exists as a yellow solid at room temperature. It shows allotropy (e.g. rhombic and monoclinic sulphur) and is a common impurity in fossil fuels such as coal and petroleum. Carbon is black, iodine is dark purple and aluminium is a silvery metal.

(v) How many electrons can nitrogen accept in its outermost shell?

(a) 2

✓ **(b) 3**

(c) 4

(d) 5

✓ **Correct Answer: (b) 3**

Explanation: Nitrogen has atomic number 7 and configuration $1s^2 2s^2 2p^3$, so its outermost shell holds 5 electrons. To attain the stable configuration of the nearest noble gas (Neon) it needs **3 more electrons** to complete its octet, forming the N^{3-} ion.

(vi) Which element is the most reactive element?

(a) Oxygen

(b) Chlorine

✓ **(c) Fluorine**

(d) Nitrogen

✓ **Correct Answer: (c) Fluorine**

Explanation: Fluorine is the most electronegative and most reactive element. It lies in Group 17 (halogens), Period 2, with a very small atomic size and a high effective nuclear charge, so it is extremely eager to gain one electron. Nitrogen is fairly inert because of its strong triple bond, while oxygen and chlorine are reactive but less than fluorine.

(vii) Which element has the highest melting point?

✓ **(a) Na**

(b) K

(c) Rb

(d) Cs

✓ **Correct Answer: (a) Na**

Explanation: Na, K, Rb and Cs all belong to Group 1 (alkali metals). Going down the group the atomic size increases and the metallic bond becomes weaker, so the melting points decrease. Sodium is at the top of this list, so it has the **highest melting point**.

(viii) In what order does the metallic character change in the second group?

(a) $\text{Mg} > \text{Ca} > \text{Ba} > \text{Sr}$

(b) $\text{Sr} > \text{Ba} > \text{Ca} > \text{Mg}$

(c) $\text{Mg} > \text{Sr} > \text{Ca} > \text{Ba}$

✓ **(d) $\text{Ba} > \text{Sr} > \text{Ca} > \text{Mg}$**

✓ **Correct Answer:** (d) $\text{Ba} > \text{Sr} > \text{Ca} > \text{Mg}$

Explanation: Metallic character **increases down a group** because atomic size increases and the effective nuclear charge on the valence electrons decreases, making it easier to lose electrons. In Group 2 the increasing order is $\text{Mg} < \text{Ca} < \text{Sr} < \text{Ba}$, so the decreasing order is **$\text{Ba} > \text{Sr} > \text{Ca} > \text{Mg}$** .

(ix) Which of the following best describes the correct order of oxygen, fluorine and nitrogen's atomic radii?

(a) $O < F < N$

(b) $N < F < O$

✓ **(c) $F < O < N$**

(d) $O < N < F$

✓ **Correct Answer: (c) $F < O < N$**

Explanation: Atomic radius **decreases from left to right** across a period because the nuclear charge increases and pulls the electrons closer. N, O and F are in the second period in the order N, O, F, so the radii decrease as $N > O > F$, which can also be written as **$F < O < N$** .

(x) The element having less value of ionization energy and less value of electron affinity is likely to belong to:

✓ **(a) Group 1**

(b) Group 13

(c) Group 16

(d) Group 17

✓ **Correct Answer: (a) Group 1**

Explanation: Low ionization energy means the element loses electrons easily, which is typical of metals on the left of the periodic table. Low electron affinity means it has little tendency to accept an electron. **Group 1** (alkali metals) have the lowest ionization energies in their periods and very low electron affinities, and they readily lose their single valence electron to form cations.

2. Questions for Short Answers

(i) Why was atomic number chosen to arrange the elements in the periodic table?

Answer: Atomic number (Z) is the number of protons in the nucleus of an atom. It was chosen as the basis of arrangement because it gives a **unique identity** to every element and increases regularly by one from one element to the next.

Mendeleev's table, based on atomic mass, had anomalies (e.g. tellurium placed before iodine although it has the higher atomic mass). Moseley showed that the atomic number is the fundamental property that determines the chemical properties of an element. Arranging by atomic number resolved these anomalies and gave the modern periodic law.

(ii) What is the significance of the word periodic?

Answer: The word “**periodic**” means the recurrence of similar physical and chemical properties of elements at regular intervals when they are arranged in order of increasing atomic number.

Just as the seasons repeat, the properties of elements repeat after certain intervals (periods). This is due to the periodic recurrence of similar valence shell electronic configurations.

(iii) Why does the size of a period increase as we move down the periodic table?

Answer: The number of elements in a period increases because the number of available subshells to be filled increases:

- Period 1 fills the 1s subshell (2 elements).
- Periods 2 and 3 fill s and p subshells (8 elements each).
- Periods 4 and 5 fill s, d and p subshells (18 elements each).
- Periods 6 and 7 fill s, f, d and p subshells (32 elements each).

As new subshells become available for filling, the period accommodates more elements, so its size increases.

(iv) In a group, the elements have the same number of electrons in the outermost shell. Why is

it so?

Answer: Elements in the same group have similar outer electronic configurations. For example, Group 1 elements have 1 valence electron (ns^1) and Group 2 elements have 2 (ns^2).

As we move down a group, a new principal energy shell is added, but the number of electrons in the outermost shell stays the same. This identical valence shell configuration is the reason for their similar chemical properties.

(v) Do you expect calcium to be more reactive than sodium? Give the reason of your answer.

Answer: No. **Sodium (Na) is more reactive than calcium (Ca).**

Sodium is an alkali metal (Group 1) with a single valence electron which it loses very easily to attain a noble gas configuration. Calcium (Group 2) has two valence electrons and forms Ca^{2+} . The first ionization energy of sodium is lower than that of calcium and its single electron is less tightly held, so sodium reacts more vigorously (e.g. with water) than calcium.

(vi) Which element has the maximum atomic radius and which element has the minimum atomic radius in third period?

Answer: In the third period (Na to Ar) the atomic radius decreases from left to right.

- **Maximum atomic radius:** Sodium (Na)
- **Minimum atomic radius:** Chlorine (Cl), among the reactive elements of the period

(vii) Why are the most electronegative elements present in sixth and seventh groups?

Answer: Elements of Groups 16 and 17 (the sixth and seventh groups in older nomenclature) have a high effective nuclear charge and small atomic radii, and they need only 1 or 2 electrons to complete their octet, so they attract electrons strongly.

Among them, the Group 17 elements (halogens) are the most electronegative, and **fluorine** is the most electronegative element of all.

(viii) The first ionization energy value of magnesium is less than the second one. Give reason.

Answer: The first ionization energy is the energy needed to remove the first electron from a neutral atom: $\text{Mg} \rightarrow \text{Mg}^+ + \text{e}^-$. The second is the energy needed to remove an electron from the positive ion: $\text{Mg}^+ \rightarrow \text{Mg}^{2+} + \text{e}^-$.

After the first electron is lost, the Mg^+ ion has the same number of protons but fewer electrons, so the effective nuclear charge per electron is greater and the ion is smaller. The remaining electron is held more tightly by the nucleus. Removing an electron from a positively charged ion always needs more energy than removing it from a neutral atom.

Hence the **second ionization energy is greater than the first**. (Mg^{2+} then has the stable neon configuration, which is why magnesium forms 2+ ions and its third ionization energy is extremely high.)

(ix) Is it possible for two metals or two non-metals to form an ionic bond?

Answer: No. An ionic bond is formed between a **metal and a non-metal**.

- **Two metals:** both tend to lose electrons (low electronegativity) and form positive ions, so there is no electron acceptor.

- **Two non-metals:** both tend to gain or share electrons (high electronegativity), so they form covalent bonds by sharing electrons to complete their octets.

An ionic bond needs a large difference in electronegativity, which is only possible for a metal-non-metal combination.

(x) Which element has the least value of ionization energy and which element has the highest value of electronegativity?

Answer:

- **Least ionization energy:** Cesium (Cs) or Francium (Fr). Francium is the lowest in theory, but cesium is the one usually cited as the most reactive metal in practice.
- **Highest electronegativity:** Fluorine (F)

3. Constructed Response Questions

(i) Suppose a new element is discovered. Where would you like to accommodate this element in the periodic table?

Answer: A newly discovered element is placed in the periodic table according to its **atomic number and electronic configuration**.

If its properties match a particular group (based on its valence electrons), it is placed in that group and period. If its configuration fits the s, p, d or f block, it is placed in that block. New synthetic superheavy elements are added at the end of the table, in the 7th period or a new 8th period, according to their atomic number.

(ii) What is the first element of the periodic table? Will it lose an electron or gain it?

Answer: The first element is **Hydrogen (H)** with atomic number 1 and configuration $1s^1$.

It can lose one electron to form H^+ (like an alkali metal), or gain one electron to attain the helium configuration $1s^2$ and form the hydride ion H^- (like a halogen).

In most reactions with non-metals hydrogen loses an electron (H^+), but with highly active metals such as sodium it gains an electron (H^-).

(iii) Atomic radii of boron and aluminum are 88 pm and 125 pm respectively. Which element is expected to lose electron or electrons easily?

Answer: Aluminum (Al) is expected to lose electrons more easily.

Aluminum has the larger atomic radius (125 pm against 88 pm for boron), so its outermost electrons are farther from the nucleus and feel a weaker effective nuclear charge. Its ionization energy is therefore lower than that of boron, which makes it easier for aluminum to lose its valence electrons.

(iv) How would you find the atomic radius of an atom?

Answer: Atomic radius is not a fixed value because the electron cloud has no definite boundary. It is measured experimentally by these methods:

- **X-ray diffraction:** measure the distance between two adjacent atoms in a crystal and halve it (covalent radius).
- **Electron diffraction:** works like X-ray diffraction and is used to find bond lengths.
- **Van der Waals radius:** half the distance between two non-bonded atoms of a gas.
- **Metallic radius:** half the distance between two adjacent metal atoms in the lattice.

(v) Why is it not possible for oxygen atom to accept three electrons to form O^{3-} ion like nitrogen which can accept electrons to form N^{3-} ?

Answer: Oxygen (atomic number 8, configuration 2, 6) needs only **2 electrons** to complete its octet and form O^{2-} with the neon configuration. Nitrogen (2, 5) needs 3 electrons to form N^{3-} .

For oxygen to accept a third electron, the electron would have to be forced into an already full shell of the small, already negative O^{2-} ion. The strong electrostatic repulsion makes this energetically highly unfavorable, so O^{3-} is not stable.

4. Descriptive Questions

(i) Which information is needed to locate the elements in the periodic table if you do not know its atomic number? Is atomic mass helpful for this purpose?

Answer: You need the element's **electronic configuration** or its chemical properties. The number of valence electrons tells the **group** and the highest energy level (shell) tells the **period**.

Is atomic mass helpful? Mendeleev arranged the elements by atomic mass and used it to predict properties. However, atomic mass is **not entirely reliable** for locating elements in the modern table because of anomalies (e.g. tellurium has a higher atomic mass than iodine, but iodine comes first because its atomic number is lower).

The modern periodic table is based strictly on atomic number, so atomic mass gives only a rough idea and is not the fundamental factor for placement.

(ii) How many blocks of elements are present in the periodic table? Are these blocks helpful in studying the properties of elements?

Answer: There are **four blocks**: the **s-block**, **p-block**, **d-block** and **f-block**.

Yes, they are very helpful. A block shows which subshell (s, p, d or f) is receiving the last electron, and elements of a block share similar properties:

- **s-block:** mostly reactive metals.
- **p-block:** metals, non-metals and metalloids.
- **d-block:** transition metals with variable oxidation states.
- **f-block:** inner transition metals.

(iii) Explain the variation in the following properties in the periods giving reasons. (a) Atomic radius (b) Ionization energy

(a) Atomic radius: It **decreases** from left to right across a period.

Reason: The nuclear charge increases by one at each step while electrons are added to the same outermost shell. The greater nuclear charge pulls the electron cloud closer to the nucleus, so the radius decreases.

(b) Ionization energy: It **increases** from left to right across a period.

Reason: As the atomic size decreases, the outermost electrons are held more tightly by the nucleus, so more energy is needed to remove one.

(iv) Which physical properties of elements may lead us to know what type of bond it will form?

Answer: The key properties are:

- **Electronegativity:** a large difference (greater than 1.7) between the combining elements suggests an ionic bond; a small difference (less than 1.7) suggests a covalent bond.
- **Ionization energy:** a low value shows a tendency to lose electrons (ionic bonds with non-metals, or metallic bonds among metals).
- **Electron affinity:** a high value shows a tendency to gain electrons (ionic bonds with metals, covalent bonds with non-metals).
- **State, hardness and conductivity:** metals tend to form metallic bonds and non-metals covalent bonds, and these properties give further hints.

(v) Write down the names of four non-metals which exist in solid state at normal temperature.

Answer: Four non-metals that are solids at room temperature:

1. Carbon (C)
2. Sulphur (S)
3. Phosphorus (P)
4. Iodine (I)

(vi) Why do second and third periods have equal number of elements while all other periods contain different number of elements?

Answer: The second and third periods both have **8 elements**. In them electrons fill only the **s and p subshells** (2s and 2p in period 2; 3s and 3p in period 3), and s and p together hold $2 + 6 = 8$ electrons.

In the 4th and 5th periods the d-subshell (capacity 10) also fills, giving 18 elements each. The 6th and 7th periods also involve the f-subshell (capacity 14), giving 32 elements each.

Only periods 2 and 3 follow the simple s-p filling pattern, so only they have the same number of elements.

5. Investigative Questions

(i) Arrangement of the elements in the form of a periodic table is a remarkable achievement of chemists. Comment on this statement citing the benefits of this table.

Answer: The periodic table is a remarkable achievement because it brought order to the study of the elements. **Its benefits:**

1. **Systematic study:** it organizes all known elements by atomic number, making it easy to study their properties.
2. **Prediction of new elements:** Mendeleev predicted the existence and properties of undiscovered elements (e.g. gallium, germanium) long before they were found.
3. **Periodic trends:** it clearly shows trends in atomic radius, ionization energy and electronegativity.
4. **Relationship between elements:** it groups similar elements together (e.g. alkali metals, halogens).

5. **Foundation of modern chemistry:** it is a framework for understanding bonding, structure and reactivity.

(ii) Both lithium and beryllium show behaviour different from rest of the alkali and alkaline earth metals respectively. Can you think of the possible reasons for this difference?

Answer: Lithium and beryllium behave differently because of their **very small atomic size and high charge density** (charge-to-radius ratio).

- **Lithium (Group 1):** it is much smaller than the other alkali metals and has a higher ionization energy, so it is less reactive. It forms covalent compounds (e.g. organolithium compounds) and reacts directly with nitrogen to form Li_3N , unlike the other alkali metals.
- **Beryllium (Group 2):** its small size and high charge density make its compounds mainly covalent (BeCl_2 is covalent, while MgCl_2 is ionic). It has a very high ionization energy and does not react with water as readily as the rest of the group.

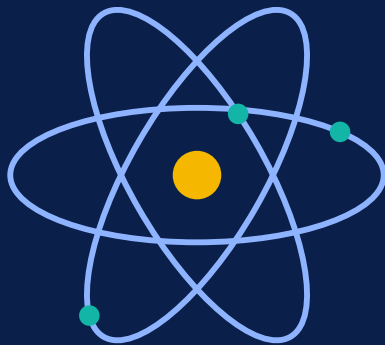
The same small size and high charge density also explain beryllium's diagonal relationship with aluminum.

(iii) Modern periodic table is the amended form of the earlier table developed by Mendeleev. Elaborate how these two tables are different from each other.

Answer: The main differences are:

1. **Basis:** Mendeleev's table is based on atomic mass; the modern table is based on atomic number.
2. **Isotopes:** Mendeleev's table had no separate place for isotopes; in the modern table isotopes share one position because they have the same atomic number.
3. **Anomalies:** Mendeleev's table had anomalies (e.g. Ar before K, Te before I) that broke the atomic-mass order; arranging by atomic number places them correctly.
4. **Periodic law:** Mendeleev stated properties as a function of atomic mass; the modern law states them as a function of atomic number (electronic configuration).

5. **Groups:** Mendeleev divided groups into A and B subgroups; the modern table divides elements into s, p, d and f blocks based on electronic configuration.
6. **Noble gases:** Mendeleev's original table had no group for the noble gases (discovered later); the modern table has Group 18 for them.



Thank You!

for studying with

scholareye.xyz

- ✓ MCQs solved with explanations
- ✓ Short & constructed questions
- ✓ Descriptive & investigative questions

Keep exploring. Keep learning.

More chapter-wise solutions at scholareye.xyz

scholareye.xyz