# 9th Class Chemistry Chapter # 8 Exercise Solutions – Punjab Board

## Periodic Table and Periodicity

## MCQs with Answers & Explanation

### Q1.In which period and group will you place the element which is a metal and has the electronic configuration of the outermost shell as $3s^2$?

**Options:**

- (a) Third period and 13th group
- (b) Second period and 15th group
- **(c) Third period and 2nd group**
- (d) Third period and 1st group

**Answer:** (c) Third period and 2nd group

**Explanation:**
The electronic configuration **$3s^2$** means:

- Principal quantum number = 3 → It's in the **3rd period**
- Two electrons in the s-orbital → Group **2 (alkaline earth metals)**
  Example: **Magnesium (Mg)** = $1s^2\ 2s^2\ 2p^6\ 3s^2$ → 3rd period, group 2

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### Q2: Identify the electron deficient compound:

**Options:**

- (a) $ns^2$
- (b) $nd^3$
- (c) $ns^2\ np^5$
- **(d) $ns^2\ np^3$**

**Answer:** (d) $ns^2\ np^3$

**Explanation:**

- A compound is **electron deficient** when it does **not have a complete octet**.
- $ns^2\ np^3$ = total of 5 valence electrons → **needs 3 more to complete octet**

- Hence, it is **electron deficient**.
  For example, **Nitrogen** (with configuration $2s^2\ 2p^3$) is electron deficient in some compounds like **$BF_3$**, **$BH_3$**, etc.

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## Q3: Which is the heaviest metal?

**Options:**

- (a) Pb
- (b) Cu
- **(c) Au**
- (d) Ag

**Answer:** (c) Au (Gold)

**Explanation:**
The **atomic mass** of the elements is as follows:

- Pb = 207 u
- Cu = 63.5 u
- Au = **197 u**
- Ag = 107.9 u

Although Pb has slightly higher atomic mass than Au, **Gold (Au)** is considered **heavier due to higher density and atomic structure** among noble/heavy metals in practical chemistry comparisons.

## Q4: A yellow solid element exists in allotropic forms which is also present in fossil fuels. Indicate the name.

**Options:**

- (a) Carbon
- (b) Iodine
- (c) Aluminium
- **(d) Sulphur**

**Answer:** (d) Sulphur

**Explanation:**
Sulphur is a **yellow solid**, exists in many **allotropic forms** (rhombic, monoclinic, plastic), and is commonly found in **fossil fuels** like coal and crude oil.

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### Q5: How many electrons can nitrogen accept in its outermost shell?

**Options:**

- (a) 2
- **(b) 3**
- (c) 4
- (d) 5

**Answer:** (b) 3

**Explanation:**
Nitrogen has 5 valence electrons (**$2s^2$ $2p^3$**) and needs **3 more electrons** to complete its **octet (8)** — so it can accept **3 electrons**.

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### Q6: Which element is the most reactive element?

**Options:**

- (a) Oxygen
- (b) Chlorine
- **(c) Fluorine**
- (d) Nitrogen

**Answer:** (c) Fluorine

**Explanation:**
Fluorine is the **most reactive non-metal** due to its:

- Smallest atomic size
- Highest electronegativity
- Strong tendency to gain electrons

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### Q7: Which element has the highest melting point?

**Options:**

- **(a) Na**
- (b) K
- (c) Rb
- (d) Cs

**Answer:** (a) Na

**Explanation:**
Down the group in alkali metals, **melting point decreases**. So among Na, K, Rb, Cs — **sodium (Na)** has the **highest melting point**.

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### Q8: In which order does the metallic character change in the second group?

**Options:**

- (a) Mg > Ca > Ba > Sr
- (b) Sr > Ba > Ca > Mg
- (c) Mg > Sr > Ca > Ba
- **(d) Ba > Sr > Ca > Mg**

**Answer:** (d) Ba > Sr > Ca > Mg

**Explanation:**
In group 2 (alkaline earth metals), **metallic character increases down the group**.
So correct order is: **Ba > Sr > Ca > Mg**

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### Q9: Which of the following best describe the correct order of oxygen, fluorine, and nitrogen atomic radius?

**Options:**

- (a) O < F < N
- (b) N < F < O
- **(c) F < O < N**
- (d) O < N < F

**Answer:** (c) F < O < N

**Explanation:**
Atomic radius **decreases across a period** from left to right.
So order is:
**F (smallest) < O < N (largest)**

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### Q10: The element having less value of ionization energy and less value of electron affinity is likely to belong to:

**Options:**

- **(a) Group 1**
- (b) Group 13
- (c) Group 16
- (d) Group 17

**Answer:** (a) Group 1

**Explanation:**
Group 1 elements (alkali metals):

- Lose electrons easily → **Low ionization energy**
- Don't attract electrons strongly → **Low electron affinity**

## Short Answer Questions

### i. Why was atomic number chosen to arrange the elements in the periodic table?

**Answer:**
Atomic number represents the number of protons (and electrons in a neutral atom), which determines the chemical properties of an element. Earlier arrangement by atomic mass had some exceptions (e.g., Ar before K), but when elements are arranged by **atomic number**, they fall into proper groups with similar properties. Therefore, atomic number was chosen for correct periodic arrangement.

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### ii. What is the significance of the word "periodic"?

**Answer:**
The word *periodic* means **"repeating after regular intervals."** In the periodic table, the properties of elements repeat in a predictable pattern when arranged by atomic number. This repetition is known as **periodicity of properties.**

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

**Answer:**
Actually, this seems to be a mistake in the question wording.
**Correct version:** "Why does the size of an atom increase as we move **down a group**?"
Because as we move down a group, new electron shells are added. Even though nuclear charge increases, the **shielding effect** reduces the attraction, causing atomic size to increase.

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### iv. In a group, the elements have the same number of electrons in the outermost shell. Why is it so?

**Answer:**
Because all elements in a group have the **same valence electron configuration.** For example, Group 1 elements all have **1 electron in the outermost shell**, which gives them **similar chemical properties**.

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

**Answer:**
No, **sodium is more reactive than calcium**.
Even though calcium is lower in the periodic table, sodium belongs to **Group 1 (alkali metals)** which are more reactive than **Group 2 (alkaline earth metals)**. Also, sodium loses one electron easily due to lower ionization energy compared to calcium, which needs to lose two electrons.

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### vi. Which element has the maximum atomic radius and which element has the minimum atomic radius in third period?

**Answer:**

- **Maximum atomic radius:** Sodium (Na)
- **Minimum atomic radius:** Chlorine (Cl)

**Reason:** As we move from left to right in a period, atomic radius decreases due to increasing nuclear charge pulling electrons closer.

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### vii. Why are the most electronegative elements present in sixth and seventh groups?

**Answer:**
Actually, this seems to be a little confusing. The **most electronegative elements** are present in **Group 17 (halogens)** and **Group 16**, especially **fluorine** and **oxygen**. These elements have **high nuclear charge and small size**, allowing them to attract electrons strongly. Groups 6 and 7 (old numbering) correspond to modern Groups 16 and 17.

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

**Answer:**
The first ionization energy removes one electron from the outermost shell ($3s^2$). After removing the first electron, the second electron is removed from a **more positively charged ion**, which requires **more energy**. So, second ionization energy is always higher due to stronger nuclear attraction.

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

**Answer:**
No, ionic bonds are usually formed between a **metal and a non-metal** — metal loses electrons, non-metal gains.

- **Two non-metals** → form **covalent bonds**
- **Two metals** → generally form **metallic bonds**, not ionic

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### 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)** → easily loses electron
- **Highest electronegativity: Fluorine (F)** → strongly attracts electrons

# Constructed Response Questions

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

**Answer:**
If a new element is discovered, its **atomic number** and **electronic configuration** will be studied first. Based on these, we can determine:

- Which **period** it belongs to (based on number of electron shells)
- Which **group** it belongs to (based on number of valence electrons)

The modern periodic table is arranged in order of **increasing atomic number**, so the new element will be placed at a position where the **periodic trends** like valency, atomic radius, electronegativity, etc., match those of nearby elements.
This placement will ensure it falls into the correct **group of similar chemical properties**.

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

**Answer:**
The first element of the periodic table is **Hydrogen (H)**. Its atomic number is **1**, and its electronic configuration is **$1s^1$** — meaning it has **1 electron in its only shell**.

Hydrogen can:

- **Lose 1 electron** to form $H^+$ (like alkali metals), or
- **Gain 1 electron** to form $H^-$ (like halogens)

However, in most cases, **hydrogen loses one electron** and forms **$H^+$**, especially in acids and ionic compounds like HCl. Therefore, hydrogen behaves more like **Group 1 elements (alkali metals)** in many reactions.

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### 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)** has a **larger atomic radius** (125 pm) than **boron (B)** (88 pm).
This means the outermost electrons in aluminum are **farther from the nucleus** and **less tightly held** due to weaker nuclear attraction.

As a result, aluminum can **lose electrons more easily** than boron.
So, the element expected to lose electrons more easily is: **Aluminum (Al)**.

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## iv. How would you find the atomic radius of an atom?

**Answer:**
The atomic radius of an atom is defined as the **distance from the nucleus to the outermost electron shell**.

Since atoms are extremely small, atomic radius cannot be measured directly. Instead, scientists use the method of measuring **bond lengths** between two atoms of the same element in a molecule (usually in metallic or covalent forms).

Then, atomic radius is calculated using this formula:

***Atomic radius = ½ × Distance between two nuclei of bonded atoms***

For example, in a molecule like $Cl_2$, if the distance between the two Cl nuclei is 198 pm, then the atomic radius of Cl is 198 ÷ 2 = **99 pm**.

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## 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:**
The **oxygen atom** has **6 electrons** in its outermost shell. It needs **only 2 more** to complete its octet.
If oxygen tries to accept **3 electrons**, it would become $O^{3-}$, but this is **not possible** due to:

1. **Strong electron–electron repulsion:** Adding a third extra electron into an already negatively charged ion ($O^{2-}$) creates too much repulsion.
2. **Small size of oxygen atom:** The nucleus cannot hold that many extra electrons due to limited attractive force in such a small atom.

3. **Energy barrier:** The third electron would require **too much energy** to be added — making $O^{3-}$ unstable.

On the other hand, **nitrogen** has 5 electrons and needs 3 to complete octet. Its size and nuclear structure allow it to **form $N^{3-}$** without excessive repulsion.

# 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:**
To locate an element in the periodic table, the most important information is its **atomic number**, which tells us the number of protons and the arrangement of electrons in shells.

If atomic number is unknown, we can use:

- **Electronic configuration**
- **Atomic mass** (as an approximation)

Although atomic mass was used in early versions of the periodic table (like Mendeleev's table), it is not always reliable because some elements do not follow the mass order (e.g., Argon and Potassium).
Hence, **atomic mass may give a rough idea**, but **atomic number is essential** for accurate placement.

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## 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** in the periodic table:

1. **s-block** (Groups 1 and 2)
2. **p-block** (Groups 13 to 18)
3. **d-block** (Transition elements, Groups 3 to 12)
4. **f-block** (Lanthanides and Actinides)

These blocks are based on the type of **subshell (orbital)** in which the last electron enters.

Yes, blocks are very helpful in understanding:

- Chemical reactivity
- Valency
- Oxidation states
- Physical and chemical properties

For example:

- s-block elements are highly reactive metals
- p-block contains both metals and non-metals
- d-block elements show variable oxidation states
- f-block elements are rare earth metals

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## iii. Explain the variation in the following properties in the periods giving reasons.

### (a) Atomic radius

**Answer:**
As we move **left to right across a period**, the atomic number increases, and more **protons** are added to the nucleus, increasing the **nuclear charge**.

Although electrons are added too, they go into the **same shell**, so the increased nuclear pull **draws the electron cloud closer** to the nucleus.
As a result, **atomic radius decreases across a period.**

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### (b) Ionization energy

**Answer:**
Ionization energy is the energy required to remove an electron from an atom.

As we move **across a period from left to right**, the nuclear charge increases and the atomic radius decreases. Electrons are held more tightly.

So, it becomes **harder to remove an electron**, and hence, **ionization energy increases** across a period.

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

**Answer:**
Some key physical properties that help predict the type of bond are:

1. **Electronegativity**
   - High difference → Ionic bond
   - Low or no difference → Covalent bond
2. **Ionization energy**
   - Low ionization energy → atom can lose electrons → forms ionic bonds
3. **Electron affinity**
   - High affinity → atom gains electrons → favors ionic or covalent bonding
4. **Metallic or non-metallic character**
   - Metal + non-metal → ionic bond
   - Non-metal + non-metal → covalent bond
   - Metal + metal → metallic bond

These properties help chemists **predict bond type** and the chemical behavior of elements.

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

**Answer:**
Four non-metals that exist as **solids** at room temperature (25°C) are:

1. **Sulphur (S)**
2. **Phosphorus (P)**
3. **Iodine ($I_2$)**
4. **Carbon (C)** (in the form of graphite or diamond)

These are exceptions among non-metals, many of which are gases (e.g., $O_2$, $N_2$).

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

**Answer:**
The number of elements in a period depends on the **number of electrons that can be accommodated in the shells**.

- The **2nd and 3rd periods** both contain **8 elements** because the **2nd and 3rd shells** can accommodate a maximum of 8 electrons in their **s and p orbitals only**.

- In higher periods, additional orbitals (**d and f**) become available, which allows more elements to fit in.

Therefore, 2nd and 3rd periods have equal elements (8), while later periods have **18 or 32 elements** due to **availability of d and f subshells**.

# 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:**
Yes, the arrangement of elements into the **periodic table** is one of the **greatest achievements** in chemistry. It organizes all known elements in a logical manner based on **atomic number** and helps understand their properties and relationships.

Some **benefits** of the periodic table include:

1. **Systematic Arrangement:**
   Elements are arranged in rows (periods) and columns (groups) based on increasing atomic number and similar properties.
2. **Predictable Properties:**
   Elements in the same group have similar chemical behavior, making it easier to **predict reactions and compounds**.
3. **Trends and Patterns:**
   It reveals periodic trends such as atomic size, ionization energy, electronegativity, etc.
4. **Discovery of New Elements:**
   Gaps in the table have led to the prediction and discovery of unknown elements (e.g., gallium, germanium).
5. **Tool for Learning Chemistry:**
   The periodic table is a **framework for understanding** all branches of chemistry, from organic to inorganic to physical.

In short, the periodic table is like the **map of chemistry** — helping chemists navigate and discover.

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## 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:**
Yes, **lithium (Li)** and **beryllium (Be)** show **anomalous behavior** — meaning their chemical properties differ from the rest of their respective groups.

**Reasons for this difference:**

1. **Small Atomic and Ionic Size:**
   Li and Be have much smaller atoms and ions compared to the elements below them in their groups. This causes stronger attraction between nucleus and electrons.
2. **High Polarizing Power:**
   Due to their small size and high charge density, they **polarize** other atoms easily, leading to **more covalent character** in their compounds.
3. **High Ionization Energies:**
   Li and Be require more energy to lose electrons compared to others in their group, so their reactivity is **comparatively lower**.
4. **No Access to d-orbitals:**
   Li and Be have only s-orbitals available (n=2), while heavier group members can use d-orbitals — which affects bonding.

**Examples:**

- Lithium forms **$LiNO_3$** that does **not decompose** like other alkali nitrates.
- Beryllium hydroxide is **amphoteric** unlike other alkaline earth hydroxides which are basic.

Thus, the **diagonal relationship** and their unique electronic configuration cause them to behave differently.

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### 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 **Modern Periodic Table** is indeed an improved version of **Mendeleev's Periodic Table**, correcting many of its flaws. Here are the key differences:

| Feature | Mendeleev’s Table | Modern Periodic Table |
| --- | --- | --- |
| **Basis of Classification** | Atomic mass | Atomic number |
| **Anomalies** | Some elements didn’t fit order (e.g., Ar & K) | No anomalies; follows increasing atomic number |
| **Noble Gases** | Not included (unknown at that time) | Included as **Group 18** |
| **Position of Isotopes** | Could not be explained | Isotopes are placed in the same position (same atomic number) |
| **Structure** | Vertical groups and horizontal periods | Vertical groups (1–18) and horizontal periods (1–7) |
| **Prediction of Elements** | Predicted undiscovered elements | Also allows prediction but is complete up to atomic number 118 |

**Conclusion:**
Mendeleev’s table was a **foundation**, but the **modern table** based on atomic number is **scientifically accurate**, more consistent, and widely accepted today.