# MHT CET 2022 Aug 5 Shift 1 Question Paper with Solutions

| **Time Allowed :**3 Hours | **Maximum Marks :**200 | **Total Questions :**200 |
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**General Instructions**

**Read the following instructions very carefully and strictly follow them:**

1. The test is of 3 hours duration.
2. The question paper consists of 200 questions. The maximum marks are 200.
3. There are three parts in the question paper consisting of Physics, Chemistry and Biology (Botany and Zoology) having 50 questions in each part of equal weightage.

**1. How many atoms are in a bcc unit cell?**

**Solution:**
**Step 1: Understand the positions of atoms in BCC -**
In a Body-Centered Cubic (BCC) arrangement, atoms are located at all eight corners of the cube and one single atom is located at the geometric center of the cube.
**Step 2: Calculate contribution from the corners -**
Each atom at a corner is shared by 8 adjacent unit cells. Therefore, the contribution of one corner atom to a single unit cell is 1/8. Since there are 8 corners:

$$\text{Contribution from corners} = 8 \times \frac{1}{8} = 1 \text{ atom}$$

**Step 3: Calculate contribution from the body center -**
The atom at the body center is not shared by any other unit cell. It lies entirely within the specific unit cell.

$$\text{Contribution from center} = 1 \times 1 = 1 \text{ atom}$$

**Step 4: Find the total number of atoms (Z) -**

$$Z = (\text{Total corner contribution}) + (\text{Total center contribution})$$

$$Z = 1 + 1 = 2$$

**Quick Tip**

Remember the 'Z' values for common unit cells: Simple Cubic = 1, BCC = 2, and FCC = 4. This is fundamental for solving density and packing efficiency problems.

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**2. Find Density.**

**Solution:**
**Step 1: Basic definition of Density -**
Density ($\rho$) is defined as the mass of the unit cell divided by its volume.

$$\rho = \frac{\text{Mass of unit cell}}{\text{Volume of unit cell}} \quad \ldots (i)$$

**Step 2: Calculate the Mass of the unit cell -**
The mass of the unit cell is the product of the number of atoms in the unit cell ($Z$) and the mass of a single atom ($m$).

$$\text{Mass of unit cell} = Z \times m$$

The mass of a single atom ($m$) is the Molar Mass ($M$) divided by Avogadro's Number ($N_A$).

$$m = \frac{M}{N_A} \implies \text{Mass of unit cell} = \frac{Z \times M}{N_A}$$

**Step 3: Calculate the Volume of the unit cell -**
For a cubic unit cell with edge length '$a$', the volume ($V$) is:

$$V = a^3$$

**Step 4: Substitute into the density formula -**
Substitute the mass and volume back into equation ($i$):

$$\rho = \frac{\frac{Z \times M}{N_A}}{a^3}$$

$$\rho = \frac{Z \times M}{a^3 \times N_A}$$

Quick Tip

When calculating, pay close attention to units. If edge length is in picometers ($pm$), convert it to centimeters ($cm$) by multiplying by $10^{-10}$ to get density in $g/cm^3$.

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**3. Froth is a Solution of?**

**Solution:**
**Step 1: Identify the components of Froth -**
Froth (or foam) is a colloidal system. Every colloid consists of a 'Dispersed Phase' (the substance being spread) and a 'Dispersion Medium' (the substance in which it is spread).
**Step 2: Determine the Phase and Medium -**
In froth, air or other gases are trapped as tiny bubbles within a liquid.

- **Dispersed Phase:** Gas
- **Dispersion Medium:** Liquid

**Step 3: Classification -**
Colloids where a gas is dispersed in a liquid are specifically called **Foams**. Common examples include soap suds, whipped cream, and shaving cream.

> Quick Tip
>
> Do not confuse 'Foam' (Gas in Liquid) with 'Liquid Aerosol' (Liquid in Gas, like fog) or 'Solid Foam' (Gas in Solid, like pumice stone).

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**4. The first oxidation of a secondary alcohol is?**

**Solution:**
**Step 1: Analyze the structure of a Secondary ($2^{\circ}$) Alcohol -**
In a secondary alcohol, the hydroxyl ($-OH$) group is attached to a carbon atom which is further bonded to two other carbon atoms (alkyl groups). Its general formula is $R_2CHOH$.
**Step 2: The Oxidation Process -**
Oxidation of alcohols involves the removal of a hydrogen atom from the $-OH$ group and another hydrogen atom from the carbon atom to which the $-OH$ is attached (the $\alpha$-carbon).
**Step 3: Formation of the Carbonyl Group -**
The removal of these two hydrogens creates a double bond between the carbon and oxygen ($C = O$).

$$R - CH(OH) - R \xrightarrow{[O]} R - C(= O) - R + H_2O$$

**Step 4: Identify the product -**
Since the carbonyl group ($C = O$) is bonded to two alkyl groups ($R$), the resulting compound is a **Ketone**.

> Quick Tip
>
> Primary alcohols oxidize to Aldehydes (and then to Carboxylic acids), while Secondary alcohols stop at Ketones because there is no remaining hydrogen on the carbonyl carbon to be oxidized.

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**5. Dow's process is used ?**

**Solution:**
**Step 1: Identify the objective of the Dow's Process -**
Dow's process is a major industrial method used for the commercial production of Phenol from halogenated aromatic hydrocarbons.
**Step 2: The First Stage (Nucleophilic Substitution) -**
Chlorobenzene is reacted with a concentrated solution of Sodium Hydroxide ($NaOH$). Because the $C - Cl$ bond in chlorobenzene has partial double bond character, extreme conditions are required.

- **Temperature:** $\approx$ 623 K (350°C)
- **Pressure:** $\approx$ 300 atm

This forms Sodium Phenoxide ($C_6H_5ONa$).

$$C_6H_5Cl + 2NaOH \xrightarrow{623K, 300atm} C_6H_5ONa + NaCl + H_2O$$

**Step 3: The Second Stage (Acidification) -**
The sodium phenoxide is then treated with dilute $HCl$ to release the free Phenol.

$$C_6H_5ONa + HCl \rightarrow C_6H_5OH + NaCl$$

Quick Tip

Dow's process is a classic example of Nucleophilic Aromatic Substitution ($S_NAr$) occurring via a 'Benzyne' intermediate or through drastic conditions.

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**6. The highest oxidation state of manganese is?**

**Solution:**
**Step 1: Write the electronic configuration of Mn -**
Manganese (Mn) has an atomic number of 25. Its ground-state electronic configuration is:

$$[Ar]3d^5 4s^2$$

**Step 2: Identify valence electrons -**
Manganese has 2 electrons in the 4$s$ orbital and 5 unpaired electrons in the 3$d$ orbitals.
**Step 3: Determine the maximum oxidation state -**
The maximum oxidation state of a transition metal is often the sum of its $ns$ and $(n-1)d$ electrons.

$$\text{Max Oxidation State} = 2(4s) + 5(3d) = +7$$

**Step 4: Example compound -**
In the permanganate ion ($MnO_4^-$), manganese is in its highest oxidation state of +7.

Quick Tip

Manganese shows the widest range of oxidation states (from +2 to +7) among the 3d-transition series elements.

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**7. Polymers used for making toys are?**

**Solution:**
**Step 1: Analyze Polystyrene -**

Polystyrene is a clear, hard, and brittle plastic. It is commonly used for making inexpensive plastic toys, model kits, and puzzles.

**Step 2: Analyze PVC -**

Polyvinyl chloride (PVC) is versatile. When plasticized, it becomes flexible and is used to make soft toys, dolls, and action figures.

**Step 3: Analyze HDPE and LDPE -**

High-density polyethylene (HDPE) and Low-density polyethylene (LDPE) are used for durable, non-toxic toys like building blocks (e.g., LEGO) and sand buckets.

**Step 4: Conclusion -**

Since all these polymers are extensively used in the toy industry depending on the required flexibility and strength, "All of the above" is the correct choice.

> Quick Tip
>
> Polystyrene is often chosen for toys because it is easy to mold and can be made in bright, attractive colors.

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**8. The radius of the third Bohr orbit for Hydrogen is?**

**Solution:**

**Step 1: State the Bohr radius formula -**

The radius of the $n^{th}$ orbit for a hydrogen-like atom is given by:

$$r_n = a_0 \times \frac{n^2}{Z}$$

Where:

- $a_0$ (Bohr radius) = 0.529 Å (or 52.9 pm)
- $n$ = Principal quantum number (orbit number)
- $Z$ = Atomic number

**Step 2: Identify values for the third orbit of H -**

For Hydrogen, $Z = 1$. For the third orbit, $n = 3$.

**Step 3: Calculate the radius -**

$$r_3 = 0.529 \times \frac{3^2}{1}$$

$$r_3 = 0.529 \times 9$$

$$r_3 = 4.761 \text{ Å}$$

**Step 4: Result in pm -**

$r_3 = 476.1$ pm.

Quick Tip

The radius of Bohr orbits increases in the ratio of squares of the orbit number ($1^2 : 2^2 : 3^2 \dots$), meaning the orbits get significantly farther apart as $n$ increases.

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**9. The number of sigma ($\sigma$) bonds in Vanillin is?**

**Solution:**
**Step 1: Draw the structure of Vanillin -**
Vanillin (4-hydroxy-3-methoxybenzaldehyde) consists of a benzene ring with three functional groups: an aldehyde ($-CHO$), a hydroxyl ($-OH$), and a methoxy ($-OCH_3$).
**Step 2: Count bonds in the Benzene ring -**
The ring has 6 $C-C$ bonds and 3 $C-H$ bonds (where substituents are not attached).

- 6 $\sigma$ bonds from $C-C$
- 3 $\sigma$ bonds from $C-H$

**Step 3: Count bonds in functional groups -**

- Aldehyde ($-CHO$): $1(C - C_{ring}) + 1(C = O \text{ is } 1\sigma) + 1(C - H) = 3\sigma$
- Hydroxyl ($-OH$): $1(C_{ring} - O) + 1(O - H) = 2\sigma$
- Methoxy ($-OCH_3$): $1(C_{ring} - O) + 1(O - C_{methyl}) + 3(C - H_{methyl}) = 5\sigma$

**Step 4: Total sum -**
Total $\sigma = 6(\text{ring}) + 3(\text{ring H}) + 3(\text{ald}) + 2(\text{OH}) + 5(\text{methoxy}) = 19$.

Quick Tip

To avoid mistakes, always draw the complete expanded structure including all hidden hydrogen atoms before counting $\sigma$ and $\pi$ bonds.

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**10. Which is the most unstable carbocation?**

**Solution:**
**Step 1: Understand carbocation stability -**
Stability depends on the hybridization of the carbon carrying the positive charge. Higher $s$-character means higher electronegativity, which makes it harder for the carbon to hold a positive charge.
**Step 2: Compare hybridization -**

- $CH_3CH_2^+$: Positive charge on $sp^2$ carbon (33% $s$-character).

- $CH_2 = CH^+$ (Vinyl): Positive charge on *sp* carbon (50% *s*-character).

**Step 3: Analyze Vinyl and Phenyl ions -**
In Vinyl and Phenyl ($C_6H_5^+$) carbocations, the positive charge is on a carbon involved in a double bond. Because *sp* carbons are more electronegative, they are extremely unstable with a positive charge.
**Step 4: Comparison -**
While Methyl is unstable, Vinyl carbocations are even less stable because the positive charge is held by a more electronegative carbon atom.

> Quick Tip
>
> Stability order: Tertiary ¿ Secondary ¿ Primary ¿ Methyl ¿ Vinyl. Vinyl carbocations are so unstable they are rarely formed in standard reactions.

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**11. Aldol condensation between which of the following compounds followed by dehydration gives 4-Methylpent-3-en-2-one?**

(1) Two Molecules of $CH_3COCH_3$
(2) Two Molecules of $CH_3CHO$
(3) $CH_3CHO$ and $HCHO$
(4) $CH_3CHO$ and $CH_3COCH_3$

**Correct Answer:** (1) Two Molecules of $CH_3COCH_3$

**Solution:**
**Step 1: Write the structure of the product -**
The product is 4-Methylpent-3-en-2-one (also known as Mesityl oxide).
Structure: $(CH_3)_2C = CH - CO - CH_3$.
**Step 2: Use retrosynthetic analysis -**
In aldol condensation followed by dehydration, a double bond is formed by removing $H_2O$. To find the reactants, break the $C = C$ bond:

- Add Oxygen ($= O$) to the carbon atom that does *not* have the carbonyl group.
- Add two Hydrogen atoms ($H_2$) to the alpha-carbon (the one adjacent to the carbonyl group).

This gives us: $(CH_3)_2C = O$ and $CH_3 - CO - CH_3$.
**Step 3: Identify the starting material -**
Both fragments are molecules of Propanone (Acetone).
**Step 4: Chemical Reaction -**
$2CH_3COCH_3 \xrightarrow{Ba(OH)_2} (CH_3)_2C(OH)CH_2COCH_3 \xrightarrow{\Delta, -H_2O} (CH_3)_2C = CHCOCH_3$.

> Quick Tip
>
> To identify Aldol products, look for the $\alpha, \beta$-unsaturated carbonyl structure. The $\beta$-carbon always comes from the carbonyl carbon of the second molecule.

**12. Which of the following is not a transition element?**

(1) Sc
(2) Pt
(3) Ag
(4) Zn

**Correct Answer:** (4) Zn

**Solution:**
**Step 1: Define a transition element -**
According to the IUPAC definition, a transition element is one which has an **incomplete** ***d*****-subshell** either in its neutral atomic state or in any of its common oxidation states.
**Step 2: Examine the electronic configurations -**
- **Sc (Z=21):** $[Ar]3d^1 4s^2$ (Incomplete *d*-subshell).
- **Pt (Z=78):** $[Xe]4f^{14}5d^9 6s^1$ (Incomplete *d*-subshell).
- **Ag (Z=47):** $[Kr]4d^{10}5s^1$. Although the atom is $d^{10}$, it is classified as a transition metal because its ions (like $Ag^{2+}$) can have incomplete shells.
**Step 3: Analyze Zinc (Zn) -**
Zinc (Z=30) has the electronic configuration $[Ar]3d^{10}4s^2$.
Its most common ion, $Zn^{2+}$, has the configuration $[Ar]3d^{10}$.
**Step 4: Conclusion -**
Since Zinc has a **completely filled *d*-subshell** in both its ground state and its ionic state, it is not considered a transition element, even though it is a *d*-block element.

> Quick Tip
>
> Group 12 elements (Zn, Cd, Hg) are often called "non-typical transition elements" because their *d*-orbitals are full and do not participate in bonding in the same way as other transition metals.

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**13. Father of green chemistry is?**

**Solution:**
**Step 1: Identify the contribution -**
The term "Green Chemistry" was coined by **Paul Anastas**.
**Step 2: Historical context -**
In 1991, Paul Anastas (then at the U.S. EPA) and John Warner developed the framework for designing chemical products and processes that reduce or eliminate the use of hazardous substances.
**Step 3: The 12 Principles -**
Anastas and Warner published the **12 Principles of Green Chemistry** in 1998, which serve as a guide for sustainable chemical practice.

Quick Tip

Green chemistry is also known as sustainable chemistry. It focuses on the design phase to prevent pollution rather than treating it after it is created.

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**14. Relation between $P10$ and $P$ in vapor pressure?**

**Solution:**
**Step 1: Define the symbols -**
Let $P^0$ be the vapor pressure of a pure solvent and $P$ be the vapor pressure of a solution containing a non-volatile solute.
**Step 2: Apply Raoult's Law -**
According to Raoult's Law: $P = P^0 \times X_{solvent}$, where $X_{solvent}$ is the mole fraction of the solvent.
**Step 3: Analyze the mole fraction -**
In a solution, the mole fraction of the solvent ($X_{solvent}$) is always less than 1 (because $X_{solvent} + X_{solute} = 1$).

$$P = P^0 \times (\text{a value less than 1}) \implies P < P^0$$

**Step 4: Physical explanation -**
The presence of non-volatile solute particles on the surface of the liquid reduces the number of solvent molecules available to escape into the vapor phase, thus lowering the vapor pressure.

Quick Tip

The difference ($P^0 - P$) is known as the "Lowering of Vapor Pressure." It is a fundamental concept for all colligative properties.

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**15. Variation of capacitive reactance.**

**Solution:**
**Step 1: Define Capacitive Reactance -**
Capacitive reactance ($X_C$) is the opposition offered by a capacitor to the flow of alternating current (AC). It is measured in Ohms ($\Omega$).
**Step 2: Mathematical Formula -**
The formula for capacitive reactance is given by:

$$X_C = \frac{1}{\omega C}$$

Since angular frequency $\omega = 2\pi f$, the formula becomes:

$$X_C = \frac{1}{2\pi f C}$$

Where:

- $f$ = frequency of the AC source (in Hertz)
- $C$ = capacitance (in Farads)

**Step 3: Analyze the relationship with frequency -**
From the formula, it is evident that for a constant capacitance ($C$), the capacitive reactance is **inversely proportional** to the frequency ($f$).

$$X_C \propto \frac{1}{f}$$

**Step 4: Behavioral Analysis -**

- **At Low Frequencies:** As $f$ decreases, $X_C$ increases. For Direct Current (DC), where $f = 0$, $X_C$ becomes infinite ($\infty$). Thus, a capacitor blocks DC.
- **At High Frequencies:** As $f$ increases, $X_C$ decreases. At very high frequencies, the capacitor offers almost zero resistance and acts as a short circuit.

Quick Tip

The graph of $X_C$ versus $f$ is a **rectangular hyperbola**. This inverse relationship is the reason why capacitors are used in filters to allow high-frequency signals while blocking low-frequency or DC signals.

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**16. Thermal Conductivity**

**Solution:**
**Step 1: Definition -**
Thermal conductivity ($k$) is a measure of a material's ability to conduct heat. It is a material constant that describes the rate at which heat energy passes through a unit thickness of a material per unit area per unit temperature difference.
**Step 2: Fourier's Law of Heat Conduction -**
The rate of heat flow ($Q$) through a uniform slab is given by:

$$\frac{Q}{t} = \frac{kA(T_1 - T_2)}{L}$$

Where:

- $A$ = Cross-sectional area through which heat flows.
- $T_1 - T_2$ = Temperature difference across the material.
- $L$ = Thickness or length of the conductor.
- $k$ = Coefficient of Thermal Conductivity.

**Step 3: Units and Dimensions -**
The SI unit of thermal conductivity is $\mathbf{W\ m^{-1}\ K^{-1}}$ (Watt per meter-Kelvin). Its dimensional formula is $[MLT^{-3}\theta^{-1}]$.
**Step 4: Dependency -**
Thermal conductivity depends on the nature of the material (e.g., metals vs. insulators), its state (solid, liquid, or gas), and temperature. Metals generally have high thermal conductivity due to the presence of free electrons.

> Quick Tip
>
> For an ideal conductor, $k = \infty$, and for an ideal insulator, $k = 0$. In real materials, Diamond has exceptionally high thermal conductivity.

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**17. Intensive Property**

**Solution:**
**Step 1: Define Intensive Property -**
In thermodynamics, an intensive property is a physical property of a system that does **not** depend on the system size or the amount of material in the system. It is a bulk property.
**Step 2: Contrast with Extensive Property -**
Unlike extensive properties (like mass or volume), which change as the amount of matter changes, intensive properties remain constant regardless of the sample size.
**Step 3: Common Examples -**

- **Temperature:** If you split a cup of boiling water into two, the temperature of both parts remains 100°C.
- **Pressure:** Pressure is the same throughout a uniform system at equilibrium.
- **Density:** The ratio of mass to volume is constant for a uniform substance.
- **Molar properties:** Molar volume, molar enthalpy, etc.

**Step 4: Mathematical check -**
If we divide a system into two parts, properties that stay the same (like color or boiling point) are intensive. Properties that are halved (like weight or internal energy) are extensive.

> Quick Tip
>
> A simple way to remember: The ratio of two extensive properties is always an **intensive** property. For example: Density = $\frac{\text{Mass}}{\text{Volume}}$.

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**18. Find resistance in a delta shape terminal.**

**Solution:**

**Step 1: Understand the Delta ($\Delta$) Configuration -**

A Delta network consists of three resistors connected end-to-end to form a triangle. Let the resistors be $R_a, R_b$, and $R_c$.

**Step 2: Identify the Terminals -**

Suppose we want to find the equivalent resistance ($R_{eq}$) between two specific terminals (say, across resistor $R_a$).

**Step 3: Analyze series and parallel paths -**

When looking across one resistor ($R_a$):

1. The other two resistors ($R_b$ and $R_c$) are connected in **series** with each other.
2. Their combined series resistance is $R_s = R_b + R_c$.
3. This series combination is then in **parallel** with the first resistor $R_a$.

**Step 4: Final Formula -**

The equivalent resistance across that pair of terminals is:

$$R_{eq} = \frac{R_a \times (R_b + R_c)}{R_a + (R_b + R_c)}$$

> Quick Tip
>
> If all three resistors in the delta are equal ($R$), the equivalent resistance between any two corners is simply $\frac{2}{3}R$.

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**19. Find ratio of the final surface energy**

**Solution:**

**Step 1: Problem Context -**

This typically refers to the coalescing of smaller drops into one large drop. Let's assume $n$ small drops of radius $r$ coalesce to form one large drop of radius $R$.

**Step 2: Conservation of Volume -**

$$\text{Volume of large drop} = n \times \text{Volume of small drops}$$

$$\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3 \implies R = n^{1/3} r$$

**Step 3: Calculate Initial Surface Energy ($U_i$) -**

Surface energy $U$ = Surface Tension ($T$) $\times$ Area ($A$).

$$U_i = n \times (T \times 4\pi r^2) = 4n\pi r^2 T$$

**Step 4: Calculate Final Surface Energy ($U_f$) -**

$$U_f = T \times 4\pi R^2 = T \times 4\pi (n^{1/3} r)^2 = 4n^{2/3}\pi r^2 T$$

**Step 5: Determine the Ratio -**
The ratio of final surface energy to initial surface energy is:

$$\frac{U_f}{U_i} = \frac{4n^{2/3}\pi r^2 T}{4n\pi r^2 T} = \frac{n^{2/3}}{n} = n^{-1/3} \text{ or } \frac{1}{\sqrt[3]{n}}$$

> **Quick Tip**
>
> When drops coalesce, surface area decreases, energy is released (as heat), and the temperature of the liquid increases.

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**20. Calculate the phase angle**

**Solution:**
**Step 1: Context of Phase Angle ($\phi$) -**
In an AC circuit (specifically an LCR series circuit), the phase angle $\phi$ describes the lead or lag between the total voltage and the current.
**Step 2: Use the Impedance Triangle -**
In a series LCR circuit, the resistance ($R$) is on the base, and the net reactance ($X_L - X_C$) is the perpendicular.
**Step 3: The Formula -**
The phase angle is calculated using:

$$\tan\phi = \frac{X_L - X_C}{R}$$

Where:

- $X_L = 2\pi f L$ (Inductive Reactance)
- $X_C = \frac{1}{2\pi f C}$ (Capacitive Reactance)
- $R$ = Resistance

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

**Step 4: Interpretation -**

- If $X_L > X_C$, $\phi$ is positive (Circuit is Inductive; Voltage leads Current).
- If $X_L < X_C$, $\phi$ is negative (Circuit is Capacitive; Current leads Voltage).

> **Quick Tip**
>
> At resonance, $X_L = X_C$, so $\tan\phi = 0$, which means $\phi = 0°$. The voltage and current are in phase.

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