KEAM 2026 Pharmacy April 20

Question Paper with Solution

Conducted by CEE Kerala

General Instructions

(i) **Duration:** The total duration of the examination is 3 hours (180 minutes).

(ii) **Total Marks:** The complete paper carries a maximum of 600 marks.

(iii) **Structure:** The paper has 3 Sections:

- **Section A:** 45 Multiple Choice Questions (Physics).
- **Section B:** 30 Multiple Choice Questions (Chemistry).
- **Section B:** 75 Multiple Choice Questions (Mathematics).

(iv) **Compulsory Questions:** All 150 questions are compulsory.

(v) Each question has four options. Only **one** option is correct.

(vi) **Correct Answer:** +4 marks.

(vii) **Incorrect Answer:** −1 (Negative marking).

(viii) **Unanswered/Marked for Review:** 0 marks.

physics

1. The electromagnetic waves travel with

(A) the same speed in all media

(B) the speed of sound in free space

(C) the speed of light $c = 3 \times 10^8$ ms^1 in solid medium

(D) the speed of light $c = 3 \times 10^8$ ms^1 in fluid medium

(E) the speed of light $c = 3 \times 10^8$ ms^1 in free space

Correct Answer: (E) the speed of light $c = 3 \times 10^8$ ms^1 in free space

Solution:

Step 1: Understanding the Concept:

Electromagnetic (EM) waves consist of oscillating electric and magnetic fields. A defining characteristic of EM waves is that they do not require a material medium to propagate; they can travel through a vacuum (free space).

Step 2: Key Formula or Approach:

The speed of electromagnetic waves in a vacuum is a fundamental constant, given by the formula:

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \approx 3 \times 10^8 \text{ m/s}$$

where μ_0 is the permeability of free space and ϵ_0 is the permittivity of free space. In any material medium, the speed v is given by $v = \frac{c}{n}$, where n is the refractive index of the medium ($n > 1$).

Step 3: Detailed Explanation:

Let's analyze the given options:

- (A) is incorrect because the speed depends on the medium's refractive index. EM waves slow down when entering a denser medium.
- (B) is incorrect because sound is a mechanical wave that cannot travel in free space, meaning its speed is zero there, whereas EM waves travel at their maximum speed.
- (C) and (D) are incorrect because light slows down when it enters a solid or fluid medium due to their refractive indices being greater than 1.
- (E) is correct. Electromagnetic waves, including light, travel at their maximum speed $c = 3 \times 10^8$ m/s in free space (a vacuum).

Step 4: Final Answer:

The electromagnetic waves travel with the speed of light $c = 3 \times 10^8$ ms^1 in free space.

Quick Tip: Always remember that $c = 3 \times 10^8$ m/s is the universal speed limit, achievable only in a perfect vacuum. In any other medium, the speed of the wave will be less than c.

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2. The de Broglie wavelength and kinetic energy of a particle is 2000 Å and 1 eV respectively. If its kinetic energy becomes 1 MeV, then its de Broglie wavelength is

(A) 2 Å
(B) 1 Å
(C) 4 Å
(D) 10 Å
(E) 5 Å

Correct Answer: (A) 2 Å

Solution:

Step 1: Understanding the Concept:
The de Broglie hypothesis states that a moving particle has an associated wave nature. The wavelength of this matter wave (λ) is inversely proportional to the particle's momentum (p).

Step 2: Key Formula or Approach:
The de Broglie wavelength is given by:

$$\lambda = \frac{h}{p}$$

The kinetic energy (K) and momentum (p) of a non-relativistic particle are related by $K = \frac{p^2}{2m}$, which gives $p = \sqrt{2mK}$. Substituting this into the wavelength formula yields:

$$\lambda = \frac{h}{\sqrt{2mK}}$$

For the same particle, mass m is constant, so $\lambda \propto \frac{1}{\sqrt{K}}$.

Step 3: Detailed Explanation:
Let the initial state be 1 and the final state be 2.

Given values:

$\lambda_1 = 2000$ Å

$K_1 = 1$ eV

$K_2 = 1$ MeV $= 10^6$ eV

Using the proportional relationship, we set up the ratio:

$$\frac{\lambda_2}{\lambda_1} = \sqrt{\frac{K_1}{K_2}}$$

Substitute the known values into the equation:

$$\frac{\lambda_2}{2000 \text{ Å}} = \sqrt{\frac{1 \text{ eV}}{10^6 \text{ eV}}}$$

$$\frac{\lambda_2}{2000 \text{ Å}} = \sqrt{10^{-6}}$$

$$\frac{\lambda_2}{2000 \text{ Å}} = 10^{-3}$$

Now, solve for the final wavelength λ_2:

$$\lambda_2 = 2000 \text{ Å} \times 10^{-3}$$

$$\lambda_2 = 2 \text{ Å}$$

Step 4: Final Answer:

The new de Broglie wavelength is 2 Å.

Quick Tip: When evaluating proportional changes, setting up a ratio like λ_2/λ_1 is the most efficient method as it eliminates the need to calculate intermediate constants like mass or momentum directly. Make sure both kinetic energy values are in the same unit before dividing.

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3. A plane electromagnetic wave travels in free space along X-direction. If the value of B (in

tesla) at a particular point in space and time is $1.2\times10^{-8}\hat{k}$. The value of E (in Vm^{1}) at that point is

(A) $1.2\hat{j}$

(B) $3.6\hat{k}$

(C) $1.2\hat{k}$

(D) $3.6\hat{j}$

(E) $0.4\hat{i}$

Correct Answer: (D) $3.6\hat{j}$

Solution:

Step 1: Understanding the Concept:

In an electromagnetic wave propagating through free space, the electric field vector ($\vec{E}$), magnetic field vector ($\vec{B}$), and the direction of wave propagation ($\vec{v}$) are mutually perpendicular.

Step 2: Key Formula or Approach:

Two main relationships are used here:

1. Magnitude Relationship: $E_0 = cB_0$, where $c = 3 \times 10^8$ m/s.

2. Direction Relationship: The direction of wave propagation is given by the cross product of the electric and magnetic field directions: $\hat{v} = \hat{E} \times \hat{B}$.

Step 3: Detailed Explanation:

First, find the magnitude of $\vec{E}$:

Given $B_0 = 1.2 \times 10^{-8}$ T.

Using the magnitude formula:

$$E_0 = c \times B_0$$

$$E_0 = (3 \times 10^8 \text{ m/s}) \times (1.2 \times 10^{-8} \text{ T})$$

$$E_0 = 3 \times 1.2 = 3.6 \text{ V/m}$$

Second, find the direction of $\vec{E}$:

Given direction of propagation $\hat{v} = \hat{i}$ (X-direction).

Given direction of magnetic field $\hat{B} = \hat{k}$ (Z-direction).

Using the cross product relationship:

$$\hat{i} = \hat{E} \times \hat{k}$$

From the standard right-hand rule for unit vectors, we know that $\hat{j} \times \hat{k} = \hat{i}$.

Therefore, the direction of the electric field must be $\hat{j}$.

Combining magnitude and direction:

$$\vec{E} = E_0 \hat{E} = 3.6\hat{j}$$

Step 4: Final Answer:

The value of E at that point is $3.6\hat{j}$ Vm^1.

Quick Tip: To quickly find the direction, use the cyclic permutation of vectors $\hat{i}, \hat{j}, \hat{k}$. For an EM wave, the sequence $\vec{E} \to \vec{B} \to \vec{v}$ follows the right-hand rule. If you know any two, you can find the third by ensuring the cross product aligns properly in the cycle.

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4. The magnetic flux (in weber) linked with a coil of resistance 10 is varying with respect to time t as $\phi = 4t^2 + 2t + 1$. Then the current in the coil at time $t = 1$ second is

(A) 0.5 A

(B) 2 A

(C) 1.5 A

(D) 1 A

(E) 2.5 A

Correct Answer: (D) 1 A

Solution:

Step 1: Understanding the Concept:

According to Faraday's law of electromagnetic induction, a time-varying magnetic flux through a coil induces an electromotive force (EMF) in the coil. This induced EMF then drives a current through the coil, which is governed by Ohm's law.

Step 2: Key Formula or Approach:

1. The magnitude of induced EMF ($|\epsilon|$) is the rate of change of magnetic flux:

$$|\epsilon| = \left|\frac{d\phi}{dt}\right|$$

2. The induced current (I) is given by Ohm's Law:

$$I = \frac{|\epsilon|}{R}$$

where R is the resistance of the coil.

Step 3: Detailed Explanation:

The given equation for magnetic flux is:

$$\phi = 4t^2 + 2t + 1$$

Differentiate the flux equation with respect to time t to find the induced EMF:

$$\frac{d\phi}{dt} = \frac{d}{dt}(4t^2 + 2t + 1)$$

$$\frac{d\phi}{dt} = 8t + 2$$

Now, calculate the magnitude of the EMF at the specific instant $t = 1$ second:

$$|\epsilon| = |8(1) + 2|$$

$$|\epsilon| = 10 \text{ V}$$

Given the resistance of the coil is $R = 10$ (ohms), we calculate the induced current:

$$I = \frac{|\epsilon|}{R}$$

$$I = \frac{10}{10}$$

$$I = 1 \text{ A}$$

Step 4: Final Answer:

The current in the coil at time $t = 1$ second is 1 A.

Quick Tip: Always differentiate the flux function first to get an expression for the EMF as a function of time. Only substitute the specified time value into the derivative equation as your final step before calculating the current.

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5. The work functions of two metals are 2.75 eV and 2 eV respectively. If these are irradiated by photons of energy 3 eV, the ratio of maximum momenta of the photoelectrons emitted respectively by them is

(A) 1:2

(B) 1:3

(C) 1:4

(D) 2:1

(E) 4:1

Correct Answer: (A) 1:2

Solution:

Step 1: Understanding the Concept:

The photoelectric effect is described by Einstein's equation, which dictates that the maximum kinetic energy of emitted photoelectrons equals the energy of the incident photons minus the metal's work function.

Step 2: Key Formula or Approach:

1. Einstein's Photoelectric Equation:

$$K_{\max} = E - \Phi$$

where $K_{\max}$ is maximum kinetic energy, E is photon energy, and Φ is the work function. 2. The relation between kinetic energy and momentum (p):

$$p = \sqrt{2mK_{\max}}$$

Since the mass of the electron (m) is constant, the ratio of momenta for two different metals is:

$$\frac{p_1}{p_2} = \sqrt{\frac{K_1}{K_2}}$$

Step 3: Detailed Explanation:

Let's list the given parameters:

Incident photon energy, $E = 3$ eV

Work function of metal 1, $\Phi_1 = 2.75$ eV

Work function of metal 2, $\Phi_2 = 2$ eV

Calculate the maximum kinetic energy for the first metal (K_1):

$$K_1 = E - \Phi_1$$

$$K_1 = 3 \text{ eV} - 2.75 \text{ eV} = 0.25 \text{ eV}$$

Calculate the maximum kinetic energy for the second metal (K_2):

$$K_2 = E - \Phi_2$$

$$K_2 = 3 \text{ eV} - 2 \text{ eV} = 1 \text{ eV}$$

Calculate the ratio of their maximum momenta:

$$\frac{p_1}{p_2} = \sqrt{\frac{K_1}{K_2}}$$

$$\frac{p_1}{p_2} = \sqrt{\frac{0.25 \text{ eV}}{1 \text{ eV}}}$$

$$\frac{p_1}{p_2} = \sqrt{0.25}$$

$$\frac{p_1}{p_2} = 0.5 = \frac{1}{2}$$

Step 4: Final Answer:

The ratio of the maximum momenta of the photoelectrons is 1 : 2.

Quick Tip: There's no need to convert electron-volts to Joules or calculate the actual mass of the electron because you are looking for a ratio. The conversion factors and mass terms cancel out, simplifying the math significantly.

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6. If the potential at A is zero, potential at B is

(A) 0 V

(B) 4 V

(C) 6 V

(D) 2 V

Correct Answer: (A) 0 V

Solution:

Step 1: Understanding the Concept:

To determine the electric potential at a specific point in a circuit given the potential at another reference point, one must traverse the circuit path and account for the voltage drops or gains across the electrical components connecting them.

Step 2: Key Formula or Approach:

This type of problem utilizes Kirchhoff's Voltage Law (KVL) and Ohm's Law. Starting from a known potential V_A, the potential at B is found by summing the potential changes ΔV along the path:

$$V_B = V_A + \sum \Delta V$$

where ΔV can be $\pm IR$ for resistors and $\pm E$ for batteries.

Step 3: Detailed Explanation:

The given image provides the question text and options but crucially lacks the associated circuit diagram showing points A and B, as well as the intermediate components (resistors, batteries) and their respective values.

Because the circuit diagram is missing from the provided material, it is impossible to trace the path from A to B and calculate the voltage changes. Consequently, a numerical solution cannot be rigorously derived. The provided answer is a structural placeholder.

Step 4: Final Answer:

The problem is incomplete due to a missing circuit diagram, making it unsolvable as presented.

Quick Tip: In questions involving potentials at specific nodes, always carefully trace the path from the node with the known potential to the target node. Pay strict attention to polarity: traversing a battery from negative to positive adds voltage, and traversing a resistor in the direction of current subtracts voltage.

Chemistry

1. From the following pairs of ions which one is not an iso-electronic pair?

(a) Na, Mg^3

(b) Mn^2, Fe^3

(c) Fe^2, Mn^3

(d) O^2, F

Correct Answer: (c) Fe^2, Mn^3

Solution:

Step 1: Understanding the Concept:

Isoelectronic species are atoms, ions, or molecules that possess the same total number of electrons. To determine which pair is not isoelectronic, we must calculate the electron count for each ion presented in the options.

Step 2: Key Formula or Approach:

The number of electrons in an ion can be calculated using the formula:

Number of electrons = Atomic number (Z) − Charge of the ion.

Note: The options provided in the original text contain typographical errors, lacking standard '+' and '-' charge indicators. To solve the problem logically, we must interpret them as common, stable ions: Na^+, Mg^{2+}, Mn^{2+}, Fe^{3+}, Fe^{2+}, Mn^{3+}, and O^{2-}, F^-.

Step 3: Detailed Explanation:

Let's analyze each pair based on their standard ionic forms:

- **Pair (a) interpreted as Na^+, Mg^{2+}:**

Sodium (Na) has $Z = 11$. The number of electrons in $Na^+ = 11 - 1 = 10$.

Magnesium (Mg) has $Z = 12$. The number of electrons in $Mg^{2+} = 12 - 2 = 10$.

Both have 10 electrons, making them an isoelectronic pair.

- **Pair (b) interpreted as Mn^{2+}, Fe^{3+}:**

Manganese (Mn) has $Z = 25$. The number of electrons in $Mn^{2+} = 25 - 2 = 23$.

Iron (Fe) has $Z = 26$. The number of electrons in $Fe^{3+} = 26 - 3 = 23$.

Both have 23 electrons, making them an isoelectronic pair.

- **Pair (c) interpreted as Fe^{2+}, Mn^{3+}:**

Iron (Fe) has $Z = 26$. The number of electrons in $Fe^{2+} = 26 - 2 = 24$.

Manganese (Mn) has $Z = 25$. The number of electrons in $Mn^{3+} = 25 - 3 = 22$.

They have different numbers of electrons (24 and 22 respectively), so they are **not** an isoelectronic pair.

- **Pair (d) interpreted as O^{2-}, F^{-}:**

Oxygen (O) has $Z = 8$. The number of electrons in $O^{2-} = 8 - (-2) = 10$.

Fluorine (F) has $Z = 9$. The number of electrons in $F^{-} = 9 - (-1) = 10$.

Both have 10 electrons, making them an isoelectronic pair.

Step 4: Final Answer:

The pair consisting of iron(II) and manganese(III) ions is not isoelectronic. Therefore, option (c) is the correct choice.

Quick Tip: When dealing with exam questions that appear to have typographical errors (like missing charge signs), use your chemical knowledge to infer the most likely intended meaning. Common stable oxidation states are usually what the examiner meant to write.

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2. The correct sequence of bond enthalpy of 'C-X' bond is:

(a) CH-F > CH-Cl > CH-Br > CH-I

(b) CH-F < CH-Cl > CH-Br > CH-I

(c) CH-Cl > CH-F > CH-Br > CH-I

(d) CH-F < CH-Cl < CH-Br < CH-I

Correct Answer: (a) CH-F > CH-Cl > CH-Br > CH-I

Solution:

Step 1: Understanding the Concept:

Bond enthalpy, also known as bond dissociation energy, is a measure of bond strength. It is the energy required to break one mole of a specific type of chemical bond in the gas phase. For carbon-halogen (C-X) bonds, this strength is intimately related to the atomic size of the halogen involved.

Step 2: Key Formula or Approach:

There is a fundamental inverse relationship between bond length and bond enthalpy. As the size of the halogen atom increases, the carbon-halogen bond length increases. A longer bond implies less effective orbital overlap between the carbon and halogen atoms, which results in a weaker bond and consequently, a lower bond enthalpy.

Step 3: Detailed Explanation:

Let's consider the halogens belonging to Group 17 of the periodic table: Fluorine (F), Chlorine (Cl), Bromine (Br), and Iodine (I).

As you move down the group, the number of electron shells increases, leading to an increase in atomic radius. Thus, the order of atomic size is:

$$F < Cl < Br < I$$

Because of this increasing size, the distance between the carbon nucleus and the halogen nucleus increases when they form a bond. This gives the following order for C-X bond lengths:

$$C\text{-}F < C\text{-}Cl < C\text{-}Br < C\text{-}I$$

Since shorter bonds have more effective orbital overlap and are thus stronger, the energy required to break them is higher. Therefore, the bond enthalpy decreases as the halogen becomes larger:

$$\text{C-F bond enthalpy} > \text{C-Cl bond enthalpy} > \text{C-Br bond enthalpy} > \text{C-I bond enthalpy}$$

This expected trend perfectly matches the sequence provided in option (a). *Note that 'CH-X' in the options is a general representation intended to mean the carbon-halogen bond.*

Step 4: Final Answer:

The correct decreasing sequence of bond enthalpy is CH-F > CH-Cl > CH-Br > CH-I.

Quick Tip: A simple rule to remember for organic halides: Larger halogens form longer, weaker bonds. This is why alkyl iodides are generally the most reactive towards nucleophilic substitution, as the weak C-I bond breaks easily.

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3. CHCHBr → (aq. KOH) → A → (PCl) → B

Final product B:

(A) CHCHOH

(B) CHCHCl

(C) CHCHBr

(D) CHCHO

(E) CHCHCOOH

Correct Answer: (B) CHCHCl

Solution:

Step 1: Understanding the Concept:

This problem outlines a two-step synthetic pathway. The first step involves treating an alkyl halide with aqueous potassium hydroxide, a standard condition for a nucleophilic substitution reaction that yields an alcohol. The second step involves reacting that alcohol with a phosphorus chloride reagent, which is a common method for converting alcohols back into alkyl halides, specifically alkyl chlorides.

Step 2: Key Formula or Approach:

Analytical Note: The chemical structures provided in the question (like 'CHCHBr') lack standard numerical subscripts. Based on standard organic chemistry curriculum, these most likely represent ethyl derivatives, where 'CHCH' stands for the ethyl group CH_3CH_2-. We will proceed with this logical assumption.

Reaction 1: Alkyl Halide + aq. KOH $\rightarrow$ Alcohol (via S_N2 or S_N1 mechanism)

Reaction 2: Alcohol + $PCl_3/PCl_5 \rightarrow$ Alkyl Chloride

Step 3: Detailed Explanation:

- **Step 1: Identifying Product A**

Assuming the starting material 'CHCHBr' is ethyl bromide (CH_3CH_2Br).

When ethyl bromide is treated with aqueous KOH, the hydroxide ion (OH^-) acts as a strong nucleophile and substitutes the bromide ion (Br^-), which is a good leaving group.

$$CH_3CH_2Br + KOH\ (aq) \rightarrow CH_3CH_2OH + KBr$$

Thus, intermediate product A is ethanol (CH_3CH_2OH). In the abbreviated notation of the question, this corresponds to 'CHCHOH'.

- **Step 2: Identifying Final Product B**

The intermediate A, ethanol (CH_3CH_2OH), is now reacted with a phosphorus chloride reagent, simply denoted as '(PCl)'. This typically implies phosphorus trichloride (PCl_3) or phosphorus pentachloride (PCl_5). Both serve the same primary function: replacing the hydroxyl group (—OH) with a chlorine atom (—Cl).

Using PCl_5 as an example:

$$CH_3CH_2OH + PCl_5 \rightarrow CH_3CH_2Cl + POCl_3 + HCl$$

The final product B is ethyl chloride (CH_3CH_2Cl). Translating this back into the specific, albeit typo-ridden, notation style of the options, it becomes 'CHCHCl'.

Comparing this deduction with the given options, we find it perfectly matches option (B).

Step 4: Final Answer:

The final product B is CHCHCl.

Quick Tip: Always pay close attention to the reaction conditions specified over the arrow. The presence of water ("aq. KOH") directs the reaction towards nucleophilic substitution forming an alcohol. If the reagent was alcoholic KOH ("alc. KOH"), it would act as a strong base, causing an elimination reaction to form an alkene instead.

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4. One mole of an alkene on ozonolysis gives a mixture of one mole pentan-3-one and one mole methanal. The alkene is (2024)

(a) 3-ethylbut-1-ene
(b) 2-methylpent-1-ene
(c) 2-ethylbut-1-ene
(d) 4-methylpent-2-ene
(e) 4-methylpent-1-ene

Correct Answer: (c) 2-ethylbut-1-ene

Solution:

Step 1: Understanding the Concept:

Ozonolysis is a powerful analytical reaction used to determine the position of double bonds in alkenes. During ozonolysis, ozone (O_3) completely cleaves the carbon-carbon double bond. Each of the carbon atoms that originally formed the double bond becomes double-bonded to an oxygen atom, resulting in the formation of smaller carbonyl compounds like aldehydes and ketones.

Step 2: Key Formula or Approach:

To deduce the structure of the original alkene from its given ozonolysis products, we use a simple reverse-engineering strategy:

1. Draw the chemical structures of the given product molecules.

2. Orient the molecules so that their carbonyl oxygen atoms (=O) are facing each other.

3. "Remove" these oxygen atoms and connect the two bare carbon atoms with a new carbon-carbon double bond.

Step 3: Detailed Explanation:

The problem states the products are pentan-3-one and methanal.

- First, let's draw pentan-3-one. It's a five-carbon chain ketone with the carbonyl group on the third carbon:

$$CH_3\text{-}CH_2\text{-}C(=O)\text{-}CH_2\text{-}CH_3$$

- Next, let's draw methanal (also known as formaldehyde). It's the simplest aldehyde:

$$H_2C{=}O$$

Now, applying our retro-synthetic "cut and paste" strategy:

Align the products:

$$(CH_3CH_2)_2C{=}O \quad + \quad O{=}CH_2$$

Remove the oxygen atoms and join the central carbons:

$$(CH_3CH_2)_2C{=}CH_2$$

Finally, we need to determine the proper IUPAC name for this reconstructed alkene:

1. **Identify the longest parent chain:** The longest continuous carbon chain that includes both carbons of the double bond has 4 carbon atoms. Thus, the parent name is based on 'butene'.

2. **Number the chain:** Number from the end that gives the lowest numbers to the double bond carbons.

$$CH_2 = C(CH_2CH_3) - CH_2 - CH_3$$

1 2 3 4

The double bond starts at C-1, so it is a 'but-1-ene'.

3. **Identify substituents:** There is an ethyl group ($-CH_2CH_3$) attached to carbon number 2.

4. **Assemble the name:** Putting it all together, the IUPAC name is **2-ethylbut-1-ene**.

This matches option (c).

Step 4: Final Answer:

The original alkene is 2-ethylbut-1-ene.

Quick Tip: This "erase the Os and draw a double bond" trick is the fastest and most reliable way to solve any structural ozonolysis problem on a multiple-choice exam. Practicing this visual method will save you valuable time.

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5. Correct order of acidic strength:

(A) Phenol > Ethanol > Acetic acid

(B) Acetic acid > Phenol > Ethanol

(C) Ethanol > Phenol > Acetic acid

(D) Phenol > Acetic acid > Ethanol

(E) Acetic acid > Ethanol > Phenol

Correct Answer: (B) Acetic acid > Phenol > Ethanol

Solution:

Step 1: Understanding the Concept:

The fundamental principle for comparing the acidic strength of different organic compounds is to assess the stability of their corresponding conjugate bases. An acid is considered strong

if it easily donates a proton (H^+). It will readily do so if the resulting negative species (the conjugate base) is stable. A more stable conjugate base corresponds to a stronger parent acid.

Step 2: Key Formula or Approach:

Determine the structure of the conjugate base for each given compound by removing an acidic proton. Then, evaluate and rank their stabilities based on electronic effects, primarily resonance delocalization and inductive effects.

Step 3: Detailed Explanation:

Let's examine the three compounds and their conjugate bases:

1. **Acetic acid (CH_3COOH):**

When it loses a proton, it forms the acetate ion (CH_3COO^-). This conjugate base is extremely stable because the negative charge is delocalized equally over two highly electronegative oxygen atoms via resonance. These equivalent resonance structures provide significant stabilization.

2. **Phenol (C_6H_5OH):**

Losing a proton yields the phenoxide ion ($C_6H_5O^-$). This ion also enjoys resonance stabilization; the negative charge initially on the oxygen atom can be delocalized into the π-electron system of the aromatic benzene ring. However, in these resonance structures, the negative charge is distributed onto carbon atoms, which are significantly less electronegative than oxygen. Consequently, this resonance is less effective at stabilizing the charge than the equivalent resonance seen in the acetate ion. Therefore, phenol is a weaker acid than acetic acid.

3. **Ethanol (C_2H_5OH):**

Deprotonation of ethanol gives the ethoxide ion ($C_2H_5O^-$). This ion lacks any resonance stabilization. Furthermore, the attached ethyl group ($-CH_2CH_3$) exerts an electron-donating inductive effect (+I effect). This pushes additional electron density onto the already negatively charged oxygen atom, intensifying the charge and destabilizing the ion. Because its conjugate base is the least stable, ethanol is the weakest acid of the three.

Synthesizing these observations, the order of conjugate base stability is:
Acetate ion > Phenoxide ion > Ethoxide ion
This directly translates to the order of acidic strength for their parent molecules:
Acetic acid > Phenol > Ethanol

Step 4: Final Answer:
The correct decreasing order of acidic strength is Acetic acid > Phenol > Ethanol.

Quick Tip: When evaluating resonance stabilization in conjugate bases, remember the rule of equivalence: Resonance structures that are identical (equivalent) are far more stabilizing than a greater number of non-equivalent structures. This is why carboxylic acids are stronger than phenols, despite phenols having more resonance contributors.

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6. Arrange the following amines in the decreasing order of their basic strength : Aniline (I), Benzylamine (II), p-toluidine (III)

(a) I > II > III
(b) III > II > I
(c) II > I > III
(d) III > I > II
(e) II > III > I

Correct Answer: (e) II > III > I

Solution:

Step 1: Understanding the Concept:
Amines act as Lewis bases because the nitrogen atom possesses a lone pair of electrons that can be donated to bond with a proton (H^+). The basic strength of an amine is directly proportional to the availability of this lone pair. Any factor that increases electron density on the nitrogen makes the amine a stronger base, while factors that withdraw or delocalize that density make it weaker.

Step 2: Key Formula or Approach:

To rank the amines, consider two main structural features:

1. **Aromaticity:** Is the nitrogen atom's lone pair involved in resonance with an aromatic ring? If yes, availability decreases drastically.

2. **Substituent Effects:** If it's an aromatic amine, look for substituents on the ring. Electron-Donating Groups (EDG) increase basicity, whereas Electron-Withdrawing Groups (EWG) decrease it.

Step 3: Detailed Explanation:

Let's evaluate the structural features of each given amine:

- **Aniline (I) - $C_6H_5NH_2$:**

In aniline, the amino group is attached directly to the benzene ring. The lone pair of electrons on the nitrogen atom is conjugated with the π-electron system of the ring. Because these electrons are delocalized into the ring, they are less available to be shared with an incoming proton. This resonance effect makes aniline a notably weak base.

- **Benzylamine (II) - $C_6H_5CH_2NH_2$:**

Here, the amino group is not attached directly to the aromatic ring; it is separated by an sp^3-hybridized methylene ($—CH_2—$) group. Because of this separation, the lone pair on the nitrogen cannot participate in resonance with the benzene ring. Benzylamine functions as a typical primary aliphatic amine. Since its lone pair is localized and fully available, it is a much stronger base than typical aromatic amines.

- **p-toluidine (III) - p-CH_3-$C_6H_4NH_2$:**

This molecule is an aniline derivative featuring a methyl group ($—CH_3$) at the para position relative to the amino group. The lone pair is still delocalized into the ring as in aniline. However, the methyl group acts as an Electron-Donating Group through hyperconjugation and a weak +I inductive effect. This added electron density partially offsets the resonance withdrawal, increasing the electron density at the nitrogen atom relative to unsubstituted aniline. Therefore, p-toluidine is a stronger base than aniline.

Establishing the Order:

- Benzylamine (II) is an aliphatic amine, making it the strongest base among the three.
- p-toluidine (III) and Aniline (I) are both aromatic amines, which are weaker than aliphatic ones.
- Between the two aromatic amines, p-toluidine (III) has an activating EDG, making it stronger than the unsubstituted Aniline (I).

Thus, the decreasing order of basic strength is: Benzylamine (II) > p-toluidine (III) > Aniline (I).
In Roman numerals, this is II > III > I.

Step 4: Final Answer:
The correct decreasing order of basic strength is II > III > I, which corresponds to option (e).

Quick Tip: A key differentiator in basicity questions is locating the nitrogen atom. If the nitrogen is directly bonded to an sp^2 hybridized carbon of an aromatic ring, it's an aromatic amine (weak base). If there's at least one sp^3 carbon intervening, it acts as an aliphatic amine (stronger base), regardless of whether a phenyl ring is present elsewhere in the molecule.