JEE Main 2023 24th Jan Shift 2 Question Paper with Solutions

Time Allowed :3 Hours	Maximum Marks :300	Total Questions :90

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 90 questions, out of which 75 are to attempted. The maximum marks are 300.
3. There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 30 questions in each part of equal weightage.
4. Each part (subject) has two sections.
   (i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each question carries 4 marks for correct answer and –1 mark for wrong answer.
   (ii) Section-B: This section contains 10 questions. In Section-B, attempt any five questions out of 10. The answer to each of the questions is a numerical value. Each question carries 4 marks for correct answer and –1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer

Section - A

1. Which one amongst the following are good oxidizing agents? A. Sm^{2+} B. Ce^{2+} C. Ce^{4+} D. Tb^{4+}

Choose the most appropriate answer from the options given below:

(1) C only

(2) D only

(3) A and B only

(4) C and D only

Correct Answer: (4) C and D only

Solution: The ions Ce^{4+} and Tb^{4+} are strong oxidizing agents, as they have a high tendency to gain electrons and reduce to their respective lower oxidation states.

Quick Tip

Oxidizing agents are substances that gain electrons and in the process, get reduced. Look for elements with high positive oxidation states.

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2. What is the number of unpaired electrons(s) in the highest occupied molecular orbital of the following species: $N_2, N_2^+, O_2, O_2^?$

(1) 0, 1, 2, 1

(2) 2, 1, 2, 1

(3) 1, 0, 1, 0

(4) 2, 1, 0, 1

Correct Answer: (1) 0, 1, 2, 1

Solution:

- N_2: σ^*1s and $\sigma 2p^2$ are fully paired, so no unpaired electrons.
- N_2^+: Loss of one electron leaves one unpaired electron in the π^*2p orbital.
- O_2: The π^*2p orbitals have two unpaired electrons.
- O_2^+: Removal of one electron results in one unpaired electron.

Quick Tip

Use molecular orbital theory to determine the number of unpaired electrons by observing the electron configuration of each species.

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3. Which of the following cannot be explained by crystal field theory?

(1) The order of spectrochemical series

(2) Magnetic properties of transition metal complexes

(3) Colour of metal complexes

(4) Stability of metal complexes

(1) The order of spectrochemical series

(2) Magnetic properties of transition metal complexes

(3) Colour of metal complexes

(4) Stability of metal complexes

Correct Answer: (1)

Solution: Crystal field theory (CFT) explains the magnetic properties, colour, and stability of metal complexes, but it cannot explain the order of the spectrochemical series. CFT introduces the concept of splitting of d-orbitals but does not predict the actual ordering of ligands in the series.

Quick Tip

While CFT explains many properties of metal complexes, it does not predict the actual order of the spectrochemical series, which is derived from empirical data.

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4. A student has studied the decomposition of a gas AB_3 at 25°C. He obtained the following data.

$$\text{p (mm Hg)} 50, 100, 200, 400 \quad \text{Relative} t_{1/2} \quad 4, 2, 1, 0.5$$

The order of the reaction is:

(1) 0.5

(2) 2

(3) 1

(4) 0 (zero)

Correct Answer: (2)

Solution: Using the formula for the half-life of a reaction:

$$t_{1/2} \propto (P_0)^{-n}$$

where P_0 is the initial pressure and $t_{1/2}$ is the half-life. Solving for the order n:

$$\frac{4}{2} = \left(\frac{50}{100}\right)^{-n} \quad \Rightarrow \quad n = 2$$

Quick Tip

To determine the order of a reaction, use the relationship between the initial pressure and the half-life. The order of the reaction is derived by observing the change in $t_{1/2}$.

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5. The number of s-electrons present in an ion with 55 protons in its unipositive state is:

(1) 8

(2) 9

(3) 12

(4) 10

Correct Answer: (4) 10

Solution: The atomic number $Z = 55$, so the electron configuration of the neutral atom is:

$$[\text{Xe}]6s^2 4d^{10} 5p^5$$

When the ion is in the unipositive state, one electron is lost, and it becomes:

$$[\text{Xe}]6s^1 4d^{10} 5p^5$$

Thus, the number of s-electrons is 10.

Quick Tip

In an ion, the number of s-electrons can be determined by observing the electron configuration, considering the loss of electrons due to ionization.

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6. In which of the following reactions the hydrogen peroxide acts as a reducing agent?

(1) $PbS + H_2O_2 \rightarrow PbSO_4 + 4H_2$

(2) $Fe_2O_3 + H_2O_2 \rightarrow 2FeO_2 + 2H_2O$

(3) $HCl + H_2O_2 \rightarrow HOCl + Cl_2$

(4) $MnO_2 + H_2O_2 \rightarrow Mn^{2+} + 2OH^-$

Correct Answer: (4)

Solution: In the reaction:

$$MnO_2 + H_2O_2 \rightarrow Mn^{2+} + 2OH^-$$

hydrogen peroxide is reduced (loses oxygen) and acts as a reducing agent. In this reaction, the H_2O_2 donates electrons to reduce MnO_2.

Quick Tip

To identify the reducing agent, look for the species that gets oxidized in the reaction. The reducing agent donates electrons.

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7. The metal which is extracted by oxidation and subsequent reduction from its ore is:

(1) Al

(2) Ag

(3) Cu

(4) Fe

Correct Answer: (2) Ag

Solution: Silver (Ag) is extracted by oxidation of silver ores, followed by reduction to metal using a reducing agent such as carbon.

Quick Tip

In metallurgy, metals like silver are often extracted by oxidation followed by reduction, typically using carbon as a reducing agent.

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8. Given below are two statements: Statement I and Statement II.

Statement I: $H_2N - C_6H_5$ under Clemensen reduction conditions will give $HOOC - C_6H_5$.

Statement II: $Cl - C_6H_5$ under Wolff-Kishner reduction condition will give $HOOC - C_6H_5$.

In light of the above statements, choose the correct answer from the options given below:

(1) Statement I is false but Statement II is true

(2) Both Statement I and Statement II are false

(3) Statement I is true but Statement II is false

(4) Both Statement I and Statement II are true

Correct Answer: (3) Statement I is true but Statement II is false

Solution: Clemensen reduction converts an amide to a carboxylic acid, and this is true for

Statement I. However, Wolff-Kishner reduction reduces C_6H_5Cl to C_6H_5 (i.e., removes the chlorine), so the second statement is incorrect.

Quick Tip

The Clemensen reduction reduces amides to carboxylic acids, while Wolff-Kishner reduction typically removes functional groups like halides.

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9. Given below are two statements, one is labelled as Assertion A and the other is labelled as Reason R

Assertion A: Beryllium has less negative value of reduction potential compared to the other alkaline earth metals.

Reason R: Beryllium has large hydration energy due to small size of Be^{2+} but relatively large value of atomization enthalpy.

In the light of the above statements, choose the most appropriate answer from the options given below:

(1) A is correct but R is not correct

(2) Both A and R are correct and R is the correct explanation of A

(3) A is not correct but R is correct

(4) Both A and R are correct but R is not the correct explanation of A

Correct Answer: (2)

Solution: Beryllium has a relatively less negative reduction potential compared to other alkaline earth metals due to its large hydration energy. However, its atomization enthalpy is large. This explains its behavior as a reducing agent. The reason is related to the small size and high hydration energy of Be^{2+}.

Quick Tip

In the study of reduction potentials, remember that smaller ions with high hydration energy tend to be more stable, reducing their tendency to reduce other species.

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10. Match List I with List II

LIST I Type		LIST II Name	
A.	Antifertility drug	I.	Norethindrone
B.	Tranquilizer	II.	Meprobomate
C.	Antihistamine	III.	Seldane
D.	Antibiotic	IV.	Ampicillin

Choose the correct answer from the options given below:

(1) A-I, B-II, C-III, D-IV

(2) A-IV, B-III, C-II, D-I

(3) A-I, B-III, C-II, D-IV

(4) A-II, B-I, C-III, D-IV

Correct Answer: (4)

Solution:

The correct matching is:

- A - II: Antifertility drug - Norethindrone

- B - I: Tranquilizer - Meprobamate

- C - III: Antihistamine - Seldane

- D - IV: Antibiotic - Ampicillin

Quick Tip

Study the properties and uses of common drug categories to better match them with their appropriate names and functions.

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11. Given below are two statements, one is labelled as Assertion A and the other is labelled as Reason R

Assertion A: Benzene is more stable than hypothetical cyclohexatriene. Reason R: The delocalized π-electron cloud is attracted strongly by nuclei of carbon atoms.

In the light of the above statements, choose the correct answer from the options given below:

(1) A is true but R is false

(2) A is false but R is true

(3) Both A and R are correct but R is NOT the correct explanation of A

(4) Both A and R are correct and R is the correct explanation of A

Correct Answer: (3)

Solution: Assertion A is true because benzene is indeed more stable than hypothetical cyclohexatriene, due to its resonance-stabilized structure. Reason R is true because the delocalized π-electron cloud in benzene is stabilized by the attraction to the carbon atoms' nuclei. However, this does not explain why benzene is more stable than cyclohexatriene.

Quick Tip

In resonance-stabilized molecules like benzene, the delocalized electrons contribute to the stability of the molecule, reducing reactivity compared to hypothetical structures like cyclohexatriene.

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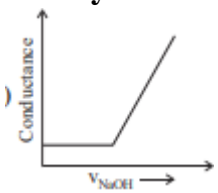
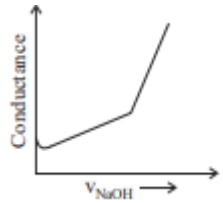
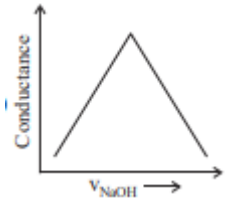
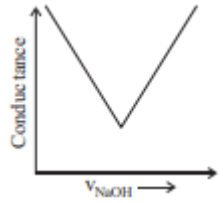
12. Choose the correct representation of conductometric titration of benzoic acid vs sodium hydroxide.

(1)


(2)


(3)


(4)


Correct Answer: (2)

Solution: The correct representation of conductometric titration shows an initial increase in conductivity as sodium hydroxide dissociates, followed by a plateau and a sharp increase at

the equivalence point when excess sodium hydroxide is added.

Quick Tip

During conductometric titrations, the conductivity changes with the dissociation of ions in the solution, allowing you to track the progress of the titration by plotting conductivity vs. titrant volume.

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13. Find out the major products from the following reactions.

$$\text{B} \xrightarrow{H_2O, NaBH_4} \text{A}$$

$$\text{B} \xrightarrow{BH_3, THF} \text{A}$$

$$\text{B} \xrightarrow{H_2O, OH^-} \text{B}$$

(1) A = Alcohol, B = Aldehyde

(2) A = Aldehyde, B = Alcohol

(3) A = Acid, B = Aldehyde

(4) A = Ketone, B = Acid

Correct Answer: (1)

Solution:

In the given reactions:

- B is reduced by $NaBH_4$ to form an alcohol (A).

- B reacts with BH_3 and THF to form another alcohol (A), typically through hydroboration.

- B undergoes an oxidation reaction with H_2O and OH^-, resulting in an aldehyde (B).

Thus, the correct products are alcohol (A) and aldehyde (B).

Quick Tip

In reduction reactions involving sodium borohydride $NaBH_4$ and borane BH_3, aldehydes and ketones are typically reduced to alcohols. Keep in mind the reagents used and their typical reactions.

14. Correct statement is:

(1) An average human being consumes more food than air

(2) An average human being consumes nearly 15 times more air than food

(3) An average human being consumes equal amount of food and air

(4) An average human being consumes 100 times more air than food

Correct Answer: (2)

Solution: An average human consumes more air than food. It is well known that the amount of air inhaled far exceeds the amount of food consumed, with air being used for respiration and metabolic processes.

Quick Tip

The average human needs to breathe approximately 12-16 times per minute, which results in the consumption of much more air than food in a day.

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15. Given below are two statements:

Statement I: Pure Aniline and other Arylamines are usually colourless.

Statement II: Arylamines get coloured on storage due to atmospheric reduction.

In the light of the above statements, choose the most appropriate answer from the options given below:

(1) Both Statement I and Statement II are incorrect

(2) Both Statement I and Statement II are correct

(3) Statement I is correct but Statement II is incorrect

(4) Statement I is incorrect but Statement II is correct

Correct Answer: (3)

Solution: Statement I is correct because pure aniline and other arylamines are indeed colourless. Statement II is incorrect because arylamines do not get coloured on storage due to atmospheric reduction. Instead, they may darken due to oxidation or exposure to light.

Quick Tip

Pure arylamines, like aniline, are typically colourless but may darken when exposed to light or air due to oxidation.

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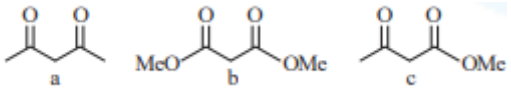
16. Which will undergo deprotonation most readily in basic medium?



(1) a only

(2) b only

(3) a and b

(4) b and c

Correct Answer: (1)

Solution: Deprotonation occurs most readily when the resulting conjugate base is stabilized. Among the compounds, compound (a) has the most resonance stabilization, which makes it the most likely to undergo deprotonation in basic medium.

Quick Tip

Look for resonance-stabilized structures when identifying compounds that undergo deprotonation most readily in basic medium.

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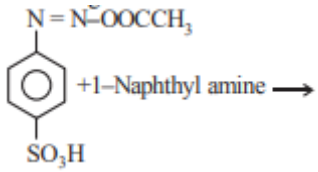
17. Choose the correct colour of the product for the following reaction:



(1) Yellow

(2) White

(3) Red

(4) Blue

Correct Answer: (3)

Solution: The reaction involves a diazonium coupling reaction, which typically results in the formation of a red product, especially in the case of the naphthylamine derivative.

Quick Tip

In diazonium reactions, the colour of the product is often indicative of the type of coupling reaction, with many reactions forming red or yellow products.

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18. Identify the correct statements about alkali metals.

A. The order of standard reduction potential M^+/M for alkali metal ions is Na > K > Rb > Li.

B. CsI is highly soluble in water.

C. Lithium carbonate is highly stable to heat.

D. Potassium dissolved in concentrated liquid ammonia is blue in colour and paramagnetic.

E. All the alkali metal hydrides are ionic solids.

Choose the correct answer from the options given below:

(1) A only

(2) A, B, D only

(3) C and E only

(4) A, B and E only

Correct Answer: (3)

Solution:

Statement A is incorrect, the correct order of reduction potential is Li > Na > K > Rb.

Statement B is correct as CsI is highly soluble in water.

Statement C is true for lithium carbonate which is stable to heat.

Statement D is correct because potassium dissolved in liquid ammonia forms a blue paramagnetic solution.

Statement E is correct as alkali metal hydrides are typically ionic solids.

Quick Tip

Alkali metals display a range of interesting chemical and physical properties, including their reduction potentials, solubility in water, and behaviour in liquid ammonia.

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19. The hybridization and magnetic behaviour of cobalt ion in $[Co(NH_3)_6]^{3+}$ complex is:

(1) sp^2 and diamagnetic

(2) d^3 and paramagnetic

(3) d^5 and diamagnetic

(4) d^2s^2 and paramagnetic

Correct Answer: (3)

Solution: In the complex $[Co(NH_3)_6]^{3+}$, cobalt has an oxidation state of +3. The hybridization is d^3, and the complex is paramagnetic due to the presence of unpaired electrons.

Quick Tip

When determining the hybridization and magnetic properties, examine the oxidation state and the electron configuration of the metal ion in the complex.

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20. $K_2Cr_2O_7$ paper acidified with dilute H_2SO_4 turns green when exposed to:

(1) Carbon dioxide

(2) Sulphur trioxide

(3) Hydrogen sulphide

(4) Sulphur dioxide

Correct Answer: (4) Sulphur dioxide

Solution: The reaction between potassium dichromate and sulfur dioxide in acidic medium results in a color change. The sulfur dioxide reduces the chromium in potassium dichromate from the Cr^{6+} state to the Cr^{3+} state, which produces a green color. This is a characteristic reaction used to detect the presence of sulfur dioxide.

Quick Tip

This reaction is a redox process where sulfur dioxide acts as a reducing agent, and potassium dichromate acts as the oxidizing agent. The green color indicates the reduction of Cr^{6+} to Cr^{3+}.

Section - B

21. The number of statement(s) which are the characteristics of physisorption is____

Solution: Physisorption is characterized by weak van der Waals forces and is highly specific in nature, with a high enthalpy of adsorption. It decreases with an increase in temperature and does not require activation energy. - Statement A is correct because physisorption involves weak intermolecular forces. - Statement B is correct because the enthalpy of adsorption is high due to the weak forces involved.

Quick Tip

Physisorption is a physical adsorption process, and it typically occurs at low temperatures. The amount adsorbed decreases with an increase in temperature because the weak forces are easily overcome.

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22. Sum of π-bonds present in peroxodisulphuric acid and pyrosulphuric acid is:

Solution:

The structure of peroxodisulphuric acid involves π-bonds in the oxygen-sulfur-oxygen linkages, while pyrosulphuric acid has similar linkages.

- In peroxodisulphuric acid, there are 4 π-bonds.

- In pyrosulphuric acid, there are another 4 π-bonds.

Thus, the total number of π-bonds is 8.

Quick Tip

To count π-bonds in chemical structures, look for double bonds involving oxygen and sulfur atoms. These contribute to the overall π-bond count.

23. Maximum number of isomeric monochloro derivatives that can be obtained from 2,2,5,5-tetramethylhexane by chlorination is:

Solution: The chlorination of 2,2,5,5-tetramethylhexane can produce different isomers depending on where the chlorine atom is attached. The maximum number of isomers that can be formed is 3, as the chlorine atom can attach to three distinct positions on the molecule.

Quick Tip

To determine the number of possible isomers in chlorination reactions, consider all the unique positions where chlorine can attach. The symmetry of the molecule will determine the number of isomers.

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24. Total number of tripeptides possible by mixing of valine and proline is:

Solution: When mixing valine (Val) and proline (Pro), the possible tripeptides are given by the combinations of these amino acids in the three positions. There are 8 possible tripeptides that can be formed from these two amino acids, as each position can be occupied by either valine or proline.

Quick Tip

To find the total number of possible tripeptides, use the formula 2^3 if only two types of amino acids are involved, where each position can hold either type.

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25. The number of units, which are used to express concentration of solutions from the following is: _____

Mass percent, Mole, Mole fraction, Molarity, ppm, Molarity.

Solution: Mass percent, mole, mole fraction, molarity, and ppm are commonly used to express the concentration of solutions. These units are essential in chemical analysis to determine the amount of solute in a given amount of solvent or solution.

Quick Tip

These concentration terms are used in different contexts, with molarity and mole fraction being common in chemistry, while ppm is used for trace concentrations.

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26. The number of statement(s), which are correct with respect to the compression of carbon dioxide from point (a) in the Andrews isotherm from the following is:

A. Carbon dioxide remains as a gas upto point (b)

B. Liquid carbon dioxide appears at point (c)

C. Liquid and gaseous carbon dioxide coexist between points (b) and (c)

D. As the volume decreases from (b) to (c), the amount of liquid decreases

Solution: In the Andrews isotherm, carbon dioxide behaves as follows:

- At point (a), CO_2 exists as a gas.

- At point (b), liquid carbon dioxide starts to appear.

- Between points (b) and (c), both liquid and gaseous CO_2 coexist.

- As the volume decreases from point (b) to point (c), the amount of liquid CO_2 decreases.

Hence, statement A and C are correct, and the correct answer is (2).

Quick Tip

The Andrews isotherm describes the behavior of gases under compression. Remember that gases may liquefy under pressure when temperature conditions are right.

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27. Let V.P. of pure B be P_0. When $X_A = 0.7$ and $X_B = 0.3$, the Total pressure is 350 mm Hg. If $X_A = 0.2$ and $X_B = 0.8$, the total pressure becomes 410 mm Hg. Calculate the vapor pressure of A and B.

Solution: From the given data, we use Raoult's Law:

$$P = X_A \cdot P_A^0 + X_B \cdot P_B^0$$

From the first equation:

$$350 = 0.7 \cdot P_A^0 + 0.3 \cdot P_B^0 \quad \text{(i)}$$

From the second equation:

$$410 = 0.2 \cdot P_A^0 + 0.8 \cdot P_B^0 \quad \text{(ii)}$$

Solving the system of equations gives:

$$P_A^0 = 314\,\text{mm Hg} \quad \text{and} \quad P_B^0 = 434\,\text{mm Hg}$$

Quick Tip

Raoult's Law is helpful in calculating vapor pressures of components in mixtures. Use the mole fractions and the total pressure to solve for individual vapor pressures.

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28. One mole of an ideal monatomic gas is subjected to changes as shown in the graph. The magnitude of the work done (by the system or on the system) is:

Solution: The work done in a thermodynamic process can be calculated by finding the area under the curve in the $P - V$ graph. Here, the graph shows an isothermal process, so the work done is calculated using:

$$W = P(V_2 - V_1)$$

where V_2 and V_1 are the final and initial volumes, respectively. The magnitude of work is $6.2\,\text{bar L} = 620\,\text{J}$.

Quick Tip

For isothermal processes, the work done is related to the change in volume and the constant temperature. Use the equation $W = nRT \ln\left(\frac{V_2}{V_1}\right)$ for more detailed calculations.

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29. If the pKa of lactic acid is 5, then the pH of 0.005 M calcium lactate solution at 25°C is:

Solution: The pH of a salt solution is calculated using the formula:

$$\text{pH} = 7 + \frac{1}{2}\left(\text{pKa} + \log C\right)$$

where:

- pKa of lactic acid = 5,

- concentration of calcium lactate = 0.005 M,

- concentration of lactate ion = 0.005 M.

Substituting the values, we get:

$$\text{pH} = 7 + \frac{1}{2}\left(5 + 2 \times 10 \times \log(0.005)\right) = 7 + \frac{1}{2}\left[5 + 2 \times (-2\log 10)\right] = 7 + \frac{1}{2}\left[5 - 2 \times 10\right] = 7 + \frac{1}{2}(-10) = 8.5$$

Quick Tip

Remember, pH of a salt solution can be calculated using the pKa of the acid and concentration of the salt, especially for weak acid-strong base salts.

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30. Following figure shows the spectrum of an ideal black body at four different temperatures. The number of correct statement(s) from the following is:

Solution: The spectrum of Black body radiation is explained using quantization of energy. As temperature increases, the peak of the spectrum shifts to shorter wavelengths (or higher frequencies), which is known as Wien's Law.

- $T_3 > T_2 > T_1$, as higher temperature results in more energy distribution at shorter wavelengths.

- The black body is modeled as a collection of particles performing simple harmonic motion.

- The peak of the spectrum shifts to shorter wavelengths as temperature increases.

Quick Tip

This is a direct application of Planck's Law and Wien's displacement law, where the peak wavelength shifts to shorter wavelengths at higher temperatures.
