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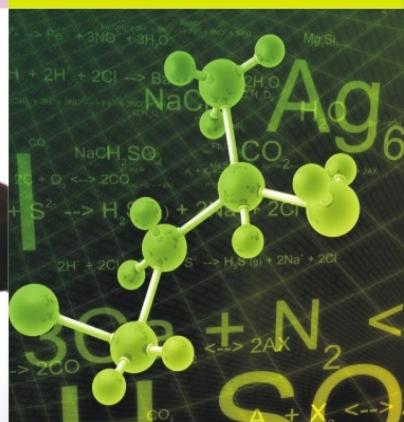
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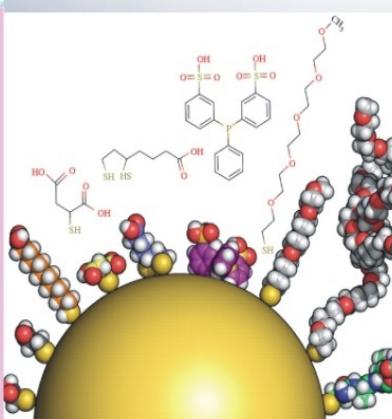
**UPKAR'S**

# **CSIR-UGC NET/JRF/SET**

# **CHEMICAL SCIENCES**



*Through Solved  
Problems*



**Dr. HEMANT KULSHRESTHA &  
Prof. AJAY TANEJA**

 **UPKAR'S**

**CSIR-UGC  
NET/JRF/SET  
CHEMICAL SCIENCES**

**Through Solved Problems**

(With Multiple Objective Questions and their Explanations)

*By*

Dr. Hemant Kulshrestha  
Head, Department of Chemistry  
St. John's College  
Agra  
&  
Prof. Ajay Taneja  
Department of Chemistry  
Dr. B. R. Ambedkar University  
Agra

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*Revised & Enlarged Edition*

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ISBN : 978-81-7482-381-6

**Code No. 1588**

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**Printed at :** UPKAR PRAKASHAN (Printing Unit) Bye-pass, AGRA

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## PREFACE

We are extremely delighted to present this Revised Edition of Chemical Sciences which will cover the total need of the student preparing for CSIR-UGC (NET) examination for selection of scholars for Junior Research Fellowship of CSIR and UGC and for determining the eligibility for Lectureship in the Colleges and Universities of India.

Our major objective is also to develop confidence among the candidates who are taking competitive examination in the field related to Chemical Sciences providing them solved objective as well as short descriptive type questions which covers both fundamental and practical aspects of the topic. This book is designed to satisfy the challenging requirements of NET (CSIR-UGC), GATE, SET, ONGC, IARI, BARC and M. Phil., Ph.D. Entrance of Various Indian Universities.

The final form of this book is the outcome of an extensive survey of related literature than our knowledge. We have tried to consult the best available sources of information in respect to various topics discussed. We sincerely hope that the book will go a long way to satisfy the long felt need of students for a friendly book on Chemistry.

We gratefully acknowledge the assistance and constructive comments of our colleagues and Research students during the preparation of this book especially to Dr. Jaiswar Gautam, Asst. Professor Department of Chemistry, Dr. B. R. Ambedkar University, Agra and Mr. Ram Kumar, Asst. Professor Department of Chemistry, St. John's College, Agra for assisting us at various stages of writing this book. Any suggestions for improvement of the book are welcome and will be gratefully acknowledged.

*—Authors*

## **CONTENTS**

- Previous Years' Solved Papers

### **PART 'A'**

#### **General Aptitude**

**1–96**

### **PART 'B' & 'C'**

#### **Inorganic Chemistry**

|     |   |         |
|-----|---|---------|
| 1.  | Chemical Periodicity .....  | 3–17    |
| 2.  | Structure and Bonding .....                                       | 18–50   |
| 3.  | Concepts of Acids and Bases .....                                 | 51–68   |
| 4.  | Main Group Elements and their Compounds .....                     | 69–176  |
| 5.  | Chemistry of Transition Elements and Coordination Compounds ..... | 177–262 |
| 6.  | Inner Transition Elements .....                                   | 263–279 |
| 7.  | Organometallic Compounds .....                                    | 280–324 |
| 8.  | Gases and Metal Clusters .....                                    | 325–337 |
| 9.  | Analytical Chemistry .....  | 338–360 |
| 10. | Bio-Inorganic Chemistry .....                                     | 361–392 |
| 11. | Spectroscopy .....  | 393–412 |
| 12. | Nuclear Chemistry .....   | 413–440 |

#### **Physical Chemistry**

|        |   |         |
|--------|---|---------|
| 1.     | Basic Principles of Quantum Mechanic .....  | 3–24    |
| 2 & 3. | Approximate Methods of Quantum Mechanics : The Variation Method and Perturbation Theory, Term Symbols Many Electron Systems ..... | 25–38   |
| 4.     | Chemical Bonding in Diatomics : MO, VB Theories, Huckel Theory for Conjugated II-Electron Systems .....                           | 39–54   |
| 5.     | Group Theoretical Representation, Symmetry and Quantum Mechanics .....  | 55–71   |
| 6.     | Molecular Spectroscopy .....  | 72–101  |
| 7.     | Chemical Thermodynamics .....   | 102–152 |
| 8.     | Statistical Thermodynamics .....  | 153–174 |
| 9.     | Electro Chemistry .....   | 175–204 |

|     |                             |         |
|-----|-----------------------------|---------|
| 10. | Chemical Kinetics .....     | 205–250 |
| 11. | Colloids and Surfaces ..... | 251–271 |
| 12. | Solid State .....           | 272–290 |
| 13. | Polymer Chemistry .....     | 291–306 |
| 14. | Data Analysis .....         | 307–320 |

### Organic Chemistry

|     |  |         |
|-----|--|---------|
| 1.  | IUPAC Nomenclature .....                   | 3–18    |
| 2.  | Principle of Stereochemistry .....         | 19–37   |
| 3.  | Aromaticity .....                          | 38–51   |
| 4.  | Organic Reactive Intermediates .....       | 52–68   |
| 5.  | Mechanism of Organic Reactions .....       | 69–108  |
| 6.  | Selective Organic Name Reactions .....     | 109–179 |
| 7.  | Organic Transformations and Reagents ..... | 180–228 |
| 8.  | Concepts in Organic Synthesis .....        | 229–241 |
| 9.  | Asymmetric Synthesis .....                 | 242–259 |
| 10. | Pericyclic Reactions .....                 | 260–288 |
| 11. | Heterocyclic Chemistry .....               | 289–307 |
| 12. | Chemistry of Natural Products .....        | 308–351 |
| 13. | Spectroscopy .....                         | 352–380 |

### Interdisciplinary Topics

|    |   |       |
|----|---|-------|
| 1. | Chemistry in Nanoscience and Technology ..... | 3–9   |
| 2. | Catalysis and Green Chemistry .....           | 10–18 |
| 3. | Medicinal Chemistry .....                     | 19–29 |
| 4. | Supramolecular Chemistry .....                | 30–36 |
| 5. | Environmental Chemistry .....                 | 37–48 |

## **GENERAL INFORMATION**

### **SCHEME OF EXAMINATION**

**Time : 3 Hrs.**

**Max. Marks : 200**

Single Paper Test having Multiple Choice Questions (MCQs) is divided in three parts.

#### **PART 'A'**

This part shall carry 20 questions pertaining to General aptitude with emphasis on logical reasoning graphical analysis, analytical and numerical ability, quantitative comparisons, series formation, puzzles etc. The candidates shall be required to answer any 15 questions. Each question shall be of two marks. The total marks allocated to this section shall be 30 out of 200.

#### **PART 'B'**

This part shall contain 50 Multiple Choice Questions (MCQs) generally covering the topics given in the syllabus. A candidate shall be required to answer any 35 questions. Each question shall be of two marks. The total marks allocated to this section shall be 70 out of 200.

#### **PART 'C'**

This part shall contain 75 questions that are designed to test a candidate's knowledge of scientific concepts and/or application of the scientific concepts. The questions shall be of analytical nature where a candidate is expected to apply the scientific knowledge to arrive at the solution to the given scientific problem. A candidate shall be required to answer any 25 questions. Each question shall be of four marks. The total marks allocated to this section shall be 100 out of 200.

- There will be negative marking @25% for each wrong answer.
- To enable the candidates to go through the questions, the question paper booklet shall be distributed 15 minutes before the scheduled

time of the exam. The Answer sheet shall be distributed at the scheduled time of the exam.

### **SYLLABUS**

#### **PART 'A'**

This part shall carry 20 questions pertaining to General aptitude with emphasis on logical reasoning graphical analysis, analytical and numerical ability, quantitative comparisons, series formation, puzzles etc. The candidates shall be required to answer any 15 questions. Each question shall be of two marks. The total marks allocated to this section shall be 30 out of 200.

#### **COMMON SYLLABUS FOR PART 'B' & 'C'**

##### **Inorganic Chemistry**

1. Chemical periodicity.
2. Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules (VSEPR Theory).
3. Concepts of acids and bases, Hard-Soft acid base concept, Non-aqueous solvents.
4. **Main group elements and their compounds :** Allotropy, synthesis, structure and bonding, industrial importance of the compounds.
5. **Transition elements and coordination compounds :** Structure, bonding theories, spectral and magnetic properties, reaction mechanisms.
6. **Inner transition elements :** Spectral and magnetic properties, redox chemistry, analytical applications.
7. **Organometallic compounds :** Synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis.
8. Cages and metal clusters.
9. **Analytical chemistry :** Separation, spectroscopic, electro- and thermoanalytical methods.

10. **Bioinorganic chemistry :** Photosystems, porphyrins, metalloenzymes, oxygen transport, electron- transfer reactions; nitrogen fixation, metal complexes in medicine.
11. Characterisation of inorganic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques.
12. **Nuclear chemistry :** Nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis.

### Physical Chemistry

1. **Basic principles of quantum mechanics :** Postulates; operator algebra; exactly-solvable systems — particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling.
2. **Approximate methods of quantum mechanics :** Variational principle; perturbation theory up to second order in energy; applications.
3. Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle.
4. Chemical bonding in diatomics; elementary concepts of MO and VB theories; Huckel theory for conjugated  $\pi$ -electron systems.
5. Chemical applications of group theory; symmetry elements; point groups; character tables; selection rules.
6. **Molecular spectroscopy :** Rotational and vibrational spectra of diatomic molecules; electronic spectra; IR and Raman activities – selection rules; basic principles of magnetic resonance.
7. **Chemical thermodynamics :** Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; elementary description of phase transitions; phase equilibria and phase rule; thermodynamics of ideal and non-ideal gases, and solutions.
8. **Statistical thermodynamics :** Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities – calculations for model systems.
9. **Electrochemistry :** Nernst equation, redox systems, electrochemical cells; Debye-Hückel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations.
10. **Chemical kinetics :** Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; enzyme kinetics; salt effects; homogeneous catalysis; photochemical reactions.
11. **Colloids and surfaces :** Stability and properties of colloids; isotherms and surface area; heterogeneous catalysis.
12. **Solid state :** Crystal structures; Bragg's law and applications; band structure of solids.
13. **Polymer chemistry :** Molar masses; kinetics of polymerization.
14. **Data analysis :** Mean and standard deviation; absolute and relative errors; linear regression; covariance and correlation coefficient.

### Organic Chemistry

1. IUPAC nomenclature of organic molecules including regio- and stereoisomers.
2. Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction.
3. Aromaticity: Benzenoid and non-benzenoid compounds – generation and reactions.
4. Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes.
5. Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.
6. Common named reactions and rearrangements – applications in organic synthesis.

7. **Organic transformations and reagents :** Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic). Chemo, regio and stereoselective transformations.
8. **Concepts in organic synthesis :** Retro-synthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups.
9. **Asymmetric synthesis :** Chiral auxiliaries, methods of asymmetric induction –substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution – optical and kinetic.
10. **Pericyclic reactions :** Electrocyclisation, cycloaddition, sigmatropic rearrangements and other related concerted reactions.
- Principles and applications of photochemical reactions in organic chemistry.
- Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S).
- Chemistry of natural products :** Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids.
- Structure determination of organic compounds by IR, UV-Vis,  $^1\text{H}$  &  $^{13}\text{C}$  NMR and Mass spectroscopic techniques.

### Interdisciplinary Topics

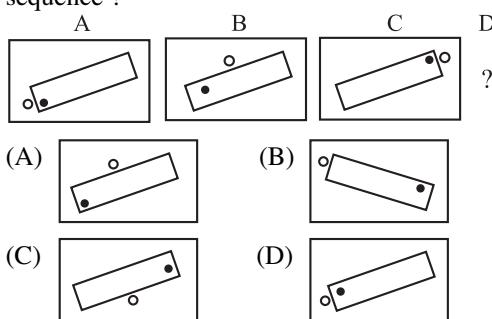
1. Chemistry in nanoscience and technology.
  2. Catalysis and green chemistry.
  3. Medicinal chemistry.
  4. Supramolecular chemistry.
  5. Environmental chemistry.
-

# **CSIR-UGC-NET/JRF Exam., June 2016 Solved Paper**

## **Chemical Sciences**

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**PART A**



2 | CSIR Chemical Sci. (J-16)

Allowing for experimental errors, which of the following expressions best describes the relationship between  $t$  and  $v$ ?

- (A)  $v \propto t^2$       (B)  $(v - 5) \propto t^2$   
 (C)  $v = 5t + t^2$       (D)  $(v - 5) = (t + 5)^2$

19. The difference between the squares of the ages (in complete years) of a father and his son is 899. The age of the father when his son was born—

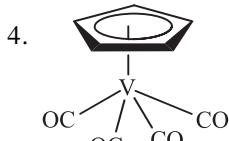
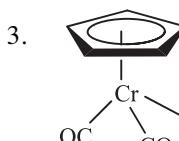
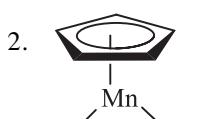
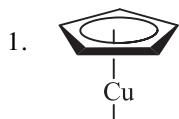
- (A) cannot be ascertained due to inadequate data  
 (B) is 27 years  
 (C) is 29 years  
 (D) is 31 years

20. A bicycle tube has a mean circumference of 200 cm and a circular cross section of diameter 6 cm. What is the approximate volume of water (in cc) required to completely fill the tube, assuming that it does not expand?

- (A)  $600\pi$       (B)  $1200\pi$   
 (C)  $3600\pi$       (D)  $1800\pi$

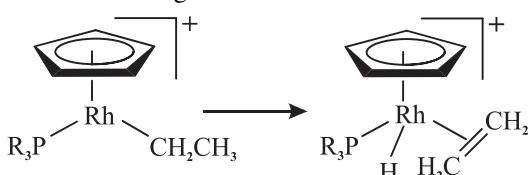
## PART B

21. Identify the species, those obey the 18 electron rule, from the following—



- (A) 1 and 2      (B) 2 and 3  
 (C) 3 and 4      (D) 1 and 4

22. The following transformation



is an example of—

- (A) oxidative addition  
 (B) insertion  
 (C)  $\beta$ -hydride elimination  
 (D) reductive elimination

23.  $[\text{Ni}^{II}\text{L}_6]^{n+}$  or  $n^-$  shows absorption bands at 8500, 15400, and 26000  $\text{cm}^{-1}$  whereas  $[\text{Ni}^{II}\text{L}'_6]^{n+}$  or  $n^-$ , at 10750, 17500 and 28200  $\text{cm}^{-1}$ .  $\text{L}$  and  $\text{L}'$  are respectively—

- (A)  $\text{OH}^-$  and  $\text{N}_3^-$   
 (B)  $\text{Cl}^-$  and  $\text{I}^-$   
 (C)  $\text{NCS}^-$  and  $\text{RCO}_2^-$   
 (D)  $\text{H}_2\text{O}$  and  $\text{NH}_3$

24. The number of microstates present in  ${}^3\text{F}$  term is—

- (A) 3      (B) 21  
 (C) 9      (D) 28

25.  $\text{CpM}$  [ $\text{Cp}$  is  $(\eta^5\text{-C}_5\text{H}_5)$ ] fragment isolobal with a  $\text{BH}$  fragment is—

- (A)  $\text{CpGe}$       (B)  $\text{CpMn}$   
 (C)  $\text{CpRu}$       (D)  $\text{CpCo}$

26. The number of metal-metal bonds is—

- $[\text{Co}_2\text{Fe}_2(\text{Co})_{11}(\mu_4\text{-PPPh})_2]$  is—  
 (A) 3      (B) 4  
 (C) 5      (D) 6

27. Correct combination for  $\pi$  and  $\pi^*$  orbitals in  $\text{B}_2$  molecule is—

- | $\pi$        | $\pi^*$  |
|--------------|----------|
| (A) Gerade   | Ungerade |
| (B) Ungerade | Gerade   |
| (C) Gerade   | Gerade   |
| (D) Ungerade | Ungerade |

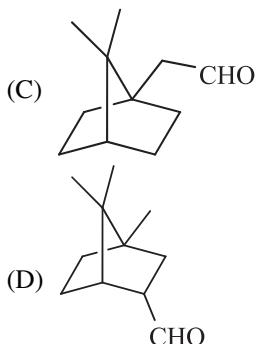
28. The correct shape of  $[\text{TeF}_5]^-$  ion on the basis of VSEPR theory is—

- (A) Trigonal bipyramidal  
 (B) Square pyramidal  
 (C) Pentagonal planar  
 (D) See-saw

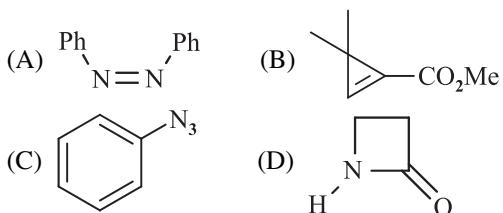
29. The numbers of P-S and P-P bonds in the compound  $\text{P}_4\text{S}_3$  are, are respectively—

- (A) 6 and 3      (B) 4 and 3  
 (C) 3 and 6      (D) 6 and 2

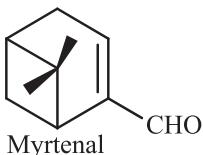




40. Among the following, the compound that displays an IR band at  $2150\text{ cm}^{-1}$  is—

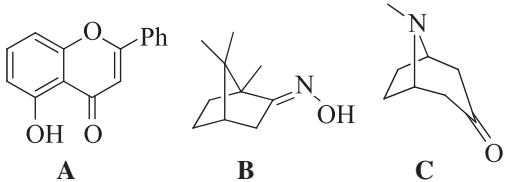


41. In the  $^1\text{H}$  NMR spectrum of myrtenal, the two methyl groups are expected to display signals at (chemical shift values ( $\delta$ ) in ppm)



- (A) 1.35 (s, 3H) and 5.0 (s, 3H)  
 (B) 0.74 (s, 3H) and 1.33 (s, 3H)  
 (C) 1.22 (s, 6H)  
 (D) 0.70 (s, 6H)

42. Among the following, the compound(s) that can be classified as terpene derivative is(are)

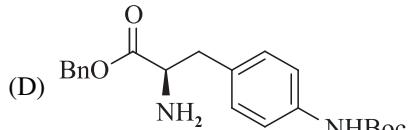
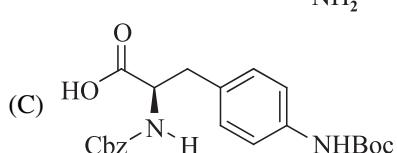
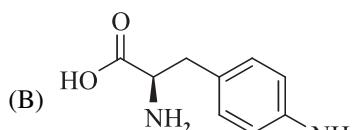
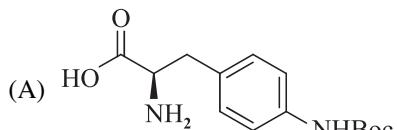
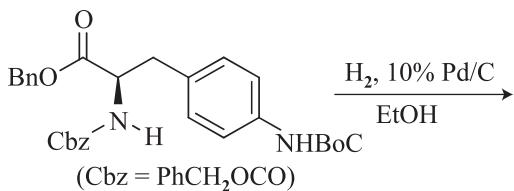


- (A) A and B  
 (B) A only  
 (C) B only  
 (D) B and C

43. The frontier orbital interactions involved in the formation of the carbocation intermediate in the reaction of isobutylene with HCl are—  
 (A)  $\pi$  of olefin and  $\sigma^*$  of HCl

- (B)  $\pi$  of olefin and  $\sigma$  of HCl  
 (C)  $\pi^*$  of olefin and  $\sigma^*$  of HCl  
 (D)  $\pi^*$  of olefin and  $\sigma$  of HCl

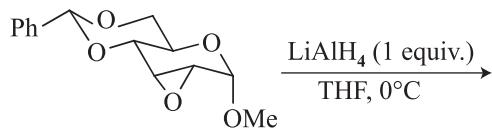
44. The major product formed in the following reaction is—

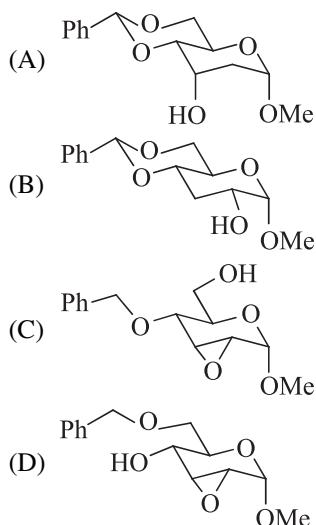


45. In the UV-visible absorption spectrum of an  $\alpha, \beta$ -unsaturated carbonyl compound, with increasing solvent polarity—

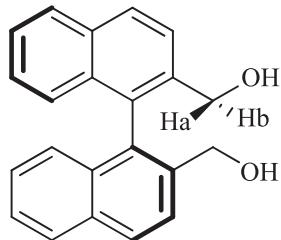
- (A) n- $\pi^*$  transitions undergo hypsochromic shift,  $\pi-\pi^*$  undergo bathochromic shift  
 (B) n- $\pi^*$  transitions undergo bathochromic shift,  $\pi-\pi^*$  undergo hypsochromic shift  
 (C) both n- $\pi^*$  and  $\pi-\pi^*$  transitions undergo bathochromic shift  
 (D) both n- $\pi^*$  and  $\pi-\pi^*$  transitions undergo hypsochromic shift

46. The major product formed in the following reaction is—



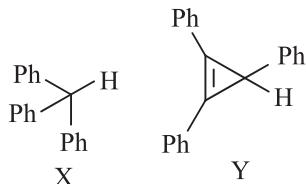


47. In the following compound, the stereochemical descriptor for H<sub>a</sub> and H<sub>b</sub> is—



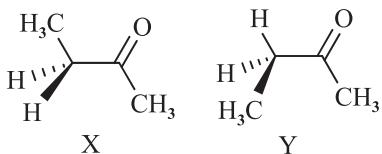
- (A) enantiotopic  
 (B) diasterotopic  
 (C) homotopic  
 (D) constitutionally heterotopic

48. The correct statement are about the reaction of **X** and **Y** with NaNH<sub>2</sub> are—

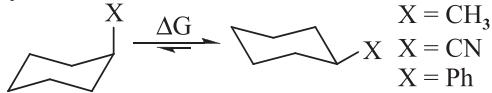


1. **X** reacts faster than **Y**  
 2. **Y** reacts faster than **X**  
 3. **X** and **Y** behave as Lewis acids  
 4. **X** is stronger Bronsted acid than **Y**
- (A) 1 and 3                    (B) 1 and 4  
 (C) 2 and 3                    (D) 2 and 4

49. The correct statements about conformations **X** and **Y** of 2-butanone are—

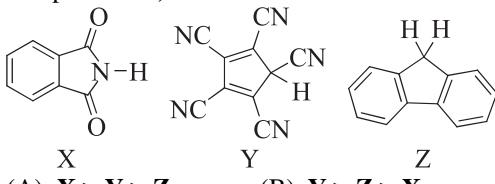


1. **X** is more stable than **Y**  
 2. **Y** is more stable than **X**  
 3. Methyl groups in **X** are *anti*  
 4. Methyl groups in **Y** are *gauche*
- (A) 1 and 4                    (B) 1 and 3  
 (C) 2 and 3                    (D) 1, 3 and 4
50. The correct order of the magnitude of ‘A values’ for the given substituents in cyclohexane derivatives is—



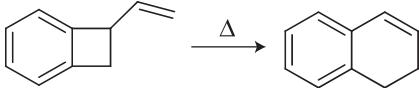
- (A) Ph > CN > Me            (B) Me > Ph > CN  
 (C) CN > Me > Ph            (D) Ph > Me > CN

51. The correct order of pKa values for the compounds **X**, **Y** and **Z** is—



- (A) **X** > **Y** > **Z**            (B) **Y** > **Z** > **X**  
 (C) **Z** > **X** > **Y**            (D) **Y** > **X** > **Z**

52. The following transformation proceeds through two consecutive electrocyclic processes, which are—

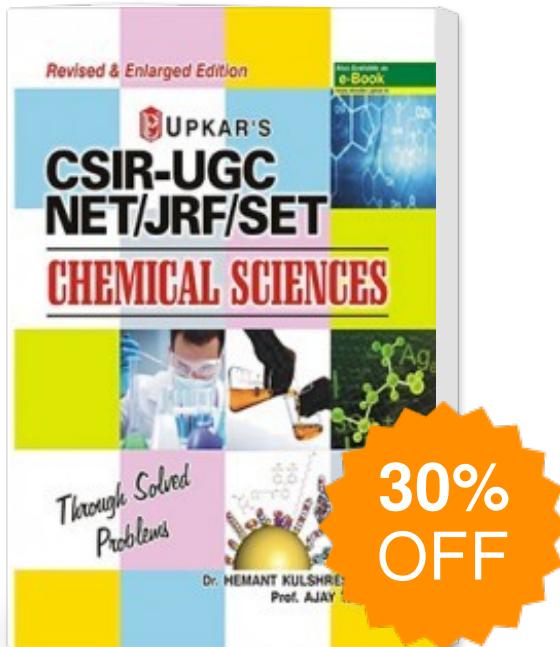


- (A) 4π conrotatory and 6π conrotatory  
 (B) 4π disrotatory and 6π conrotatory  
 (C) 4π conrotatory and 6π disrotatory  
 (D) 4π disrotatory and 6π disrotatory

53. The simultaneous eigenfunctions of angular momentum operators L<sup>2</sup> and L<sub>z</sub> are—

- (A) all of 2s, 2p<sub>x</sub>, 2p<sub>y</sub> and 2p<sub>z</sub> orbitals  
 (B) only 2s, 2p<sub>x</sub> and 2p<sub>y</sub> orbitals  
 (C) only 2s and 2p<sub>z</sub> orbitals  
 (D) only 2p<sub>z</sub> orbital

# CSIR-UGC NET/JRF/SET Chemical Sciences



Publisher : Upkar Prakashan

ISBN : 9788174823816

Author : Dr Hemant  
Kulshrestha And Dr Ajay  
Taneja

Type the URL : <http://www.kopykitab.com/product/10398>



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