VIVEKANANDA COLLEGE, TIRUVEDAKAM WEST

(Autonomous & Residential)

[Affiliated to Madurai Kamaraj University]

M.Sc. Chemistry Degree (Semester) Examinations, November 2018

Part – III : Core Subject : First Semester : Paper – I

ORGANIC CHEMISTRY – I

Under CBCS – Credit 5

Time: **3** Hours Max. Marks: **75**

SECTION – A

Answer ALL Questions : **(5 × 1 = 5)**

1. Which one of the following molecule shows intra molecular hydrogen bonding

   a) ortho- nitrobenzoic acid b) benzaldehyde

   c) Phenol d) Toluene

2. How many number of unpaired electron present in carbene

   a) 1 b) 2 c) 3 d) 4

3. Which one of the following annulenes is aromatic?

   a) [14]-annulenes b) [18]-annulenes

   c) [30]-annulenes d) all of these

4. Which of the following does not possess any element of symmetry?

   a) ethane b) (+) tartaric acid

   c) carbon tetrachloride d) meso-tartaric acid

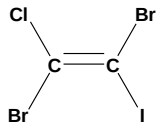
5. Specific rotation for freshly prepared monosaccharide is

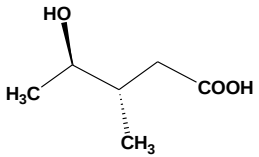
   a) + 111° b) + 52.5° c) + 60.2° d) + 120°

SECTION – B

Answer any FIVE Questions : **(5 × 2 = 10)**

6. Define the inductive and field effects.
7. What you mean the Inclusion compounds.
8. Explain stereo chemical evidence for the trace of the intermediate using the reaction of *cis*-2-butene with $KMnO_4$.
9. What is the microscopic reversibility? Why this principle is not applicable to reversible photochemical reaction?
10. How will you identify the aromatic compounds by NMR spectroscopy?
11. Find out the configurational nomenclature of the following compounds.

i) 

ii) 

12. Define the anomeric effect in aldopyranosides.

SECTION – C

Answer ALL Questions : **(5 × 6 = 30)**

13. a) Illustrate the classifications and characters of electron donor-acceptor complexes.

(OR)

b) Define the following terms: i) Delocalized bonds ii) Hyper conjugation iii) Cross conjugation **(2 + 2 + 2)**

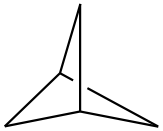
14. a) Explain the kinetic isotope effects and how it is used to investigate the reaction mechanism.

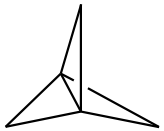
(OR)

b) How to determine the presence of an intermediate in reaction mechanism?

15. a) i) Explain the aromatic properties of cyclooctatetraenebefore and after dissolution in con. H_2SO_4.

ii) Write the names of the following compounds. (4 + 2)

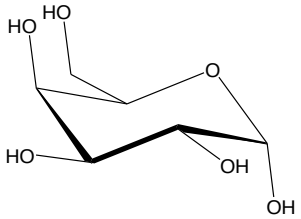
i) 

ii) 

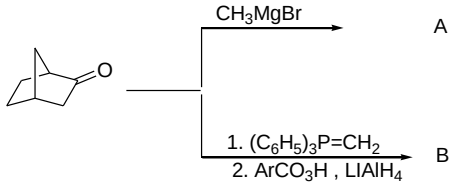
16. a) Explain the aromatic character of tropyliumcation, tropone and tropolones.

(OR)

b) i) Transform the formula of galactose shown below into a Fischer projection formula and state whether it is the α or the β anomer.



ii) Identify the product of following reaction and justify your product.



(OR)

b) Discuss the specification of absolute configuration of allenes and spirans with example.

17. a) Prove that the glucose is a pyranose sugar.

(OR)

b) Discuss the structural elucidation of α-santonin.

SECTION – D

Answer any THREE Questions : **(3 × 10 = 30)**

18. Explain and enumerate the effects of structure on the strength of acid bases.

19. Discuss the formation and stability of following reaction intermediates.

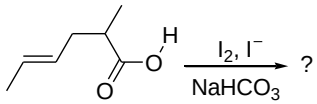
    i) Carbocations ii) Carbanions iii) Nitrenes

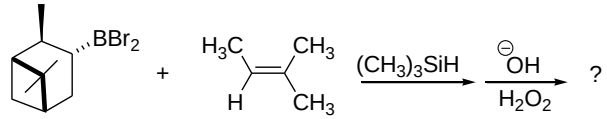
    iv) Carbenes v) Free radicals

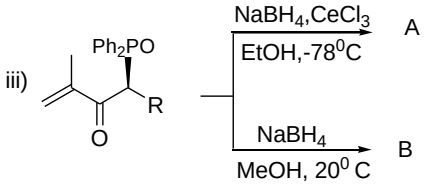
20. a) Discuss the alternant and non-alternant hydrocarbons with energy level diagram of benzyl cation, free radical and carbanion.

    b) Illustrate the Huckel's rule for hydrocarbons. **(5 + 5)**

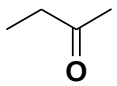
21. i) Identify the reaction and product. **(2 + 2 + 4 + 2)**

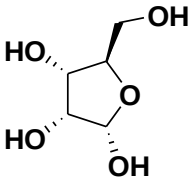
i) 

ii) 

iii) 

ii) Find out heterotopic atoms or groups in each of the following. Indicate whether the group is enantiotopic or diastereotopic.

i) 

ii) 

22. Write the structural elucidation and stereochemistry of quinine.

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M.Sc. Chemistry Degree (Semester) Examinations, November 2018

Part – III : Core Subject : First Semester : Paper – II

INORGANIC CHEMISTRY – I

Under CBCS – Credit 4

Time: **3** Hours Max. Marks: **75**

SECTION – A

Answer ALL Questions : **(5 × 1 = 5)**

1. Which of the following statements is incorrect?
   a) Madelung constants for MX_2 lattices are greater than those for MX lattices
   b) Use of the Born-Lande equation is restricted to lattices for which an electrostatic model is appropriate
   c) Madelung constants are structure dependent
   d) A lattice energy is an internal energy change, and $\Delta_{lattice}$ U(0 K) = $\Delta_{lattice}$H(298 K)
2. The shape and hybridisation of ClF_3 is
   a) T-shaped and sp^3 b) T-shaped and sp^3d
   c) Trigonal planar and sp^3d d) Trigonal planar and sp^3d^2
3. Which one of the following is an example of Usanovich acid?
   a) Fe (III) b) Fe (II) c) Sn (II) d) Tn (IV)
4. Quartz and Feldspar are examples having _____ structure
   a) Tetrahedron b) Sheet
   c) Poly tetrahedral d) Framework
5. Which of the following pairs represents isobars?
   a) $^{17}O_8$ and $^{16}O_8$ b) $^{40}K_{19}$ and $^{40}Ca_{20}$
   c) $^{15}N_7$ and $^{16}O_8$ d) $^{235}U_{92}$ and $^{238}U_{92}$

SECTION – B

Answer any FIVE Questions : **(5 × 2 = 10)**

6. State Fajans rule.
7. What is effective nuclear charge?
8. State Bent's rule.
9. Define Bronsted -Lowry concept.
10. Classify the following boranes by structural type a) $B_{10}H_{14}$ b) B_2H_7
11. Neutron is a better projectile for carrying out nuclear reactions. Why?
12. Distinguish between fissile isotope and fertile isotope.

SECTION – C

Answer ALL Questions : **(5 × 6 = 30)**

13. a) Derive Born Lande equation and discuss the factors affecting lattice energy.

(OR)

b) Explain ccp and fcc crystal structures with example.

14. a) Based on VSEPR theory predict the shape of PF_5, XeF_2 and XeF_4.

(OR)

b) What is H – bonding?
Explain its types and importance of hydrogen bonding

15. a) Discuss HSAB theory and its application with suitable examples.

(OR)

b) Explain the chemical behaviour of liquid NH_3 as non-aqueous solvent.

16. a) Detail the structural importance of isopolyanion.

(OR)

b) Discuss the chemistry of S-N compounds.

17. a) Write note on i) Radio active equilibrium ii) Transuranic elements

(OR)

b) What is nuclear fusion? Describe the principle of hydrogen bomb.

SECTION – D

Answer any THREE Questions : **(3 × 10 = 30)**

18. Write the pictorial representation of Born-Haber cycle for the formulation of MX type salt.
19. Draw the MO diagram for CO and NO and calculate the bond order.
20. Write notes on the i) Levelling effects in non-aqueous solvents
    ii) Reaction in liq. HF
21. Discuss the structure and bonding in Boranes.
22. Give an account on i) Scintillation counter
    ii) Cyclotron

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M.Sc. Chemistry Degree (Semester) Examinations, November 2018

Part – III : Core Subject : First Semester : Paper – III

PHYSICAL CHEMISTRY – I

Under CBCS – Credit 4

Time: **3** Hours Max. Marks: **75**

SECTION – A

Answer ALL Questions : **(5 × 1 = 5)**

1. Eigen values of a Hermitian operator are always _____.

   a) zero b) infinity c) imaginary d) real

2. The zero-point energy for a rotator is _____.

   a) 1 b) 2 c) 3 d) zero

3. Chemical potential is increase in the _____ at constant T, P when one mole of that constituent is added to the system

   a) entropy b) enthalpy c) work d) free energy

4. Increase in the concentration of the reactants leads to the change in _____.

   a) collision frequency b) activation energy

   c) heat of reaction d) threshold energy

5. Which of the following gases will have the highest rate of diffusion?

   a) methane b) ammonia c) carbondioxide d) hydrogen

SECTION – B

Answer any FIVE Questions : **(5 × 2 = 10)**

6. Find out the eigenvalue of the operation $\hat{A}\, e^{(ikx)}$, where $\hat{A} = -i\hbar\, d/dx$

7. What are Hermitian operators?

8. Give the solution for the Θ (θ) function of a rigid rotator with J=0 and m=0.
9. What is the zero point energy value of simple harmonic oscillator?
10. Distinguish between intensive and extensive thermodynamic properties.
11. What is steady state approximation?
12. Calculate the root mean square velocity of ozone at 250K.

SECTION – C

Answer ALL Questions : **(5 × 6 = 30)**

13. a) Discuss the Planck's theory of blackbody radiation.

(OR)

b) Explain the postulates of quantum mechanics.

14. a) Set up and solve the Schrodinger wave equation for a particle in a 1D box.

(OR)

b) Explain the following: i) Quantum mechanical tunnelling
ii) shape of s-orbitals

15. a) Derive and explain Gibbs-Duhem equation.

(OR)

b) Discuss any one method of determination of fugacity of real gases.

16. a) Explain the collision theory of bimolecular gaseous reactions.

(OR)

b) Discuss the effect of salt on reaction kinetics.

17. a) Explain the equipartition principle. Why does it fail for diatomic and polyatomic molecules?

(OR)

b) Calculate the mean kinetic energy (E_{trans}) in Joules for the molecules at 350K i) He ii) CO_2 and iii) UF_6

SECTION – D

Answer any THREE Questions : **(3 × 10 = 30)**

18. a) Distinguish between matter waves and electromagnetic waves.
b) Significance of commutation of operators.
c) Difference between ψ and ψ^2.

19. Set up the Schrodinger wave equation for hydrogen atom and give the solutions for $\Phi_{(0)}$, $\Theta_{(0,0)}$, $R_{(1,0)}$, $\psi_{(100)}$ and $E_{(100)}$.

20. Discuss the Onsager reciprocal relationship with an example.

21. Discuss the activated complex theory of molecular reactions.

22. a) Describe Maxwell's distribution of molecular velocities.
b) Write a note on liquid crystals.

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M.Sc. Chemistry Degree (Semester) Examinations, November 2018

Part – III : Core Subject : Third Semester : Paper – I

ORGANIC CHEMISTRY – III

Under CBCS – Credit 5

Time: **3** Hours Max. Marks: **75**

SECTION – A

Answer ALL Questions : **(5 × 1 = 5)**

1. Which is the correct order of increasing wave number of the stretching vibrations of (1) C-H (alkane), (2) O-H (alcohol), (3) C=O (ketone), and (4) C≡C (alkyne)?

   a) (4) < (3) < (2) < (1) b) (3) < (4) < (2) < (1)

   c) (3) < (4) < (1) < (2) d) (4) < (3) < (1) < (2)

2. The ^{1}H NMR spectrum of a compound B shows a doublet and a septet. Which of the following statements is true?

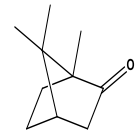
   a) The spectroscopic data are consistent with **B** containing a propyl ($CH_3CH_2CH_2$) group

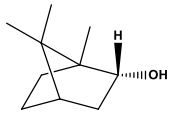
   b) The spectroscopic data are consistent with **B** being $(CH_3)_2CCl_2$

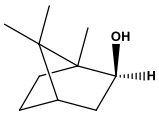
   c) The spectroscopic data are consistent with **B** containing a CH_3CH_2 group

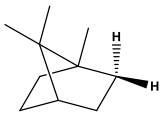
   d) The spectroscopic data are consistent with **B** being $(CH_3)_2CHCl$

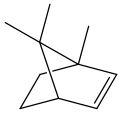
3. Major stereoselective product is



a) 

b) 

c) 

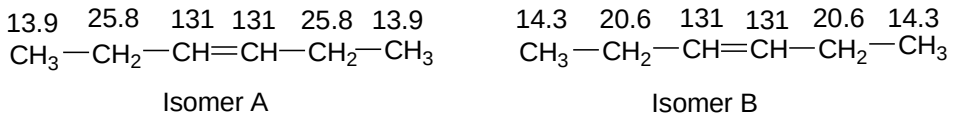
d) 

4. Cheletropic reactions are a subclass of _____ reactions.
   a) electrocyclic b) rearrangement
   c) cycloaddition d) sigmatropic
5. The photochemical isomerization of 4,4-diphenyl cyclohexadienone gives a ketone and phenols. This reaction is known as _____.
   a) Barton reaction b) Zimmermann rearrangement
   c) Norrish type II d) Paterno-Buchi

SECTION – B

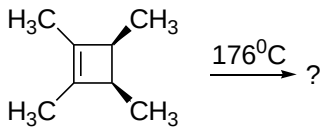
Answer any FIVE Questions : **(5 × 2 = 10)**

6. What is a chromophore? Give example.
7. Arrange the increasing order of –O-H and –C-O IR stretching frequency of phenol, 1°, 2° and 3° alcohols.
8. The NMR spectrum of N,N-dimethylformamide shows two signals for two methyl groups at room temperature while only one signal at high temperature. Why?
9. The ^{13}C NMR spectra of the two stereoisomeric 3-hexenes shows the following δ values.

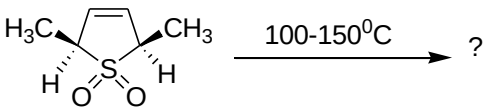


Identify *cis*and *trans* isomers.

10. Find the product of the following reaction.



11. Complete the following reaction



12. Write a note on the Norrish Type II reaction.

SECTION – C

Answer ALL Questions : **(5 × 6 = 30)**

13. a) i) State the Beer Lambert Law. **(3)**
    ii) Discuss the solvent effect on the α,β-unsaturated carbonyl compounds of UV-vis spectrum. **(3)**

(OR)

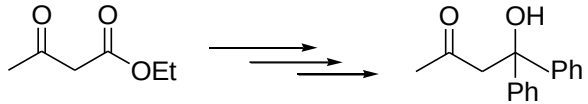
b) Discuss about mass electronic effects in IR spectroscopy.

14. a) Explain spin-spin splitting and coupling system of furan-2-aldehyde and 1-nitropropane.

(OR)

b) Discuss the geminal and vicinal couplings in NMR spectroscopy.

15. a) Explain the following conversion using synthetic strategy.

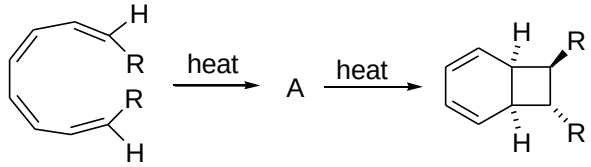


(OR)

b) Write note on classification of synthons with examples.

16. a) Find the product of the following reactions and explain the electron motion.

i)



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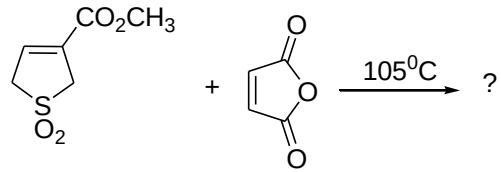
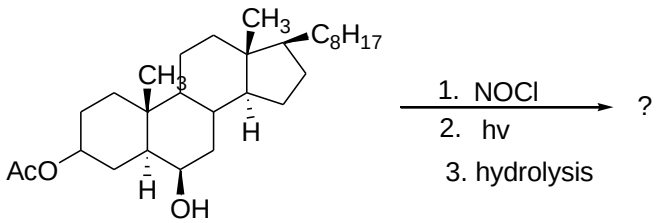


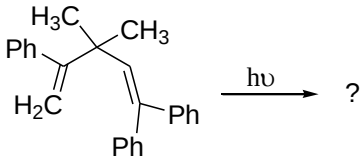
(OR)

b) Discuss the correlation diagram for thermal and photochemical interconversion ofcyclohexadiene-hexatriene using FMOs.

17. a) i) Write the reaction mechanism and product of the following reaction. **(3)**



ii) Complete the following reaction **(3)**



(OR)

b) Explain the following reactions with example. **(3 + 3)**

i) cis-trans isomerization and ii) photo reduction

SECTION – D

Answer any THREE Questions : **(3 × 10 = 30)**

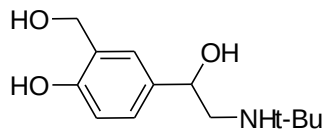
18. Explain the various stretching modes of–CH_3, -CH_2-, carboxylicacid anhydride, -NH_2 and nitro groups.

19. a) Write the principle and working methods of ^{13}C NMR spectroscopy.

b) Calculate the resonance frequency of the ^{1}H nucleus when subjected to field strength of 5.25 tesla. ($h=6.626x10^{-34}Js$; $\beta_N=5.051x10^{-27}JT^{-1}$; g=5.585 for ^{1}H).

c) Explain the effect of shift reagents in ^{1}H NMR with example. **(4+3+3)**

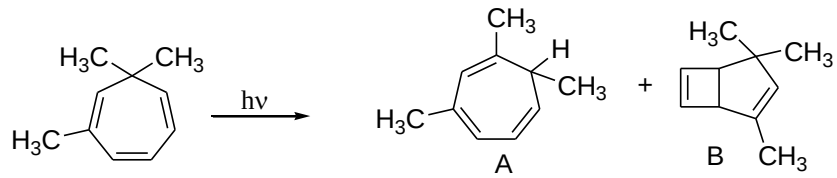
20. Find out the suitable synthons of the salbutamol using reterosynthetic analysis. Give its synthesis using the found synthons.



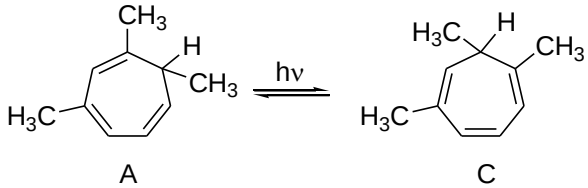
Salbutamol

21. i) What type of processes are involved the following transformation? Explain. **(4 + 3 + 3)**

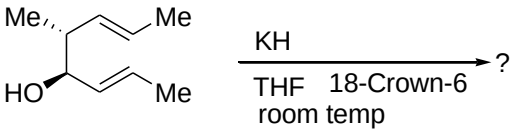
a)



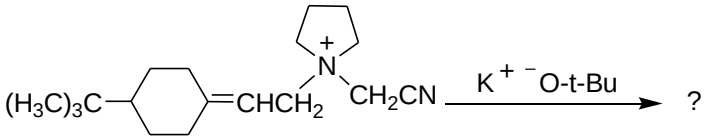
b)



ii) Write the transition state and theproduct of the following reaction.

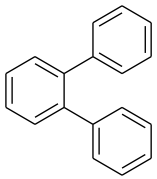


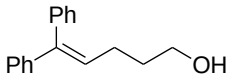
iii) Find out the product and write the mechanism for the following reaction.



22. Complete the following reactions **(6 + 4)**

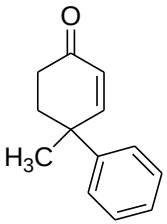
i) **a)** PhCH═O +  $\xrightarrow{h\nu}$?

b)  $\xrightarrow{h\upsilon,\ O_2}$?

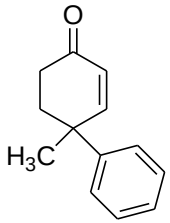
c) 

$\xrightarrow[C_{14}H_8(CN)_2]{h\nu}$?

ii) Write the reaction mechanism and product of the following reactions.



$\xrightarrow[T_1(\pi,\pi*)]{h\upsilon}$?



$\xrightarrow[T_1(n,\pi*)]{h\upsilon}$?

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VIVEKANANDA COLLEGE, TIRUVEDAKAM WEST

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M.Sc. Chemistry Degree (Semester) Examinations, November 2018

Part – III : Core Subject : Third Semester : Paper – I

INORGANIC CHEMISTRY – III

Under CBCS – Credit 4

Time: **3** Hours Max. Marks: **75**

SECTION – A

Answer ALL Questions : **(5 × 1 = 5)**

1. The metal atom present in the active site of carboxy peptidase is _____.
   a) cobalt b) zinc c) iron d) magnesium
2. The ligand system present in the vitamin B_{12} is _____.
   a) phorphyrin b) corrin c) phthalocyanin d) crown ether
3. Which type of defect is observed when amolecule is heated _____.
   a) vacancy b) interstitial c) schottky d) frenkel
4. Which one of the following ray is used in Mossbauer spectroscopy
   a) gamma b) alpha c) beta d) x-ray
5. Elements after atomic number 92 are called _____.
   a) Actinoids b) lanthanoids
   c) inner-transition elements d) transuranium elements

SECTION – B

Answer any FIVE Questions : **(5 × 2 = 10)**

6. Indicate the function of carboxypeptidase.
7. Write any two characteristics of cytochrome P-450.
8. Mention the biological role of vitamin B_{12}.
9. What are the advantages of neutron diffraction studies?
10. What are dislocations? Mention the types.
11. What is chemical shifts in NMR spectroscopy?
12. Why La^{3+} and Lu^{3+} ions are not para magnetic.

SECTION – C

Answer ALL Questions : **(5 × 6 = 30)**

13. a) Discuss the binding of O_2 in haemoglobin. **(OR)**
    b) Explain the structure and functional characteristics of carbonic anhydrase.
14. a) Write note on iron sulphur protein. **(OR)**
    b) Describe the invivo nitrogen fixation.
15. a) Discuss band theory of solids. **(OR)**
    b) Briefly explain the different crystal systems.
16. a) Explain the terms Zero field splitting and Kramer's degeneracy. Applying the two phenomenan, predict the number of EPR spectral lines for $[Mn(H_2O)_6]^{2+}$. **(OR)**
    b) How Massbauer spectroscopy is useful in the study of oxidation state, back bonding and structures of metal carbonyls.
17. a) In what respects actinides resembles with lanthanide elements.

    (OR)

    b) Explain how the lanthanide complexes are used as shift reagents.

SECTION – D

Answer any THREE Questions : **(3 × 10 = 30)**

18. Explain the structure and functions of Myoglobin.
19. Discuss the function of chlorophyll in photosynthesis and elucidate the pathway of electron transports sequence in PS-1 and PS-11
20. What are crystal defects? Explain Schottky and Frenkel defects.
21. Discuss the application of NMR spectroscopy in structure determination. Write note on the NMR studies on exchange reactions between ligands and metal ions.
22. Describe the spectral and magnetic property of lanthanides and actinides.

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M.Sc. Chemistry Degree (Semester) Examinations, November 2018

Part – III : Core Subject : Third Semester : Paper – III

PHYSICAL CHEMISTRY – III

Under CBCS – Credit 4

Time: **3** Hours Max. Marks: **75**

SECTION – A

Answer ALL Questions : **(5 × 1 = 5)**

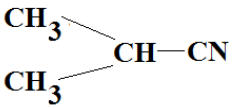
1. Which one of the following molecules contains 3 vertical planes.
   a) water b) benzene
   c) BrF_5 d) 1, 3, 5 trichlorobenzene
2. A linear molecule has_____ operations
   a) 29 b) 4 c) infinite d) 24
3. δ value of TMS in NMR spectra is fixed at _____.
   a) 0 b) 1 c) 2 d) 3
4. Which of the following molecule shows ESR spectra?
   a) H_2O b) O_2 c) H_2O_2 d) CO_2
5. The pH of blood is maintained by CO_2 and H_2CO_3 in the body and chemical constituents of blood. This is called _____.
   a) Colloidal action b) Buffer action
   c) Acidic action d) Salt balance

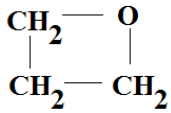
SECTION – B

Answer any FIVE Questions : **(5 × 2 = 10)**

6. Assign the point group for i) Ethylene ii) Acetylene
7. Give the matrix representation for inversion and identity operations.
8. Give the selection rule for IR allowed spectral transition by group theory.
9. State mutual exclusion principle.

10. Predict the number of signals obtained for the following in ^{1}H-NMR spectrum:

i) 

ii) 

11. How many number of hyperfine ESR signals is obtained for $\cdot CH_3$ and naphthalene anion radicals?

12. What is the significance of viscosity in biological system?

SECTION – C

Answer ALL Questions : **(5 × 6 = 30)**

13. a) Explain the following symmetry operations with an example:

i) Inversion ii) Improper axis of rotation

(OR)

b) What are the important rules regarding reducible and irreducible representations?

14. a) Explain the IR spectrum of water molecule using group theory.

(OR)

b) Show that $n \rightarrow \pi^*$ is a forbidden electronic transition in formaldehyde using group theory.

15. a) Describe the spin-spin splitting in high resolution ^{1}H-NMR spectrum.

(OR)

b) Explain the principle of FT-NMR spectrum.

16. a) Discuss the principle of ESR spectroscopy.

(OR)

b) Explain the possible NQR transitions for the nucleus with I = 1 under various electric field gradients.

17. a) Derive and explain the Henderson-Hasselbalch equation.

(OR)

b) Discuss about Danielli and Davson membrane model.

SECTION – D

Answer any THREE Questions : **(3 × 10 = 30)**

18. Construct the irreducible representation character table for C_{2V} point group based on the Great Orthogonality Theorem.

19. Discuss the possible hybridisations present in CH_4 molecule using group theory. (Provide character table for Td point group)

20. Explain the following: i) Relaxation process in NMR

ii) Nuclear Overhauser effect

21. a) Write a note on zero field splitting in ESR spectroscopy.

b) Discuss the applications of NQR spectroscopy.

22. Explain the principle, advantage and limitation of tracer technique.

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VIVEKANANDA COLLEGE, TIRUVEDAKAM WEST
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M.Sc. Chemistry Degree (Semester) Examinations, November 2018
Part – III : Elective Subject : First Semester : Paper – I

COMPUTER APPLICATIONS IN CHEMISTRY
Under CBCS – Credit 5

Time: **3** Hours Max. Marks: **75**

SECTION – A

Answer ALL Questions : **(5 × 2 = 10)**

1. The direction of a rectangular page for viewing and printing is called
   a) Orientation b) Direction c) Print Layout d) Preview
2. DNS stands for _____.
   a) Domain Null System b) Disk Name System
   c) Domain Number System d) Domain Name System
3. Which of the following is not a compound assignment operator?
   a) /= b) += c) %= d) ==
4. If the H^+ concentration is 0.0001 M/l, what is the pH?
   a) 4 b) -4 c) 5 d) -5
5. Conformational analysis will be effectively visualized at
   a) 2D Chemdraw b) 3D Chemdraw
   c) both a and b d) DFT

SECTION – B

Answer any FIVE Questions : **(5 × 2 = 10)**

6. Write the salient features of windows.
7. Define 'Internet' What are its uses?
8. How to create an e-mail?
9. Define 'Symbolic Constants'.
10. How do you calculate the pH of the given solution?
11. State the Beer – Lambert's Law.
12. Define chamdraw.

SECTION – C

Answer ALL Questions : **(5 × 6 = 30)**

13. a) Describe how MS word is useful for typing text and equation in chemistry.

(OR)

b) Give a brief note on Chemdraw.

14. a) Write briefly about www.

(OR)

b) Describe the applications of internet.

15. a) Write a note an variables.

(OR)

b) Give a short note on conditional operators & bit operators.

16. a) Discuss about library function.

(OR)

b) Define calculation of cell parameters.

17. a) List the differences between the chemdraw and chem 3D.

(OR)

b) Write a note on geometry optimization property.

SECTION – D

Answer any THREE Questions : **(3 × 10 = 30)**

18. How MS Access can be used for creating and accessing database?
19. Discuss on the advantages and disadvantages of E-mail.
20. Describe the increment and decrement operator.
21. Explain the array and its types.
22. How NMR spectra can be simulated and interpretated using chemdraw tools?

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VIVEKANANDA COLLEGE, TIRUVEDAKAM WEST
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M.Sc. / M.Com. Degree (Semester) Examinations, November 2018
Part – IV : Non-Major Subject : Third Semester : Paper – I

FORENSIC CHEMISTRY
Under CBCS – Credit 5

Time: **3** Hours Max. Marks: **75**

SECTION – A

Answer ALL Questions : **(5 × 1 = 5)**

1. Which of following is not an optional service, which may be provided by a full-service crime laboratory?
   a) Voiceprint Analysis Unit b) Latent Fingerprint Unit
   c) Polygraph Unit d) Photography Unit
2. At high dose level alcohol affects
   a) CNS b) SNS c) ANS d) NS
3. Whorls are divided into how many distinct groups?
   a) 6 b) 8
   c) 10 d) there is no minimum number
4. If father and mother both have the blood type AB, then the impossible blood type of their child is:
   a) A b) B c) AB d) O
5. Polygraph is an _____.
   a) Analytical device b) Software c) DNA device d) Medicine

SECTION – B

Answer any FIVE Questions : **(5 × 2 = 10)**

6. What are the branches of forensic science?
7. Mention any four heart related issues associated with consuming of alcohol.
8. What is an individual characteristic?
9. Explain types of fingerprint.
10. Define forensic serology.
11. Differentiate spatter and transfer.
12. Explain the term polygraph.

SECTION – C

Answer ALL Questions : **(5 × 6 = 30)**

13. a) What is meant by forensic science?
    Write a short note on forensic history.
    (OR)
    b) List and define various types of evidence.
    What types of evidence does a crime laboratory analyze?
14. a) Briefly discuss any five effects of alcohol in our human body.
    (OR)
    b) Give any five important sources for poison.
15. a) Discuss sense of crime print. **(OR)**
    b) Discuss the difference between latent, negative and plastic fingerprints.
16. a) Write a short note on bloodstain pattern analysis. **(OR)**
    b) Write down all the activities undertaken in serology division.
17. a) Illustrate the working principle of polygraph. **(OR)**
    b) Write shortly on the various stages in DNA testing.

SECTION – D

Answer any THREE Questions : **(3 × 10 = 30)**

18. Write down the various divisions of forensic laboratory.
19. How the Blood Alcohol Content (BAC) is testing in Drinkers?
20. Write note on classification of fingerprints.
21. Explain in detail about blood types and paternity determination.
22. Write briefly about the administration of the test, Questioning and Environmental conditions in Polygraph analysis.

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