020/2021

Question Booklet Alpha Code **A**

Question Booklet Serial Number

Total No. of Questions : 100 **Time : 75 Minutes**

Maximum : 100 Marks

INSTRUCTIONS TO CANDIDATES

1. The question paper will be given in the form of a Question Booklet. There will be four versions of question booklets with question booklet alpha code viz. A, B, C & D.
2. The Question Booklet Alpha Code will be printed on the top left margin of the facing sheet of the question booklet.
3. The Question Booklet Alpha Code allotted to you will be noted in your seating position in the Examination Hall.
4. If you get a question booklet where the alpha code does not match to the allotted alpha code in the seating position, please draw the attention of the Invigilator IMMEDIATELY.
5. The Question Booklet Serial Number is printed on the top right margin of the facing sheet. If your question booklet is un-numbered, please get it replaced by new question booklet with same alpha code.
6. The question booklet will be sealed at the middle of the right margin. Candidate should not open the question booklet, until the indication is given to start answering.
7. Immediately after the commencement of the examination, the candidate should check that the question booklet supplied to him contains all the 100 questions in serial order. The question booklet does not have unprinted or torn or missing pages and if so he/she should bring it to the notice of the Invigilator and get it replaced by a complete booklet with same alpha code. This is most important.
8. A Blank sheet of paper is attached to the question booklet. This may be used for rough work.
9. **Please read carefully all the instructions on the reverse of the Answer Sheet before marking your answers.**
10. Each question is provided with four choices (A), (B), (C) and (D) having one correct answer. Choose the correct answer and darken the bubble corresponding to the question number using Blue or Black Ball-Point Pen in the OMR Answer Sheet.
11. **Each correct answer carries 1 mark and for each wrong answer 1/3 mark will be deducted. No negative mark for unattended questions.**
12. No candidate will be allowed to leave the examination hall till the end of the session and without handing over his/her Answer Sheet to the Invigilator. Candidates should ensure that the Invigilator has verified all the entries in the Register Number Coding Sheet and that the Invigilator has affixed his/her signature in the space provided.
13. Strict compliance of instructions is essential. Any malpractice or attempt to commit any kind of malpractice in the Examination will result in the disqualification of the candidate.

Total Marks : 100 Marks

Time : 1 hour and 15 minutes

1. A solution of HCl in water is 10.0% HCl by mass. Find the mole fraction of HCl in this solution.
(A) 0.036 (B) 0.051 (C) 0.012 (D) 0.060

2. A cylinder fitted with a frictionless piston contains 2.00 mol of He perfect gas at pressure 1.00 atm and is in a large constant-temperature bath at 500 K. The pressure is reversibly increased to 10.00 atm. Calculate the work done on this process. ($R = 8.314\ J\ mol^{-1}\ K^{-1}$)
(A) 19147 J (B) 8314 J (C) 831.4 J (D) 1914.7 J

3. Which of this statement is incorrect for a fixed amount of a perfect gas ?
(A) Internal energy (U) and enthalpy (H) each depend only on T.
(B) $PdV = nRdT$ for every infinitesimal process.
(C) $C_{P,m} - C_{V,m} = R$.
(D) $dU = C_V\ dT$ for a reversible process

4. Which of the following equation relates the chemical potential and the composition of a mixture ?
(A) Gibbs-Helmholtz (B) Joule-Thomson
(C) Debye-Huckel (D) Gibbs-Duhem

5. The change in entropy for reversible phase change ($\Delta H = +$) at constant temperature and pressure is
(A) Positive (B) Negative
(C) Zero (D) Either positive or negative

6. Identify the correct Clausius-Clapeyron equation from the following options (V_f and V_i are final and initial specific volumes, respectively) :
(A) $\frac{dP}{dT} = \frac{\Delta H}{T(V_i - V_f)}$ (B) $\frac{dT}{dP} = \frac{\Delta H}{T(V_i - V_f)}$
(C) $\frac{dP}{dT} = \frac{\Delta H}{T(V_f - V_i)}$ (D) $\frac{dP}{dT} = \frac{\Delta H}{T(V_i + V_f)}$

7. According to $A_2\ (g) \rightleftharpoons 2A(ads)$, the Langmuir adsorption isotherm for the dissociative adsorption of isotherm (where, ads = adsorbed, P is the partial pressure of A_2 and k is the ratio of rate constant for adsorption and desorption) is
(A) $\theta = \frac{kP}{1+kP}$ (B) $\theta = \sqrt{\frac{kP}{1+kP}}$ (C) $\theta = \frac{k}{1+kP}$ (D) $\theta = \frac{\sqrt{kP}}{1+\sqrt{kP}}$

8. The equation, $\ln \gamma_{\pm} = -z^+|z^-|AI_m^{1/2}$ is called the Debye-Hückel limiting law (I_m = molality-scale ionic strength; $\gamma_{\pm}$ = molality-scale mean ionic activity coefficient). Under which condition the experimental data show that the equation does give the correct limiting behaviour for electrolyte solutions ?
(A) $I_m \to 1$ (B) $I_m \to 0$ (C) $I_m = 1$ (D) $I_m \to \infty$

9. Calculate the ionic strength I_m in a solution that contains 0.0200 mol KCl, 0.0050 mol $MgCl_2$, 0.0020 mol $MgSO_4$ and 100 g H_2O.

(A) 0.0430 $mol.kg^{-1}$ (B) 0.0860 $mol.kg^{-1}$
(C) 0.430 $mol.kg^{-1}$ (D) 0.860 $mol.kg^{-1}$

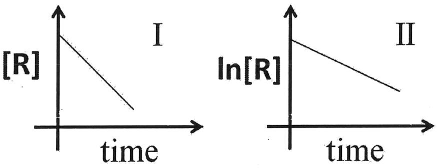
10. Read the following statements carefully :

(i) The incident electron beam ionizes an atomic core level electron.
(ii) The energy released when a higher-energy electron falls back to fill the core level is transferred to a valence electron, which is ejected into the gas phase where it is detected.

These processes involving in the principle of

(A) XPS (B) UPS
(C) Auger Electron Spectroscopy (D) LEED

11. The concentration of a reactant R varies with time for two different reactions (I and II) which are shown below.



The order of these reactions I and II, respectively, are

(A) 1 and 0 (B) 0 and 2 (C) 1 and 2 (D) 0 and 1

12. Which one of the following process is non-spontaneous ?

(A) Flow of heat from hot end to cold end
(B) Expansion of a gas into vacuum
(C) Freezing of water at 0 °C and 1 atm pressure
(D) Formation of trimethylphosphine oxide from trimethylphosphine and oxygen.

13. The standard electrode potential values for the following half-cell reactions

$Cd^{2+} + 2e^- \rightarrow Cd$; $Zn^{2+} + 2e^- \rightarrow Zn$

are –0.40 V and –0.76 V, respectively. Which of the following statement is true ?

(A) Cadmium is more electropositive than zinc
(B) Zinc is more electropositive than cadmium
(C) Zinc is more electronegative
(D) None of the above

14. From the following half-cell reactions :

$Mn^{2+} + 2e^- \rightarrow Mn \quad E° = -1.18V$;
$Mn^{3+} + 2e^- \rightarrow Mn^{2+} \quad E° = +1.51V$;

determine the standard reduction potential value and conclude whether the following reaction is feasible or not.

$3Mn^{2+} \rightarrow 2Mn^{3+} + Mn$

(A) –2.69 V, feasible (B) –0.33 V, feasible
(C) –0.33 V, not feasible (D) –2.69 V, not feasible

15. The point group of CO_2 is $D_{\infty h}$. Which pair of molecules in the below options also have same point group ?

(A) HCCH and XeF_2 (B) NO_2^+ and NO_2
(C) XeF_2 and N_2O (D) C_2H^- and LiH.

16. For 1.00 mol.dm^{-3} KCl(aq) at 25 °C and 1 atm, the conductivity κ is 0.115 Ω^{-1} cm^{-1}. Calculate their molar conductivity, Λ_m in Ω^{-1} m^2 mol^{-1}.

(A) 115 (B) 0.115 (C) 0.0115 (D) 0.00115

17. Pick out the correct answer/s among the following statements :

(i) Addition of a solute at constant T and P to a solution containing solvent A always decreases chemical potential μ_A

(ii) The vapour pressure of a solution of A and B at temperature T is always less than the vapour pressure of pure A at T.

(A) All of the above (i and ii) (B) Only (i)
(C) Only (ii) (D) None of the above

18. Consider the following statements about the salt bridge :

(i) It enhances the rate of the reaction.
(ii) It can minimizes the junction potential.
(iii) It consists of an electrolyte in a gel.

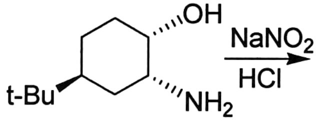
The correct statement/s is/are

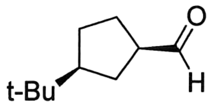
(A) Only (i and iii) (B) All of the above (i, ii and iii)
(C) Only (iii) (D) Only (ii and iii)

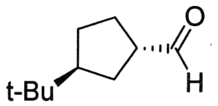
19. The gas-phase reaction, $2NO_2Cl \rightarrow 2NO_2 + Cl_2$ has rate law in the form of $r = k[NO_2Cl]$. The rate determining step consistent with this rate law is

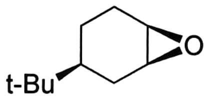
(A) $2NO_2Cl \rightarrow 2NO_2 + Cl_2$ (B) $NO_2Cl \rightarrow NO_2 + Cl$
(C) $NO_2 + Cl \rightarrow NO_2Cl$ (D) $NO_2Cl + Cl \rightarrow NO_2 + Cl_2$

20. Identify the correct product of the following reaction :



(A)


(B)


(C)


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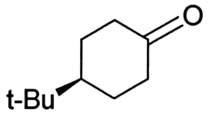
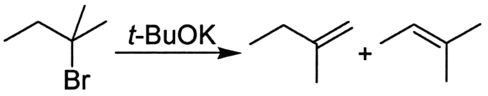


21. Consider the following reaction :



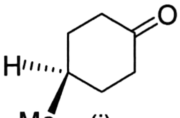
Which options contain the statements of the above reaction is correct ?

(i) E1 reaction
(ii) E2 reaction
(iii) Major product is more substituted alkene.
(iv) Major product is less substituted alkene.

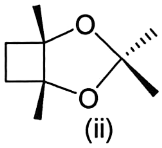
(A) Only (i & iii) (B) Only (ii & iii) (C) Only (i & iv) (D) Only (ii & iv)

22. One of the space groups for monoclinic crystal system is $P2_1/c$. Here, the 2_1 symmetry element corresponds to operation of
- (A) Rotation followed by a reflection in a plane
- (B) Translation followed by a reflection in a plane parallel to the translation axis
- (C) Rotation of an axis and translation along that axis
- (D) Purely rotational.

23. Which of the following molecules is/are chiral ?



(i)



(ii)

(A) Both (i and ii) (B) Only (ii) (C) Only (i) (D) None of them

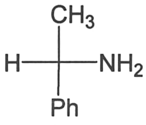
24. The incorrect feature of R/S-BINAP (2,2'-bis(diphenylphosphino)-1,1'-binaphthyl) from the following list is
- (A) A chiral centre exist
- (B) No stereogenic centre
- (C) Rotation between two naphthyl rings is restricted.
- (D) No chiral centre also no plane of symmetry.

25. Identify the most relevant statement about enantiomers from the following options :
- (A) They have unidentical physical properties but same biological effects.
- (B) They have identical physical properties but quite different biological effects.
- (C) They have identical physical and biological properties.
- (D) Both physical and biological properties are unidentical.

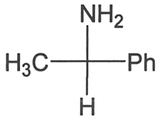
26. Which one of the following rearrangement has given considerable evidence for involving cyclopropanone as reaction intermediate ?

(A) Favorskii (B) Pinacol (C) Wolff (D) Curtius

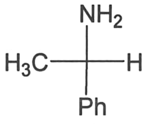
27. Among the four Fischer projections given below, identify a compound which is different from the remaining three ?



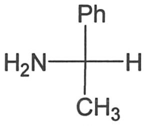
(i)



(ii)



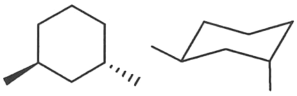
(iii)



(iv)

(A) (i) (B) (ii) (C) (iii) (D) (iv)

28. What is the stereochemical relationship between these two molecules ?

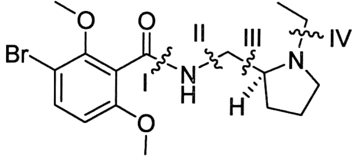


- (A) Identical
- (B) Enantiomers
- (C) Diastereomers
- (D) Geometrical isomers.

29. In which medium, benzil-benzilic acid rearrangement occurs ?

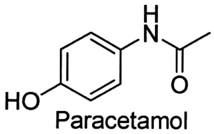
(A) Basic (B) Slightly acidic (C) Neutral (D) Strongly acidic.

30. Which of the disconnection (I-IV) is best likely to occur for the following structure ?

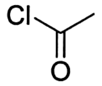


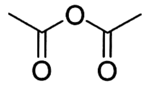
(A) Disconnection I
(B) Disconnection II
(C) Disconnection III
(D) Disconnection IV

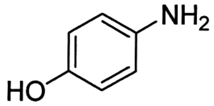
31. To carry out a retrosynthetic analysis of paracetamol, pick out a reagent (A-D) which is least likely to be useful.

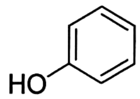


Paracetamol

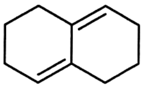
(A) 

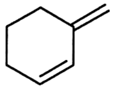
(B) 

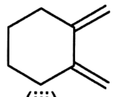
(C) 

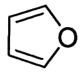
(D) 

32. Which one of the option containing dienes can undergo Diels-Alder reaction ?


(i)


(ii)

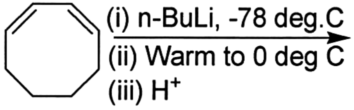

(iii)

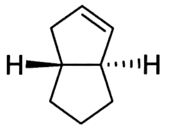


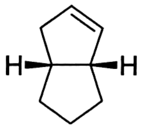
(iv)

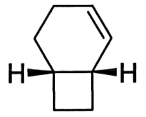
(A) Only (i & iii)
(B) Only (ii & iv)
(C) Only (iii & iv)
(D) Only (ii, iii & iv)

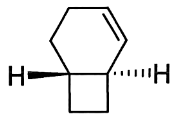
33. Identify a correct product for the following reaction :



(A) 

(B) 

(C) 

(D) 

34. How many nodes exist in LUMO (Lowest Unoccupied Molecular Orbital) of 1, 3, 5-hexatriene ?

(A) 2
(B) 3
(C) 4
(D) 5

35. Why does the body need sunlight to make provitamin D2 ?

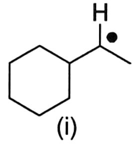
(A) For the conversion of ergosterol to provitamin D2 through sigmatropic rearrangement
(B) For the conversion of cholesterol to provitamin D2 through electrocyclic reaction
(C) For the conversion of ergosterol to provitamin D2 through electrocyclic reaction
(D) For the conversion of cholesterol to provitamin D2 through cycloaddition reaction.

36. Match the items of List I (Alkaloid) with List II (Skeleton of their structure) :

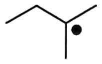
List I		**List II**	
(i)	Nicotine	(m)	Quinoline
(ii)	Papaverine	(n)	Isoquinoline
(iii)	Resperine	(o)	Pyrrolidine
(iv)	Quinine	(p)	Indole

(A) i-p; ii-o; iii-n; iv-m
(B) i-n; ii-p; iii-o; iv-m
(C) i-n; ii-m; iii-p; iv-o
(D) i-o; ii-n; iii-p; iv-m

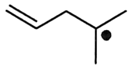
37. Of the following radicals, which is the most stable ?



(i)



(ii)



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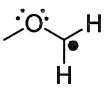
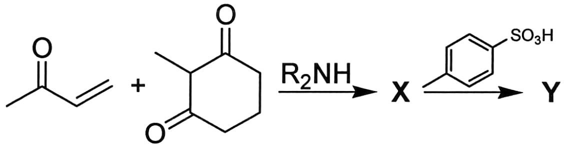


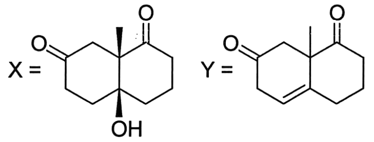
(iv)

(A) (i) (B) (ii) (C) (iii) (D) (iv)

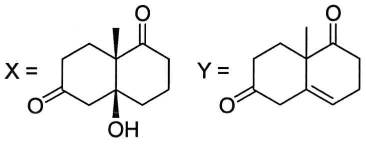
38. Identify the products (X and Y) in the following reaction :



(A)



(B)



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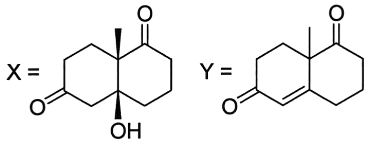

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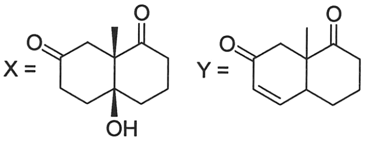
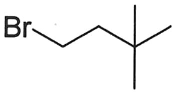
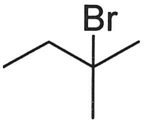


39. Identify a major product, when 2-methylbutane is allowed to react with bromine in presence of light or heat.

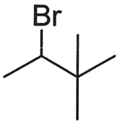
(A)



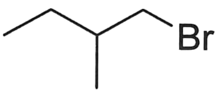
(B)



(C)



(D)



40. Which one of the following reaction has positive Hammett reaction constant, ρ value ?

(A) S_N2 displacement of iodide from ethyl iodide by phenoxide anions

(B) Hydrolysis of α, α-dimethylbenzyl chloride through S_N1 pathway.

(C) Nucleophilic substitution reaction between piperidine and l-bromo-2-nitrobenzene

(D) Nitration of substituted benzene derivatives.

41. The first Stokes line and the first anti-Stokes line in the rotational Raman spectrum of N_2O are displaced from the Rayleigh line by 2.508 cm^{-1} on each side. Determine the rotational constant of N_2O.

(A) 2.514 cm^{-1} (B) 1.257 cm^{-1} (C) 0.629 cm^{-1} (D) 0.419 cm^{-1}

42. Pick out a pair of molecule from the following options, which can exhibit both pure rotational and a rotational Raman spectrum ?

(A) CO and CH_4 (B) N_2 and H_2O

(C) NO and HCCD (D) CO_2 and N_2O.

43. From the list of molecules, which would you expect the infrared active vibrations to be Raman inactive and vice versa ?

(A) Iodobenzene (B) Benzene (C) Vinyl fluoride (D) NO_2

44. Which of the compound is most suitable with an infrared spectrum of the following data : a broad absorption band at 3000 cm^{-1} with some sharper bands appearing on its shoulder at about 3060 cm^{-1}; a strong absorption at about 1700 cm^{-1}; a sharp band at 1600 and 1475 cm^{-1}; a series of sharp bands between 650 and 800 cm^{-1} ?

(A) Ethanol
(B) Phenol
(C) Benzoic acid
(D) Acetic acid

45. Which of the given coordination complex cannot exhibit quadrupole splitting in ^{57}Fe Mössbauer spectrum ?

(i) $K_4[Fe(CN)_6]$
(ii) $[Fe(CO)_5]$
(iii) $Na_3[Fe(CN)_6]$
(iv) $Na_2[Fe(CN)_5NO]$

(A) (i)
(B) (ii)
(C) (iii)
(D) (iv)

46. The chemical shift between fat protons and water results in a frequency difference of around 210 Hz at 1.5 T. What would be their frequency difference at 4.5 T ?

(A) 210 Hz
(B) 420 Hz
(C) 630 Hz
(D) 70 Hz

47. ^{1}H NMR spectrum shows a singlet while ^{13}C NMR exhibits two signals. Based on these data, pick out a correct molecule from these options ?

(A) Chloroethane
(B) 1,2-Dibromoethane
(C) Benzene
(D) Acetone

48. Which of the following molecule would give the most prominent peak in the mass spectrum corresponding to a radical cation formed by McLafferty rearrangement ?

(i) $CH_3CH_2COCH_2CH_3$;
(ii) $CH_3CH_2CH_2COCH_3$;
(iii) $(CH_3)_2CHCOCH_3$;
(iv) $(CH_3)_2CHCOCH(CH_3)_2$.

(A) (i)
(B) (ii)
(C) (iii)
(D) (iv)

49. Find out a correct characteristic/s about n to π^* transition :

(i) The molar absorptivity of the transition is generally less than 2000.
(ii) Hydrogen bonding solvent cause pronounced blue shifts.
(iii) The absorption band corresponding to the n to π^* transition is absent for hydrocarbon.

(A) Only (i & ii)
(B) Only (i & iii)
(C) Only (i)
(D) All of the above (i, ii & iii)

50. The absorption band maximum for iodine occurs at about 520 nm in the solvent CCl_4. Assign a correct transition for this absorption.

(A) π to σ^*
(B) n to σ^*
(C) π^* to σ^*
(D) π to π^*

51. Predict the number of lines in the EPR spectrum of a solution of dimethyl nitroxide radical $(CH_3)_2NO$, assuming the lines do not overlap ? ($I = 1$ for ^{14}N; $I = \frac{1}{2}$ for ^{1}H)

(A) 21
(B) 12
(C) 24
(D) 3

52. Which one of the following species is EPR silent ?

(i) $[S_3]^-$
(ii) $[S_6]^{2-}$
(iii) $[SO_2]^-$
(iv) $[S_4]^-$

(A) (i)
(B) (ii)
(C) (iii)
(D) (iv)

53. Consider the following statements about the electronic spectra of octahedral high spin complexes.

(i) Co^{3+} can exhibit usually three absorption peaks.

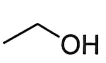
(ii) Cr^{3+} can display maximum one absorption peak.

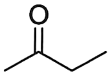
(iii) Mn^{2+} has low molar extinction coefficient value ($\sim 10^{-2}$ $Lmol^{-1}$ cm^{-1})

The correct statement/s is/are

(A) All of the above (i, ii & iii)
(B) Only (i & ii)
(C) Only (ii and iii)
(D) Only (iii)

54. Arrange the following compounds in decreasing order of pK_a (K_a = Acid dissociation constant) :


(i)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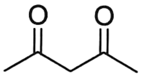
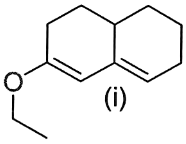
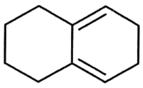
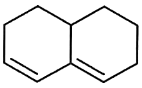

(iii)

(A) ii > i > iii (B) iii > i > ii (C) i > ii > iii (D) iii > ii > i

55. By making use of Woodward-Fieser rule, arrange the following compounds in increasing order of λ_{max} ?


(i)


(ii)


(iii)

(A) ii < i < iii (B) iii < i < ii (C) i < ii < iii (D) iii < ii < i

56. The results of an analysis are 26.97 g compared with the accepted value of 27.06 g. The absolute error (in g) and relative error (in %) are

(A) –0.09 and –0.33
(B) 0.09 and –0.33
(C) –0.09 and 0.33
(D) 0.09 and 0.33

57. In HPLC, the expression for resolution of column is given by $R_s = \frac{2(t_{rB} - t_{rA})}{(W_A + W_B)}$ here the terms W_A and W_B describe

(A) Weight of analytes A and B
(B) Retention time of analytes A and B
(C) Base width of analytes A and B
(D) Selectivity factor of analytes A and B

58. Which one of the statement is not relevant towards the application of GC-MS ?

(A) Tool for performing separations
(B) Useful for effectiveness of purification procedure
(C) The peak height or peak area of an eluate from a GC column has been widely used for quantitative analyses.
(D) Provides more authentic qualitative information than most of the spectroscopic methods.

59. The magnitude of strength of various kinds of non-covalent interactions such as (i) ion-ion, (ii) ion-dipole, and (iii) dipole-dipole, follow the order,

(A) ii > i > iii (B) iii > i > ii (C) i > ii > iii (D) iii > ii > i

60. Consider the following statements with respect to hydrogen bonding :

(i) High degree of directionality.

(ii) special kind of dipole-dipole interaction.

(iii) HF_2^- ion is linear with the hydrogen atom between the two fluorine atoms $[F \cdots H \cdots F]^-$ involving strong hydrogen bond.

The correct statements are

(A) Only (i & iii)
(B) Only (i & ii)
(C) Only (ii & iii)
(D) All of the above (i, ii & iii)

61. Identify a complex, which does not obey 18-electron rule.

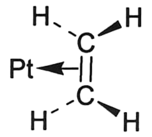
(A) $Co_6(CO)_{16}$
(B) $Fe_2(CO)_9$
(C) $Co_4(CO)_{12}$
(D) $Fe_3(CO)_{12}$

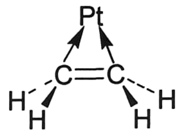
62. Match the items in List I (organometallic complex) with their most appropriate structure in List II :

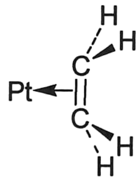
List I		**List II**	
(i)	$[Cp_3Ni_2]^+$	(m)	Open-faced sandwiches
(ii)	vapor state of CpIn	(n)	Tilted rings
(iii)	solid state of CpIn	(o)	Polymer
(iv)	Cp_2ReH	(p)	Triple deckers

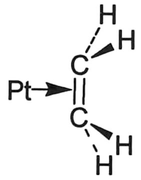
(A) i-p; ii-m; iii-o; iv-n
(B) i-n; ii-p; iii-o; iv-m
(C) i-n; ii-m; iii-p; iv-o
(D) i-o; ii-n; iii-p; iv-m

63. Zeise's salt, $[Pt(C_2H_4)Cl_3]^-$ has shown that the ethylene occupies the fourth co-ordination site of the square planar complex. Identify the correct representation of π co-ordination of an ethylene ligand with platinum metal.

(A)


(B)


(C)


(D)


64. Match the items in List I (name of process) with their most appropriate catalyst (List II):

List I		**List II**	
(i)	Wilkinson catalyst	(m)	$[Rh(CO)_2I_2]^-$
(ii)	Oxo process	(n)	$[PdCl_4]^{2-}$
(iii)	Monsanto acetic acid process	(o)	$Co_2(CO)_8$
(iv)	Wacker process	(P)	$[(Ph_3P)_3RhCl]$

(A) i-o; ii-n; iii-p; iv-m
(B) i-p; ii-n; iii-o; iv-m
(C) i-n; ii-m; iii-p; iv-o
(D) i-p; ii-o; iii-m; iv-n

65. Which characterization technique would useful to confirm hydride functionality in $H_2Fe(CO)_4$?

(A) Mass spectrometry
(B) Infra-red
(C) ^1H NMR
(D) Mössbauer

66. Identify the second nuclide formed in the fission reaction :

$${}^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{103}_{42}\mathrm{Mo} + 2{}^{1}_{0}\mathrm{n}$$

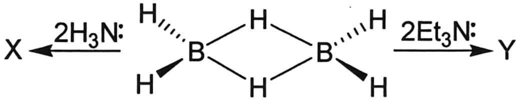
(A) ${}^{131}_{50}\mathrm{Sn}$ (B) ${}^{131}_{50}\mathrm{Sb}$ (C) ${}^{131}_{50}\mathrm{In}$ (D) ${}^{131}_{50}\mathrm{I}$

67. Talc is a kind of silicate mineral, which can be simply defined as

(A) Magnesium analogue of kaolin (B) Magnesium analogue of pyrophyllite

(C) Aluminium analogue of serpentine (D) Calcium analogue of kaolin

68. Complete the following equation :



(A) X = $[BH_2(NH_3)_2]BH_4$; Y = H_3BNEt_3

(B) X = H_3BNH_3; Y = H_3BNEt_3

(C) X = $[BH_2(NH_3)_2]BH_4$; Y = $[BH_2(NEt_3)_2]BH_4$

(D) X = H_3BNH_3; Y = $[BH_2(NEt_3)_2]BH_4$

69. How many π electrons present in trisulfur trinitride anion, $[S_3N_3]^-$?

(A) 10 (B) 12 (C) 6 (D) 8

70. The number of P-P bond present in a molecule, P_4S_9 is

(A) 1 (B) 0 (C) 3 (D) 2

71. Match the List – I (enzymes/coenzymes) with their most appropriate metal ions in List – II :

List – I		**List – II**	
(i)	Vitamin B_{12}	(m)	Molybdenum
(ii)	Carbonic Anhydrase	(n)	Zinc
(iii)	Catechol oxidase	(o)	Cobalt
(iv)	Xanthine oxidase	(p)	Copper

(A) i-p; ii-o; iii-m; iv-n (B) i-n; ii-m; iii-p; iv-o

(C) i-p; ii-n; iii-o; iv-m (D) i-o; ii-n; iii-p; iv-m

72. Match the List – I (types of nitrides) with their example in List – II :

List – I		**List – II**	
(i)	Ionic nitrides	(m)	KNO_2
(ii)	Covalent nitrides	(n)	W_2N
(iii)	Metallic nitrides	(o)	As_4N_4
		(p)	Na_3N

(A) i-p; ii-o; iii-n (B) i-n; ii-o; iii-m

(C) i-p; ii-n; iii-m (D) i-m; ii-n; iii-p

73. The term symbol for a ground state of carbon atom is ${}^3P_0$. Here the value '0' describes

(A) Total electron spin (B) Total angular momentum

(C) Spin multiplicity (D) Total orbital angular momentum

74. Read the following statement and reason, pick out a suitable answer from the following option :

Statement : In Inorganic Chemistry, one of the analogues of benzene is borazine. This is misnomer because the chemical properties of borazine and benzene are quite different.

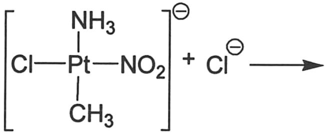
Reason : Due to the difference in electronegativity between boron and nitrogen, the more electron density is localized on boron atom so weakens the π-bonding in the ring.

(A) Both statement and reason are acceptable.
(B) Both statement and reason are unacceptable.
(C) Statement is acceptable but the reason needs to correct.
(D) Reason is acceptable but the statement needs to correct.

75. Arrange the following molecules in decreasing order of infrared P=O stretching frequency :
F_3PO, Cl_3PO, Br_3PO, ClF_2PO.

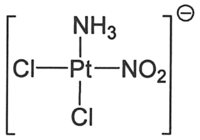
(A) $F_3PO > Cl_3PO > Br_3PO > ClF_2PO$ (B) $ClF_2PO > F_3PO > Cl_3PO > Br_3PO$
(C) $F_3PO > ClF_2PO > Cl_3PO > Br_3PO$ (D) $Br_3PO > Cl_3PO > F_3PQ > ClF_2PO$

76. Predict the product of the following reaction :



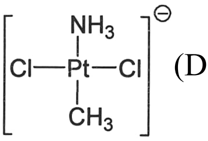
$$\left[Cl-\underset{CH_3}{\overset{NH_3}{Pt}}-NO_2\right]^{\ominus} + Cl^{\ominus} \longrightarrow$$

(A) No reaction (B)



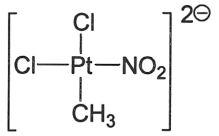
$$\left[Cl-\underset{Cl}{\overset{NH_3}{Pt}}-NO_2\right]^{\ominus}$$

(C)



$$\left[Cl-\underset{CH_3}{\overset{NH_3}{Pt}}-Cl\right]^{\ominus}$$

(D)



$$\left[Cl-\underset{CH_3}{\overset{Cl}{Pt}}-NO_2\right]^{2\ominus}$$

77. Among the following complex, which one has high rate of water exchange : $[Na(OH_2)_6]^+$, $[Cr(OH_2)_6]^{3+}$, $[Al(OH_2)_6]^{3+}$, $[Mg(OH_2)_6]^{2+}$

(A) $[Na(OH_2)_6]^+$ (B) $[Cr(OH_2)_6]^{3+}$ (C) $[Al(OH_2)_6]^{3+}$(D) $Mg(OH_2)_6]^{2+}$

78. Usually, a redox reaction occur between Co^{3+} complex and $[Cr(OH_2)_6]^{2+}$ through inner sphere mechanism. Pick out a correct order based on rate constant for the reaction between $[Cr(OH_2)_6]^{2+}$ and various Co^{3+} complexes, i.e., $[Co(NH_3)_6]^{3+}$, $[Co(NH_3)_5Cl]^{2+}$, $[Co(NH_3)_5I]^{2+}$.

(A) $[Co(NH_3)_6]^{3+} > [Co(NH_3)_5Cl]^{2+} > [Co(NH_3)_5I]^{2+}$
(B) $[Co(NH_3)_6]^{3+} < [Co(NH_3)_5Cl]^{2+} < [Co(NH_3)_5I]^{2+}$
(C) $[Co(NH_3)_6]^{3+} > [Co(NH_3)_5Cl]^{2+} < [Co(NH_3)_5I]^{2+}$
(D) $[Co(NH_3)_6]^{3+} < [Co(NH_3)_5Cl]^{2+} > [Co(NH_3)_5I]^{2+}$

79. An iron rod is placed parallel to magnetic field of intensity 1000 A/m. The magnetic flux through the rod is 3×10^{-4} Wb and its cross-sectional area is 3 cm^2. The magnetic permeability of the rod in $WbA^{-1}m^{-1}$ is

(A) 10^{-4} (B) 10^{-1} (C) 10^{-3} (D) 10^{-2}

80. Recently, a new allotrope of carbon was discovered by three Scientists : Przemyslaw Gawel, Leo Gross & Harry L. Anderson and published (Science, 2019, Vol. 365, Issue 6459, pp. 1299-1301). Pick out that finding from the given options.

(A) sp hybridized cyclo[18]carbon (B) C_{70} fullerene rugby ball
(C) Carbon nanotubes (D) Graphene

81. What is the dimension of the normalized wave function representing a particle in an one dimensional box of length l ?

(A) $(l)^{1/2}$ (B) $(l)^{-1/2}$ (C) dimensionless (D) $m(l)^{1/2}$

82. According to Dulong and Petit law, the heat capacity at constant volume of monatomic solids is

(A) 5R (B) 3R (C) 5RT (D) 3RT

83. Which function among the following is an odd function ?

(A) $\frac{2}{l}\sin\left(\frac{\pi}{2}+\frac{n\pi x}{l}\right)$ (B) $\left(\frac{\alpha}{\pi}\right)^{1/4} e^{-\alpha x^2}$ (C) $\frac{2}{l}\sin\left(\frac{n\pi x}{l}\right)$ (D) $\frac{2}{l}x\sin\left(\frac{n\pi x}{l}\right)$

84. What is the expectation value of position operator for the ground state wave function of simple Harmonic oscillator ?

(A) 0 (B) $\frac{hv}{2}$ (C) $\frac{hv}{4}$ (D) α

85. Calculate the degeneracy of the energy level $\frac{14h^2}{8ma^2}$ for particle in a three-dimensional cubic box of length a.

(A) 1 (B) 3 (C) 6 (D) 9

86. The partition function of a two-level system with a non-degenerate state (at an energy 0) and an upper doubly degenerate state (with an energy $\in$) is

(A) $q = e^{-\beta\in 1} + e^{-\beta\in 2}$ (B) $q = 1 + e^{-\beta\in}$

(C) $q = 1 + 2e^{-\beta\in}$ (D) $q = 2e^{\beta\in} + e^{-\beta\in}$

87. If N, V, E, T, μ, represent the composition, volume, energy, temperature and chemical potential of a thermodynamic system, then a canonical ensemble will have

(A) N, V, E are common. (B) N, V, E, T are common.

(C) N, V, T are common. (D) μ, ,V, T are common.

88. What are the relative populations of the states of a two-level system when the temperature is infinite ?

(A) 0 (B) 0.5 (C) 1.0 (D) 2.0

89. What is the residual entropy of carbon monoxide ?

(A) R (B) Rln(2) (C) 2 Rln(2) (D) 0.5 Rln(2)

90. How many significant figures does each of the following numbers (0.0523 and 900.0) have ?

(A) 5 and 2 (B) 4 and 2 (C) 4 and 3 (D) 3 and 4

91. Identify a pair of noble gas fluoride, which has the ability to convert metallic mercury to HgF_2 ?

(A) XeF_2 and XeF_6 (B) KrF_2 and XeF_6

(C) XeF_2 and XeF_4 (D) XeF_2, XeF_4 and XeF_6

92. $[TiCl_6]^{3-}$ show a slight compression in bond length of Ti-Cl due to Jahn-Teller effect. Two absorption peaks in electronic spectrum arise because of the transition from the

(A) Ground state ($^2B_{2g}$) to excited states ($^2B_{1g}$ and $^2A_{1g}$)

(B) Ground state (^2E_g) to excited states ($^2B_{1g}$ and $^2A_{1g}$)

(C) Ground state ($^2T_{2g}$) to excited states (^2E_g and $^2A_{1g}$)

(D) Ground state ($^2T_{2g}$) to excited state (^2E_g)

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93. The compound 1, 2-dichloroethylene has two geometrical isomers. Choose the correct option related to their symmetry.

(A) Both isomers possess σ_h plane.

(B) Both isomers possess σ_v plane.

(C) None of them have σ_h plane.

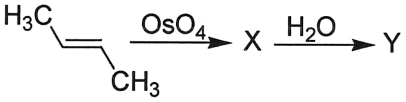
(D) One isomer has a σ_v plane and the other has σ_h plane.

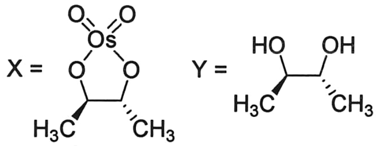
94. If all of the vertices of the deltahedron are occupied, the structure is called a *closo*. Identify a *closo* structure of boron hydrides from the given below options.

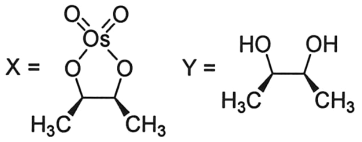
(A) Decaborane(14) (B) Hexaborane(10)

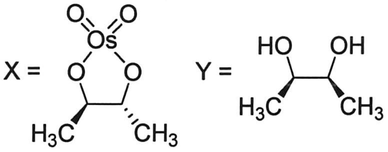
(C) Heptaborane(9) (D) Octaborane(12)

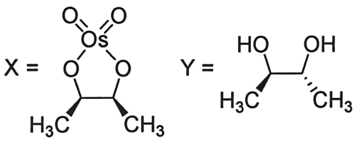
95. The major products formed in the following reactions are



(A) 

(B) 

(C) 

(D) 

96. How many inorganic sulfur present in bacterial rubredoxin ?

(A) 4 (B) 2 (C) 0 (D) 1

97. If all the lattice points of an hcp structure are occupied by uniform hard spheres that touch each other, the % of volume unoccupied is

(A) 74 (B) 48 (C) 52 (D) 26

98. Consider the following statements about liquid crystals :

(i) Isotropic

(ii) Flow like liquids but have much of the long-range order of solids

(iii) The molecules can move about, and the intermolecular spacings are irregular.

The correct statement is/are

(A) Only (i & ii) (B) Only (ii & iii)

(C) Only (i and iii) (D) All of the above (i, ii and iii)

99. Read the following statements, then choose the best answers from the given options :

(i) Each lattice point in a crystal has the same environment.

(ii) No atom need lie at a lattice point.

(iii) The basis must have the same stoichiometric composition as the entire crystal.

(A) Only (i & ii) (B) Only (ii & iii)

(C) Only (i and iii) (D) All of the above (i, ii and iii)

100. Which class of dielectric material exhibits a hysteresis loop of polarization versus electric field ?

(A) Ferrites (B) Elecrets (C) Dipole (D) Ferroelectrics

SPACE FOR ROUGH WORK