

Section – A

1. The pair of metals that would react in their metallic form directly with carbon monoxide affording metal-carbonyl compounds is:

- (a) Co and Mn
- (b) Mn and Fe
- (c) Fe and Ni
- (d) Ni and Co

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2. H_2O_2 functions as the oxidizing agent in acidic solution for

- (a) $[\text{Fe}(\text{CN})_6]^{4-}$ and NH_2OH
- (b) $[\text{Fe}(\text{CN})_6]^{3-}$ and NH_2OH
- (c) MnO_4^- and NH_4OH
- (d) MnO_4^- and NH_2OH

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3. Out of the following complexes; $\text{Ni}(\text{H}_2\text{O})_6^{2+}$, $\text{Mn}(\text{H}_2\text{O})_6^{2+}$, $\text{Cr}(\text{H}_2\text{O})_6^{2+}$, and $\text{Ti}(\text{H}_2\text{O})_6^{3+}$; the ideal octahedral geometry is not observed in

- (a) $\text{Ni}(\text{H}_2\text{O})_6^{2+}$ and $\text{Mn}(\text{H}_2\text{O})_6^{2+}$
- (b) $\text{Mn}(\text{H}_2\text{O})_6^{2+}$ and $\text{Cr}(\text{H}_2\text{O})_6^{2+}$
- (c) $\text{Ni}(\text{H}_2\text{O})_6^{2+}$, $\text{Cr}(\text{H}_2\text{O})_6^{2+}$,
- (d) $\text{Cr}(\text{H}_2\text{O})_6^{2+}$ and $\text{Ti}(\text{H}_2\text{O})_6^{3+}$

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4. The number of bridging and terminal carbonyls present in $\text{Co}_4(\text{CO})_{12}$ at low temperature respectively are

- (a) 0 and 12
- (b) 3 and 9
- (c) 4 and 8
- (d) 6 and 6

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5. The expected spin – only magnetic moments for $[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{FeF}_6]^{3-}$ respectively are

(a) 1.73 and 1.73 B.M.

(b) 1.73 and 5.92 B.M.

(c) 0.0 and 1.73 B.M.

(d) 0.0 and 5.92 B.M.

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6. Arrange following compounds in order of increasing dipole moment: BF_3 , H_2S , and H_2O

(a) $\text{BF}_3 < \text{H}_2\text{S} < \text{H}_2\text{O}$

(b) $\text{BF}_3 > \text{H}_2\text{S} > \text{H}_2\text{O}$

(c) $\text{BF}_3 < \text{H}_2\text{S} > \text{H}_2\text{O}$

(d) $\text{BF}_3 > \text{H}_2\text{S} < \text{H}_2\text{O}$

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7. The bond dissociation energies of four bonds, $\text{X} - \text{A}$, $\text{X} - \text{B}$, $\text{X} - \text{C}$, and $\text{X} - \text{D}$ are 240, 280, 380, and 480 KJ mol^{-1} , respectively. The atom with smallest size is

(a) A

(b) B

(c) C

(d) D

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8. Arrange the following metal – carbonyl complexes in the decreasing order of the carbonyl stretching frequency: $[\text{Ni}(\text{CO})_4]$, $[\text{Co}(\text{CO})_4]^-$, and $[\text{Fe}(\text{CO})_4]^{2-}$.

(a) $[\text{Fe}(\text{CO})_4]^{2-} > [\text{Co}(\text{CO})_4]^- > [\text{Ni}(\text{CO})_4]$

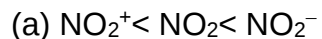
(b) $[\text{Co}(\text{CO})_4]^- > [\text{Ni}(\text{CO})_4] > [\text{Fe}(\text{CO})_4]^{2-}$

(c) $[\text{Fe}(\text{CO})_4]^{2-} = [\text{Co}(\text{CO})_4]^- > [\text{Ni}(\text{CO})_4]$

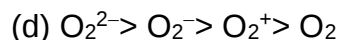
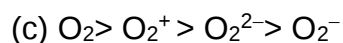
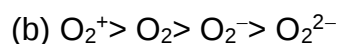
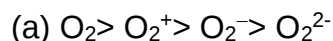
(d) $[\text{Ni}(\text{CO})_4] > [\text{Co}(\text{CO})_4]^- > [\text{Fe}(\text{CO})_4]^{2-}$

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9. The correct increasing order of O – N – O bond angle is

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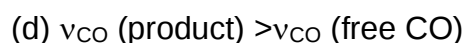
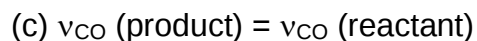
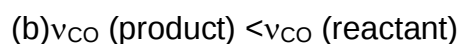
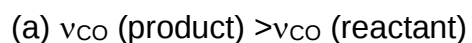
10. The correct sequence for the bond order of O_2 , O_2^+ , O_2^- , and O_2^{2-} is

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11. Alkali metal superoxides are obtained by the reaction of

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12. For the reaction $\text{trans-}[\text{IrCl}(\text{CO})(\text{PPh}_3)_2] + \text{Cl}_2 \rightarrow \text{trans-}[\text{IrCl}_3(\text{CO})(\text{PPh}_3)_2]$, the correct observation is

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13. The iridium complex that exhibits a triplet as well as a doublet in its ^{31}P NMR spectrum is

- (a) *trans*- $[\text{IrCl}(\text{CO})(\text{PPh}_3)_2]$
- (b) *mer*- $[\text{IrCl}_3(\text{PPh}_3)_3]$
- (c) *fac*- $[\text{IrCl}_3(\text{PPh}_3)_3]$
- (d) $[\text{Ir}(\text{PPh}_3)_4]^+$

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14. Which of the following does not contain a C_3 axis ?

- (a) POCl_3
- (b) ClF_3
- (c) $[\text{H}_3\text{O}]^+$
- (d) $[\text{NH}_4]^+$

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15. Which of the following statement is true about the change in symmetry on going from BF_3 to $[\text{BF}_4]^-$?

- (a) The point group changes from D_{3h} to T_d
- (b) The point group changes from D_{3v} to T_d
- (c) The point group changes from D_{3h} to D_{4h}
- (d) The point group changes from D_{3v} to C_{3v}

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16. In a solid 'AB' having the NaCl structure, atoms 'A' occupy the corners of the cubic unit cell. If all the face-centered atoms along one of the axes are removed then the resultant stoichiometry of the solid will be

- (a) AB_2
- (b) A_2B
- (c) A_3B_4
- (d) A_4B_3

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17. How many equivalents of nitric acid are needed to neutralize 45.0 ml of a 5.0 M solution of barium hydroxide?

- (a) 0.225 equivalents
- (b) 0.900 equivalents
- (c) 0.113 equivalents
- (d) 0.450 equivalents

18. A white crystalline substance dissolves in water. On passing H_2S gas to this solution, a black precipitate is obtained. The black precipitate dissolves completely in hot HNO_3 . On adding a few drops of conc. H_2SO_4 , a white precipitate is obtained. The white precipitate is

- (a) BaSO_4
- (b) SrSO_4
- (c) PbSO_4
- (d) CdSO_4

19. An element has successive ionization energies of 900, 1800, 14800 and 21000 kJmol^{-1} . To which Group of the Periodic Table does the element belong?

- (a) I
- (b) II
- (c) III
- (d) IV

20. Iodine exists in different oxidation states from -1 to $+7$. Which one of the following iodine containing ions could **not** undergo disproportionation?

- (a) I^+
- (b) I^-
- (c) IO^-
- (d) IO_3^-

21. The pair of gaseous molecules/ions having tetrahedral structure is

- (a) SnCl_4 and PH_4^+
- (b) SeCl_4 and XeF_4
- (c) ICl_4^- and PH_4^+
- (d) SnCl_4 and ICl_4^-

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22. Which one of the following pairs of electronic configurations of high-spin 3d transition metal ions in an octahedral ligand field undergoes a substantial Jahn-Teller distortion ?

- (a) d^3 and d^9
- (b) d^4 and d^9
- (c) d^5 and d^9
- (d) d^6 and d^9

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23. Which one of the following pairs consists of a good oxidizing and a good reducing agent respectively ?

- (a) Ce(IV) and Ln(III)
- (b) Ln(III) and Eu(II)
- (c) Ce(IV) and Eu(II)
- (d) Ln(III) and Ce(III)

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24. The correct sequence of steps in the olefin hydrogenation reaction using Wilkinson's catalyst, $[\text{Rh}(\text{PPh}_3)_3\text{Cl}]$, is

- (a) olefin addition followed by oxidative addition of H_2
- (b) olefin addition followed by reductive elimination of phosphine
- (c) phosphine dissociation followed by oxidative addition of H_2
- (d) oxidative addition of H_2 followed by phosphine dissociation

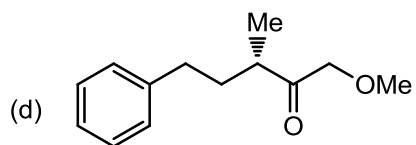
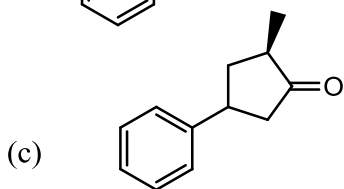
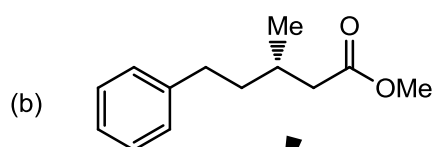
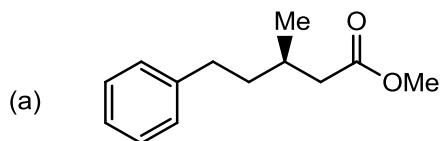
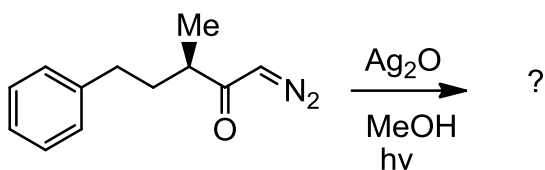
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25. Considering the two complexes, $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Ni}(\text{NH}_3)_6]^{2+}$, the correct statement is

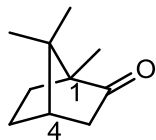
- (a) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is diamagnetic but $[\text{Ni}(\text{NH}_3)_6]^{2+}$ is paramagnetic
 (b) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is paramagnetic but $[\text{Ni}(\text{NH}_3)_6]^{2+}$ is diamagnetic
 (c) Both $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Ni}(\text{NH}_3)_6]^{2+}$ are diamagnetic
 (d) $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Ni}(\text{NH}_3)_6]^{2+}$ are paramagnetic



26. The major product formed in the following reaction is



27. Assign the absolute configuration at the two chiral centres of the following compound.

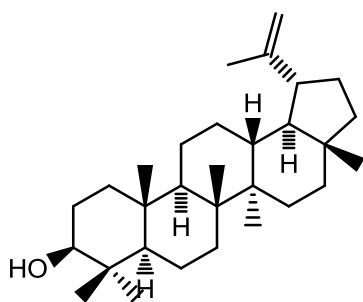


- (a) 1R, 4R
- (b) 1R, 4S
- (c) 1S, 4R
- (d) 1S, 4S

28. In the IR spectrum of neat methyl salicylate, the O-H band appears at

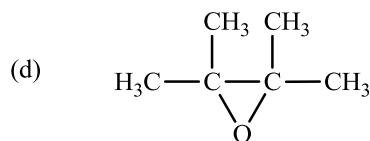
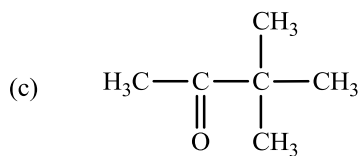
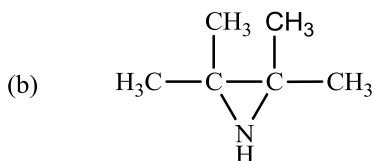
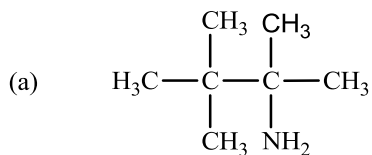
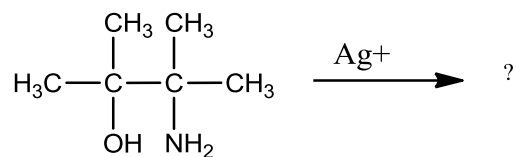
- (a) 3200 cm^{-1}
- (b) 3250 cm^{-1}
- (c) 3350 cm^{-1}
- (d) 3400 cm^{-1}

29. The following structure of Lupeol contains isoprene unit which are

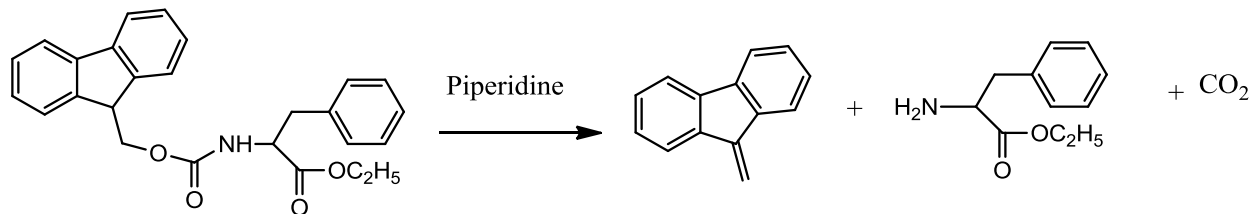


- (a) 2
- (b) 4
- (c) 6
- (d) 8

30. The major product formed in the following reaction is



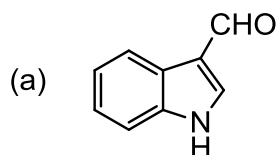
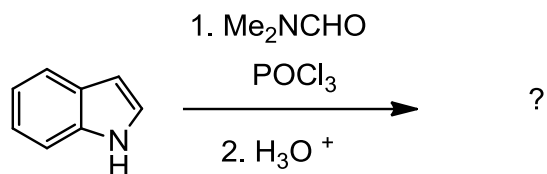
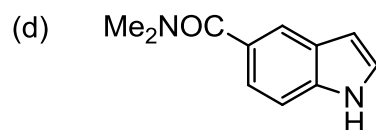
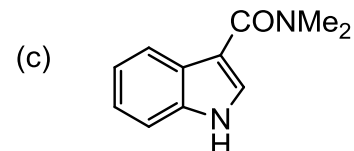
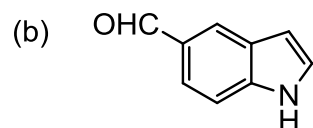
31. The mechanism involved in the following conversion is



- (a) E_1 elimination
- (b) E_2 elimination
- (c) E_1 cb elimination
- (d) Syn elimination



32. The major product formed in the following reaction is

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33. In the Infra Red spectrum of p-nitrophenyl acetate, the carbonyl absorption band appears at

(a) 1670 cm^{-1}

(b) 1700 cm^{-1}

(c) 1730 cm^{-1}

(d) 1760 cm^{-1}

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34. Histidine amino acid contains

(a) Tetrahydropyrrole

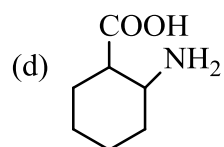
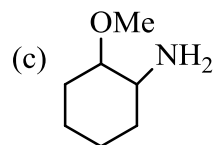
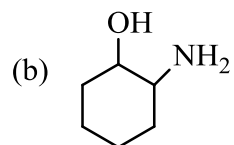
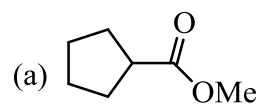
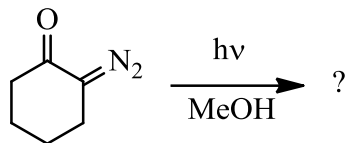
(b) Pyridine

(c) Indole

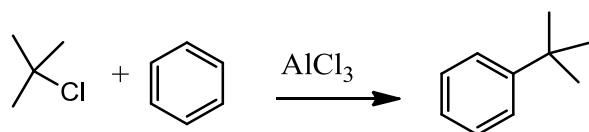
(d) Imidazole

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35. The major product formed in the following reaction is



36. The reactive intermediate involved in the following reaction is



(a) a carbanion

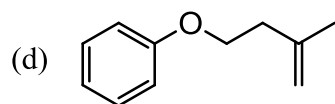
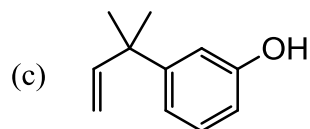
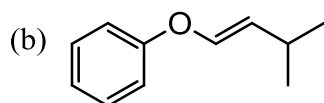
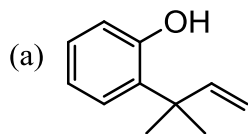
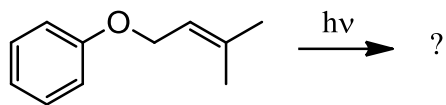
(b) a carbocation

(c) a free radical

(d) an aryne



37. Identify the major product formed in the following reaction.


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38. The gauche ($\theta = 60^\circ$) conformation of n-butane shows

- (a) plane of symmetry and is achiral
- (b) plane of symmetry and is chiral
- (c) C_2 axis of symmetry and is chiral
- (d) centre of symmetry and is achiral

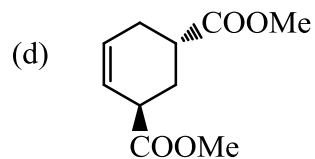
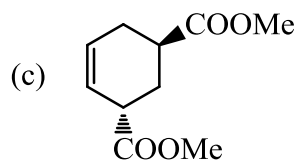
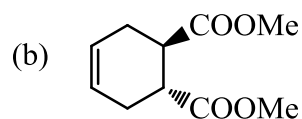
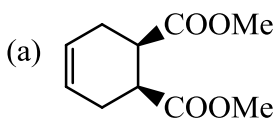
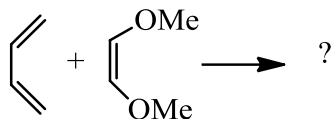
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39. The composition of Lindlar's catalyst is

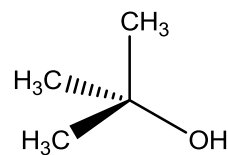
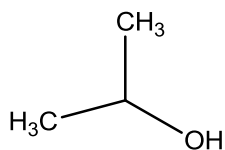
- (a) Pd, CaCO_3 , $\text{Pb}(\text{OAc})_2$
- (b) Pd, Na_2CO_3 , $\text{Pb}(\text{OAc})_2$
- (c) Pt, CaCO_3 , $\text{Pb}(\text{OAc})_2$
- (d) Pt, CaCO_3 , $\text{Pb}(\text{OAc})_2$

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40. Identify the major product formed in the following reaction



41. Arrange the following in the decreasing order of acidity.



A

B

C

D

(a) $\text{D} > \text{B} > \text{C} > \text{A}$

(b) $\text{A} > \text{C} > \text{B} > \text{D}$

(c) $\text{D} > \text{C} > \text{B} > \text{A}$

(d) $\text{A} > \text{B} > \text{C} > \text{D}$



42. Natural ribonucleic acid (RNA) is a genetic material in all living organism. It contains

- (a) adenine, guanine, cytosine, thymine
- (b) adenine, guanine, inosine, thymine
- (c) adenine, guanine, thymine, uracil
- (d) adenine, guanine, 5-iodouracil, thymine

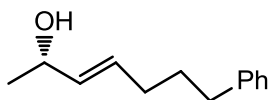
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43. Circular dichroism of α -helix peptide or α -helical protein shows band at

- (a) 208 and 222 nm
- (b) 222 nm
- (c) 214 and 216 nm
- (d) 205 and 230 nm

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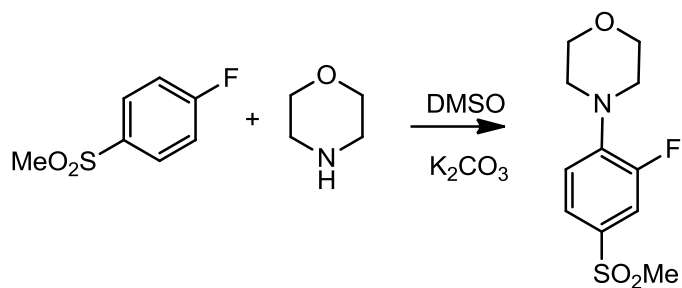
44. The IUPAC name for the given compound is



- (a) (2R, 3Z) -7-phenylhept-3-en-2-ol
- (b) (2S, 3Z) -7-phenylhept-3-en-2-ol
- (c) (2R, 3E) -7-phenylhept-3-en-2-ol
- (d) (2S, 3E) -7-phenylhept-3-en-2-ol

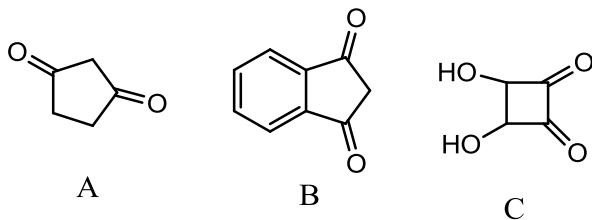
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45. The following reaction is



- (a) Aromatic *ipso* substitution reaction
- (b) Aromatic electrophilic substitution reaction
- (c) Aromatic nucleophilic substitution reaction
- (d) Aromatic free radical substitution reaction

46. The correct order of acidity of the compounds A-C is



- (a) $\text{A} > \text{B} > \text{C}$
- (b) $\text{B} > \text{C} > \text{A}$
- (c) $\text{C} > \text{A} > \text{B}$
- (d) $\text{B} > \text{A} > \text{C}$

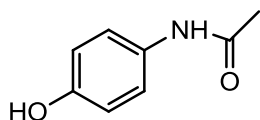
47. Match the following drugs with their medicinal activity

- A. AZT i) Cancer
B. Taxol ii) Malaria
C. Artemisinin iii) HIV

- (a) A- iii , B- ii , C-i
(b) A-iii, B- i, C- ii
(c) A-ii, B- i, C-iii
(d) A-ii, B-iii, C- i

☐

48. The paracetamol shows carbonyl peak at



- (a) 1700 cm^{-1}
(b) 1720 cm^{-1}
(c) 1710 cm^{-1}
(d) 1667 cm^{-1}

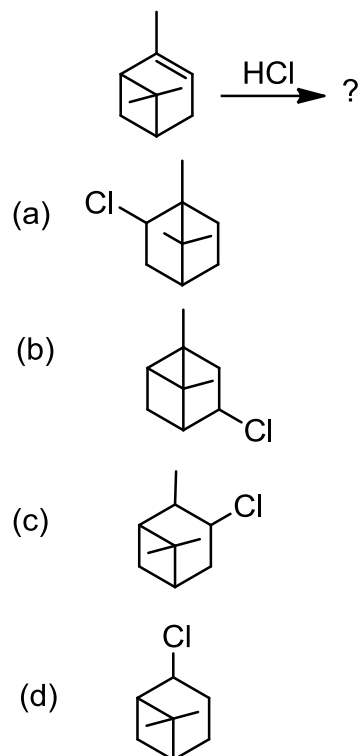
☐

49. Name the scientists who discovered double helix DNA

- (a) James Watson & F Miescher
(b) Francis Crick & H G Khurana
(c) H G Khurana & Erwin Chargaff
(d) James Watson & Francis Crick

☐

50. The major product formed in the following reaction is



51. Which of the following is true:

- (a) $[L_x, L_y] = 0$
 (b) $[L_x, L_y] = i\hbar L_y$
 (c) $[L_x, L_y] = i\hbar L_z$
 (d) $[L_x, L_y] = i\hbar L_x$



52. The Michaelis-Menten equation for Enzyme Kinetics is a non-linear relationship between the substrate concentration (**[S]**) and the rate of the reaction (**V**) which can be written as:

- (a) $(V_{\max} - V)(K_M + [S]) = K_M \cdot V_{\max}$
 (b) $(V_{\max} - V) / (K_M + [S]) = K_M \cdot V_{\max}$
 (c) $(V_{\max} - V)(K_M + [S]) = K_M$
 (d) None of the above.



53. Which of the following is true:

- (a) $(\partial U / \partial S)_V = T$
- (b) $(\partial U / \partial V)_S = p$
- (c) $(\partial H / \partial S)_p = V$
- (d) $(\partial H / \partial V)_p = T$

☐

54. A protein containing a single tryptophan residue, buried in a hydrophobic pocket displays

- (a) Strong fluorescence with high quantum yield.
- (b) Weak fluorescence with low quantum yield
- (c) Moderate fluorescence
- (d) No fluorescence at all

☐

55. Which of the following ∇^2 is used in the representation of Schroedinger equation in spherical co-ordinates:

- (a) $\nabla^2 = (\partial^2 / \partial x^2) + (\partial^2 / \partial y^2) + (\partial^2 / \partial z^2)$
- (b) $\nabla^2 = (\partial^2 / \partial r^2) + (2/r) (\partial / \partial r)$
- (c) $\nabla^2 = (\partial^2 / \partial r^2) + (2/r) (\partial / \partial r) + (1/r^2) \{ (1/\sin^2\theta) (\partial^2 / \partial \phi^2) + (\partial / \partial \theta)(\sin \theta (\partial / \partial \theta)) \}$
- (d) $\nabla^2 = (1/r) \partial / \partial r (r \partial / \partial r) + (1/r^2) (\partial^2 / \partial \phi^2) + (\partial^2 / \partial z^2)$

☐

56. When a protein, with 8 Cys residues, is totally denatured in 6.0 M urea and β -mercaptoethanol and then again re-natured by dialyzing the β -mercaptoethanol out in the presence of 6.0 M urea, the predicted percentage of the activity of the re-natured protein in comparison to the native fully active protein will be approximately:

- (a) 1%
- (b) 0.01%
- (c) 100%
- (d) 0.1%

☐

57. The bond length of a homo-nuclear di-atomic molecule can be obtained by:

- (a) Vibrational Raman Spectroscopy.
- (b) Rotational Raman Spectroscopy.
- (c) Microwave Spectroscopy.
- (d) Vibrational Spectroscopy.

☐

58. Which of the following is true:

- (a) $[x, p_x] = 0$ and $[E, t] = 0$
- (b) $[x, p_x] \neq 0$ and $[E, t] \neq 0$
- (c) $[x, p_x] = 0$ and $[E, t] \neq 0$
- (d) $[x, p_x] \neq 0$ and $[E, t] = 0$

☐

59. The Bragg's equation for crystallography can be written as:

- (a) $n\lambda = (2 d \sin \theta)$
- (b) $n\lambda = (2/d) \sin \theta$
- (c) $n\lambda = (2 d / \sin \theta)$
- (d) $n\lambda = 1/ (2 d \sin \theta)$

☐

60. In the case of a spectrum of a single molecule, line broadening is due to:

- (a) Doppler Effect.
- (b) Collisional Effects.
- (c) Uncertainty Effects.
- (d) None of the above.

☐

61. The activation energy (E_a) of a chemical reaction can be determined by plotting:

- (a) Logarithm of rate constant versus absolute temperature.
- (b) Logarithm of rate constant versus logarithm of absolute temperature.
- (c) Rate constant versus reciprocal of absolute temperature.
- (d) Logarithm of rate constant versus reciprocal of absolute temperature.

☐

62. In an NMR experiment, the longitudinal relaxation time (T_1) is given by:

- (a) $M_z(t) - M_0 \propto \exp(-t/T_1)$
- (b) $M_z(t) - M_0 \propto \exp(t/T_1)$
- (c) $M_0 - M_z(t) \propto \exp(-t/T_1)$
- (d) $M_z(t) - M_0 \propto -(t/T_1)$

☐

63. Which of the following is the correct normalization co-efficient of the wave function

$$\psi = A \sin (n\pi x / L)$$

for a particle in a one-dimensional box of length L .

(a) $\sqrt{\frac{L}{2}}$

☐

(b) $\sqrt{\frac{1}{L}}$

(c) $\sqrt{2}$

(d) $\sqrt{\frac{2}{L}}$

64. The Henderson-Hasselbalch equation is defined as:

(a) $\text{pH} = \text{pK}_a + \log [\text{acid}] / [\text{salt}]$

(b) $\text{pK}_a = \text{pH} + \log [\text{salt}] / [\text{acid}]$

(c) $\text{pK}_a = \text{pH} + \log [\text{acid}] / [\text{salt}]$

(d) $\text{pH} = \text{pK}_a + \log [\text{salt}] / [\text{acid}]$

☐

65. In a reverse microemulsion, w_0 is defined as:

(a) $w_0 = [\text{surfactant}] / [\text{water}]$

(b) $w_0 = [\text{water}] / [\text{surfactant}]$

(c) $w_0 = 1 / [\text{water}]$

(d) $w_0 = 1 / [\text{surfactant}]$

☐

66. In the case of a particle in a one-dimensional box, the energy of an energy state is given by:

(a) $E_n = n^2 h^2 / 8ma^2$ where $n = 1, 2, 3, \dots$

(b) $E_n = n^2 h^2 (8ma^2)$ where $n = 1, 2, 3, \dots$

(c) $E_n = n^2 h^2 a^2 / 8m$ where $n = 1, 2, 3, \dots$

(d) $E_n = 8mn^2 h^2 / a^2$ where $n = 1, 2, 3, \dots$

☐

67. As the temperature of a solution is increased, the conduction in an electrolytic solution will:

- (a) Become zero.
- (b) Remain the same.
- (c) Increase.
- (d) Decrease.

☐

68. The general solution for the differential equation

$$(d^2y / dx^2) + 16 y = 0$$

is given by:

- (a) $Ae^{-4x} + Be^{4x}$
- (b) $Ae^{-4ix} + Be^{4ix}$
- (c) $Ae^{-2ix} + Be^{2ix}$
- (d) $Ae^{-2x} + Be^{2x}$

☐

69. The Lambert-Beer Law is valid for:

- (a) Colloidal solution.
- (b) Concentrated inhomogeneous solution.
- (c) Dilute homogeneous solution.
- (d) None of the above.

☐

70. A calomel electrode is reversible with respect to:

- (a) AgCl
- (b) Cl^- ions
- (c) Ag^+ ions
- (d) None of the above.

☐

71. In a second order chemical reaction, the rate law can be determined from the linearity of:

- (a) $\log c$ versus t
- (b) $1/c$ versus t
- (c) $\log c$ versus $1/t$

☐

(d) $1/c$ versus $1/t$

72. The Born-Oppenheimer approximation states that:

- (a) The atoms in a molecule are regarded as fixed.
- (b) The nuclei of atoms in a molecule are regarded as fixed.
- (c) The electrons of atoms in a molecule are regarded as fixed.
- (d) The nuclei and electrons in a molecule are regarded as fixed.

☐

73. The molecule ethene belongs to the symmetry group:

- (a) D_{2h}
- (b) D_{3h}
- (c) D_{3d}
- (d) D_{2d}

☐

74. Which of the following is the correct partition for indistinguishable and distinguishable partition function independent molecules:

- (a) $q^N / N!$ and $q^N / N!$
- (b) q^N and q^N
- (c) q^N and $q^N / N!$
- (d) $q^N / N!$ and q^N

☐

75. The Term symbol for a Na atom in its ground state is:

- (a) $^2P_{3/2}$
- (b) $^2P_{1/2}$
- (c) $^2S_{1/2}$
- (d) $^2D_{3/2}$

☐

Answer Key:

Q1. (c)	Q16. (c)	Q31. (c)	Q46. (c)	Q61. (d)
Q2. (a)	Q17. (d)	Q32. (a)	Q47. (b)	Q62. (a)
Q3. (d)	Q18. (c)	Q33. (d)	Q48. (d)	Q63. (d)
Q4. (b)	Q19. (b)	Q34. (d)	Q49. (d)	Q64. (*)
Q5. (d)	Q20. (b)	Q35. (a)	Q50. (a)	Q65. (b)
Q6. (a)	Q21. (a)	Q36. (b)	Q51. (c)	Q66. (a)
Q7. (d)	Q22. (b)	Q37. (a)	Q52. (a)	Q67. (c)
Q8. (d)	Q23. (c)	Q38. (c)	Q53. (a)	Q68. (b)
Q9. (d)	Q24. (c)	Q39. (a)	Q54. (a)	Q69. (c)
Q10. (b)	Q25. (d)	Q40. (a)	Q55. (c)	Q70. (b)
Q11. (a)	Q26. (a)	Q41. (b)	Q56. (a)	Q71. (b)
Q12. (b)	Q27. (d)	Q42. (*)	Q57. (b)	Q72. (b)
Q13. (b)	Q28. (a)	Q43. (a)	Q58. (b)	Q73. (a)
Q14. (b)	Q29. (c)	Q44. (d)	Q59. (a)	Q74. (d)
Q15. (a)	Q30. (c)	Q45. (*)	Q60. (c)	Q75. (c)

Note: (*) There is a mistake in the options on question number 42, 45, and 64 and everybody has been given two marks for that question.