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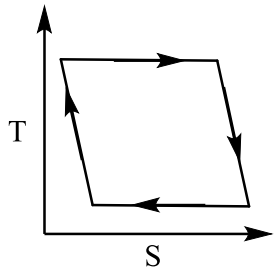
JAM – 2020 – CY

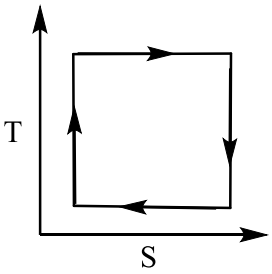
Attempt ALL the questions. Q.1 – Q.10 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

1. **The graph that represents the temperature (T) − entropy (S) variation of a Carnot cycle is**

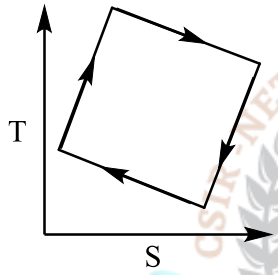
(a)



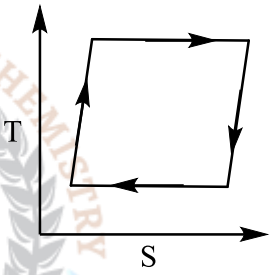
(b)



(c)



(d)



2. **For the radical chain reaction below, the correct classification for step-2 and step-3 is, respectively,**

step-1 : $Br_2 + M \longrightarrow 2Br^{\cdot} + M$

step-2 : $Br^{\cdot} + H_2 \rightleftharpoons HBr + H^{\cdot}$

step-3 : $H^{\cdot} + Br_2 \longrightarrow HBr + Br^{\cdot}$

(a) chain propagating, chain terminating
(b) chain branching, chain terminating
(c) chain propagating, chain propagating
(d) chain propagating, chain branching

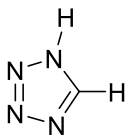
3. **The salt bridge in a galvanic cell allows the flow of**

(a) ions but NOT electrons
(b) BOTH ions and electrons
(c) electrons but NOT ions
(d) NEITHER ions NOR electrons

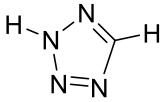
4. **The nucleobase NOT found in DNA is**

(a) Thymine (b) Uracil (c) Guanine (d) Adenine

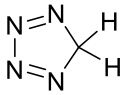
5. **The correct statement for the following structures is**



1



2



3

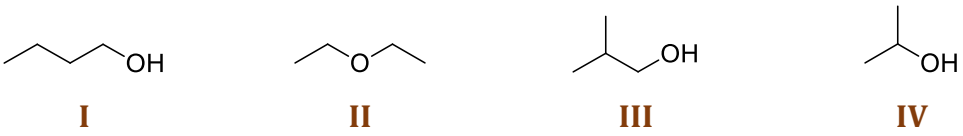
(a) 1, 2 and 3 are resonance structures

(b) 1 and 2 are resonance structures, whereas 3 is an isomer of 1 and 2

(c) 1 and 3 are resonance structures, whereas 2 is an isomer of 1 and 3

(d) 1, 2 and 3 are constitutional isomers

6. The correct order of boiling points of compounds I - IV is



I **II** **III** **IV**

(a) II > I > III > IV (b) II > III > I > IV

(c) I > III > IV > II (d) I > IV > III > II

7. One of the products of the hydrolysis of calcium phosphide at 25 °C is

(a) phosphine (b) phosphoric acid (c) phosphorus pentoxide (d) white phosphorus

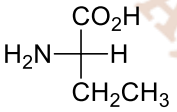
8. Treatment of formic acid with concentrated sulfuric acid gives

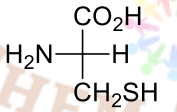
(a) $CO + H_2O$ (b) $CO_2 + H_2$ (c) $HCHO + ½\ O_2$ (d) no product (no reaction)

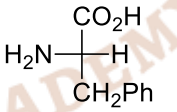
9. The d-orbitals involved in the hybridization to form square planar and trigonal bipyramidal geometries are, respectively,

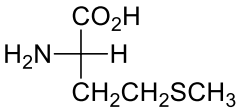
(a) $\mathbf{d_{z^2}}$ and $\mathbf{d_{z^2}}$ (b) $\mathbf{d_{yz}}$ and $\mathbf{d_{z^2}}$ (b) $\mathbf{d_{x^2-y^2}}$ and $\mathbf{d_{z^2}}$ (b) $\mathbf{d_{x^2-y^2}}$ and $\mathbf{d_{yz}}$

10. The amino acid with R configuration is

(a) 

(b) 

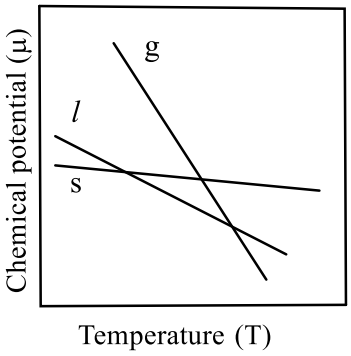
(c) 

(d) 

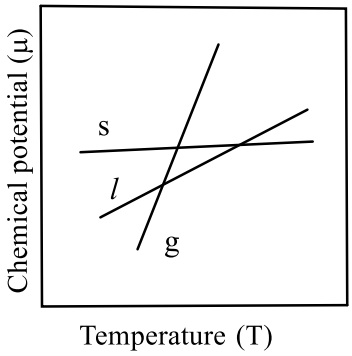
Attempt ALL the questions. Q.11 – Q.30 Multiple Choice Question (MCQ), carry TWO mark each (for each wrong answer: – 2/3).

11. At constant pressure, the μ – T diagram for a pure substance that sublimes is (s = solid, l = liquid and g = gas)

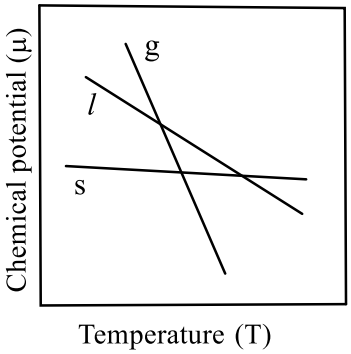
(a)



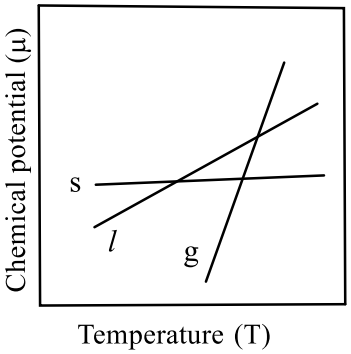
(b)



(c)



(d)



12. **The force constant for $H^{35}Cl$ and $D^{35}Cl$ are the same and both can be considered as harmonic oscillators. $H^{35}Cl$ has a fundamental vibrational transition at 2886 cm^{-1}. The ratio of the zero-point energy of $H^{35}Cl$ to that of $D^{35}Cl$ is**

(a) 0.515 (b) 0.717 (c) 1.395 (d) 1.946

13. **The correct statement regarding the determinants (Det) of matrices R, S and T is**

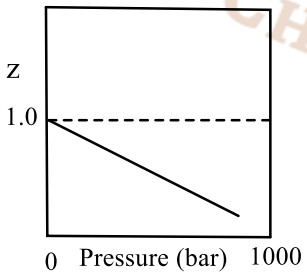
$$R = \begin{bmatrix} 3 & 2 & 4 \\ 4 & 5 & 7 \\ 1 & 3 & 8 \end{bmatrix} \quad S = \begin{bmatrix} 2 & 3 & 4 \\ 5 & 4 & 7 \\ 3 & 1 & 8 \end{bmatrix} \quad T = \begin{bmatrix} 3 & 4 & 1 \\ 2 & 5 & 3 \\ 4 & 7 & 8 \end{bmatrix}$$

(a) $\mathrm{Det(R)} = \mathrm{Det(S)} \neq \mathrm{Det(T)}$ (b) $\mathrm{Det(R)} = \mathrm{Det(T)} \neq \mathrm{Det(S)}$

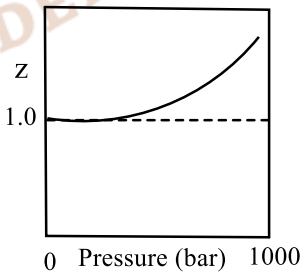
(c) $\mathrm{Det(R)} = \mathrm{Det(S)} = \mathrm{Det(T)}$ (d) Det(R), Det(S), Det(T) are all different

14. **The Boyle temperature (T_B) is defined as the temperature at which the properties of a real gas coincide with those of an ideal gas in the low-pressure limit. The graph that shows the pressure dependence of the compression factor (Z) for a real gas at T_B is**

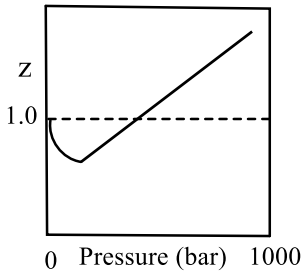
(a)



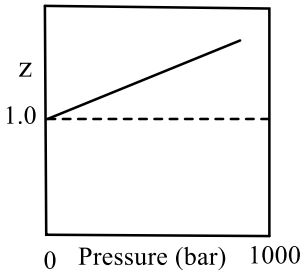
(b)



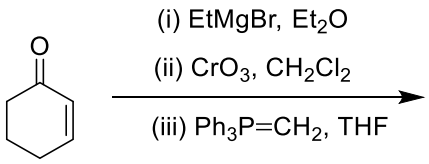
(c)

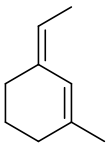
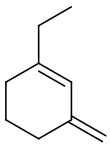
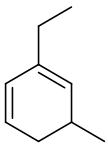
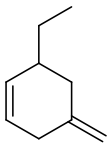


(d)



15. **The major product formed in the following reaction sequence is**



(a)  (b)  (c)  (d) 

16. The geometries of the species $[Br_3]^+$, $[Br_3]^-$ and $[BrF_3]$ are, respectively,

(a) linear, trigonal bipyramidal and trigonal bipyramidal

(b) linear, linear and trigonal planar

(c) tetrahedral, trigonal bipyramidal and trigonal bipyramidal

(d) tetrahedral, trigonal pyramidal and trigonal planar

17. The cage-type structure adopted by boron hydride, $[B_5H_{11}]$, is

(a) closo (b) nido (c) hypo (d) arachno

18. The order of the M–C bond strength in the following species is

(Atomic number for Cr = 24, Mn = 25, Ti = 22, Co = 27)

$[Cr(CO)_6]$	$[Mn(CO)_6]^+$	$[Ti(CO)_6]^{2-}$	$[Co(CO)_4]^-$
I	II	III	IV

(a) II > I > IV > III (b) I > III > II > IV

(c) III > IV > I > II (d) III > I > II > IV

19. The number of non-bonding electrons present in the frontier molecular orbitals of HF is

(a) 10 (b) 4 (c) 6 (d) 8

20. The coordination number of aluminum ion and the number of bridging hydrogen atoms in $[Al(BH_4)_4]^-$ are, respectively,

(a) 8 and 8 (b) 6 and 6 (c) 4 and 6 (d) 8 and 12

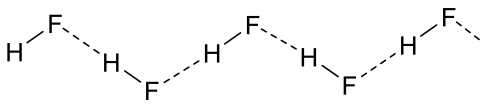
21. The complex which does NOT obey 18-electron rule is

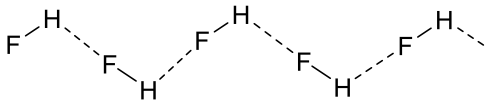
(Atomic number for Mn = 25, Fe = 26, Co = 27, Ru = 44)

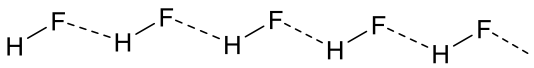
(a) $[Co_2(CO)_8]$ (b) $[Fe(CO)_4]^{2-}$ (c) $[HMn(CO)_5]$ (d) $[(\eta^5\text{-}C_5H_5)RuCl(CO)(PPh_2)]$

22. The solid-state structure of HF is

(a) H–F----H–F----H–F---- H–F---

(b) 

(c) 

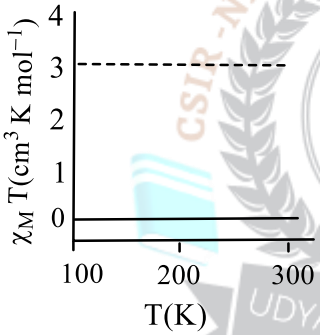
(d) 

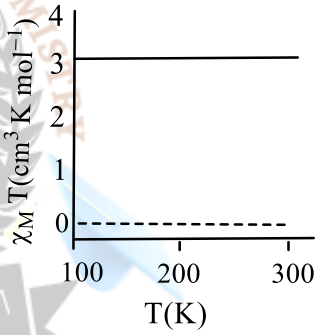
23. **The number of d-d transition(s) expected for the complex $[Cu(NH_3)_2(H_2O)_4]^{2+}$ is**

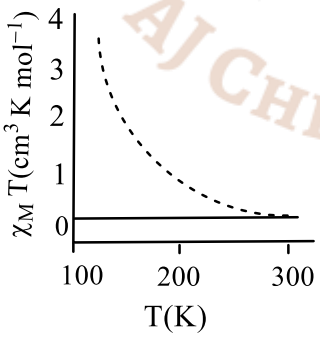
(a) 1 (b) 2 (c) 3 (d) 4

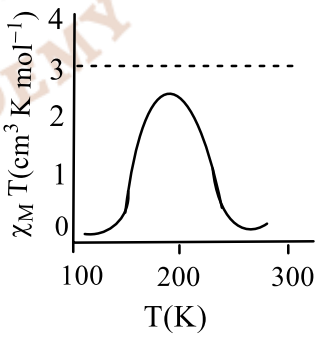
24. **The plot showing the magnetic behavior of oxy- (solid line) and deoxy-haemoglobin (dashed line) is**

(χ_M = molar magnetic susceptibility, T = temperature)

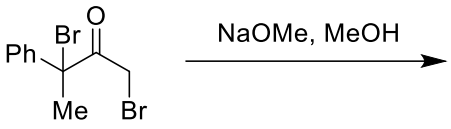
(a) 

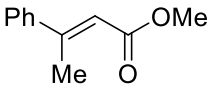
(b) 

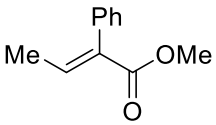
(c) 

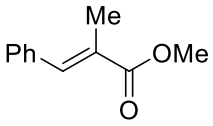
(d) 

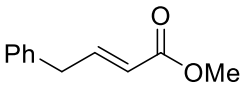
25. **The major product formed in the following reaction is**



(a) 

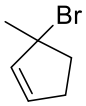
(b) 

(c) 

(d) 

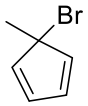
26. The rate of solvolysis of I–IV follows

I



II

III

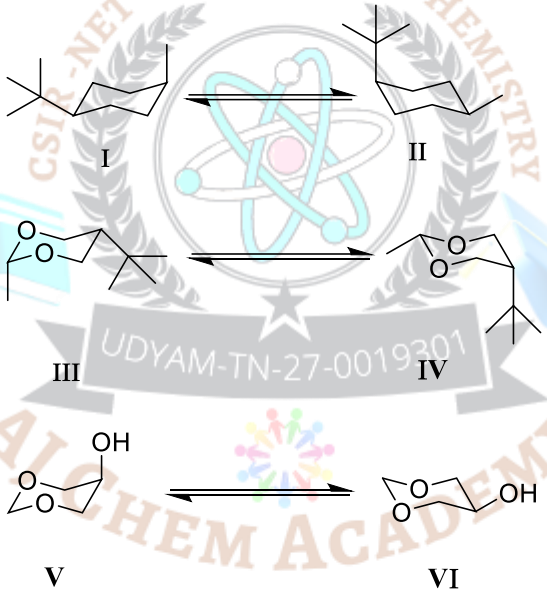


IV

(a) I > II > III > IV (b) III > I > II > IV

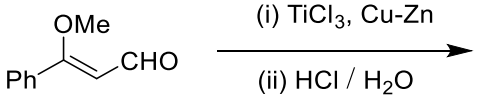
(c) III > II > I > IV (d) IV > I > II > III

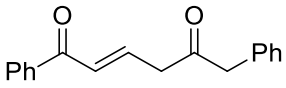
27. The more stable species in each pair of conformers are

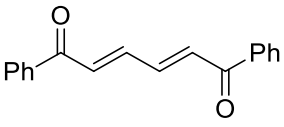


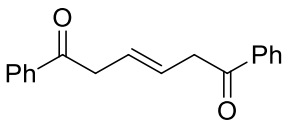
(a) II, IV and V (b) I, IV and V (c) II, III and V (d) I, IV and VI

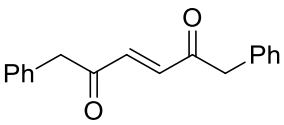
28. The major product formed in the following reaction sequence is



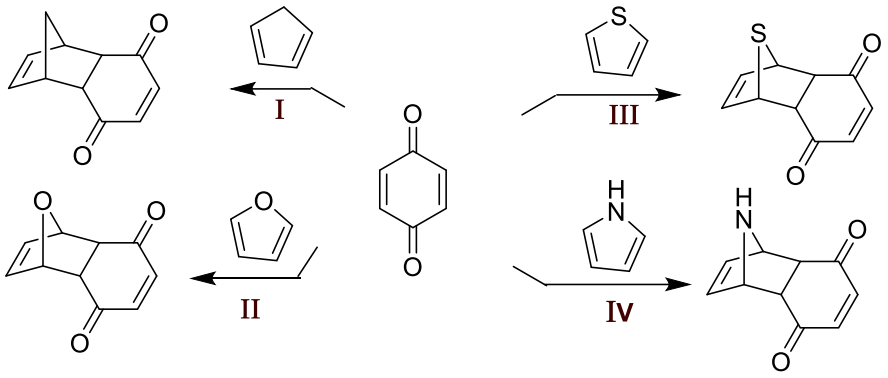
(a) 

(b) 

(c) 

(d) 

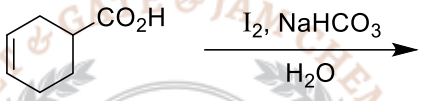
29. For the Diels-Alder reactions I–IV, the activation barriers follow the order

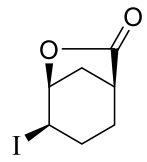
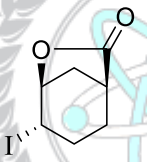
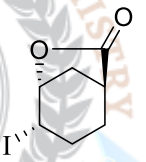
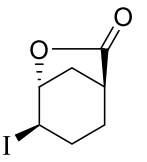


(a) II > I > III > IV (b) I > III > IV > II

(c) III > IV > II > I (d) IV > III > II > I

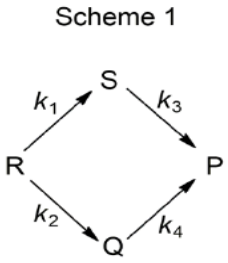
30. The major product formed in the following reaction is

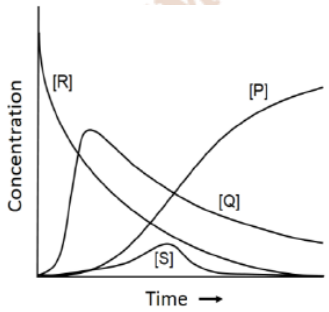


(a)  (b)  (c)  (d) 

Attempt ALL the questions. Q.31 – Q.40 Multiple Select Question (MSQ), carry TWO mark each (no negative marks).

31. For the reaction shown in Scheme-1, the concentration profiles of different species are provided.





Based on this graph, the correct condition(s) regarding the rate constants is(are)

(a) $k_2 > k_4$ (b) $k_3 > k_1$ (c) $k_2 > k_1$ (d) $k_1 = k_2$

32. Ψ(x,y,z) describes the wavefunction of a particle. The probability of finding the particle between x and x + dx, y and y + dy, z and z + dz, can be expressed as

(a) $\Psi^*(x,y,z)\,\Psi(x,y,z)$ (b) $|\Psi(x,y,z)|^2\,dx\,dy\,dz$

(c) $\Psi^*(x,y,z)\,\Psi(x,y,z)\,dx\,dy\,dz$ (d) $\int_{-\infty}^{\infty} dx \int_{-\infty}^{\infty} dy \int_{-\infty}^{\infty} dz\,\Psi^*(x,y,z)\,\Psi(x,y,z)$

33. In water, the enthalpy of a protein in its folded state (H_F) is lower than that in its

unfolded state (H_{UF}). The entropies of the folded and unfolded states are S_F and S_{UF}, respectively. The condition(s) under which this protein spontaneously folds in water at a temperature T, is(are)

(a) $S_{UF} < S_F$ (b) $S_{UF} = 0$ (c) $S_{UF} = S_F$ (d) $(S_F - S_{UF}) > (H_F - H_{UF})/T$

34. The soft Lewis base(s) is(are)

(a) I^- (b) CO (c) H^- (d) CH_3NC

35. The boron adduct(s), which show(s) three signals in ^{1}H-NMR spectrum with the intensity ratio 1 : 2 : 3 is(are)

(a) $(CH_3)_3B{:}\,N(CH_3)_3$ (b) $(CH_3CH_2)_3B{:}\,N(CH_3CH_2)_3$

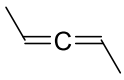
(c) $H_3B{:}\,N(CH_3CH_2)_3$ (d) $(CH_3CH_2)_3B{:}\,NH_3$

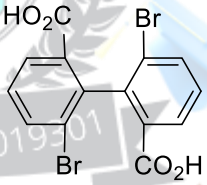
36. The transition metal complex(es) with zero magnetic moment, zero dipole moment and CFSE of $-2.4\ \Delta_0$ is(are)

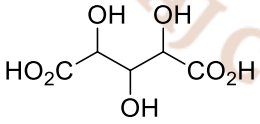
(a) $[Mn(CO)_5(CH_3)]$ (b) $[\text{trans-}Ni(\text{ethylenediamine})_2Cl_2]$

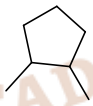
(c) $[\text{trans-}Co(CN)_4(H_2O)_2]^-$ (d) $[\text{trans-}Fe(CN)_4Cl_2]^{4-}$

37. Achiral stereoisomer(s) is (are) possible for

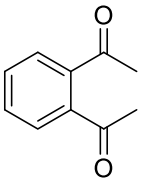
(a) 

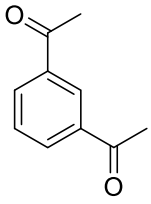
(b) 

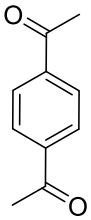
(c) 

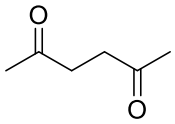
(d) 

38. The compound(s) which will have only two signals in the ^{1}H-NMR spectrum in 3 : 2 ratio is (are)

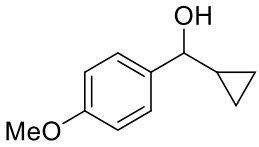
(a) 

(b) 

(c) 

(d) 

39. The correct sequence of reactions for the synthesis of the following molecule is (are)



(a) (i) 4-iodophenol, Mg, ether

(ii) cyclopropanecarbaldehyde, THF

(iii) $CsCO_3$, MeI, THF

(b) (i) bromocyclopropane, Mg, ether

(ii) 4-hydroxybenzaldehyde, THF

(iii) $CsCO_3$, MeI, THF

(c) (i) 4-iodophenol,$CsCO_3$, MeI, THF

(ii) Mg, ether

(iii) cyclopropanecarbaldehyde, THF

(d) (i) bromocyclopropane, Mg, ether

(ii) methyl 4-methoxybenzoate, THF

40. The organometallic reagent(s) among the following is(are)

(a) Lithium divinylcuprate (b) Lithium diisopropylamide

(c) Potassium tert-butoxide (d) Isopropyl magnesiumiodide

Attempt ALL the questions. Q.41 – Q.50 Numerical Answer Type (NAT), carry ONE mark each (no negative marks).

41. The function $x^4e^{-2x/3}$ (for $x > 0$) has a maximum at a value of x equal to _____(rounded off to two decimal places)

42. The longest wavelength of light absorbed by a hydrogen-like atom is 2.48 nm. The nuclear charge (Z) of the atom is_____(Round off to nearest integer)

(Rydberg constant RH = 109700 cm^{-1})

43. Fullerene (C_{60}) crystallizes in an *fcc* unit cell (edge length = 14.14 Å) with one C_{60} centered at each lattice point. The smallest distance (in Å) between the centers of two C_{60} molecules is_____ (Round off to two decimal places)

44. A film of stearic acid partially covers the water surface in a container. The work needed to decrease this coverage by 1 cm^2 is 25.0×10^{-7} J. The surface tension (in N/m) of the film is _____(Round off to three decimal places)

(Surface tension of pure water is 0.072 N/m)

45. The value of 'n' in $[P_nO_{18}]^{6-}$ is_____

46. The total number of all possible isomers of $[Co(H_2NCH_2CH_2NH_2)_2Cl_2]^+$ and $[Co(H_2NCH_2CH_2NH_2)_3]^{3+}$ together is_____

47. The number of lone pairs present in phosphonic acid (phosphorus acid) is_____

48. Total number of constitutional isomers possible for trimethyl cyclohexane is _____

49 The dihedral (torsional) angle (in degrees) between the two methyl groups in the most stable conformation of n-butane is_____ (Round off to nearest integer)

50. The degree of unsaturation (double bond equivalent) for a compound with molecular formula $C_{14}H_{12}O_2$ is_____

Attempt ALL the questions. Q.51 – Q.60 Numerical Answer Type (NAT), carry TWO marks each (no negative marks).

51. The heat of formation of MgO at 300 K and 1 bar pressure is $-600.60\ kJ\ mol^{-1}$. The free energy (in $kJ\ mol^{-1}$) of formation of MgO at 280 K is_____(Round off to nearest integer)

Given: In the range 280-300 K, the constant pressure heat capacities (C_P) and molar entropies (S_m) are:

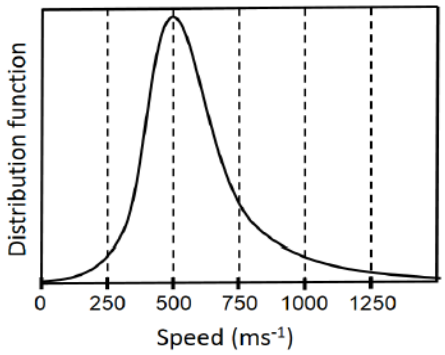
	Mg	O_2	MgO
$C_P\ (in\ J\ mol^{-1}\ K^{-1})$	24.9	29.4	27.0
$S_m\ (in\ J\ mol^{-1}\ K^{-1})$	0	205.2	0

52. Sea water containing 1 M NaCl has to be desalinated at 300 K using a membrane permeable only to water. The minimum pressure (in bars) required on the sea-water side of the membrane is_____ (Round off to one decimal place)

$(R = 8.3\ J\ mol^{-1}\ K^{-1})$, $(1\ bar = 10^5\ N/m^2)$

53. A bacterial colony grows via cell division where each mother bacterium independently produces two daughter cells in 20 minutes. If the concentration of bacteria is $10^4\ cm^{-3}$, the colony becomes harmful. Starting from a colony with an initial concentration of $5\ cm^{-3}$, the time taken (in minutes) for the colony to become harmful is_____ (Round off to nearest integer)

54. The Maxwell distribution of speeds of a gas at 300 K is given below



The molar mass (in $g\ mol^{-1}$) of this gas is_____(Round off to one decimal place)

($R = 8.3\ J\ mol^{-1}\ K^{-1}$)

55. At a certain wavelength, liquid P transmits 70 %, whereas liquid Q transmits 30 % of the incident light when separately placed in a spectrophotometric cell (path length = 1 cm). In a binary mixture of liquids P and Q (assume non-interacting liquids), the absorbance in the same cell is 0.25. The volume fraction of liquid P in the binary mixture is _____ (Round off to two decimal places)

56. The mean ionic activity coefficient for a 0.01 M aqueous solution of $Ca_3(PO_4)_2$ is _____(Round off to three decimal places)(Given: $\log_{10}\gamma_{\pm} = -0.509\ z_+|z_-|\sqrt{I}$)

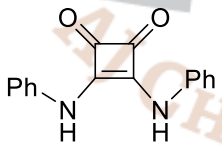
57. For the reaction, $CuSO_4(aq) + Zn(s) \longrightarrow ZnSO_4(aq) + Cu(s)$, the value of ΔG^0 (in $kJ\ mol^{-1}$) is_____ (Round off to the nearest integer)

(Reduction potential: $Cu^{2+}(aq)/Cu(s) = +0.34\ V$; $Zn^{2+}(aq)/Zn(s) = -0.76\ V$ and Faraday constant $= 96485\ C\ mol^{-1}$)

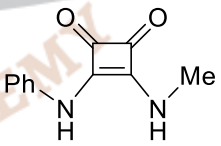
58. Titanium tetrachloride ($TiCl_4$) reacts with THF to form an octahedral complex X under inert atmosphere at 25 ℃. If 5.0 g of $TiCl_4$ is used and the yield is 80 %, the amount of X (in grams) formed is _____ (Round off to one decimal places)

(Use atomic weights: Ti = 48, Cl = 35.5, O = 16, C = 12 and H = 1)

59. The total number of tautomers possible for I and II together is_____

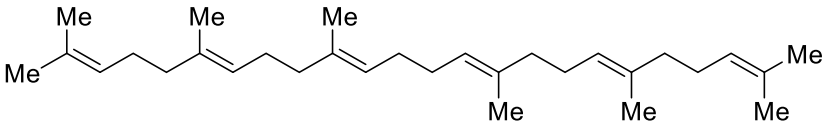


I



II

60. The total number of head to tail isoprene linkages in the following molecule is____



Answer Key

Q.No	Ans		Q.No	Ans		Q.No	Ans
1.	b		21.	d		41.	5.97 to 6.06
2.	c		22.	b		42.	7 to 7
3.	a		23.	c		43.	9.90 to 10.10
4.	b		24.	a		44.	0.040 to 0.050
5.	d		25.	a		45.	6 to 6

6.	c		26.	c		46.	5 to 5
7.	a		27.	b		47.	6 to 6
8.	a		28.	c		48.	6 to 6
9.	c		29.	c		49.	180 to 180
10.	b		30.	b		50.	9 to 9
11.	c		31.	a & b & c		51.	– 574 to – 570
12.	c		32.	b & c		52.	24.8 to 25 (OR) 49.7 to 49.9
13.	b		33.	a & b & c & d		53.	210 to 225
14.	b		34.	a & b & c & d		54.	19.8 to 20.2
15.	b		35.	c &d		55.	0.73 to 0.75
16.	c		36.	c & d		56.	0.063 to 0.069
17.	d		37.	c & d		57.	– 213 to – 211
18.	c		38.	c & d		58.	6.9 to 7.1
19.	b		39.	c		59.	13 to 13
20.	a		40.	a & d		60.	4 to 4

Q. 1 – 10	1 Mark (MCQ)					Q. 41 – 50	1 Mark (NAT)
Q. 11 – 30	2 Mark (MCQ)		Q. 31 – 40	2 Mark (MSQ)		Q. 51 – 60	2 Mark (NAT)