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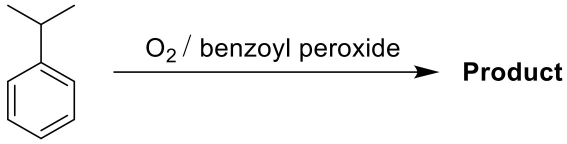
Q.1 – Q.25 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

1. In the proton decoupled ^{13}C-NMR spectrum of 7-norbornanone, the number of signals obtained is

(a) 7 (b) 3 (c) 4 (d) 5

2. Identify the most probable product in the given reaction



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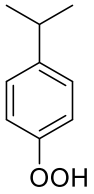

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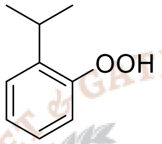

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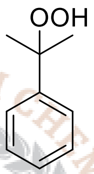

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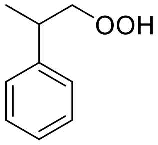
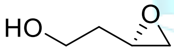


3. In the cyclization reaction given below, the most probable product formed is

(a)


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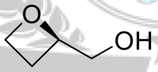

(c)


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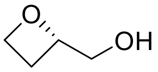


4. If Δy and Δp_y are the uncertainties in the y-coordinate and the y component of the momentum of a particle respectively, then, according to uncertainty principle $\Delta y \times \Delta p_y$ is ($\hbar = \frac{h}{2\pi}$ and h is Planck 's constant)

(a) $\geq \hbar$ (b) $> \hbar/2$ (c) $> \hbar$ (d) $\geq \hbar/2$

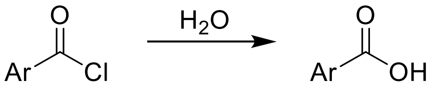
5. The average length of a typical α-helix comprised of 10 amino acids is

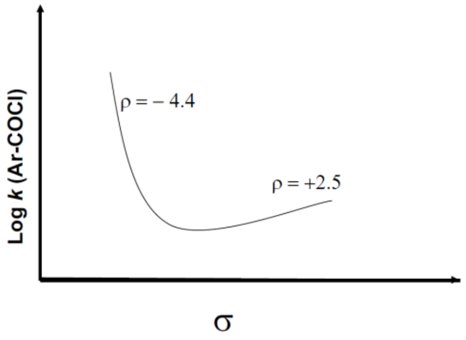
(a) 10Å (b) 15Å (c) 36Å (d) 54Å

6. Number of thymine residues in a 5000 kb DNA containing 23% guanine residues is:

(a) 2.70×10^6 (b) 2.70×10^7 (c) 1.35×10^6 (d) 1.35×10^7

7. Show below is a Hammett plot obtained for the reaction





The change in slope of the plot indicates that

(a) The reaction does not follow linear free energy relationship

(b) electrons are being withdrawn from the transition state in the mechanism

(c) electrons are being donated to the transition state in the mechanism

(d) the mechanism of the reaction is changing

8. The ratio of relative intensities of the two molecular ion peaks of methyl bromide (CH_3Br) in the mass spectrum is:

(a) $M^+ : (M+2)^+ = 1:3$ (b) $M^+ : (M+2)^+ = 3:1$

(c) $M^+ : (M+2)^+ = 1:1$ (d) $M^+ : (M+2)^+ = 1:2$

9. A disaccharide that will not given Benedict's test and will not form osazone is

(a) maltose (b) lactose (c) cellobiose (d) sucrose

10. Choose the allowed transition

(a) ${}^1\Sigma_g^+ \rightarrow {}^3\Sigma_u^+$ (b) ${}^1\Sigma_g^+ \rightarrow {}^3\Sigma_u^-$ (c) ${}^1\Sigma_g^+ \rightarrow {}^1\Sigma_u^+$ (d) ${}^1\Sigma_g^+ \rightarrow {}^1\Sigma_u^-$

11. The angular part of the wavefunction for the electron in a hydrogen atom is proportional to $\sin^2\theta \cos\theta e^{2i\phi}$. The values of the azimuthal quantum number (ℓ) and the magnetic quantum number (m) are respectively,

(a) 2 and 2 (b) 2 and –2 (c) 3 and 2 (d) 3 and –2

12. Let ϕ_x^C and ϕ_z^C denote the wavefunctions of the $2p_x$ and $2p_z$ orbitals of carbon, respectively, and ϕ_x^0 and ϕ_z^0 represent the wavefunction of the $2p_x$ and $2p_z$ orbitals of oxygen, respectively. If c_1 and c_2 are constants used in linear combinations and the CO molecule is oriented along the z axis, then, according to molecular orbital theory, the π-bonding molecular orbital has a wavefunction given by

(a) $c_1\phi_z^C + c_2\phi_x^0$ (b) $c_1\phi_z^C + c_2\phi_z^0$ (c) $c_1\phi_x^C + c_2\phi_z^0$ (d) $c_1\phi_x^C + c_2\phi_x^0$

13. The bond that gives the most intense band in the infrared spectrum for its stretching vibration is

(a) C–H (b) N –H (c) O –H (d) S–H

14. If x_A and x_B are the respective mole fractions of A and B in a ideal solution of the two and T_A, T_B, T are the fusion temperatures of pure-A, pure-B and the ideal solution respectively, then

(a) $1 - x_B = \exp\left[\frac{-\Delta H^0_{fus(B)}}{R}\left(\frac{1}{T} - \frac{1}{T_B}\right)\right]$ (b) $1 - x_B = \exp\left[\frac{\Delta H^0_{fus(A)}}{R}\left(\frac{1}{T} - \frac{1}{T_A}\right)\right]$

(c) $1 - x_B = \exp\left[\frac{\Delta H^0_{fus(B)}}{R}\left(\frac{1}{T} - \frac{1}{T_B}\right)\right]$ (d) $1 - x_B = \exp\left[\frac{-\Delta H^0_{fus(A)}}{R}\left(\frac{1}{T} - \frac{1}{T_A}\right)\right]$

15. For a reaction involving two steps given below

First step : $G \leftrightarrow 2H$

Second step : $G + H \longrightarrow P$

assume that the first step attains equilibrium rapidly. The rate of formation of P is proportional to

(a) $[G]^{1/2}$ (b) $[G]$ (c) $[G]^2$ (d) $[G]^{3/2}$

16. A metal chelate that can be used for separation and quantitative analysis of aluminium ions by gas chromatography is

(a) EDTA (b) ethylene glycol (c) dinonyl phthalate (d) trifluoroacetylacetone

17. The enthalpies of hydration of Ca^{2+}, Mn^{2+} and Zn^{2+} follow the order

(a) $Mn^{2+} > Ca^{2+} > Zn^{2+}$ (b) $Zn^{2+} > Ca^{2+} > Mn^{2+}$

(c) $Mn^{2+} > Zn^{2+} > Ca^{2+}$ (d) $Zn^{2+} > Mn^{2+} > Ca^{2+}$

18. The number of terminal carbonyl groups present in $Fe_2(CO)_9$ is

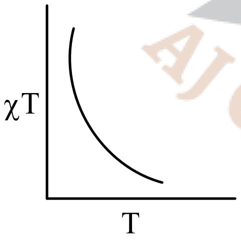
(a) 2 (b) 5 (c) 6 (d) 3

19. Among the following substituted silanes, the one that gives cross-linked silicone polymer upon hydrolysis is

(a) $(CH_3)_4Si$ (b) CH_3SiCl_3 (c) $(CH_3)_2SiCl_2$ (d) $(CH_3)_3SiCl$

20. The plot of χT versus T for a paramagnetic complex which strictly follows Curie equation is: (where χ is molar magnetic susceptibility and T is the temperature)

(a)



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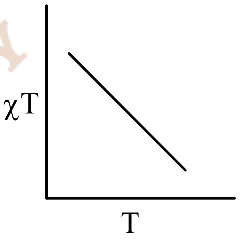

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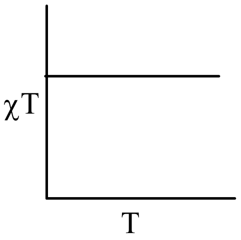

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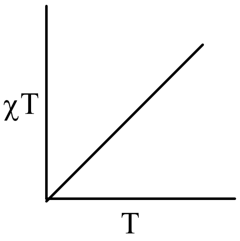


21. Among the following donors, the one that forms most stable adduct with the Lewis acid $B(CH_3)_3$ is:

(a) 4-methylpyridine (b) 2,6- dimethylpyridine

(c) 4-nitropyridine (d) 2,6-di-tert-butylpyridine

22. The complex with inverse-spinel structure is

(a) Co_3O_4 (b) Fe_3O_4 (c) $MgAlO_4$ (d) Mn_3O_4

23. The IUPAC nomenclature of $Na[PCl_6]$ is

(a) sodium hexachlorophosphine(V) (b) sodium hexachlorophosphate(V)

(c) sodium hexachlorophosphine (d) sodium hexachlorophosphite(V)

24. An intermediate formed during the hydroformylation of olefins using $Co_2(CO)_8$ as catalyst is

(a) $HCo(CO)_6$ (b) $H_4Co(CO)_3$ (c) $H_2Co(CO)_4$ (d) $HCo(CO)_4$

25. The order of polarity of NH_3, NF_3 and BF_3 is:

(a) $NH_3 < NF_3 < BF_3$ (b) $BF_3 < NF_3 < NH_3$

(c) $BF_3 < NH_3 < NF_3$ (d) $NF_3 < BF_3 < NH_3$

Q.26 – Q.55 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 2/3).

26. From a carboxymethyl-cellulose column at pH 6.0, arginine, valine and glutamic acid will elute in the order

(a) arginine, valine, glutamic acid (b) arginine, glutamic acid, valine

(c) glutamic acid, arginine, valine (d) glutamic acid, valine, arginine

27. Symmetry operations of the four C_2 axes perpendicular to the principal axis belong to the same class in the point group(s)

(a) D_4 (b) D_{4d} (c) D_{4h} (d) D_{4h} and D_{4d}

28. At 298K, the EMF of the cell: $Pt\,|H_2\,(1bar)|H^+\,(solution)\,||Cl^-|Hg_2Cl_2|Hg$ is $0.7530V$. The standard potential of the calomel electrode is $0.2802\ V$. If the liquid junction potential is zero, the pH of the solution is:

(a) 4.7 (b) 7.4 (c) 8.0 (d) 12.7

29. The wavefunction of a 1-D harmonic oscillator between $x = +\infty$ and $x = -\infty$ is given by $\varphi(x) = N(2x^2 - 1)e^{-x^2/2}$. The value of N that normalizes the function $\varphi(x)$ is (Given: $\int_{-\infty}^{+\infty} x^{2n}e^{-x^2}dx = \frac{1.3.5...(2n-1)}{2^n}\sqrt{\pi}$)

(a) $\left(\frac{1}{8\sqrt{\pi}}\right)^{\frac{1}{2}}$ (b) $\left(\frac{1}{3\sqrt{\pi}}\right)^{\frac{1}{2}}$ (c) $\left(\frac{1}{2\sqrt{\pi}}\right)^{\frac{1}{2}}$ (d) $\left(\frac{1}{4\sqrt{\pi}}\right)^{\frac{1}{2}}$

30. Consider the reaction, $H_2 + C_2H_4 \longrightarrow C_2H_6$

The molecular diameters of H_2 and C_2H_4 are 1.8 Å and 3.6 Å respectively. The pre-exponential factor in the rate constant calculated using collision theory in $m^3(mole)^{-1}s^{-1}$ is approximately.

(For this reaction at 300 K, $\left(\frac{8k_BT}{\pi\mu}\right)^{\frac{1}{2}} N_A = 1.11 \times 10^{27}\ m(mole)^{-1}s^{-1}$, where the symbols have their usual meanings)

(a) 2.5×10^8 (b) 2.5×10^{14} (c) 9.4×10^{17} (d) 9.4×10^{23}

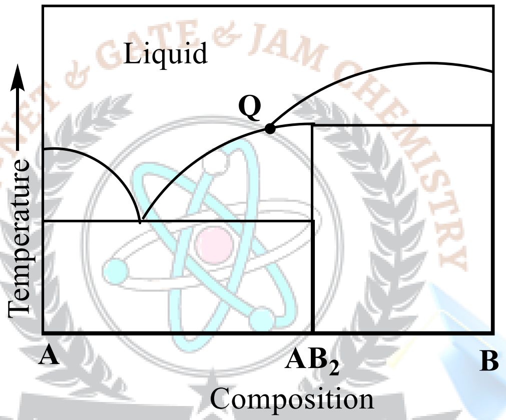
31. The molecular partition function of a system is given by

$q(T) = \left(\frac{k_BT}{hc}\right)^{\frac{3}{2}} \left(\frac{8\pi^3 mk_BT}{h^2}\right)^{\frac{3}{2}}$, where the symbols have their usual meanings.

The heat capacity at constant volume for this system is

(a) 3R (b) 6R (c) 9R/2 (d) 3R/2

32. Consider the phase diagram given below.

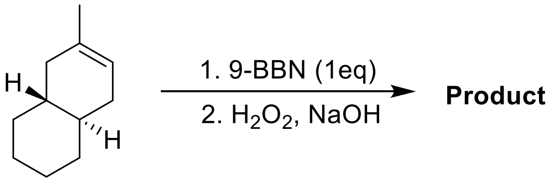


At the intersection point Q the phases that are in equilibrium are

(a) Solid A, solid B and Solid AB_2 (b) Solid A, solid AB_2 and liquid

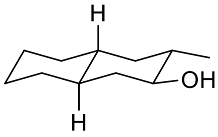
(c) solid B, solid AB_2 and liquid (d) solid A, solid B, solid AB_2 and liquid

33. Identify the product from the following reaction



(9-BBN = 9-borabicyclo[3.3.1]nonane)

(a)



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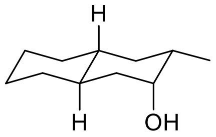

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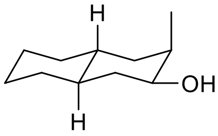

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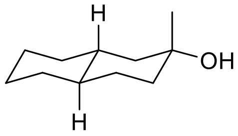
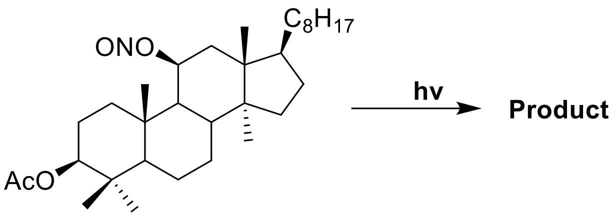
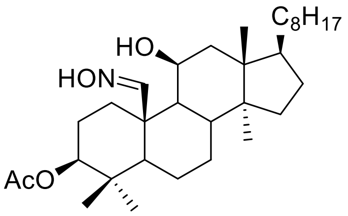


34. The product from the following reaction is



(a)



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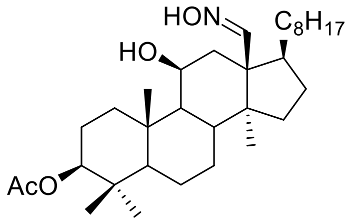

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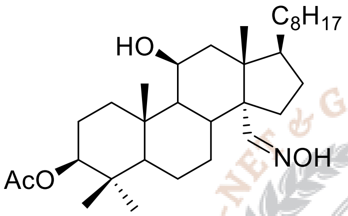

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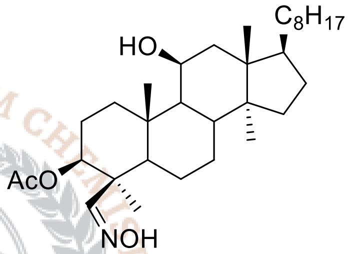
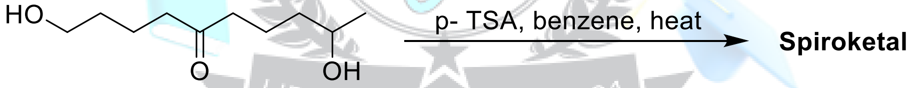
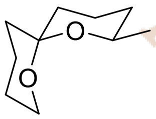


35. **The acid catalyzed cyclization of 5-ketodecan-1,9-diol is given below, The most predominant spiroketal is**



(p-TSA = p-toluenesulfonic acid)

(a)



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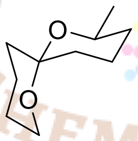

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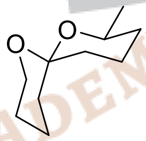

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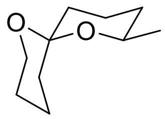


36. **For a face centered cubic lattice, the Miller indices for the first Bragg's peak (smallest Bragg angle) are**

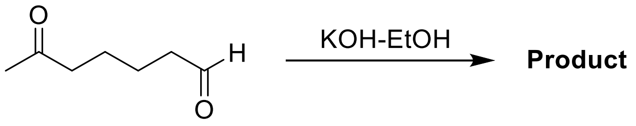
(a) 002 (b) 111 (c) 001 (d) 110

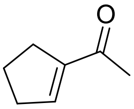
37. **For the titration of a 10 mL (aq) solution of $CaCO_3$, 2mL of 0.001 M Na_2EDTA is required to reach the end point. The concentration of $CaCO_3$**

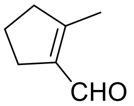
(assume molecular weight of $CaCO_3 = 100$) is

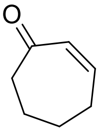
(a) 5×10^{-4} g/mL (b) 2×10^{-4} g/mL (c) 5×10^{-5} g/mL (d) 2×10^{-5} g/mL

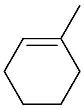
38. **In the given reaction, the product formed is**



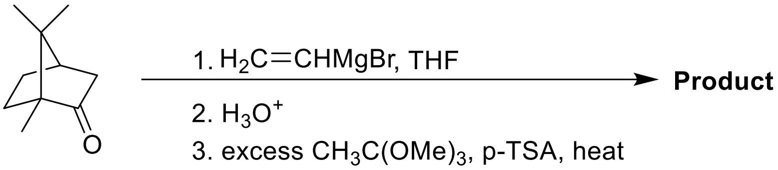
(a) 

(b) 

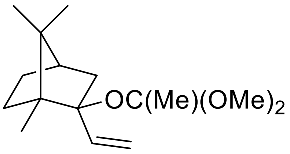
(c) 

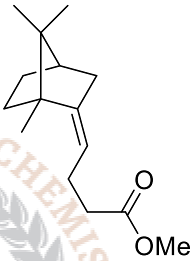
(d) 

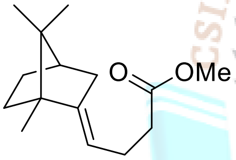
39. In the reaction given below, identify the product

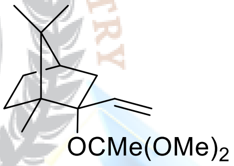


(p-TSA = p-toluenesulfonic acid; THF = tetrahydrofuran)

(a) 

(b) 

(c) 

(d) 

40. Consider the following pairs of complexes, the electron transfer rate will be fastest in the pair

(a) $[CoF(NH_3)_5]^{2+}$ and $[Cr(OH_2)_6]^{2+}$

(b) $[Co(NH_3)_5(OH_2)]^{3+}$ and $[Cr(OH_2)_6]^{2+}$

(c) $[Co(NH_3)_6]^{3+}$ and $[Cr(OH_2)_6]^{2+}$

(d) $[CoI(NH_3)_5]^{2+}$ and $[Cr(OH_2)_6]^{2+}$

41. The extent of Mossbauer quadrupole splitting of iron follows the order

(a) $FeCl_2.4H_2O > K_2[Fe(CN)_5(NO)] > FeCl_3.6H_2O$

(b) $K_2[Fe(CN)_5(NO)] > FeCl_2.4H_2O > FeCl_3.6H_2O$

(c) $FeCl_3.6H_2O > K_2[Fe(CN)_5(NO)] > FeCl_2.4H_2O$

(d) $FeCl_2.4H_2O > FeCl_3.6H_2O > K_2[Fe(CN)_5(NO)]$

42. Hemoglobin is an oxygen carrying protein. The correct statement about oxy-hemoglobin is that

(a) the metal is low-spin in +3 oxidation state while dioxygen is in O_2^- form

(b) the metal is high-spin in +3 oxidation state while dioxygen is in O_2^- form

(c) The metal is low-spin in +3 oxidation state while dioxygen is in neutral form

(d) the metal is high-spin in +3 oxidation state while dioxygen is in neutral form

43. If a mixture of NaCl, conc. H_2SO_4 and $K_2Cr_2O_7$ is heated in a dry test tube, a red vapour (P) is formed. This vapour (P) dissolves in aqueous NaOH to form a yellow solution, which upon treatment with $AgNO_3$ forms a red solid (Q). P and Q are, respectively

(a) CrO_2Cl_2 and $Ag_2Cr_2O_7$
(b) $Na_2[CrOCl_5]$ and Ag_2CrO_4
(c) $Na_2[CrOCl_5]$ and $Ag_2Cr_2O_7$
(d) CrO_2Cl_2 and Ag_2CrO_4

44. For the following reaction

$$2\,MnO_4^- + 5\,H_2C_2O_4 + 6\,H^+ \longrightarrow 2\,Mn^{2+} + 8\,H_2O + 10\,CO_2$$

$$E^0_{(MnO_4^-/Mn^{2+})} = +1.51\text{ V and } E^0_{(CO_2/H_2C_2O_4)} = -0.49\text{ V.}$$

At 298 K, the equilibrium constant is:

(a) 10^{500}
(b) 10^{338}
(c) 10^{38}
(d) 10^{833}

45. The ground states of high-spin octahedral and tetrahedral Co(II) complexes are respectively

(a) ${}^4T_{2g}$ and ${}^4A_2$
(b) ${}^4T_{1g}$ and ${}^4A_2$
(c) ${}^3T_{1g}$ and ${}^4A_2$
(d) ${}^4T_{1g}$ and ${}^3T_1$

46. The INCORRECT statement about Zeise's salt is:

(a) Zeise salt is diamagnetic
(b) The oxidation state of Pt in Zeise's salt is +2
(c) All the Pt–Cl bond lengths in Zeise's salt are equal
(d) C–C bond length of ethylene moiety in Zeise's salt is longer than that of free ethylene molecule

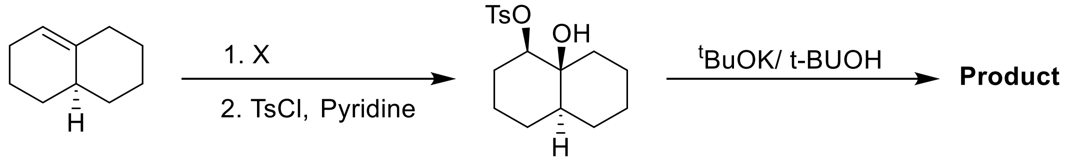
47. The number of possible isomers for the square planar mononuclear complex $[(NH_3)_2M(CN)_2]$ of a metal M is:

(a) 2
(b) 4
(c) 6
(d) 3

Common Data for Q. 48 and Q. 49:

Consider the reaction sequence shown below :

(TsCl = p-toluenesulfonyl chloride)

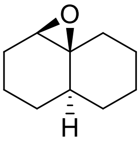


48. The oxidant-X used in step-1 is

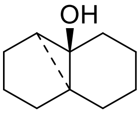
(a) CrO_3
(b) OsO_4
(c) $NaIO_4$
(d) m-CPBA followed by NaOH

49. **The product is**

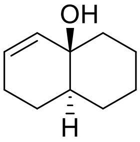
(a)



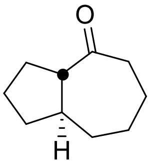
(b)



(c)

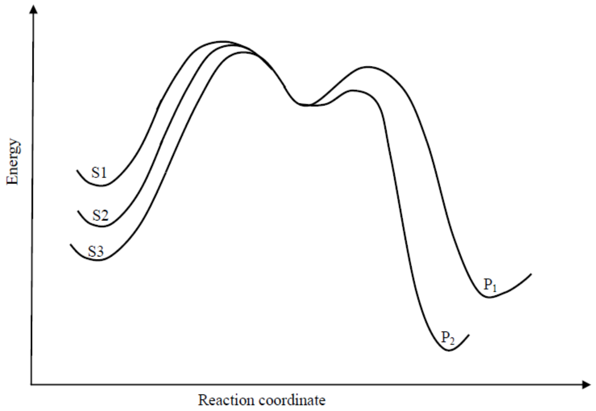


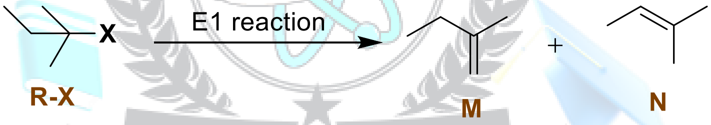
(d)



Common Data for Q. 50 and Q. 51

Consider the E1 reaction of tert-amyl halides from the energy profile give below.





50. **In the above reaction, $X = Cl, Br$ or I. Based on the graph, identify the alkyl halides (R−X) as S1, S2 and S3**

	S1	S2	S3		S1	S2	S3
(a)	R–Cl ;	R–Br ;	R–I	(b)	R–I ;	R–Br ;	R–Cl
(c)	R–Cl ;	R–I ;	R–Br	(d)	R–I ;	R–Cl ;	R–Br

51. **Identify product P_1 and its yield relative to P_2**

(a) P_1 is M and is the major product (b) P_1 is N and is the minor product

(c) P_1 is N and is the major product (d) P_1 is M and is the minor product.

Statement for Linked Answer Questions for Q.52 and Q.53

A 20491 cm^{-1} laser line was used to excite oxygen molecules (made of ^{16}O only) to obtain the rotational Raman spectrum. The resulting rotational Raman spectrum of oxygen molecule has the first Stokes line at 20479 cm^{-1}.

52. **The rotational constant (usually denoted as B) for the oxygen molecule is**

(a) 1.2 cm^{-1} (b) 2.0 cm^{-1} (c) 3.0 cm^{-1} (d) 6.0 cm^{-1}

53. **The next rotational Stokes line is expected at**

(a) 20467 cm^{-1} (b) 20469 cm^{-1} (c) 20471 cm^{-1} (d) 20475 cm^{-1}

Statement for Linked Answer Questions for Q.54 and Q.55:

Huckel molecular orbital theory can be applied to the allene radical

$$H_2C{=}CH{-}\dot{C}H_2$$

54. The secular determinant (where α, β and E have their usual meanings) is given by

(a) $\begin{vmatrix} \alpha-E & \beta & 0 \\ \beta & \alpha-E & \beta \\ 0 & \beta & \alpha-E \end{vmatrix}$ (b) $\begin{vmatrix} \alpha-E & 0 & 0 \\ 0 & \alpha-E & \beta \\ 0 & \beta & \alpha-E \end{vmatrix}$

(c) $\begin{vmatrix} \alpha-E & \beta & 0 \\ \beta & \alpha-E & 0 \\ 0 & 0 & \alpha-E \end{vmatrix}$ (d) $\begin{vmatrix} \alpha-E & -\beta & 0 \\ -\beta & \alpha-E & -\beta \\ 0 & -\beta & \alpha-E \end{vmatrix}$

55. The possible values of E are

(a) $\alpha+\sqrt{2}\beta, \alpha, \alpha-\sqrt{2}\beta$ (b) $\alpha+2\sqrt{2}\beta, \alpha, \alpha-2\sqrt{2}\beta$

(c) $\alpha+\beta, \alpha, \alpha-\beta$ (d) $\alpha+2\beta, \alpha, \alpha-2\beta$

Answer Key

Q.No	Ans		Q.No	Ans		Q.No	Ans		Q.No	Ans
1.	b		16.	d		31.	a		46.	c
2.	c		17.	d		32.	c		47.	a
3.	c		18.	c		33.	a		48.	b
4.	d		19.	b		34.	a or b		49.	d
5.	b		20.	c		35.	a		50.	b
6.	c		21.	a		36.	b		51.	d
7.	d		22.	b		37.	d		52.	a
8.	c		23.	b		38.	a		53.	b
9.	d		24.	d		39.	c		54.	a
10.	c		25.	b		40.	d		55.	a
11.	c		26.	d		41.	a			
12.	d		27.	b		42.	a			
13.	c		28.	c		43.	d			
14.	d		29.	c		44.	b			
15.	d		30.	a		45.	b			