IIT GATE: 2020

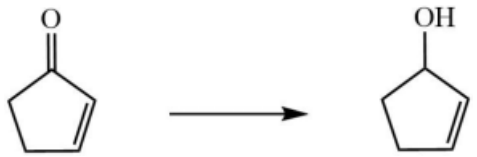
Chemistry

❖ Question Paper

Section-A

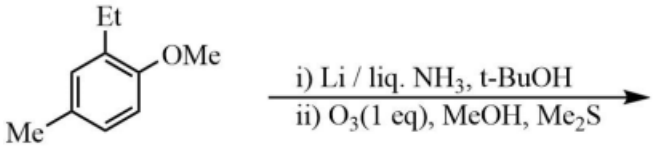
Q.1 - Q.25 carry one mark each

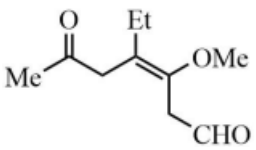
Q.1 Among the following, the suitable reagents for the given transformation is:

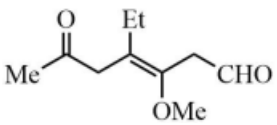


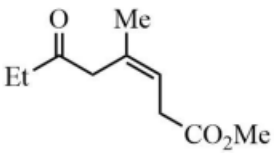
(a) H_2, Pd/C (b) $H_2N–NH_2$/KOH, Δ (c) $NaBH_4/CeCl_3 \cdot 7H_2O$ (d) Li / Liq. NH_3

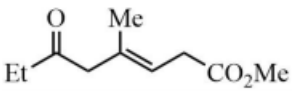
Q.2 Major product formed in the following reaction sequence is:



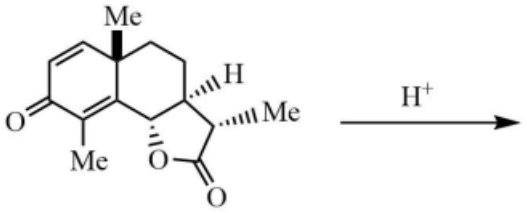
(a) 

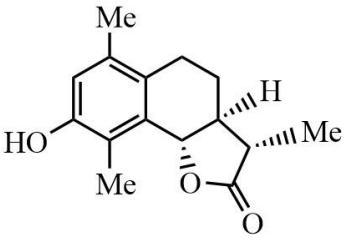
(b) 

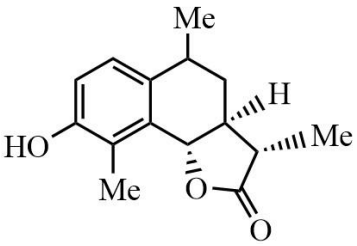
(c) 

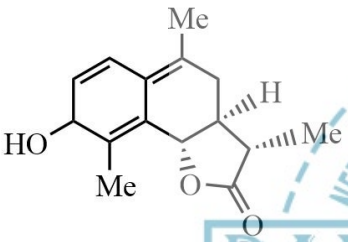
(d) 

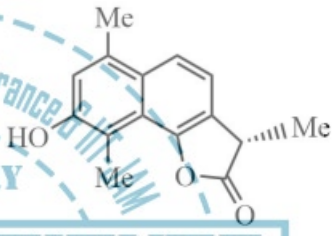
Q.3 Major product formed in the following reaction is:



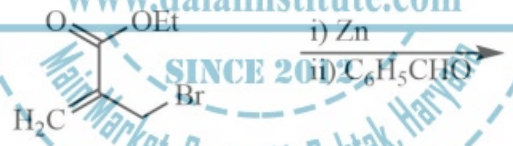
(a) 

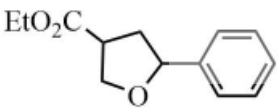
(b) 

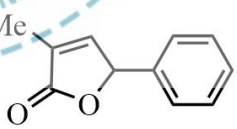
(c) 

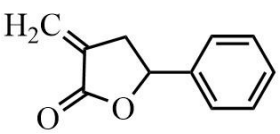
(d) 

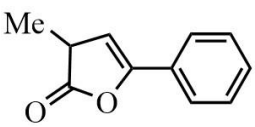
Q.4 Major product formed in the following transformation is:



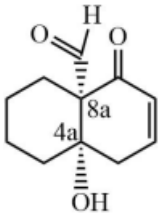
(a) 

(b) 

(c) 

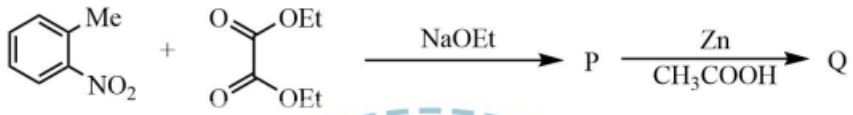
(d) 

Q.5 Absolute stereochemistry of the given compound is:

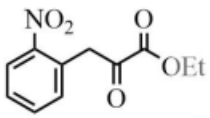
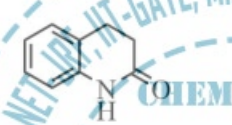


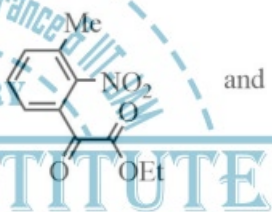
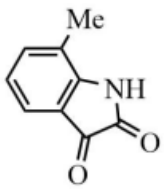
(a) 4aR, 8aS (b) 4aR, 8aR (c) 4aS, 8aS (d) 4aS, 8aR

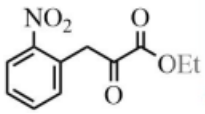
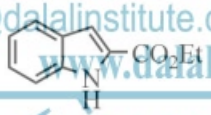
Q.6 In the following reaction sequence,

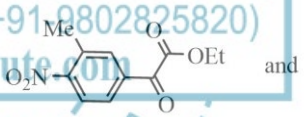
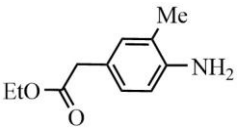


the major product P and Q are, respectively:

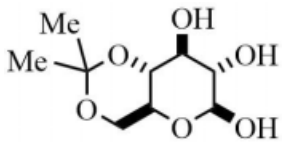
(a)  and 

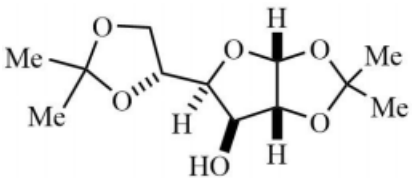
(b)  and 

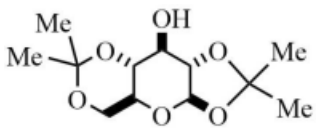
(c)  and 

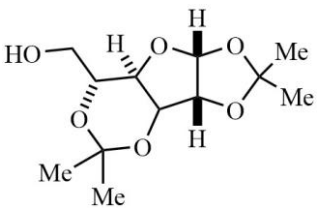
(d)  and 

Q.7 Major product formed in the given reaction is:

(a) 

(b) 

(c) 

(d) 

Q.8 The correct statement regarding the substitution of coordinated ligands in $Ni(CO)_4$ and $Co(NO)(CO)_3$ is:

(Given: Co–N–O bond is nearly linear, atomic number of Co and Ni are 27 and 28, respectively)

(a) $Ni(CO)_4$ and Co(NO)(CO) follow associative and dissociative pathways, respectively.

(b) $Ni(CO)_4$ and Co(NO)(CO) follow dissociative and associative pathways, respectively.

(c) Both $Ni(CO)_4$ and Co(NO)(CO) follow associative pathways

(d) Both $Ni(CO)_4$ and Co(NO)(CO) follow dissociative pathways

Q.9 The correct statement about hexagonal boron nitride is:

(a) It is a good electrical conductor.

(b) It has same layer stacking as that of graphite

(c) It is reactive towards fluorine

(d) It has lower thermal stability in air compared to that of graphite

Q.10 In oxy-hemocyanin, the coordination number, mode of oxygen binding, colour and the net magnetic behaviour of copper ions, respectively are:

(Given atomic number of Cu is 29)

(a) Five, μ-η^2: η^2-O_2^-, colourless and paramagnetic

(b) Five, μ-η^1: η^1-O_2^-, colourless and paramagnetic

(c) Four, μ-η^1: η^1-O_2^-, blue and diamagnetic

(d) Five, μ-η^2: η^2-O_2^-, blue and diamagnetic

Q.11 Among the following species, the one that has pentagonal shape is:

(Given atomic numbers of O, F, S, I and Xe are 8, 9, 16, 53 and 54, respectively)

(a) $XeOF_4$ (b) IF_5 (c) $[SF_5]^-$ (d) $[XeF_5]^-$

Q.12 A solution containing a metal complex absorbs at 480 nm with molar extinction coefficient of 15,000 L mol^{-1} cm^{-1}. If the path length of the cell is 1.0 cm and transmittance is 20.5%, the concentration (in mol L^{-1}) of the metal complex is:

(a) 1.37×10^{-5} (b) 2.29×10^{-5} (c) 4.59×10^{-5} (d) 8.75×10^{-5}

Q.13 Among the following linear combination of atomic orbitals, the correct representation of the lowest unoccupied π-molecular orbital of butadiene is:

(a) $\Psi = -0.372\phi_1 + 0.602\phi_2 - 0.602\phi_3 + 0.372\phi_4$

(b) $\Psi = 0.602\phi_1 - 0.372\phi_2 - 0.372\phi_3 + 0.602\phi_4$

(c) $\Psi = 0.602\phi_1 + 0.372\phi_2 - 0.372\phi_3 + 0.602\phi_4$

(d) $\Psi = 0.372\phi_1 + 0.602\phi_2 + 0.602\phi_3 + 0.372\phi_4$

Q.14 The activity of 'm' molal $CuSO_4$ solution can be expressed in terms of its mean activity coefficient ($\gamma_\pm$) as:

(a) $m^2\gamma_\pm^2$ (b) $4m^3\gamma_\pm^3$ (c) $16m^4\gamma_\pm^4$ (d) $108m^5\gamma_\pm^5$

Q.15 The character table for a pyramidal AB_3 molecule of C_{3V} point group is given below:

C_{3v}	E	$2C_3$	$3\sigma_v$		
A_1	1	1	1	z	$x^2 + y^2, z^2$
A_2	1	1	−1	R_z	
E	2	−1	0	(x, y) (R_x, R_y)	$(x^2 - y^2, xy)$ (xz, yz)

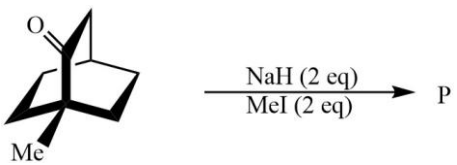
The reducible representation of pyramidal AB_3 is

C_{3v}	E	$2C_3$	$3\sigma_v$
Γ	12	0	2

The correct option representing all the normal Raman active modes of pyramidal AB_3 is:

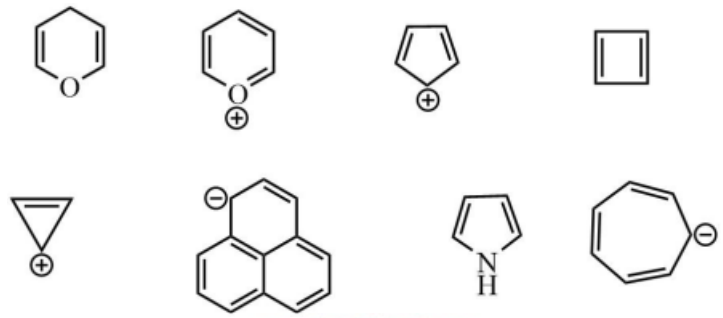
(a) $A_1 + A_2 + 2E$ (b) $3E$ (c) $3A_1 + A_2 + E$ (d) $2A_1 + 2E$

Q.16 In the following reaction,



the number of peaks exhibited by the major product P in its broadband proton decoupled ^{13}C NMR spectrum is……

Q.17 Among the following,



the total number of aromatic species is ……

Q.18 The maximum number of microstates for d^2 electronic configuration is ……..

Q.19 In a uranium recovery process, an aqueous solution of uranyl ion is evaporated, dried in air at 400°C and subsequently reduced with hydrogen at 700°C to obtain a uranium compound (X). the oxidation state of uranium in X is ……

(Given: atomic number of U is 92)

Q.20 For a cubic crystal system, the powder X-ray diffraction pattern reduced using Cu K_α source (λ = 1.54 Å) shows a peak at 33.60° (2θ) for (111) plane. The lattice parameter '*a*' (in Å, *rounded off to two decimal places*) is

Q.21 In an NMR spectrometer operating at a magnetic field strength of 16.45 T, the resonance frequency (in MHz, *rounded off to one decimal place*) of ^{19}F nucleus is……..

(Given: *g* factor of ^{19}F = 5.255; $\beta_N = 5.05 \times 10^{-27}$ J T^{-1}; $h = 6.626 \times 10^{-34}$ J s)

Q.22 When three moles of helium is mixed with one mole of neon at constant temperature and pressure (25°C, 1 atm), the entropy of mixing (in J K^{-1}, *rounded off to two decimal places*) is ……

(Given: R = 8.314 J K^{-1} mol^{-1})

Q.23 At 25°C, the *emf* (*in volts, rounded off three decimal places*) of the cell,

$Ag|AgBr(s)|Br^{-}\ (a = 0.20),\ Cu^{2+}(a = 0.48),\ Cu^{+}(a = 0.24)|\ Pt$

is .....

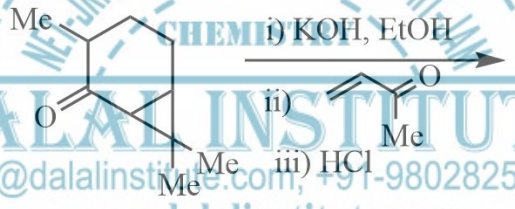
(Given: The standard emf of the cell is 0.082 V; R = 8.314 J K^{-1} mol^{-1}; F = 96500 C mol^{-1})

Q.24 For an enzyme catalysed reaction, the plot of inverse of initial rate against inverse of initial substrate concentration is linear with slope 0.16 s and intercept 2.12 mol^{-1} L s. The estimated value of Michaelis constant (in mol L^{-1}, *rounded off to two decimal places*) is .....

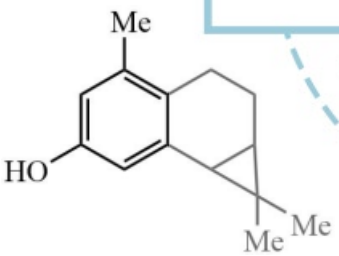
Q.25 Fluorescence quantum yield and fluorescence lifetime of a molecule are 0.4 and 5×10^{-9} s, respectively. If the fluorescence decay rate constant is Y (*rounded off to nearest integer*) is .....

Q.26 – Q.55 carry two marks each.

Q.26 Major product formed in the following reaction sequence is:



(a)



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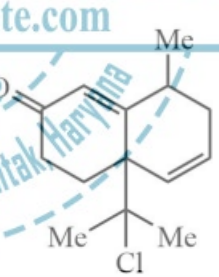
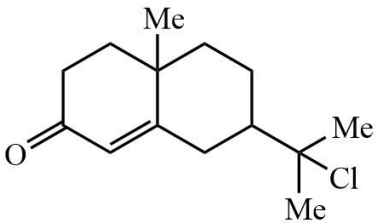
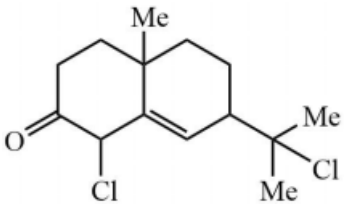


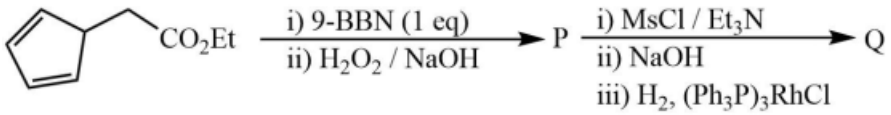
(c)

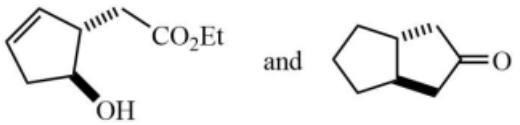


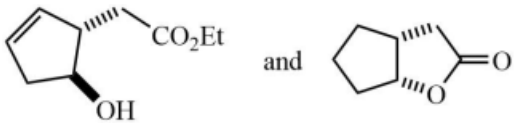
(d)

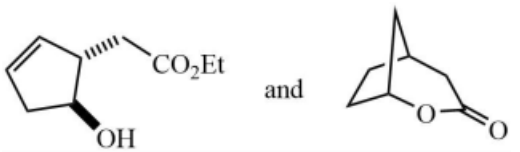


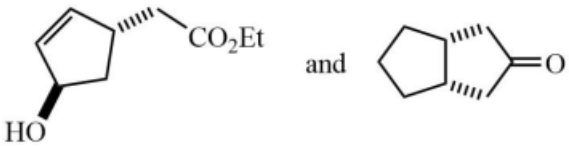
Q.27 Major products P and Q in the given reaction sequence are, respectively:



(a) 

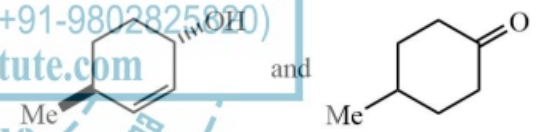
(b) 

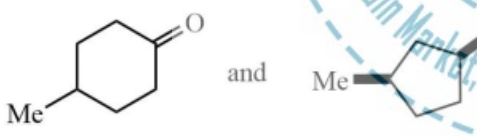
(c) 

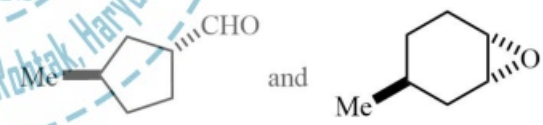
(d) 

Q.28 Major products P and Q in the given reaction sequence are:

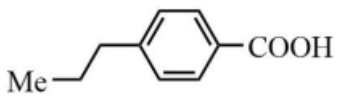
(a) 

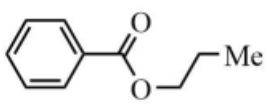
(b) 

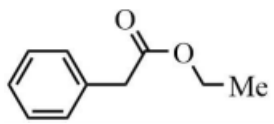
(c) 

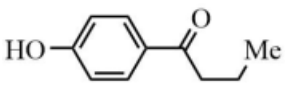
(d) 

Q.29 A compound with molecular formula $C_{10}H_{12}O_2$ showed a strong IR band at ~ 1720 cm^{-1}, a peak at *m/z* 122 in the mass spectrum and the following ^1H NMR signals: δ 8.1–8.0(2H, m), 7.6–7.5(1H, m), 7.5–7.3(2H, m), 4.3(2H, t), 1.8(2H, sextet) and 1.0(3H, t). The structure of the compound is:

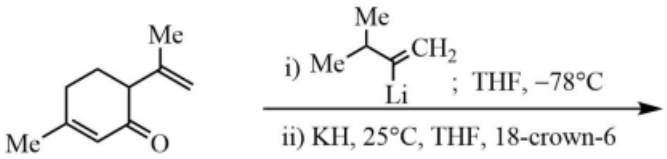
(a) 

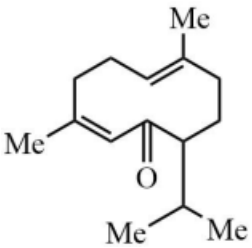
(b) 

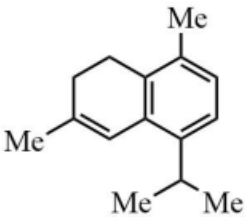
(c) 

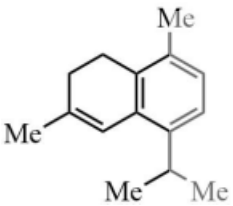
(d) 

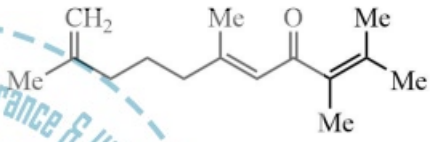
Q.30 Major product formed in the following synthetic sequence is:



(a) 

(b) 

(c) 

(d) 

Q.31 The correct statement with respect to the stereochemistry of -hydroxy acids P and Q formed in the following reactions is:

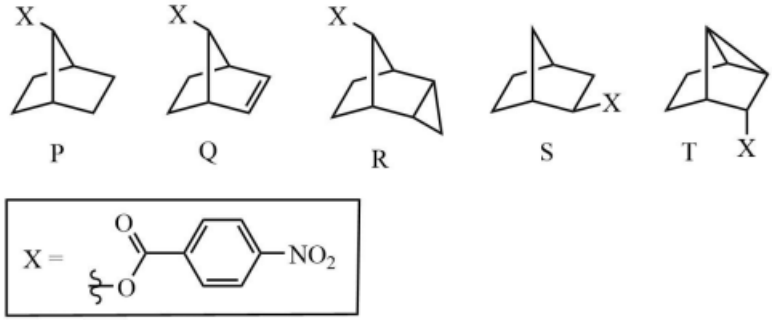
(a) Both P and Q are formed with retention of configuration

(b) Both P and Q are formed with inversion of configuration

(c) P is formed with retention of configuration and Q with inversion of configuration

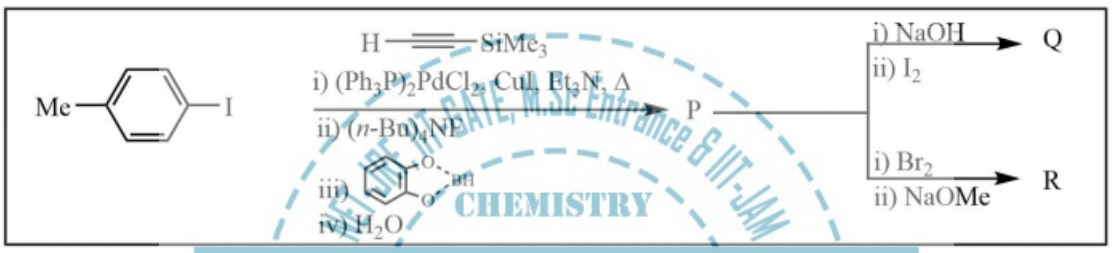
(d) P is formed with inversion of configuration and Q with retention of configuration

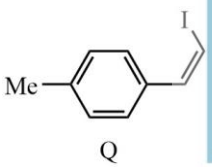
Q.32 The rate of solvolysis of the given compound is in the order:



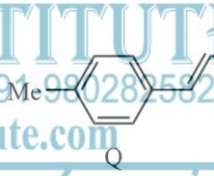
(a) T > R > Q > S > P (b) Q > T > R > P > S (c) R > T > Q > S > P (d) T > Q > R > S > P

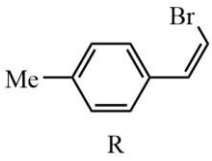
Q.33 In the following reaction sequence, the major products Q and R are

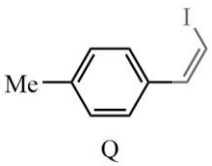


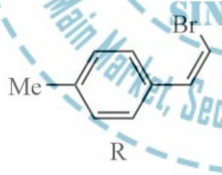
(a) 

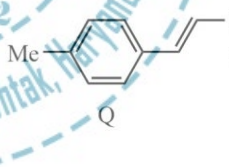
and 

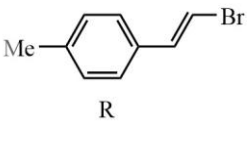
(b) 

and 

(c) 

and 

(d) 

and 

Q.34 In the electronic absorption spectrum of an aqueous solution of $[Ni(NH_3)_6]^{2+}$, a very weak band is observed between the bands due to the transitions $^3A_{2g} \rightarrow {}^3T_{2g}$ and $^3A_{2g} \rightarrow {}^3T_{1g}(F)$.The transition responsible for the very weak band is

(Given: atomic number of Ni is 28)

(a) $^3A_{2g} \rightarrow {}^1T_{1g}$ (b) $^3A_{2g} \rightarrow {}^1T_{2g}$ (c) $^3A_{2g} \rightarrow {}^1E_g$ (d) $^3A_{2g} \rightarrow {}^1A_{2g}$

Q.35 The experimental magnetic moment (3.4 BM) of a hydrated salt of Eu^{3+} at 27°C is significantly different from the calculated value. The difference is due to

(Given: atomic number of Eu is 63)

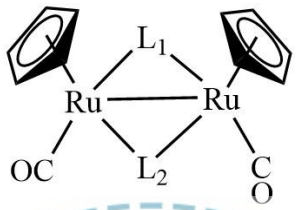
(a) Population of electrons at higher J levels *via* thermal excitation

(b) Strong ligand field splitting of f–orbitals

(c) Strong spin–orbit coupling

(d) Pairing of electrons in f–orbitals.

Q.36 The correct combination of L_1 and L_2 among H^-, NO^-, $MeCH^{2-}$ and CO, that will satisfy the 18-electron rule for both metal centers in the following neutral molecule, is



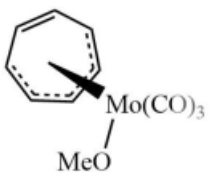
(Given: atomic number of Ru is 44)

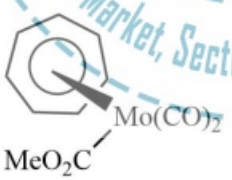
(a) H^-, NO^- (b) NO^-, $MeCH^{2-}$ (c) $MeCH^{2-}$, CO (d) H^-, CO

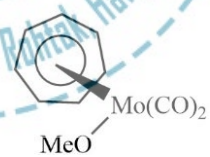
Q.37 In the following reaction sequence,

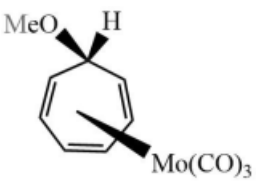
the structure of B is

(Given: atomic number of Mo is 42)

(a) 

(b) 

(c) 

(d) 

Q.38 The following table lists the reaction/conversion catalysed by metalloenzymes.

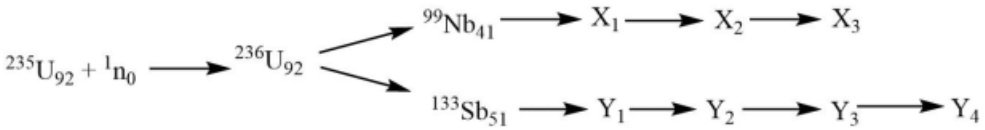
Reaction/conversion		Metalloenzyme	
P	$R–H + O_2 + 2H^+ + 2e^- \rightarrow R–OH + H_2O$	I	Coenzyme B_{12}
Q	$O_2 + 4e^- + 8H^+ \rightarrow 2H_2O + 4H^+$	II	Cytochrome P-450
R	$2H_2O_2 \rightarrow 2H_2O + O_2$	III	Cytochrome c oxidase
S	$NH_2–CH_2–CO_2H \rightarrow NH_2–CH(CH_2OH)–CO_2H$	IV	Catalase

The correct combination is

(a) P-II; Q-I; R-III; S-IV (b) P-IV; Q-III; R-II; S-I

(c) P-II; Q-III; R-IV; S-I (d) P-I; Q-IV; R-III; S-II

Q.39 The fission reaction of $^{235}_{92}U$ with thermal neutron is represented below.

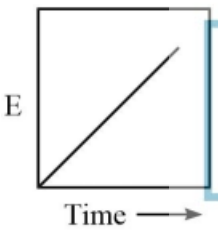


$^{99}_{41}Nb$ and $^{133}_{51}Sb$ are the primary fission fragment pair, which undergo series of radioactive decay to form stable nuclei X_3 and Y_4 (chain enders). The X_3 and Y_4, respectively are:

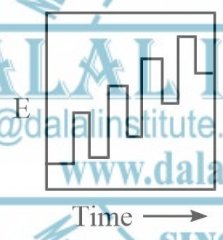
(a) $^{96}_{41}Nb$ and $^{130}_{51}Sb$ (b) $^{99}_{44}Ru$ and $^{133}_{55}Cs$ (c) $^{93}_{38}Sr$ and $^{127}_{35}Ag$ (d) $^{87}_{35}Br$ and $^{124}_{43}Tc$

Q.40 The correct 'voltage (E) *versus* time' excitation signal used in cyclic voltammetry is

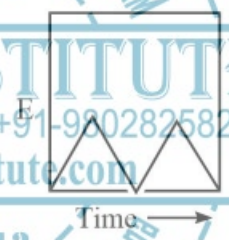
(a)



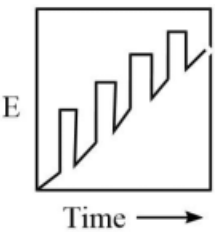
(b)



(c)



(d)



Q.41 The hydrogen-like radial wave function of the 3s orbital is given as

where $\rho = 2Zr/a_0$; Z = atomic number; r = distance form the nucleus and a_0= Bohr radius. Position of the radial nodes (in units of a_0) of the 3*s* orbital are at

(a) $\frac{3+\sqrt{3}}{2Z}, \frac{3-\sqrt{3}}{2Z}$ (b) $\frac{6+3\sqrt{3}}{2Z}, \frac{6-3\sqrt{3}}{2Z}$ (c) $\frac{9+3\sqrt{3}}{2Z}, \frac{9-3\sqrt{3}}{2Z}$ (d) $\frac{3+3\sqrt{3}}{2Z}, \frac{3-3\sqrt{3}}{2Z}$

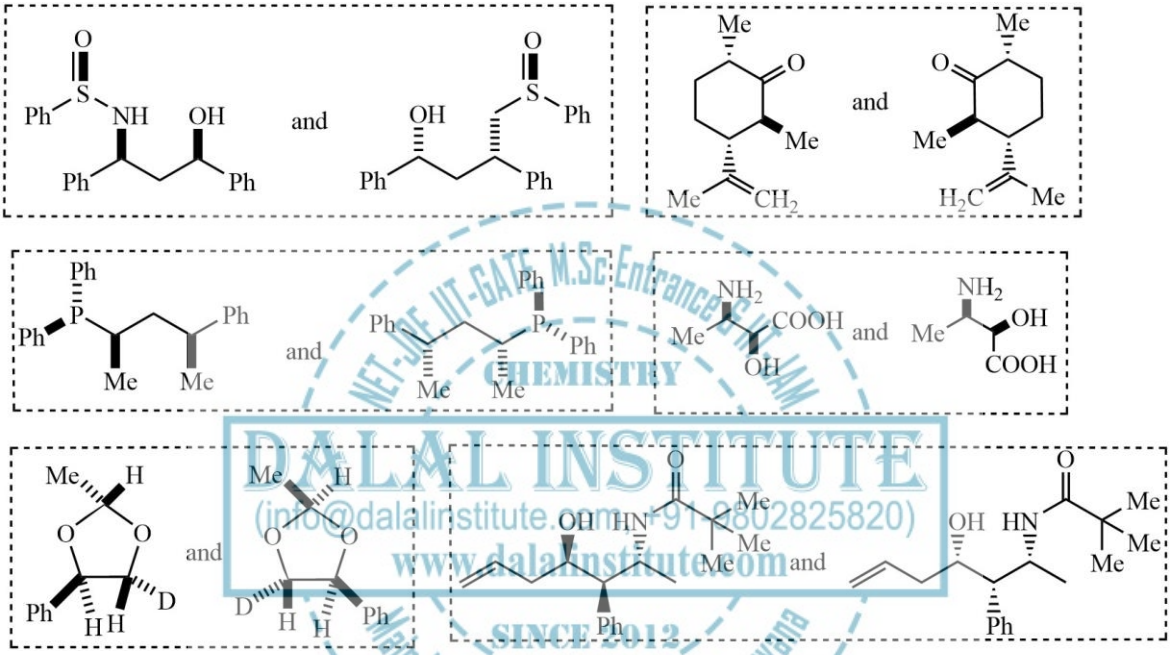
Q.42 ΔG_f^0 and ΔH_f^0 for Fe(g) are 370.7 kJ mol^{-1} and 416.3 kJ mol^{-1} at 298 K, respectively. Assuming ΔH_f^0 is constant in the interval 250 K to375 K, ΔG_f^0 (*rounded off to the nearest integer*) for Fe(*g*) at 375 K is:

(a) 359 kJ mol^{-1} (b) 338 kJ mol^{-1} (c) 325 kJ mol^{-1} (d) 310 kJ mol^{-1}

Q.43 Adsorption of N_2 on TiO_2 was carried out at 75 K. A plot of $\frac{z}{(1-z)v}$ *versus* z $(z = \frac{p}{p^o})$ gives a straight line with an intercept, 4.0×10^{-6} mm^{-3} and slope, 1.0×10^{-3} mm^{-3}. The volume (*rounded off to the nearest integer*) corresponding to the monolayer coverage is:

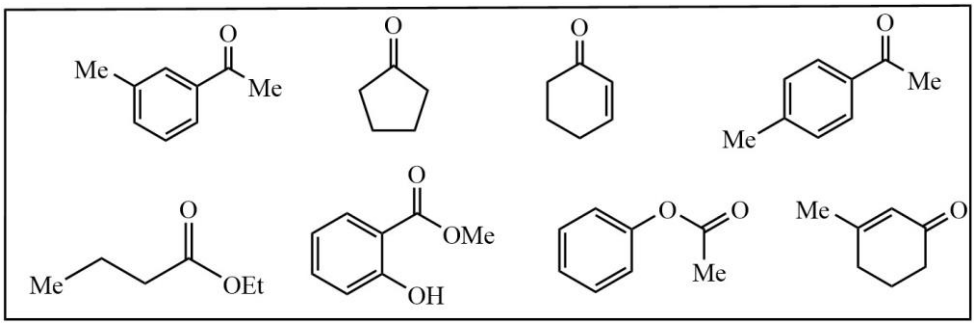
(a) 996 mm^3 (b) 785 mm^3 (c) 690 mm^3 (d) 555 mm^3

Q.44 Among the following sets,



the total number of sets of diastereomeric is ……..

Q.45 Among the following,



the total number of compounds showing characteristic carbonyl stretching frequency less than 1700 cm^{-1} in their IR spectra is ……..

Q.46 Consider that AgX crystallizes in rock salt structure. The density of AgX is 6477 kg/m^3 and unit cell length is 577.5 pm. Atomic weight of Ag is 107.87 g mol^{-1}. The atomic weight of X (in g mol^{-1}, *rounded off to two decimal places*) is …….

Q.47 The total number of $g_{\|}$ lines expected in the EPR spectrum of a solution of bis(salicylaldimine) copper(II) having pure ^{63}Cu and ^{14}N at 77 K is ……..

(Given: I values of ^{63}Cu, ^{14}N and ^{1}H are 3/2, 1 and ½, respectively)

Q.48 Among the following,

$[B_{12}H_{12}]^{2-}$, $[Ni_5(CO)_{12}]^{2-}$, $[C_2B_9H_{11}]^{2-}$, $Rh_6(CO)_{16}$, $Os_6(CO)_{20}$, B_5H_{11}, B_6H_{10}

The total number of species having *nido* structure is ……..

(Given: atomic number of H, B, C, O, Ni, Rh and Os are 1, 5, 6, 8, 28, 45 and 76 respectively)

Q.49 The frequency (in cm^{-1}, *rounded off to two decimal places*) for pure rotational line in the spectrum of NO molecule due to change in the quantum number from J =1 to J = 2 is …….

(Given: Moment of inertia of NO = 1.6427×10^{-46} kg m^2; $h = 6.626 \times 10^{-34}$ J s; $c = 3 \times 10^8$ m/s)

Q.50 The % error (*rounded off to two decimal places*) in the ground state energy of a particle in a one-dimensional box of length 'a' described by a trial variation function $\varphi = x(a-x)$, where $0 \leq x \leq a$, is …….

(Given: The true ground state energy of the above system is $\hbar^2/8ma^2$; $\int_0^a \varphi^* \varphi d\tau = a^5/30$)

Q.51 Assuming no interaction between rotational and vibrational energy levels in HF, the frequency (in cm^{-1}, *rounded off to nearest integer*) of the R branch line originating from J = 4 in its IR spectrum is ……...

(Given: Rotational constant for HF = 19.35 cm^{-1}; $\bar{\nu}_n = 4138.52$ cm^{-1})

Q.52 The Vander Waals constants a and b for gaseous CO are given as 1.49 L^2 atm mol^{-2} and 0.0399 L mol^{-1}, respectively. The fugacity (in atm, *rounded off to two decimal places*) of CO at 35 °C and 95 atm is ……..

(Given: R = 0.082 L atm K^{-1} mol^{-1})

Q.53 At 30°C, the vapour pressure and density of a 1.0 M aqueous solution of sucrose are 31.207 mm Hg and 1.1256 g/mL, respectively. If the vapour pressure of pure water at 30 °C is 31.824 mm Hg, the activity coefficient (*rounded off to three decimal places*) of water in the given solution is ……

(Given: The molar mass of sucrose = 342.3 g mol^{-1})

Q.54 For the ring opening reaction of cyclopropane to propane at 25 °C, the pre-exponential factor is 4.3×10^{15} s^{-1}. The entropy of activation (in J K^{-1} mol^{-1}, *rounded off to two decimal places*) is …….

(Given: $h = 6.626 \times 10^{-34}$ J s; $k_B = 1.38 \times 10^{-23}$ J K^{-1}; R = 8.314 J K^{-1} mol^{-1})

Q.55 In a reaction, reactant X is converted to products Y and Z consecutively with rate constants 6.0×10^{-2} min^{-1} and 9.0×10^{-3} min^{-1}, respectively. If the initial amount of X is 12.5 moles, the number of moles (*rounded off to one decimal places*) of Y formed after 10 minutes is …….

Section-B

Q.56 – Q.60 carry one mark each.

Q.56 While I agree …… his proposal this time, I do not agree ……. him.

(a) to, with (b) With, to (c) with, with (d) to, to

Q.57 The recent measures to improve the output would …… the level of production to our satisfaction.

(a) increase (b) decrease (c) speed (d) equalise

Q.58 Select the word that fits the analogy:

White: Whitening : : Light: ……

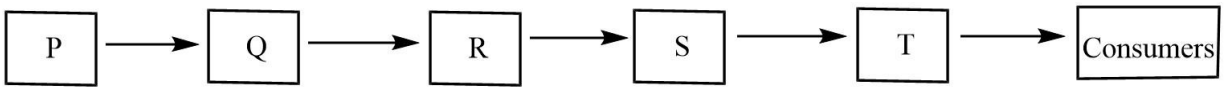
(a) Lightning (b) Lightening (c) Lighting (d) Enlightening

Q.59 In one of the greatest innings ever seen in 142 years of Test history. Ben stokes upped the tempo in a five-and-a- half hour long stay of 219 balls including 11 fours and 8 sixes that saw him finish on a 135 not out as England squared the five-match series.

Based on their connotations in the given passage, which one of the following meanings does not match?

(a) upped = increased (b) squared = lost (c) tempo = enthusiasm (d) saw = resulted in

Q.60 There are five levels {P, Q, R, S, T} in a linear supply chain before a product reaches customers, as shown in the figure.



At each of the five levels, the price of the product is increased by 25%, if the product is produced at level P at the cost of Rs. 120 per unit, what is the price paid (in rupees) by the customers?

(a) 187.50 (b) 234.38 (c) 292.96 (d) 366.21

Q.61 – Q.65 carry two marks each.

Q.61 Climate change and resilience deal with two aspects – reduction of sources of non-renewable energy resources and reducing vulnerability of climate change aspects. The terms 'mitigation' are used to refer to these aspects, respectively.

Which of the following assertions is best supported by the above information?

(a) Mitigation deals with consequences of climate change.

(b) Adaptation deals with causes of climate change.

(c) Mitigation deals with actions taken to reduce the use of fossil fuels.

(d) Adaptations deals with actions taken to combat green-house gas emissions.

Q.62 Find the missing element in the following figure.

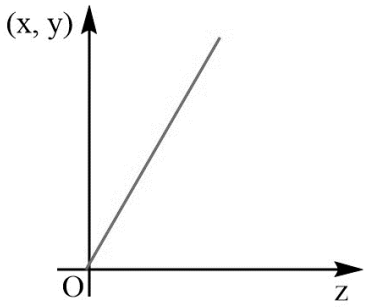
(a) *d* (b) *e* (c) *w* (d) *Y*

Q.63 It was estimated that 52 men can complete a strip in a newly constructed highway connecting cities P and Q in 10 days. Due to an emergency, 12 men were sent to another project. How many number of days, more than the original estimate, will be required to complete the strip?

(a) 3 days (b) 5 days (c) 10 days (d) 13 days

Q.64 An engineer measures three quantities X, Y and Z in an experiment. She finds that they follow a relationship that is represented in the figure below: (the product of X and Y linearly varies with Z)

Then, which of the following statements is false?



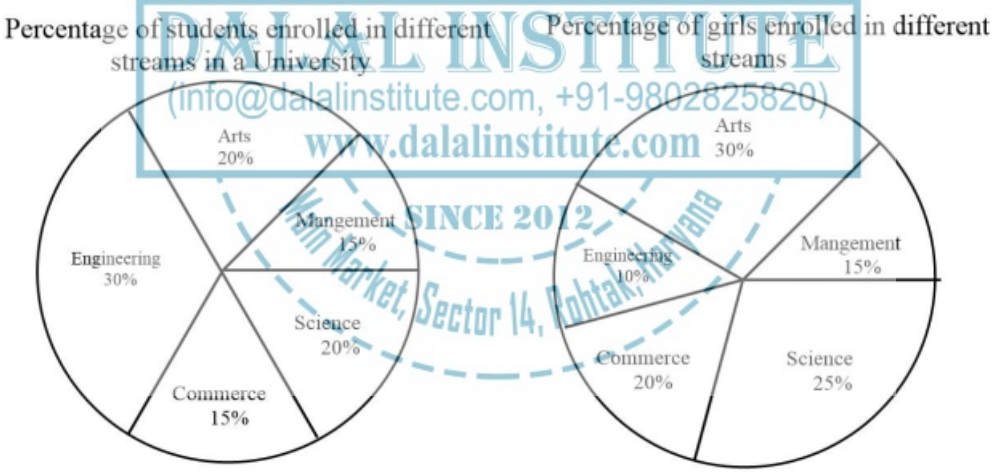
(a) For fixed Z; X is proportional to Y

(b) For fixed Y; X is proportional to Z

(c) For fixed X; Z is proportional to Y

(d) XY/Z is constant

Q.65 The two pie-charts given below show the data of total students and only girls registered in different streams in a university. If total number of students registered in the university is 5000, an the total number of the registered girls is 1500; then the ratio of boys enrolled in Arts to the girls enrolled in Management is …….



(a) 2 : 1

(b) 9 : 22

(c) 11 : 9

(d) 22 : 9

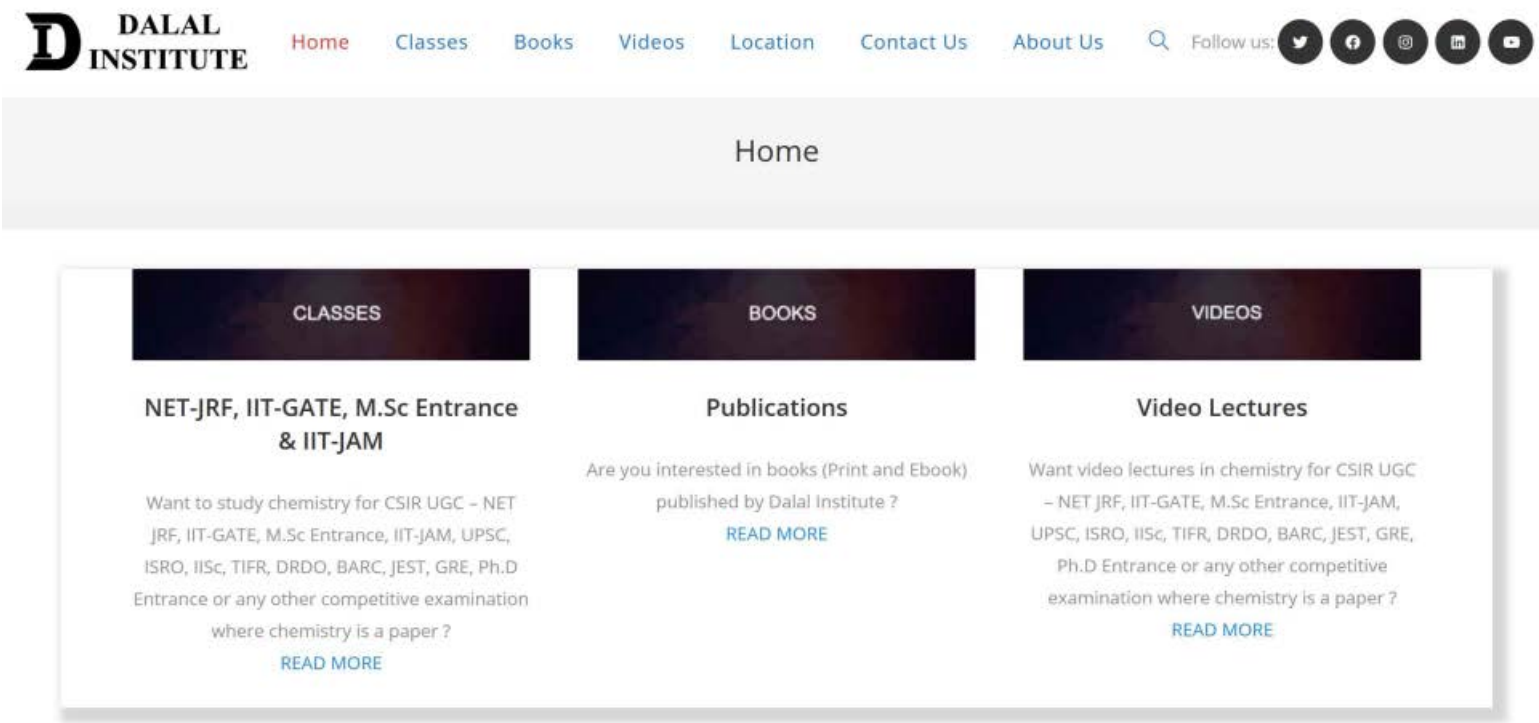


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Table of Contents

IIT-GATE: Model Test **5**

Chemistry 5

- Question Paper 5
- Answer Key 19
- Solution 20

IIT-GATE: 2011 ..... **24**

Chemistry 24

- Question Paper 24
- Answer Key 41
- Solution 42

IIT-GATE: 2012 ..... **46**

Chemistry 46

- Question Paper 46
- Answer Key 63
- Solution 64

IIT-GATE: 2013 ..... **68**

Chemistry 68

- Question Paper 68
- Answer Key 83
- Solution 84

IIT-GATE: 2014 ..... **90**

Chemistry 90

- Question Paper 90
- Answer Key 106
- Solution 107

IIT-GATE: 2015 ..... **111**

Chemistry 111

- Question Paper 111

- ❖ Answer Key 126
- ❖ Solution 127

IIT-GATE: 2016 131

Chemistry 131

- ❖ Question Paper 131
- ❖ Answer Key 150
- ❖ Solution 151

IIT-GATE: 2017 155

Chemistry 155

- ❖ Question Paper 155
- ❖ Answer Key 171
- ❖ Solution 172

IIT-GATE: 2018 175

Chemistry 175

- ❖ Question Paper 175
- ❖ Answer Key 191
- ❖ Solution 192

IIT-GATE: 2019 196

Chemistry 196

- ❖ Question Paper 196
- ❖ Answer Key 216
- ❖ Solution 217

IIT GATE: 2020 222

Chemistry 222

- ❖ Question Paper 222
- ❖ Answer Key 239
- ❖ Solution 240

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