

1) PART A

Question No. 1 / Question ID 701115

Marks: 2.00

The letters in the word JOKER represent the numbers 1, 2, 3, 4, 5 but not necessarily in that order. J is an odd number, O is neither 4 nor 5, K is 1, E is either 4 or 5, R is none of 2, 3, and 4. What is J?

1. 2
2. 3
3. 4
4. 5

Question No. 2 / Question ID 701114

Marks: 2.00

Among four playing cards, a Heart is to the immediate left of a Spade, a 9 is to the left of a J, a Diamond to the right of a Heart, a 7 is the left most card and a Club is the right most card. An 8 is to the left of a 9. Then the 9 is a

1. Spade
2. Heart
3. Diamond
4. Club

Question No. 3 / Question ID 701116

Marks: 2.00

From a starting point, A walks 5 km along a direction between north and east and B walks 4 km towards west. A then walks 4 km towards west in such a way that she reaches exactly north of her starting point. B turns to her right and walks 3 km. Now B is at

1. the same place as A is
2. 1 km south of A
3. 1 km southwest of A
4. 4 km west of A

Classes *A* and *B* have equal strengths and equal numbers of boys and girls. All students from *A* are vegetarian and some students from *B* are vegetarian. Which one of the following statements is definitely FALSE?

1. All boys are vegetarians
2. All girls are vegetarians
3. Majority of students are vegetarian
4. Majority of students are non-vegetarian

Question No. 5 / Question ID 701103

Marks: 2.00

Choose the option to fill in the blank that will make the following statement logically correct:

THE CORRECT COUNT OF THE NUMBER OF OCCURRENCES OF THE LETTER "E" IN THIS SENTENCE IS _____.

1. TWELVE
2. THIRTEEN
3. FOURTEEN
4. FIFTEEN

Question No. 6 / Question ID 701120

Marks: 2.00

Betty, Helen, Samantha and Valerie each plays exactly one unique game out of Basketball, Hockey, Soccer and Volleyball, but no one plays a game with same initial as her name. If Valerie plays Basketball and Helen does not play Soccer, then

1. Helen plays Basketball
2. Betty plays Soccer
3. Samantha plays Volleyball
4. Valerie plays Hockey

Question No. 7 / Question ID 701105

Marks: 2.00

Choose the correct chronological order of the following, for a student-
A: examination, B: result, C: preparation, D: joining a job.

1. C, A, B, D
2. A, D, B, C
3. C, B, A, D
4. D, C, B, A

Question No. 8 / Question ID 701113

Marks: 2.00

A person cycling with a uniform speed covers one-fifth of the distance at 04:52 pm and half at 05:40 pm. At what time will he reach the destination?

1. 06:00 pm
2. 06:40 pm
3. 06:48 pm
4. 07:00 pm

Question No. 9 / Question ID 701111

Marks: 2.00

The third smallest three-digit odd number using the digits 1 to 9 is

1. 105
2. 123
3. 113
4. 115

Question No. 10 / Question ID 701104

Marks: 2.00

In a three-party meet, parties A, B and C sent 5 representatives each. Everyone greeted everyone else, except none of party A greeted any of party C and vice versa. The number of greetings was

1. 50
2. 160
3. 210
4. 225

Question No. 11 / Question ID 701117

Marks: 2.00

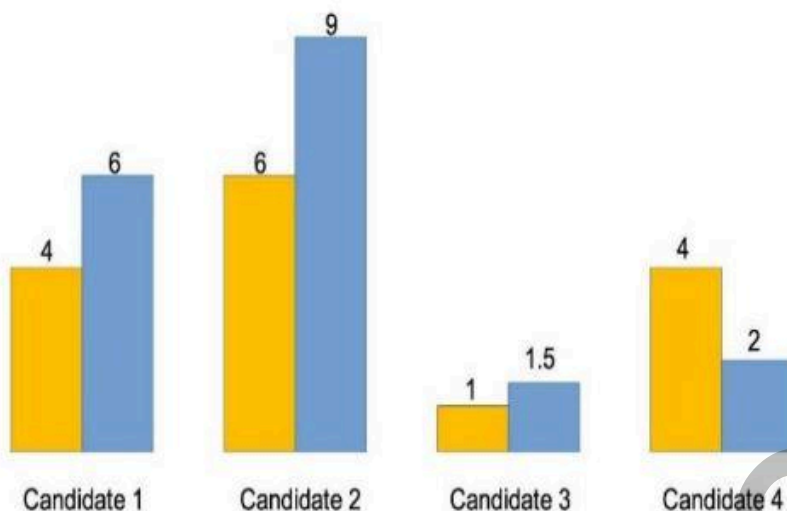
A certain number of apples are distributed without cutting in such a way that A gets one-fourth of the total and each of the remaining people gets an equal number. If A gets thrice each of the others, then which of the following could NOT be a possible number of apples?

1. 16
2. 12
3. 24
4. 36

Question No. 12 / Question ID 701112

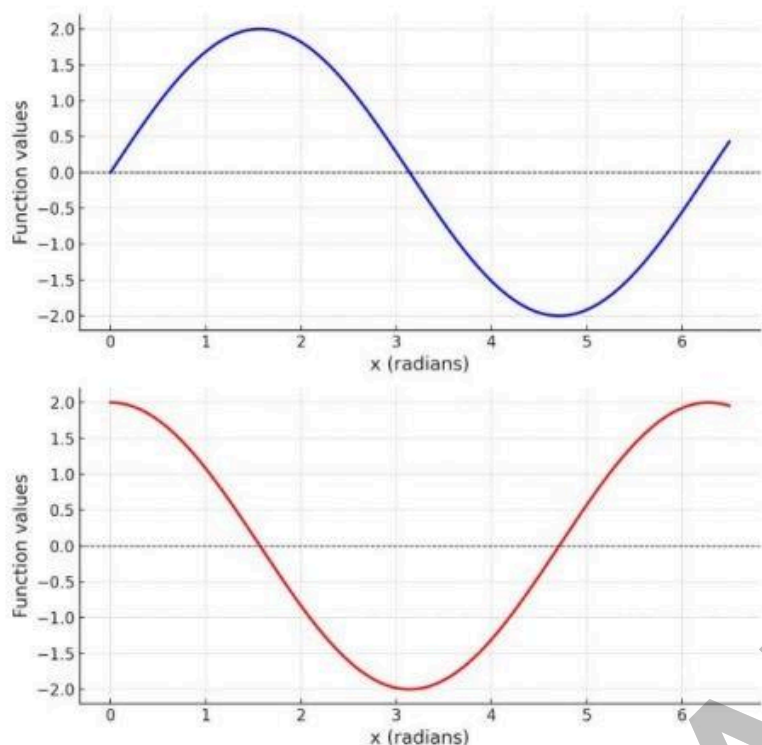
Marks: 2.00

The bar-diagram shows the change in net-asset (in million dollars) of four candidates as declared in their nomination forms during two successive general elections in a country. Which of the following inferences is definitely true?



1. Candidates 1 and 2 did equally well for their constituencies but spent different amounts as the percentage growth of their assets is the same.
2. Candidate 3 was the most enterprising as the percentage growth of his assets is the maximum.
3. The percentage decline in asset of candidate 4 is the same as the percentage increase in asset of candidate 3.
4. The constituency of candidate 4 is the largest.

What is represented by the given figures?

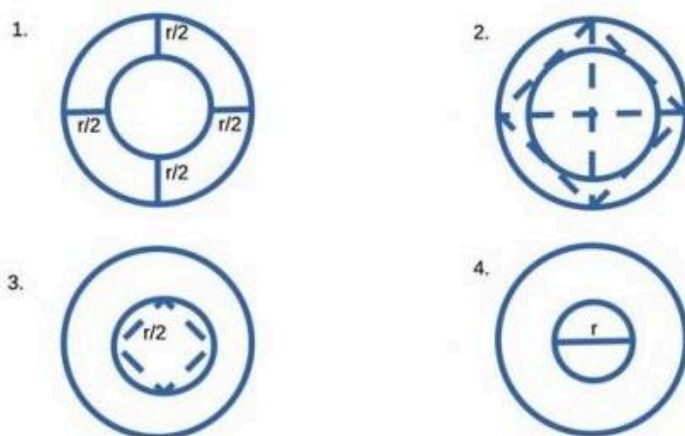


1. Upper panel represents $\sin^2 x$ while lower one is $\cos^2 x$
2. Lower panel represents the slope of the upper curve.
3. Upper panel represents $\sin 2x$ while lower one is $\cos 2x$
4. Multiplication of y (function values) in the two panels gives 2 for any value of x .

Question No. 14 / Question ID 701118

Marks: 2.00

From a circular pizza of radius r , a circular pizza of half its area is to be cut. Which one of the following diagrams helps to identify the smaller pizza (inner circle) correctly? The lines are guides to arrive at the correct circle.



Question No. 15 / Question ID 701109

Marks: 2.00

A square sheet of paper is folded along its diagonal to form an isosceles right triangle, and then hypotenuses are folded successively two times to form isosceles right triangles. If the length of each equal side is 10 cm after the third folding, what was the initial area of the sheet?

1. 100 cm^2
2. 200 cm^2
3. 400 cm^2
4. 800 cm^2

Question No. 16 / Question ID 701101

Marks: 2.00

At what uniform speed must Ramesh travel the remaining distance to reach Durgapur from Kolkata with an average speed of 70 km/h, given that he has already traveled halfway at a speed of 60 km/h?

1. 80 km/h
2. 84 km/h
3. 85 km/h
4. 90 km/h

Question No. 17 / Question ID 701119

Marks: 2.00

In a region, earthquakes are the only cause behind landslides, landslides are one of the causes behind accidents, and deaths are one of the possible results of accidents. If there was no earthquake in the region during a year, which of the following would **definitely** hold true for that year?

1. There were no accidents
2. There could have been accidents, but no deaths
3. There were no landslides
4. There could have been landslides, but no accidents

Question No. 18 / Question ID 701107

Marks: 2.00

The shortest distance on the surface between two opposite corners of a cube having side of 1 unit length is closest to _____ units.

1. 1.73
2. 1.41
3. 3.00
4. 2.24

Question No. 19 / Question ID 701110

Marks: 2.00

Within a steel frame of a window of 2 m width and 3 m height, steel rods are to be fixed parallel to its height at a uniform interval of 10 cm. What is the minimum total length of steel rod required?

1. 38 m
2. 40 m
3. 57 m
4. 60 m

Question No. 20 / Question ID 701106

How many 4-digit numbers can be generated from the digits 1, 2, 3, 4, 5 such that no digit appears more than once, in which 1 is always somewhere to the left of 2 which is always somewhere to the left of 3?

1. 8
2. 4
3. 6
4. 12

2) PART B

Question No. 1 / Question ID 701131

Marks: 2.00

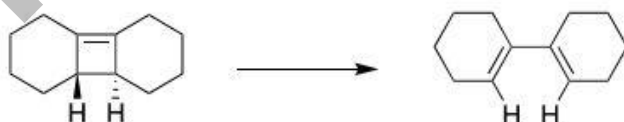
For a given metal ion, the correct order of the nephelauxetic effect of ligands is (en = ethylene diamine)

1. $\text{CN}^- > \text{en} > \text{NH}_3 > \text{I}^-$
2. $\text{I}^- > \text{CN}^- > \text{NH}_3 > \text{en}$
3. $\text{CN}^- > \text{I}^- > \text{en} > \text{NH}_3$
4. $\text{I}^- > \text{CN}^- > \text{en} > \text{NH}_3$

Question No. 2 / Question ID 701136

Marks: 2.00

The following reaction occurs under



1. photochemical conditions via a disrotatory ring-opening
2. photochemical conditions via a conrotatory ring-opening
3. thermal conditions via a disrotatory ring-opening
4. thermal conditions via a conrotatory ring-opening

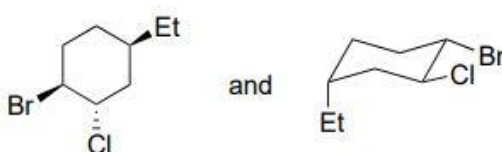
Product of two reflection operations $\sigma_v \sigma'_v$ is equivalent to

1. i
2. C_n
3. σ_h
4. σ_d

The steps involved in the reaction of acetaldehyde with formaldehyde in the presence of NaOH to produce pentaerythritol $[C(CH_2OH)_4]$ are

1. Claisen condensation followed by Knoevenagel condensation
2. Cannizzaro reaction followed by Claisen condensation
3. Knoevenagel condensation followed by aldol reactions
4. aldol reactions followed by Cannizzaro reaction

The following structures are



1. identical
2. enantiomers
3. diastereomers
4. constitutional isomers

Question No. 6 / Question ID 701124

Marks: 2.00

The solvent that shifts the Schlenk equilibrium to the right side is



(R = isopropyl)

1. hexane
2. tetrahydrofuran
3. dioxane
4. diethyl ether

- ☐ 1
☐ 2
☐ 3
☐ 4

Question No. 7 / Question ID 701127

Marks: 2.00

The standard reduction potentials of lanthanides (Ln^{3+}/Ln) are

1. similar to each other and also similar to those of late transition metals
2. different from each other but similar to lighter *p*-block elements
3. similar to each other and also similar to those of *s*-block elements
4. different from each other but similar to those of *s*-block elements

Question No. 8 / Question ID 701125

Marks: 2.00

The order of polarity of the B—C bond for the following compounds is

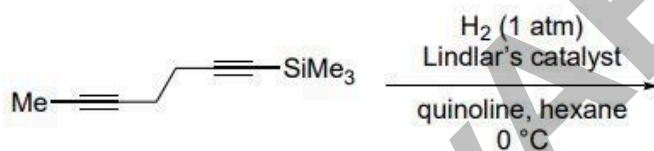
$\text{B}(\text{C}\equiv\text{CH})_3$ (**P**); $\text{B}(\text{CH}=\text{CH}_2)_3$ (**Q**); $\text{B}(\text{CH}_2-\text{CH}_3)_3$ (**R**); $\text{B}(\text{CH}_2-\text{C}_6\text{H}_5)_3$ (**S**)

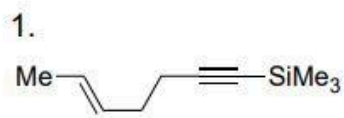
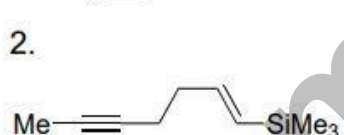
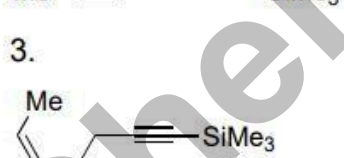
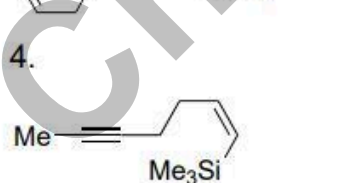
1. **R < S < Q < P**
2. **S < R < Q < P**
3. **R < S < P < Q**
4. **P < Q < R < S**

At $T = 0\text{ K}$, the entropy (in J K^{-1}) of 2 moles of CO is closest to

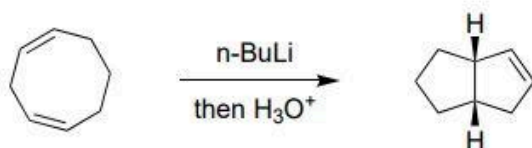
- 0
- 5.76
- 11.53
- 23.05

The major product formed in the following reaction is

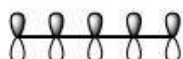


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- 
- 
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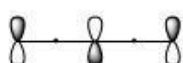
The HOMO of the intermediate involved in the following reaction is



1.



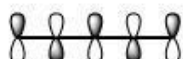
2.



3.



4.



Question No. 12 / Question ID 701159

Marks: 2.00

Correct statement about polymerization is

1. The average molar mass of the polymer product does not depend upon the time length of stepwise polymerization
2. The slower the initiation of the chain, the higher the average molar mass of the polymer in chain polymerization
3. In chain polymerization, an activated monomer attacks a minimum of three other monomers to link
4. The average chain length of a polymer in stepwise polymerization is linearly dependent on the fraction of the reacted monomers

Question No. 13 / Question ID 701121

Marks: 2.00

In the absence of nitrogen, the enzyme nitrogenase functions as

1. nitrile hydratase
2. carboxypeptidase
3. urease
4. hydrogenase

Question No. 14 / Question ID 701152

Marks: 2.00

The rotational quantum number associated with the most intense transition in the microwave spectrum of a diatomic molecule varies with temperature (T) as

1. T
2. \sqrt{T}
3. T^2
4. $1/\sqrt{T}$

Question No. 15 / Question ID 701132

Marks: 2.00

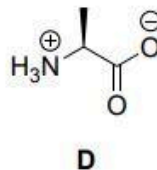
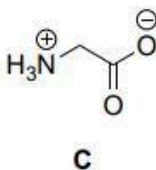
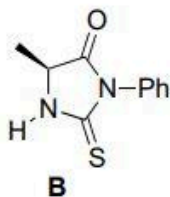
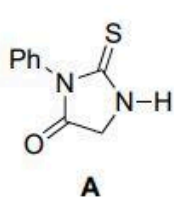
Nanoparticles have length scales

1. between 0.1 to 1000 nm in any dimension
2. in any nanometer scale and always in one particular dimension
3. between 1 to 500 nm and always in one particular dimension
4. between 1 to 100 nm in any dimension

Question No. 16 / Question ID 701141

Marks: 2.00

The reaction of dipeptide, $\text{H}_2\text{N-Gly-Ala-CO}_2\text{H}$, with PhNCS at pH 8 followed by treatment with $\text{CF}_3\text{CO}_2\text{H}$ produces



1. **A and D**
2. **B and C**
3. **A and B**
4. **C and D**

Question No. 17 / Question ID 701123

Marks: 2.00

The enzyme nitrogenase converts one mole of N_2 to x mole of NH_3 and y mole of H_2 using z mole of protons and w mole of electrons. The values of x , y , z , and w , respectively, are

1. 2, 0, 6, and 6
2. 1, 0, 6, and 6
3. 1, 2, 8, and 8
4. 2, 1, 8, and 8

Question No. 18 / Question ID 701150

Marks: 2.00

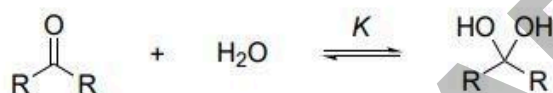
The lowest energy π -MO of butadiene has an energy of
 [β is resonance energy]

1. -1.61804β
2. -0.61804β
3. 0.61804β
4. 1.61804β

Question No. 19 / Question ID 701146

Marks: 2.00

For the following equilibrium, the correct match for the carbonyl compounds in **Column P** with the equilibrium constant K in **Column Q** is



	Column P		Column Q
A.	CH_3CHO	i.	1.2×10^6
B.	Cl_3CCHO	ii.	1.06
C.	$\text{CF}_3\text{C(O)CF}_3$	iii.	2000

1. A – iii; B – ii; C – i
2. A – ii; B – iii; C – i
3. A – ii; B – i; C – iii
4. A – i; B – iii; C – ii

Question No. 20 / Question ID 701140

Marks: 2.00

The correct order for the relative rate of addition of $\text{CCl}_3\cdot$ to 2-methylpropene (**A**), styrene (**B**) and 2-methylbut-2-ene (**C**) is

1. **A > B > C**
2. **B > A > C**
3. **B > C > A**
4. **C > B > A**

Question No. 21 / Question ID 701157

Marks: 2.00

Consider the statements

- a. Decomposition of H_2O_2 in aqueous solution catalyzed by bromide ion is a homogeneous catalytic reaction.
- b. Hydrogenation of ethene to ethane accelerated by Pd or Ni particles is a heterogeneous catalytic reaction.
- c. Enzymes increase the equilibrium constants of the reactions.
- d. Turnover number is the number of catalytic cycles till the catalyst becomes inactive.

The set of correct statements is

1. a, b and c only
2. b, c and d only
3. a, b, and d only
4. c, d and a only

Question No. 22 / Question ID 701149

Marks: 2.00

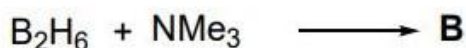
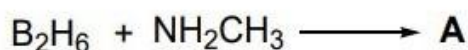
The number of D and P terms that arise from p^3 electronic configuration of an atom, respectively, are

1. 3 and 2
2. 2 and 3
3. 2 and 2
4. 1 and 1

Question No. 23 / Question ID 701122

Marks: 2.00

In the following reaction, **A** and **B**, respectively, are



1. $\text{H}_3\text{BNH}_2\text{CH}_3$ and H_3BNMe_3
2. $[\text{BH}_2(\text{NH}_2\text{CH}_3)_2]^+[\text{BH}_4]^-$ and H_3BNMe_3
3. $\text{H}_3\text{BNH}_2\text{CH}_3$ and $[\text{BH}_2(\text{NMe}_3)_2]^+[\text{BH}_4]^-$
4. $[\text{BH}_2(\text{NH}_2\text{CH}_3)_2]^+[\text{BH}_4]^-$ and $[\text{BH}_2(\text{NMe}_3)_2]^+[\text{BH}_4]^-$

Question No. 24 / Question ID 701133

Marks: 2.00

The correct statement is
(en = ethylene diamine)

1. $\text{K}_3[\text{CuF}_6]$ is paramagnetic and sodium nitroprusside is diamagnetic
2. Both $\text{K}[\text{AgF}_4]$ and $\text{K}_3[\text{CuF}_6]$ are diamagnetic
3. Both $[\text{Co}(\text{en})_3]\text{Cl}_3$ and $\text{K}_3[\text{CuF}_6]$ are paramagnetic
4. Sodium nitroprusside is paramagnetic and $[\text{Co}(\text{en})_3]\text{Cl}_3$ is diamagnetic

Question No. 25 / Question ID 701129

The order of acceptor strength towards Me_2S donor is

1. $\text{AlCl}_3 > \text{BCl}_3 > \text{GaCl}_3$
2. $\text{BCl}_3 > \text{GaCl}_3 > \text{AlCl}_3$
3. $\text{GaCl}_3 > \text{AlCl}_3 > \text{BCl}_3$
4. $\text{AlCl}_3 > \text{GaCl}_3 > \text{BCl}_3$

Question No. 26 / Question ID 701128

Marks: 2.00

The option showing the correct structural types for ZnFe_2O_4 and KMnF_3 , respectively, is

1. Perovskite and Fluorite
2. Perovskite and Antifluorite
3. Spinel and Perovskite
4. Spinel and Fluorite

Question No. 27 / Question ID 701158

Marks: 2.00

The radii of the cation and anion of an ionic compound are 74 pm and 170 pm, respectively. The coordination number of the cation and the best possible geometry of the compound are, respectively

1. 4, tetrahedral
2. 6, octahedral
3. 8, cubic
4. 4, square planar

Question No. 28 / Question ID 701130

Marks: 2.00

Quantum confinement leads to

1. increase in the band gap of the semiconductors
2. decrease in the band gap of the metal nanoparticles
3. decrease in the band gap of the semiconductors
4. no change in the band gap of the quantum dots

Question No. 29 / Question ID 701154

Marks: 2.00

A two-level system consists of a double degenerate excited state which is ϵ energy above the ground state. The y-intercept of the $\ln(P_e/P_g)$ vs. $1/T$ plot is (P_e and P_g are the probabilities associated with the excited and ground states, respectively.)

1. 0
2. 2
3. $2 \ln 2$
4. $\ln 2$

Question No. 30 / Question ID 701147

Marks: 2.00

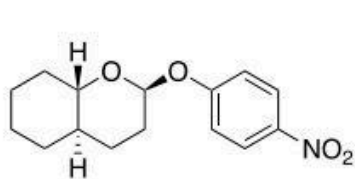
For an electron in a hydrogen atom, with azimuthal quantum number, $l = 1$ and magnetic quantum number, $m = 1$, the angle (in degrees) between the z -axis and the orbital angular momentum vector is

1. 0
2. 45
3. 54.7
4. 90

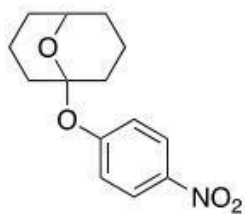
Question No. 31 / Question ID 701139

Marks: 2.00

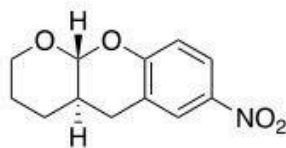
The correct order for the rate of acidic hydrolysis of the following cyclic acetals is



I



II



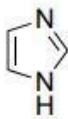
III

1. III > II > I
2. I > III > II
3. I > II > III
4. II > I > III

Question No. 32 / Question ID 701134

Marks: 2.00

The correct option for the pK_a of following pairs of compounds is



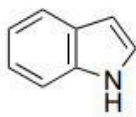
I



II



III



IV

1. I > II and III > IV
2. I > II and IV > III
3. II > I and III > IV
4. II > I and IV > III

Question No. 33 / Question ID 701155

Marks: 2.00

The ionic strength (in mol kg^{-1}) of an aqueous solution of 0.03 mol kg^{-1} $\text{K}_3[\text{Fe}(\text{CN})_6]$ is closest to

1. 0.27
2. 0.18
3. 0.12
4. 0.15

Question No. 34 / Question ID 701156

Marks: 2.00

The half-lives for the forward and reverse reactions that are first order in both directions, are 24 ms and 39 ms, respectively. The relaxation time for return to equilibrium after a temperature jump is closest to

1. 21 ms
2. 32 ms
3. 43 ms
4. 11 ms

Question No. 35 / Question ID 701145

Marks: 2.00

The correct order for the X-H bond dissociation energies (BDE) in the following compounds is

1. $\text{Me}_3\text{Si-H} > \text{Me}_3\text{C-H} > \text{Me}_3\text{Sn-H}$
2. $\text{Me}_3\text{C-H} > \text{Me}_3\text{Si-H} > \text{Me}_3\text{Sn-H}$
3. $\text{Me}_3\text{C-H} > \text{Me}_3\text{Sn-H} > \text{Me}_3\text{Si-H}$
4. $\text{Me}_3\text{Sn-H} > \text{Me}_3\text{C-H} > \text{Me}_3\text{Si-H}$

- ☐ 1
- ☒ 2 (Chosen Option)
- ☐ 3
- ☐ 4

Question No. 36 / Question ID 701135

Marks: 2.00

For the reaction of RBr with EtONa/EtOH, the correct match for the R groups in **Column P** with the relative rates in **Column Q** is
(for R = CH₃CH₂, relative rate = 1)

	Column P		Column Q
A.	CH ₃	i.	4.2×10^{-6}
B.	CH ₃ CH ₂ CH ₂	ii.	0.03
C.	(CH ₃) ₂ CHCH ₂	iii.	0.28
D.	(CH ₃) ₃ CCH ₂	iv.	17

1. A – iv; B – iii; C – ii; D – i
2. A – iv; B – i; C – iii; D – ii
3. A – iii; B – ii; C – iv; D – i
4. A – ii; B – iii; C – i; D – iv

Question No. 37 / Question ID 701148

Marks: 2.00

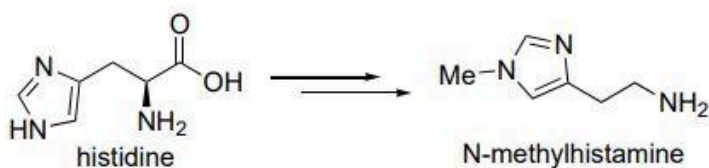
In a 3-dimensional isotropic harmonic oscillator, the degeneracy of the state with energy equal to $(9/2) \hbar \omega$ is [ω is the angular frequency]

1. 3
2. 9
3. 6
4. 10

Question No. 38 / Question ID 701160

Marks: 2.00

The co-enzymes involved in the following biosynthesis are



- A. Pyridoxal phosphate (PLP)
- B. S-Adenosylmethionine (SAM)
- C. Pyridoxamine phosphate (PMP)
- D. Adenosine triphosphate (ATP)

1. **A and B**
2. **B and C**
3. **A and D**
4. **C and D**

Question No. 39 / Question ID 701143

Marks: 2.00

In the ^1H NMR, the methylene protons of $\text{ClCH}_2\text{—C}(\text{Cl})(\text{Br})\text{CH}_3$ (**X**) and $\text{CH}_3\text{CH}_2\text{—C}(\text{Cl}_2)\text{CH}_3$ (**Y**) appear as

1. **X = Y = AB quartet**
2. **X = Y = quartet**
3. **X = AB quartet; Y = quartet**
4. **X = quartet; Y = AB quartet**

Question No. 40 / Question ID 701126

Marks: 2.00

Consider the statements for the complexes $[\text{RhCl}_3(\text{H}_2\text{O})_3]$ (**X**) and $[\text{Ir}(\text{CO})(\text{Cl})(\text{PPh}_3)_2]$ (**Y**)

- A. **X** has two isomers
- B. **Y** has two isomers
- C. Both **X** and **Y** are prone to oxidative addition
- D. d_{z^2} orbital is most destabilized in **Y**

The correct option is

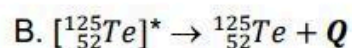
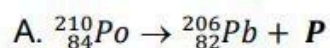
- 1. A, B and C only
- 2. B, C and D only
- 3. A and B only
- 4. A and C only

3) PART C

Question No. 1 / Question ID 701179

Marks: 4.00

Consider the following reactions



The correct option for **P**, **Q**, **R** and **S** is

- | | | | |
|----------------------------------|--------------------------|-------------------------------|------------------------------|
| 1. $\text{P} = {}^4_2\text{He},$ | $\text{Q} = \gamma,$ | $\text{R} = {}^0_{-1}e,$ | $\text{S} = {}^0_1e$ |
| 2. $\text{P} = {}^0_1e,$ | $\text{Q} = {}^0_{-1}e,$ | $\text{R} = \gamma,$ | $\text{S} = {}^4_2\text{He}$ |
| 3. $\text{P} = {}^0_{-1}e,$ | $\text{Q} = {}^0_1e,$ | $\text{R} = {}^4_2\text{He},$ | $\text{S} = \gamma$ |
| 4. $\text{P} = {}^4_2\text{He}$ | $\text{Q} = \gamma,$ | $\text{R} = {}^0_1e$ | $\text{S} = {}^0_{-1}e$ |

Question No. 2 / Question ID 701215

Marks: 4.00

In a diffusion-controlled reaction in benzene between two species with similar radii having 2.0 mol m^{-3} initial concentrations, the time (in ns) required for the concentration of the species to fall to half of their initial values at 320 K is closest to

[The viscosity coefficient of benzene is 0.601 cP and $1 \text{ cP} = 10^{-3} \text{ kg m}^{-1} \text{ s}^{-1}$]

1. 26
2. 76
3. 42
4. 62

Question No. 3 / Question ID 701167

Marks: 4.00

List I and **List II** give the molecular formula and the geometry of the species, respectively.

	List I		List II
a	$[\text{Zn}\{\text{N}(\text{CH}_2\text{CH}_2\text{NH}_2)_3\}\text{Cl}]^+$	i	Trigonal bipyramidal
b	$[\text{Cu}(2,2\text{-bpy})\{\text{NH}(\text{CH}_2\text{COO})_2\}]$	ii	Square pyramidal
c	$[\text{ZrF}_7]^{3-}$	iii	Monocapped trigonal prism
d	$[\text{AgTe}_7]^{3-}$	iv	Trigonal planar

The option showing the correct match of species in **List I** and metal geometry in **List II** is

1. a-i, b-ii, c-iii, d-iv
2. a-i, b-ii, c-iv, d-iii
3. a-i, b-iii, c-ii, d-iv
4. a-ii, b-i, c-iii, d-iv

Question No. 4 / Question ID 701177

Marks: 4.00

A mixture of CaO and CaCO_3 is analyzed using thermogravimetry (TG) technique. The TG curve of the sample indicates that there is a mass change from 155.2 mg to 125.3 mg. The percentage of CaCO_3 in the mixture is close to

1. 54.2%
2. 27.1%
3. 43.8%
4. 29.9%

Question No. 5 / Question ID 701184

Marks: 4.00

The correct sequence of reagents to effect the following transformation is



1. i. heat; ii. n-BuLi; iii. n-BuBr; iv. HgCl_2 , H_2O
2. i. n-BuLi; ii. n-BuBr; iii. heat; iv. HgCl_2 , H_2O
3. i. heat; ii. HgCl_2 , H_2O ; iii. n-BuLi; iv. n-BuBr
4. i. n-BuLi; ii. n-BuBr; iii. HgCl_2 , H_2O ; iv. Heat

Question No. 6 / Question ID 701212

Marks: 4.00

At 0°C , the standard volume of transition from ice to water is $-1.6\text{ cm}^3\text{ mol}^{-1}$ and the corresponding standard entropy of transition is $22\text{ J K}^{-1}\text{ mol}^{-1}$. An increase in pressure by 100 bar would result in lowering of freezing point (in K) of water by (1 bar = 10^5 Pa)

1. 1.23
2. 0.56
3. 0.73
4. 1.46

C_{2v}	E	C_2	σ_v	σ'_v		
A_1	1	1	1	1	z	x^2, y^2, z^2
A_2	1	1	-1	-1	R_z	xy
B_1	1	-1	1	-1	x, R_y	yz
B_2	1	-1	-1	1	y, R_x	zx

For formaldehyde (character table is shown above), the allowed electronic transition by x -polarized light is

1. $^1A_1 \rightarrow ^1A_1$
2. $^1A_1 \rightarrow ^1A_2$
3. $^1A_1 \rightarrow ^1B_1$
4. $^1A_1 \rightarrow ^1B_2$

The correct reagent to effect the following transformation is



1. 6N HCl
2. 1N NaOH
3. Morpholine, $\text{Pd}(\text{PPh}_3)_4$
4. $\text{CF}_3\text{CO}_2\text{H}$

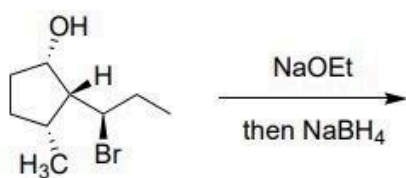
For a quantum particle in a one-dimensional simple harmonic oscillator, $\langle x^2 \rangle = \hbar(n + 1/2)/m\omega$ and $\langle p_x^2 \rangle = m\hbar\omega(n + 1/2)$ for the quantum number n . The product of uncertainty of position and momentum for $n = 1$ is

1. $3\hbar/2$
2. $\hbar/2$
3. $2\hbar$
4. \hbar

Question No. 10 / Question ID 701182

Marks: 4.00

The major product formed in the following reaction is



1. CCC/C=C\CCO
2. CCC/C=C\CCO
3. CCC/C=C\CC(O)C
4. CCC/C=C\CCO

Question No. 11 / Question ID 701207

Marks: 4.00

The atomic mass of X and Y are 5 amu and 40 amu, respectively. For the diatomic molecule XY, the spacing between any two successive lines is 8 cm^{-1} in the microwave spectrum. The bond length of XY (in Å) is closest to

$$\left(\frac{h}{8\pi^2c} = 2.8 \times 10^{-44} \text{ Js}^2\text{m}^{-1}, 1 \text{ amu} = 1.667 \times 10^{-27} \text{ kg}\right)$$

1. 0.688
2. 0.974
3. 1.377
4. 1.948

Question No. 12 / Question ID 701211

Marks: 4.00

One mole of a monoatomic ideal gas at 1 atm pressure undergoes compression from 49.2 L to 24.6 L under adiabatic reversible conditions. The final temperature (in K) of the gas is closest to

1. 952
2. 848
3. 756
4. 1697

Question No. 13 / Question ID 701178

Marks: 4.00

Consider the following statements regarding the magnetic properties of lanthanide ions.

- A. Observed magnetic moments are highly dependent on the ligand field
- B. Only ground J state is populated
- C. Spin-orbit couplings are in the order of $\sim 1000 \text{ cm}^{-1}$ while the ligand field effects are only about $\sim 100 \text{ cm}^{-1}$
- D. The spin-only formula cannot be used to calculate the magnetic moment of f^7 configuration

The option showing the correct statements is

- 1. **A and B** only
- 2. **B and C** only
- 3. **A and D** only
- 4. **C and D** only

Question No. 14 / Question ID 701164

Marks: 4.00

Consider the reactions in **List I** and related enzymes in **List II**

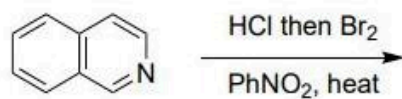
List I		List II	
a	superoxide to oxygen	i	amine oxidase
b	hydrolysis of peptide	ii	Ni-superoxide dismutase
c	hydroxylation of camphor	iii	carboxypeptidase
d	primary amine to aldehyde	iv	cytochrome P450

The option showing the correct match is

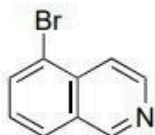
- 1. a-ii, b-iii, c-iv, d-i
- 2. a-iv, b-i, c-ii, d-iii
- 3. a-iii, b-ii, c-i, d-iv
- 4. a-ii, b-i, c-iv, d-iii

Question No. 15 / Question ID 701185

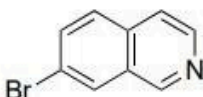
The major product formed in the following reaction is



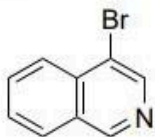
1.



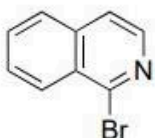
2.



3.



4.



Question No. 16 / Question ID 701219

Marks: 4.00

Mark-Houwink equation can be used to determine molecular weight of a polymer.

The values of empirical constants are $1.6 \times 10^{-4} \text{ dL g}^{-1}$ and 0.60. If the intrinsic viscosity of the polymer solution is 0.04 dL g^{-1} , the molar mass (in g mol^{-1}) of the polymer is closest to

1. 10000

2. 1101

3. 16000

4. 9600

Question No. 17 / Question ID 701203

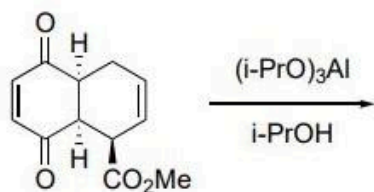
A particle, confined in a one-dimensional box between $x=0$ to $x=L$, is perturbed by a constant potential V on the left half of the box ($x=0$ to $x=L/2$) and by $V/3$ on the right half ($x=L/2$ to $x=L$). The first-order perturbation correction to the ground state energy is

1. $V/2$
2. $2V/3$
3. $3V/4$
4. $3V/2$

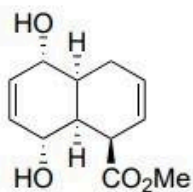
Question No. 18 / Question ID 701200

Marks: 4.00

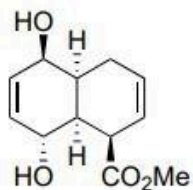
The major product formed in the following reaction is



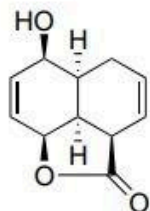
1.



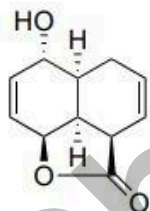
2.



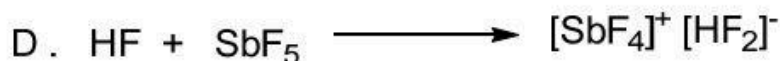
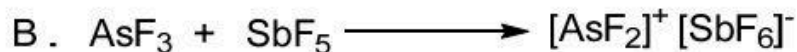
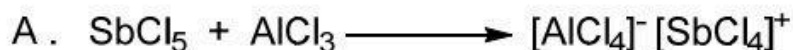
3.



4.



Consider the following reactions



The correct option is

1. **A** and **B** only
2. **B** and **C** only
3. **C** and **D** only
4. **A** and **D** only

Question No. 20 / Question ID 701166

Marks: 4.00

To an aqueous solution of NaX and NaY , the addition of sulphamic acid ($\text{H}_2\text{NSO}_3\text{H}$) followed by acidification releases a nitrogen-containing gas **P**. Addition of KI and a starch solution does not yield a blue color, indicating complete removal of NaX . However, the blue color appears when a piece of granulated Zn is added. The reaction proceeds with the evolution of a nitrogen containing gas **Q**.

The correct option of **X**, **Y**, **P** and **Q**, respectively, is

1. $[\text{NO}_2]^-$, $[\text{NO}_3]^-$, N_2 , NO
2. $[\text{NO}_3]^-$, $[\text{NO}_2]^-$, N_2 , NO
3. $[\text{NO}_3]^-$, $[\text{NO}_2]^-$, NO , N_2
4. $[\text{NO}_2]^-$, $[\text{NO}_3]^-$, NO , N_2

- ☐ 1
☐ 2
☐ 3
☐ 4

Question No. 21 / Question ID 701204

Marks: 4.00

The total number electronic transitions between triplet D and triplet F multiplets due to spin-orbit coupling is

1. 6
2. 5
3. 3
4. 1

Question No. 22 / Question ID 701201

Marks: 4.00

The expression for d -orbitals with $n = 3$, $l = 2$ and $m = \pm 2$ is

$$\psi_{32\pm 2} = NR'(r) r^2 \sin^2 \theta e^{\pm 2i\phi}$$

where N is a constant. r, θ, ϕ are spherical polar co-ordinates. $R'(r)$ is a function of r .

The orbital generated from a linear combination of ψ_{322} and ψ_{32-2} orbitals,

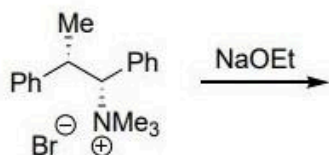
$\frac{1}{i}(\psi_{322} - \psi_{32-2})$, is

1. d_{z^2}
2. d_{xy}
3. d_{yz}
4. d_{zx}

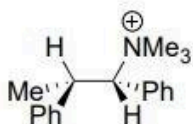
Question No. 23 / Question ID 701181

Marks: 4.00

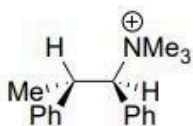
The conformation of the reactant that gives (*E*)-1,2-diphenyl-1-propene in the following reaction is



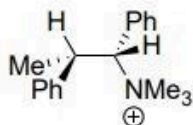
1.



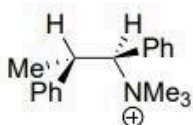
2.



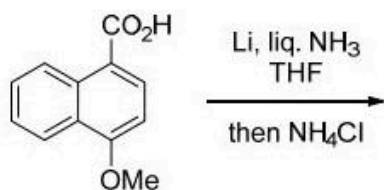
3.



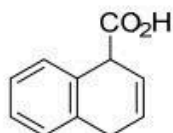
4.



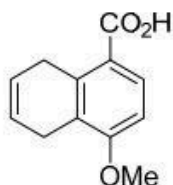
The major product formed in the following reaction is



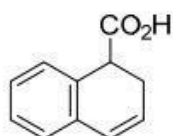
1.



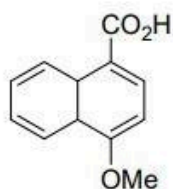
2.



3.



4.



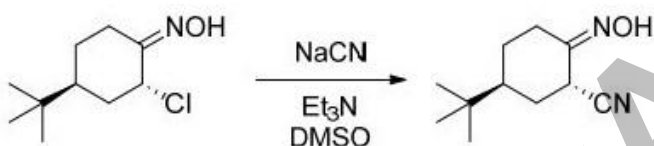
The average time for which a hydrogen atom remains adsorbed on a given surface is 35% shorter at 1000 K than at 600 K. The activation energy (in kJ mol^{-1}) for desorption is closest to

1. 2.3
2. 3.4
3. 4.5
4. 5.4

Question No. 26 / Question ID 701199

Marks: 4.00

For the following transformation, the product is formed through



1. an $\text{S}_{\text{N}}2$ reaction
2. an $\text{S}_{\text{N}}1$ reaction
3. a 1,2-elimination followed by a 1,4-addition reaction
4. a 1,4-elimination followed by a 1,4-addition reaction

Question No. 27 / Question ID 701209

Marks: 4.00

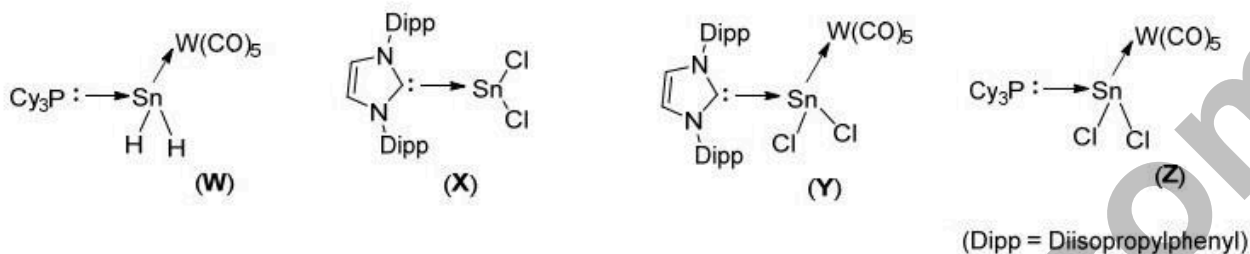
A correct statement, which always holds good, involving the zeroth-order (E_0^0), first-order (E_0^1) and second-order (E_0^2) perturbed energies for the ground state is [E_0 is the exact ground state energy]

1. $E_0^0 + E_0^1 + E_0^2 > E_0$
2. $E_0^0 + E_0^1 > 0$
3. $E_0^0 + E_0^1 \geq E_0$
4. $E_0^2 > 0$

Question No. 28 / Question ID 701162

Marks: 4.00

The correct option of the Isomer Shifts in ^{119}Sn Mossbauer Spectra for the following compounds is



1. $Z > Y$
2. $W > Y$
3. $Y > X$
4. $W > X$

Question No. 29 / Question ID 701176

Marks: 4.00

Match the given metal species in **List I** with the corresponding properties in **List II**

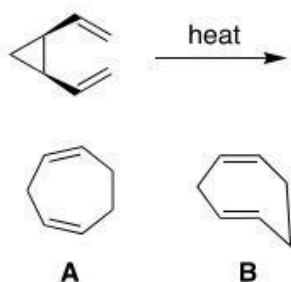
List I		List II	
a	$[\text{Co}(\text{H}_2\text{O})_6]^{2+}$	i	magnetic moment higher than spin-only value and weak JT distortion
b	$[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$	ii	spin-only magnetic moment and absence of JT distortion
c	$\text{NiCl}_2(\text{PPh}_3)_2$	iii	paramagnetic and tetrahedral
d	$\text{Pd}(\text{PPh}_3)_4$	iv	diamagnetic and tetrahedral

The correct option is

1. a – ii, b – iii, c – i, d – iv
2. a – i, b – ii, c – iii, d – iv
3. a – iii, b – ii, c – iv, d – i
4. a – i, b – iv, c – ii, d – iii

Question No. 30 / Question ID 701186

The correct statement about the following reaction is

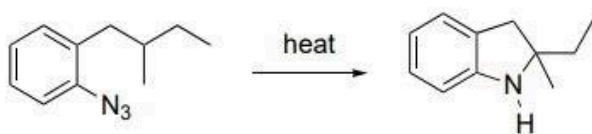


1. **A** is formed as major product via a chair-like transition state
2. **B** is formed as major product via a chair-like transition state
3. **A** is formed as major product via a boat-like transition state
4. **B** is formed as major product via a boat-like transition state

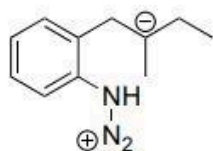
Question No. 31 / Question ID 701194

Marks: 4.00

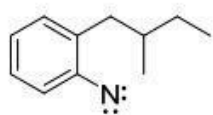
The intermediate involved in the following transformation is



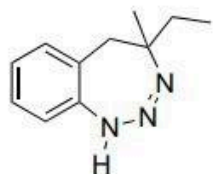
1.



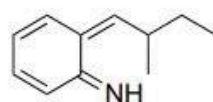
2.



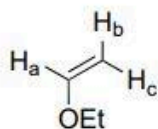
3.



4.



The correct match of the labelled protons for ethyl vinyl ether in **Column P** with their chemical shift in **Column Q** is



	Column P		Column Q
A.	H _a	i.	6.45 (dd, $J = 13, 7$ Hz)
B.	H _b	ii.	4.05 (dd, $J = 7, 2$ Hz)
C.	H _c	iii.	4.20 (dd, $J = 13, 2$ Hz)

1. A – i; B – iii; C – ii
2. A – i; B – ii; C – iii
3. A – iii; B – i; C – ii
4. A – ii; B – i; C – iii

Question No. 33 / Question ID 701217

Marks: 4.00

Colloidal solutions are stabilized by

1. van der Waals' forces
2. small particle size
3. shape of particles
4. electrical double layer at the surface of the particles

Question No. 34 / Question ID 701175

Marks: 4.00

Match the correct set of IR bands to the given compounds (Cp = C₅H₅, Cp* = C₅Me₅)

a) Cp ₂ Ti(CO) ₂	i) 1979 and 1897 cm ⁻¹
b) CpCp*Ti(CO) ₂	ii) 1956 and 1875 cm ⁻¹
c) Cp* ₂ Ti(CO) ₂	iii) 1930 and 1850 cm ⁻¹

- a-ii, b-iii, c-i
- a-iii, b-i, c-ii
- a-i, b-iii, c-ii
- a-i, b-ii, c-iii

Question No. 35 / Question ID 701163

Marks: 4.00

Consider the moieties in the enzymes that engage in hydrogen bonding with the substrates.

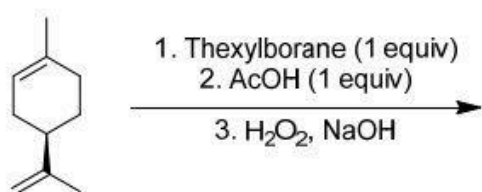
Enzymes → Moieties ↓	Haemoglobin	Nickel-superoxide dismutase	[FeFe] hydrogenase	Hemerythrin
A	tyrosine	μ-hydroxo	histidine	aza(dithiolato)
B	histidine	μ-hydroxo	aza(dithiolato)	tyrosine
C	histidine	tyrosine	aza(dithiolato)	μ-hydroxo
D	μ-hydroxo	aza(dithiolato)	histidine	tyrosine

The correct option is

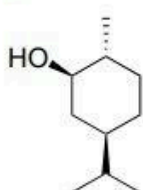
- A
- B
- C
- D

Question No. 36 / Question ID 701183

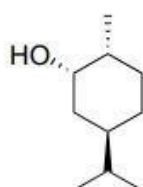
The major product formed in the following reaction sequence is



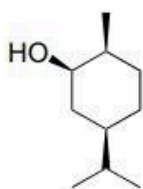
1.



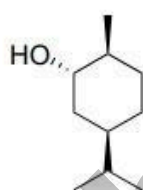
2.



3.



4.



Question No. 37 / Question ID 701173

Marks: 4.00

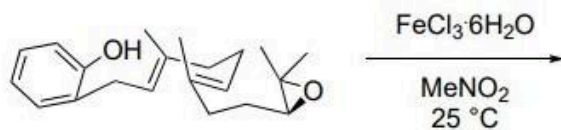
Consider the following statements regarding the electronic spectra of lanthanide complexes.

- A. They exhibit fewer absorption bands due to a small number of microstates
- B. Their spectra are dependent on coordination number and geometry
- C. Molar extinction coefficients (ϵ) are smaller compared to transition metal complexes
- D. Their absorption bands are sharp due to weak vibronic coupling
- E. Ligand field effects are negligible

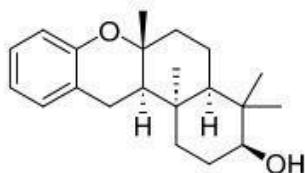
The option with correct statements is

- 1. A, B, D only
- 2. A, C, D only
- 3. C, D, E only
- 4. B, C, E only

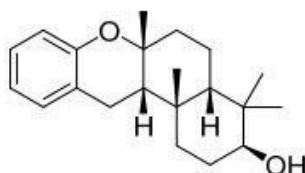
The major product formed in the following reaction is



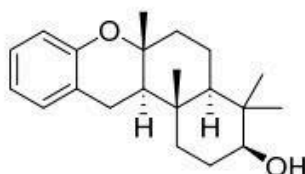
1.



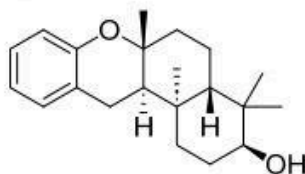
2.



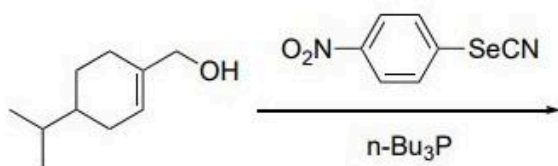
3.



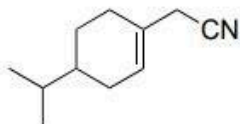
4.



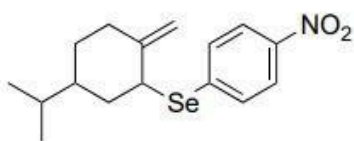
The major product formed in the following reaction is



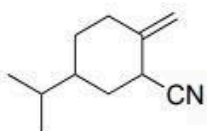
1.



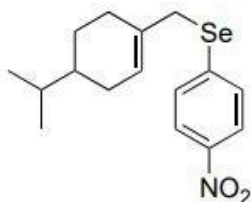
2.



3.



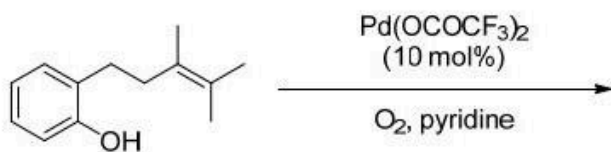
4.



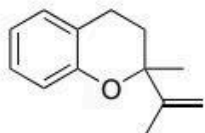
Question No. 40 / Question ID 701197

Marks: 4.00

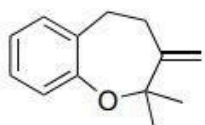
The major product formed in the following reaction is



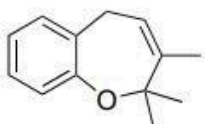
1.



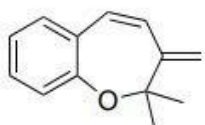
2.



3.



4.



Question No. 41 / Question ID 701220

Marks: 4.00

If mean of a data set {25,29,25,32,24 and x} is 27, then the median is

1. 32

2. 27

3. 26

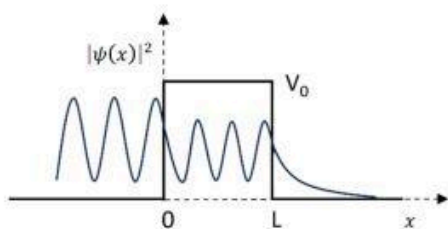
4. 25

Question No. 42 / Question ID 701202

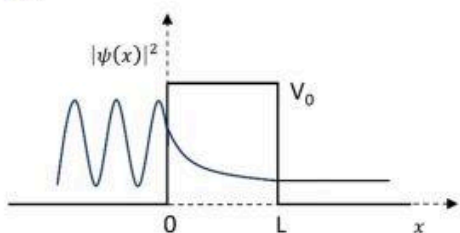
Marks: 4.00

A particle incident from the region $x < 0$ is under a potential barrier with finite height V_0 and finite width L , as in the diagrams. When the total energy (E) of the incident particle is less than V_0 , the correct plot of the probability density ($|\psi(x)|^2$) with distance (x) is

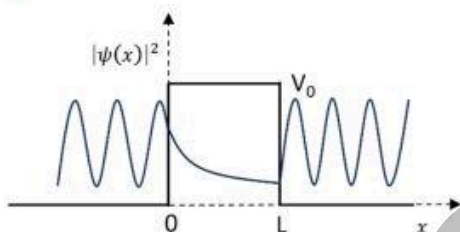
1.



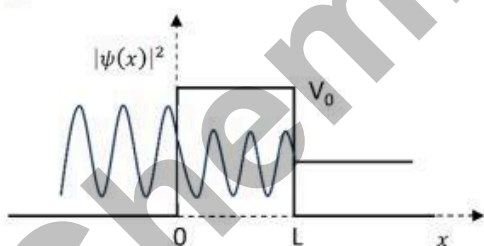
2.



3.



4.



The correct catalyst for conversion of acetophenone to (S)-1-phenylethanol under high pressure of hydrogen is

[DPEN = 1,2-diphenyl-1,2-ethylenediamine]

1. [(S)-BINAP]RuCl₂
2. [(R)-BINAP]RuCl₂
3. [(S)-BINAP][(S,S)-DPEN]RuCl₂/t-BuOK
4. [(R)-BINAP][(R,R)-DPEN]RuCl₂/t-BuOK

Question No. 44 / Question ID 701210

Marks: 4.00

At 25 °C, the total volume, V (in cm³) of an ethanol solution containing 1.0 kg of water fits the following expression

$$V/\text{cm}^3 = 1000 + 60\left(\frac{m}{m^o}\right) - 0.5\left(\frac{m}{m^o}\right)^2$$

Here m is molality and $m^o = 1 \text{ mol kg}^{-1}$. The partial molar volume of ethanol (in cm³mol⁻¹) in the solution prepared by mixing 460 g of ethanol and 2 kg of water is [Molar mass of ethanol = 46 g mol⁻¹]

1. 50
2. 40
3. 55
4. 45

Question No. 45 / Question ID 701171

Marks: 4.00

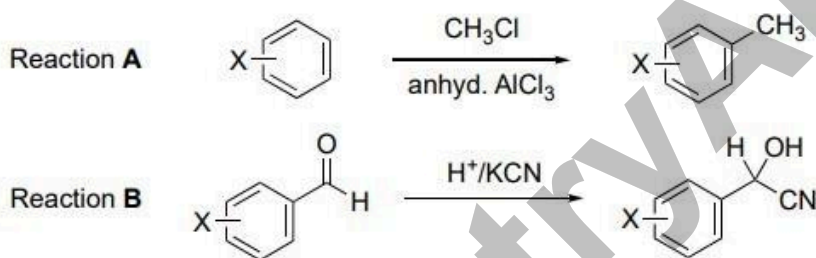
A molybdenum compound **A** is obtained by the CO displacement reaction of Mo(CO)_6 with P^iPr_3 . **A** reacts with H_2 to give compound **B**. Compounds **A** and **B** are

1. $[\text{Mo(P}^i\text{Pr}_3)_6]$ and $[\text{Mo(P}^i\text{Pr}_3)_5(\eta^2\text{-H}_2)]$
2. $[\text{Mo(CO)}_3(\text{P}^i\text{Pr}_3)_2]$ and $[\text{Mo(CO)}_3(\text{P}^i\text{Pr}_3)_2(\eta^2\text{-H}_2)]$
3. $[\text{Mo(CO)}_3(\text{P}^i\text{Pr}_3)_3]$ and $[\text{Mo(CO)}_3(\text{P}^i\text{Pr}_3)_2(\eta^2\text{-H}_2)]$
4. $[\text{Mo(CO)}_4(\text{P}^i\text{Pr}_3)_2]$ and $[\text{Mo(CO)}_4(\text{P}^i\text{Pr}_3)(\text{H})_2]$

Question No. 46 / Question ID 701192

Marks: 4.00

The slope of the Hammett plot (ρ) of $\log k_X/k_H$ against the substituent constant (σ) for the reactions **A** and **B** will, respectively, be

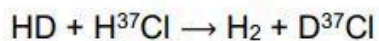


1. negative and positive
2. negative and negative
3. positive and negative
4. positive and positive

Question No. 47 / Question ID 701208

Marks: 4.00

The fundamental vibrational frequencies of H_2 and H^{37}Cl are 4395 cm^{-1} and 2988 cm^{-1} , respectively. Considering all molecules are in their respective ground vibrational state, the energy change (in cm^{-1}) of the reaction below



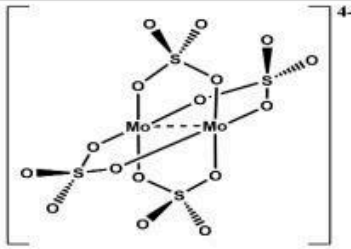
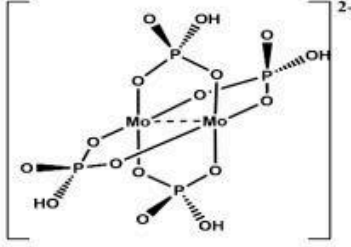
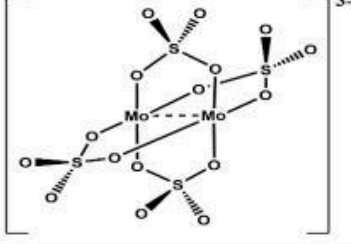
is closest to

[Assume that force constant remains same with isotopic substitution]

1. -65
2. -130
3. -260
4. -520

Question No. 48 / Question ID 701168

Marks: 4.00

Complex	Configuration	M-M Bond order
a. 	i. $\sigma^2 \pi^4$	p. 3
b. 	ii. $\sigma^2 \pi^4 \delta^1$	q. 4
c. 	iii. $\sigma^2 \pi^4 \delta^2$	r. 3.5

The option showing complexes with their correct electronic configuration and bond order is

1. a-iii-q; b-i-p; c-ii-r
2. a-i-p; b-iii-r; c-ii-q
3. a-ii-r; b-iii-q; c-i-p
4. a-ii-q; b-i-r; c-iii-p

Question No. 49 / Question ID 701218

Marks: 4.00

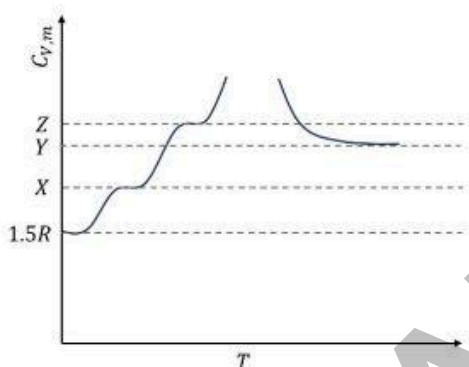
Cu crystallizes in face-centered cubic lattice. Considering each Cu atom as hard sphere and in contact with its nearest neighbors, the fraction of volume of the unit cell occupied by Cu atoms is

1. 0.16
2. 0.56
3. 0.74
4. 0.36

Question No. 50 / Question ID 701213

Marks: 4.00

The variation of molar heat capacity at constant volume ($C_{V,m}$) with temperature (T) of a gaseous diatomic molecule is shown in the diagram below. The values of X , Y and Z , respectively, are
[the diagram is not to the scale and discontinuity in the diagram represents dissociation]

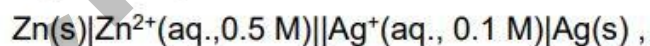


1. $2.0 R, 2.5 R, 3.0 R$
2. $2.5 R, 3.0 R, 3.5 R$
3. $3.5 R, 4.0 R, 4.5 R$
4. $3.0 R, 3.5 R, 4.0 R$

Question No. 51 / Question ID 701214

Marks: 4.00

For the given cell,



the emf (in V) of the cell at 25°C is closest to

[At 25°C , $E_{\text{Zn}^{2+}/\text{Zn}}^0 = -0.76 \text{ V}$ and $E_{\text{Ag}^{+}/\text{Ag}}^0 = +0.80 \text{ V}$.]

1. 0.05
2. 0.04
3. 1.56
4. 1.51

Question No. 52 / Question ID 701180

Marks: 4.00

The option showing the correct statements about radioactive decay is

- A. All radioactive processes are 1st order
- B. Radioactive decay is dependent on temperature
- C. Activation energy of a radioactive process is zero
- D. The rate of decay depends on the amount of radioactive materials

- 1. A, B, and D only
- 2. A, C and D only
- 3. B, C and D only
- 4. A, B, and C only

Question No. 53 / Question ID 701174

Marks: 4.00

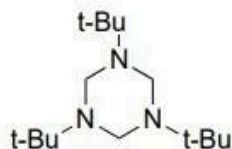
The ground state term, Lande factor (g), and the calculated magnetic moment (m_{calc}) for Pr^{3+} (atomic number = 59) are

- 1. $^3\text{H}_4$, 0.80, 2.68
- 2. $^3\text{H}_4$, 0.80, 3.58
- 3. $^5\text{I}_4$, 1.33, 2.68
- 4. $^6\text{H}_{5/2}$, 1.33, 3.58

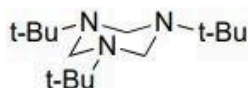
Question No. 54 / Question ID 701195

Marks: 4.00

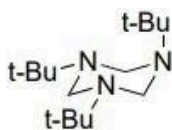
The most stable conformation of the following compound is



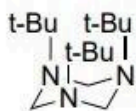
1.



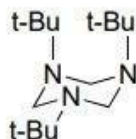
2.



3.



4.



Question No. 55 / Question ID 701169

Marks: 4.00

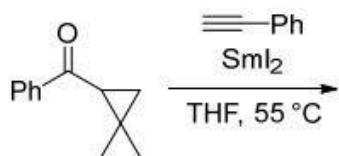
In the extraction of lanthanides, when an aqueous solution of Ln^{3+} is poured into a cation exchange resin column, the Ln^{3+} that moves fastest through the resin is

1. Lu^{3+}
2. La^{3+}
3. Gd^{3+}
4. Sm^{3+}

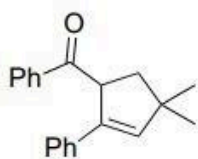
Question No. 56 / Question ID 701196

Marks: 4.00

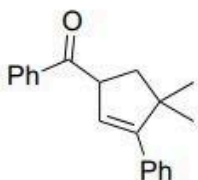
In the presence of single electron transfer reagent, SmI_2 , the major product formed in the following reaction is



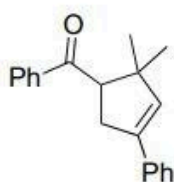
1.



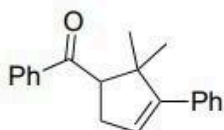
2.



3.



4.



Given are the statements regarding the overall stability constants ($\log\beta$) for the formation of $[M(en)_3]^{2+}$ and $[M(EDTA)]^{2-}$ (en = ethylene diamine, $EDTA$ = ethylenediamine tetraacetate), where M^{2+} is a divalent metal ion ($M^{2+} = Mn^{2+}, Fe^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Zn^{2+}$)

- A. The $\log\beta$ is lowest for Mn^{2+} in both $[M(en)_3]^{2+}$ and $[M(EDTA)]^{2-}$ series (Mn^{2+} to Zn^{2+})
- B. The $\log\beta$ value for $[Mn(EDTA)]^{2-}$ is lower than $[Mn(en)_3]^{2+}$
- C. The $\log\beta$ values increase in the series (Mn^{2+} to Zn^{2+}) for both $EDTA$ and "en" complexes
- D. ΔS° remains nearly constant along the series

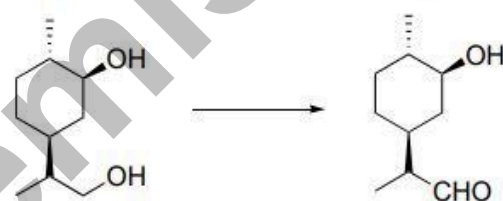
The option with the correct statements is

- 1. **B and C** only
- 2. **A, B and D** only
- 3. **A and D** only
- 4. **A, B and C** only

Question No. 58 / Question ID 701189

Marks: 4.00

The correct set of reagents to effect the following transformation is



- 1. TEMPO, NCS, CH_2Cl_2/H_2O (pH 8.6)
- 2. MnO_2 , acetone
- 3. CrO_3 , H_2SO_4 , H_2O -acetone
- 4. TEMPO (cat.), $NaOCl$ (cat.), $NaClO_2$, toluene/phosphate buffer pH 6.8

Question No. 59 / Question ID 701170

Marks: 4.00

Assuming the molecules are static, the ^{19}F NMR spectra of ClF_3 (**X**) and ClF_5 (**Y**) consists of

1. **X**: doublet and triplet; **Y**: singlet
2. **X**: singlet; **Y**: singlet
3. **X**: doublet and triplet; **Y**: doublet and quintet
4. ☒ **X**: singlet; **Y**: triplet and quartet
 - ☐ 2
 - ☐ 3
 - ☒ 4 (Chosen Option)

Question No. 60 / Question ID 701172

Marks: 4.00

A chromium carbonyl compound $\text{Cr}(\text{CO})_6$ reacts with NaBH_4 to give **A**. The Lewis base **A** reacts with another molecule of $\text{Cr}(\text{CO})_6$ to form compound **B** with the release of CO . In another reaction, compound **A** reacts with BH_3 to produce **C**. Compounds **A**, **B** and **C**, respectively, are

1. $[\text{Cr}(\text{CO})_5(\text{BH}_4)]^-$, $[(\text{CO})_5\text{Cr}(\text{BH}_4)-\text{Cr}(\text{CO})_5]^-$ and $[\text{Cr}(\text{CO})_4\text{B}_2\text{H}_7]^-$
2. $[\text{Cr}(\text{CO})_5\text{H}]^-$, $[(\text{CO})_5\text{Cr}-\text{H}-\text{Cr}(\text{CO})_5]^-$ and $[\text{Cr}(\text{CO})_4\text{BH}_4]^-$
3. $[\text{Cr}(\text{CO})_5(\text{BH}_4)]^-$, $[(\text{CO})_5\text{Cr}-\text{BH}_4-\text{Cr}(\text{CO})_5]^-$ and $[\text{Cr}(\text{CO})_5\text{BH}_4]^-$
4. $[\text{Cr}(\text{CO})_5\text{H}]^-$, $[(\text{CO})_4\text{Cr}-\text{H}-\text{Cr}(\text{CO})_6]^-$ and $[\text{Cr}(\text{CO})_5\text{BH}_4]^-$