

CSIR NET CHEMICAL SCIENCES JUNE 2024
(IFAS SOLVED PAPER)

1. Sohan drinks 20% of the milk present in a bottle in one sip. How much milk will remain in the bottle after the first 3 sips, if it contained 1 litre milk to begin with?

1. 400 ml
2. 512 ml
3. 600 ml
4. 625 ml

2. At 10 minutes past 4 o'clock, the angle between the hour and minute hands of a clock is

1. 62.5°
2. 60°
3. 65°
4. 67.5°

3. The shadow of a vertical pole, formed due to a nearby lamp which is at a height of 12 m, measures 4 m. If the lamp is moved horizontally 2 m further away from the pole, the length of the shadow measures 8 m. What is the height (in m) of the pole?

1. 6
2. $6\sqrt{2}$
3. $6\sqrt{3}$
4. 8

4. In a class, among the boys B is taller than 10 boys, but shorter than 13 others. Among girls, G is taller than 6 girls, but shorter than 8 others. Two boys and three girls are shorter than B, but taller than G. Assuming no two persons have the same height, G is

1. taller than 19, but shorter than 19 others
2. taller than 17, but shorter than 22 others
3. taller than 16, but shorter than 23 others
4. taller than 14, but shorter than 24 others

5. A ball dropped from a height bounces back to half the height. If the ball is dropped from height h then after the third bounce, up until it starts falling again, it would have covered a total distance of

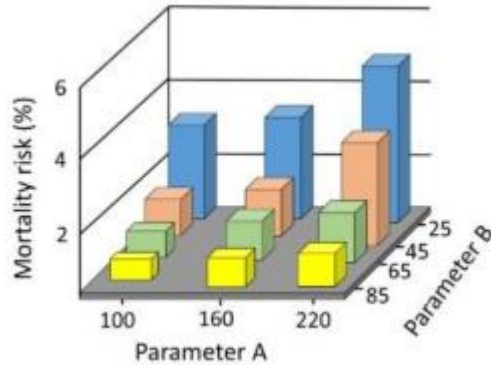
1. $\frac{7}{4}h$
2. $\frac{21}{8}h$
3. $\frac{15}{8}h$
4. $\frac{9}{4}h$

6. In a row, C is positioned right at the middle of A and B. A is at the 10th position from the left and B is at the 9th position from the right. If A and B exchange their positions, A becomes 34th from the left. The position of C is

1. 24th from the left.

2. 22nd from the right.
3. 22nd from the left.
4. 23rd from the right.

7. The following graph shows the mortality risk of a disease with respect to parameters A and B.



Of the following, which would be the best indicator of higher mortality risk associated with the disease?

1. A/B
2. $A \times B$
3. $B - A$
4. $A + B$

8. Suppose that the growth rate of the number of individuals (N) in a population in an environment with a carrying capacity K is modelled as $\frac{dN}{dt} = rN \frac{K-N}{K}$ where r is the per capita growth rate and t is time; r and K are positive constants. At which of the following values of N will the population growth rate be the maximum?

1. $N \approx 0$
2. $N = K$
3. $N = K/2$
4. $N = K/4$

9. Four clocks ring at different intervals which are 30, 60, 80 and 90 minutes. If they rang simultaneously at 10 AM, then they would next ring together at

1. 12 noon
2. 10 PM
3. 12 midnight
4. 10 AM

10. An even number of apples can be distributed into three groups in the ratio 1:2:4 by leaving out three apples. How many apples will be left out if the same number of apples is distributed among three groups in the ratio 3:5:6?

1. 0
2. 3
3. 7
4. 10

11. A rope whose thickness (diameter) is d , is wound around a peg on the floor to form a flat coil (a spiral). If the diameter of the peg is $10d$, and 10 complete windings are formed, then the length of the rope is

1. $155 \pi d$
2. $310 \pi d$
3. $205 \pi d$
4. $160 \pi d$

12. In a group of 6 persons of unequal heights, D is shorter than A and C, but taller than E and F. Two persons are taller than B, and one person is shorter than E. Which of the following inferences is NOT NECESSARILY valid?

1. A is the tallest of all.
2. C is taller than B.
3. F is the shortest of all.
4. B is taller than D.

13. In a very large population, 30% of the individuals have brown coloured eyes, while all others have black coloured eyes. If we take a random sample of 4 individuals from this population, the probability that at least one of them has brown coloured eyes is the closest to

1. 0.24
2. 0.41
3. 0.59
4. 0.76

14. An open cylindrical container of height $10/\pi$ m is to be made to hold 10m^3 of water. If the thickness of the container wall as well as the base is 1 cm, the volume of material (in m^3) needed to make the container is approximately

1. 0.83
2. 0.16
3. 0.23
4. 0.13

15. If A, B and C are decimal digits and $ABC + BCA + CAB + 6(A + B + C)$ is a perfect square, then $A + B + C =$

1. 13
2. 17
3. 19
4. 23

16. BALL is to SPORT as _____ is to MUSIC.

1. SINGER
2. TELEVISION
3. PIANO
4. GRAMOPHONE

17. The following table shows the number of boys and girls enrolled for three subjects

	Science	English	Economics
Boys	56	30	24
Girls	32	28	30

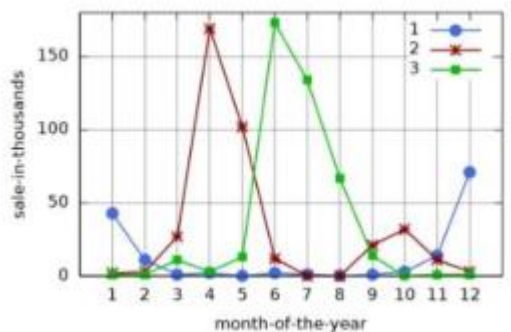
What is the probability that a randomly chosen student is a girl enrolled for English?

1. $522/4000$
2. $58/200$
3. $28/90$
4. $28/200$

18. The timetable of a class with five periods is so set that the fourth period is of a language. Mathematics is just before Geography. The period of Science is not the first or the last. The order of the periods is

1. Mathematics, Science, Geography, Malayalam, History
2. Science, History, Mathematics, Kannada, Geography
3. Mathematics, Geography, Science, Marathi, History
4. Mathematics, Geography, History, Sanskrit, Science

19. The use (as measured by sales) of three items of personal wear - raincoats, sun-hats and sweaters - over a year (months Jan - Dec or 1 - 12) in central India is shown in the graph.



The most likely match of curves 1, 2, 3 with the items is

1. 1 → sweaters, 2 → raincoats, 3 → sun-hats
2. 1 → raincoats, 2 → sun-hats, 3 → sweaters
3. 1 → raincoats, 2 → sweaters, 3 → sun-hats
4. 1 → sweaters, 2 → sun-hats, 3 → raincoats

20. A ball is rolling over the surface of the earth (assumed to be spherical) at a constant ground speed. Which of the following is a necessarily correct statement about the change in its position in terms of latitude and longitude?

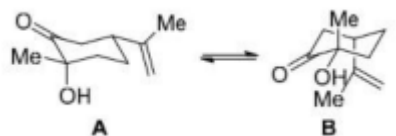
1. Both change at a constant rate
2. Only the latitude changes at a constant rate
3. Only the longitude changes at a constant rate
4. There need be no pattern to their change

PART B

1. The correct order of covalency in the X-F bonds among the following species is

1. $\text{SiF}_4 < \text{PF}_5 < \text{SF}_6 < \text{IF}_7$
2. $\text{SiF}_4 < \text{PF}_5 < \text{IF}_7 < \text{SF}_6$
3. $\text{IF}_7 < \text{SF}_6 < \text{PF}_5 < \text{SiF}_4$
4. $\text{IF}_7 < \text{SiF}_4 < \text{PF}_5 < \text{SF}_6$

2. The correct statements about the following conformational equilibrium of ketone are



- I. A predominates in DMSO due to opposing dipole interaction
- II. B predominates in DMSO due to intramolecular hydrogen bonding
- III. A predominates in isooctane due to opposing dipole interaction
- IV. B predominates in isooctane due to intramolecular hydrogen bonding

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

3. From the data given in the following table,

Ion	OH^-	Cl^-	Br^-	SO_4^{2-}
Ionic mobility ($\times 10^{-8} \text{m}^2 \text{S}^{-1} \text{V}^{-1}$)	20.6	7.9	8.1	8.3

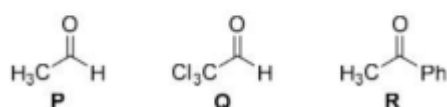
the correct order for an effective radius of the anions in water at 25°C is

1. $\text{OH}^- < \text{SO}_4^{2-} < \text{Br}^- < \text{Cl}^-$
2. $\text{OH}^- > \text{SO}_4^{2-} > \text{Br}^- > \text{Cl}^-$
3. $\text{OH}^- < \text{Cl}^- < \text{Br}^- < \text{SO}_4^{2-}$
4. $\text{OH}^- > \text{Cl}^- > \text{Br}^- > \text{SO}_4^{2-}$

4. The reaction of $[(\eta^5 - \text{C}_5\text{H}_5)\text{Fe}(\text{CH}_3)(\text{CO})_2]$ with PPh_3 results in

1. $[(\eta^5 - \text{C}_5\text{H}_5)\text{Fe}(\text{CH}_3)(\text{CO})(\text{PPh}_3)] + \text{CO}$
2. $[(\eta^5 - \text{C}_5\text{H}_5)\text{Fe}(\text{CH}_3)(\text{CO})_2(\text{PPh}_3)]$
3. $[(\eta^5 - \text{C}_5\text{H}_5)\text{Fe}(\text{COCH}_3)(\text{CO})(\text{PPh}_3)]$
4. $[(\eta^5 - \text{C}_5\text{H}_5)\text{Fe}(\text{COCH}_3)(\text{PPh}_3)] + \text{CO}$

5. The correct order of the dissociation constants for hydrates of the following compounds is



1. $\text{R} > \text{Q} > \text{P}$
2. $\text{R} > \text{P} > \text{Q}$

3. $Q > R > P$
4. $P > Q > R$

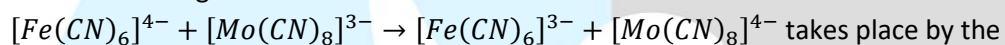
6. The mean and variance are equal for

1. Gaussian distribution
2. Poisson distribution
3. Exponential distribution
4. Uniform distribution

7. An isolobal fragment of $(\eta^6 - C_6H_6)Cr(CO)_2$ is

1. $Fe(CO)_4$
2. CH_3^+
3. $(\eta^6 - C_5H_5)Mn(CO)_3$
4. CH_3

8. The reaction given below



1. inner-sphere mechanism mediated by the CN^- bridge
2. outer-sphere mechanism mediated by the CN^- bridge
3. inner-sphere mechanism with no net chemical change
4. outer-sphere mechanism with no net chemical change

9. Match columns I and II.

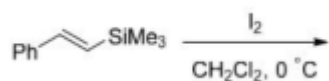
Column I	Column II ($\epsilon, M^{-1}cm^{-1}$)
a. $[TiCl_6]^{2-}$	i. ~ 500
b. $[V(H_2O)_6]^{3+}$	ii. ~ 0.02
c. $[CoCl_4]^{2-}$	iii. $\sim 10^4$
d. $[Mn(H_2O)_6]^{2+}$	iv. ~ 10

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

10. The commutator $[x^2, p_x^2]$ is equal to [x : position operator, p_x : momentum operator]

1. $2xi\hbar$
2. $2i\hbar$
3. $4i\hbar$
4. $2i\hbar (xp_x + p_x x)$

11. The major product formed in the following reaction is



1.	
2.	
3.	
4.	

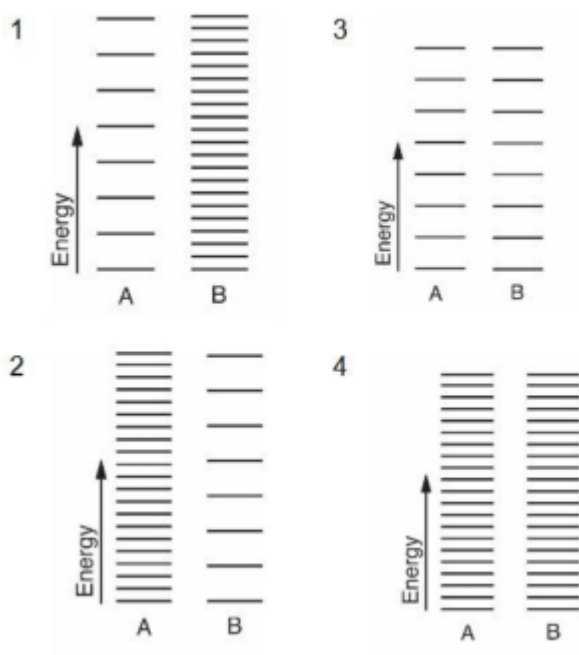
12. The correct statement about the pre-exponential factor in Arrhenius equation is that

1. it is dimensionless.
2. it necessarily has s^{-1} in its dimension, regardless of the order of the reaction.
3. it does not necessarily have s^{-1} in its dimension.
4. it has concentration in its dimension, regardless of the order of the reaction.

13. The correct statement about Diels-Alder reaction of furan and maleic anhydride is

1. the major product is endo and its formation is thermodynamically controlled
2. the major product is endo and its formation is kinetically controlled
3. the major product is exo and its formation is thermodynamically controlled
4. the major product is exo and its formation is kinetically controlled

14. Consider the chemical reaction $A(g) \rightleftharpoons B(g)$ at a particular temperature with equilibrium constant greater than one. The schematic energy levels of molecules A and B are given below. The correct option of energy levels, among the following, is



15. The substitution reaction of $[Co(CN)_5Cl]^{3-}$ with OH^- to give $[Co(CN)_5(OH)]^{3-}$ is

1. slow and depends on the concentration of both the reactants
2. fast and depends only on the concentration of the Co complex
3. slow and depends only on the concentration of the Co complex
4. fast and depends on the concentration of both the reactants

16. Symmetry number of a molecule is defined as the order of rotational subgroup of the molecular point group to which the molecule belongs. The symmetry number of BCl_3 is

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

17. The first reflection in powder X-ray diffraction pattern of a cubic crystal system arises from the plane (111). The Bravais lattice is

1. face-centered cubic.
2. body-centered cubic.
3. simple cubic.
4. indeterminable due to insufficient data.

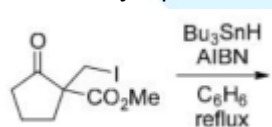
18. The oxidation state and formal charge of nitrogen in the product (IR absorption band at 1553 cm^{-1}) of the reaction between butyl bromide and AgNO_2 , respectively, are

1. +3 and 0
2. +3 and +1
3. +5 and 0
4. +5 and +1

19. The [Re-Re] bond order follows

1. $\text{K}_2[\text{Re}_2\text{Cl}_8] > [\text{Re}_2\text{Cl}_4(\text{PMe}_2\text{Ph})_4] > [\text{Re}_2\text{Cl}_4(\text{PMe}_2\text{PH})_4]\text{Cl}$
2. $[\text{Re}_2\text{Cl}_4(\text{PMe}_2\text{Ph})_4] > [\text{Re}_2\text{Cl}_4(\text{PMe}_2\text{PH})_4]\text{Cl} > \text{K}_2[\text{Re}_2\text{Cl}_8]$
3. $\text{K}_2[\text{Re}_2\text{Cl}_8] > [\text{Re}_2\text{Cl}_4(\text{PMe}_2\text{PH})_4]\text{Cl} > [\text{Re}_2\text{Cl}_4(\text{PMe}_2\text{Ph})_4]$
4. $[\text{Re}_2\text{Cl}_4(\text{PMe}_2\text{PH})_4]\text{Cl} > [\text{Re}_2\text{Cl}_4(\text{PMe}_2\text{Ph})_4] > \text{K}_2[\text{Re}_2\text{Cl}_8]$

20. The major product formed in the following reaction is

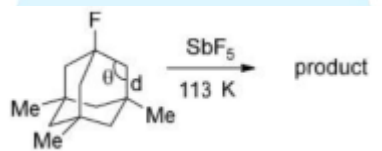


1.	
2.	
3.	
4.	

21. The high kinetic stability of $\text{Cr}(\text{norbornyl})_4$ is due to

1. the absence of α -hydrogen atom
2. the β -hydride elimination leading to a bridgehead olefin
3. the absence of vacant coordination site on the Cr center
4. agostic interaction of β -C-H with Cr

22. The corresponding bond angle (θ) and the bond length (d) of the product, respectively, are



1. 100.6° and $1.608 \text{ \AA}$
2. 112.3° and $1.608 \text{ \AA}$
3. 100.6° and $1.430 \text{ \AA}$
4. 112.3° and $1.430 \text{ \AA}$

23. The metals in the active site of acetylene hydratase, urease, carboxypeptidase and sulfite oxidase, respectively, are

1. Cu, Mo, Ni and Zn
2. W, Ni, Zn and Mo
3. Mo, Ni, Zn and Co
4. W, Co, Mo and Cu

24. In the rotational Raman spectrum of a diatomic molecule, the energy gap between the first Stokes and first anti-Stokes lines is

[B: rotational constant]

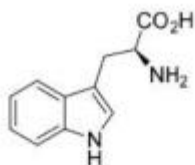
1. $6B$
2. $4B$
3. $12B$
4. $8B$

25. Based on Derjaguin, Landau, Verwey and Overbeek (DLVO) theory, the stability of colloids depends on

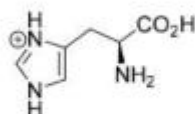
1. only electrical double layer repulsion.
2. only van der Waals attraction.
3. electrical double layer repulsion and van der Waals attraction.
4. electrical double layer and van der Waals attractions.

26. Assuming that the amide backbone of a protein does not play significant role in binding, the amino acid that can effectively recognize HPO_4^{2-} in a protein is

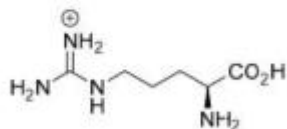
1.



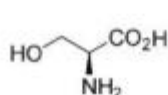
2.



3.



4.



27. An ideal gas undergoes isothermal expansion from V_1 to V_2 in two different ways, (i) reversibly and (ii) irreversibly. The correct statement is [notations have their usual meaning]

1. $|W_{rev}| > |W_{irr}|$, $|Q_{rev}| < |Q_{irr}|$
2. $|W_{rev}| > |W_{irr}|$, $|Q_{rev}| > |Q_{irr}|$
3. $|W_{rev}| < |W_{irr}|$, $|Q_{rev}| < |Q_{irr}|$
4. $|W_{rev}| < |W_{irr}|$, $|Q_{rev}| > |Q_{irr}|$

28. In a proton decoupled ^{13}C NMR of a compound, number of carbons in each signal cannot be calculated from the integration because signal intensities get affected by

- i. NOE induced by attached protons
- ii. different relaxation times of different carbons
- iii. poor isotopic abundance of ^{13}C

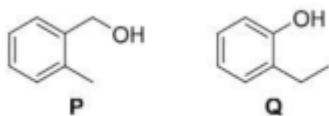
1. Only ii
2. Both i and iii
3. Both ii and iii
4. Both i and ii

29. According to Wade's rules, $\text{TeB}_9\text{H}_{11}$ is an example of

1. closo-borane
2. nido-borane
3. arachno-borane

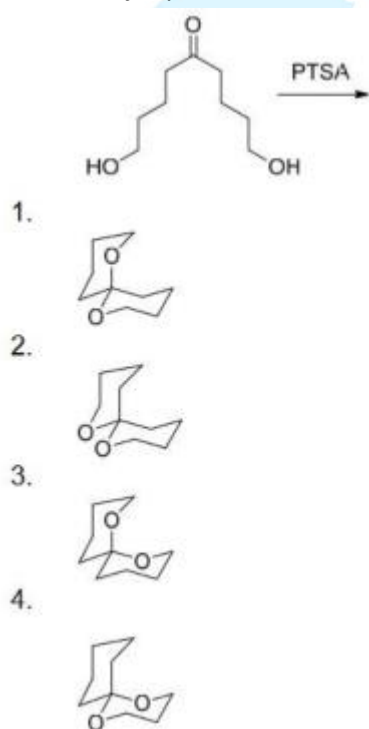
4. hypho-borane

30. The base peaks (m/z) in the EI mass spectra of compounds P and Q appear, respectively, at

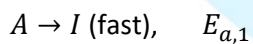
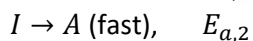
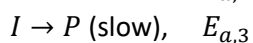


1. 91 and 107
2. 104 and 107
3. 107 and 104
4. 107 and 93

31. The major product formed in the following reaction is



32. The reaction $A \rightarrow P$ consists of the following three elementary steps with their respective activation energies



Activation energy of the overall reaction is

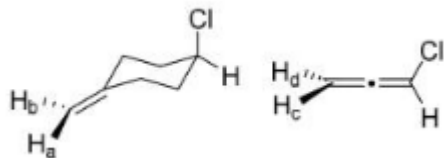
1. $E_{a,1} + E_{a,2} + E_{a,3}$
2. $E_{a,1} + E_{a,2} - E_{a,3}$
3. $E_{a,2}$
4. $E_{a,1} - E_{a,2} + E_{a,3}$

33. The transition(s) giving rise to the yellow sodium D line(s) is/are

1. $^2P_{3/2} \leftarrow ^2S_{1/2}$ and $^2P_{1/2} \leftarrow ^2S_{1/2}$

2. ${}^2D_{3/2} \leftarrow {}^2P_{1/2}$
3. ${}^2D_{3/2} \leftarrow {}^2S_{1/2}$ and ${}^2P_{1/2} \leftarrow {}^2S_{1/2}$
4. ${}^2D_{3/2} \leftarrow {}^2P_{3/2}$ and ${}^2P_{3/2} \leftarrow {}^2S_{1/2}$

34. The correct topicity of H_a and H_c in the following molecules is



1. $H_a = H_c = \text{pro-R}$
2. $H_a = H_c = \text{pro-S}$
3. $H_a = \text{pro-R}; H_c = \text{pro-S}$
4. $H_a = \text{pro-S}; H_c = \text{pro-R}$

35. Consider the following statements regarding ZnS.

- I. ZnS shows both cubic and hexagonal structures
- II. Sphalerite exhibits ZnS structure
- III. ZnS is a semiconductor
- IV. ZnS can be precipitated from an aqueous acidic solution of zinc salts by passing H_2S

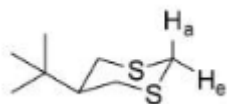
The option containing the correct statements is

1. I, II and III only
2. II and IV only
3. I and III only
4. II, III and IV only

36. In the upper atmosphere, SF_6 undergoes photolysis to form species A. Species A combines with O_2 giving a radical B. The correct statement is

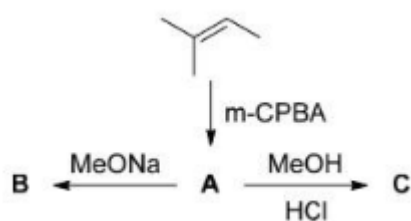
1. Unpaired electrons in A and B are located on sulfur and oxygen atoms, respectively
2. Unpaired electrons in A and B are on sulfur atom only
3. Species A is diamagnetic
4. The hybridization of central atoms in A and B are different

37. In the following dithiane, the correct statement about acidity of H_a and H_e protons and the reason for the stability of the carbanion formed by deprotonation is

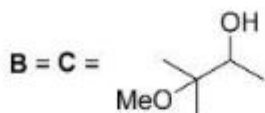


1. H_a is more acidic; axial carbanion is delocalised into the σ^* orbital of C-S bond
2. H_e is more acidic; equatorial carbanion is delocalised into the σ^* orbital of C-S bond
3. H_a is more acidic; axial carbanion is delocalised into the empty 3d orbital of sulfur
4. H_e is more acidic; equatorial carbanion is delocalised into the empty 3d orbital of sulfur

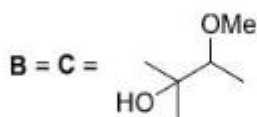
38. The major products B and C formed in the following set of reactions are



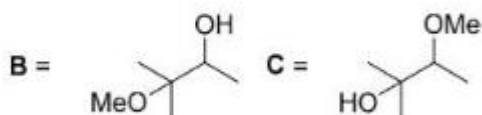
1.



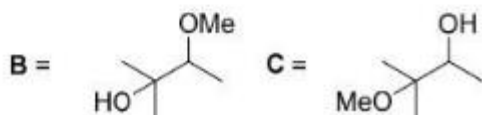
2.



3.



4.



39. An isoelectronic, neutral, linear nitrosyl complex of $[(\eta^5 - C_5H_5)Cu(CO)]$ is

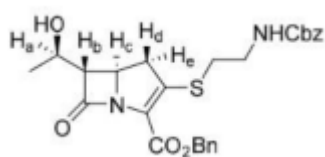
1. $[(\eta^5 - C_5H_5)Ni(NO)]$
2. $[(\eta^5 - C_5H_5)Cr(NO)_2]_2$
3. $[Mn(CO)_3NO]$
4. $[Fe(CO)(NO)_2]$

40. The correct order of the slopes (magnitude) for the p vs T plot of various phase boundaries is

1. solid-liquid > solid-vapour > liquid-vapour
2. liquid-vapour > solid-vapour > solid-liquid
3. solid-vapour > solid-liquid > liquid-vapour
4. solid-liquid > liquid-vapour > solid-vapour

PART C

1. The ^1H NMR data corresponding to the labelled protons of the following compound is given below. The signal corresponding to H_b is



^1H NMR: δ 84.19 (dt, $J = 9.0, 2.5$ Hz), 4.13 (dq, $J = 7.0, 6.5$ Hz), 3.35 (dd, $J = 18.0, 9.0$ Hz), 3.15 (dd, $J = 7.0, 2.5$ Hz), 3.08 (dd, $J = 18.0, 9.0$ Hz) ppm

1. 4.19 (dt, $J = 9.0, 2.5$ Hz)
2. 4.13 (dq, $J = 7.0, 6.5$ Hz)
3. 3.35 (dd, $J = 18.0, 9.0$ Hz)
4. 3.15 (dd, $J = 7.0, 2.5$ Hz)

2. The correct sequence of reagents which will give A as the major product is

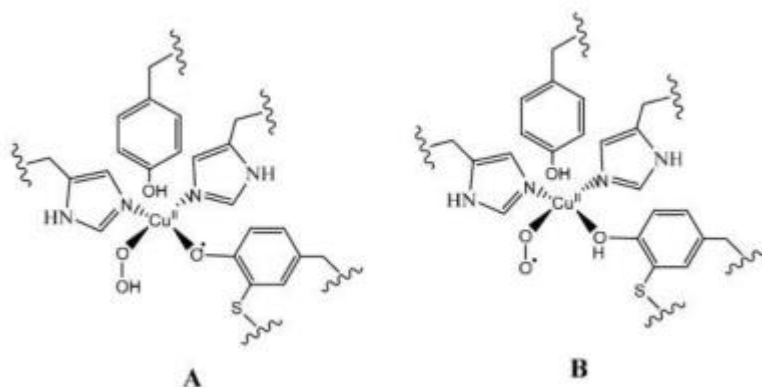


1. i. 2, 2-dimethoxypropane, PTSA; ii. Dess-Martin periodinane; iii. TrCl , Et_3N
2. i. TrCl , Et_3N ; ii. 2, 2-dimethoxypropane, PTSA; iii. Dess-Martin periodinane
3. i. TrCl , Et_3N ; ii. Dess-Martin periodinane; iii. 2, 2-dimethoxypropane, PTSA
4. i. Dess-Martin periodinane; ii. TrCl , Et_3N ; iii. 2, 2-dimethoxypropane, PTSA

3. The mean activity coefficient ($\gamma_{\pm}$) of 0.1 m aqueous solution of CdCl_2 at 298 K and 1 bar is 0.228. Under this condition, the potential of the cell, $\text{Cd(s)} | \text{CdCl}_2(\text{aq.}, 0.1 \text{ m}) | \text{AgCl(s)} | \text{Ag(s)}$, is [$E^\circ(\text{AgCl/Ag, Cl}^-) = 0.22 \text{ V}$; $E^\circ(\text{Cd}^{2+}/\text{Cd}) = -0.40 \text{ V}$]

1. 0.75 V
2. 0.62 V
3. 0.89 V
4. 0.49 V

4. Intermediate compounds A and B, proposed in the catalytic cycle for the enzyme galactose oxidase, can be distinguished by one or more of the following methods.



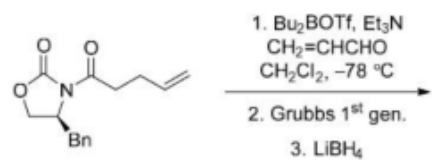
- A. Room temperature EPR spectroscopy
- B. Vibrational Spectroscopy
- C. Electrospray Ionisation Mass Spectrometry
- D. Electronic Spectroscopy

The correct option is

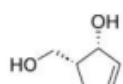
1. B and D only

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

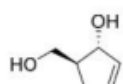
5. The major product formed in the following reaction sequence is



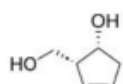
1.



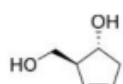
2.



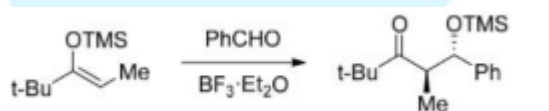
3.



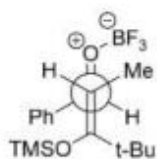
4.



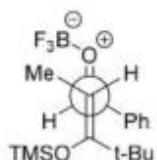
6. The transition state arrangement that explains the stereochemistry of the product in the following reaction is



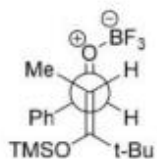
1.



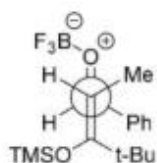
2.



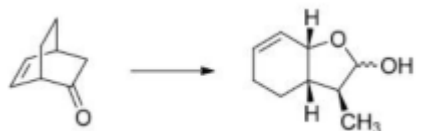
3.



4.



7. The correct sequence of reagents to effect the following transformation is

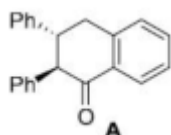


1. i. $\text{CH}_3\text{CO}_3\text{H}$, H^+ then $2\text{N H}_2\text{SO}_4$; ii. LDA, MeI; iii. DIBAL-H, -78°C
2. i. DIBAL-H, -78°C ; ii. $\text{CH}_3\text{CO}_3\text{H}$, H^+ then $2\text{N H}_2\text{SO}_4$; iii. LDA, MeI
3. i. $\text{CH}_3\text{CO}_3\text{H}$, H^+ then $2\text{N H}_2\text{SO}_4$; ii. DIBAL-H, -78°C ; iii. LDA, MeI
4. i. LDA, MeI; ii. DIBAL-H, -78°C ; iii. $\text{CH}_3\text{CO}_3\text{H}$, H^+ then $2\text{N H}_2\text{SO}_4$

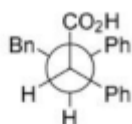
8. For the reaction $A(s) \rightarrow A(l)$, ΔG_m at 300 K is 6 kJ mol^{-1} . If the heat absorbed in the process is 9 kJ mol^{-1} , the temperature (in K) at which A starts melting is [Assume ΔH to be constant with temperature]

1. 1000
2. 900
3. 1500
4. 750

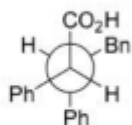
9. The conformer of threo-2,3,4-triphenylbutyric acid that gives the product A in the presence of anhydrous HF is



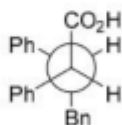
1.



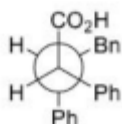
2.



3.



4.



10. The formation constant ($\log K_1$) of metal ions X^{n+} , Y^{m+} and Z^{p+} with halides in water is given below.

Metal ion	F^-	Cl^-	Br^-
X^{n+}	6.0	1.5	0.5
Y^{m+}	1.0	6.5	13.0
Z^{p+}	0.5	8.5	15.5

Consider the following statements

- A. X^{n+} is a hard acid; Y^{m+} is a soft acid
- B. X^{n+} is a soft acid; Z^{p+} is a hard acid
- C. Y^{m+} is a soft acid; Z^{p+} is a soft acid

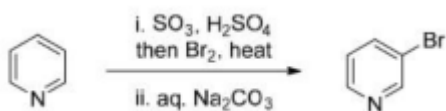
The correct option is

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

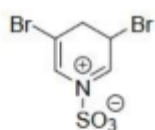
11. In Hückel approximation, the π - energy for the cyclopropenyl cation is [α and β are coulomb integral and resonance integral, respectively]

- 1. $2\alpha + 4\beta$
- 2. $\alpha + \beta$
- 3. $3\alpha + 3\beta$
- 4. $3\alpha + 6\beta$

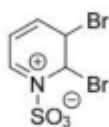
12. The intermediate involved in the following reaction is



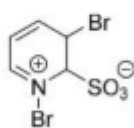
1.



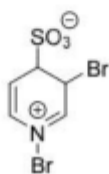
2.



3.



4.



13. The correct statement about the following transformation is



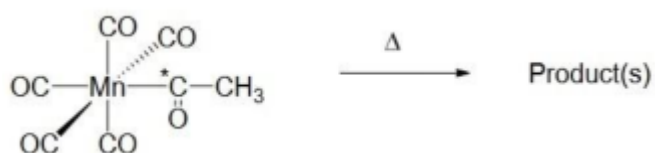
1. [1, 5]-carbon shift with inversion and [1, 5]-hydrogen shift with retention
2. both [1, 5]-carbon shift and [1, 5]-hydrogen shift with inversion
3. [1, 5]-carbon shift with retention and [1, 5]-hydrogen shift with inversion
4. both [1, 5]-carbon shift and [1, 5]-hydrogen shift with retention

14. The correct statement about the following transformation is

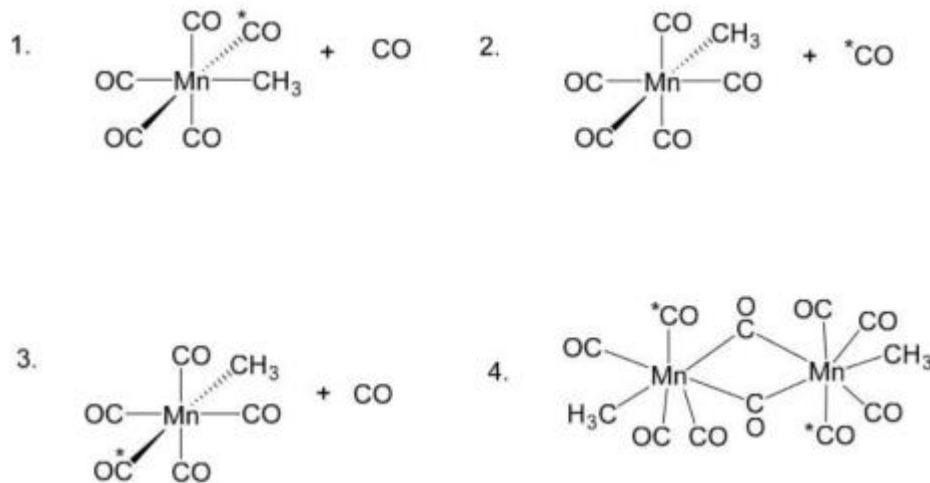


1. *threo* isomer gives the product via Norrish type-I reaction
2. *threo* isomer gives the product via Norrish type-II reaction
3. *erythro* isomer gives the product via Norrish type-I reaction
4. *erythro* isomer gives the product via Norrish type-II reaction

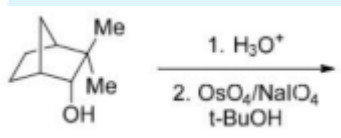
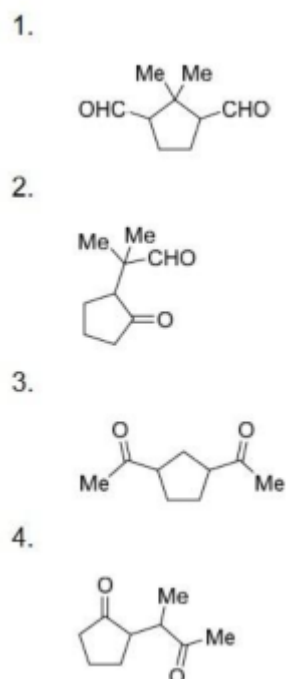
15. In the following reaction,



The product(s) is/are



16. The major product formed in the following sequence of reactions is

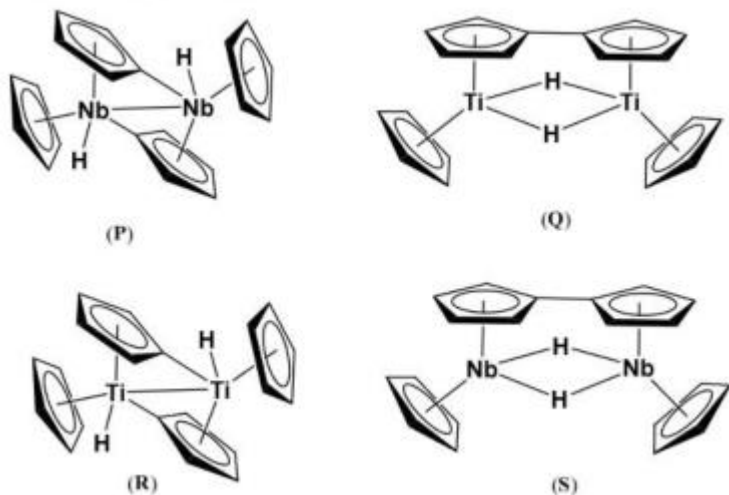


17. Two moles of calcium phosphate on reduction with carbon in the presence of silica resulted in the formation of a phosphorus compound X in 90% yield. The weight of X is (Atomic weight, Ca 40, P 31, Si 28, O 16, C 12, H 1)

1. 124 g

2. 111.6 g
3. 255.6
4. 198 g

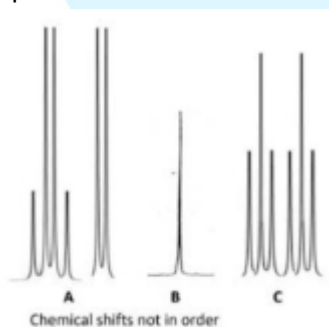
18. Consider the following structures.



- A. The structure for niobocene is P
 - B. The structure for titanocene is Q
 - C. The structure for niobocene is S
 - D. The structure for titanocene is R
- The option containing the correct statements is

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

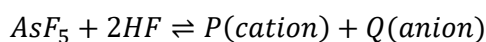
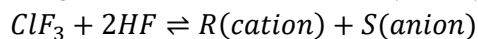
19. Reaction of white phosphorus with sulfur gives a mixture of products A, B and C. The ^{31}P NMR spectral features of the resultant mixture are shown below.



The products A, B and C, respectively, are

1. P_4S_3 , P_4S_{10} and P_4S_7
2. P_4S_7 , P_4S_{10} and P_4
3. P_4S_3 , P_4 and P_4S_{10}
4. P_4S_{10} , P_4 and P_4S_7

20. Consider the following reactions and the related statements.

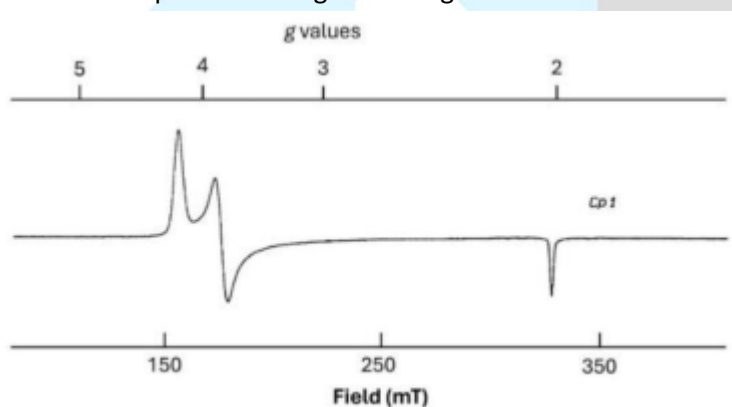


- A. P is bent
- B. Q is octahedral
- C. R is bent
- D. S is linear

The option containing the correct statement is

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

21. The EPR spectrum along with the g values of FeMo co-factor in nitrogenase is shown below.



The overall spin of the system is

- 1. $1/2$
- 2. $3/2$
- 3. $5/2$
- 4. $7/2$

22. The raising and lowering operators are denoted as L_+ and L_- , respectively. The correct commutator relation between angular momentum (L) and its various components (L_x , L_y and L_z) is

- 1. $[L^2, L_+] = [L^2, L_-] = \hbar L_z$
- 2. $[L^2, L_+] = [L^2, L_-] = \hbar L_x$
- 3. $[L^2, L_+] = [L^2, L_-] = \hbar L_y$
- 4. $[L^2, L_+] = [L^2, L_-] = 0$

23. Consider the following statements regarding molecular orbitals of a water molecule.

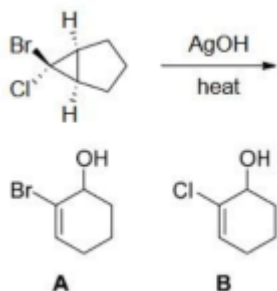
- A. The photoelectron spectrum of water shows that two MOS containing the lone-pairs are not of the same energy.
- B. The O-H bond orbitals have a symmetry.
- C. The HOMO is predominantly an oxygen p orbital.
- D. Increasing H-O-H bond angle leads to the destabilization of the HOMO.

The option containing the correct statements is

- 1. A and C only
- 2. A and D only

3. B and C only
4. B and D only

24. The correct statement about the following transformation is



1. A is formed as the major product via conrotatory ring opening
2. A is formed as the major product via disrotatory ring opening
3. B is formed as the major product via conrotatory ring opening
4. B is formed as the major product via disrotatory ring opening

25. The resistances of 0.1 M KCl and 0.05 M NaCl in a conductivity cell are $90\ \Omega$ and $200\ \Omega$, respectively. If the specific conductivity of 0.1 M KCl is $11.2 \times 10^{-3}\ S\ cm^{-1}$, then the molar conductance (in $S\ cm^2\ mol^{-1}$) of 0.05 M NaCl is closest to

1. 10^5
2. 10^2
3. 10^3
4. 10^4

26. The correct match for the reaction given in Column P with the Hammett reaction constant (ρ) given in Column Q is

Column P	Column Q
A.	i. -0.95
B.	ii. -2.98
C.	iii. -0.30

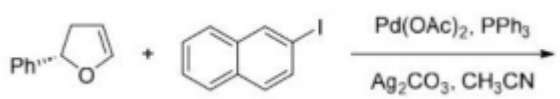
1. A-i; B-i; C-iii
2. A-iii; B-i; C-ii
3. A-iii; B-ii; C-i
4. A-ii; B-iii; C-i

27. For a point group having the irreducible representations A_1 , A_2 and E , the values of a , b and c in the following partial character table are

	E	$2C_3$	$3C_2$
E	a	b	c

1. $a = 2, b = 1, c = 0$
2. $a = 2, b = -1, c = 0$
3. $a = -1, b = 2, c = 1$
4. $a = 2, b = 1, c = -1$

28. The major product formed in the following transformation is



- 1.
- 2.
- 3.
- 4.

29. Unimolecular decomposition of NH_3 on tungsten surface is inhibited by one of the products, H_2 . The rate of surface catalyzed decomposition is given by [P_i and K_i are, respectively, the partial pressure and surface binding constant of the i^{th} species; k_c is the rate constant of rate determining step]

1. $\frac{k_c K_{NH_3} P_{NH_3} K_{H_2} P_{H_2}}{(1 + K_{NH_3} P_{NH_3} K_{H_2} P_{H_2})^2}$
2. $\frac{k_c K_{NH_3} P_{NH_3}}{1 + K_{NH_3} P_{NH_3}}$
3. $\frac{k_c K_{NH_3} P_{NH_3}}{1 + K_{NH_3} P_{NH_3} K_{H_2} P_{H_2}}$
4. $\frac{k_c K_{NH_3} P_{NH_3} K_{H_2} P_{H_2}}{1 + K_{NH_3} P_{NH_3} K_{H_2} P_{H_2}}$

30. During the growth of semiconductor nanoparticles, the fluorescence changes with time as

1. blue $\rightarrow$ violet $\rightarrow$ green $\rightarrow$ red

2. red → green → violet → blue
3. violet → blue → green → red
4. blue → red → violet → green

31. Match the species given in List I with the appropriate descriptions in List II

List I	List II
a. Al_2Me_6	I. 1D-polymeric
b. LiH	II. 3c-2e bonds
c. HF	III. 4c-2e bonds
d. CH_3Li	IV. Ionic hydride

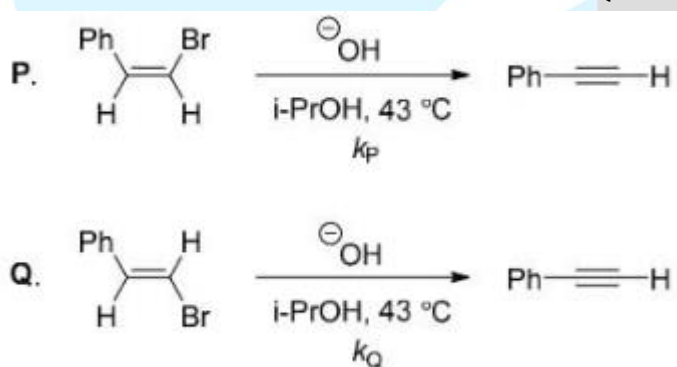
The correct option is

1. a-II, b-IV, c-III, d-I
2. a-III, b-I, c-IV, d-II
3. a-II, b-IV, c-I, d-III
4. a-III, b-II, c-I, d-IV

32. The rate constant (k_{CT}) of a bimolecular reaction according to collision theory is given by $k_{CT} = N_A \left(\frac{8k_B T}{\pi \mu} \right)^{1/2} \sigma e^{-E_0/RT}$. E_0 is related to activation energy (E_a) of the Arrhenius equation as

1. $E_0 = \frac{RT}{2} + E_a$
2. $E_a = RT + \frac{1}{2} E_0$
3. $E_0 = RT + \frac{1}{2} E_a$
4. $E_a = \frac{RT}{2} + E_0$

33. The correct statement for the reactions P and Q is



1. $k_P > k_Q$; P goes via an E2 and Q goes via an E1cB pathway
2. $k_P > k_Q$; both P and Q go via an E2 pathway
3. $k_Q > k_P$; P goes via an E1cB and Q goes via an E2 pathway
4. $k_Q > k_P$; both P and Q go via an E1cB pathway

34. The ground state term symbols of the metal hydrates $[\text{Eu}(\text{H}_2\text{O})_n]^{3+}$ and $[\text{Tb}(\text{H}_2\text{O})_n]^{3+}$, respectively, are

1. $^7F_0$ and $^7F_6$
2. $^7F_0$ and $^2F_{7/2}$

3. ${}^2F_{5/2}$ and ${}^7F_6$
4. ${}^3H_4$ and ${}^5I_8$

35. Consider an arbitrary un-normalized wave function ψ expanded in terms of eigenstates of Hamiltonian H , where

$$H|\phi_n\rangle = \varepsilon_n|\phi_n\rangle, n = 0, 1, 2, \dots$$

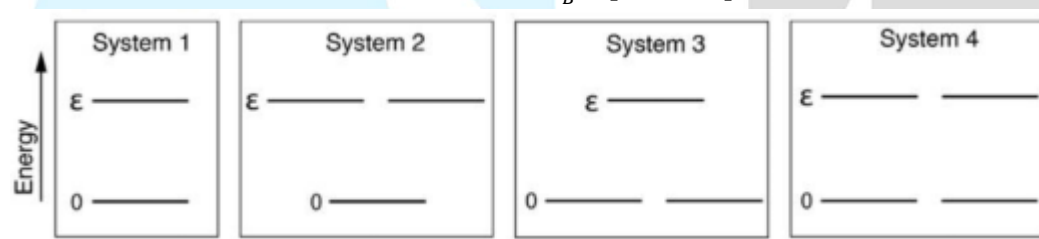
$$\varepsilon_0 \leq \varepsilon_1 \leq \varepsilon_2 \text{ etc.}$$

$$\psi = \sum_n a_n \phi_n$$

The correct option, which definitely holds for any set of $\{a_n\}$, is

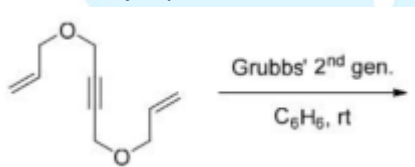
1. $\frac{\sum_n |a_n|^2 \varepsilon_n}{\sum_n |a_n|^2} < \varepsilon_0$
2. $\frac{\sum_n |a_n|^2 \varepsilon_n}{\sum_n |a_n|^2} \geq \varepsilon_0$
3. $\frac{\sum_n a_n \varepsilon_n}{\sum |a_n|} \geq \varepsilon_0$
4. $\frac{\sum_n a_n \varepsilon_n}{\sum_n |a_n|^2} < \varepsilon_0$

36. From the energy diagrams of different single particle systems given below, the one with the lowest Helmholtz free energy at a temperature $T = \frac{\varepsilon}{k_B}$ is $\left[\frac{1}{e} = 0.37\right]$



1. System 1
2. System 2
3. System 3
4. System 4

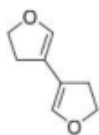
37. The major product formed in the following reaction is



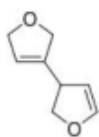
1.



2.



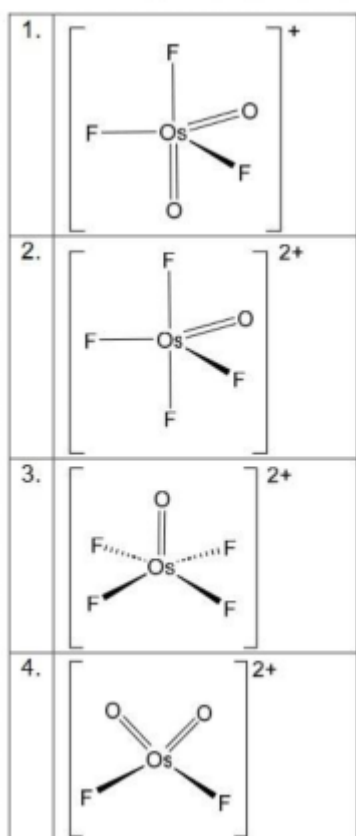
3.



4.



38. Consider a 0.3 M solution of $\text{cis-OsO}_2\text{F}_4$ in neat SbF_5 . The ^{19}F NMR spectrum of the Os containing species in this solution shows a doublet and a triplet at 122.4 ppm and 129.5 ppm, respectively. The Os species generated is



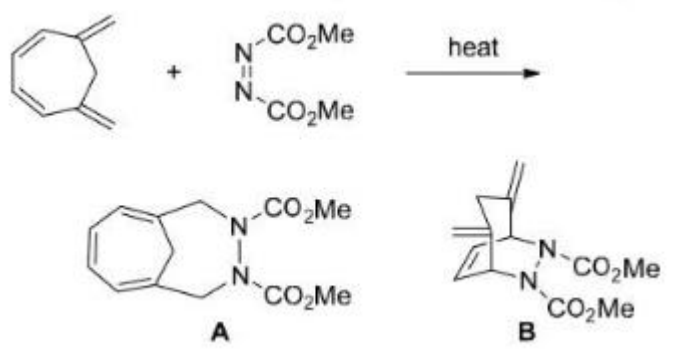
39. The chemical shifts of CH_3 and CH_2 protons in a molecule are 1.15 and 3.35 ppm, respectively. When the magnetic field is 2 T, the absolute difference between the local magnetic fields (in T) for these two protons is

1. 4.4×10^6
2. 2.2×10^{-6}
3. 4.4×10^{-6}
4. 2.2×10^6

40. At a given temperature, an atom accesses $^2S_{1/2}$, $^2P_{1/2}$ and $^2P_{3/2}$ atomic states with energies $0 k_B T$, $0.5 k_B T$ and $0.5 k_B T$, respectively. The fraction of atoms in the P states is

1. $\frac{3e^{-0.5}}{1+3e^{-0.5}}$
2. $\frac{e^{-0.5}}{1+2e^{-0.5}}$
3. $\frac{1+4e^{-0.5}}{2e^{-0.5}}$
4. $\frac{2e^{-0.5}}{1+2e^{-0.5}}$

41. The major cycloaddition product (A or B) formed and the orbital interactions involved in the following transformation, respectively, are



1. A and $8\pi_s + 2\pi_a$
2. A and $8\pi_s + 2\pi_a$
3. B and $4\pi_s + 2\pi_a$
4. B and $4\pi_s + 2\pi_a$

42. For elements P, Q, R and S, the corresponding valencies and average orbital energies are listed below.

Element	Valency	Average Valence Orbital Energy (eV)
P	i	-19
Q	j	-22.5
R	k	-9
S	l	-7

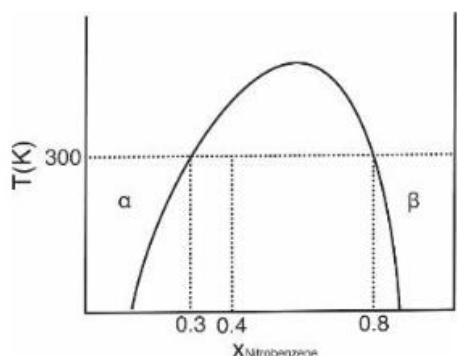
Based on the Van-Arkel diagram, the correct option from the following

- A. $S_j Q_l$ is covalent.
- B. $P_k R_i$ is ionic.
- C. $R_l S_k$ is metallic.
- D. $P_j Q_i$ is covalent

is

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

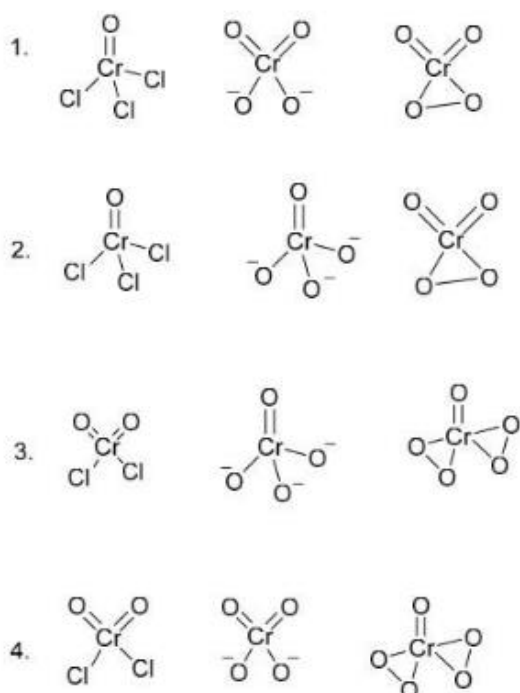
43. A mixture of 0.6 mol of hexane and 0.4 mol of nitrobenzene was prepared at 300 K. Based on the phase diagram given below, the number of moles of hexane in α phase is
[α phase: hexane rich phase, β phase: nitrobenzene rich phase]



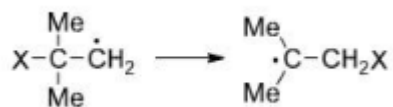
1. 0.56
2. 0.42
3. 0.38
4. 0.32

44. Exposing CrO_3 to hydrogen chloride gas gives a red-vapor of compound P. When P is passed through a dilute solution of NaOH , it turns yellow due to the formation of complex ion Q. Adding acidified H_2O_2 to a solution of Q results in a dark blue compound R.

The option containing the correct structures of P, Q and R, respectively, is



45. The correct order of the rate for the following rearrangement that involves a three membered intermediate is



P: $\text{X} = -\text{CH} = \text{CH}_2$

Q: $\text{X} = \text{Me}_3\text{CC}(\text{O}) -$

R: $\text{X} = -\text{C} \equiv \text{N}$

1. $\text{P} > \text{Q} > \text{R}$
2. $\text{R} > \text{P} > \text{Q}$
3. $\text{Q} > \text{P} > \text{R}$
4. $\text{P} > \text{R} > \text{Q}$

46. Reaction of an aqueous acidic solution of CoCl_2 with KNO_2 gives a yellow precipitate X and with NH_4SCN , a blue-colored compound Y. Compounds X and Y, respectively, are

1. $\text{K}_4[\text{Co}(\text{NO}_2)_6]$ and $\text{Co}(\text{SCN})_2$
2. $\text{K}_3[\text{Co}(\text{NO}_2)_6]$ and $\text{Co}(\text{SCN})_2$
3. $\text{K}_3[\text{Co}(\text{NO}_2)_6]$ and $(\text{NH}_4)_2[\text{Co}(\text{SCN})_4]$
4. $\text{K}_4[\text{Co}(\text{NO}_2)_6]$ and $(\text{NH}_4)_2[\text{Co}(\text{SCN})_4]$

47. From the following 18-electron complex(es), identify those which predominantly undergoes / undergo substitution reaction by $\text{P}(\text{OMe})_3$; via an associative mechanism.

- A. $\text{Mn}(\text{CO})_4\text{NO}$
- B. $\text{trans-Cr}(\text{CO})_4(\text{PPh}_3)_2$
- C. $\text{cis-Mn}(\text{CO})_5\text{Br}$
- D. $(\eta^5 - \text{C}_5\text{H}_5)\text{Co}(\text{CO})_2$

The correct option is

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

48. A vanadium compound X is obtained by heating NH_4VO_3 . X reacts with dil. HCl to form another vanadium compound Y along with chlorine gas. Y is

1. VCl_3
2. VCl_5
3. VOCl_2
4. VOCl_3

49. The fluorescence of A is quenched by 10% in the presence of 10 mM of B. If the fluorescence lifetime of A in the absence of B is 5 ns, the rate constant (in $\text{M}^{-1}\text{s}^{-1}$) for interaction between B and photo-excited A is

1. 1.2×10^9
2. 2.2×10^9
3. 3.2×10^9

4. 4.2×10^9

50. The number-average degree of polymerization ($\bar{X}_n$) of self-catalyzed polyesterification, a 3rd order reaction, is expressed as $[M]_0$: initial monomer concentration]

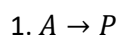
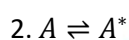
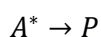
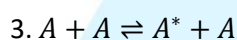
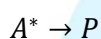
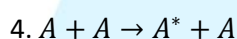
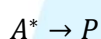
1. $\bar{X}_n^2 = 2[M]_0^2 kt + 1$

2. $\bar{X}_n^2 = 2[M]_0 kt + 1$

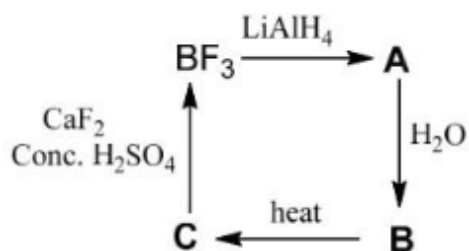
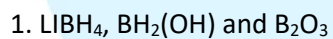
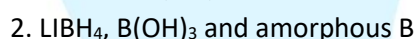
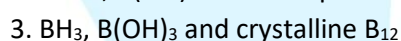
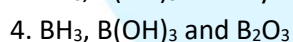
3. $\bar{X}_n^2 = [M]_0 kt + 1$

4. $\bar{X}_n^2 = 2[M]_0^2 kt$

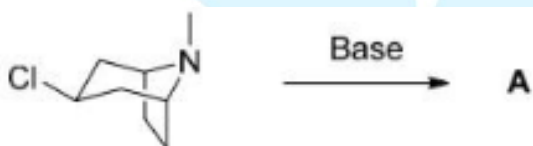
51. The order of the reaction $A \rightarrow P$ is 2 when the concentration of A is small. However, at higher concentrations of A , the order changes to 1. The mechanism of the reaction is [Assume that steady state approximation can be applied on A^*]



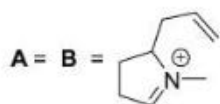
52. In the following reaction, A, B and C, respectively, are



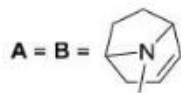
53. The major products A and B formed in the following transformations are



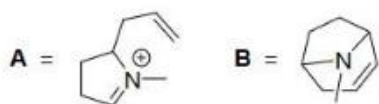
1.



2.



3.



4.



54. The symmetry of the first excited state of one of the normal modes in NH_3 is E . Based on the character table for the C_{3v} point group given below, the symmetry of the second excited state for this mode in terms of the irreducible representations is

C_{3v}	E	$2C_3$	$3\sigma_v$
A_1	1	1	1
A_2	1	1	-1
E	2	-1	0

1. $2A_2 + E$
2. $2A_1 + E$
3. $A_1 + A_2 + E$
4. $2A_1 + 2A_2$

55. The unperturbed energies (in eV) of a three-level system are $\varepsilon_0 = 2$, $\varepsilon_1 = 4$ and $\varepsilon_2 = 6$. The matrix elements of a perturbation V (in eV) between the levels (in subscript) are $V_{10} = 4$, $V_{20} = 6$, and $V_{12} = 10$. The second-order correction to the ground state energy (in eV) in the presence of perturbation V is

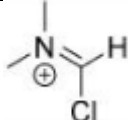
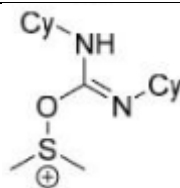
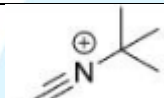
1. $-\frac{25}{4}$
2. -67
3. -17
4. -16

56. The separation between first two reflection planes of a face-centred cubic crystal is [a is the unit cell length]

1. $0.077a$
2. $0.77a$
3. $0.57a$

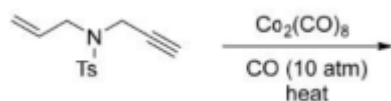
4. 0.057a

57. The correct match for the intermediates given in Column P with the reactions given in Column Q is

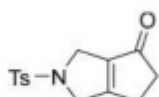
Column P	Column Q
A. 	i. Pfitzner-Moffatt oxidation
B. 	ii. Vilsmeier-Haack reaction
C. 	iii. Ritter reaction
D. 	iv. Swern oxidation

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

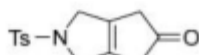
58. The major product formed in the following reaction is



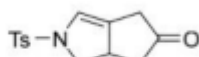
1.



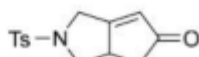
2.



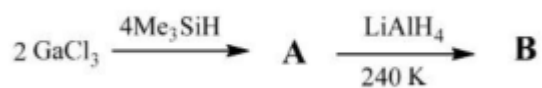
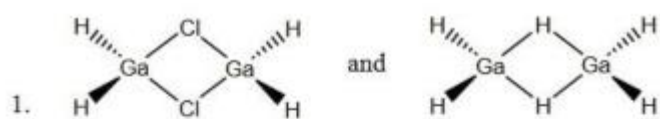
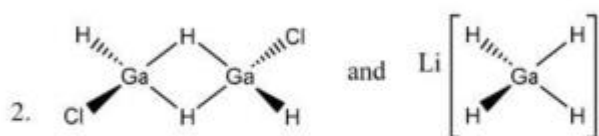
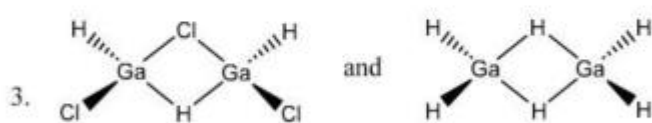
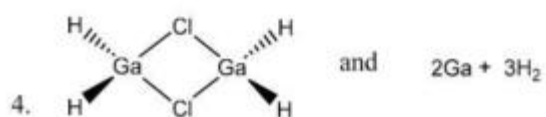
3.



4.



59. In the following reaction, A and B, respectively, are



60. The β -activity of 0.9 g of carbon from the wood of a present-day tree is 0.25 Bq. If the activity of 0.9 g carbon isolated from the wood of an ancient artifact is 0.19 Bq under the same conditions (^{14}C : $t_{1/2} = 5730$ years), the age of the ancient artifact is

1. 4010 years
2. 3000 years
3. 2268 years
4. 5573 years