PART A

1. Percentage marks scored by a student in six different papers are in the ratio 9: 10: 11: 13: 14:15 If the average percentage marks is 60 then in how many papers did the student score more than 60%?

A. 1

B. 2

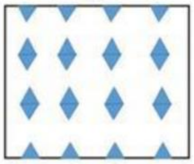
C. 3

D. 4

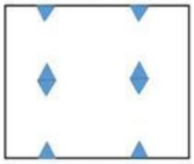
2. A square paper is folded twice to a square shape one fourth in area to the original square. Then two equilateral triangles are cut (as shown with shaded triangles in figure) from two opposite sides.

How does the paper appear after fully unfolding?

A



B



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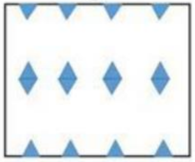
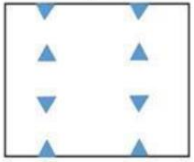


D



A. A

B. B

C. C

D. D

3. An OTP is made of four digits each from 0 to 9. If digits at two positions are known, what is the probability of constructing the full OTP within 20 trials?

A. 0.1

B. 0.2

C. 0.3

D. 0.4

4. Mohan flew from Delhi to Vizag via Mumbai. Flight speed was 600 km/h from Delhi to Mumbai sector, while it was 1000 km h from Mumbai to Vizag sector. Assuming the distance between Delhi-Mumbai and Mumbai-Vizag is the same, what was the average speed with which Mohan flew?

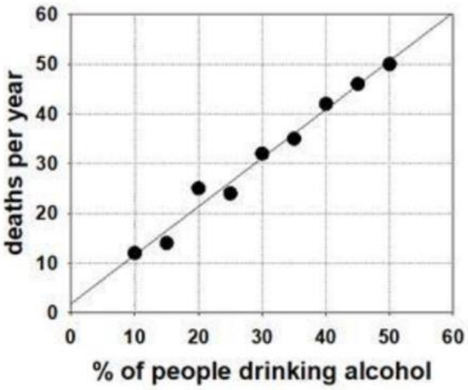
A. 750 km/h

B. 800 km/h

C. 850 km/h

D. 900 km/h

5. Given graph depicts the data of people drinking alcohol and deaths per year in nine villages. Which of the following can be definitely concluded from this graph?



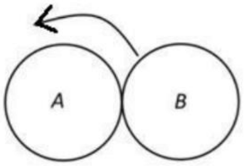
A. Drinking alcohol kills people.

B. Percentage of people drinking alcohol is determined by the number of deaths per year.

C. Alcohol kills people only in the villages.

D. In the village where 50% people drink alcohol, 50 people die each year.

6. Two circular coins A and B are of the same size. A is stationary and B rolls over A touching its surface without slipping. The number of rotations B makes around its centre when it completes one revolution around A is



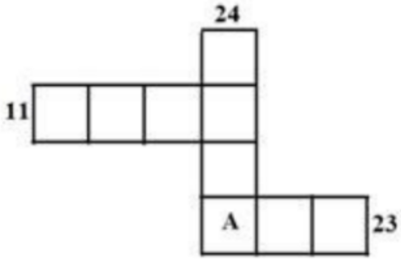
A. $\frac{1}{2}$

B. 1

C. 2

D. 3

7. The squares in the following grid are filled with numbers 1 to 9 without any repetition, such that they add to 11 and 23 in the two horizontal rows and to 24 in the vertical column. What number appears in the square marked **A**?



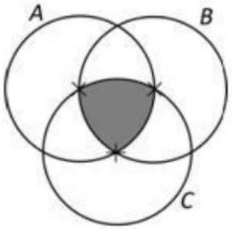
A. 6

B. 7

C. 8

D. 9

8. A. B and C are circles of unit radius. Their centres are marked (×). The area of the shaded region is (hint: area of an equilateral triangle of unit side length is $\frac{\sqrt{3}}{4}$)



A. $\left(\frac{\pi}{2}-\frac{\sqrt{3}}{2}\right)$

B. $\left(\frac{\sqrt{3}}{4}+\pi\right)$

C. $\left(\frac{\sqrt{3}\pi}{4}\right)$

D. $\left(\frac{\sqrt{3}}{4}-\frac{\pi}{8}\right)$

9. Two cylindrical candles A and B of same height (H cm) and radius r and r/2 cm, respectively are ignited at the same time. If the candle A is reduced to 0.8 H height in 30 minutes, what would be the remaining height of the candle B in 30 minutes?

A. 0.6 H

B. 0.4 H

C. 0.2 H

D. 0.8 H

10. Among A, B, C and D. C is shorter than D but smarter than D. B is taller than D, but not smarter than D. A is not taller than C, but smarter than C. Then among them

A. A is the shortest and B is the least smart

B. B is the shortest and C is the least smart

C. B is the shortest and A is the least smart

D. C is the shortest and A is the least smart.

11. Consider a dataset A with 55 distinct observations. A new dataset C is created by adding 2023 to all observations in dataset A. Which of the following is NOT true?

A. Mean of C = 2023 + Mean of A.

B. Variance of C = Variance of A.

C. (Maximum - Minimum) of C = 2023 + (Maximum -Minimum) of A.

D. Median of C = 2023 + Median of A.

12. A number N when increased by 17 becomes divisible by 392. What would be the remainder if N is divided by 98?

A. 69

B. 81

C. 86

D. 91

13. Consider a cube of side 50 inch. After painting it red, it is cut into 10 inch cubes. How many of the 10 inch cubes would have at least two of their faces red?

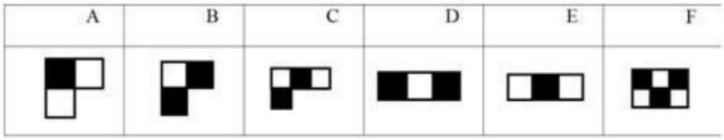
A. 56

B. 36

C. 44

D. 54

14. Which of the following patterns can be repeatedly used without overlapping to make a 8 × 8 chess board?



A. Combination of A and B

B. C only

C. Combination of D and E

D. F only

15. Dividing sixty by half and adding half of forty yields

A. 50

B. 70

C. 100

D. 140

16. Suppose a, b, c, d and e are five positive integers such that the values of a + b, b + c, c + d, de and e + 7 are same. Which of the following values is always same as a?

A. c + e

B. c + d +7

C. d + e – 7

D. (b + c + d)/3

17. Area of a circle inscribed in a regular hexagon of side a is

A. $\frac{2\sqrt{3}}{2}a^2$

B. $6a^2$

C. πa^2

D. $\frac{3\pi}{4}a^2$

18. Hypothetically, if the rotation rate of Earth about its axis is doubled, what would be the time difference (in standard seconds) between 30°E and 60°E longitudes in the equatorial region?

A. 1800

B. 3600

C. 5400

D. 7200

19. Starting from the same point at the same time, A and B run on a 3600 m circular track with speeds of 4 m/s and 6 m/s, clockwise. After A completes the first round on the track, she reverses direction and runs anticlockwise. After how many seconds of starting the run would they cross for the first time?

A. 1200

B. 1620

C. 1080

D. 1020

20. Two varieties of sugar A and B. costing Rs.40 per kg and Rs. 50 per kg, respectively were mixed before selling. The mixture containing 500 kg of A, was sold with a gain of 10% for Rs. 88,000.

How many kilograms of B did the sold mixture contain?

A. 1200

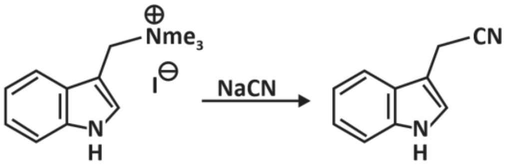
B. 1300

C. 1400

D. 1500

PART B

1.



The above reaction involves

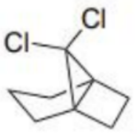
A. nucleophile addition followed by elimination

B. nucleophilic aromatic substitution

C. elimination followed by nucleophile addition

D. bimolecular nucleophilic substitution

2. The number of signals expected for the given compound in 'H and 13C NMR spectra, respectively, are



A. 7 and 8

B. 6 and 5

C. 7 and 5

D. 6 and 8

3. Three measurements of the lead content of a lead oxide nanoparticle sample yielded 15.67 mg, 15.69 mg and 16.03 mg, respectively. The standard deviation (in mg) is

A. 0.25

B. 0.15

C. 0.30

D. 0 20

4. Among the following, the correct thermodynamic equation of state is

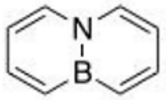
A. $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial T}{\partial S}\right)_V - P$

B. $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$

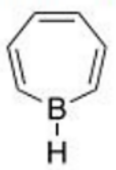
C. $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial S}\right)_V - P$

D. $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial A}{\partial V}\right)_T - P$

5. According to Hückel's rule



M



N

A. M and N are antiaromatic

B. M and N are aromatic

C. M is aromatic and N is antiaromatic

D. M is antiaromatic and N is aromatic

6. For a transition metal M, the correct order of ^{13}C NMR spectral shift [in ppm relative to $Si(CH_3)_4$] for the moieties M-CHs, M-CO and M-C_6H_5, is

A. M—CH_3 < M—C_6H_5 < M—CO

B. M—CO < M—CH_3 < M—C_6H_5

C. M—C_6H_5 < M—CH_3 <M—CO

D. M—CO < M—C_6H_5 < M—CH_3

7. The character table for the point group D_{3h} is given below.

D_{3h}	E	$2C_3$ (z)	$3C'_2$	σ_h (xy)	$2S_3$	$3\sigma_v$		
A'_1	+1	+1	+1	+1	+1	+1	-	$X^2 + y^2, z^2$
A'_2	+1	+1	–1	+1	+1	–1	R_z	-
E’	+2	-1	0	+2	-1	0	(x, y)	$(x^2–y^2, xy)$
A''_1	+1	+1	+1	-1	-1	-1	-	-

A”$_2$	+1	+1	-1	-1	-1	+1	z	-
E”	+2	-1	0	-2	+1	0	(R_x, R_y)	(xz, yz)

In the electronic ground state, BF_3 has D_{3h} symmetry. Therefore,

A. a fundamental transition to an A'$_1$ state is IR active.

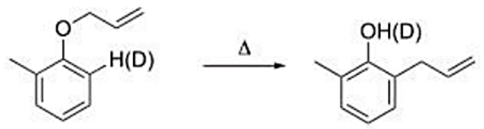
B. a fundamental transition to the A'$_2$ state is neither IR active nor Raman active.

C. a fundamental transition to the A”$_2$ state is Raman active.

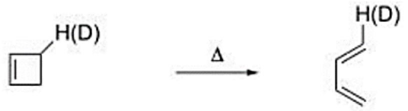
D. a fundamental transition to the E" state is both IR active, as well as Raman active.

8. Among the following reaction(s), deuterium primary kinetic isotope effect is seen in

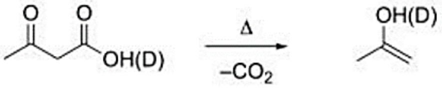
A.



B.



C.



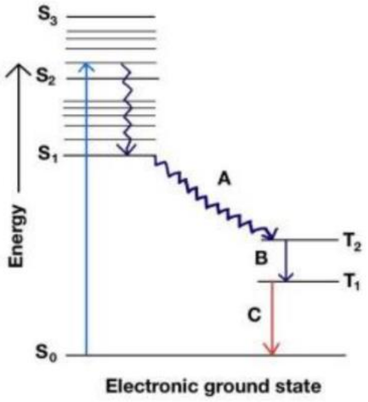
A. A and B

B. B and C

C. Only A

D. Only C

9. In the Jablonski diagram given below, the initial excitation takes place from the singlet ground state to the second singlet excited state, ($S_o \rightarrow S_z$). Match the processes to the events marked as A, B and C.



A. A: Internal conversion, B: Fluorescence, C: Phosphorescence

B. A: Inter system crossing, B: Phosphorescence, C: Phosphorescence

C. A: Internal conversion, B: Phosphorescence, C: Phosphorescence

D. A: Inter system crossing, B: Fluorescence, C: Phosphorescence

10. Of the following statements regarding lanthanoid(Ill) ions/complexes,

A. the metal ion interacts weakly with ligand orbitals.

B. a large number of microstates result in large number of transitions.

C. the f orbitals are deeply buried.

D. they show strong f-f electronic transitions.

the correct statements are

A. A, C and D only

B. B, C and D only

C. A, B and C only

D. B and C only

11. Transition state theory was developed to explain the empirical Arrhenius expression for rate constants. For a non-linear transition state with N atoms, the effective number of vibrational degrees of freedom used in calculating its vibrational partition function is

A. 3N - 6

B. 3N - 7

C. 3N - 5

D. 3N – 8

12. For the proteolytic digestive enzyme pepsin with an isoelectric point (pl) $\approx$ 1, the correct statements, among the following, are

A. It has many aspartic acid residues

B. It has many lysine residues

C. It is involved in the hydrolysis of peptide bonds

D. It is involved in the degradation of fatty acids

A. A and C only

B. B and C only

C. A and D only

D. B and D only

13. The silver salt with the highest solubility product (K_{sp}) in water is

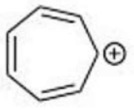
A. AgI

B. AgCl

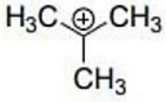
C. AgF

D. AgBr

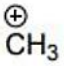
14. In the gas phase, the correct order of hydride affinity for the given carbocations is



A



B



C

A. A > C > B

B. B > C > A

C. C > B > A

D. C > A > B

15. The coordination numbers of cobalt ion in solid $C_{S3}CoCl_5$ and zine ion in solid $(NH_4)_3ZnCl_5$ are, respectively,

A. 5 and 4

B. 4 and 4

C. 4 and 5

D. 5 and 5

16. For the radicals CH_3^* (A), $CH_3CH_2^*$ (B), c-$C_6H_{11}^*$ (C), the correct order for the relative rates of addition to $CH_2 = CHCN$ is

A. A > C > B

B. C > B > A

C. C > A > B

D. B > A > C

17. If A_xB_y crystallizes in an fcc lattice, with atom A occupying every comer and atom B occupying the center of each face of the unit cell, the correct stoichiometry is

A. AB_3

B. AB_2

C. A_2B

D. A_3B

18. In the fission reaction

$$^{235}_{92}U + ^{1}_{0} + ^{1}_{0}n \rightarrow ^{140}_{56}Ba + ^{93}_{36}Kr + 3^{1}_{0}n$$

A. for given masses of ^{235}U (235.0439 amu), ^{140}Ba (139.9106 amu), ^{93}Kr (92.9313 amu) and n (1.00867 amu), and 1 amu (931.494 MeV/c^2), the energy released is

A. 135.0 MeV

B. 200.2 MeV

C. 172.0 MeV

D. 150.0 MeV

19. The change in the entropy and the Gibbs free energy of a system are denoted by ΔS and ΔG, respectively. For reversible melting of ice at 1 atm and 0 °C,

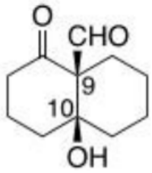
A. $\Delta S >$ and $\Delta G < 0$

B. $\Delta S >$ and $\Delta G = 0$

C. $\Delta S =$ and $\Delta G = 0$

D. $\Delta S =$ and $\Delta G < 0$

20. The absolute configuration of the stereogenic centres present in the following molecule is



A. 9R, 10S

B. 9R, 10R

C. 9S, 10S

D. 9S, 10R

21. The feature that incorrectly describes an ideal detector in gas chromatography, is

A. the adequate sensitivity should be in the range of 10^{-8} to 10^{-15} g solute/s.

B. it has a short response time that is independent of flow rate.

C. it is non-destructive of the sample.

D. there is a linear response to a 10-fold change only in the solute concentration.

22. X, Y and Z are three p-block elements in the second row of the periodic table, with electron affinities (in kJ/mol) of -15, -142 and -333, respectively. The correct statement among the following, is

A. Y has the highest first ionization energy.

B. X has the most number of p-electrons.

C. X has the highest proton affinity.

D. Z has the highest electronegativity.

23. The pair of complexes/ions that does not obey the 18-electron rule, is

A. $[V(CO)_6]$ and $[Ti(Cp)_2Cl_2]$

2. $[Mn(Br)(CO)_5]$ and $[Mn(CO)_5]^-$

3. $[Co(CO)_3PPh_5]^-$ and $[C_{o4}(CO)_{12}]$

4. $[Fe(CO)_5]$ and $[Fe_2(CO)_9]$

24. Consider the following two data sets: $A = \{x_1, x_2, \ldots\ldots, x_{xn}\}$; $B = \{\lambda x_1, \lambda x_2, \ldots., \lambda x_n\}$, where x_i are independent random variables and λ is a positive constant. The ratio of the standard deviation and the average values for the date sets, $r_B = \frac{\sigma_B}{\langle B \rangle}$ and $r_A = \frac{\sigma_A}{\langle A \rangle}$, are related by

A. $r_B = r_A$

B. $r_B = r_A \frac{1}{\lambda}$

C. $r_B = r_A\lambda$

D. $r_B = r_A\sqrt{\lambda}$

25. The two energy levels ($n_x = 1$, $n_y = 6$) and ($n_x = 3$, $n_y = 2$) of a particle in a two-dimensional rectangular box (potential is zero inside, and infinite outside) of sides L_x and L_y are found to be degenerate. If $L_x = 1$ in appropriate units, then L_y is

A. 2

B. 3

C. 4

D. 6

26. At 298 K, a zine electrode is submerged in an acidic 0.9 M Zn^{2+} solution, which is connected by a salt bridge to a 0.3 M Ag^+ solution containing a silver electrode. Given that $Zn/Zn^{2+} = 0.76$ V and $Ag/Ag^+ = -0.80$ V vs SHE at 298 K, the initial voltage of the cell (vs SHE) would be

A. 0.01 V

B. 1.56 V

C. 0.04 V

D. 1.53 V

27. Of the following, the correct statements about carboxypeptidase-A are

A. Zn^{2+} ion acts as a Lewis acid.

B. The substitution of Zn^{2+} ion by Co^{2+} ion renders the enzyme inactive.

C. Two histidine nitrogen atoms, glutamate oxygen atoms) and a water molecule coordinate to a Zn^{2+} ion.

D. Three histidine nitrogen atoms and a water molecule coordinate to a Zn^{2+} ion.

A. A and C only

B. A, C and D only

C. B and D only

D. A and B only

28. The correct set of possible term symbols for the electronic configuration $1s^2 2s^1 2p^1$ is

A. $^1P_1$, $^3P_0$, $^3S_0$

B. $^1P_0$, $^3P_2$, $^3P_0$, $^3P_1$

C. $^1P_1$, $^3P_2$, $^3P_0$, $^3S_1$

D. $^1P_1$, $^3P_2$, $^3P_0$, $^3P_1$

29. The number of oxygen atoms bonded to each phosphorus centre in P_4O_6 and P_4O_{10} respectively, are

A. 4 and 5

B. 3 and 5

C. 3 and 4

D. 5 and 4

30. The EI (electron-impact) mass spectrum of $CH_3(CH_2)_2CN$ will show a base peak at m/z value of

A. 54

B. 26

C. 41

D. 70

31. Given that the pK_{at} and pK_{a2} values for alanine are 2.34 and 9.68, respectively, its isoelectric point (pl) is

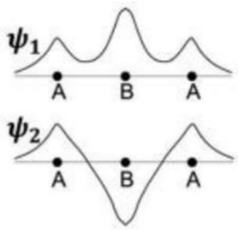
A. 6.01

B. 12.02

C. 7.34

D. 4.14

32. The following plots schematically show the variation of two molecular orbitals Ψ_1 and Ψ_2 along the internuclear axis of a linear triatomic molecule A_2B



If the atomic orbitals corresponding to atoms A and B are, respectively, ϕ_a and ϕ_B the molecular orbitals Ψ_1 and Ψ_2 have the form (all the coefficients are positive)

A. $\Psi_1 = a_1\phi_A + b_1\phi_B + c_1\phi_A$

$\Psi_2 = a_2\phi_A - b_2\phi_B - c_2\phi_A$

B. $\Psi_1 = a_1\phi_A + b_1\phi_B + a_1\phi_A$

$\Psi_2 = a_2\phi_A - b_2\phi_B + a_2\phi_A$

C. $\Psi_1 = a_1\phi_A + b_1\phi_B + c_1\phi_A$

$\Psi_2 = a_2\phi_A - b_b\phi_B + c_2\phi_A$

D. $\Psi_1 = a_1\phi_A + b_1\phi_B + a_1\phi_A$

$\Psi_2 = -a_2\phi_A - b_2\phi_B - a_1\phi_A$

33. The value of the Hammett substituent constant (σ) for *p*-OMe is -0.30. If the pK_a of benzoic acid is 4. 19, that of p-anisic acid is

A. 4.79

B. 3.89

C. 3.59

D. 4.49

34. Considering nitrogen as a central atom, the structures of H3C-N=C=S and HaSi- N=C=S respectively, are

A. bent and linear

B. linear and linear

C. bent and bent

D. linear and bent

35. In the process of desulfurization of flue gas, SO_2 is passed through an absorber containing slaked lime in the presence of O_2. The final product is

A. $CaSO_2.3H_2O$

B. $CaSO_4.CaCO_3$

C. $CaSO_4.2H_20$

D. CaS_2O_4

36. Among the following, the NMR inactive nucleus is

A. $^{14}N_7$

B. $^{31}P_{15}$

D. $^{24}Mg_{12}$

D. $^{29}Si_{14}$

37. The ground state term and the calculated magnetic moment (in BM) for Dy^{3+} ion respectively, are

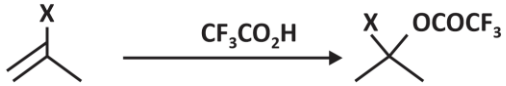
A. $^6H_{15/2}$ and 5.91

B. $^6H_{15/2}$ and 10.65

C. $^6H_{5/2}$ and 6.23

D. $^6H_{5/2}$ and 5.91

38. Based on the given data on the first-order rate constant for the following reactions, the correct statement is



X	k $(10^5\ s^{-1})$
H	4.81
F	340
Cl	1.70

A. F and Cl inductively stabilize the intermediate carbocation

B. Cl stabilizes the intermediate carbocation better than H

C. Cl stabilizes the intermediate carbocation better than F

D. E stabilizes the intermediate carbocation better than H

39. The ^1H NMR spectrum of a mixture of chloroform and acetone shows two singlets at 87.25 and 2.1 pm with integral heights of 12 and 18 mm, respectively. The molar ratio of chloroform to acetone in the mixture is

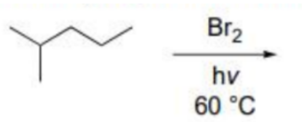
A. 1:6

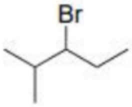
B. 3:2

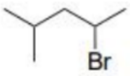
C. 1:3

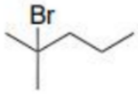
D. 4:1

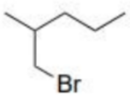
40. The major product formed in the given reaction is



A. 

B. 

C. 

D. 

PART C

1. Among the assertions

A. UO_2^+ is thermodynamically stable in water.

B. UO_2^{2+} is a hard acid.

C. The geometry of UO_2^{2+} is bent.

Both the 5f and 6d orbitals of U are involved in bonding with the 2p orbitals of oxygen atom.

The correct statements for UO_2^{n+} are

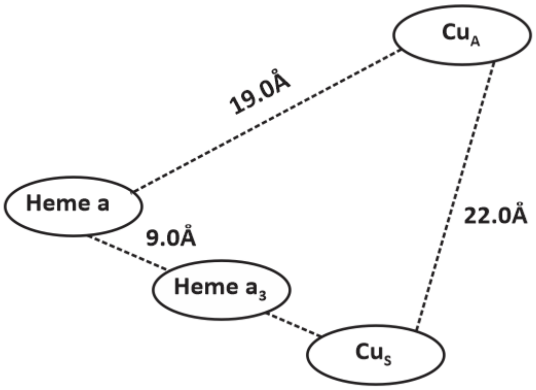
A. A and C only

B. B and D only

C. B, C and D only

D. A and B only

2. For the four active metal centres in cytochrome c oxidase shown below,



A. Electron transfer involves Heme a and Cu_A while O_2 binding involves Heme a_3 and Cu_B.

B. O_2 only interacts with Cu_B to form a Cu(II)-O_2^- species with no role for both the hemes.

C. Heme a is 5-coordinate species with an axial His ligation.

D. Cus is a monomeric 3-coordinate species while Cu. is a dicopper species.

the correct statements are

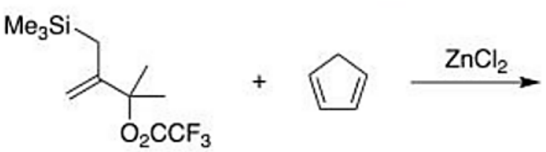
A. A, B and C only

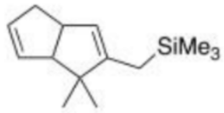
B. C and D only

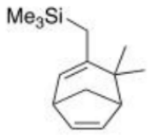
C. B, C and D only

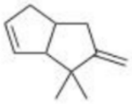
D. A and D only

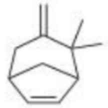
3. The major product formed in the given reaction is



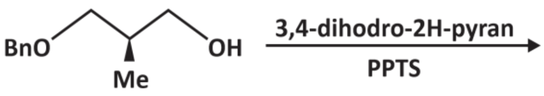
A. 

B. 

C. 

D. 

4. The major product(s) of the given reaction is (are)



A. a mixture of diastereomers

B. a mixture of enantiomers

C. a single enantiomer

D. a single diastereomer

5. Consider the cell, Pt|H_2(g,p^0)|HC(aq)||AgCl(s)|Ag, and the corresponding cell reaction 2 AgCl(s) + H_2(g) $\rightarrow$ 2 Ag(s) + 2 HC(aq) where, p^0 is the standard pressure. In terms of the molality b of HClaq), and the mean activity coefficient γ, the Nernst equation for the cell reaction is

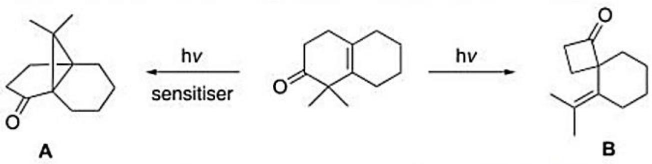
A. $E = E_0 - \frac{2RT}{F}\ln(\gamma b)$

B. $E = E_0 - \frac{RT}{F}\ln(\gamma b)$

C. $E = E_0 - \frac{RT}{2F}\ln(\gamma b)$

D. $E = E_0 - \frac{RT}{F}\ln(2\gamma b)$

6. The mechanisms for the formation of molecules A and B involve, respectively,



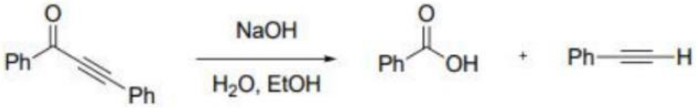
A. oxa-di- π-methane rearrangement and Norrish type II cleavage

B. Norrish type I cleavage and oxa-di-7-methane rearrangement

C. oxa-di-π-methane rearrangement and Norrish type I cleavage

4. Norrish type I cleavage and Norrish type II cleavage

7. The correct expression for the rate of the given reaction is



A. Rate = k[ketone][HO^-]

B. Rate = k[ketone]^2[HO^-]

C. Rate = k[ketone][HO^-]^2

D. Rate = k[ketone]

8. The vibrational energy for a diatomic molecule is given by $G(u) = \left(v + \frac{1}{2}\right)v_e - \left(v + \frac{1}{2}\right)^2 v_e x_e$, where v_e is the fundamental frequency and x_e is the anharmonicity constant. The infrared spectrum of Be molecule in an excited state shows two transitions at 1078.48 cm^{-1} and 1062.42 cm^{-1}, identified as transitions between vibrational levels 2 $\rightarrow$ 3 and 3 $\rightarrow$ 4, respectively. The Ve and v_e x_e (in cm^{-1}) for BeO molecule in this state, respectively, are

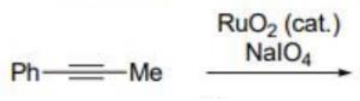
A. 1126.66 and 8.03

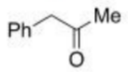
B. 1030.30 and -8.03

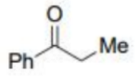
C. 1174.84 and 16.06

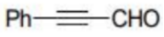
D. 1078.48 and 8.03

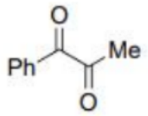
9. The major product formed in the given reaction is



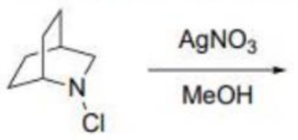
A. 

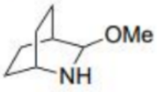
B. 

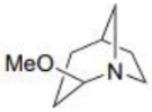
C. 

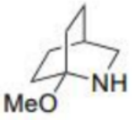
D. 

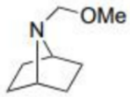
10. The major product formed in the given reaction is



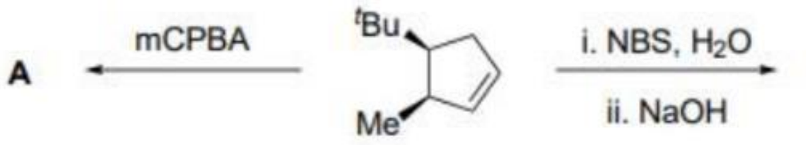
A. 

B. 

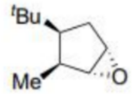
C. 

D. 

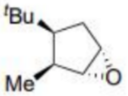
11. The major products A and B in the given reactions are



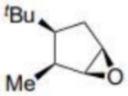
A. **A = B =**



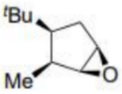
B. **A =**



C. **A =**



D. **A = B =**



12. The correct statements in the following reaction sequence,

$$CO_2 + \mathbf{P} \xleftarrow[\text{reaction B}]{[OH]^-} Fe(CO)_5 \xrightarrow[\text{reaction A}]{H^-} \mathbf{P} + CO$$

$$\mathbf{P} \xrightarrow{\text{excess } [OH]^-} \mathbf{Q}$$

A. the ν_{CO} in P is lower than ν_{CO} in $Fe(CO)_5$.

B. reaction B proceeds via coordinated formyl intermediate.

C. Q is isolelectronic with Ni(CO)4.

D. P is used as a catalyst in water-gas shift reaction.

are

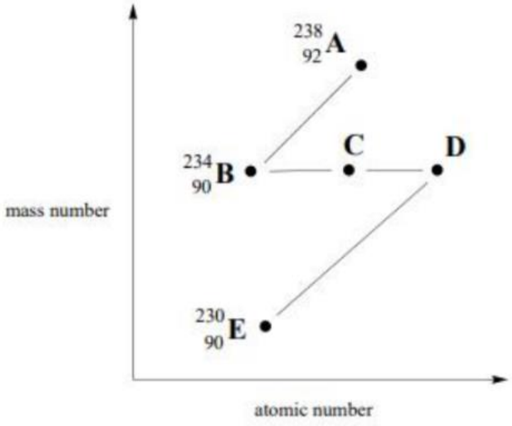
A. A, B and C only

B. B, C and D only

C. A, C and D only

D. A and C only

13. Statements A-D below pertain to the given decay series,



A. The radionuclide (D) is formed by two successive β-particle emissions from the radionuclide (B).

B. The radionuclide (E) is formed by successive β-particle and a-particle emissions from the radionuclide (C).

C. The atomic number of the radionuclide (C) is 91.

D. The atomic number of the radionuclide (D) is 90.

The correct statements are

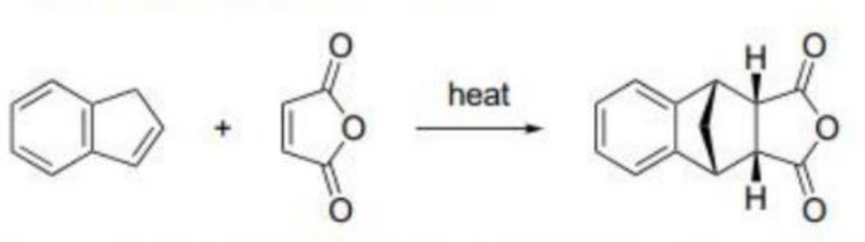
A. A and C only

B. B and D only

C. C and D only

D. A, B and C only

14. The given reaction proceeds via



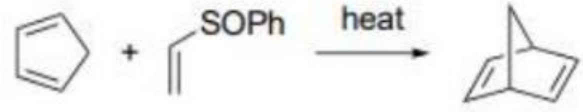
A. A [1,3]-H shift followed by [4+2] cycloaddition

B. A [1,5]-H shift followed by [4+2] cycloaddition

C. A [3+2] cycloaddition followed by hydride shift

D. A [4+2] cycloaddition followed by alkyl shift

15. In the given reaction, CH_2=CHS(O)Ph is a synthetic equivalent of



A. ethyne

B. ethene

C. ethane

D. ketene

16. An ideal gas with an initial pressure P and volume V undergoes an isothermal and reversible expansion. If the change in entropy due to this expansion is AS, the magnitude of work done by the gas is

A. $nR\Delta S$

B. $nR\Delta S/PV$

C. $PV\Delta S/nR$

D. PV/nR

17. A perturbation $H' = V_0(3\cos^2\phi - 1)$, where V_0 is a constant, is applied to a rigid rotator undergoing a rotational motion in a plane. The first order energy correction to the ground state is

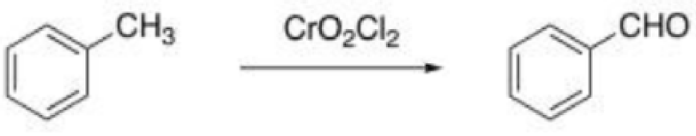
A. $2V_0$

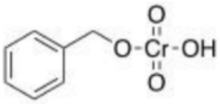
B. $\frac{1}{4}V_0$

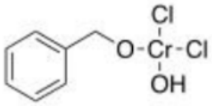
C. $\frac{1}{2}V_0$

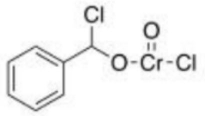
D. V_0

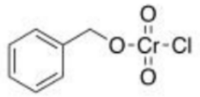
18. The intermediate involved in the given Etard reaction is



A. 

B. 

C. 

D. 

19. Identify P and Q in the following reaction sequence

$$[\mathrm{Mn(CO)_5}]^- + \mathrm{C_3H_5Cl} \longrightarrow \mathrm{P} \xrightarrow{\Delta \text{ or } h\nu} \mathrm{Q}$$

A. P = $[(\eta^1\text{-}C_3H_5)Mn(CO)_4Cl]^-$ and Q = $[(\eta^3\text{-}C_3H_5)Mn(CO)_4]$

B. P = $[(\eta^3\text{-}C_3H_5)Mn(CO)_4Cl]$ and Q = $[(\eta^1\text{-}C_3H_5)Mn(CO)_4]^-$

C. P = $[(\eta^3\text{-}C_3H_5)Mn(CO)_4Cl]^2$ and Q = $[(\eta^1\text{-}C_3H_5)Mn(CO)_4]^2$

D. P = $[(\eta^1\text{-}C_3H_5)Mn(CO)_5Cl]^-$ and Q = $[(\eta^3\text{-}C_3H_5)Mn(CO)_4]$

20. Consider four non-interacting ^{4}He atoms, each of which can occupy three energy levels of energies 0, a and 2a. The number of microstates having total energy E = 3a is

A. 4

B. 12

C. 2

D. 1

21. For the Hamiltonian operator $H = \frac{1}{2m}\hat{p}^2 + \lambda\hat{x}^4$, the best choice among the following trail variational wavefunctions for estimating the ground state energy is

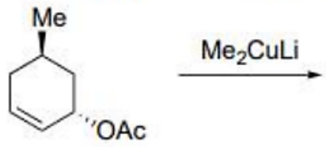
A. $\frac{1}{x^2 + a^2}$

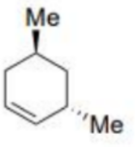
B. $\frac{a}{x^2}$

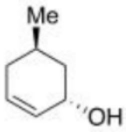
C. $\frac{a}{x}$

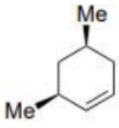
D. $\frac{1}{(x^2 + a^2)^2}$

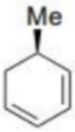
22. The major product formed in the given reaction is



A. 

B. 

C. 

D. 

23. Consider ammonia to be an ideal gas, with each molecule of ammonia occupying an effective area of 7 Å^2 on barium fluoride surface. The adsorption follows the following isotherm.

$$\frac{z}{(1-z)V} = \frac{1}{cV_m} + \frac{(c-1)z}{cV_m}$$

where $z = \frac{p}{p^x}$, c is constant, and V_m the is monolayer capacity (volume of the absorbed gas) at STP. The plot of $\frac{z}{(1-z)V}$ against z gives the intercept as 4.66×10^{-4} cm^{-3} and slope as 0.0761 cm^{-3}. The surface are of adsorption (in m^2) is close to

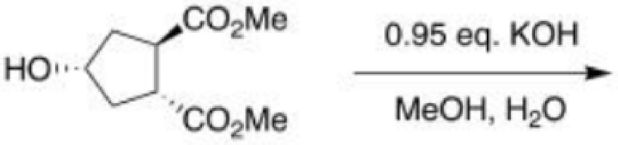
A. 24.5

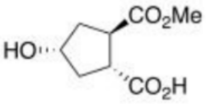
B. 2.5

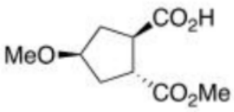
C. 33.2

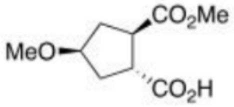
D. 1.9

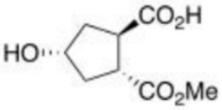
24. The major product formed in the given reaction is



A. 

B. 

C. 

D. 

25. A reaction follows the rate law $-\frac{d[A]}{dt}=k[A]^2$. Starting from an initial concentration $[A]_0$, the time taken for the concentration to reduce to $\frac{[A]_0}{4}$, namely the quarter-life of A, is

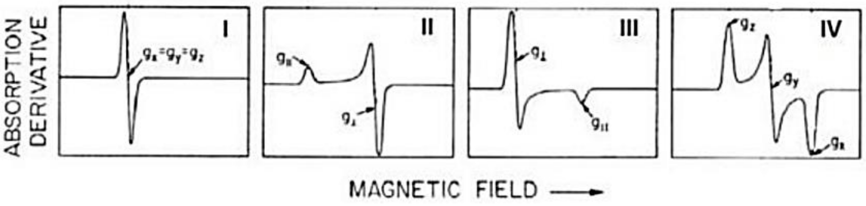
A. $\frac{\ln k}{2}$

B. $\frac{1}{k[A]_0}$

C. $\frac{\ln 2}{k}$

D. $\frac{3}{k[A]_0}$

26. The electron paramagnetic resonance spectrum from among the following, which represents a metal ion with S=1/2 in rhombic symmetry,



A. IV

B. III

C. II

D. I

27. For the Eu^{3+} ion (At No: 63),

A. the calculated and the observed magnetic moments are in agreement with each other.

B. the higher energy states $^7F_1$ and $^2F_2$ are populated and increase the observed magnetic moment.

C. the 4f orbital is more than half-filled.

D. the ground state term symbol is $^7F_0$.

Of the above, the correct statements are

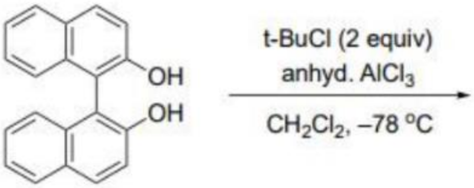
A. A and D only

B. A and B only

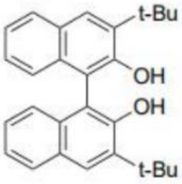
C. C and D only

D. B and D only

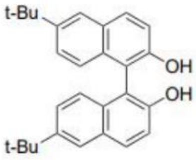
28. The major product formed in the given reaction is



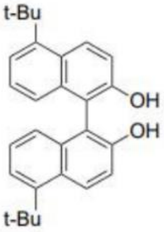
A.



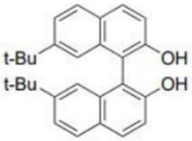
B.



C.



D.



29. Given the spectral transitions for $[CrF_6]^{3-}$ complex as, 671 nm $[^4A_{2g} \rightarrow {}^4T_{2g}]$, 441 nm $[^4A_{2g} \rightarrow {}^4T_{1g}(F)]$ and 291 nm $[^4A_{2g} \rightarrow {}^4T_{1g}(P)]$, the Reach parameter B’ is closet to

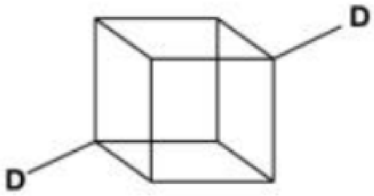
A. 2813 cm^{-1}

B. 1986 cm^{-1}

C. 827 cm^{-1}

D. 213 cm^{-1}

30. Sym-cubane-da, the structure of which is given below, is a bi-substituted isotopomer of cubane, where two hydrogens are substituted by deuterium.



The point group of this molecule is

A. D_{2h}

B. D_{3d}

C. C_{3v}

D. C_{2h}

31. The tunnelling probability of a particle with energy E incident on a potential barrier of height V and width L is given by the expression

$$T(E) = 16\frac{E}{V_0}\left(1 - \frac{E}{V_0}\right)e^{-2kL}$$

where k is a constant. For a certain particle with $E = \frac{V_0}{2}$, the tunnelling probability was found to be 1.6 × 10^{-7}. If the width of the potential is halved, then the tunnelling probability will be

A. 3.2×10^{-7}

B. 8.0×10^{-4}

C. 6.4×10^{-7}

D. 3.2×10^{-3}

32. Match the following complexes with their characteristics

Complex	**d-electron(s)**	**Total valence electrons**
(i) $[WCl_6]$	(a) 2	(x) 12
(ii) $[WCl_6]^-$	(b) 1	(y) 13
(iii) $[WCl_6]^{2-}$	(c) 0	(z) 14

The correct combination is

A. (i) (c) (x); (ii) (b) (y); (iii) (a) (z)

B. (i) (a) (x); (ii) (b) (z); (jii) (c) (y)

C. (i) (c) (z); (ii) (b) (y); (iii) (a) (x)

D. (iii) (c) (x); (ii) (b) (z); (i) (a) (y)

33. The rate of an acid-catalyzed reaction in aqueous solution follows the rate equation given below.

$$v = k[X^+]\,[Y^{2-}]\,[H^+]$$

The rate constants for the reaction at ionic strengths of 16 mol L^{-1} and 9 mol L^{-1} are k_1 and k_2, respectively.

The value $\log\left(\frac{k_1}{k_2}\right)$ in the units of the Debye-Huckel constant B, is

A. –2

B. $\frac{4}{3}$

C. $\frac{16}{9}$

D. –4

34. The correct set of reagents required to convert ethyl benzoate to ethylbenzene is

A. (1) MeMgI (excess); (2) $H3O^+$; (3) 1,2-ethanedithiol, $BF_3.Et_2O$; (4) H_2, Raney Ni

B. (1) Me_2TiCp_2: (2) H_3O^+; (3) 1,2-ethanediol, BF_3 Et_2O; (4) N_2H_4, H_2O_2

C. (1) Me_2TiCp_2: (2) H_3O^+; (3) 1,2-ethanedithiol, $BF_3.Et_2O$; (4) H_2, Raney Ni

D. (1) EtMgI (excess): (2) H_3O^+: (3) 1,2-ethanediol, BF_3 Et_2O; (4) N_2H_4, H_2O_2

35. The difference between the lowest energy and the next higher energy conformers (in kcal mol^{-1}) of meso-2.3-dibromobutane is

Given: Gauche interactions (kcal mol^{-1}): Me/Me = 0.90; Me/Br = 0.25; Br/Br = 0.75

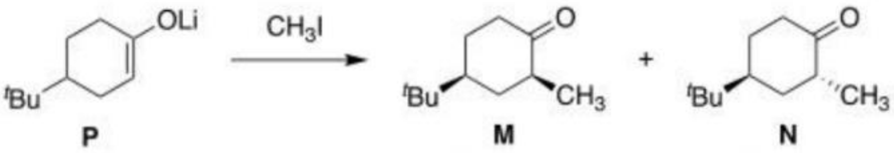
A. 1.40

B. 1.65

C. 1.90

D. 0.50

36. Alkylation of lithium enolate P occurs through a



A. chair-like transition state and the major product is N

B. chair-like transition state and the major product is M

C. twist boat-like transition state and the major product is M

D. twist boat-like transition state and the major product is N

37. The operator for the square of the angular momentum for an electron in a hydrogenic atom is given below.

$$\hat{L}^2 = \hbar^2\left[\frac{\partial^2}{\partial\theta^2}+\cot\theta\frac{\partial}{\partial\theta}+\frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\phi^2}\right]$$

A correct form of the angular function for the p_x orbital is

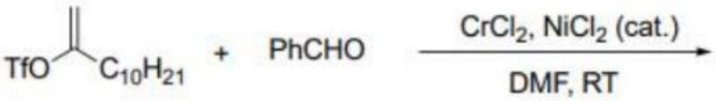
A. $\sin\theta e^{2i\phi}$

B. $\sin\theta e^{i\phi}$

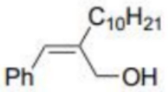
C. $\cos\theta e^{i\phi}$

D. $\cos\theta\, e^{2i\phi}$

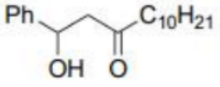
38. The major product formed in the given reaction is



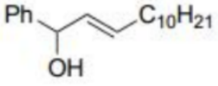
A.



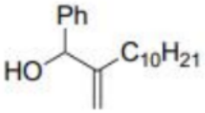
B.



C.



D.



39. The statement regarding the properties of Type I Blue copper proteins that is true is

A. The Cu(II) centre is bound to His and Cys amino acids only.

B. In the EPR spectrum, the A value in Blue copper proteins is greater than the Ai value of free Cu(II) ion.

C. There is an intense absorption band in the electronic spectrum at $\lambda_{max} \approx 600\,\text{nm}$ and $\varepsilon_{max} \approx 100$ times greater than the Emax of aqueous Cu(II) ion.

D. It exists as a pair of Cu(II) centres.

40. Among SF_4, $[ClO_4]^-$, $FClO_3$ and $[IF_4]^+$ the number of species having "see-saw" shape is

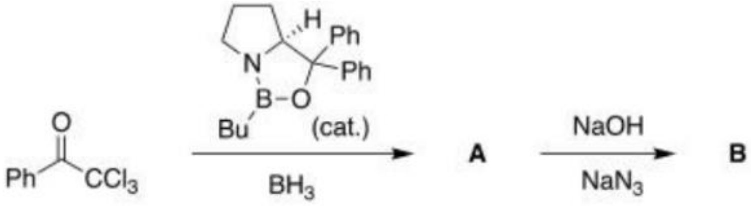
A. 2

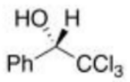
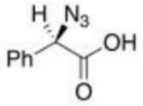
B. 1

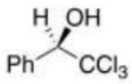
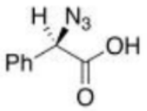
C. 3

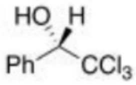
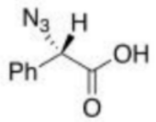
D. 4

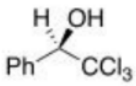
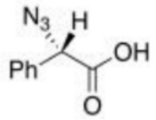
41. The major products A and B formed in the given reaction sequence are



A. **A** =  **B** = 

B. **A** =  **B** = 

C. **A** =  **B** = 

D. **A** =  **B** = 

42. The result of applying the operator $e^{-ia\hat{p}/\hbar}$ on the function f(x) is

A. $+a\frac{df(x)}{dx}$

B. f(x + a)

C. $-a\frac{df(x)}{dx}$

D. f(x – a)

43. In the solid state, methyllithium is tetrameric and has a Li_4 core. The correct statement about the structure and bonding in methyllithium is

A. Each methyl anion is bridging between two Li-centres via 3-center-2-electron bonding.

B. Each methyl anion binds to three Li centres via 4-center-2-electron bonding.

C. It possesses a 2-center-2-electron bond.

D. Each methyl anion is terminally bound to each Li-centre.

44. A particular sample of polymer has 100 chains with molecular weight 1000, 200 chains with molecular weight 10000, and 200 chains with molecular weight 100000.

The polydispersity of the sample is

A. 1.485

B. 1.970

C. 2.068

D. 3.532

45. Consider the following reaction scheme and the related statements.

$$\mathrm{BrF} \xrightarrow{\text{disproportionation}} \mathrm{Br_2\,(g)} + \mathbf{X}\ \text{(T shaped geometry)}$$

$$\mathbf{X} \xrightarrow{\text{self ionization}} \mathbf{Y}\ \text{(cation)} + \mathbf{Z}\ \text{(anion)}$$

A. X, Y and Z have the same number of lone pairs of electrons.

B. Y has a bent shape.

C. Z is sp^3 hybridized and has tetrahedral shape.

D. X is used as a non-aqueous solvent.

The correct statements are

A. A and B only

B. A and D only

C. C and D only

D. A, B, and D only

46. The correct statements concerning $H(CHB_{11}Cl_{11})$, are

A. Its conjugate base is a non-coordinating anion.

B. $[CHB_{11}Cl_{11}]^-$ has a stable icosahedral geometry.

C. It is a superacid.

D. It can protonate fullerene and benzene.

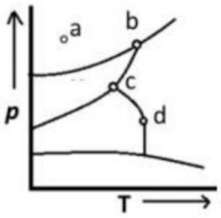
A. A and C only

B. B, C and D only

C. A, B, C and D

D. A, B and C only

47. The phase diagram for a one-component system is shown below.



The number of degrees of freedom at the points marked a, b, c and d, respectively, are

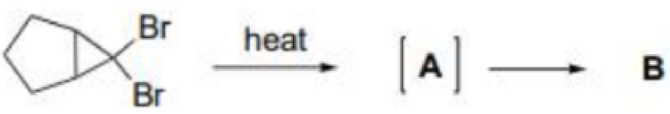
A. 2, 0, 0, 1

B. 1, 3, 3, 2

C. 2, 1, 0, 1

D. 0, 1, 2, 1

48. The intermediate A and the major product B formed in the given reaction, respectively, are



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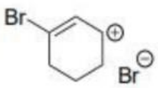

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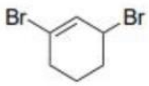
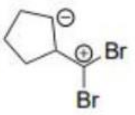
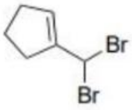


B. **A =**

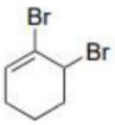


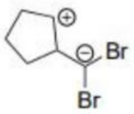
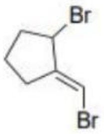
B =



C. **A =**

B =



D. **A =**  **B =** 

49. Acetone undergoes photodissociation upon absorption of 330 m light. Exposure of a gaseous sample of acetone to a radiant power of 20 mW at 330 m for a period of 3 hours results in the photodissociation of 75 umol of acetone. The quantum yield for the photodissociation, assuming all the light is absorbed, is

A. 1.26×10^{-4}

B. 1.26×10^{-1}

C. 1.26×10^{-3}

D. 1.26×10^{-2}

50. The number of cation vacancies per mole, when NaCl is doped with 10^{-3} mol% of BCl_3, is

A. 12.046×10^{23}

B. 12.046×10^{18}

C. 6.023×10^{20}

D. 6.023×10^{18}

51. The correct order of second ionization enthalpies, is

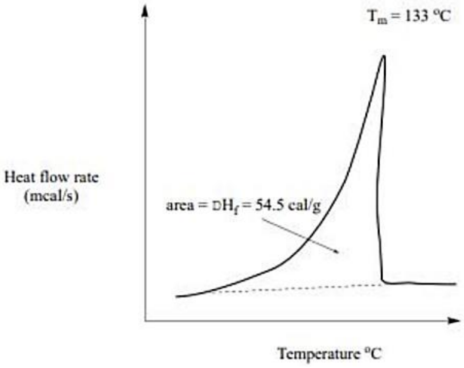
A. B>C>N> Be

B. N>C> Be > B

C. B>N>C> Be

D. N>B>C> Be

52. In the differential scanning calorimetry plot of a polyethylene sample (given below), if the heat of fusion is 68.4 cal/g, the percent crystallinity of the sample,



is

A. 100%

B. 55%

C. 68%

D. 79%

53. The transference number of the hydrogen ion in an aqueous solution containing HCl and NaCl is 0.5. The limiting molar conductivities of H^+, Na^+ and Cl^- are, respectively, 350 × 10^{-4} Sm^2mol^{-1}, 50 × 10^{-4} Sm^2mol^{-1} and 75 × 10^{-4} Sm^2 mol^{-1}. The ratio of the concentrations of HCl and NaCl, namely $\frac{[HCl]}{[NaCl]}$ is

A. $\frac{10}{11}$

B. $\frac{11}{5}$

C. $\frac{5}{11}$

D. $\frac{11}{10}$

54. A yellow-colored complex P upon addition of aqueous HNO; forms a very pale violet-colored complex Q. Complex Q on reaction with NaCl forms a yellow-colored complex R. The species P, Q and R, respectively, that are consistent with the above observations, are

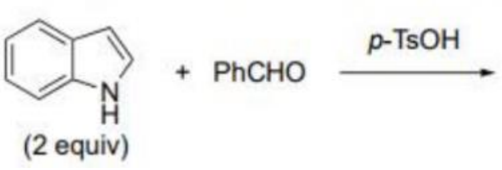
A. P = $[Fe(H_2O)_5(OH)]^{2+}$; Q = $[Fe(H_2O)_6]^{3+}$ and R = $[Fe(H_2O)_5(Cl)]^{2+}$

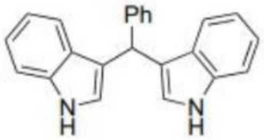
B. P = $[Fe(H_2O)_5(OH)]^{+}$; Q = $[Fe(H_2O)_6]^{2+}$ and R = $[Fe(H_2O)_5(Cl)]^{2+}$

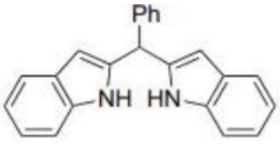
C. P = $[Fe(H_2O)_5(NH_3)]^{2+}$; Q = $[Fe(H_2O)]_5$ (NH3]$^{3+}$ and R = $[Fe(H_2O)_5Cl]^{2+}$

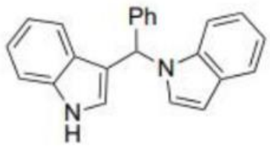
D. P = $[Fe(H_2O)_5(OH_3)]^{3+}$; Q = $[Fe(H_2O)_6]^{3+}$ and R = $[Fe(H_2O)_3Cl_3]$

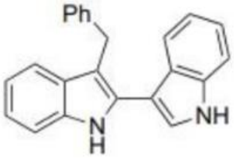
55. The major product formed in the given reaction is



A.


B.


C. 

D. 

56. A three-state system with energies $E=-\varepsilon_0 0,+\varepsilon_0$ is in a thermal equilibrium at a temperature T. If $\beta\varepsilon_0 = x,$ the probability of finding the system with energy E = 0 is [recall, cosh $x=\frac{1}{2}(e^x+e^{-x})$]

A. $(2 \cosh x)^{-1}$

B. $\frac{1}{2}\cosh x$

C. $(1 + 2 \cosh x)^{-1}$

D. 1 + 2 cosh x

57. Five moles of $[B_9H_{14}]^-$ react with two moles of BsH9 at 85° C resulting in the evolution of nine moles of H_2 and the formation of a monoanionic borane cluster that has a

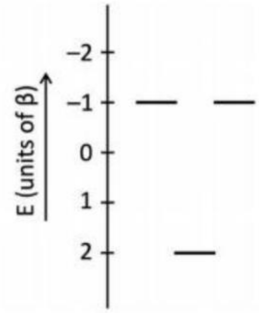
A. Nido structure

B. Closo structure

C. Arachno structure

D. Hypo structure

58. The energy level diagram for the π -molecular orbitals of the cyclic C_3H_3 radical is given below.



The delocalization energy of the molecule in the ground state (in units of β, where β is Hückel's constant for interaction energy) is

A. 3

B. 1

C. 0

D. 2

59. The number of unpaired electrons in [Cp_2Fe], [Cp_2Ni] and [Cp_2Co] complexes are, respectively,

A. 0, 0 and 1

B. 0, 2 and 1

C. 0, 1 and 2

D. 2, 2 and 1

60. Of the following assertions regarding the mechanism of electron transfer,

A. An outer-sphere mechanism involves electron transfer from reductant to oxidant, with the coordination shells or spheres of each staying intact.

B. In inner-sphere mechanism, the reductant and oxidant share a ligand in their inner or primary coordination sphere which assists in electron being transferred.

C. In inner-sphere mechanism, an oxidant possesses at least one ligand capable of binding simultaneously to two metal ions.

D. In inner-sphere mechanism, ligands of reductant are substitutionally inert.

The correct statements are

A. A and D only

B. A, B and C only

C. B and C only

D. B, C and D only