Chemistry 2022

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Q.1 - Q.5 Carry ONE mark each.

1. Inhaling the smoke from a burning ________ could ________ you quickly.
   (a) tier/tier
   (b) tire/tyre
   (c) tyre/tire
   (d) tyre/tier

2. A sphere of radius r cm is packed in a box of cubical shape.

   What should be the minimum volume (in cm^3) of the box that can enclose the sphere?
   (a) $\frac{r^3}{8}$
   (b) r^3
   (c) $2r^3$
   (d) $8r^3$

3. Pipes P and Q can fill a storage tank in full with water in 10 and 6 minutes, respectively. Pipe R draws the water out from the storage tank at a rate of 34 litres per minute. P, Q and R operate at a constant rate.

   If it takes one hour to completely empty a full storage tank with all the pipes operating simultaneously, what is the capacity of the storage tank (in litres)?
   (a) 26.8
   (b) 60.0
   (c) 120.0
   (d) 127.5

4. Six persons P, Q, R, S, T and U are sitting around a circular table facing the center not necessarily in the same order. Consider the following statements:
   - P sits next to S and T.

- Q sits diametrically opposite to P.
- The shortest distance between S and R is equal to the shortest distance between T and U.

Based on the above statements, Q is a neighbor of

(a) U and S
(b) R and T
(c) R and U
(d) P and S

5. A building has several rooms and doors as shown in the top view of the building given below. The doors are closed initially.

What is the minimum number of doors that need to be opened in order to go from the point P to the point Q?

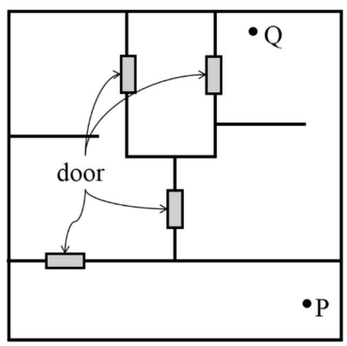


Figure 1

(a) 4
(b) 3
(c) 2
(d) 1

Q. 6 – Q. 10 Carry TWO marks each.

6. Rice, a versatile and inexpensive source of carbohydrate, is a critical component of diet worldwide. Climate change, causing extreme weather, poses a threat to sustained availability of rice. Scientists are working on developing Green Super Rice (GSR), which is resilient under extreme weather conditions yet gives higher yields sustainably

Which one of the following is the CORRECT logical inference based on the information given in the above passage?

(a) GSR is an alternative to regular rice, but it grows only in an extreme weather

(b) GSR may be used in future in response to adverse effects of climate change

(c) GSR grows in an extreme weather, but the quantity of produce is lesser than regular rice

(d) Regular rice will continue to provide good yields even in extreme weather

7. A game consists of spinning an arrow around a stationary disk as shown below. When the arrow comes to rest, there are eight equally likely outcomes. It could come to rest in any one of the sectors numbered 1, 2, 3, 4, 5, 6, 7 or 8 as shown.

   Two such disks are used in a game where their arrows are independently spun.

   What is the probability that the sum of the numbers on the resulting sectors upon spinning the two disks is equal to 8 after the arrows come to rest?

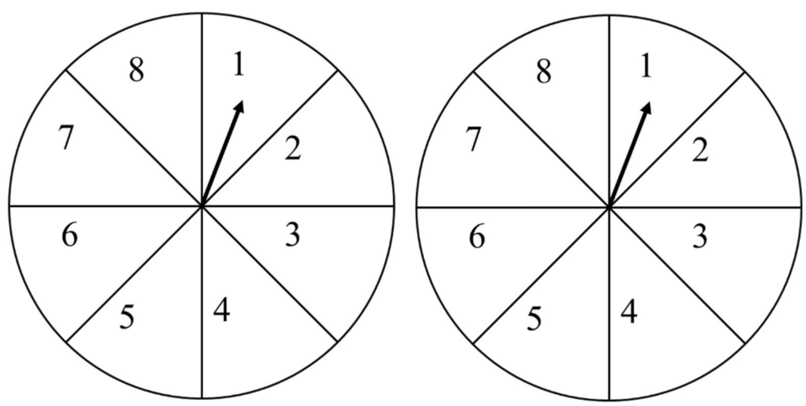


Figure 2

(a) $\frac{1}{16}$

(b) $\frac{5}{64}$

(c) $\frac{3}{32}$

(d) $\frac{7}{64}$

8. Consider the following inequalities.

   (i) $3p - q < 4$

   (ii) $3q - p < 12$

   Which one of the following expressions below satisfies the above two inequalities?

   (a) $p + q < 8$

   (b) $p + q = 8$

   (c) $8 \leq p + q < 16$

   (d) $p + q \geq 16$

9. Given below are three statements and four conclusions drawn based on the statements.

Statement 1: Some engineers are writers.
Statement 2: No writer is an actor.
Statement 3: All actors are engineers.

Conclusion I: Some writers are engineers
Conclusion II: All engineers are actors.
Conclusion III: No actor is a writer.
Conclusion IV: Some actors are writers.

Which one of the following options can be logically inferred?

(a) Only conclusion I is correc
(b) Only conclusion II and conclusion III are correct
(c) Only conclusion I and conclusion III are correct
(d) Either conclusion III or conclusion IV is correct

10. Which one of the following sets of pieces can be assembled to form a square with a single round hole near the center? Pieces cannot overlap.

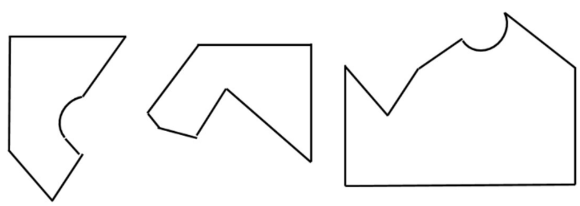


Figure 3

(a)

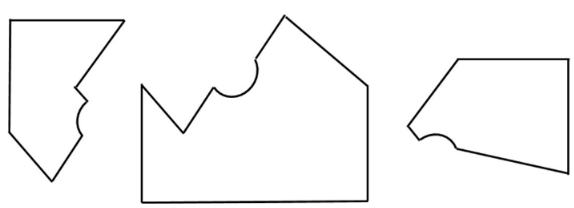


Figure 4

(b)

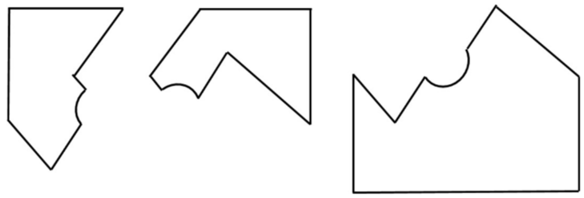


Figure 5

(c)

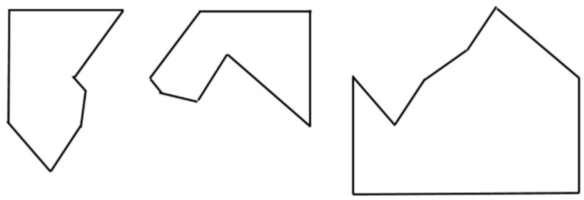


Figure 6

(d)

Q.11 – Q.35 Carry ONE mark Each

11. The major product M formed in the following reaction is

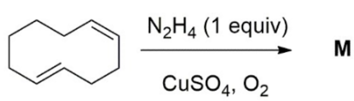


Figure 7

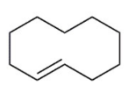


Figure 8

(a)

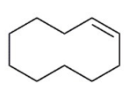


Figure 9

(b)

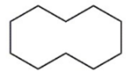


Figure 10

(c)

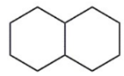


Figure 11

(d)

12. The starting material Y in the following reaction is

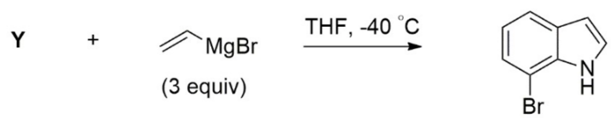


Figure 12

Figure 13

(a)

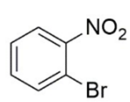


Figure 14

(b)

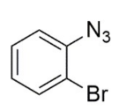


Figure 15

(c)

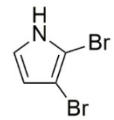


Figure 16

(d)

13. The major product in the given reaction is Q. The mass spectrum of Q shows {[M] = molecular ion peak}

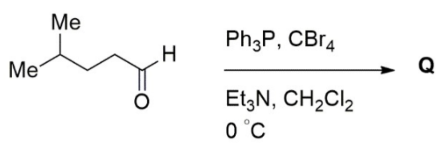


Figure 17

(a) [M], [M+2] and [M+4] with relative intensity of 1:2:1
(b) [M] and [M+2] with relative intensity of 1:1
(c) [M], [M+2] and [M+4] with relative intensity of 1:3:1
(d) [M] and [M+2] with relative intensity of 2:1

14. A tripeptide on treatment with PhNCS (pH = 8.0) followed by heating with dilute HCl afforded a cyclic compound M and a dipeptide. The dipeptide on treatment with PhNCS (pH = 8.0) followed by heating with dilute HCl afforded a cyclic compound N and an acyclic compound O. The CORRECT sequence (from N- to C-terminus) of the tripeptide is

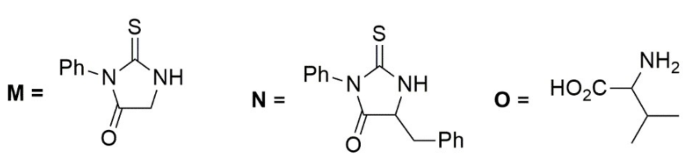


Figure 18

(a) glycine-phenylalanine-valine
(b) valine-phenylalanine-glycine
(c) glycine-tyrosine-valine
(d) glycine-phenylalanine-alanine

15. The major product M in the following reaction is

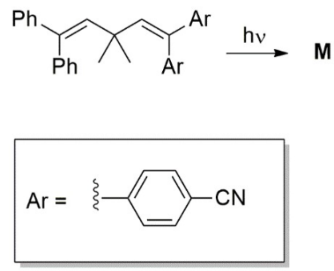


Figure 19

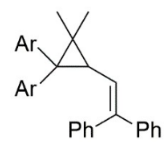


Figure 20

(a)

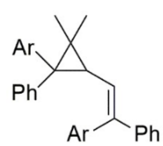


Figure 21

(b)

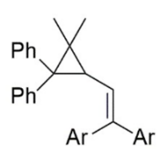


Figure 22

(c)

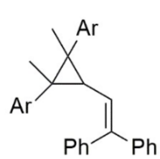


Figure 23

(d)

16. The major product T formed in the following reaction is

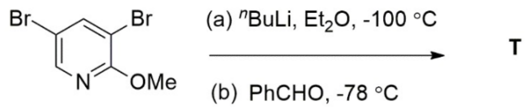


Figure 24

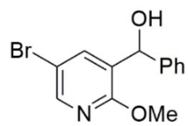


Figure 25

(a)

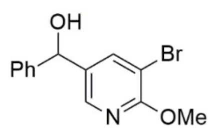


Figure 26

(b)

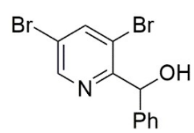


Figure 27

(c)

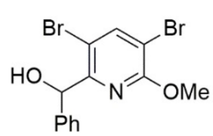


Figure 28

(d)

17. In differential thermal analysis (DTA)

(a) the temperature differences between the sample and reference are measured as a function of temperature

(b) the differences in heat flow into the reference and sample are measured as a function of temperature

(c) the change in the mass of the sample is measured as a function of temperature

(d) the glass transition is observed as a sharp peak

18. The v_{o-o} resonance Raman stretching frequency (cm^{-1}) of the coordinated dioxygen in *oxy-hemoglobin* and *oxy-hemocyanin* appears, respectively, nearly at

(a) 1136 and 744

(b) 1550 and 744

(c) 744 and 1136

(d) 744 and 1550

19. The number of metal-metal bond(s), with σ, π, δ character, present in $[Mo_2(CH_3CO_2)_4]$ complex is(are), respectively,

(a) 1, 2, 1

(b) 1, 2, 0

(c) 1, 1, 0

(d) 1, 1, 1

20. $1s_A$ and $1s_B$ are the normalized eigenfunctions of two hydrogen atoms H_A and H_B, respectively. If S = $\langle s_A \mid s_B \rangle$, the option that is ALWAYS CORRECT is

(a) S = 1

(b) S = 0

(c) S = imaginary constant

(d) $0 \leq S \leq 1$

21. The pure vibrational spectrum of a hypothetical diatomic molecule shows three peaks with the following intensity at three different temperatures.

Peak	Intensity(Arbitrary Unit)		
	300K	600K	900K
I	1.0	1.0	1.0
II	0.1	0.1	0.1
III	0.02	0.04	0.06

Table 1: Caption

The CORRECT statement is

(a) Peak I appears at the lowest energy
(b) Peak II appears at the lowest energy
(c) Peak III appears at the lowest energy
(d) Peak I appears at the highest energy

22. The point group of SF_6 is

(a) D_{6h} (b) O_h (c) D_{6d} (d) C_{6v}

23. A point originally at (1, 3, 5) was subjected to a symmetry operation $\hat{O}_1$ that shifted the point to $(-1, -3, 5)$. Subsequently, the point at $(-1, -3, 5)$ was subjected to another symmetry operation $\hat{O}_2$ that shifted this point to $(-1, -3, -5)$.The symmetry operators $\hat{O}_1$ and $\hat{O}_2$ are, respectively

(a) $\hat{C}_2$(x) and $\hat{\sigma}$(xy)
(b) $\hat{C}_2$(z) and $\hat{\sigma}$(xy)
(c) $\hat{\sigma}$(xy) and $\hat{C}_2$(z)
(d) $\hat{S}_1$ and $\hat{S}_2$

24. Adsorption of a gas with pressure P on a solid obeys the Langmuir adsorption isotherm. For a fixed fractional coverage, the correct relation between K and P at a fixed temperature is

[$K = k_a/k_b, k_a$ and k_b are the rate constants for adsorption and desorption, respectively. Assume non-dissociative adsorption.]

(a) $K \propto P^{-1/2}$ (b) $K \propto P$ (c) $K \propto P^{-1}$ (d) $K \propto P^{-1/2}$

25. The temperature dependence of the rate constant for a second-order chemical reaction obeys the Arrhenius equation. The SI unit of the 'pre-exponential factor' is

(a) s^{-1}
(b) $m^3 mol^{-1} s^{-1}$
(c) $mol m^3 s^{-1}$
(d) $(m^3 mol^{-1})^2 s^{-1}$

26. The CORRECT reagent(s) for the given reaction is(are)

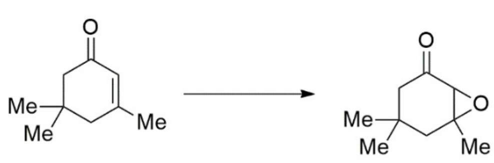


Figure 29

(a) H_2O_2 , NaOH

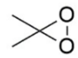


Figure 30

(b)

(c) DIBAL-H, then mCPBA

(d) SO_3 - pyridine, Me_2SO

27. The CORRECT statement(s) about the ^{1}H NMR spectra of compounds **P and Q** is(are)

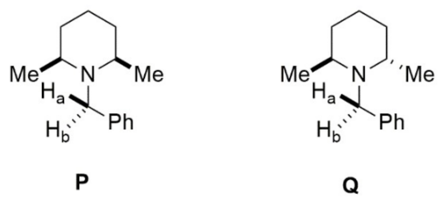


Figure 31

(a) **P** shows a sharp singlet at δ = 3.70 ppm (for H_a and H_b)

(b) **Q** shows a sharp singlet at δ = 3.70 ppm (for H_a and H_b)

(c) **P** shows a AB-quartet centered at δ = 3.63 ppm (for H_a and H_b)

(d) **Q** shows a AB-quartet centered at δ = 3.63 ppm (for H_a and H_b)

28. The CORRECT statement(s) about thallium halides is(are)

(a) TlF is highly soluble in water whereas other Tl-halides are sparingly soluble

(b) TlF adopts a distorted NaCl structure

(c) TlI_3 is isomorphic with CsI_3 and the oxidation state of Tl is +3

(d) Both TlBr and TlCl have CsCl structure

29. The CORRECT statement(s) about the spectral line broadening in atomic spectra is(are)

(a) The collision between atoms causes broadening of the spectral line

(b) Shorter the lifetime of the excited state, the broader is the line width

(c) Doppler broadening is more pronounced as the flame temperature increases

(d) In flame and plasma, the natural line broadening exceeds the collisional line broadening

30. Match the CORRECT option(s) from column A with column B according to the metal centre present in the active site of metalloenzyme.

A		B	
P	Cu	I	B_{12}-coenzyme
Q	Mo	II	Carboxypeptidase
R	Co	III	Nitrate reductase
S	Zn	IV	Cytochrome P-450
		V	Tyrosinase

Table 2: Caption

31. The CORRECT statement(s) about the following phase diagram for a hypothetical pure substance X is(are)

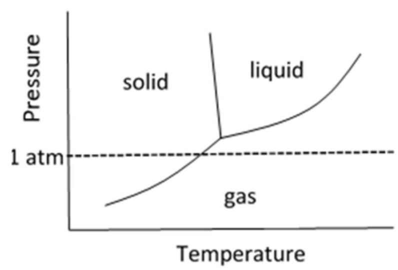


Figure 32

(a) The molar volume of solid X is less than the molar volume of liquid X

(b) X does not have a normal boiling point

(c) The melting point of X decreases with increase in pressure

(d) On increasing the pressure of the gas isothermally, it is impossible to reach solid phase before reaching liquid phase

32. The parameter(s) fixed for each system in a canonical ensemble is(are)

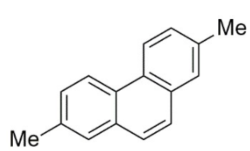
(a) temperature

(b) pressure

(c) volume

(d) composition

33. The number of peaks exhibited by T in its broadband proton decoupled ^{13}C NMR spectrum recorded at 25 °C in $CDCl_3$ is



T

Figure 33

34. The diffraction angle (in degree, rounded off to one decimal place) of (321) sets of plane of a metal with atomic radius 0.125 nm, and adopting BCC structure is

(Given: the order of reflection is 1 and the wavelength of X-ray is 0.0771 nm)

35. For the angular momentum operator $\hat{L}$ and the spherical harmonics $Y_{lm}(\theta, \phi)$,

$$\left(\hat{L}_x^2 + \hat{L}_y^2\right) Y_{21}(\theta, \phi) = n\, \hbar^2\, Y_{21}(\theta, \phi).$$

The value of n is

Q.26 – Q.55 Carry TWO marks Each

36. The major product P obtained in the following reaction sequence is

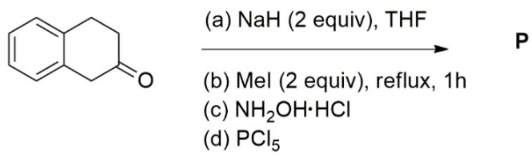


Figure 34

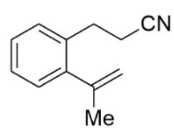


Figure 35

(a)

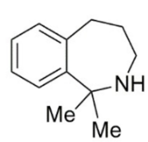


Figure 36

(b)

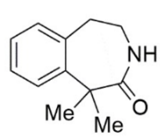


Figure 37

(c)

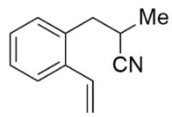


Figure 38

(d)

37. The major product Q obtained in the following reaction sequence is

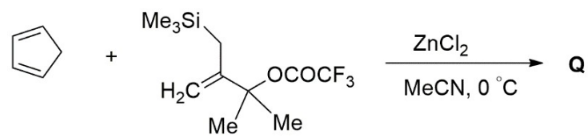


Figure 39

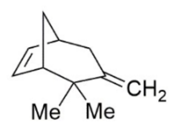


Figure 40

(a)

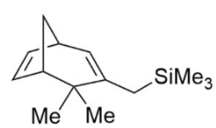


Figure 41

(b)

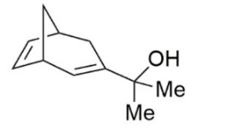


Figure 42

(c)

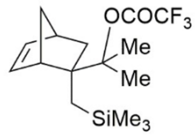


Figure 43

(d)

38. The major product P obtained in the following reaction sequence is

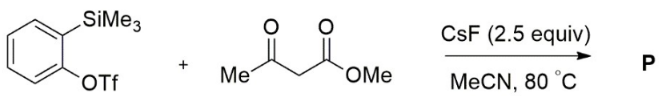


Figure 44

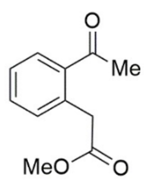


Figure 45

(a)

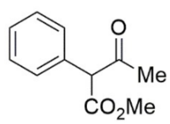


Figure 46

(b)

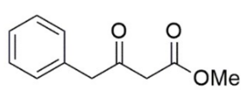


Figure 47

(c)

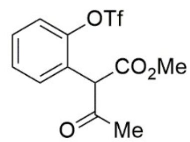


Figure 48

(d)

39. The major product P obtained in the following reaction sequence is

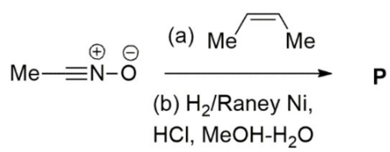


Figure 49

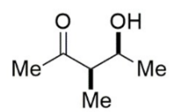


Figure 50

(a)

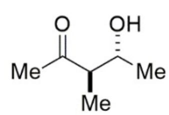


Figure 51

(b)

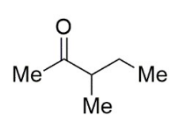


Figure 52

(c)

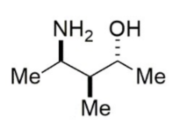


Figure 53

(d)

40. The major product P obtained in the following reaction sequence is

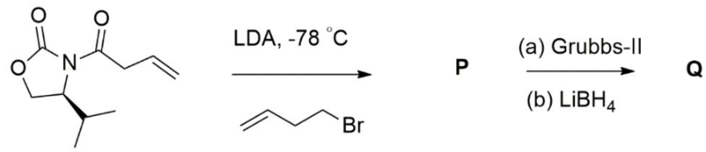


Figure 54

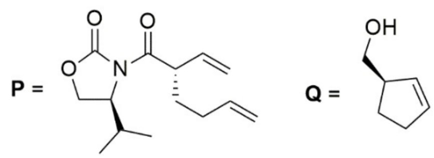


Figure 55

(a)

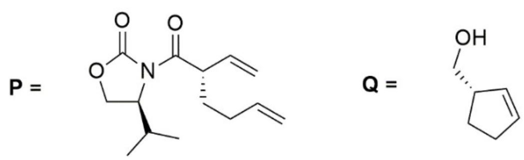


Figure 56

(b)

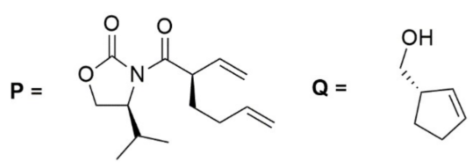


Figure 57

(c)

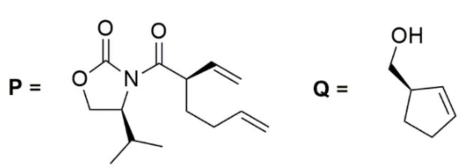


Figure 58

(d)

41. The major product P obtained in the following reaction sequence is

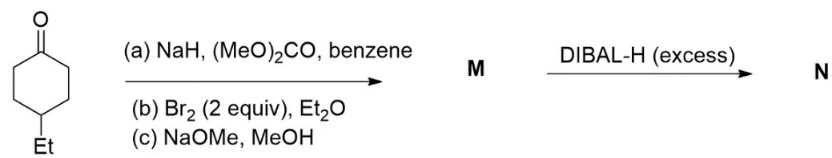


Figure 59

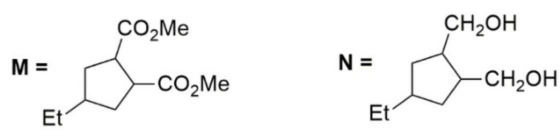


Figure 60

(a)

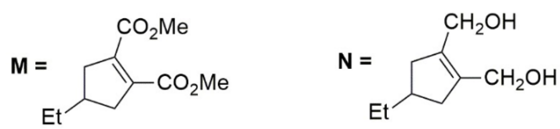


Figure 61

(b)

Figure 62

(c)

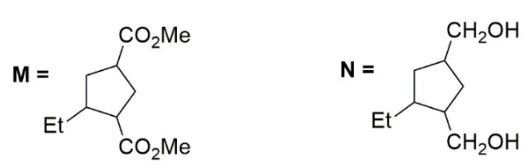


Figure 63

(d)

42. Three different crystallographic planes of a unit cell of a metal are given below (solid circles represent atom). The crystal system of the unit cell is

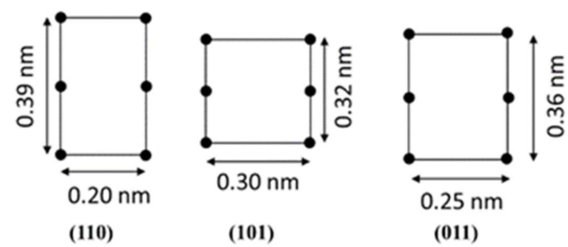


Figure 64

(a) triclinic
(b) monoclinic
(c) tetragonal
(d) orthorombic

43. The number of equivalents of H_2S gas released from the active site of *rubredoxin, 2-iron ferredoxin, and 4-iron ferredoxin* when treated with mineral acid, respectively, are

(a) 4,6,8
(b) 0,2,4
(c) 1,2,4
(d) 0,2,3

44. The number of $\nu_{S=O}$ stretching vibration band(s) observed in the IR spectrum of the high-spin $[Mn(dmso)_6]^{3+}$ complex (dmso: dimethylsulfoxide) is

(a) only one
(b) two with intensity ratio 1:2
(c) two with intensity ratio 1:1
(d) six with intensity ratio 1:1:1:1:1:1

45. *indicates a radioactive isotope

$$[Fe(H_2O)_6]^{2+} + [Fe^*(H_2O)_6]^{3+} \xrightarrow{k_{11}} [Fe(H_2O)_6]^{3+} + [Fe^*(H_2O)_6]^{2+}$$

$$[Fe(bpy)_3]^{2+} + [Fe^*(bpy)_3]^{3+} \xrightarrow{k_{22}} [Fe(bpy)_3]^{3+} + [Fe^*(bpy)_3]^{2+}$$

(bpy = bipyridyl)

$$[Co(NH_3)_6]^{2+} + [Co^*(NH_3)_6]^{3+} \xrightarrow{k_{33}} [Co(NH_3)_6]^{3+} + [Co^*(NH_3)_6]^{2+}$$

Figure 65

The rate constants in the given self-exchange electron transfer reactions at a certain temperature follow

(a) $k_{11} > k_{22} > k_{33}$

(b) $k_{22} > k_{11} > k_{33}$

(c) $k_{22} > k_{22} > k_{11}$

(d) $k_{22} > k_{33} > k_{11}$

46. The CORRECT distribution of the products in the following reaction is

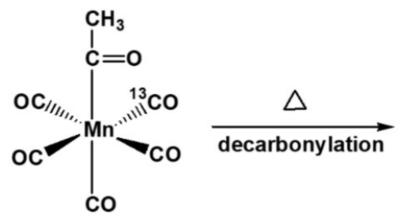


Figure 66

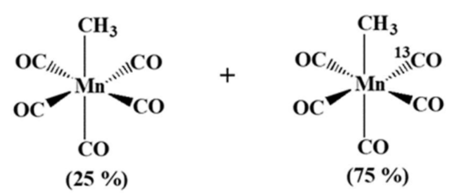


Figure 67

(a)

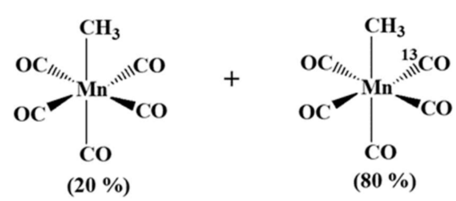


Figure 68

(b)

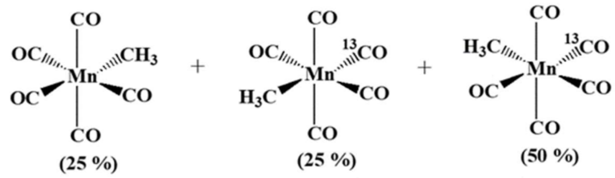


Figure 69

(c)

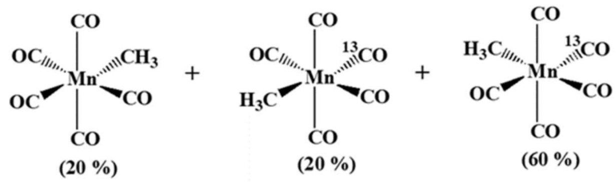


Figure 70

(d)

47. The addition of $K_4[Fe(CN)_6]$ to a neutral aqueous solution of the cationic species of a metal produces a brown precipitate that is insoluble in dilute acid. The cationic species is

(a) Fe^{3+} (b) $UO_2{}^{2+}$ (c) Th^{4+} (d) Cu^{2+}

48. The electronic spectrum of a Ni(II) octahedral complex shows four $d-d$ bands, labelled as **P, Q, R, and S**. Match the bands corresponding to the transitions.

λ_{max}, nm (ϵ , $M^{-1}cm^{-1}$		Transitions	
P	1000 (50)	I	${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(P)$
Q	770 (8)	II	${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(F)$
R	630 (55)	III	${}^3A_{2g}(F) \rightarrow {}^3T_{2g}(F)$
S	375 (110)	IV	${}^3A_{2g}(F) \rightarrow {}^3E_g(D)$

Table 3: Caption

(a) P-IV, Q-III, R-II, S-I
(b) P-III, Q-IV, R-II, S-I
(c) P-II, Q-IV, R-I, S-III
(d) P-I, Q-IV, R-II, S-III

49. In the following table, the left column represents the rigid-rotor type and the right column shows a set of molecules.

P. Symmetric Motor (Oblate)	1.SiH_4
Q. Symmetric Motor (Prolate)	2.CH_3Cl
R. Spherical Rotor	C_6H_6
S. Asymmetrical Rotor	CH_3OH
	CO_2

Table 4: Caption

(a) P-1, Q-2, R-3, S-4

(b) P-3, Q-2, R-1, S-4

(c) P-3, Q-5, R-1, S-2

(d) P-5, Q-4, R-3, S-2

50. The CORRECT statement regarding the following three normal modes of vibration of SO_3

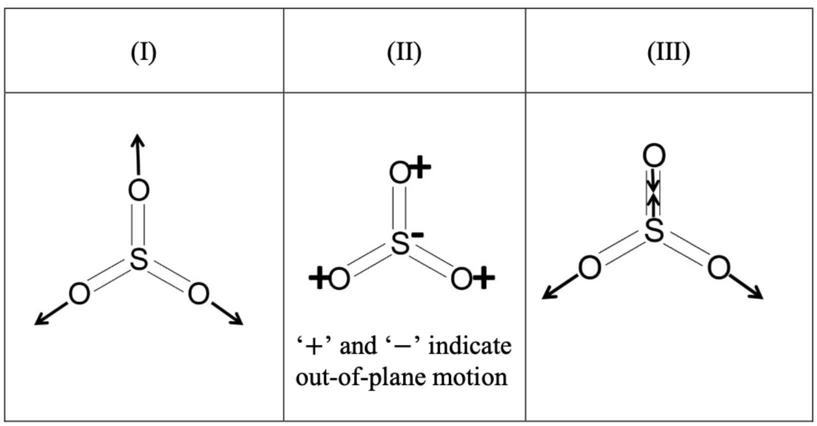


Figure 71

(a) (I) and (II) are infrared active while (III) is infrared inactive

(b) (I) is infrared inactive while (II) and (III) are infrared active

(c) (I) and (III) are infrared inactive while (II) is infrared active

(d) None of the modes are infrared active since SO3 has zero dipole moment

51. The reaction(s) that yield(s) 3-phenylcyclopentanone as the major product is(are)

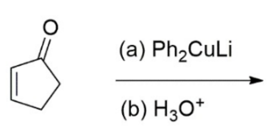


Figure 72

(a)

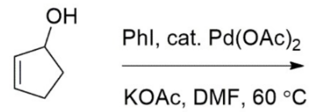


Figure 73

(b)

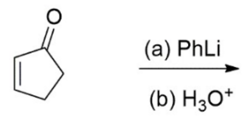


Figure 74

(c)

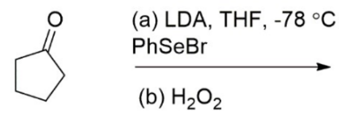
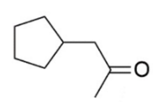


Figure 75

(d)

52. The reaction(s) that yield(s) M as the major product is(are)



M

Figure 76

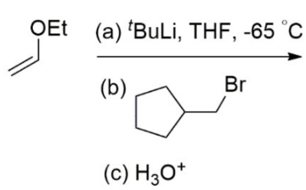


Figure 77

(a)

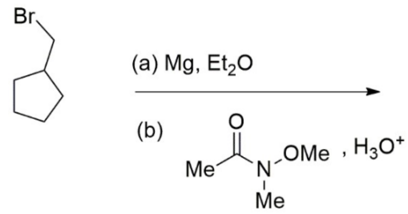


Figure 78

(b)

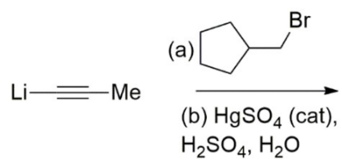


Figure 79

(c)

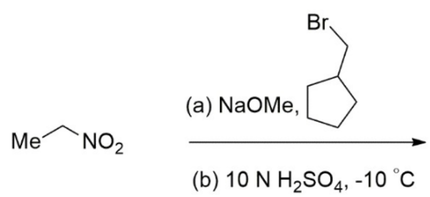


Figure 80

(d)

53. The CORRECT statement(s) regarding $B_{10}H_{14}$ is(are)

   (a) Brønsted acidity of $B_{10}H_{14}$ is higher than that of B_5H_9
   (b) Structurally $B_{10}H_{14}$ is a closo-borane
   (c) The metal-promoted fusion of $B_5H_8^-$ produces $B_{10}H_{14}$
   (d) Both $B_{10}H_{14}$ and $B_{10}H_{12}(SEt_2)_2$have the same number of valence electrons

54. The CORRECT statement(s) about the Group-I metals is(are)

   (a) Reactivity of Group-I metals with water decreases down the group
   (b) Among the Group-I metals, Li spontaneously reacts with N_2 to give a red-brown layer-structured material
   (c) Thermal stability of Group-I metal peroxides increases down the group
   (d) All the Group-I metal halide are high-melting colorless crystalline solids

55. The compound(s) that satisfies/satisfy the 18-electron rule is(are)

(Atomic number of Os = 76, Rh = 45, Mo = 42, and Fe = 26)

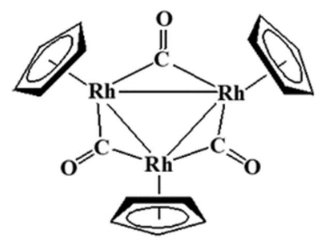


Figure 81

(a)

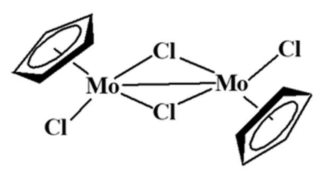


Figure 82

(b)

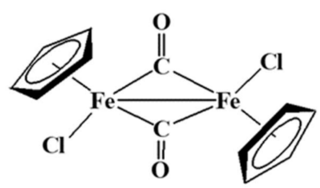


Figure 83

(c)

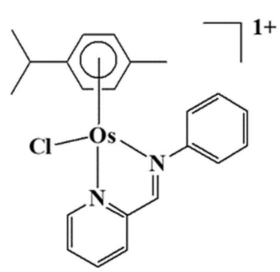


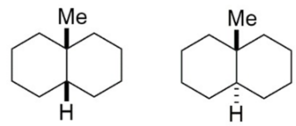
Figure 84

(d)

56. For three operators $\hat{A}$, $\hat{B}$, and $\hat{C}$, $\hat{A}$, $\hat{B}$, $\hat{C}$ + $\hat{B}$, $\hat{C}$, $\hat{A}$

(a) $\hat{C}$, $[\hat{A}, \hat{B}]$
(b) $\hat{C}$, $[\hat{B}, \hat{A}]$
(c) $[\hat{B}, \hat{A}]$, $\hat{C}$
(d) $\hat{A}$, $[\hat{B}, \hat{C}]$

57. The difference between the number of Gauche-butane interactions present in P and Q is



P Q

Figure 85

58. The calculated magnetic moment (in BM, rounded off to two decimal places) of a Ce^{3+} complex is

59. The state of the electron in a He+ ion is described by the following normalized wavefunction

$$\Psi(r, \theta . \phi) = \sqrt{\frac{3}{8}}\, R_{21}(r) Y_{10}(\theta, \phi) - i \sqrt{\frac{7}{16}} R_{10}(r) Y_{00}(\theta, \phi) + x R_{32}(r) Y_{20}(\theta, \phi).$$

Figure 86

Here, R_{nl} and Y_{lm} represent the radial and angular components of the eigenfunctions of He+ ion, respectively, and x is an unknown constant. If the energy of the ion is measured in the above state, the probability (rounded off to two decimal places) of obtaining the energy of $-\frac{2}{9}$ atomic unit is

60. A certain wavefunction for the hydrogen-like atom is given by

$$\Psi(r, \theta, \phi) = \frac{2^{\frac{1}{2}}}{81\, \pi^{\frac{1}{2}}} \left(\frac{Z}{a_0}\right)^{5/2} \left(6 - \frac{Zr}{a_0}\right) r\, e^{-Zr/3a_0} \cos\theta\ .$$

Figure 87

The number of node(s) in this wavefunction is

61. EMF of the following cell

$Cu \mid CuSO_4$ (aq, 1.0 mol/kg) $\parallel Hg_2SO_4$(s)$\mid Hg(l) \mid Pt$

at 25 °C and 1 bar is 0.36 V. The value of the mean activity coefficient (rounded off to three decimal places) of $CuSO_4$ at 25 °C and 1 bar is

[Given: Standard electrode potential values at 25 °C for]

$Cu^{2+} + 2e^{-} \rightarrow$ Cu and

$Hg_2SO_4 + 2e^{-} \rightarrow$ 2Hg + $SO_4{}^{2-}$

are 0.34 V and 0.62 V, respectively.

Consider: RT/F at 25°C = 0.0256 V

62. The radius of gyration (in nm, rounded off to one decimal place), for three dimensional random coil linear polyethylene of molecular weight 8,40,000 is

[Given: C-C bond length = 0.154 nm]

63. The activation energy of the elementary gas-phase reaction O_3 + NO $\rightarrow$ $NO_2 + O_2$ is 10.5 kJ mol^{-1}. The value of the standard enthalpy of activation (rounded off to two decimal places in kJ mol-1) at 25 °C is

[Given: R is 8.314 $Jmol^{-1}K^{-1}$]

64. In a collection of molecules, each molecule has two non-degenerate energy levels that are separated by 5000 cm^{-1}. On measuring the population at a particular temperature, it was found that the ground state population is 10 times that of the upper state. The temperature (in K, rounded off to the nearest integer) of measurement is

[Given: Value of the Boltzmann constant = 0.695 $cm^{-1}K^{-1}$]

65. The change in entropy of the surroundings (in JK^{-1}, rounded off to two decimal places) to convert 1 mol of supercooled water at 263 K to ice at 263 K at 1 bar is

[Consider: $\Delta_{fus}H$ at 273 K = 6.0 kJ mol^{-1}, and the molar heat capacity of water is higher than that of ice by 37.0 $JK^{-1}mol^{-1}$ in the temperature range of 263 K to 273 K]