

**PAPER : IIT-JAM 2022**  
**CHEMISTRY-CY**

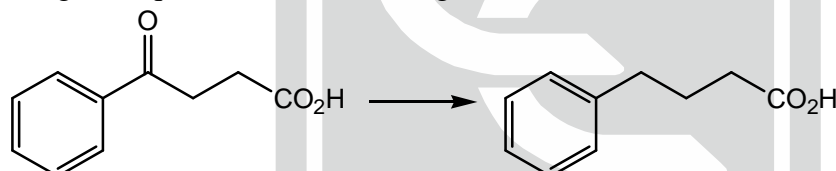
- Section-A contains 30 Multiple Choice Questions (MCQ). Each question has 4 choices (a), (b), (c) and (d), for its answer, out of which ONLY ONE is correct. From Q.1 to Q.10 carries 1 Marks and Q.11 to Q.30 carries 2 Marks each.
- Section-B contains 10 Multiple Select Questions (MSQ). Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which ONE or MORE than ONE is/are correct. For each correct answer you will be awarded 2 marks.
- Section-C contains 20 Numerical Answer Type (NAT) questions. From Q.41 to Q.50 carries 1 Mark each and Q.51 to Q.60 carries 2 Marks each. For each NAT type question, the value of answer is between 0 to 9.
- In all sections, questions not attempted will result in zero mark. In Section-A (MCQ), wrong answer will result in negative marks. For all 1 mark questions, 1/3 marks will be deducted for each wrong answer. For all 2 marks questions, 2/3 marks will be deducted for each wrong answer. In Section-B (MSQ), there is no negative and no partial marking provisions. There is no negative marking in Section-C (NAT) as well.

**SECTION-A**

Multiple Choice Questions (MCQ)

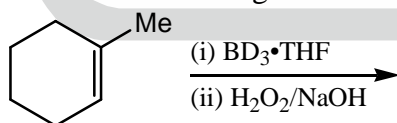
**Q.1 – Q.10 carry ONE mark each.**

1. The reagent required for the following transformation



- (a)  $\text{NaBH}_4$       (b)  $\text{LiAlH}_4$       (c)  $\text{H}_3\text{B} \cdot \text{THF}$       (d)  $\text{Zn(Hg)/HCl}$

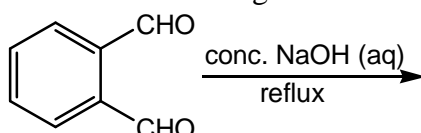
2. The major product formed in the following reaction



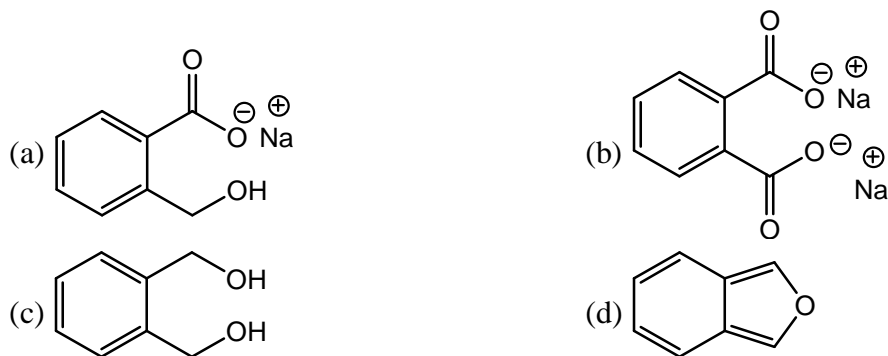
is

- (a) (b) (c) (d)

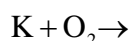
3. The major product formed in the following reaction



is



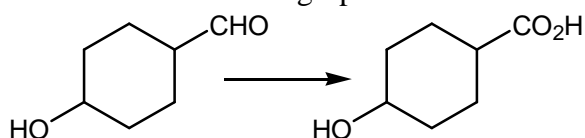
4. The major product formed in the following reaction



is

- (a)  $K_2O$                       (b)  $K_2O_2$                       (c)  $KO_2$                       (d)  $K_2O_3$

5. Which one of the following options is best suited for effecting the transformation?



- (a)  $MnO_2$                       (b)  $DMSO, (COCl)_2, Et_3N$   
 (c)  $Al(Oi-Pr)_3$                       (d)  $Ag_2O/NH_4OH$

6. The structure of  $[XeF_8]^{2-}$  is

- (a) cubic                      (b) hexagonal bipyramid  
 (c) square antiprism                      (d) octagonal

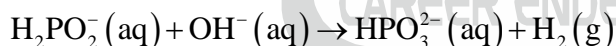
7. Among the following, the compound that forms the strongest hydrogen bond is

- (a) HF                      (b) HCl                      (c) HBr                      (d) HI

8. Among the following, the biomolecule with a direct metal-carbon bond is

- (a) coenzyme  $B_{12}$                       (b) nitrogenase                      (c) chlorophyll                      (d) hemoglobin

9. For the reaction,



the rate expression is  $k[H_2PO_2^-][OH^-]^2$ . If the concentration of  $H_2PO_2^-$  is doubled, the rate is

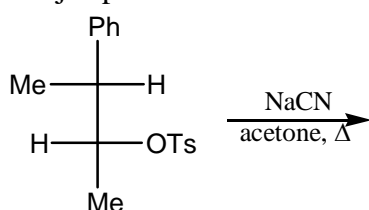
- (a) tripled                      (b) halved                      (c) doubled                      (d) unchanged

10. The nature of interaction involved at the gas-solid interface in physisorption is

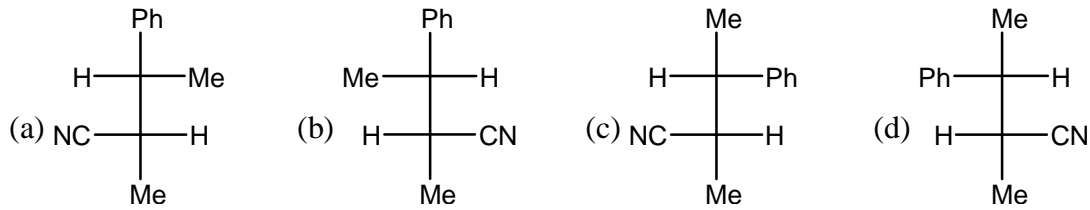
- (a) ionic                      (b) van der Waals  
 (c) hydrogen bonding                      (d) covalent

**Q.11 – Q.30 carry TWO marks each.**

11. The major product formed in the following reaction



is

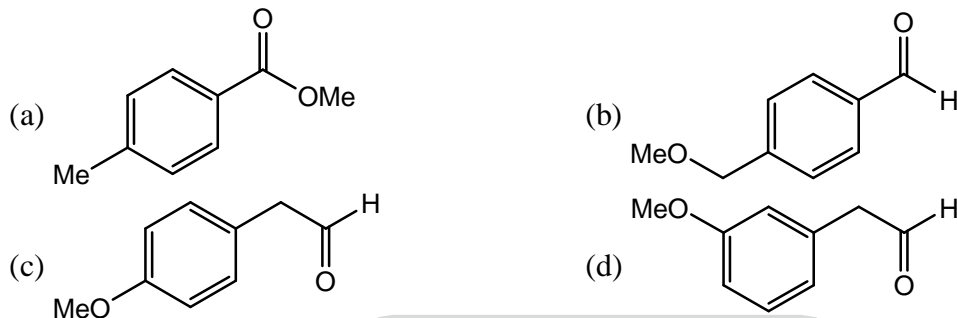


12. An organic compound having molecular formula  $C_9H_{10}O_2$  exhibits the following spectral characteristics

$^1H$  NMR :  $\delta$  9.72(t, 1H), 7.1(d, 2H), 6.7(d, 2H), 3.8(s, 3H), 3.6(d, 2H)

IR :  $\sim 1720\text{ cm}^{-1}$

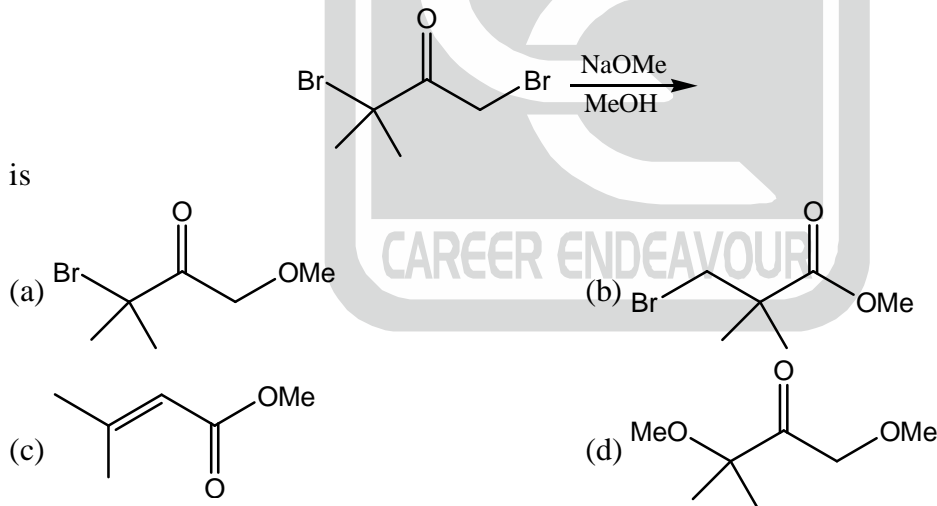
The most probable structure of the compound is



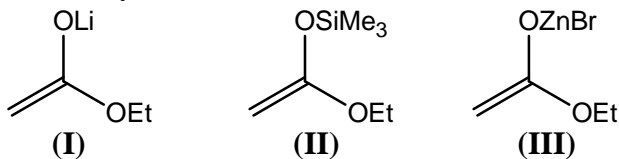
13. The major product formed in the reaction of (2S, 3R)-2-chloro-3-phenylbutane with NaOEt in EtOH is

(a) (E)-2-phenyl-but-2-ene (b) (Z)-2-phenyl-but-2-ene  
 (c) 3-phenyl-but-1-ene (d) (2R, 3R)-2-ethoxy-3-phenylbutane

14. The major product formed in the following reaction



15. The reactivity of the enol derivatives



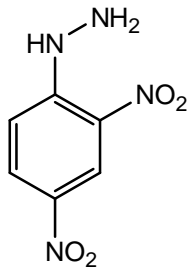
towards benzaldehyde follows the order

(a)  $I > II > III$  (b)  $III > II > I$  (c)  $II > I > III$  (d)  $I > III > II$

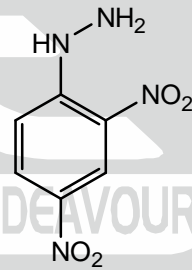
16. All possible lattice types are observed in the

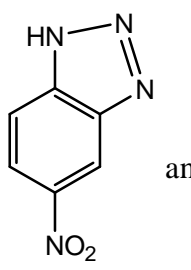
(a) cubic crystal system (b) monoclinic crystal system  
 (c) tetragonal crystal system (d) orthorhombic crystal system



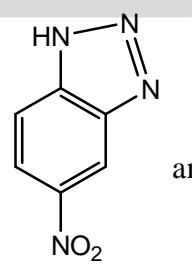
17. The structure types of  $B_{10}H_{10}^{2-}$  and  $B_{10}H_{14}$ , respectively, are  
 (a) *closo* and *nido* (b) *nido* and *arachno*  
 (c) *nido* and *closo* (d) *closo* and *arachno*
18. The ground state and maximum number of spin-allowed electronic transitions possible in  $Co^{2+}$  tetrahedral complex, respectively, are  
 (a)  $^4A_2$  and 3 (b)  $^4T_1$  and 2 (c)  $^4A_2$  and 2 (d)  $^4T_1$  and 3
19. The correct statement about the geometries of  $BH_2^+$  and  $NH_2^+$  based on valence shell electron pair repulsion (VSEPR) theory is  
 (a) both  $BH_2^+$  and  $NH_2^+$  are trigonal planar  
 (b)  $BH_2^+$  is linear and  $NH_2^+$  is trigonal planar  
 (c)  $BH_2^+$  is trigonal planar and  $NH_2^+$  is linear  
 (d) both  $BH_2^+$  and  $NH_2^+$  are linear
20. The order of increasing CO stretching frequencies in  $[Co(CO)_4]^-$ ,  $[Cu(CO)_4]^+$ ,  $[Fe(CO)_4]^{2-}$  and  $[Ni(CO)_4]$  is  
 (a)  $[Cu(CO)_4]^+ < [Ni(CO)_4] < [Co(CO)_4]^- < [Fe(CO)_4]^{2-}$   
 (b)  $[Fe(CO)_4]^{2-} < [Co(CO)_4]^- < [Ni(CO)_4] < [Cu(CO)_4]^+$   
 (c)  $[Co(CO)_4]^- < [Fe(CO)_4]^{2-} < [Cu(CO)_4]^+ < [Ni(CO)_4]$   
 (d)  $[Ni(CO)_4] < [Cu(CO)_4]^+ < [Co(CO)_4]^- < [Fe(CO)_4]^{2-}$
21. The reaction of 2,4-dinitrofluorobenzene with hydrazine produces a yellow orange solid **X** used for the identification of an organic functional group **G**, **X** and **G**, respectively, are
- 

(a) and carboxylic acid



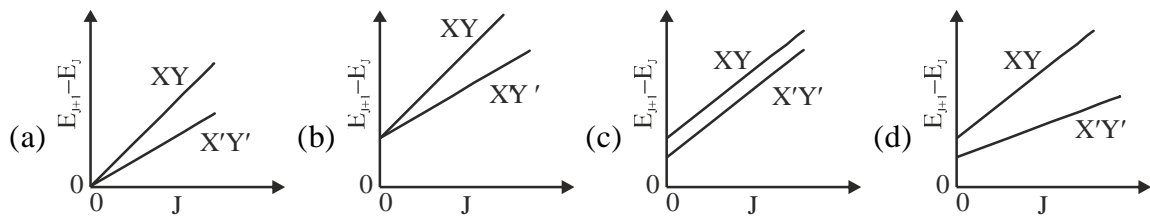
(b) and aldehyde
- 

(c) and aldehyde



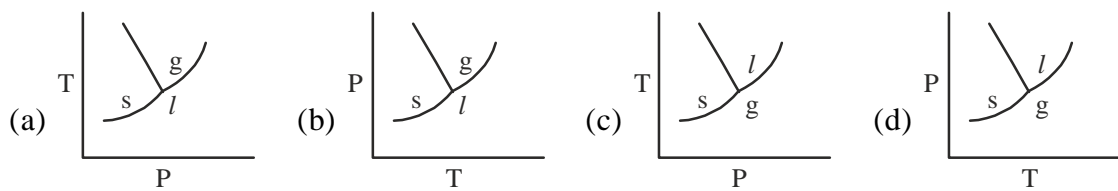
(d) and carboxylic acid
22. The stability of adducts  $H_3B \cdot PF_3$ ,  $H_3B \cdot NMe_3$ ,  $H_3B \cdot CO$ ,  $H_3B \cdot OMe_2$  follows the order  
 (a)  $H_3B \cdot OMe_2 < H_3B \cdot CO < H_3B \cdot PF_3 < H_3B \cdot NMe_2$   
 (b)  $H_3B \cdot PF_3 < H_3B \cdot CO < H_3B \cdot NMe_2 < H_3B \cdot OMe_2$   
 (c)  $H_3B \cdot CO < H_3B \cdot PF_3 < H_3B \cdot NMe_2 < H_3B \cdot OMe_2$   
 (d)  $H_3B \cdot PF_3 < H_3B \cdot CO < H_3B \cdot OMe_2 < H_3B \cdot NMe_2$

23. The spacing between successive rotational energy levels of a diatomic molecule XY and its heavier isotopic analogue X'Y' varies with the rotational quantum number, J, as



24. The ratio of the  $2p \rightarrow 1s$  transition energy in  $\text{He}^+$  to that in the H atom is closest to  
 (a) 1 (b) 2 (c) 4 (d) 8

25. The phase diagram of water is best represented by



26. Capillary W contains water and capillary M contains mercury. The contact angles between the capillary wall and the edge of the meniscus at the air-liquid interface in W and M are  $\theta_W$  and  $\theta_M$ , respectively.

The contact angles satisfy the conditions

- (a)  $\theta_W > 90^\circ$  and  $\theta_M > 90^\circ$  (b)  $\theta_W > 90^\circ$  and  $\theta_M < 90^\circ$   
 (c)  $\theta_W < 90^\circ$  and  $\theta_M > 90^\circ$  (d)  $\theta_W < 90^\circ$  and  $\theta_M < 90^\circ$
27. The Maxwell-Boltzmann distribution  $f(v_x)$  of one-dimensional velocities  $v_x$  at temperature  $T$  is

[Given:  $A$  is normalization constant such that  $\int_{-\infty}^{\infty} f(v_x) dv_x = 1$  and  $k_B$  is the Boltzmann constant]

- (a)  $A \exp(-mv_x^2 / 2k_B T)$  (b)  $A \exp(-mv_x^2 / k_B T)$   
 (c)  $A v_x^2 \exp(-mv_x^2 / 2k_B T)$  (d)  $A v_x^2 \exp(-mv_x^2 / k_B T)$
28. The potential for a particle in a one-dimensional box is given as:

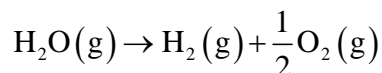
$$V(x) = 0 \text{ for } 0 \leq x \leq L, \text{ and } V(x) = \infty \text{ elsewhere}$$

The locations of the internal nodes of eigenfunctions  $\psi_n(x)$ ,  $n \geq 2$ , are

[Given:  $m$  is an integer such that  $0 < m < n$ ]

- (a)  $x = \frac{m+1}{n} L$  (b)  $x = \frac{m}{n} L$  (c)  $x = \frac{m}{n+1} L$  (d)  $x = \frac{m+1}{n+1} L$

29. The number of CO stretching bands in the infrared spectrum of  $\text{Fe}(\text{CO})_5$  is  
 (a) 1 (b) 2 (c) 3 (d) 4
30. The standard Gibbs free energy change for the reaction,



at 2500 K is  $+118 \text{ kJmol}^{-1}$

The equilibrium constant for the reaction is

[Given:  $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$ ]

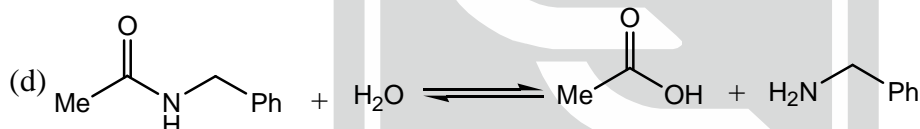
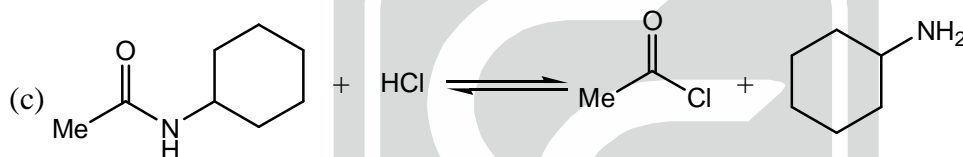
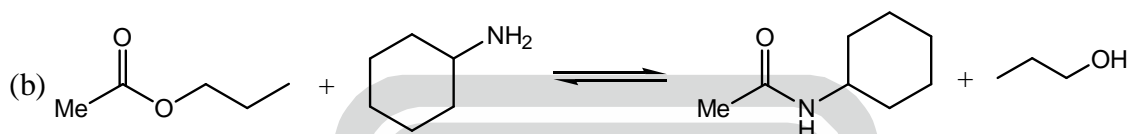
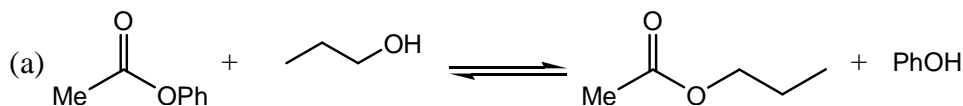
- (a) 0.994 (b) 1.006 (c)  $3.42 \times 10^{-3}$  (d) 292.12

### SECTION-B

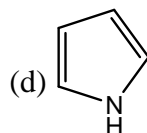
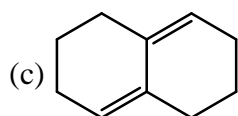
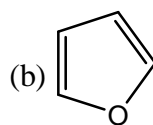
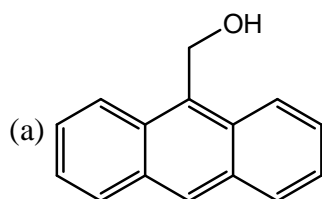
#### Multiple Select Questions (MSQ)

**Q.31 – Q.40 carry TWO marks each.**

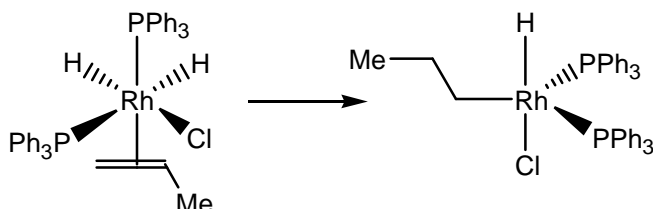
31. Among the following, the reaction(s) that favor(s) the formation of the products at  $25^\circ\text{C}$  is/are



32. Among the following, the correct statement(s) is/are
- (a) The first  $\text{pK}_a$  of malonic acid is lower than  $\text{pK}_a$  of acetic acid while its second  $\text{pK}_a$  is higher than the  $\text{pK}_a$  of acetic acid.
- (b) The first  $\text{pK}_a$  of malonic acid is higher than  $\text{pK}_a$  of acetic acid while its second  $\text{pK}_a$  is lower than the  $\text{pK}_a$  of acetic acid.
- (c) Both the first and the second  $\text{pK}_{as}$  of malonic acid are lower than the  $\text{pK}_a$  of acetic acid.
- (d) Both the first and the second  $\text{pK}_{as}$  of malonic acid are higher than the  $\text{pK}_a$  of acetic acid.
33. The compound(s) that participate(s) in Diels-Alder reaction with maleic anhydride is/are



34. Among the following, the suitable route(s) for the conversion of benzaldehyde to acetophenone is/are
- (a)  $\text{CH}_3\text{COCl}$ , anhydrous  $\text{AlCl}_3$   
 (b) (i)  $\text{HS}(\text{CH}_2)_3\text{SH}$ ,  $\text{F}_3\text{B} \cdot \text{OEt}_2$ ; (ii)  $n\text{-BuLi}$ ; (iii)  $\text{MeI}$ ; (iv)  $\text{HgCl}_2$ ,  $\text{CdCO}_3$ ,  $\text{H}_2\text{O}$   
 (c)  $\text{NaNH}_2$ ,  $\text{MeI}$   
 (d) (i)  $\text{MeMgBr}$ ; (ii) aq. acid; (iii) pyridinium chlorochromate (PCC)
35. The reaction,



involve(s)

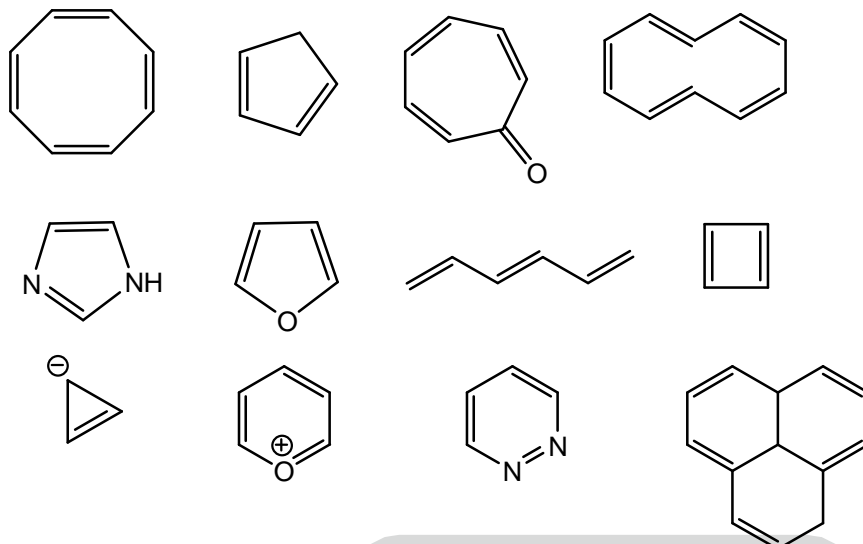
- (a) migratory insertion  
 (b) change in electron count of Rh from 18 to 16  
 (c) oxidative addition  
 (d) change in electron count of Rh from 16 to 18
36. The reason(s) for the lower stability of  $\text{Si}_2\text{H}_6$  compared to  $\text{C}_2\text{H}_6$  is/are
- (a) silicon is more electronegative than hydrogen  
 (b) Si-Si bond is weaker than C-C bond  
 (c) Si-H bond is weaker than C-H bond  
 (d) the presence of low-lying d-orbitals in silicon
37. For an N-atom non-linear polyatomic gas, the constant volume molar heat capacity  $C_{v,m}$  has the expected value of  $3(N-1)R$ , based on the principle of equipartition of energy. The correct statement(s) about the measured value of  $C_{v,m}$  is/are
- (a) The measured  $C_{v,m}$  is independent of temperature  
 (b) The measured  $C_{v,m}$  is dependent of temperature  
 (c) The measured  $C_{v,m}$  is typically lower than the expected value  
 (d) The measured  $C_{v,m}$  is typically higher than the expected value.
38. Zinc containing enzyme(s) is/are
- (a) carboxypeptidase  
 (b) hydrogenase  
 (c) carbonic anhydrase  
 (d) urease
39. The conversion of  $\text{ICl}$  to  $\text{ICl}^+$  involve(s)
- (a) the removal of an electron from a  $\pi^*$  molecular orbital of  $\text{ICl}$   
 (b) an increase in the bond order from 1 in  $\text{ICl}$  to 1.5 in  $\text{ICl}^+$   
 (c) the formation of a paramagnetic species  
 (d) the removal of an electron from a molecular orbital localized predominantly on Cl
40. The common point defect(s) in a solid is/are
- (a) Wadsley defect  
 (b) Schottky defect  
 (c) Suzuki defect  
 (d) Frenkel defect

## SECTION-C

## Numerical Answer Type (NAT)

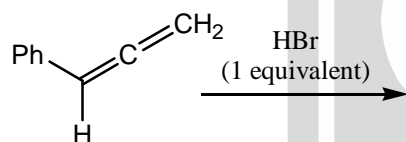
Q.41 – Q.40 carry ONE mark each.

41. Among the following,



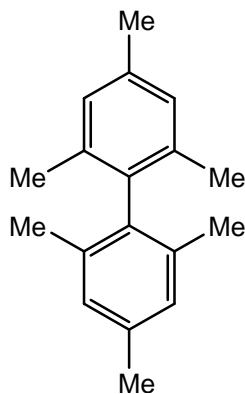
the number of aromatic compound is \_\_\_\_\_

42. The number of stereoisomers possible for the major product formed in the reaction



is \_\_\_\_\_

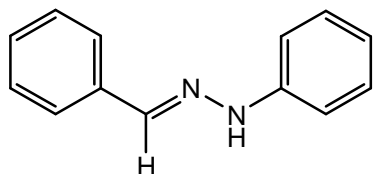
43. The number of signals observed in the  $^1\text{H}$  NMR spectrum of the compound



is \_\_\_\_\_



44. The reaction of 122 g of benzaldehyde with 108g of phenylhydrazine gave 157g of the product



The yield of the product is \_\_\_\_\_%. (Round off to the nearest integer)

45. The B-B bond order in  $B_2$  is \_\_\_\_\_
46. The number of unpaired electrons in  $[Co(H_2O)_6]^{2+}$  is \_\_\_\_\_
47. The number of significant figures in  $5.0820 \times 10^2$  is \_\_\_\_\_
48. The d-spacing for the first-order X-ray ( $\lambda = 1.54 \text{ \AA}$ ) diffraction event of metallic iron (fcc) at  $2\theta = 20.2^\circ$  is \_\_\_\_\_ $\text{\AA}$ . (round off to three decimal places)
49. The volume fraction for an element in an fcc lattice is \_\_\_\_\_ (round off to two decimal places)
50. A steady current of 1.25 A is passed through an electrochemical cell for 1.5 h using a 12 V battery. The total charge, Q, drawn during this process is \_\_\_\_\_ Coulombs. (round off to the nearest integer)

**Q.51 – Q.60 carry TWO marks each.**

51. The specific rotation of optically pure (R)-1-phenylethylamine is +40 (neat, 20°C). A synthetic sample of the same compound is shown to contain 4:1 mixture of (S)- and (R)-enantiomers. The specific rotation of the neat sample at 20°C is \_\_\_\_\_ (round off to the nearest integer).
52. The number of  $\beta$  particles emitted in the nuclear reaction  ${}_{92}^{238}\text{U} \rightarrow {}_{82}^{206}\text{Pb}$  is \_\_\_\_\_
53. Iron is extracted from its ore via the reaction,  
$$\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$$
  
The volume of CO (at STP) required to produce 1 kg of iron is \_\_\_\_\_ liters. (Round off to the nearest integer).  
[Given: Atomic wt. of Fe = 56; assume STP to be 0°C and 1 atm]
54. Total degeneracy (number of microstates) for a  $Ti^{3+}$  ion in spherical symmetry is \_\_\_\_\_
55. A galvanic electrochemical cell made of  $Zn^{2+}/Zn$  and  $Cu^{2+}/Cu$  half-cells produces 1.10 V at 25°C. The ratio of  $[Zn^{2+}]$  to  $[Cu^{2+}]$  is maintained at 1.0. The  $\Delta G^\circ$  for the reaction when 1.0 mol of Zn gets dissolved is \_\_\_\_\_ kJ. (Round off to nearest integer).  
[Given: Faraday's constant = 96485 C mol<sup>-1</sup>]
56. At constant volume, 1.0 kJ of heat is transferred to 2 moles of an ideal gas at 1 atm and 298K. The final temperature of the ideal gas is \_\_\_\_\_ K. (Round off to one decimal place)  
[Given: R = 8.314 JK<sup>-1</sup> mol<sup>-1</sup>]



57. Two close lying bands in a UV spectrum occur at 274 nm and 269 nm. The magnitude of the energy gap between the two bands is \_\_\_\_\_  $\text{cm}^{-1}$ . (round off to the nearest integer)
58. The pH of an aqueous buffer prepared using  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COO}^-\text{Na}^+$  is 4.80.

The quantity  $\frac{[\text{CH}_3\text{COO}^-] - [\text{CH}_3\text{COOH}]}{[\text{CH}_3\text{COOH}]}$  is \_\_\_\_\_

(round off to three decimal places)

[Given:  $\text{pK}_a$  of  $\text{CH}_3\text{COOH}$  in water is 4.75]

59. At constant temperature, 6.40g of a substance dissolved in 78g of benzene decreases the vapor pressure of benzene from 0.125 atm to 0.119 atm. The molar mass of the substance is \_\_\_\_\_  $\text{g mol}^{-1}$ . (round off to one decimal place). [Given: mol. wt. of benzene = 78  $\text{g mol}^{-1}$ ]
60. For a van der Waals gas, the critical temperature is 150 K and the critical pressure is  $5 \times 10^6$  Pa. The volume occupied by each gas molecule is \_\_\_\_\_  $\text{\AA}^3$ . (round off to two decimal places)  
[Given:  $R = 8.314 \text{ J mol}^{-1}\text{K}^{-1}$ ,  $N_A = 6.023 \times 10^{23}$ ]

