

### Answer Key: Assistant Professor (Chemistry)

Q No	Key
1	C
2	C
3	A
4	D
5	C
6	D
7	B
8	B
9	D
10	D
11	A
12	D
13	A
14	B
15	D
16	C
17	A
18	B
19	C
20	B
21	D
22	B
23	C
24	C
25	A

Q No	Key
26	B
27	B
28	A
29	A
30	D
31	C
32	D
33	B
34	C
35	B
36	D
37	B
38	C
39	D
40	B
41	B
42	D
43	B
44	A
45	D
46	B
47	A
48	C
49	D
50	B

Test Booklet

Series

**A**

Test Booklet No.

**Test Booklet for the Post of  
Assistant Professor Chemistry**

Name of Applicant ..... Answer Sheet No. ....

Applicant ID/Roll No. : ..... Signature of Applicant : .....

Date of Examination: ..... Signature of the Invigilator(s)  
1. ....

Time of Examination : ..... 2. ....

**Duration : 1 Hour]**

**[Maximum Marks : 50**

**IMPORTANT INSTRUCTIONS**

- (i) The question paper is in the form of Test-Booklet containing **50 (Fifty)** questions. All questions are compulsory. Each question carries four answers marked (A), (B), (C) and (D), out of which only one is correct. Choose the correct option or the most appropriate option.
- (ii) On receipt of the Test-Booklet (Question Paper), the candidate should immediately check it and ensure that it contains all the pages, i.e., **50** questions. Discrepancy, if any, should be reported by the candidate to the invigilator immediately after receiving the Test-Booklet.
- (iii) A separate Answer-Sheet is provided with the Test-Booklet/Question Paper. On this sheet there are **50** rows containing four circles each. One row pertains to one question.
- (iv) The candidate should write his/her Application ID/Roll number at the places provided on the cover page of the Test-Booklet/Question Paper and on the Answer-Sheet and **NOWHERE ELSE**.
- (v) No second Test-Booklet/Question Paper and Answer-Sheet will be given to a candidate. The candidates are advised to be careful in handling it and writing the answer on the Answer-Sheet.
- (vi) For every correct answer of the question **One (1) mark will be awarded**. There will be negative marking and 1/4 (0.25) mark will be deducted for every incorrect answer.
- (vii) Marking shall be done only on the basis of answers responded on the Answer-Sheet.
- (viii) To mark the answer on the Answer-Sheet, candidate should **darken** the appropriate circle in the row of each question with Blue or Black pen.
- (ix) For each question only **one** circle should be **darkened** as a mark of the answer adopted by the candidate. If more than one circle for the question are found darkened or with one black circle any other circle carries any mark, the answer will be treated as incorrect.
- (x) The candidates should not remove any paper from the Test-Booklet/Question Paper. Attempting to remove any paper shall be liable to be punished for use of unfair means.
- (xi) Rough work may be done on the blank space provided in the Test-Booklet/Question Paper only.
- (xii) *Mobile phones (even in Switch-off mode) and such other communication/programmable devices are not allowed inside the examination hall.*
- (xiii) No candidate shall be permitted to leave the examination hall before the expiry of the time.

**DO NOT OPEN THIS QUESTION BOOKLET UNTIL ASKED TO DO SO.**

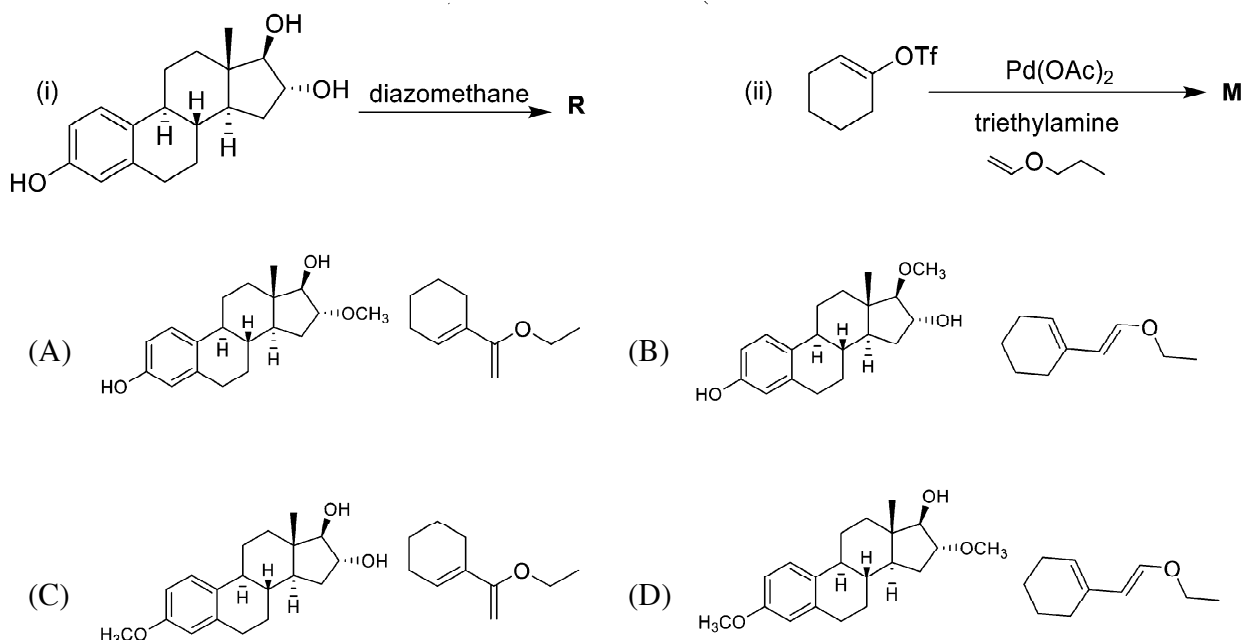
Chemistry

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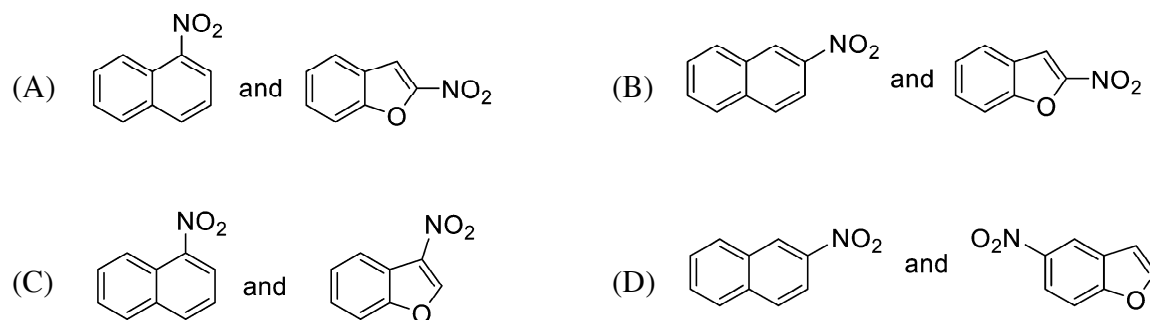
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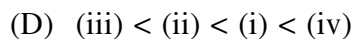
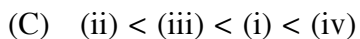
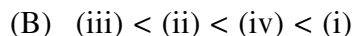
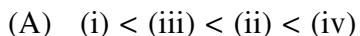
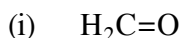
1. The energy difference between first two energy levels of an electron confined in a one-dimensional box of length 1.0 nm. (Given,  $m_e = 9.11 \times 10^{-31}$  kg,  $h = 6.626 \times 10^{-34}$  Js) is
- (A) 1.90 eV (B) 0.76 eV  
(C) 1.13 eV (D) 1.20 eV
2. Two separate reactions (i) and (ii) gives products R and M, respectively. The correct combination of products (R and M) of these reactions (i) and (ii) is



3. The major products formed in the nitration reaction of naphthalene and benzofuran, respectively, are



4. The correct order of reactivity of the following carbonyl derivatives (i-iv) towards nucleophilic addition reaction is



5. A  $^1\text{H}$ - $^1\text{H}$  coupling constant for a doublet in a compound X is measured as 5.0 Hz on a 500 MHz NMR spectrometer. Which of the following statements is *incorrect* regarding  $^1\text{H}$  NMR of X?

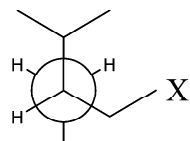
(A) The difference  $\Delta\delta$  for the two peaks of this doublet is 0.05 ppm when measured on a 100 MHz spectrometer

(B) The difference  $\Delta\delta$  for the two peaks of this doublet depends on the field strength of the spectrometer

(C) For this doublet, the coupling constant measured in Hz depends on the field strength of the spectrometer

(D) For this doublet, the coupling constant is 5.0 Hz when the spectrum of X is recorded on a 250 MHz NMR spectrometer

6. The IUPAC name of compound X is



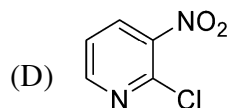
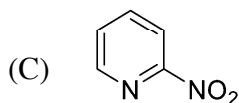
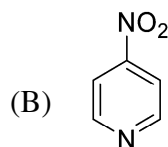
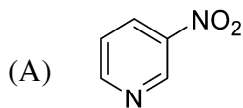
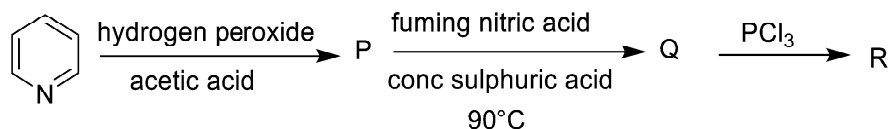
(A) 3-isopropylpentane

(B) 3-ethyl-4-methylpentane

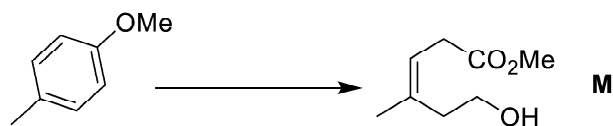
(C) 2-ethyl-3-methylpentane

(D) 3-ethyl-2-methylpentane

7. The major product R in the following sequence of reaction is

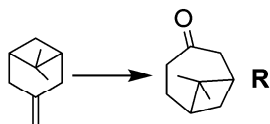


8. The most suitable reaction conditions to prepare the hydroxyl ester **M** is



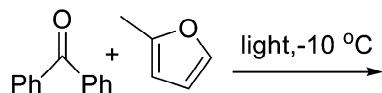
- (A) (i)  $\text{KMnO}_4$ , (ii)  $\text{NaBH}_4$                       (B) (i)  $\text{Li}$ ,  $\text{NH}_3$ ,  $t\text{-BuOH}$ ; (ii)  $\text{O}_3$ , (iii)  $\text{NaBH}_4$   
 (C) (i)  $\text{OsO}_4$ , (ii)  $\text{NaIO}_4$ , (iii)  $\text{LiAlH}_4$                       (D) (i)  $\text{Li}$ ,  $\text{NH}_3$ ; (ii)  $\text{O}_3$ ,  $\text{H}_2\text{O}_2$ ; (iii)  $\text{NaBH}_4$

9. The correct synthetic steps to prepare ketone **R** is



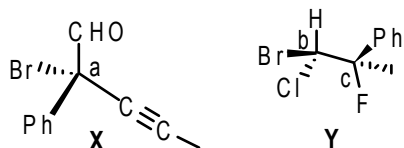
- (A) (i)  $\text{KMnO}_4$ , (ii)  $\text{OsO}_4$ ; (iii)  $\text{H}_2\text{SO}_4$                       (B) (i)  $\text{OsO}_4$ ; (ii)  $\text{H}_2\text{SO}_4$   
 (C) (i)  $\text{OsO}_4$ , (ii)  $\text{CaCO}_3$                       (D) (i)  $\text{OsO}_4$ ; (ii)  $\text{TsCl}$ ,  $\text{Py}$ ; (iii)  $\text{CaCO}_3$

10. The major product of the following reaction is :



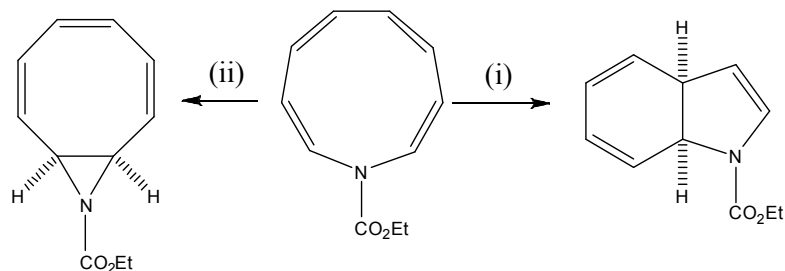
- (A)                      (B)
- (C)                      (D)

11. The R/S configurations for the following chiral centres a, b, c in compounds X & Y are, respectively :



- (A) S, S, R                      (B) S, S, S  
 (C) R, R, S                      (D) S, R, R

12. In the following electrocyclic reaction, (i) and (ii), respectively are :



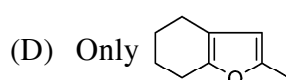
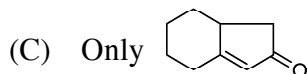
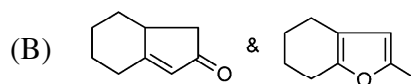
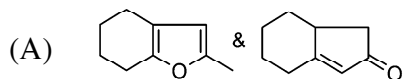
(A) (i)  $h\nu$  and (ii) heat

(B) (i)  $h\nu$  and (ii)  $h\nu$

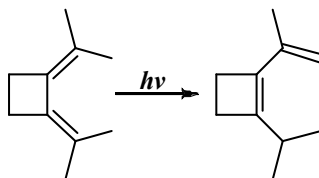
(C) (i) heat and (ii) heat

(D) (i) heat and (ii)  $h\nu$

13. The products formed on reaction of the 2-(2-oxopropyl)-cyclohexanone with acid and base, respectively, are :



14. Identify the type of sigmatropic rearrangement that is taking place in the following reaction :



(A) [1, 3]

(B) [1, 5]

(C) [1, 7]

(D) [1, 4]

15. (2S,3S)-2-bromo-3-phenylbutane is heated with a strong base. The product formed is

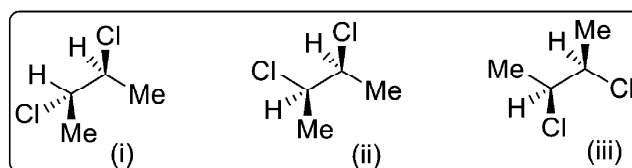
(A) (Z)-2-phenyl-2-butene

(B) 1-phenyl-2-methylpropane

(C) (Z) & (E) 2-phenyl-2-butene (equimolar)

(D) (E)-2-phenyl-2-butene

16. Pure S-2-butanol has a specific rotation of  $+13.52^\circ$ . A sample of 2-butanol in the laboratory is found to have a specific rotation of  $-3.38^\circ$ . The mole fraction of S-2-butanol in the sample is
- (A) 0.25 (B) 0.75  
(C) 0.375 (D) 0.625
17. At room temperature, cis-1,2-dichlorocyclohexane (chair) exists as
- (A) a mixture of conformational enantiomers  
(B) a mixture of conformational diastereomers  
(C) a meso compound  
(D) an optically pure stereoisomer
18. Consider the reaction  $P \rightarrow Q \rightarrow$  1-chloro-2,4-dinitrobenzene. For the highest yield of the final products, P and Q, respectively, should be
- (A) chlorobenzene, m-chloronitrobenzene  
(B) chlorobenzene, p-chloronitrobenzene  
(C) nitrobenzene, m-dinitrobenzene  
(D) nitrobenzene, m-chloronitrobenzene
19. Which of the following structures (i), (ii), and (iii) represent the same stereoisomer?

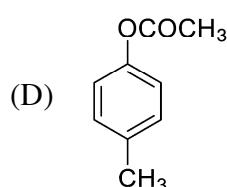
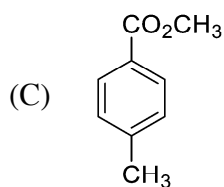
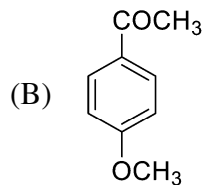
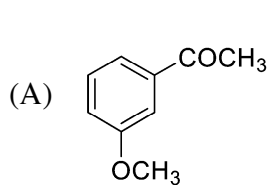


- (A) Only (i) and (ii) (B) (i), (ii) and (iii)  
(C) Only (ii) and (iii) (D) Only (iii) and (i)



20. The correct structure of the compound with following spectral data is

IR :  $1690\text{ cm}^{-2}$ ;  $^1\text{H NMR}$ :  $\delta$  2.5 (s, 3H), 3.8 (s, 3H), 6.9 (d,  $J = 8\text{ Hz}$ , 2H), 7.8 (d,  $J = 8\text{ Hz}$ , 2H) ppm;  $^{13}\text{C NMR}$ :  $\delta$  197, 165, 130, 129, 114, 56, 26 ppm



21. Which of the following molecules (I-III) will have a permanent dipole moment and will be optically active?

(I) *trans*-[CoCl<sub>2</sub>(NH<sub>3</sub>)<sub>4</sub>]; (II) *trans*-1,2-dichloroethene; (III) [CoCl(NH<sub>3</sub>)<sub>5</sub>]<sup>+</sup>

(A) Permanent dipole moment : None; Optically active : None

(B) Permanent dipole moment : (II) and (III); Optically active : (III)

(C) Permanent dipole moment : (I) and (II); Optically active : None

(D) Permanent dipole moment : (III); Optically active : None

22. For Cr<sup>2+</sup> ions, the electron pairing energy is about  $18800\text{ cm}^{-1}$  while  $\Delta_o$  value for the complex [Cr(X)<sub>6</sub>]<sup>2+</sup> is  $13900\text{ cm}^{-1}$ . Which of the following statement(s) is/are **false** regarding the complexes of Cr(II)? (X is a neutral monodentate ligand)

**Statement 1** : X is a weak field ligand

**Statement 2** : Crystal field stabilization energy of [Cr(X)<sub>6</sub>]<sup>2+</sup> is  $13900\text{ cm}^{-1}$

**Statement 3** : Spin only magnetic moment of [Cr(X)<sub>6</sub>]<sup>2+</sup> is 2.83 BM.

(A) Statements 1 and 2 only

(B) Statements 2 and 3 only

(C) Statements 1 and 3 only

(D) Statements 1, 2 and 3

23. For the compounds (I-III), determine whether they have Spinel or inverse Spinel structure?  
 (I)  $Mn_3O_4$  (II)  $NiFe_2O_4$  (III)  $Fe_3O_4$
- (A) Spinel : Compound (II) and (III) and Inverse Spinel : Compound (I)  
 (B) Spinel : Compound (I) and (II) and Inverse Spinel : Compound (III)  
 (C) Spinel : Compound (I) and Inverse Spinel : Compound (II) and (III)  
 (D) Spinel : Compound (I) and (III) and Inverse Spinel : Compound (II)
24. Which one of the following is the correct order for the C–O stretching frequency in IR?
- (A)  $[Ti(CO)_6]^{2-} > [V(CO)_6]^- > [Cr(CO)_6]$   
 (B)  $[Ti(CO)_6]^{2-} < [V(CO)_6]^- > [Cr(CO)_6]$   
 (C)  $[Ti(CO)_6]^{2-} < [V(CO)_6]^- < [Cr(CO)_6]$   
 (D)  $[Ti(CO)_6]^{2-} > [V(CO)_6]^- < [Cr(CO)_6]$
25. Predict which of the following complexes will have z-elongated structure due to Jahn-Teller distortion
- (1)  $[FeCl_6]^{4-}$  (2)  $[FeCl_6]^{3-}$  (3)  $[Ti(H_2O)_6]^{3+}$  (4)  $[V(H_2O)_6]^{3+}$
- (A) (1) and (3) only (B) (1) and (4) only  
 (C) (2) and (3) only (D) (2) and (4) only
26. The number of unpaired electrons in  $Cp_2Mn$  and  $Cp_2Ni$  are, respectively
- (A) 3 and 0 (B) 5 and 2  
 (C) 2 and 3 (D) 5 and 3
27. Which one of the following represents the correct increasing order for the crystal field splitting energy for the given complexes?
- (A)  $[Rh(NH_3)_6]^{3+} < [Co(NH_3)_6]^{3+} < [Co(NH_3)_6]^{2+} < [CoF_6]^{4-}$   
 (B)  $[CoF_6]^{4-} < [Co(NH_3)_6]^{2+} < [Co(NH_3)_6]^{3+} < [Rh(NH_3)_6]^{3+}$   
 (C)  $[CoF_6]^{4-} < [Co(NH_3)_6]^{3+} < [Co(NH_3)_6]^{2+} < [Rh(NH_3)_6]^{3+}$   
 (D)  $[Co(NH_3)_6]^{2+} < [CoF_6]^{4-} < [Co(NH_3)_6]^{3+} < [Rh(NH_3)_6]^{3+}$

28. Which of the following complex will show the spin-only magnetic moment value 3.87 BM?

(i)  $[\text{Fe}(\text{Cl})_6]^{3-}$ ; (ii)  $[\text{Co}(\text{Cl})_4]^{2-}$ ; (iii)  $[\text{Cr}(\text{Cl})_6]^{4-}$ ; (iv)  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$

(A) Complex (ii) and (iv), only (B) Complex (iii) and (iv), only

(C) Complex (i) and (ii), only (D) Complex (i) and (iii), only

29. Consider the carbene, where **X** and **Y**, respectively, are the auxiliary ligand and substituent on carbene and M is a metal centre.  $(\text{X})_5\text{MC}(\text{Y})(\text{Me})$ . Which of the following statement(s) is/are correct regarding the carbene in the above reaction?

**Statement 1** : For Fischer carbene complex, X is  $\pi$ - accepting ligand and M is in high oxidation state

**Statement 2** : For Schrock carbene, carbene C is nucleophilic.

**Statement 3** : Y should be electron donating group for a Fischer carbene complex.

(A) Statements 2 and 3 only (B) Statements 1, 2 and 3

(C) Statements 1 and 3 only (D) Statements 1 and 2 only

30. Which of the following statement(s) is/are correct for Wacker process?

**Statement 1** : It involves addition of oxygen to an alkene resulting in the formation of aldehyde.

**Statement 2** :  $[\text{PdCl}_4]^{2-}$  is the catalyst where oxidative addition of alkene takes place.

**Statement 3** : Cu(II) is used to regenerate Pd(II) from Pd(0).

(A) Statements 2 and 3 only (B) Statements 1, 2 and 3

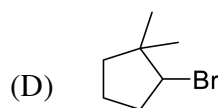
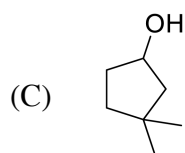
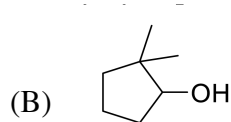
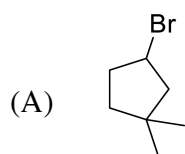
(C) Statements 1 and 2 only (D) Statements 1 and 3 only

31. Which of the following is a forbidden transition in the hydrogen atom?

(A)  $2p \rightarrow 1s$  (B)  $3p \rightarrow 2s$

(C)  $3p \rightarrow 2p$  (D)  $4d \rightarrow 2p$

32. Assume alcohols are dehydrated with sulphuric acid and alkyl halides are treated with potassium t-butoxide, which of the following compounds would be the most appropriate starting material to obtain pure 3,3-dimethylcyclopentene ?



33. The total number of states corresponding to (degeneracy of)  $4F$  term is

(A) 63

(B) 28

(C) 36

(D) 12

34. How many electrons in an atom have the following quantum numbers, ( $n = 4$  and  $m_s = -1/2$ )?

(A) 32

(B) 2

(C) 16

(D) 8

35. The separation between successive lines of pure rotational spectrum of a heteronuclear diatomic molecule is  $20 \text{ cm}^{-1}$ . The most intense transition in the absorption spectra at  $25^\circ\text{C}$  will correspond to (Given : Planck's constant =  $6.626 \times 10^{-34} \text{ Js}$ , Boltzmann constant =  $1.381 \times 10^{-23} \text{ JK}^{-1}$ )

(A)  $J = 1 \rightarrow J = 2$

(B)  $J = 3 \rightarrow J = 4$

(C)  $J = 4 \rightarrow J = 3$

(D)  $J = 5 \rightarrow J = 6$

36. The correct increasing order of bond length of the following species is :

(i)  $\text{NO}^+$  (ii)  $\text{CO}^+$  (iii)  $\text{SO}_3^{2-}$  (iv)  $\text{ClO}_2^-$

(A) (iii) < (iv) < (i) < (ii)

(B) (i) < (iii) < (ii) < (iv)

(C) (iii) < (iv) < (ii) < (i)

(D) (ii) < (i) < (iv) < (iii)

37. From the transitions between the terms given below, which is/are allowed in electronic spectrum of a many-electron atom?  
 (i)  ${}^3D_2 \rightarrow {}^3P_1$  (ii)  ${}^3P_2 \rightarrow {}^1S_0$  (iii)  ${}^3F_4 \rightarrow {}^3D_1$   
 (A) Only (ii) (B) Only (i)  
 (C) (i) and (ii) (D) (i) and (iii)
38. A ball of mass 1 g is moving with speed of 1 cm/sec in a one-dimensional box of edge length 10 cm. The value of its kinetic energy and number  $n$  corresponding to this energy, respectively, are  
 (A)  $5.0 \times 10^{-10}$  J,  $3.02 \times 10^{27}$  (B)  $5.0 \times 10^{-8}$  J,  $3.02 \times 10^{29}$   
 (C)  $5.0 \times 10^{-8}$  J,  $3.02 \times 10^{27}$  (D)  $5.0 \times 10^{-10}$  J,  $3.02 \times 10^{29}$
39. An electron with wave function  $\psi = \sqrt{2} \sin(\pi x)$  in the range from  $x = 0$  to  $x = 1$ . The probability of finding the electron in the middle half is  
 (A) 76% (B) 52%  
 (C) 50% (D) 81.8%
40. The spectroscopic constants assigned for the NO molecule are, dissociation energy,  $D_e = 6.48$  eV, Wavenumber =  $1904 \text{ cm}^{-1}$  and the rotational constant  $B = 1.705 \text{ cm}^{-1}$ . For NO, the  $J = 0$  to  $J = 1$  transition occurs at  
 (A)  $1.705 \text{ cm}^{-1}$  (B)  $3.410 \text{ cm}^{-1}$   
 (C)  $6.820 \text{ cm}^{-1}$  (D)  $121 \text{ cm}^{-1}$
41. The pure-rotational Raman spectrum of  ${}^{14}\text{N}_2$  shows a spacing of  $7.99 \text{ cm}^{-1}$  between adjacent rotational lines. The bond distance in  ${}^{14}\text{N}_2$  is  
 (A)  $0.549 \text{ \AA}$  (B)  $1.098 \text{ \AA}$   
 (C)  $2.196 \text{ \AA}$  (D) cannot be determined
42. The molar heat capacity at constant pressure of a certain solid at 10 K is  $0.43 \text{ JK}^{-1} \text{ mol}^{-1}$ . The molar entropy (in  $\text{JK}^{-1} \text{ mol}^{-1}$ ) of this solid at the same temperature is  
 (A) 0.85 (B) 0.43  
 (C) 1.29 (D) 0.14

43. The reaction in a given direction is spontaneous if the change in Helmholtz free energy,  $A$ , is negative at
- (A) Constant P and T (B) Constant V and T  
(C) Constant H and S (D) Constant T and S
44. The standard free energy of formation of a certain metal oxide  $MO(s)$  is given as a function of  $T$  by  $\Delta_f G^0$  (J/mole) =  $-298 \times 10^3 + 98 T(K)$ , while that for  $CO(g)$  is given by  $\Delta_f G^0$  (J/mole) =  $-110 \times 10^3 - 90 T(K)$ . From this data, it may be concluded that
- (A) carbon (graphite) may be used to reduce  $MO$  to  $M$  at  $T < 1000$  K  
(B) carbon may be used to reduce  $MO$  to  $M$  at  $T > 1000$  K  
(C)  $MO$  cannot be reduced using carbon at any temperature  
(D)  $MO$  will spontaneously decompose to  $M$  and  $O_2$  at room temperature (300 K).
45.  $\Delta H$  and  $\Delta U$  for the reaction  $Fe_2O_3(s) + 3H_2(g) \rightarrow 2Fe(s) + 3H_2O(l)$  at constant temperature are related as
- (A)  $\Delta H = \Delta U$  (B)  $\Delta H = \Delta U + RT$   
(C)  $\Delta H = \Delta U + 3RT$  (D)  $\Delta H = \Delta U - 3RT$
46. An oxygen molecule of mass 32 u is confined in a container of volume  $200 \text{ cm}^3$  at  $25^\circ\text{C}$ . Its translational partition function is (given that Boltzmann constant =  $1.38 \times 10^{-23} \text{ JK}^{-1}$ , Planck's constant =  $6.626 \times 10^{-34} \text{ Js}$ )
- (A) 1 (B)  $3.49 \times 10^{28}$   
(C)  $8.23 \times 10^{25}$  (D)  $1.03 \times 10^{65}$
47. A first order reaction of type  $A \rightarrow P$  is started with an initial concentration of  $A = 0.3 \text{ M}$ . The concentration of  $A$  becomes half of its initial concentration after 60 seconds. The time required to complete 70% of this reaction is
- (A) 104.2 seconds (B) 30.9 seconds  
(C) 88.6 seconds (D) 119.4 seconds

48. The proposed mechanism for a reaction,  $X \rightarrow Y$  is given below :
- (i)  $X + X \rightarrow X^* + X$  (rate constant =  $k_1$ , here energetically excited state of X is denoted as  $X^*$ ).
  - (ii)  $X^* + X \rightarrow X + X$  (rate constant =  $k_2$ ).
  - (iii)  $X^* \rightarrow Y$  (rate constant =  $k_3$ ).

Which of the following would be the correct expression for the rate of formation of Y after applying steady-state approximation to a suitable species?

- (A) Rate =  $k_2k_3[X]^2/(k_3[X] + k_1)$
  - (B) Rate =  $k_2k_3[X]^2/(k_1[X] + k_3)$
  - (C) Rate =  $k_1k_3[X]^2/(k_2[X] + k_3)$
  - (D) Rate =  $k_1k_3[X]^2/(k_3[X] + k_2)$
49. Given that the standard reduction potential ( $E^\circ$ ) for the reaction,  $O_2(g) + 4H^+ + 4e^- \rightarrow 2H_2O$  is 1.229 V at 298 K and 1 bar, and Faraday constant =  $96485 \text{ C mol}^{-1}$ . The standard Gibbs free energy change ( $\Delta G^\circ$ ) for the reaction at 298 K is
- (A)  $-118.58 \text{ kJ mol}^{-1}$
  - (B)  $-237.16 \text{ kJ mol}^{-1}$
  - (C)  $-355.74 \text{ kJ mol}^{-1}$
  - (D)  $-474.32 \text{ kJ mol}^{-1}$
50. The number of vibrational degrees of freedom for  $C_6H_6$ ,  $C_2H_2$ ,  $SO_4^{2-}$  and  $H_2O_2$  are, respectively
- (A) 30, 6, 9 & 6
  - (B) 30, 7, 9 & 6
  - (C) 29, 7, 9 & 6
  - (D) 29, 7, 9 & 5

## ROUGH WORK



## ROUGH WORK