COMBINED GEO-SCIENTIST (P) EXAM-2023

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO

T.B.C. : SDGH-F-CHE

Test Booklet Series

Serial 1008709

TEST BOOKLET

Paper-II

(CHEMISTRY)

A

Time Allowed : Two Hours   *Maximum Marks : 300*

INSTRUCTIONS

1. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET *DOES NOT* HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS, ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.

2. **Please note that it is the candidate's responsibility to encode and fill in the Roll Number and Test Booklet Series Code A, B, C or D carefully and without any omission or discrepancy at the appropriate places in the OMR Answer Sheet. Any omission/discrepancy will render the Answer Sheet liable for rejection.**

3. You have to enter your Roll Number on the Test Booklet in the Box provided alongside. *DO NOT* write *anything else* on the Test Booklet.

4. This Test Booklet contains **120** items (questions). Each item comprises four responses (answers). You will select the response which you want to mark on the Answer Sheet. In case you feel that there is more than one correct response, mark the response which you consider the best. In any case, choose *ONLY ONE* response for each item.

5. You have to mark all your responses *ONLY* on the separate Answer Sheet provided. See directions in the Answer Sheet.

6. All items carry equal marks.

7. Before you proceed to mark in the Answer Sheet the response to various items in the Test Booklet, you have to fill in some particulars in the Answer Sheet as per instructions sent to you with your Admission Certificate.

8. After you have completed filling in all your responses on the Answer Sheet and the examination has concluded, you should hand over to the Invigilator *only the Answer Sheet*. You are permitted to take away with you the Test Booklet.

9. Sheets for rough work are appended in the Test Booklet at the end.

10. **Penalty for wrong answers :**
    THERE WILL BE PENALTY FOR WRONG ANSWERS MARKED BY A CANDIDATE.

    (i)   There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, **one-third** of the marks assigned to that question will be deducted as penalty.

    (ii) If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that question.

    (iii) If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

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1. Consider the following diagram regarding the radial distribution function for 2s and 2p orbitals :

- - - 2p orbital
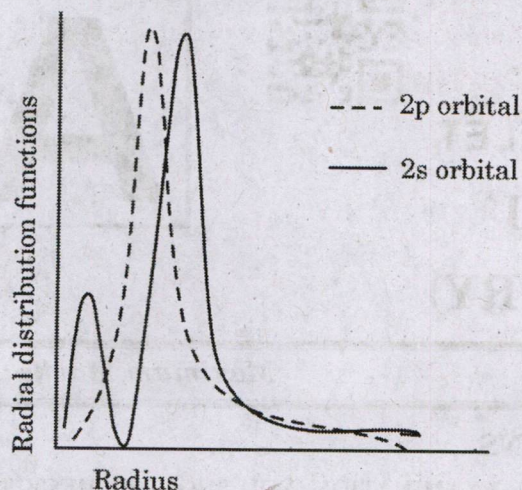
——— 2s orbital

Which one of the following statements is a correct conclusion drawn from the diagram given above ?

(a) 2s electrons are less shielded than 2p electrons.

(b) 2p electrons are less shielded than 2s electrons.

(c) 2s and 2p orbitals have equal probability of closer approach to nucleus.

(d) 2s orbital electron density is at a greater distance from nucleus than that of 2p orbital.

2. Which one of the following statements regarding wave functions is *not* correct ?

(a) The square of the wave function gives the probability of finding the electron in the space.

(b) The angular wave function of a given type of orbital is dependent on the principal quantum number.

(c) The radial function of 2s orbital is both positive and negative.

(d) The probability of finding the electron density is zero at a node in the wave function.

3. The electronic configuration of an ion M^{3+} generated from an element with atomic number 58 is :

(a) $[Xe]4f^1 5d^1 6s^2$

(b) $[Xe]4f^1$

(c) $[Rn]5f^3 6d^1 7s^2$

(d) $[Rn]5f^2$

4. Which one of the following rules for filling of atomic orbitals is violated in the electronic configuration $1s^2 2s^2 2p_x^2 2p_y^1$?

(a) Hund's rule of maximum multiplicity

(b) Pauli's exclusion principle

(c) Aufbau principle

(d) Slater's rule

5. Which one of the following pair of elements will have similar atomic radii in d-block of the periodic table ?

(a) Sc, Ti

(b) La, Hf

(c) Zr, Hf

(d) Fe, Ru

6. The number of unpaired electrons in the ground state of Lu^{3+} ion (atomic number 71) is :

(a) Zero

(b) One

(c) Two

(d) Three

7. The electronic configuration of the outermost shell of all noble gases are $ns^2 np^6$ EXCEPT :

(a) Xe

(b) Ar

(c) He

(d) Ne

8. Solutions of alkali metals in liquid ammonia are deep blue irrespective of the type of alkali metal dissolved. The deep blue colour is due to :

   (a) Formation of ammoniates of alkali metals

   (b) Generation of ammoniated electrons in solution

   (c) Formation of alkali metal amides

   (d) Formation of alkali metal hydroxides

9. Which one of the following represents the correct order of ionic radii among O^{2-}, F^-, Na^+, Mg^{2+} and Al^{3+} ?

   (a) $Al^{3+} > Mg^{2+} > Na^+ > F^- > O^{2-}$

   (b) $Na^+ > Mg^{2+} > Al^{3+} > O^{2-} > F^-$

   (c) $Na^+ > F^- > Mg^{2+} > O^{2-} > Al^{3+}$

   (d) $O^{2-} > F^- > Na^+ > Mg^{2+} > Al^{3+}$

10. The effective nuclear charge (Z_{eff}) at the periphery of O^{2-} ion is :

   (a) 3·85

   (b) 3·50

   (c) 3·80

   (d) 3·45

11. Consider the following statements regarding electron affinity :

   1. Electron affinity of fluorine is lower than that of chlorine.

   2. Electron affinity of nitrogen is higher than that of phosphorus.

   Which of the statements given above is/are correct ?

   (a) 1 only

   (b) 2 only

   (c) Both 1 and 2

   (d) Neither 1 nor 2

12. A main group element has the following four successive ionization energies in MJ mol^{-1} : 0·8995, 1·7571, 14·8487 and 21·0065. The element belongs to which group in the periodic table ?

   (a) Group II

   (b) Group XIII

   (c) Group XIV

   (d) Group XVI

13. Which allotropic form of tin has more metallic character ?

   (a) White tin (β-tin)

   (b) Grey tin (α-tin)

   (c) Yellow tin (γ-tin)

   (d) Red tin (δ-tin)

14. Which one of the following statements regarding catenation is **not** correct ?

   (a) Multiple bond formation leads to decreased catenation property.

   (b) Catenation is higher if the overlapping atomic orbitals are of small size.

   (c) Catenation results in formation of long chain compounds by an element.

   (d) Catenation is observed for electropositive elements.

15. Liquid ammonia as a solvent dissolves all alkali metals by solvating metal ions and electrons. However NH_3 itself is **not** reduced by the solvated electrons present in the solution. This is because :

   (a) Solvated electrons lose their reducing power

   (b) Ammonia binds to solvated metal ions and therefore cannot accept electrons

   (c) Nitrogen atom in ammonia is already in lowest possible oxidation state

   (d) Ammonia has electron donor properties

16. The basicity of pyrophosphoric acid, orthophosphorus acid and hypophosphorus acid are respectively :
   (a) 4, 2, 1
   (b) 4, 3, 2
   (c) 3, 3, 3
   (d) 3, 2, 1

17. Consider the following statements for Group XVI of periodic table :
   1. Oxoacids of sulphur are more numerous than other elements of Group XVI.
   2. Sulphur forms most stable $d\pi-p\pi$ bonds with oxygen.
   3. Inert pair effect becomes dominant for heavier members of the group.
   Which of the statements given above are correct ?
   (a) 1, 2 and 3
   (b) 2 and 3 only
   (c) 1 and 3 only
   (d) 1 and 2 only

18. SF_6 is inert towards hydrolysis. Which one of the following is *not* a reason for this ?
   (a) SF_6 is oxidizing in nature
   (b) S-F bond strength is very high
   (c) Sulphur does not possess vacant d orbitals in this molecule
   (d) SF_6 is a coordinately saturated molecule

19. Which one of the following statements regarding oxides of Nitrogen (NO and NO_2) is *not* correct ?
   (a) NO can bind with metal ions to form complexes but NO_2 cannot.
   (b) NO is a colourless gas but NO_2 is a brown gas.
   (c) Both NO and NO_2 are oxidizing agents.
   (d) NO_2 is reluctant to dimerisation while NO dimerises readily.

20. Which of the following statements regarding radius ratio rule is/are correct ?
   1. Radius ratio quite often fails when its value is close to one of the limiting values.
   2. Radius ratios are not affected by the polarizability of the electron clouds of ions.
   3. Radius ratio rule strictly works if the ions are treated as hard spheres.
   4. Radius ratio rule will not work if an ionic compound shows polymorphism.
   Select the correct answer using the code given below :
   (a) 2 only
   (b) 1, 3 and 4
   (c) 3 and 4 only
   (d) 1 and 3 only

21. The coordination numbers for the elements in *ccp*, *bcc* and *hcp* packing are :
   (a) 6, 8 and 12 respectively
   (b) 12, 8 and 12 respectively
   (c) 12, 8 and 6 respectively
   (d) 8, 12 and 6 respectively

22. Which one of the following represents the correct order of polarizing power among Al^{3+}, Na^+, and Mg^{2+} ?
   (a) $Na^+ < Mg^{2+} < Al^{3+}$
   (b) $Al^{3+} < Mg^{2+} < Na^+$
   (c) $Na^+ < Al^{3+} < Mg^{2+}$
   (d) $Al^{3+} < Na^+ < Mg^{2+}$

23. Schottky defect is observed in a crystal lattice when :
   (a) A pair of oppositely charged ions are missing from their lattice positions in a crystal
   (b) An ion leaves the lattice position and occupies the interstitial position
   (c) The lattice position of an anion is occupied by an electron
   (d) Some of the similar charged ions of other elements are present in interstices

24. Which one of the following is the basis of VSEPR theory ?

(a) Number of bonded pairs of electrons around central atom

(b) Number of lone pairs of electrons around central atom

(c) Number of bonded and lone pairs of electrons around central atom

(d) Number of hybrid orbital atoms of central atom

25. In which one of the following geometries is Berry pseudorotation observed ?

(a) Triangular planar

(b) Square planar

(c) Trigonal bipyramidal

(d) Octahedral

26. Consider the following statements regarding the resonating structures contributing to the resonance hybrid of a molecule :

1. Contributing structures should have same number of unpaired electrons.

2. Contributing structures should have negative charge residing on more electronegative atom.

3. Contributing structures should not have large energy difference between them.

Which of the statements given above is/are correct ?

(a) 1 only

(b) 1 and 2 only

(c) 1, 2 and 3

(d) 2 and 3 only

27. Cobalt (III) chloride forms several octahedral complexes with ammonia. Which one of the following will **not** give test of chloride ions with $AgNO_3$ at 25°C ?

(a) $CoCl_3.6NH_3$

(b) $CoCl_3.5NH_3$

(c) $CoCl_3.4NH_3$

(d) $CoCl_3.3NH_3$

28. Which one of the following group of species contains all ambidentate ligands ?

(a) $C_2O_4^{2-}, CO_3^{2-}, NO_3^{-}$

(b) $SCN^{-}, NO_2^{-}, NO_3^{-}$

(c) $CN^{-}, NO_2^{-}, SCN^{-}$

(d) CN^{-}, CO, PPh_3

29. Which one of the following is the correct IUPAC name of $Na_2[Fe(CN)_5NO]$?

(a) Sodium pentacyanonitrosylferrate(0)

(b) Sodium pentacyanonitrosylferrate(II)

(c) Sodium pentacyanonitrosylferrate(I)

(d) Sodium pentacyanonitrosylferrate(III)

30. The number of geometrical isomers possible for tetrahedral coordination compounds $[MA_4]$, $[MA_2B_2]$ and $[MABCD]$ are :

(where, M is the metal and A, B, C and D are ligands)

(a) 0, 2, 2 respectively

(b) 0, 0, 0 respectively

(c) 0, 2, 3 respectively

(d) 0, 3, 3 respectively

31. Which one of the following complexes shows optical isomerism ?

(a) $[ZnCl_4]^{2-}$

(b) $[Co(CN)_6]^{3-}$

(c) $[Cr(C_2O_4)_3]^{3-}$

(d) $[Cu(NH_3)_4]^{2+}$

32. Consider the following equilibrium reaction :

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \quad \Delta H = 180 \text{ kJ mol}^{-1}$$

Which of the following are true for the equilibrium reaction given above ?

1. The volume change at constant pressure does not affect the equilibrium

2. The formation of NO is increased at higher temperature

3. The formation of NO is decreased at higher temperature

4. The pressure change at constant volume does not affect the equilibrium

Select the correct answer using the code given below :

(a) 1 and 2 only

(b) 3 and 4 only

(c) 1, 2 and 4

(d) 1, 3 and 4

33. Which one of the following is the conjugate base of $H_2PO_4^-$?

(a) PO_4^{3-}

(b) P_2O_5

(c) H_3PO_4

(d) HPO_4^{2-}

34. The process of self-ionization of water to give H_3O^+ and OH^- is called :

(a) Neutralization

(b) Autoprotolysis

(c) Dissociation

(d) Hydrolysis

35. What will be the approximate concentration of H^+ in a solution having pH 5·5 ?

(a) $3·2 \times 10^{-6}$ M

(b) $2·4 \times 10^{-6}$ M

(c) $1·6 \times 10^{-6}$ M

(d) $1·2 \times 10^{-6}$ M

36. 100 mL of 0·1 M ethanoic acid solution is neutralized with 0·1 M sodium hydroxide solution. The pH of the solution at the equivalence point will be :

(where, pK_a of CH_3COOH is 4·76 and $\log 0·05 = -1·30$)

(a) 8·73

(b) 8·37

(c) 9·38

(d) 9·83

37. Specific gravity of a solution is defined as :

(a) Ratio of mass of a solution to the mass of an equal volume of water

(b) Ratio of molarities of two solutions

(c) Ratio of normalities of two solutions

(d) Ratio of volumes of two solutions

38. Which one of the following statements regarding Ammonium Ferrous Sulphate is **not** correct ?

(a) It's composition is constant.

(b) It's aqueous solutions tend to undergo hydrolysis.

(c) It contains considerable amount of Fe^{3+} owing to aerial oxidation.

(d) It's standard solution can be prepared by direct weighing.

39. A solution of oxalic acid needs to be heated up to 60°C before titrating with potassium permanganate solution. Which one of the following is **not** a reason for this ?

(a) It helps in removal of dissolved carbon dioxide from the solution

(b) It helps in increasing the rate of reaction

(c) High temperature decomposes $[Mn(C_2O_4)_3]^{3-}$ complex if formed during the titration

(d) Oxalic acid precipitates at room temperature

40. During iodometric titration of $CuSO_4$ solution with $Na_2S_2O_3$ solution, a student used starch solution as the indicator. However the blue black colour obtained with the indicator did **not** disappear even after adding the required amount of $Na_2S_2O_3$ from the burette (end point). What possibly could be the mistake done in this titration ?

(a) Starch solution is not a suitable indicator for iodometric titration

(b) Freshly prepared starch solution was not used

(c) Starch solution was added in the beginning of the titration

(d) The reaction medium was acidic

41. Consider the following statements regarding a gas described by Van der Waals equation :

1. It behaves similar to an ideal gas at high temperatures.

2. It behaves similar to an ideal gas at high pressures.

3. It is characterized by Van der Waals constants that are dependent on the nature of the gas.

4. It has a pressure that is lower than the pressure exerted by the same gas behaving ideally.

Which of the statements given above are correct ?

(a) 1 and 2 only

(b) 2, 3 and 4 only

(c) 1, 3 and 4 only

(d) 1, 2, 3 and 4

42. Consider the following graph for Maxwell-Boltzmann distribution of speeds :
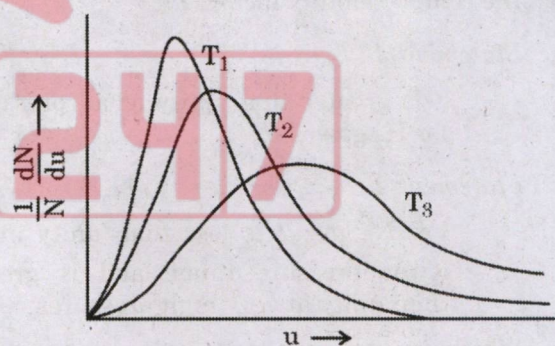
Which one of the following represents the correct order of temperatures in the graph given above ?

(a) $T_1 < T_2 < T_3$

(b) $T_3 < T_2 < T_1$

(c) $T_1 < T_3 < T_2$

(d) $T_2 < T_1 < T_3$

43. What will be the Boyle temperature of H_2 gas, if its Van der Waals constants a and b are $22 \cdot 0$ kPa dm^6 mol^{-2} and $0 \cdot 024$ dm^3 mol^{-1} respectively ?

(where, R = $8 \cdot 3$ kPa dm^3 K^{-1} mol^{-1})

(a) 56°C

(b) 110°C

(c) – 163°C

(d) – 249°C

44. At 150 K, the root mean square speed of a gas A (molar mass = 30 g mol^{-1}) is equal to the most probable speed of the gas B at 300 K. The molar mass of gas B is :

(a) 30 g mol^{-1}

(b) 40 g mol^{-1}

(c) 50 g mol^{-1}

(d) 60 g mol^{-1}

45. Consider the following statements regarding the compressibility factor (Z) :

Statement-1 :

Z is greater than unity at all pressures for H_2 gas.

Statement-2 :

For N_2 gas, Z is less than unity in the lower pressure range and is greater than unity at very high pressures.

Which one of the following is correct in respect of the above statements ?

(a) Both Statement-1 and Statement-2 are true and Statement-2 is the correct explanation of Statement-1.

(b) Both Statement-1 and Statement-2 are true, but Statement-2 is not the correct explanation of Statement-1.

(c) Statement-1 is true, but Statement-2 is false.

(d) Statement-1 is false, but Statement-2 is true.

46. Equal volumes of two gases X and Y diffused through a porous pot in 20 s and 10 s respectively. The molar mass of gas X is 200 g mol^{-1}. The molar mass of Y will be :

(a) 20 g mol^{-1}

(b) 50 g mol^{-1}

(c) 80 g mol^{-1}

(d) 100 g mol^{-1}

47. Consider the following statements regarding the number of collisions made by a single molecule (Z_1) in unit time :

1. It is directly proportional to pressure.

2. It is inversely proportional to temperature.

3. It is inversely proportional to square root of temperature.

4. It is independent of the effect of temperature and pressure.

Which of the statements given above is/are correct ?

(a) 1 and 2

(b) 1 and 3

(c) 3 only

(d) 4 only

48. Consider the following statements regarding Isothermal and Adiabatic processes :

1. Work done in a reversible isothermal process is the maximum work done.

2. Adiabatic work of expansion is greater than the isothermal work of expansion of an ideal gas.

3. Reversible and isothermal work of expansion for an ideal gas is less than that for a Van der Waals gas.

4. In an adiabatic expansion of a gas, cooling is produced.

Which of the statements given above are correct ?

(a) 1 and 2 only

(b) 3 and 4 only

(c) 1 and 4 only

(d) 1, 3 and 4

49. Consider 2·0 mol of an ideal gas being compressed reversibly from 1·0 bar to 100·0 bar at 27°C. The values of ΔU, ΔH and w are respectively :

(where, R = 8·3 J K^{-1} mol^{-1}, $ln\ 10 = 2·3$)

(a) 0, 0, 23 kJ

(b) 0, 23 0 kJ

(c) 0, 10, 0 kJ

(d) 0, 0, 10 kJ

50. Considering U as a function of variables T and V, which one of the following expressions is correct for $\left(\dfrac{\partial U}{\partial p}\right)_T$?

(a) $\left(\dfrac{\partial U}{\partial p}\right)_T = \left(\dfrac{\partial U}{\partial V}\right)_T \left(\dfrac{\partial V}{\partial p}\right)_T$

(b) $\left(\dfrac{\partial U}{\partial p}\right)_T = -\left(\dfrac{\partial U}{\partial V}\right)_p \left(\dfrac{\partial V}{\partial p}\right)_T$

(c) $\left(\dfrac{\partial U}{\partial p}\right)_T = \left(\dfrac{\partial U}{\partial T}\right)_p \left(\dfrac{\partial V}{\partial U}\right)_p$

(d) $\left(\dfrac{\partial U}{\partial p}\right)_T = -\left(\dfrac{\partial U}{\partial V}\right)_T \left(\dfrac{\partial V}{\partial p}\right)_T$

51. For a cyclic process of one mole of an ideal gas, the value of $\left(\dfrac{\partial p}{\partial T}\right)_V \left(\dfrac{\partial T}{\partial V}\right)_p \left(\dfrac{\partial V}{\partial p}\right)_T$ is :

(a) $\dfrac{-R^2}{p^2}$

(b) $+1$

(c) -1

(d) $\dfrac{R^2}{p^2}$

52. In the refining of sulphide ores, the ore is roasted with oxygen to form metal oxide and $SO_2\ (g)$. The $\Delta_r H^{\circ}_{298}$ for the roasting of sphalerite (ZnS) will be :

(where, $\Delta_f H^{\circ}_{298}\ (ZnS) = -206$ kJ mol^{-1}, $\Delta_f H^{\circ}_{298}\ (ZnO) = -348$ kJ mol^{-1} and $\Delta_f H^{\circ}_{298}\ (SO_2) = -296$ kJ mol^{-1})

(a) -238 kJ

(b) -438 kJ

(c) -583 kJ

(d) -590 kJ

53. The final temperature of one mole of a gas when it undergoes expansion from an initial pressure of 200 bar to a final pressure of 1 bar under isenthalpic conditions at 27°C is :

(where, $\mu_{JT} = 0·10$ K bar^{-1})

(a) 7°C

(b) 17°C

(c) 27°C

(d) 37°C

54. Consider the following data table for the reaction $N_2\ (g)\ +\ 3H_2\ (g)\ \longrightarrow\ 2NH_3\ (g)$ $\Delta_r H^{\circ}_{1000} = -124$ kJ mol^{-1} at 1000 K :

Substance	$N_2\ (g)$	$H_2\ (g)$	$NH_3\ (g)$
C_p°/R	3·5	3·5	4·2

(where, R = 8·3 J K^{-1} mol^{-1})

What will be the approximate heat of formation of NH_3 at 300 K ?

(a) $-35·0$ kJ mol^{-1}

(b) $-45·7$ kJ mol^{-1}

(c) $-55·4$ kJ mol^{-1}

(d) $-65·8$ kJ mol^{-1}

55. A steam engine operates between 300 K and 200 K under high pressures. The minimum amount of heat that must be drawn from the hot reservoir to obtain 1000 J of work is :

(a) 600 J

(b) 800 J

(c) 2000 J

(d) 3000 J

56. What will be the overall change in entropy for the following process using 1·00 mole of He ?

He (300 K, 1·20 atm) $\longrightarrow$ He (100 K, 12·0 atm)
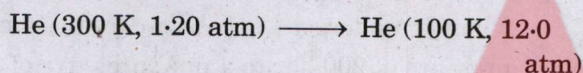
(where, heat capacity of He is 21 J K^{-1} mol^{-1}; R = 8·3 J K^{-1} mol^{-1}, ln 10 = 2·3, log 3 = 0·48; assume the helium acts ideally)

(a) $-19\cdot1$ J K^{-1}

(b) $-23\cdot2$ J K^{-1}

(c) $-42\cdot4$ J K^{-1}

(d) $-51\cdot3$ J K^{-1}

57. The term $\left[\dfrac{\partial\left(\frac{G}{T}\right)}{\partial T}\right]_p$ is equal to :

(a) $\dfrac{-S}{T}$

(b) $\dfrac{-H}{T^2}$

(c) $-H$

(d) $-S$

58. For maintaining thermodynamic equilibrium, a system should be in :

(a) Thermal equilibrium and mechanical equilibrium only

(b) Thermal equilibrium and chemical equilibrium only

(c) Mechanical equilibrium and chemical equilibrium only

(d) Thermal, mechanical and chemical equilibrium

59. Which of the following expressions regarding the criteria for spontaneity of chemical processes are correct ?

1. $dS_{U,V} \geq 0$

2. $dU_{S,V} \geq 0$

3. $dA_{T,V} \leq 0$

4. $dG_{T,p} \leq 0$

Select the correct answer using the code given below :

(a) 3 and 4 only

(b) 1 and 3 only

(c) 1, 2 and 3

(d) 1, 3 and 4

60. Match the List-I with List-II and select the correct answer using the code given below the lists :

List-I (Substance)		List-II (Limiting value of Van't Hoff factor, i)	
A.	NaCl	1.	One
B.	$C_6H_{12}O_6$	2.	Three
C.	K_3PO_4	3.	Two
D.	H_2SO_4	4.	Four

Code :

	A	B	C	D
(a)	2	1	4	3
(b)	2	4	1	3
(c)	3	4	1	2
(d)	3	1	4	2

61. Two components A and B have their pure vapour pressure in the ratio 1 : 6 and respective mole fractions in the solution in the ratio 1 : 4. The mole fraction of the component B in the vapour phase will be :

(a) 0·14

(b) 0·25

(c) 0·56

(d) 0·96

62. When 2·0 g of solute X is added to 1000 mL of pure water, the vapour pressure of water is decreased by :

(where, vapour pressure of pure water = 2·34 kPa at 20°C, molar mass of X = 200 g mol^{-1})

(a) 0·00018 kPa

(b) 0·00042 kPa

(c) 0·0031 kPa

(d) 0·0042 kPa

63. An aqueous solution of K_2SO_4 of 0·004 M concentration is isotonic with 0·01 M aqueous solution of glucose. The degree of dissociation of K_2SO_4 will be :

(a) 25%

(b) 30%

(c) 75%

(d) 85%

64. Which one of the following compounds will show the largest increase in boiling point when added to an aqueous solution ?

(a) 2 mol $MgSO_4$

(b) 2 mol $Ca(OH)_2$

(c) 2 mol NaCl

(d) 1 mol $CaCl_2$

65. Three particles of a solute A, associate in benzene to form species A_3. The degree of association of solute A is found to be 0·75. The freezing point of benzene and its freezing point depression constant are 5·5°C and 5·0 K kg mol^{-1} respectively. The freezing point of 0·25 molal solution of A will be :

(a) 3·9°C

(b) 4·9°C

(c) 5·9°C

(d) 6·9°C

66. Consider the following table regarding Henry's Law constant values for N_2 and O_2 gas in water at different temperatures :

Gas	Temperature/K	K_H/bar
N_2	293	76·48
N_2	303	88·84
O_2	293	34·86
O_2	303	46·82

Which one of the following statements is correct in respect of the table given above ?

(a) N_2 is more soluble than O_2 and the solubility decreases with decrease in temperature.

(b) O_2 is more soluble than N_2 and the solubility decreases with decrease in temperature.

(c) N_2 is more soluble than O_2 and the solubility increases with decrease in temperature.

(d) O_2 is more soluble than N_2 and the solubility increases with decrease in temperature.

67. If the limiting molar conductance values of Ba^{2+} and Cl^- are 127 S cm^2 mol^{-1} and 76 S cm^2 mol^{-1} respectively, then molar conductance at infinite dilution for $BaCl_2$ will be :

(a) 203 S m^2 mol^{-1}

(b) 279 S m^2 mol^{-1}

(c) 203×10^{-4} S m^2 mol^{-1}

(d) 279×10^{-4} S m^2 mol^{-1}

68. Which one of the following solutions has the least value of conductivity ?

(a) 0·01 M Na_2SO_4

(b) 0·01 M KCl

(c) 0·01 M HCl

(d) 0·01 M CH_3COOH

69. A potential of 5.0 V is applied to two electrodes placed 10.0 cm apart. How far would a sodium ion be expected to move in 1 hour in a dilute solution of a sodium salt at 25°C ?

(where, $\lambda(Na^+) = 50$ S cm^2 mol^{-1} and Faraday's constant = 96500 C mol^{-1})

(a) 1.13 cm

(b) 0.93 cm

(c) 0.56 cm

(d) 0.46 cm

70. Consider the following statements regarding Walden's rule :

Statement-1 :

Walden's rule is not applicable to ions of small size.

Statement-2 :

Small sized ions have high charge density, as a result they are highly solvated.

Which one of the following is correct in respect of the above statements ?

(a) Both Statement-1 and Statement-2 are true and Statement-2 is the correct explanation of Statement-1.

(b) Both Statement-1 and Statement-2 are true, but Statement-2 is not the correct explanation of Statement-1.

(c) Statement-1 is true, but Statement-2 is false.

(d) Statement-1 is false, but Statement-2 is true.

71. Consider the following graph showing variation of molar conductance with concentration :
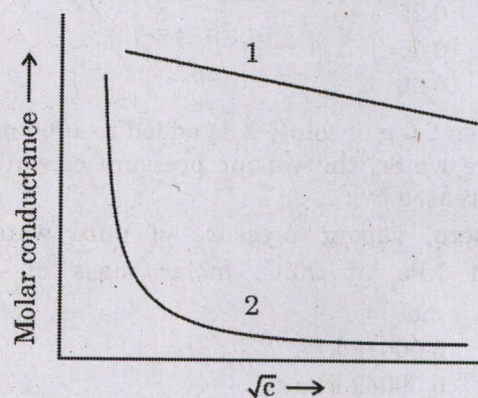
The electrolytes associated with 1 and 2 respectively are :

(a) KCl and CH$_3$COOH

(b) NH$_4$OH and CH$_3$COOH

(c) CH$_3$COOH and NaCl

(d) NaCl and KCl

72. Amide ion in liquid ammonia has abnormally high transport number because of :

(a) High frequency

(b) Abnormally high charge density

(c) Proton jump from one ammonia molecule to another

(d) Decrease in viscosity

73. Consider the following statements regarding Wien and Debye-Falkenhagen effects :
1. In very high electric fields $(E > 10^7 \text{ V/m})$, an increase in conductivity is observed as the asymmetry effect disappears.
2. In very high electric fields $(E > 10^7 \text{ V/m})$, an increase in conductivity is observed as the electrophoretic effect disappears.
3. At high frequencies, a decrease in conductivity is observed as the electrophoretic effect disappears.
4. At high frequencies, an increase in conductivity is observed as the asymmetry effect and electrophoretic effect disappear.

Which of the statements give above are correct ?
(a) 1 and 3 only
(b) 2 and 3 only
(c) 1, 3 and 4
(d) 1 and 4 only

74. The conductivity and molar conductance of a saturated solution of $BaSO_4$ are 3×10^{-6} S cm^{-1} and 150 S cm^2 mol^{-1}, respectively. The K_{sp} for $BaSO_4$ will be :
(a) 2×10^{-10}
(b) 2×10^{-16}
(c) 4×10^{-10}
(d) 4×10^{-16}

75. The molar conductivity of acetic acid solution at infinite dilution is 390 S cm^2 mol^{-1}. The molar conductivity of 0·01 M acetic acid solution is :
(where, dissociation constant of acetic acid is $1 \cdot 8 \times 10^{-5}$)
(a) 1·654 S cm^2 mol^{-1}
(b) 1·853 S cm^2 mol^{-1}
(c) 16·54 S cm^2 mol^{-1}
(d) 18·53 S cm^2 mol^{-1}

76. In a conductometric titration of Hydrochloric Acid (HCl) against Ammonium Hydroxide (NH_4OH), with the increase of volume of NH_4OH, the conductance will :
(a) Fall first and after neutralization show no appreciable change.
(b) Fall first and after neutralization rise sharply.
(c) Rise slowly and after neutralization rise sharply.
(d) Remain more or less the same and after neutralization rise sharply.

77. Consider the following conductometric titration of a mixture of HCl and CH_3COOH against NaOH. The volume corresponding to points (1) and (2) are 6·0 mL and 16·0 mL respectively. The volume of NaOH used for neutralisation of HCl and CH_3COOH are :
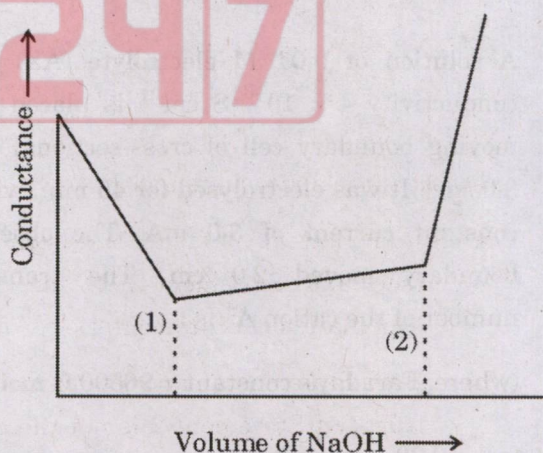
(a) 10·0 mL and 6·0 mL respectively
(b) 6·0 mL and 16·0 mL respectively
(c) 16·0 mL and 10·0 mL respectively
(d) 6·0 mL and 10·0 mL respectively

78. Which of the following statements is/are correct regarding indicator electrolyte in the moving boundary method to determine the transport number of an ion ?

1. The anions must be different in both the indicator and principal electrolyte.

2. The cation of the indicator electrolyte should move slower than the cation of the principal electrolyte.

3. The indicator electrolyte should be more dense than the principal electrolyte.

Select the correct answer using the code given below :

(a) 1, 2 and 3

(b) 1 and 2 only

(c) 2 and 3 only

(d) 3 only

79. A solution of 0·01 M electrolyte (AX) with conductivity 4×10^{-3} S cm^{-1} is placed in a moving boundary cell of cross-sectional area 3·0 cm^2. It was electrolysed for 45 min. with a constant current of 3·0 mA. The observed boundary moved 2·0 cm. The transport number of the cation A^+ is :

(where, Faraday's constant = 96500 C mol^{-1})

(a) 0·30

(b) 0·52

(c) 0·71

(d) 0·83

80. Which one of the following statements regarding transport number of the Cl^- ion is correct ?

(a) Transport number of Cl^- ion in aqueous solution of HCl is lower than the transport number of Cl^- ion in aqueous solution of NaCl.

(b) Transport number of Cl^- ion in aqueous solution of HCl is higher than the transport number of Cl^- ion in aqueous solution of NaCl.

(c) Transport numbers of Cl^- ion in aqueous solutions of HCl and NaCl are equal.

(d) The transport number of Cl^- ion is the same in aqueous solutions of NaCl and KCl.

81. Which one of the following compounds is most stabilized by resonance ?

(a)

(b)

(c)

(d)
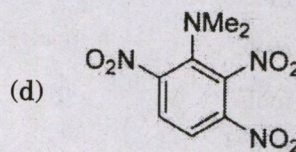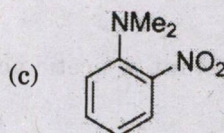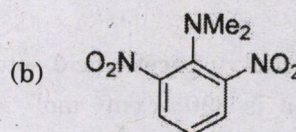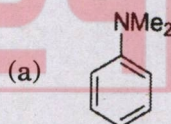
82. The relative order of stability of the following carbocations is :
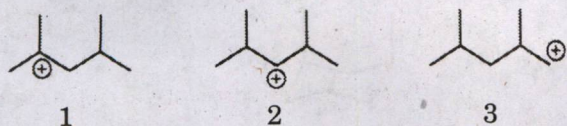
(a) $3 < 2 < 1$

(b) $1 < 2 < 3$

(c) $2 < 3 < 1$

(d) $1 < 3 < 2$

83. The correct order of heats of hydrogenation among the following alkenes (when hydrogenation is carried out in the presence of a platinum catalyst) is :
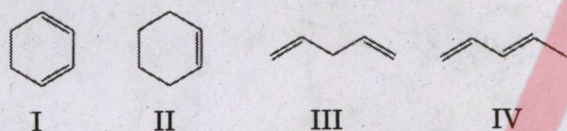
(a) $I < II < IV < III$

(b) $II < IV < I < III$

(c) $II < I < IV < III$

(d) $I < II < III < IV$

84. Which one of the following represents the high-energy Highest Occupied Molecular Orbital (HOMO) of 1,3-butadiene ?

(a)

(b)

(c)

(d)
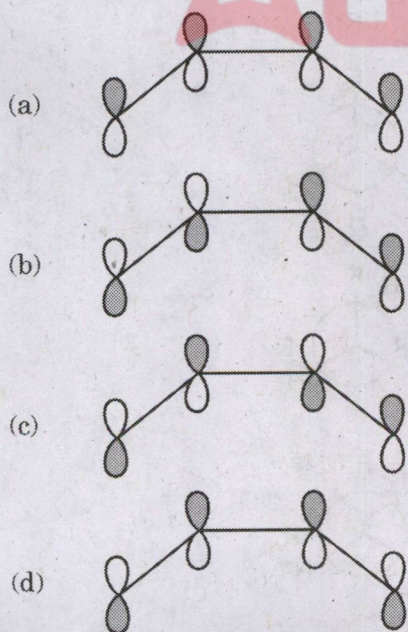
85. Which one of the following statements regarding free radicals is **not** correct ?

(a) Carbon free radical is paramagnetic in nature.

(b) Free radicals are formed by homolytic bond fission.

(c) Stability order of free radicals for the following species is :

$H_2C=CH\overset{\bullet}{C}H_2 > Ph_3\overset{\bullet}{C} > Ph_2\overset{\bullet}{C}H > Ph\overset{\bullet}{C}H_2.$

(d) p-Benzoquinone acts as an inhibitor for free-radical reactions.

86. The correct order of stability of following carbocations is :
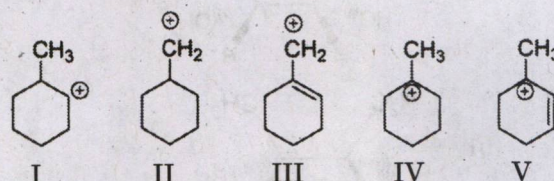
(a) $IV > III > V > II > I$

(b) $V > III > IV > I > II$

(c) $II > I > IV > III > V$

(d) $V > IV > III > II > I$

87. Which one of the following compounds does **not** contain plane of symmetry ?

(a)

(b)

(c)

(d)
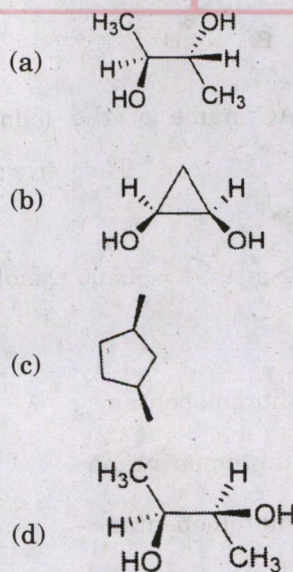
88. The two compounds given below are :

 and
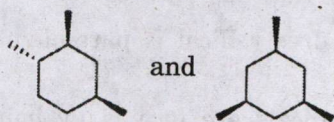
  (a) Identical
  (b) Constitutional isomers
  (c) Diastereomers
  (d) Enantiomers

89. Which one of the following is **not** a meso compound ?

  (a)

  (b)

  (c)

  (d)
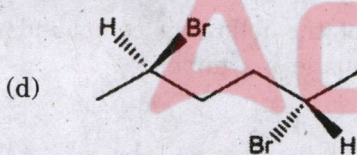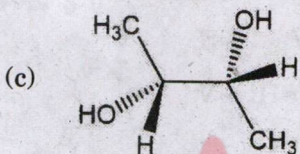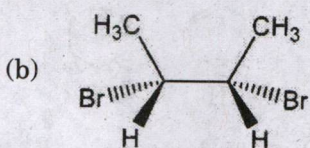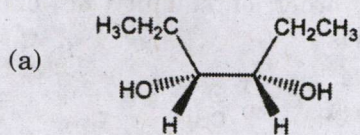
90. The correct IUPAC name of the following compound is :
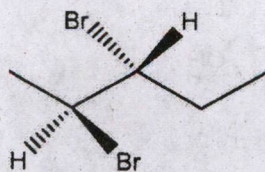
  (a) (2S, 3S)-2,3-dibromopentane
  (b) (2R, 3R)-2,3-dibromopentane
  (c) (2S, 3R)-2,3-dibromopentane
  (d) (2R, 3S)-2,3-dibromopentane

91. The most stable conformer of cis-1, 3-dimethylcyclohexane is :

  (a)

  (b)

  (c)

  (d)
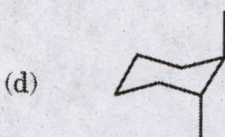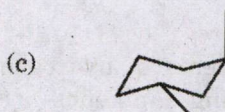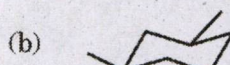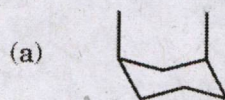
92. The most stable conformer of 1,2-difluoroethane in the gas phase is :

  (a)

  (b)

  (c)

  (d)
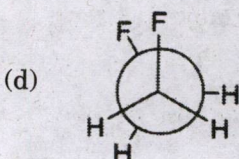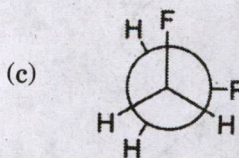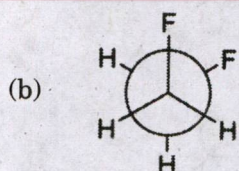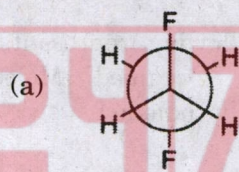
93. The major products [A] and [B] formed in the following reactions are :

(a) [A] = [B] =

(b) [A] = [B] =

(c) [A] = [B] =

(d) [A] = [B] =
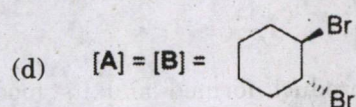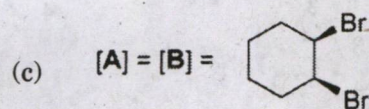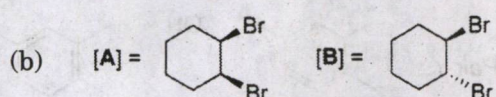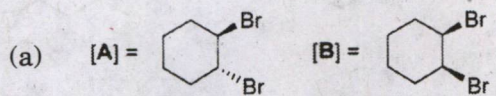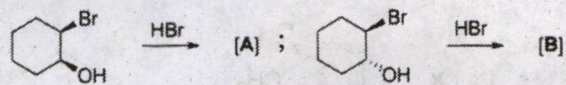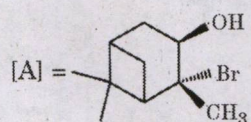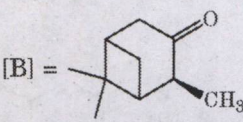
94. In the given reaction sequence, products X and Y are :

(a) respectively as major products

(b) respectively as major products

(c) respectively as major products

(d) respectively as major products
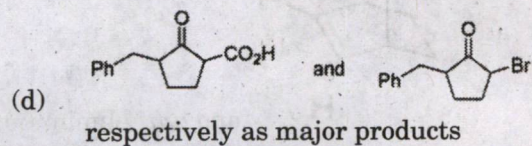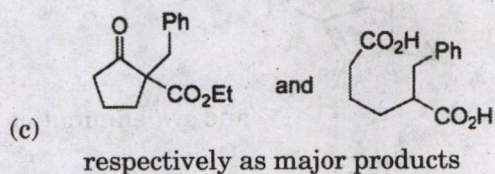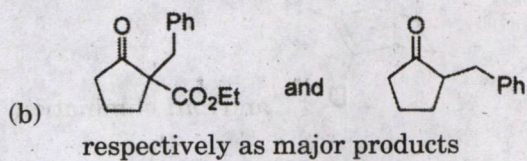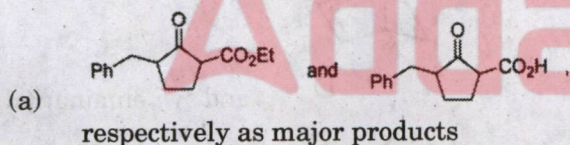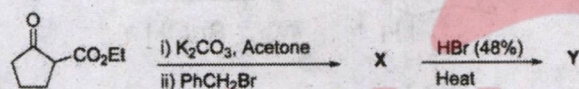
95. Deprotection of phenyl methyl ether with HI goes via :

(a) S_N2 attack at sp^3 carbon

(b) S_N1 attack at sp^2 carbon

(c) S_N2 attack at sp^2 carbon

(d) S_N1 attack at sp^3 carbon

96. The product formed in the following reaction is :

(a)

(b)

(c)

(d)
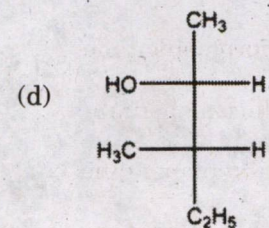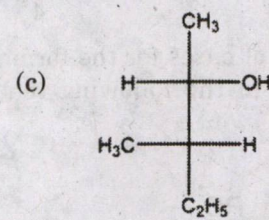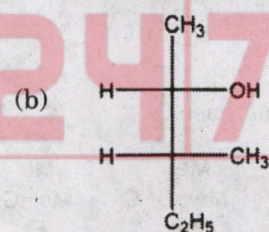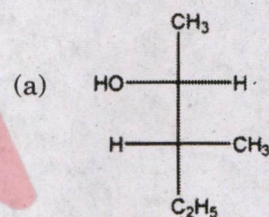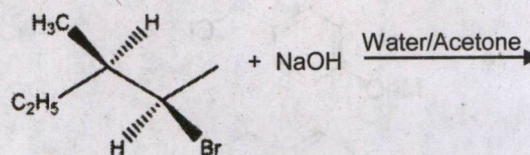
97. The correct order of reactivity of the following alkyl halides in S_N2 reaction is :
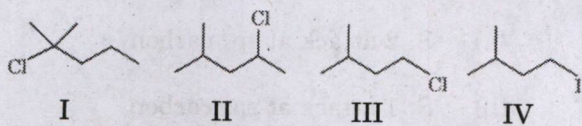
(a) IV > III > II > I
(b) I > III > II > IV
(c) IV > III > I > II
(d) II > I > IV > III

98. Which one of the following alkyl halides favours S_N1 mechanism ?

(a)

(b)

(c)

(d)
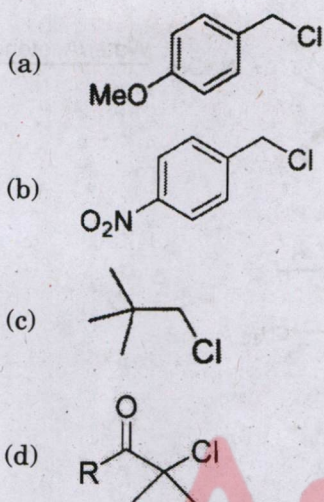
99. Consider the following bases :
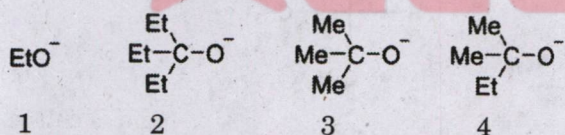
The reactivity order of bases for the formation of Zaitsev's product in the following reaction is :
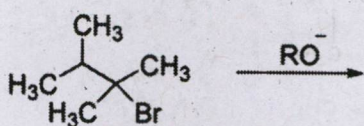
(a) 1 > 3 > 4 > 2
(b) 4 > 2 > 3 > 1
(c) 2 > 4 > 3 > 1
(d) 1 > 3 > 2 > 4

100. Which alcohol in each of the following pairs will undergo elimination reaction more rapidly when heated with conc. H_2SO_4 ?

Pair X :

Pair Y :
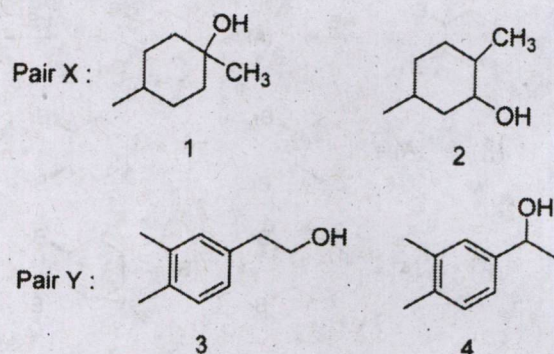
(a) 1 and 3
(b) 1 and 4
(c) 2 and 3
(d) 2 and 4

101. The major product formed and its mode of elimination in the following reaction is :
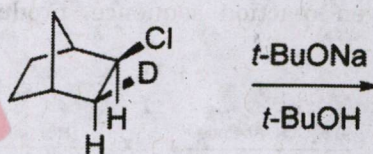
(a)

and *syn* elimination

(b)

and *anti* elimination

(c)

and *syn* elimination

(d)

and *anti* elimination

102. Which type of elimination mechanism will occur in reactions I and II, respectively ?

Reaction I $\quad H_3C - \overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle Cl}{|}}{C}} - CH_3 \quad + \quad \overset{\ominus}{O}CH_3 \longrightarrow$

Reaction II $\quad CH_3CH_2Br \quad + \quad \overset{\ominus}{O}C(CH_3)_3 \longrightarrow$
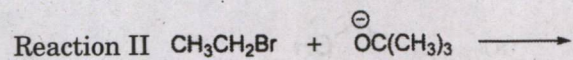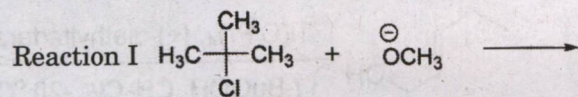
(a) E1 and E1 mechanism

(b) E2 and E2 mechanism

(c) E1 and E2 mechanism

(d) E2 and E1 mechanism

103. The correct elimination pathway for Reaction I and Reaction II are, respectively :
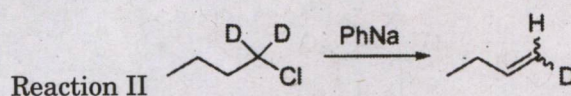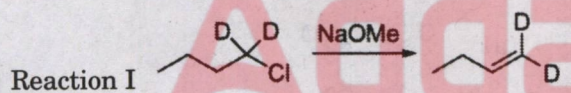
Reaction I $\xrightarrow{NaOMe}$

Reaction II $\xrightarrow{PhNa}$

(a) α-elimination and β-elimination

(b) β-elimination and α-elimination

(c) α-elimination and α-elimination

(d) β-elimination and β-elimination

104. Which one of the following is true for the reaction given below ?

$\xrightarrow{NaOMe}$ [X]
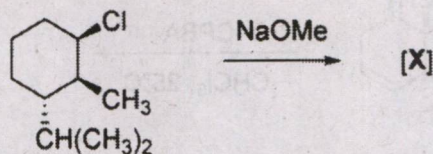
(a) [X] is and is called Hofmann product

(b) [X] is and is called Zaitsev product

(c) [X] is and is called Hofmann produdct

(d) [X] is and is called Zaitsev product

105. The major product formed in the following reaction is :
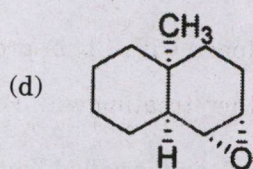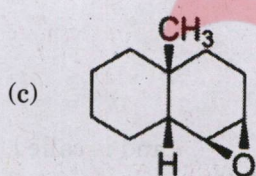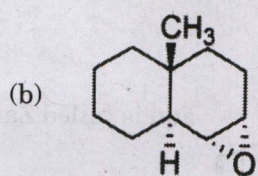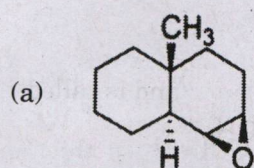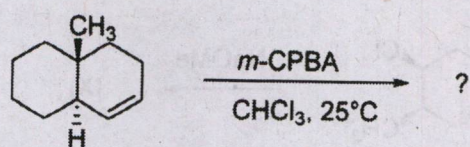
$\xrightarrow[\text{CHCl}_3,\ 25°C]{\text{m-CPBA}}$ **?**

(a)

(b)

(c)

(d)

106. The major product formed in the following reaction is :

$\xrightarrow[\text{t-BuOOH, CH}_2\text{Cl}_2,\ -20\ °C]{\text{Ti(O}^i\text{Pr)}_4,\ (+)\text{-diethyltartarate}}$

(a)

(b)

(c)

(d)

107. The product formed in the following reaction is :

$\xrightarrow[\text{(ii) H}_3\text{O}^+,\ \text{heat}]{\text{(i) NaOEt/EtOH}}$

(a)

(b)

(c)

(d)
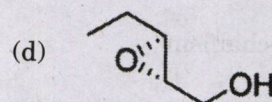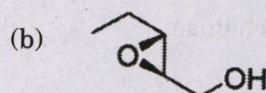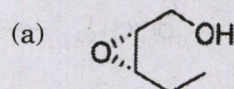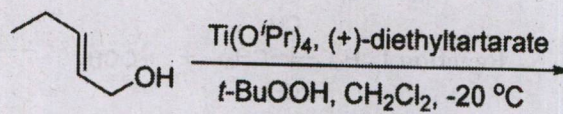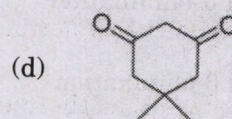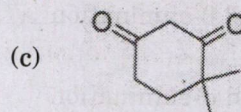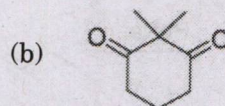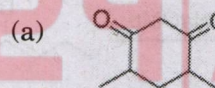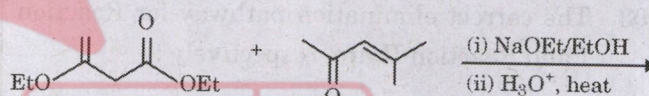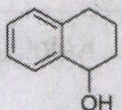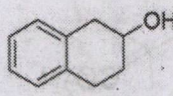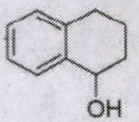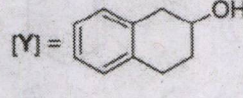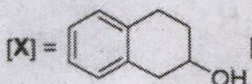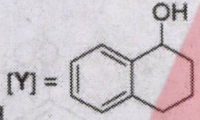
108. The major products [X] and [Y] formed in the following reactions are :

$$[X] \xleftarrow{H_3O^+} \text{(structure)} \xrightarrow[\text{(ii) NaBH}_4]{\text{(i) Hg(OAc)}_2, H_2O} [Y]$$
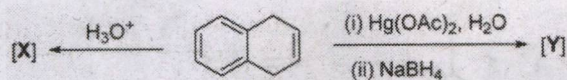
(a) [X] = [Y] =

(b) [X] = [Y] =

(c) [X] = [Y] =

(d) [X] = [Y] =
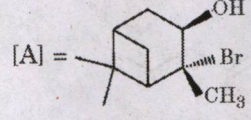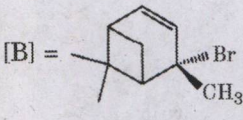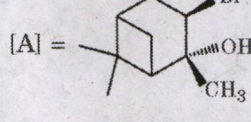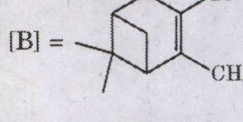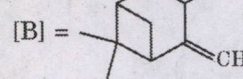
109. Identify the processes labelled as "P", "Q" and "R" in the following table summarizing energetics of free radical addition of HX (X = Cl, Br or I) to propylene :

Steps of Mechanism	$CH_3 - CH = CH_2 + X\overset{\cdot}{}$	$CH_3 - \overset{\cdot}{CH} - CH_2X + H - X$
Heat of Reaction (using HX)	ΔH (Step I)	ΔH (Step II)
HCl	Exothermic	"P"
HBr	"Q"	Exothermic
HI	Endothermic	"R"

(a) P is Endothermic, Q is Exothermic, and R is Exothermic

(b) P is Exothermic, Q is Exothermic, and R is Exothermic

(c) P is Endothermic, Q is Exothermic, and R is Endothermic

(d) P is Exothermic, Q is Endothermic, and R is Exothermic

110. The products [A] and [B] formed in the following reaction sequence are :

$$\text{(structure)} \xrightarrow[\text{H}_2\text{O}]{\text{Br}_2} [A] \xrightarrow[\Delta]{\text{H}_2\text{SO}_4} [B]$$
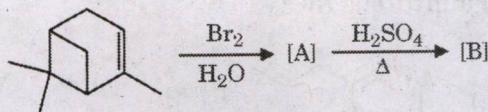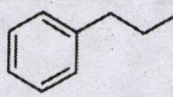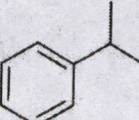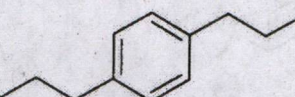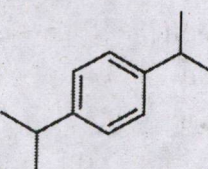
(a) [A] = [B] =

(b) [A] = [B] =

(c) [A] = [B] =

(d) [A] = [B] =
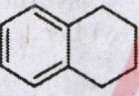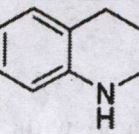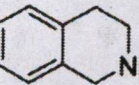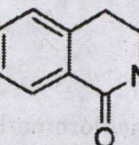
111. Which one of the following is the correct sequence for synthesis of l-bromo-3-(trichloromethyl)benzene ?

(a) Reaction of toluene with Br_2 and Fe, then treating with Cl_2 in presence of hv or heat

(b) Reaction of toluene with Cl_2 and Fe, then treating with Br_2 in presence of hv or heat

(c) Reaction of toluene with Cl_2 in presence of hv or heat, then treating with Br_2 and Fe

(d) Reaction of trichloromethyl benzene with Cl_2 in presence of hv or heat

112. What is the major product when benzene reacts with n-propyl chloride in the presence of anhydrous $AlCl_3$?
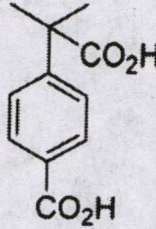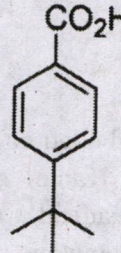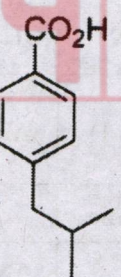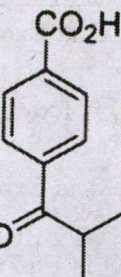
(a)

(b)

(c)

(d)

113. Which one of the following substrates undergoes bromination reaction on aromatic ring at fastest rate ?

(a)

(b)

(c)

(d)

114. The major product formed in the following reaction sequence is :
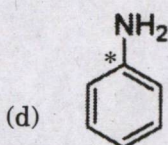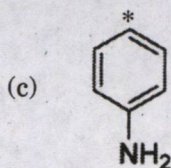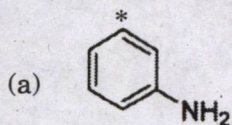

i) ⟍=, H^+
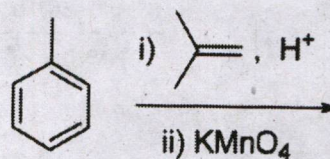
ii) $KMnO_4$

(a)

(b)

(c)

(d)

115. Which one of the following compounds will *not* be formed in the given reaction ?

$\xrightarrow[\text{liq. } NH_3]{NaNH_2}$
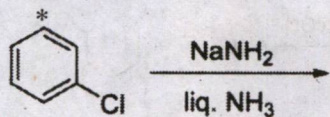
*indicates a ^{13}C label

(a)

(b)

(c)

(d)
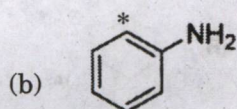
116. The correct sequence of reactions for accomplishing the following multi-step transformation is :

(a) (i) $CH_3Cl/AlCl_3$, (ii) $KMnO_4$,
(iii) HNO_3/H_2SO_4

(b) (i) HNO_3/H_2SO_4, (ii) $CH_3Cl/AlCl_3$,
(iii) $KMnO_4$

(c) (i) $CH_3Cl/AlCl_3$, (ii) HNO_3/H_2SO_4,
(iii) $KMnO_4$

(d) (i) HNO_3/H_2SO_4, (ii) $CO/HCl/AlCl_3$,
(iii) $KMnO_4$

117. Which one of the following statements is true for the given reaction ?
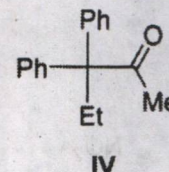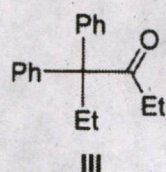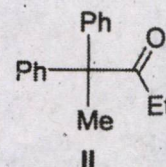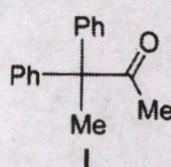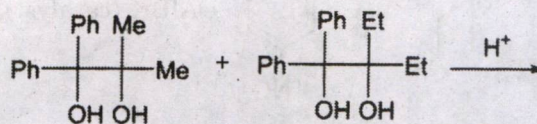
(a) I and III are called cross-over products and are formed by intermolecular reaction.

(b) II and IV are called cross-over products and are formed by intermolecular reaction.

(c) II and IV are called cross-over products and are formed by intramolecular reaction.

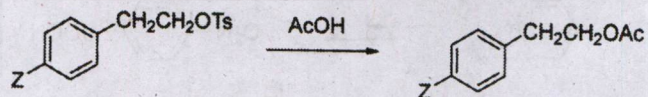(d) I and III are called cross-over products and are formed by intramolecular reaction.

118. The final product [X] formed in the following reaction is :

Br + + AlBr₃ (catalyst)

$\xrightarrow{\text{Friedel-Crafts conditions}}$ [X]

(a)

(b)

(c)

(d)

119. The major products [A] and [B] formed in the following reactions are :

 $\xrightarrow{\text{AcOH}}$ [A] ; $\xrightarrow{\text{AcOH}}$ [B]

(a) [A] = [B] =

(b) [A] = [B] =

(c) [A] = [B] =

(d) [A] = [B] =
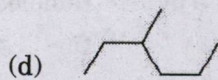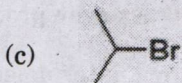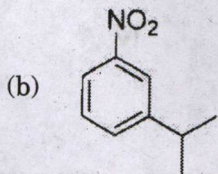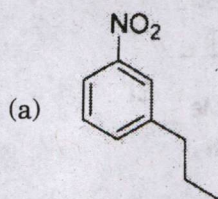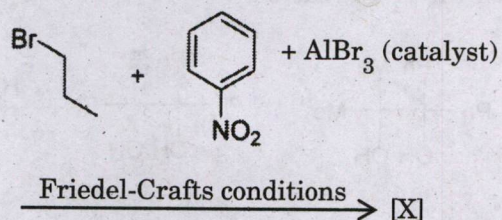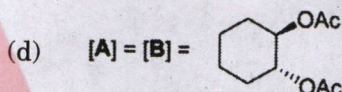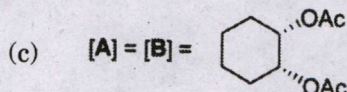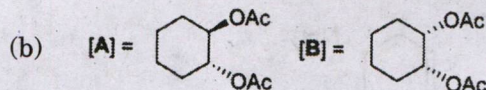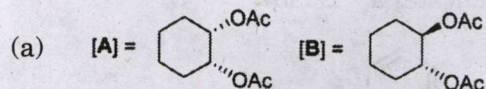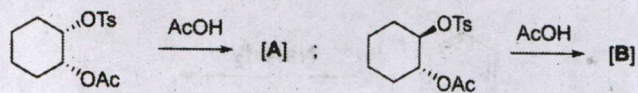
120. Consider the following solvolysis reaction :
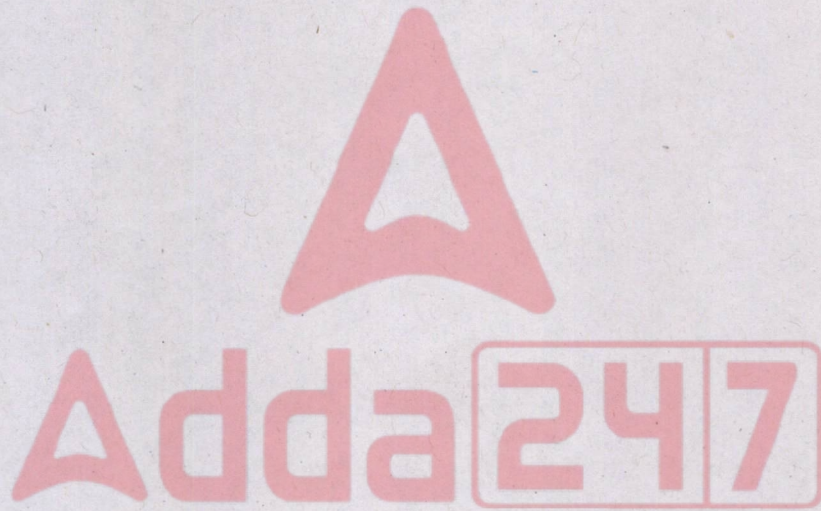
 $\xrightarrow{\text{AcOH}}$
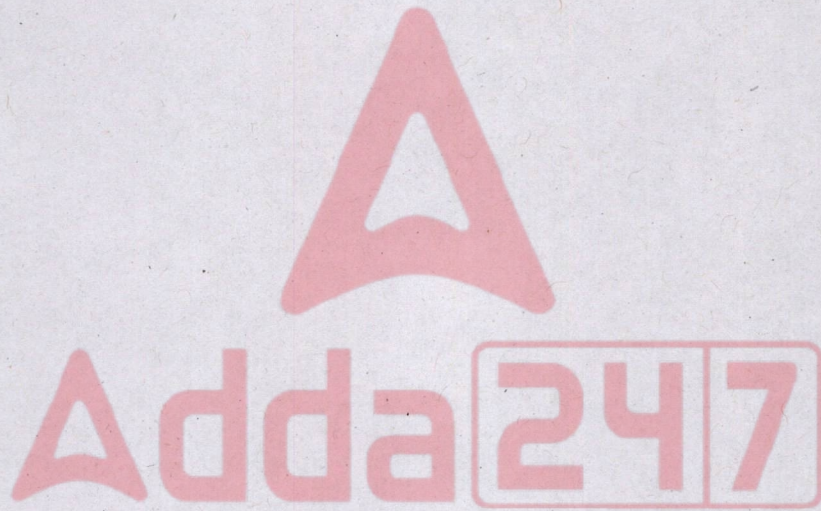
(where, Z is H or p-Cl or p-Me or p-OMe)

The extent of neighbouring group participation of phenyl group (from lower to higher) follows which one of the following order ?

(a) H < p-Cl < p-OMe < p-Me

(b) p-OMe < p-Cl < p-Me < H

(c) p-Cl < p-Me < H < p-OMe

(d) p-Cl < H < p-Me < p-OMe

SPACE FOR ROUGH WORK

SPACE FOR ROUGH WORK

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