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

23-0009-AG TEST BOOKLET

CHEMISTRY

PAPER – I

Time Allowed: 3 hours | **Maximum Marks: 300**

INSTRUCTIONS TO CANDIDATES

Read the instructions carefully before answering the questions: -

1. This Test Booklet consists of **16(sixteen) pages** and has **75 (seventy-five) items (questions).**
2. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS BOOKLET *DOES NOT* HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.
3. **Please note that it is the candidate's responsibility to fill in the Roll Number and other required details carefully and without any omission or discrepancy at the appropriate places in the OMR Answer Sheet and the Separate Answer Booklet. Any omission/discrepancy will render the OMR Answer Sheet and the Separate Answer Booklet liable for rejection.**
4. Do not write anything else on the OMR Answer Sheet except the required information. Before you proceed to mark in the OMR Answer Sheet, please ensure that you have filled in the required particulars as per given instructions.
5. Use **only Black Ball Point Pen** to fill the OMR Answer Sheet.
6. This Test Booklet is divided into 4 (four) parts – **Part – I, Part – II, Part - III** and **Part – IV**.
7. All three parts are **Compulsory.**
8. **Part-I consists of Multiple Choice-based Questions.** The answers to these questions have to be marked in the **OMR Answer Sheet** provided to you.
9. **Part-II, Part-III and Part-IV consist of Conventional Essay-type Questions.** The answers to these questions have to be written in the separate **Answer Booklet** provided to you.
10. In Part-I, each item (question) comprises of 04 (four) responses (answers). You are required to select the response which you want to mark on the OMR 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.
11. After you have completed filling in all your responses on the OMR Answer Sheet and the Answer Booklet(s) and the examination has concluded, you should hand over to the Invigilator ***only the OMR Answer Sheet and the Answer Booklet(s)***. You are permitted to take the Test Booklet with you.
12. **Penalty for wrong answers in Multiple Choice-based Questions:**

THERE WIL 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 the 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 the 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.

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

PART-I
(Multiple Choice-based Questions)

Instructions for Questions 1 to 50:

- *Choose the correct answers for the following questions.*
- *Each question carries 3 marks.*
- *No Data Books/Tables are allowed; assume the data if required anywhere.*

[3x50=150]

1. The flow of electrons in an electrolytic cell is from-
   (a) cathode to anode in a solution
   (b) cathode to anode through external supply
   (c) cathode to anode through internal supply
   (d) anode to cathode through external supply

2. Internal energy does not include-
   (a) Nuclear energy
   (b) Vibrational energy
   (c) Rotational energy
   (d) Gravitational energy

3. An endothermic reaction is allowed to take place rapidly in air, the temperature of surrounding air will _____
   (a) increase
   (b) remain unaffected
   (c) decrease
   (d) first increase then decrease

4. One faraday of electricity is passed through molten Al_2O_3, aqueous solution of $CuSO_4$ and molten $NaCl$ taken in three different electrolytic cells connected in series. The mole ratio of Al,Cu and Na deposited at the respective cathode is -
   (a) 2: 2: 3
   (b) 6: 2: 3
   (c) 6: 3: 2
   (d) 2: 3: 6

5. While charging a lead storage battery, the _____
   (a) $PbSO_4$ anode is reduced to Pb
   (b) $PbSO_4$ cathode is reduced to Pb
   (c) $PbSO_4$ cathode is oxidized to Pb
   (d) $PbSO_4$ anode is oxidized to Pb

6. Which of the following has the highest oxidizing power?
   (a) I_2
   (b) Br_2
   (c) Cl_2
   (d) F_2

7. Which of the following is an example of absorption?
   (a) Water on silica gel.
   (b) Water on calcium chloride.
   (c) Hydrogen on finely divided nickel.
   (d) Oxygen on metal surface.

8. Which of the following cations can form strong-field as well as weak-field octahedral complexes?
   (a) V^{+3}
   (b) Cr^{+3}
   (c) Ti^{+3}
   (d) Fe^{+3}

9. The value of the Madelung constant is dependent on the _____
   (a) size of cation
   (b) size of anion
   (c) co-ordination number of cation and anion
   (d) None of the above

10. What is the equation form of the Langmuir adsorption isotherm under high pressure?
   (a) $\frac{x}{m} = \frac{a}{b}$
   (b) $\frac{x}{m} = aP$
   (c) $\frac{x}{m} = \frac{1}{aP}$
   (d) $\frac{x}{m} - \frac{b}{a}$

11. What is the oxidation state of $\boldsymbol{Xe}$ in $\boldsymbol{perxenate\ ion}[\boldsymbol{XeO_6}]^{-4}$?
   (a) +4
   (b) +6
   (c) +8
   (d) None of the above.

12. Which among the following moleculesis polar?
   (a) CO_2
   (b) BF_3
   (c) BeF_2
   (d) SO_2

13. What is the calculated bond order of superoxide ion $\boldsymbol{O_2^-}$?
   (a) 2.0
   (b) 2.5
   (c) 1.5
   (d) 1.0

14. Which among NO_2, NO_2^+ and NO_2^- has the maximum bond angle?
    (a) All three have the same bond angle.
    (b) NO_2^-
    (c) NO_2
    (d) NO_2^+

15. Structure of IF_7 is _____
    (a) trigonal bipyramidal
    (b) octahedral
    (c) square pyramidal
    (d) pentagonal bipyramidal

16. Consider the following statements about the $B-H-B$ bonds in the structure of B_2H_6.
    (i) These bonds are referred to as Banana bonds.
    (ii) These bonds are referred to as Bridge bonds.
    (iii) These bonds are referred to as $3c-2e$ bonds.

    Which of the above statements about these bonds is TRUE? Select the correct answer from the codes given below.
    Codes:
    (a) Only (i)
    (b) Only (ii)
    (c) Only (iii)
    (d) (i), (ii) and (iii)

17. At $0°C$ the density of a certain oxide of a gas at **2 *bars*** is the same as that of nitrogen gas at **5 *bars***. What is the molecular mass of the oxide?
    (a) 35 g/mol
    (b) 42 g/mol
    (c) 70 g/mol
    (d) 84 g/mol

18. The critical temperature of CO_2 is-
    (a) 273 K
    (b) 300.4 K
    (c) 304.1 K
    (d) 309.2 K

19. Atmospheric pressure recorded in different cities are as follows:

Cities	Atmospheric pressure in N/m^2
Gangtok	1.01×10^5
Bangalore	1.20×10^5
Delhi	1.04×10^5
Mumbai	1.21×10^5

    On the basis of above data, select the place at which a liquid would boil first.
    (a) Gangtok
    (b) Bangalore
    (c) Delhi
    (d) Mumbai

20. Which of the following properties of water can be used to explain the spherical shape of rain droplets?
    (a) Viscosity
    (b) Critical phenomenon
    (c) Surface tension
    (d) Pressure

21. If water kept in an insulated vessel at $-10°C$ suddenly freezes, the entropy change of the system _____
    (a) decreases
    (b) increases
    (c) is equal to that of its surrounding
    (d) is zero

22. Given that $\Delta_f G°$ of $Cu^{+2}_{(aq)}$ and $Zn^{+2}_{(aq)}$ is $65\ kJ\ mol^{-1}$ and $-147.2\ kJ\ mol^{-1}$. Calculate the standard Gibbs free energy change of the following reaction -

$$Zn_{(s)} + Cu^{+2}_{(aq)} \rightarrow Cu_{(s)} + Zn^{+2}_{(aq)}$$

    (a) $-82.2\ kJ\ mol^{-1}$
    (b) $+82.2\ kJ\ mol^{-1}$
    (c) $+212.2\ kJ\ mol^{-1}$
    (d) $-212.2\ kJ\ mol^{-1}$

23. The contribution of an atom at the edge centre of a particular unit cell is -
    (a) 1/2
    (b) 1/8
    (c) 1
    (d) 1/4

24. The compound is formed by element A and B. This crystallizes in the cubic structure where atoms B are the corners of the cube while A are the body centre. The simplest formula of compound is
    (a) AB
    (b) A_2B
    (c) AB_2
    (d) AB_6

25. Which of the following sets of quantum numbers is not permitted?
    (a) $n = 2, l = 2, m = -1, s = +1/2$
    (b) $n = 2, l = 1, m = -1, s = -1/2$
    (c) $n = 2, l = 0, m = 0, s = +1/2$
    (d) $n = 2, l = 1, m = +1, s = -1/2$

26. Which of the following is/are t_{2g} orbital(s)?
    (a) p_z and p_y
    (b) d_{xy}, d_{yz} and d_{xz}
    (c) $d_{x^2-y^2}$and d_{z^2}
    (d) only d_{z^2}

27. For the reduction of silver ions with copper metal, the standard cell potential was found to be $+0.46\,V$ at $25°C$. Given that $F = 96500\,Cmol^{-1}$, find the value of standard Gibbs energy $\Delta G°$.
    (a) $-98.0\ kJ/mol$
    (b) $+98.0\ kJ/mol$
    (c) $-88.7\ kJ/mol$
    (d) $+88.7\ kJ/mol$

28. For a value of principal quantum number equal to **4**, what would the total number of possible values of magnetic quantum number be?
    (a) 7
    (b) 9
    (c) 16
    (d) 32

29. How many geometrical isomers are possible for a hypothetical octahedral complex **[Mabcdef]** ?
    (a) 9
    (b) 12
    (c) 15
    (d) 18

30. With the help of Born Haber cycle, we can calculate _____
    (a) Lattice Energy
    (b) Electron Affinity
    (c) Crystal Energy
    (d) All of the above

31. Which complex among the following would be paramagnetic in nature?
    (a) $[Fe(CN)_6]^{3-}$
    (b) $[Co(CN)_6]^{3-}$
    (c) $[Ni(CN)_4]^{2-}$
    (d) $[Fe(CN)_6]^{4-}$

32. Which complex among the following exhibits geometrical as well as optical isomerism?
    (a) $[Co(en)_2Cl_2]^+$
    (b) $[Co(en)_3]^{3+}$
    (c) $[Co(en)Cl_4]^-$
    (d) None of the above.

33. The ***principal, azimuthal*** and ***magnetic***quantum numbersare related to the _____ respectively of an electron.
    (a) size, orientation and shape
    (b) shape, size and orientation
    (c) size, shape and orientation
    (d) shape, orientation and size

34. The compounds $[Co(NH_3)_5SO_4]Br$ and $[Co(NH_3)_5Br]SO_4$ are examples of-
   (a) Linkage isomerism
   (b) Ionization isomerism
   (c) Coordination isomerism
   (d) None of the above

35. $NaCl$ is an ionic crystal with a co-ordination number of **6 : 6**. The radius ratio r_{Na^+}/r_{Cl^-} should be in between -
   (a) 0.225 *to* 0.413
   (b) 0.414 *to* 0.731
   (c) *above* 0.732
   (d) *below* 0.225

36. Which of the following statements is **TRUE**?
   (a) $Ni(CO)_4$ and $[NiCl_4]^{2-}$ are diamagnetic and $[Ni(CN)_4]^{2-}$ is paramagnetic.
   (b) $[NiCl_4]^{2-}$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $Ni(CO)_4$ is paramagnetic.
   (c) $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $[NiCl_4]^{2-}$ is paramagnetic.
   (d) $Ni(CO)_4$ is diamagnetic and $[Ni(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$ is paramagnetic.

37. Which ligand group exhibit minimum trans effect-
   (a) CN^-
   (b) C_2H_4
   (c) NH_3
   (d) H_2O

38. Which of the following is also referred to as Zeise's salt?
   (a) $K_2[PtCl_4]$
   (b) $[(C_5H_5)_2Fe]$
   (c) $K[PtCl_3(C_2H_4)]$
   (d) $[PtCl_2(C_2H_4)_2]$

39. Consider the following statements about Zeolites.
   (i) They are a three-dimensional aluminosilicate.
   (ii) They work as ion exchangers.
   (iii) They are used to separate gaseous mixtures into their components.

   Which of the above statements about Zeolites is TRUE? Select the correct answer from the codes given below.
   Codes:
   (a) Only (i)
   (b) Only (ii)
   (c) Only (iii)
   (d) (i), (ii) and (iii)

40. Which one among the following is paramagnetic in nature?

(a) B_2 (c) NO^+

(b) N_2 (d) F_2

41. Which of the lanthanide ion is paramagnetic?

(a) Ce^{4+} (c) La^{3+}

(b) Yb^{2+} (d) Eu^{2+}

42. Wurtzite structure is related to-

(a) $NaCl$ (c) CaF_2

(b) $CsCl$ (d) ZnS

43. Which among the following cells are primary cell(s)?

(I) Leclanché cell

(II) Nickel – cadmium cell

(III) Lead storage battery

(IV) Mercury cell

Select the correct answer from the codes below.

Codes:

(a) (I) and (II)

(b) (I) and (III)

(c) (II) and (II)

(d) (I) and (IV)

44. In the catalytic experiment involving the Haber's process $\boldsymbol{N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)}$, the rate of reaction was measured as $\boldsymbol{d[NH_3]/dt = 2 \times 10^{-4}\ mol\ L^{-1}s^{-1}}$. If there were no side reactions, what was the rate of reaction expressed in terms of $\boldsymbol{N_2}$?

(a) $1 \times 10^{-4}\ mol\ L^{-1}s^{-1}$ (c) $1 \times 10^{-3}\ mol\ L^{-1}s^{-1}$

(b) $4 \times 10^{-4}\ mol\ L^{-1}s^{-1}$ (d) $4 \times 10^{-3}\ mol\ L^{-1}s^{-1}$

45. Which of the following statements is correct?

(a) The rate of reaction is same at any time during the reaction.

(b) The rate of reaction is independent of temperature changes.

(c) The rate of reaction decreases with increase in concentration of reaction.

(d) The rate of reaction decreases with passage of time as the concentration of reactants decreases.

46. Which of the following is a correct statement with regard to $\boldsymbol{H_2^+}$ and $\boldsymbol{H_2^-}$?

(a) Both H_2^+ and H_2^- do not exist.

(b) H_2^- is more stable than H_2^+.

(c) H_2^+ is more stable than H_2^-.

(d) Both H_2^+ and H_2^- are equally stable.

47. A first order reaction is carried out starting with $\mathbf{10\ mol\ L^{-1}}$ of the reactant.It is **40%**complete in ***one hour***. If the same reaction is carried out with a concentration of $\mathbf{5\ mol\ L^{-1}}$, the ***percentage of the reaction*** that is complete in ***one hour*** will be:

(a) 80%
(b) 20%
(c) 40%
(d) 60%

48. The unit of a second order rate constant $\boldsymbol{k}$ will be-

(a) $mol\ L^{-1}s^{-1}$
(b) $mol^{-1}\ L\ s^{-1}$
(c) $mol^{-1}L^{-1}s^{-1}$
(d) $mol\ L^{-1}\ s$

49. Consider the following statements about catalysts.

(i) A catalyst increases the average kinetic energy of the reactant molecules.
(ii) A catalyst decreases the activation energy.
(iii) A catalyst increases the frequency of collision of the reactants.

Which of the above statements about catalysts is TRUE? Select the correct answer from the codes given below.
Codes:

(a) Only (i)
(b) Only (ii)
(c) Only (iii)
(d) (i), (ii) and (iii)

50. Chloral hydrate $\boldsymbol{CCl_3CH(OH)_2}$ molecules have two $\boldsymbol{O-H}$ bonds with same carbon atom. Even then it is a stable molecule. Its extra stability can be explained on the basis of:

(a) Inter-molecular hydrogen bonding.
(b) Intra-molecular hydrogen bonding.
(c) π hydrogen bonding.
(d) None of the above.

PART-II
(Short Answer-type Questions)

Instructions for Questions 51 to 63:

- ***Write the answers in short for any 10 (TEN) out of the thirteen questions.***
- ***Each question carries 5 marks.***
- ***No Data Books/Tables are allowed; assume the data if required anywhere.***
- ***Unless otherwise mentioned, symbols and notations have their usual meaning.***

[5x10=50]

51. Calculate the uncertainty in the position of a dust particle with mass equal to $\mathbf{1.0}\ \boldsymbol{mg}$ if the uncertainty in its velocity is $\mathbf{5.5 \times 10^{-20}}\ \boldsymbol{ms^{-1}}$.

52. Why is the dipole moment of $\boldsymbol{NF_3}$ is less than $\boldsymbol{NH_3}$?

53. What are $\boldsymbol{n}$-type semiconductors?

54. Calculate the units of the Vander Waals constants '$\boldsymbol{a}$' and '$\boldsymbol{b}$'.

55. Draw the structure of Borazine (borazole) representing the bond length and bond angle.

56. Establish the relationship between standard Gibb's energy change ($\boldsymbol{\Delta G°}$) and equilibrium constant ($\boldsymbol{K_{eq}}$).

57. Define ***Critical Solution Temperature*** (***CST***).

58. Describe ***overpotential***.

59. What is the ***Stopped Flow Method*** to study fast reactions?

60. Write the IUPAC names of –

    (a) $\boldsymbol{[Co(NH_3)_4Cl_2]Cl}$ (b) $\boldsymbol{Na_3[Fe(C_2O_4)_3]}$

61. Discuss the role of $\boldsymbol{K^+}$ and $\boldsymbol{Ca^{+2}}$ in the biological system.

62. What are ***phosphazenes***? Draw the cyclic structure of $\boldsymbol{[P_3N_3Cl_6]}$.

63. What is a photochemical reaction? Explain the mechanism of photochemical reaction occurring between hydrogen and chlorine gas.

PART-III
(Long Answer-type Questions)

Instructions for Questions 64 to 71:

- ***Answer any 5 (FIVE) out of the eight questions.***
- ***Each question carries 10 marks.***
- ***No Data Books/Tables are allowed; assume the data if required anywhere.***
- ***Unless otherwise mentioned, symbols and notations have their usual meaning.***

[10x5=50]

64. Explain why XeF_4 is square planar whereas CF_4 is tetrahedral?

65. Discuss stoichiometric and non-stoichiometric crystal defects.

66. Derive the Clausius Clapeyron equation. Calculate the latent heat of vaporisation per gram of water (the vapour pressure of water at $93°C$ and $100°C$ are **580 *mm*** and **760 *mm*** of mercury respectively).

67. Define critical constant of gases. How can they be derived from Vander Waals equation?

68. Discuss *Debye – Hückle*theory of strong electrolytes. Write the *Debye–Hückle Onsager* equation.

69. What are heterogeneous catalysts? State the characteristics and mechanism of heterogeneous catalysis with the help of an example.

70. Discuss in detail lanthanide contraction and its consequences?

71. What are interhalogen compounds? Discuss the basic nature of iodine on this basis?

PART-IV
(Essay-type Questions)

Instructions for Questions 72 to 75:

- *Answer any 2 (TWO) out of the four questions.*
- *Each question carries 25 marks.*
- *No Data Books/Tables are allowed; assume the data if required anywhere.*
- *Unless otherwise mentioned, symbols and notations have their usual meaning.*

[25x2= 50]

72. What is Joule Thomson effect? Calculate Joule Thomson coefficient and inversion temperature for a real gas.

73. Derive integrated rate equation for first order reaction. A first order reaction is 40% complete in 50 minutes. Calculate the value of the rate constant. In what time will the reaction be 80% complete?

74. What is crystal field theory (CFT) and how it is different from valency bond theory (VBT)? Explain the paramagnetic nature of $[CoF_6]^{3-}$ and diamagnetic nature of $[Co(NH_3)_6]^{3+}$ on the basis of CFT.

75. Draw the molecular orbital diagram and discuss the magnetic property of O_2, CO and NO molecules.

~~~~***~~~~
~~~~