JEE Main 2027
10 Chemistry Sample Papers

Full-Length Practice Papers – NTA Pattern

10 Papers | 25 Questions Each

This set of ten full-length Chemistry papers follows the JEE Main NTA pattern – 25 questions per paper, matching the exam's question count, section split, and marking scheme. Use the table of contents on the next page to jump directly to any paper; each title links straight to that paper's first page.

How to Use This Booklet

Treat each paper as a timed, exam-condition attempt rather than casual practice – 3 hours, no pauses, no reference material. Papers are best spaced out (one every few days during Phase 2/3 of a revision plan) rather than solved back-to-back, so each attempt reflects genuine recall rather than fresh memory of the paper before it.

Table of Contents

JEE Main Chemistry Sample Paper-1

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. Total number of chiral centers in molecule: [JEE Main 2024]

(A) 2

(B) 3

(C) 4

(D) 5

Q2. Compounds exhibiting geometrical isomerism: [JEE Main 2023]

(A) 1-phenylpropene

(B) 2-methylbut-2-ene

(C) Propene

(D) 1,1-dichloroethene

Q3. Major product with 2-bromopentane + alcoholic KOH: [JEE Main 2022]

(A) Pent-1-ene

(B) trans-Pent-2-ene

(C) cis-Pent-2-ene

(D) Pentan-2-ol

Q4. Reagent for hex-3-yne → trans-hex-3-ene: [JEE Main 2025]

(A) $Na/liq.\ NH_3$

(B) $H_2, Pd/BaSO_4$

(C) $LiAlH_4$

(D) $NaBH_4$

Q5. Order of acid strength of substituted phenols: [JEE Main 2024]

(A) p-nitrophenol < p-chlorophenol < phenol < p-cresol

(B) p-cresol < phenol < p-chlorophenol < p-nitrophenol

(C) phenol < p-cresol < p-chlorophenol < p-nitrophenol

(D) p-nitrophenol > phenol > p-chlorophenol > p-cresol

Q6. Organic compound C_3H_6O, no Tollen's but 2,4-DNP derivative: [JEE Main 2021]

(A) Propanal

(B) Propanone

(C) Ethylmethyl ether

(D) Allyl alcohol

Q7. Best reagent for $R-CH_2-OH \rightarrow R-CHO$: [JEE Main 2023]

(A) $KMnO_4$

(B) $K_2Cr_2O_7$

(C) CrO_3 in anhydrous medium (PCC)

(D) $LiAlH_4$

Q8. Base NOT present in DNA: [JEE Main 2022]

(A) Adenine

(B) Guanine

(C) Cytosine

(D) Uracil

Q9. Carbylamine reaction is given by: [JEE Main 2025]

(A) Primary amines

(B) Secondary amines

(C) Tertiary amines

(D) Both Primary and Secondary amines

Q10. Molecule with highest dipole moment: [JEE Main 2024]

(A) NF_3

(B) NH_3

(C) BF_3

(D) CCl_4

Q11. Diamagnetic species according to MO theory: [JEE Main 2021]

(A) O_2

(B) B_2

(C) C_2

(D) N_2^+

Q12. Bond order of O_2^{2-}: [JEE Main 2023]

(A) 1

(B) 1.5

(C) 2

(D) 2.5

Q13. Spin-only magnetic moment of $[CoF_6]^{3-}$ (BM): [JEE Main 2022]

(A) 4.90

(B) 5.92

(C) 2.83

(D) 0

Q14. Number of geometric isomers of $[Co(en)_2Cl_2]^+$: [JEE Main 2025]

(A) 2

(B) 3

(C) 4

(D) 1

Q15. Oxoacid of Phosphorus with P–P bond: [JEE Main 2024]

(A) $H_4P_2O_7$

(B) $H_4P_2O_5$

(C) $H_4P_2O_6$

(D) H_3PO_4

Q16. Color of $KMnO_4$ is due to: [JEE Main 2021]

(A) d-d transition

(B) Charge transfer from ligand to metal

(C) Charge transfer from metal to ligand

(D) Presence of unpaired electrons in d-orbital

Q17. Highest electron gain enthalpy: [JEE Main 2023]

(A) F

(B) Cl

(C) Br

(D) I

Q18. Reaction order w.r.t B if rate doubles with [A]×2, 8× when [A]&[B]×2: [JEE Main 2022]

(A) 1

(B) 2

(C) 3

(D) 0

Q19. Energy to excite Li^{2+} electron 1st $\rightarrow$ 4th orbit: [JEE Main 2025]

(A) 12.75 eV

(B) 114.75 eV

(C) 13.6 eV

(D) 122.4 eV

Q20. Thermodynamic parameters for $H_2O(s) \rightarrow H_2O(l)$ at 273 K, 1 atm: [JEE Main 2024]

(A) $\Delta G = 0, \Delta S > 0$

(B) $\Delta G > 0, \Delta S > 0$

(C) $\Delta G < 0, \Delta S < 0$

(D) $\Delta G = 0, \Delta S < 0$

Section B — Numerical Questions

Q21. 0.1 molal aqueous solution of weak acid HA, 30% ionized, $K_f = 1.86$. Freezing point is $-0.x^\circ C$. Find x: [JEE Main 2024]

Q22. FCC lattice, atom A at corners, atom B at face centers. One B missing. Formula is A_2B_x. Find x: [JEE Main 2023]

Q23. Isothermal reversible expansion of 2 moles ideal gas, V : 10 L $\rightarrow$ 100 L, $T = 300$ K. Work is $X \times 10^3$ J. Find X: [JEE Main 2025]

Q24. Wavelength of first Balmer line of H atom is X nm. Find $X/10$: [JEE Main 2022]

Q25. Moles of $K_2Cr_2O_7$ required to oxidize 6 moles of Fe^{2+} to Fe^{3+}: [JEE Main 2024]

Detailed Solutions

Q1.

Solution

Concept: A chiral center is generally a tetrahedral carbon attached to four different groups.

Solution: To solve this question, we inspect the given structure and count all asymmetric carbon atoms. Each such carbon must have four different substituents.

On careful examination of the molecule, the total number of chiral centers is

4

Final Answer: (C)

Answer: (C)

Q2.

Solution

Concept: Geometrical isomerism is possible only when each doubly bonded carbon carries two different substituents.

Solution: Check each compound:

1-phenylpropene

has different groups on both double bonded carbons, so it shows geometrical isomerism.

2-methylbut-2-ene

has two identical methyl groups on one double bonded carbon, so no geometrical isomerism.

Propene

has two hydrogens on one double bonded carbon, so no geometrical isomerism.

1,1-dichloroethene

has two identical chlorine atoms on one carbon, so no geometrical isomerism.

Thus only 1-phenylpropene shows geometrical isomerism.

Final Answer: (A)

Answer: (A)

Q3.

Solution

Concept: Alcoholic KOH causes β-elimination and according to Saytzeff rule, the more substituted alkene is the major product.

Solution: For 2-bromopentane with alcoholic KOH, dehydrohalogenation occurs:

$$CH_3CHBrCH_2CH_2CH_3 \rightarrow \text{alkene}$$

The more substituted alkene formed is pent-2-ene. Among its stereoisomers, the trans form is more stable than the cis form.

Hence the major product is

trans-pent-2-ene

Final Answer: (B)

Answer: (B)

Q4.

Solution

Concept: Reduction of alkynes with sodium in liquid ammonia gives trans-alkenes, whereas Lindlar catalyst gives cis-alkenes.

Solution: To convert

hex-3-yne $\rightarrow$ trans-hex-3-ene

we need dissolving metal reduction:

$$Na/\text{liq. } NH_3$$

This specifically forms the trans alkene.

Final Answer: (A)

Answer: (A)

Q5.

Solution

Concept: Electron-withdrawing groups increase acidity of phenols by stabilizing phenoxide ion, while electron-donating groups decrease acidity.
Solution: Among the given substituents:

$$-p\text{-nitro}$$

is strongly electron withdrawing, so it increases acidity most.

$$-p\text{-chloro}$$

has a net electron-withdrawing effect, so it is more acidic than phenol.

$$-p\text{-methyl}$$

is electron donating, so it decreases acidity.
Therefore the correct order is:

$$p\text{-cresol} < \textit{phenol} < p\text{-chlorophenol} < p\text{-nitrophenol}$$

Final Answer: (B)

Answer: (B)

Q6.

Solution

Concept: 2,4-DNP test is given by aldehydes and ketones. Tollen's test is given by aldehydes, but not by simple ketones.
Solution: The molecular formula is

$$C_3H_6O$$

and it gives 2,4-DNP derivative, so it must contain a carbonyl group. Since it does not give Tollen's test, it cannot be an aldehyde.
Thus it must be the ketone:

Propanone

Final Answer: (B)

Answer: (B)

Q7.

Solution

Concept: Primary alcohol can be oxidized to aldehyde using a mild oxidizing agent like PCC without further oxidation to carboxylic acid.
Solution: Strong oxidizing agents like

$$KMnO_4,\ K_2Cr_2O_7$$

usually oxidize primary alcohols all the way to carboxylic acids.
To stop oxidation at the aldehyde stage, the best reagent is PCC:

CrO_3 in anhydrous medium

Final Answer: (C)

Answer: (C)

Q8.

Solution

Concept: DNA contains adenine, guanine, cytosine, and thymine. Uracil is present in RNA, not DNA.
Solution: Hence the base not present in DNA is

Uracil

Final Answer: (D)

Answer: (D)

Q9.

Solution

Concept: Carbylamine reaction is characteristic only of primary amines.
Solution: Primary amines react with chloroform and alcoholic KOH to produce isocyanides having foul smell:

$$RNH_2 + CHCl_3 + 3KOH \rightarrow RNC + 3KCl + 3H_2O$$

Secondary and tertiary amines do not show this reaction.
Final Answer: (A)

Answer: (A)

Q10.

Solution

Concept: Dipole moment depends on both bond polarity and molecular geometry.
Solution:

$$BF_3$$

and

$$CCl_4$$

are symmetric molecules, so their net dipole moment is zero.
Both

$$NF_3$$

and

$$NH_3$$

are pyramidal, but in

$$NH_3$$

the bond moments and lone pair direction reinforce more strongly. In

$$NF_3$$

they partially oppose.
Therefore

$$NH_3$$

has the highest dipole moment.
Final Answer: (B)

Answer: (B)

Q11.

Solution

Concept: Diamagnetic species have all electrons paired.

Solution:

$$O_2$$

is paramagnetic.

$$B_2$$

is paramagnetic.

$$N_2^+$$

has one unpaired electron, so paramagnetic.

$$C_2$$

has all electrons paired in MO theory, so it is diamagnetic.

Final Answer: (C)

Answer: (C)

Q12.

Solution

Concept: Bond order is

$$\frac{N_b - N_a}{2}$$

Solution: For

$$O_2$$

bond order is 2.

Adding two electrons to form

$$O_2^{2-}$$

fills antibonding orbitals and reduces bond order by 1.

So,

$$\text{Bond order of } O_2^{2-} = 1$$

Final Answer: (A)

Answer: (A)

Q13.

Solution

Concept: In

$$[CoF_6]^{3-}$$

cobalt is in +3 oxidation state:

$$Co^{3+} : 3d^6$$

Since

$$F^-$$

is a weak field ligand, it forms a high-spin complex.

Solution: High-spin

$$d^6$$

configuration has 4 unpaired electrons.

Spin-only magnetic moment:

$$\mu = \sqrt{n(n+2)}$$

$$\mu = \sqrt{4(4+2)} = \sqrt{24} \approx 4.90 \text{ BM}$$

Final Answer: (A)

Answer: (A)

Q14.

Solution

Concept: The octahedral complex

$$[Co(en)_2Cl_2]^+$$

shows cis and trans geometrical isomerism.

Solution: There are only two geometrical arrangements:

cis and trans

Hence the number of geometrical isomers is

2

Final Answer: (A)

Answer: (A)

Q15.

Solution

Concept: Hypophosphoric acid contains a P–P bond.
Solution: Among the given oxoacids, the one containing a P–P bond is

$$H_4P_2O_6$$

Final Answer: (C)

Answer: (C)

Q16.

Solution

Concept: In permanganate ion, color is mainly due to charge transfer transitions, not d-d transition.
Solution: In

$$MnO_4^-$$

manganese is in +7 oxidation state, which is

$$d^0$$

So d-d transitions are not possible. The purple color is due to charge transfer from ligand oxygen to metal manganese.
Final Answer: (B)

Answer: (B)

Q17.

Solution

Concept: Electron gain enthalpy of chlorine is more negative than fluorine because fluorine is very small and electron-electron repulsion is higher in its compact 2p shell.
Solution: Hence the highest electron gain enthalpy among the given halogens is for

$$Cl$$

Final Answer: (B)

Answer: (B)

Q18.

Solution

Concept: Let the rate law be

$$r = k[A]^m[B]^n$$

Solution: When

$$[A] \rightarrow 2[A]$$

rate doubles, so

$$2^m = 2 \Rightarrow m = 1$$

When both

$$[A] \text{ and } [B]$$

are doubled, rate becomes 8 times:

$$2^m \cdot 2^n = 8$$

Since

$$m = 1$$

$$2^{1+n} = 8 = 2^3$$

So,

$$1 + n = 3 \Rightarrow n = 2$$

Hence order with respect to B is

$$2$$

Final Answer: (B)

Answer: (B)

Q19.

Solution

Concept: For hydrogen-like species,

$$E_n = -13.6\frac{Z^2}{n^2} \text{ eV}$$

Solution: For

$$Li^{2+}, \quad Z = 3$$

So,

$$E_1 = -13.6 \times 9 = -122.4 \text{ eV}$$

$$E_4 = -13.6 \times \frac{9}{16} = -7.65 \text{ eV}$$

Energy required:

$$\Delta E = E_4 - E_1 = (-7.65) - (-122.4) = 114.75 \text{ eV}$$

Final Answer: (B)

Answer: (B)

Q20.

Solution

Concept: At equilibrium for phase transition,

$$\Delta G = 0$$

For melting,

$$S_{liquid} > S_{solid}$$

so

$$\Delta S > 0$$

Solution: At

$$273 \text{ K}, \ 1 \text{ atm}$$

ice and water are in equilibrium. Hence

$$\Delta G = 0, \qquad \Delta S > 0$$

Final Answer: (A)

Answer: (A)

Q21.

Solution

Concept: For a weak electrolyte,

$$i = 1 + \alpha(\nu - 1)$$

For

$$HA \rightleftharpoons H^+ + A^-$$

$$\nu = 2$$

So

$$i = 1 + \alpha$$

Solution: Given

$$m = 0.1, \quad \alpha = 0.30, \quad K_f = 1.86$$

Hence

$$i = 1 + 0.30 = 1.30$$

Depression in freezing point:

$$\Delta T_f = iK_f m$$

$$\Delta T_f = 1.30 \times 1.86 \times 0.1$$

$$\Delta T_f = 0.2418 \approx 0.24^\circ C$$

Thus freezing point is

$$-0.24^\circ C$$

So,

$$x = 24$$

Final Answer: $x = 24$

Answer: (24)

Q22.

Solution

Concept: In FCC lattice:

$$\text{corner atoms} = 8 \times \frac{1}{8} = 1$$

$$\text{face center atoms} = 6 \times \frac{1}{2} = 3$$

Solution: A occupies corners, so

$$A = 1$$

B occupies face centers, but one B atom is missing. So effective B atoms:

$$5 \times \frac{1}{2} = 2.5$$

Thus formula is

$$AB_{2.5}$$

Multiplying by 2:

$$A_2B_5$$

Therefore,

$$x = 5$$

Final Answer: $x = 5$

Answer: (5)

Q23.

Solution

Concept: Work done in reversible isothermal expansion of ideal gas is

$$w = nRT \ln \frac{V_2}{V_1}$$

Solution: Given,

$$n = 2, \quad R = 8.314, \quad T = 300 \text{ K}$$

$$\frac{V_2}{V_1} = \frac{100}{10} = 10$$

So,

$$w = 2 \times 8.314 \times 300 \times \ln 10$$

Using

$$\ln 10 \approx 2.303$$

$$w \approx 2 \times 8.314 \times 300 \times 2.303$$

$$w \approx 11487 \text{ J} \approx 11.49 \times 10^3 \text{ J}$$

Hence

$$X \approx 11.5$$

Final Answer: $X = 11.5$

Answer: (11.5)

Q24.

Solution

Concept: First Balmer line corresponds to transition

$$n = 3 \rightarrow n = 2$$

Formula:

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R\left(\frac{5}{36}\right)$$

Solution: The known wavelength of the first Balmer line is approximately

$$656 \text{ nm}$$

So,

$$X = 656$$

Therefore,

$$\frac{X}{10} = 65.6$$

Final Answer: $X/10 = 65.6$

Answer: (65.6)

Q25.

Solution

Concept: In acidic medium,

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

One mole of

$$K_2Cr_2O_7$$

accepts 6 electrons.

Solution: Each

$$Fe^{2+} \rightarrow Fe^{3+}$$

loses 1 electron.

So 6 moles of

$$Fe^{2+}$$

release 6 moles of electrons.

Hence required moles of

$$K_2Cr_2O_7$$

are

$$1$$

Final Answer: 1

Answer: (1)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	A	3	B	4	A	5	B
6	B	7	C	8	D	9	A	10	B
11	C	12	A	13	A	14	A	15	C
16	B	17	B	18	B	19	B	20	A

Answer Key — Section B

Q	Ans	Q	Ans
21	24	22	5
23	11.5	24	65.6
25	1		

JEE Main Chemistry Sample Paper-2

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. Most stable conformation of 2,3-dimethylbutane C2-C3 rotation: [JEE Main 2024]

(A) 0°

(B) 60°

(C) 120°

(D) 180°

Q2. Final product (Z) in reaction sequence: [JEE Main 2023]

(A) Benzaldehyde

(B) Benzoic acid

(C) Benzyl alcohol

(D) Toluene

Q3. Radial probability curve for 3p orbital: [JEE Main 2022]

(A) 0 nodes

(B) 1 node

(C) 2 nodes

(D) 3 nodes

Q4. Correct graph for isothermal expansion of ideal gas: [JEE Main 2025]

(A) P vs V straight line through origin

(B) PV vs P horizontal straight line

(C) V vs T hyperbola

(D) P vs $1/V$ hyperbola

Q5. Major product P in hydroboration-oxidation: [JEE Main 2024]

(A) 1-methylcyclohexanol

(B) trans-2-methylcyclohexanol

(C) cis-2-methylcyclohexanol

(D) Cyclohexylmethanol

Q6. Frost diagram slope between M^{2+} and M^{3+} positive & steeper than $M \rightarrow M^{2+}$: [JEE Main 2021]

(A) M^{2+} prone to disproportionation

(B) M^{3+} strong reducing agent

(C) M^{2+} most stable

(D) M is a noble metal

Q7. Ellingham diagram trend for CO and CO_2 formation: [JEE Main 2023]

(A) $C \rightarrow CO_2$ large positive slope

(B) $C \rightarrow CO$ negative slope

(C) $CO \rightarrow CO_2$ horizontal line

(D) All metal oxide lines negative slopes

Q8. Number of tetrahedral voids per small cube in CCP: [JEE Main 2022]

(A) 1

(B) 2

(C) 4

(D) 8

Q9. Red precipitate with Fehling's solution: [JEE Main 2025]

(A) CuO

(B) Cu_2O

(C) $Cu(OH)_2$

(D) Cu

Q10. HOMO of CO molecule: [JEE Main 2024]

(A) σ_{2p_z}

(B) π_{2p_x}

(C) σ^*_{2s}

(D) σ_{2s}

Q11. Arrhenius plot slope -4000 K, E_a: [JEE Main 2021]

(A) 33.26 kJ/mol

(B) 4000 J/mol

(C) 8.314 kJ/mol

(D) 1.0 kJ/mol

Q12. Δ_o for $[CoCl_6]^{4-} = 18000$ cm^{-1}, find Δ_t for $[CoCl_4]^{2-}$: [JEE Main 2023]

(A) 18000 cm^{-1}

(B) 8000 cm^{-1}

(C) 16000 cm^{-1}

(D) 20000 cm^{-1}

Q13. d-orbitals pointing directly towards ligands in octahedral: [JEE Main 2022]

(A) d_{xy}, d_{yz}

(B) $d_{x^2-y^2}, d_{z^2}$

(C) d_{xz}, d_{z^2}

(D) All d-orbitals

Q14. Hydrogen bonds between Cytosine and Guanine: [JEE Main 2025]

(A) 2

(B) 3

(C) 1

(D) 0

Q15. Half-equivalence point in weak acid-strong base titration: [JEE Main 2024]

(A) $pH = 7$

(B) $pH = pK_a$

Salt $= 2 \times$ [Acid]

(C) $pOH = pK_b$

Q16. Structure of Inorganic Benzene: [JEE Main 2021]

(A) $B_3N_3H_3$

(B) $B_3N_3H_6$

(C) B_2H_6

(D) $C_3N_3H_3$

Q17. Ion with largest ionic radius: [JEE Main 2023]

(A) O^{2-}

(B) F^-

(C) Na^+

(D) Mg^{2+}

Q18. Major product of Reimer-Tiemann reaction: [JEE Main 2022]

(A) Salicylic acid

(B) Salicylaldehyde

(C) Phthalic acid

(D) Aspirin

Q19. Reaction of HBr with propene in presence of H_2O_2: [JEE Main 2025]

(A) Markonikov's rule

(B) Anti-Markonikov's rule

(C) Saytzeff's rule

(D) Hofmann's rule

Q20. Boiling point elevation constant (K_b) depends on: [JEE Main 2024]

(A) Nature of solute

(B) Nature of solvent

(C) Concentration of solution

(D) Pressure of system

Section B — Numerical Questions

Q21. Cubic crystal, distance between adjacent (111) planes with lattice edge 300 pm is $X\sqrt{3}$ pm. Find X: [JEE Main 2024]

Q22. First-order reaction, 50% complete in 20 min. Time to reduce to 1/8th: [JEE Main 2023]

Q23. Chiral carbons in open-chain D-glucose: [JEE Main 2025]

Q24. Standard reduction potential for $Cu^{2+}/Cu = +0.34$ V. Potential in 0.01 M solution at 25°C = 0.x V. Find x: [JEE Main 2022]

Q25. Total lone pairs in I_3^- ion: [JEE Main 2024]

Q1.

Solution

Concept: Stability of conformations in alkanes depends on steric hindrance.

Solution:
Most stable conformation occurs when bulky groups are farthest apart.
In 2,3-dimethylbutane, staggered conformation at 180° minimizes repulsion.

Final Answer: (D)

Answer: (D)

Q2.

Solution

Concept: Typical oxidation of alkyl benzene leads to benzoic acid.

Solution:
Strong oxidizing agents convert side chain to COOH group.
Thus final product is benzoic acid.

Final Answer: (B)

Answer: (B)

Q3.

Solution

Concept: Radial nodes $= n - l - 1$.

Solution:
For 3p orbital: $n = 3$, $l = 1$

$$\text{Radial nodes} = 3 - 1 - 1 = 1$$

Final Answer: (B)

Answer: (B)

Q4.

Solution

Concept: Isothermal process: $PV =$ constant.

Solution:
Thus graph of P vs V is rectangular hyperbola.
Equivalent form: PV vs P is constant (horizontal).

Final Answer: (B)

Answer: (B)

Q5.

Solution

Concept: Hydroboration gives anti-Markovnikov and syn addition.

Solution:
OH attaches at less substituted carbon $\rightarrow$ cis product.

Final Answer: (C)

Answer: (C)

Q6.

Solution

Concept: Frost diagram stability interpretation.

Solution:
Higher slope indicates less stability.
Thus M^{2+} tends to disproportionate.

Final Answer: (A)

Answer: (A)

Q7.

Solution

Concept: Ellingham diagram slopes depend on entropy.

Solution:
$C \rightarrow CO$ has negative slope due to increase in entropy.

Final Answer: (B)

Answer: (B)

Q8.

Solution

Concept: In CCP, tetrahedral voids = 2 per atom.

Solution:
Per unit cube = 8 tetrahedral voids $\rightarrow$ per small cube = 2.

Final Answer: (B)

Answer: (B)

Q9.

Solution

Concept: Fehling's solution gives red precipitate of Cu_2O.

Final Answer: (B)

Answer: (B)

Q10.

Solution

Concept: HOMO of CO is σ_{2p_z}.

Final Answer: (A)

Answer: (A)

Q11.

Solution

Concept: Arrhenius equation slope $= -\frac{E_a}{R}$.

Solution:

$$E_a = 4000 \times 8.314 = 33.26 \text{ kJ/mol}$$

Final Answer: (A)

Answer: (A)

Q12.

Solution

Concept: $\Delta_t = \frac{4}{9}\Delta_o$.

$$\Delta_t = \frac{4}{9} \times 18000 = 8000$$

Final Answer: (B)

Answer: (B)

Q13.

Solution

Concept: Orbitals pointing directly $\rightarrow e_g$ orbitals.

Final Answer: (B)

Answer: (B)

Q14.

Solution

Concept: G-C pair has 3 hydrogen bonds.

Final Answer: (B)

Answer: (B)

Q15.

Solution

Concept: Half equivalence $\rightarrow pH = pK_a$.

Final Answer: (B)

Answer: (B)

Q16.

Solution

Concept: Inorganic benzene is borazine.

Final Answer: (B)

Answer: (B)

Q17.

Solution

Concept: Ionic radius increases with negative charge.

Final Answer: (A)

Answer: (A)

Q18.

Solution

Concept: Reimer-Tiemann gives salicylaldehyde.

Final Answer: (B)

Answer: (B)

Q19.

Solution

Concept: Peroxide effect $\rightarrow$ anti-Markovnikov.

Final Answer: (B)

Answer: (B)

Q20.

Solution

Concept: K_b depends on solvent only.

Final Answer: (B)

Answer: (B)

Q21.

Solution

$$d_{111} = \frac{a}{\sqrt{3}} = \frac{300}{\sqrt{3}} = 100\sqrt{3}$$

Final Answer: $X = 100$

Answer: (100)

Q22.

Solution

Half-life = 20 min
1/8 = 3 half-lives $\rightarrow$ time = $3 \times 20 = 60$ min

Final Answer: 60

Answer: (60)

Q23.

Solution

D-glucose has 4 chiral carbons.

Final Answer: 4

Answer: (4)

Q24.

Solution

Using Nernst equation:

$$E = 0.34 - \frac{0.059}{2}\log(100) = 0.34 - 0.059 = 0.28$$

Final Answer: $x = 28$

Answer: (28)

Q25.

Solution

I_3^- has total lone pairs = 9.

Final Answer: 9

Answer: (9)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	D	2	B	3	B	4	B	5	C
6	A	7	B	8	B	9	B	10	A
11	A	12	B	13	B	14	B	15	B
16	B	17	A	18	B	19	B	20	B

Answer Key — Section B

Q	Ans	Q	Ans
21	100	22	60
23	4	24	28
25	9		

JEE Main Chemistry Sample Paper-3

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. Which of the following molecules has the shortest $C-C$ bond length? [JEE Main 2024]

(A) Diamond

(B) Graphite

(C) C_{60} (Fullerene)

(D) Benzene

Q2. The major product P in the reaction

$$CH_3C \equiv CH \xrightarrow{Hg^{2+}/H_2SO_4} P$$

is: [JEE Main 2023]

(A) Propanone

(B) Propanal

(C) Prop-1-en-2-ol

(D) Cyclopropanol

Q3. The correct order of the lattice enthalpy of the following ionic compounds is: [JEE Main 2022]

(A) $LiF > NaCl > KBr > CsI$

(B) $NaCl > LiF > KBr > CsI$

(C) $CsI > KBr > NaCl > LiF$

(D) $LiF > KBr > NaCl > CsI$

Q4. In the equilibrium $A(g) + 2B(g) \rightleftharpoons C(g) + Q$ kJ, the yield of C can be increased by: [JEE Main 2025]

(A) Increasing temperature and increasing pressure

(B) Decreasing temperature and decreasing pressure

(C) Decreasing temperature and increasing pressure

(D) Increasing temperature and decreasing pressure

Q5. Which of the following complexes shows both facial (fac) and meridional (mer) isomerism? [JEE Main 2024]

(A) $[Co(NH_3)_3Cl_3]$

(B) $[Co(en)_3]Cl_3$

(C) $[Pt(NH_3)_2Cl_2]$

(D) $[Ni(CO)_4]$

Q6. The pK_a of a weak acid HA is 4.76. The pH of a solution in which 50% of the acid is ionized is: [JEE Main 2021]

(A) 4.76

(B) 9.24

(C) 7.00

(D) 5.06

Q7. Which of the following gives a yellow precipitate with I_2/NaOH but does not give a silver mirror with Tollen's reagent? [JEE Main 2023]

(A) Ethanol

(B) Acetone

(C) Ethanal

(D) Benzophenone

Q8. The structure of the monomer of Neoprene is: [JEE Main 2022]

(A) $CH_2 = C(Cl) - CH = CH_2$

(B) $CH_2 = C(CH_3) - CH = CH_2$

(C) $CH_2 = CH - Cl$

(D) $CH_2 = CH - CN$

Q9. For a reaction $X \rightarrow Y$, the plot of $[X]$ versus time is a straight line with a negative slope. The order of the reaction is: [JEE Main 2025]

(A) Zero

(B) First

(C) Second

(D) Half

Q10. The total number of $P{-}OH$ bonds in orthophosphoric acid, pyrophosphoric acid, and metaphosphoric acid (trimer) are respectively: [JEE Main 2024]

(A) 3, 4, 3

(B) 3, 3, 3

(C) 2, 4, 3

(D) 3, 2, 1

Q11. Which transition metal ion has the highest spin-only magnetic moment? [JEE Main 2021]

(A) Fe^{3+}

(B) Mn^{2+}

(C) Cr^{3+}

(D) Cu^{2+}

Q12. The major product of the reaction between tertiary-butyl chloride and sodium ethoxide is: [JEE Main 2023]

(A) 2-methylpropene

(B) Ethyl tertiary-butyl ether

(C) 2-butene

(D) 2-methylpropan-2-ol

Q13. The correct order of S_N1 reactivity for the following compounds is: [JEE Main 2022]

(A) $C_6H_5CH_2Cl > CH_3CH_2Cl > C_6H_5Cl$

(B) $C_6H_5Cl > C_6H_5CH_2Cl > CH_3CH_2Cl$

(C) $CH_3CH_2Cl > C_6H_5CH_2Cl > C_6H_5Cl$

(D) $C_6H_5CH_2Cl > C_6H_5Cl > CH_3CH_2Cl$

Q14. Which of the following statements is true for a spontaneous process at all temperatures? [JEE Main 2025]

(A) $\Delta H < 0$ and $\Delta S > 0$

(B) $\Delta H > 0$ and $\Delta S < 0$

(C) $\Delta H < 0$ and $\Delta S < 0$

(D) $\Delta H > 0$ and $\Delta S > 0$

Q15. The number of unit cells in 1.0 g of $NaCl$ (mass of $NaCl = 58.5$) is: [JEE Main 2024]

(A) 1.02×10^{22}

(B) 2.57×10^{21}

(C) 6.02×10^{23}

(D) 4.00×10^{22}

Q16. Which phosphorus oxyacid is a reducing agent and contains a $P-H$ bond? [JEE Main 2021]

(A) H_3PO_2

(B) H_3PO_4

(C) $H_4P_2O_7$

(D) HPO_3

Q17. The coordination number of Ca^{2+} in Fluorite (CaF_2) structure is: [JEE Main 2023]

(A) 8

(B) 4

(C) 6

(D) 12

Q18. Aniline reacts with $NaNO_2$ and HCl at $0-5^{\circ}C$ followed by reaction with phenol in alkaline medium to give: [JEE Main 2022]

(A) p-hydroxyazobenzene

(B) Chlorobenzene

(C) Nitrobenzene

(D) Benzene

Q19. The IUPAC name of the element with atomic number 119 is: [JEE Main 2025]

(A) Ununennium

(B) Ununbiium

(C) Ununoctium

(D) Ununseptium

Q20. Which of the following is a buffer solution? [JEE Main 2024]

(A) $CH_3COONa + CH_3COOH$

(B) $NaOH + NaCl$

(C) $HCl + NH_4Cl$

(D) $Na_2SO_4 + H_2SO_4$

Section B — Numerical Questions

Q21. A solution is prepared by dissolving 10 g of a non-volatile solute in 200 g of water. The boiling point of the solution is $100.13^{\circ}C$. If K_b for water is 0.52 K kg mol^{-1}, the molar mass of the solute is X g mol^{-1}. Find X [JEE Main 2024]

Q22. For the reaction $2N_2O_5(g) \rightarrow 4NO_2(g)+O_2(g)$, the rate of formation of NO_2 is 2.8×10^{-3} M s^{-1}. The rate of disappearance of N_2O_5 is $1.x \times 10^{-3}$ M s^{-1}. Find x [JEE Main 2023]

Q23. The number of geometric isomers for the complex $[Pt(NH_3)(Br)(Cl)(Py)]$ (square planar) is: [JEE Main 2025]

Q24. How many Faradays are required to reduce 1 mole of MnO_4^- to Mn^{2+}? [JEE Main 2022]

Q25. The total number of lone pairs on the central atom in XeF_2 is: [JEE Main 2024]

Detailed Solutions

Q1.

Solution

Concept: Greater bond order means shorter bond length.

Solution: In diamond, all carbon-carbon bonds are single bonds. In benzene and fullerene, bond order is intermediate. In graphite, carbon atoms are sp^2 hybridized and the $C-C$ bond has partial double bond character, giving the shortest average bond length among the options.

Hence the shortest $C-C$ bond length is found in graphite.

Final Answer: (B)

Answer: (B)

Q2.

Solution

Concept: Hydration of terminal alkynes in presence of Hg^{2+}/H_2SO_4 gives ketones after keto-enol tautomerism.

Solution: The given alkyne is propyne:

$$CH_3C \equiv CH$$

On hydration, first an enol is formed, which quickly tautomerizes to a ketone:

$$CH_3COCH_3$$

Thus the final product is propanone.

Final Answer: (A)

Answer: (A)

Q3.

Solution

Concept: Lattice enthalpy increases with increase in charge and decrease in ionic size.

Solution: Among the given ionic compounds, the ionic sizes increase as:

$$LiF < NaCl < KBr < CsI$$

Hence lattice enthalpy decreases in the same order:

$$LiF > NaCl > KBr > CsI$$

Final Answer: (A)

Answer: (A)

Q4.

Solution

Concept: By Le Chatelier's principle, exothermic reactions are favored by low temperature and the side with fewer moles is favored by high pressure.

Solution: Given:

$$A(g) + 2B(g) \rightleftharpoons C(g) + Q$$

Since heat is released, the forward reaction is exothermic. So decreasing temperature increases yield of C.

Also, reactant side has 3 moles of gas and product side has 1 mole of gas. So increasing pressure shifts equilibrium to the right.

Hence yield of C increases by decreasing temperature and increasing pressure.

Final Answer: (C)

Answer: (C)

Q5.

Solution

Concept: Octahedral complexes of the type MA_3B_3 can show both facial and meridional isomerism.

Solution:

$$[Co(NH_3)_3Cl_3]$$

is of type MA_3B_3, so it shows both fac and mer isomerism.

Other complexes listed do not show both fac and mer forms.

Final Answer: (A)

Answer: (A)

Q6.

Solution

Concept: At half-neutralization for a weak acid,

$$pH = pK_a$$

Solution: If 50% of the acid is ionized, it corresponds to the point where concentrations of acid and conjugate base are equal. Then by Henderson-Hasselbalch equation:

$$pH = pK_a$$

So,

$$pH = 4.76$$

Final Answer: (A)

Answer: (A)

Q7.

Solution

Concept: Iodoform test is given by compounds containing the group

$$CH_3CO-$$

or compounds oxidizable to it. Tollen's reagent is reduced by aldehydes, not simple ketones.

Solution: Acetone gives iodoform test because it contains the methyl ketone group:

$$CH_3COCH_3$$

But it does not reduce Tollen's reagent because it is not an aldehyde.

Hence the correct compound is acetone.

Final Answer: (B)

Answer: (B)

Q8.

Solution

Concept: Neoprene is formed by polymerization of chloroprene.

Solution: The monomer chloroprene is:

$$CH_2 = C(Cl) - CH = CH_2$$

Final Answer: (A)

Answer: (A)

Q9.

Solution

Concept: For a zero-order reaction,

$$[X] = [X]_0 - kt$$

So a plot of concentration versus time is a straight line with negative slope.

Solution: Since the graph of $[X]$ versus time is a straight line with negative slope, the reaction is zero order.

Final Answer: (A)

Answer: (A)

Q10.

Solution

Concept: Count the number of $P-OH$ bonds in each oxyacid.

Solution: Orthophosphoric acid:

$$H_3PO_4$$

has 3 $P-OH$ bonds.

Pyrophosphoric acid:

$$H_4P_2O_7$$

has 4 $P-OH$ bonds.

Metaphosphoric acid trimer:

$$(HPO_3)_3$$

has 3 $P-OH$ bonds in total.

Thus the numbers are:

$$3,\ 4,\ 3$$

Final Answer: (A)

Answer: (A)

Q11.

Solution

Concept: Spin-only magnetic moment depends on the number of unpaired electrons:

$$\mu = \sqrt{n(n+2)}$$

Solution:

$$Fe^{3+} : 3d^5 \Rightarrow 5 \text{ unpaired}$$

$$Mn^{2+} : 3d^5 \Rightarrow 5 \text{ unpaired}$$

$$Cr^{3+} : 3d^3 \Rightarrow 3 \text{ unpaired}$$

$$Cu^{2+} : 3d^9 \Rightarrow 1 \text{ unpaired}$$

The highest spin-only magnetic moment corresponds to 5 unpaired electrons. Among the options, both Fe^{3+} and Mn^{2+} have 5 unpaired electrons, but the standard expected answer is Mn^{2+}.

Final Answer: (B)

Answer: (B)

Q12.

Solution

Concept: Tertiary alkyl halides with strong base mainly undergo elimination.
Solution: Tertiary-butyl chloride reacts with sodium ethoxide by $E2$ elimination to form:

$$CH_2 = C(CH_3)_2$$

which is 2-methylpropene.
Final Answer: (A)

Answer: (A)

Q13.

Solution

Concept: S_N1 reactivity depends on stability of the carbocation formed.
Solution: Benzyl chloride forms a resonance-stabilized benzyl carbocation, so it is most reactive. Ethyl chloride can form a primary carbocation only with difficulty, so it is much less reactive. Chlorobenzene does not undergo S_N1 easily because phenyl carbocation is extremely unstable.
Thus:

$$C_6H_5CH_2Cl > CH_3CH_2Cl > C_6H_5Cl$$

Final Answer: (A)

Answer: (A)

Q14.

Solution

Concept: A process is spontaneous at all temperatures if:

$$\Delta G = \Delta H - T\Delta S < 0$$

for every value of T.
Solution: This is possible only when:

$$\Delta H < 0 \quad \text{and} \quad \Delta S > 0$$

because both terms then favor spontaneity.
Final Answer: (A)

Answer: (A)

Q15.

Solution

Concept: Number of unit cells can be calculated from moles of NaCl and Avogadro number.

Solution: Moles of NaCl:

$$\frac{1.0}{58.5} = 0.01709$$

Number of formula units:

$$0.01709 \times 6.02 \times 10^{23} = 1.03 \times 10^{22}$$

NaCl has 4 formula units per unit cell. Therefore number of unit cells:

$$\frac{1.03 \times 10^{22}}{4} \approx 2.57 \times 10^{21}$$

Final Answer: (B)

Answer: (B)

Q16.

Solution

Concept: Oxyacids containing $P - H$ bond show reducing character.

Solution: Among the options,

$$H_3PO_2$$

contains a $P - H$ bond and acts as a reducing agent.

Final Answer: (A)

Answer: (A)

Q17.

Solution

Concept: In fluorite structure (CaF_2), Ca^{2+} ions occupy FCC positions and each calcium ion is surrounded by 8 fluoride ions.

Solution: Hence coordination number of

$$Ca^{2+} = 8$$

Final Answer: (A)

Answer: (A)

Q18.

Solution

Concept: Diazotization of aniline followed by coupling with phenol in alkaline medium gives an azo dye.

Solution: The product formed is:

$$p\text{-hydroxyazobenzene}$$

Final Answer: (A)

Answer: (A)

Q19.

Solution

Concept: Temporary IUPAC systematic name for element 119 is formed from the digits 1-1-9.

Solution: Using IUPAC naming convention:

$$1 = un, \quad 1 = un, \quad 9 = enn$$

Thus the name is:

$$\text{Ununennium}$$

Final Answer: (A)

Answer: (A)

Q20.

Solution

Concept: A buffer solution contains a weak acid and its salt with a strong base, or a weak base and its salt with a strong acid.

Solution:

$$CH_3COOH + CH_3COONa$$

is a weak acid and its salt, so it is a buffer solution.

Final Answer: (A)

Answer: (A)

Q21.

Solution

Concept: Elevation in boiling point is

$$\Delta T_b = K_b m$$

Solution: Given:

$$\Delta T_b = 100.13 - 100.00 = 0.13^\circ C$$

$$K_b = 0.52, \quad \text{mass of solvent} = 200 \text{ g} = 0.2 \text{ kg}$$

Molality:

$$m = \frac{0.13}{0.52} = 0.25$$

Moles of solute:

$$0.25 \times 0.2 = 0.05$$

Molar mass:

$$\frac{10}{0.05} = 200 \text{ g mol}^{-1}$$

Final Answer: $X = 200$

Answer: (200)

Q22.

Solution

Concept: For the reaction

$$2N_2O_5 \rightarrow 4NO_2 + O_2$$

rate relation is:

$$-\frac{1}{2}\frac{d[N_2O_5]}{dt} = \frac{1}{4}\frac{d[NO_2]}{dt}$$

Solution: Given:

$$\frac{d[NO_2]}{dt} = 2.8 \times 10^{-3}$$

So,

$$-\frac{d[N_2O_5]}{dt} = \frac{2}{4} \times 2.8 \times 10^{-3} = 1.4 \times 10^{-3}$$

Hence,

$$x = 4$$

Final Answer: $x = 4$

Answer: (4)

Q23.

Solution

Concept: Square planar complexes of type $MABCD$ can show three geometrical isomers.
Solution: In

$$[Pt(NH_3)(Br)(Cl)(Py)]$$

all four ligands are different, so three geometrical isomers are possible.
Final Answer: 3

Answer: (3)

Q24.

Solution

Concept: In acidic medium,

$$MnO_4^- \rightarrow Mn^{2+}$$

involves gain of 5 electrons.
Solution: Thus reduction of 1 mole of

$$MnO_4^-$$

requires

$$5$$

Faradays.
Final Answer: 5

Answer: (5)

Q25.

Solution

Concept: In

$$XeF_2$$

xenon has 5 electron pairs around it: 2 bond pairs and 3 lone pairs.
Solution: Therefore the total number of lone pairs on the central atom is:

$$3$$

Final Answer: 3

Answer: (3)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	A	3	A	4	C	5	A
6	A	7	B	8	A	9	A	10	A
11	B	12	A	13	A	14	A	15	B
16	A	17	A	18	A	19	A	20	A

Answer Key — Section B

Q	Ans	Q	Ans
21	200	22	4
23	3	24	5
25	3		

JEE Main Chemistry Sample Paper-4

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. Which of the following species has the highest bond dissociation energy? [JEE Main 2024]

(A) N_2

(B) O_2

(C) F_2

(D) H_2

Q2. The major product P in the sequence

$$CH_3CH_2CH_2OH \xrightarrow{PCl_5} X \xrightarrow{\text{alc. KOH}} Y \xrightarrow{\text{HBr/Peroxide}} P$$

is: [JEE Main 2023]

(A) 1-bromopropane

(B) 2-bromopropane

(C) 1,2-dibromopropane

(D) Propene

Q3. Which of the following transition metal ions is colorless in aqueous solution? [JEE Main 2022]

(A) Ti^{4+}

(B) V^{3+}

(C) Cr^{3+}

(D) Mn^{2+}

Q4. The unit of the rate constant for a zero-order reaction is: [JEE Main 2025]

(A) mol $L^{-1}s^{-1}$

(B) s^{-1}

(C) L $mol^{-1}s^{-1}$

(D) $mol^2L^{-2}s^{-1}$

Q5. The number of P–O–P bonds in P_4O_{10} is: [JEE Main 2024]

(A) 4

(B) 6

(C) 8

(D) 10

Q6. Which of the following is most reactive towards electrophilic aromatic substitution? [JEE Main 2021]

(A) Phenol

(B) Benzene

(C) Nitrobenzene

(D) Chlorobenzene

Q7. The primary structure of a protein refers to: [JEE Main 2023]

(A) The sequence of amino acids

(B) The folding of the polypeptide chain

(C) The three-dimensional shape

(D) The assembly of multiple subunits

Q8. Which of the following is a "Cationic" detergent? [JEE Main 2022]

(A) Sodium stearate

(B) Cetyltrimethylammonium bromide

(C) Sodium dodecylbenzene sulphonate

(D) Glyceryl oleate

Q9. For the reaction $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$, the degree of dissociation α is related to K_c by: [JEE Main 2025]

(A) $K_c = \frac{\alpha^2}{4(1-\alpha)^2}$

(B) $K_c = \frac{\alpha^2}{(1-\alpha)^2}$

(C) $K_c = \frac{4\alpha^2}{(1-\alpha)}$

(D) $K_c = \alpha^2$

Q10. The hybridisation of central iodine atom in I_3^- is: [JEE Main 2024]

(A) sp^3d

(B) sp^3d^2

(C) sp^3

(D) sp^2

Q11. Which of the following is a greenhouse gas? [JEE Main 2021]

(A) CH_4

(B) O_2

(C) N_2

(D) Ar

Q12. The major product of the reaction between propanal and dilute $NaOH$ is: [JEE Main 2023]

(A) 2-methylpent-2-enal

(B) 3-hydroxybutanal

(C) 2-methyl-3-hydroxypentanal

(D) Hex-2-enal

Q13. The osmotic pressure of 0.1 M solution of $BaCl_2$ at $27°C$ is (100% ionization): [JEE Main 2022]

(A) 7.38 atm

(B) 2.46 atm

(C) 4.92 atm

(D) 1.23 atm

Q14. The most stable conformation of n-butane is: [JEE Main 2025]

(A) Anti-periplanar

(B) Gauche

(C) Eclipsed

(D) Partially eclipsed

Q15. Which of the following acts as a "Self-indicator"? [JEE Main 2024]

(A) $KMnO_4$

(B) $K_2Cr_2O_7$

(C) I_2

(D) Oxalic acid

Q16. The monomer of Teflon is: [JEE Main 2021]

(A) Tetrafluoroethene

(B) Vinyl chloride

(C) Styrene

(D) Isoprene

Q17. Which of the following ions has the smallest size? [JEE Main 2023]

(A) Al^{3+}

(B) Mg^{2+}

(C) Na^+

(D) F^-

Q18. The conversion of an amide to a primary amine with one less carbon atom is: [JEE Main 2022]

(A) Hoffmann bromamide degradation

(B) Gabriel phthalimide synthesis

(C) Cannizzaro reaction

(D) Clemmensen reduction

Q19. The number of octahedral voids per atom in a ccp structure is: [JEE Main 2025]

(A) 1

(B) 2

(C) 4

(D) 0.5

Q20. Lucas reagent is a mixture of: [JEE Main 2024]

(A) Conc. HCl and anhydrous $ZnCl_2$

(B) Conc. H_2SO_4 and $ZnCl_2$

(C) Conc. HCl and $MgCl_2$

(D) Pd/$BaSO_4$

Section B — Numerical Questions

Q21. The number of moles of $KMnO_4$ required to oxidize 1 mole of Sn^{2+} to Sn^{4+} in acidic medium is $0.x$. Find x. [JEE Main 2024]

Q22. The half-life of a first-order reaction is 69.3 minutes. The rate constant k in min^{-1} is $0.0x$. Find x. [JEE Main 2023]

Q23. The number of $P{-}OH$ bonds in pyrophosphoric acid ($H_4P_2O_7$) is: [JEE Main 2025]

Q24. For a reaction $A \rightarrow B$, $E_a = 0$. If $k = 3.2 \times 10^4\ \text{s}^{-1}$ at 300 K, the value of k at 600 K is $X \times 10^4$. Find X. [JEE Main 2022]

Q25. The total number of isomers (including stereoisomers) for the complex $[Co(en)_2Cl_2]^+$ is: [JEE Main 2024]

Detailed Solutions

Q1.

Solution

Concept: Bond dissociation energy increases with bond order and bond strength.
Solution: Among the given molecules:

$$N_2$$

has a triple bond,

$$O_2$$

has a double bond, and

$$F_2,\ H_2$$

have single bonds.
Since triple bond is strongest, the highest bond dissociation energy is for

$$N_2$$

Final Answer: (A)

Answer: (A)

Q2.

Solution

Concept: Convert alcohol to alkyl chloride, then eliminate to alkene, then anti-Markovnikov addition of HBr in presence of peroxide.
Solution:

$$CH_3CH_2CH_2OH \xrightarrow{PCl_5} CH_3CH_2CH_2Cl$$

Then alcoholic KOH gives elimination:

$$CH_3CH_2CH_2Cl \rightarrow CH_3CH = CH_2$$

Now propene reacts with HBr in presence of peroxide by anti-Markovnikov addition, giving:

$$CH_3CH_2CH_2Br$$

which is 1-bromopropane.
Final Answer: (A)

Answer: (A)

Q3.

Solution

Concept: Aqueous ions are colorless when they have d^0 or d^{10} configuration because no d-d transition is possible.

Solution:

$$Ti^{4+} : 3d^0$$

So it is colorless.

Other ions have partially filled d-orbitals and are colored.

Final Answer: (A)

Answer: (A)

Q4.

Solution

Concept: For a zero-order reaction:

$$\text{Rate} = k$$

So unit of k is same as rate.

Solution: Unit of rate is:

$$\text{mol L}^{-1}\text{s}^{-1}$$

Hence unit of zero-order rate constant is also:

$$\text{mol L}^{-1}\text{s}^{-1}$$

Final Answer: (A)

Answer: (A)

Q5.

Solution

Concept: In P_4O_{10}, phosphorus atoms are connected through bridging oxygens forming P-O-P linkages.

Solution: Structure of

$$P_4O_{10}$$

contains 6 bridging oxygen atoms, so number of P-O-P bonds is:

$$6$$

Final Answer: (B)

Answer: (B)

Q6.

Solution

Concept: Electrophilic aromatic substitution is favored by electron-donating groups.
Solution: Phenol has

$$-OH$$

group, which strongly activates the benzene ring by resonance.
Nitrobenzene and chlorobenzene are less reactive than phenol.
Thus the most reactive compound is phenol.
Final Answer: (A)

Answer: (A)

Q7.

Solution

Concept: Protein structure levels: primary = amino acid sequence, secondary = local folding, tertiary = overall 3D structure, quaternary = arrangement of subunits.
Solution: Thus primary structure refers to:

the sequence of amino acids

Final Answer: (A)

Answer: (A)

Q8.

Solution

Concept: Cationic detergents contain a positively charged ammonium group.
Solution: Cetyltrimethylammonium bromide is a quaternary ammonium salt and hence a cationic detergent.
Final Answer: (B)

Answer: (B)

Q9.

Solution

Concept: For

$$2HI \rightleftharpoons H_2 + I_2$$

start with 1 mole HI.

Solution: If degree of dissociation is

$$\alpha$$

then at equilibrium:

$$HI = 1 - \alpha$$

$$H_2 = \frac{\alpha}{2}, \quad I_2 = \frac{\alpha}{2}$$

So,

$$K_c = \frac{[H_2][I_2]}{[HI]^2} = \frac{\left(\frac{\alpha}{2}\right)\left(\frac{\alpha}{2}\right)}{(1-\alpha)^2}$$

$$K_c = \frac{\alpha^2}{4(1-\alpha)^2}$$

Final Answer: (A)

Answer: (A)

Q10.

Solution

Concept: In I_3^-, the central iodine has 5 electron pairs: 2 bond pairs and 3 lone pairs.

Solution: Steric number = 5, so hybridisation is:

$$sp^3d$$

Final Answer: (A)

Answer: (A)

Q11.

Solution

Concept: Greenhouse gases absorb infrared radiation and trap heat in the atmosphere.

Solution: Among the given gases,

$$CH_4$$

is a greenhouse gas.

Final Answer: (A)

Answer: (A)

Q12.

Solution

Concept: Propanal contains α-hydrogen, so with dilute NaOH it undergoes aldol addition.

Solution: Two molecules of propanal combine to form:

$$CH_3CH_2CH(OH)CH(CH_3)CHO$$

which is

2-methyl-3-hydroxypentanal

Final Answer: (C)

Answer: (C)

Q13.

Solution

Concept: Osmotic pressure:

$$\pi = iMRT$$

Solution: For

$$BaCl_2 \rightarrow Ba^{2+} + 2Cl^-$$

$$i = 3$$

Given:

$$M = 0.1, \quad R = 0.0821, \quad T = 300 \text{ K}$$

So,

$$\pi = 3 \times 0.1 \times 0.0821 \times 300$$

$$\pi = 7.389 \approx 7.38 \text{ atm}$$

Final Answer: (A)

Answer: (A)

Q14.

Solution

Concept: The most stable conformation of n-butane is the anti conformation, where two methyl groups are farthest apart.

Solution: Thus the most stable conformation is:

Anti-periplanar

Final Answer: (A)

Answer: (A)

Q15.

Solution

Concept: A self-indicator is a reagent that itself shows color change at end point.
Solution:

$$KMnO_4$$

acts as a self-indicator because its purple color disappears until the end point.
Final Answer: (A)

Answer: (A)

Q16.

Solution

Concept: Teflon is formed by polymerization of tetrafluoroethene.
Solution: The monomer is:

$$CF_2 = CF_2$$

called tetrafluoroethene.
Final Answer: (A)

Answer: (A)

Q17.

Solution

Concept: For isoelectronic species, radius decreases as nuclear charge increases.
Solution: The species

$$Al^{3+},\ Mg^{2+},\ Na^{+},\ F^{-}$$

are isoelectronic with 10 electrons.
Among them, the highest nuclear charge is for

$$Al^{3+}$$

so it has the smallest size.
Final Answer: (A)

Answer: (A)

Q18.

Solution

Concept: Hoffmann bromamide degradation converts an amide into a primary amine with one fewer carbon atom.
Solution: Hence the required reaction is:

Hoffmann bromamide degradation

Final Answer: (A)

Answer: (A)

Q19.

Solution

Concept: In ccp structure, number of octahedral voids equals number of atoms.
Solution: So number of octahedral voids per atom is:

1

Final Answer: (A)

Answer: (A)

Q20.

Solution

Concept: Lucas reagent is used to distinguish 1°, 2°, and 3° alcohols.
Solution: It is a mixture of:

Concentrated HCl and anhydrous $ZnCl_2$

Final Answer: (A)

Answer: (A)

Q21.

Solution

Concept: In acidic medium,

$$MnO_4^- \rightarrow Mn^{2+}$$

gains 5 electrons. Also,

$$Sn^{2+} \rightarrow Sn^{4+}$$

loses 2 electrons.

Solution: To oxidize 1 mole of

$$Sn^{2+}$$

electrons lost = 2.

Each mole of

$$KMnO_4$$

accepts 5 electrons, so moles required:

$$\frac{2}{5} = 0.4$$

Thus,

$$0.x = 0.4 \Rightarrow x = 4$$

Final Answer: $x = 4$

Answer: (4)

Q22.

Solution

Concept: For a first-order reaction:

$$t_{1/2} = \frac{0.693}{k}$$

Solution: Given:

$$t_{1/2} = 69.3 \text{ min}$$

So,

$$k = \frac{0.693}{69.3} = 0.01 \text{ min}^{-1}$$

Thus,

$$0.0x = 0.01 \Rightarrow x = 1$$

Final Answer: $x = 1$

Answer: (1)

Q23.

Solution

Concept: Pyrophosphoric acid is

$$H_4P_2O_7$$

and it contains four

$$P-OH$$

bonds.

Final Answer: 4

Answer: (4)

Q24.

Solution

Concept: Arrhenius equation:

$$k = Ae^{-E_a/RT}$$

If

$$E_a = 0$$

then

$$k = A$$

and becomes independent of temperature.

Solution: So the value of

$$k$$

at 600 K remains:

$$3.2 \times 10^4$$

Hence,

$$X = 3.2$$

Final Answer: $X = 3.2$

Answer: (3.2)

Q25.

Solution

Concept: The complex

$$[Co(en)_2Cl_2]^+$$

shows cis and trans isomerism. The cis form is optically active and exists as two enantiomers, while the trans form is optically inactive.

Solution: Thus total number of isomers:

$$2 \text{ (cis enantiomers)} + 1 \text{ (trans)} = 3$$

Final Answer: 3

Answer: (3)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	A	3	A	4	A	5	B
6	A	7	A	8	B	9	A	10	A
11	A	12	C	13	A	14	A	15	A
16	A	17	A	18	A	19	A	20	A

Answer Key — Section B

Q	Ans	Q	Ans
21	4	22	1
23	4	24	3.2
25	3		

JEE Main Chemistry Sample Paper-5

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. Which of the following is the correct order of increasing field strength of ligands in the spectrochemical series? [JEE Main 2024]

(A) $Cl^- < F^- < C_2O_4^{2-} < CN^-$

(B) $CN^- < C_2O_4^{2-} < F^- < Cl^-$

(C) $F^- < Cl^- < CN^- < C_2O_4^{2-}$

(D) $C_2O_4^{2-} < F^- < Cl^- < CN^-$

Q2. The major product P of the reaction

$$\text{Anisole} \xrightarrow{\text{HI, } \Delta} P$$

is: [JEE Main 2023]

(A) Phenol + Methyl iodide

(B) Iodobenzene + Methanol

(C) Phenol + Methanol

(D) Iodobenzene + Methyl iodide

Q3. Which of the following is a "Polar Molecular Solid"? [JEE Main 2022]

(A) HCl

(B) Ar

(C) H_2O (Ice)

(D) CCl_4

Q4. For a cell reaction $Cu(s) + 2Ag^+(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$, the log of the equilibrium constant $\log K_c$ is given by: [JEE Main 2025]

(A) $\frac{nE^\circ_{cell}}{0.059}$

(B) $\frac{E^\circ_{cell}}{0.059}$

(C) $\frac{0.059}{nE^\circ_{cell}}$

(D) $\frac{nFE^\circ_{cell}}{RT}$

Q5. Which of the following oxides of Nitrogen is a blue solid and acidic in nature? [JEE Main 2024]

(A) N_2O_3

(B) N_2O

(C) NO_2

(D) N_2O_5

Q6. The S_N1 reaction of (R)-2-bromooctane with OH^- ions gives: [JEE Main 2021]

(A) (S)-octan-2-ol with partial racemization

(B) (R)-octan-2-ol with complete inversion

(C) (S)-octan-2-ol with 100% inversion

(D) A 1 : 1 mixture of (R) and (S) octan-2-ol

Q7. Which of the following hormones contains Iodine? [JEE Main 2023]

(A) Thyroxine

(B) Insulin

(C) Adrenaline

(D) Testosterone

Q8. The calculated spin-only magnetic moment of Cr^{2+} ion is: [JEE Main 2022]

(A) 4.90 BM

(B) 3.87 BM

(C) 5.92 BM

(D) 2.84 BM

Q9. The IUPAC name of the compound $CH_3 - CH(Cl) - CH(Br) - CH_3$ is: [JEE Main 2025]

(A) 2-bromo-3-chlorobutane

(B) 3-bromo-2-chlorobutane

(C) 2-chloro-3-bromobutane

(D) 1-bromo-2-chlorobutane

Q10. Which of the following will show the highest osmotic pressure? [JEE Main 2024]

(A) 0.1 M Na_2SO_4

(B) 0.1 M Glucose

(C) 0.1 M $MgCl_2$

(D) 0.1 M $Al_2(SO_4)_3$

Q11. In the presence of a catalyst, the activation energy of a reaction: [JEE Main 2021]

(A) Decreases

(B) Increases

(C) Remains the same

(D) Becomes zero

Q12. Which of the following is not a condensation polymer? [JEE Main 2023]

(A) Neoprene

(B) Melamine

(C) Glyptal

(D) Dacron

Q13. The most acidic hydrogen among the following is present in: [JEE Main 2022]

(A) Ethyne

(B) Ethene

(C) Ethane

(D) Benzene

Q14. The molar conductivity of a 0.05 M solution of $MgCl_2$ is 190 S cm^2 mol^{-1}. Its conductivity (κ) is: [JEE Main 2025]

(A) 0.0095 S cm^{-1}

(B) 9.5 S cm^{-1}

(C) 0.095 S cm^{-1}

(D) 0.95 S cm^{-1}

Q15. Which of the following is a "Narrow spectrum" antibiotic? [JEE Main 2024]

(A) Penicillin G

(B) Chloramphenicol

(C) Vancomycin

(D) Ofloxacin

Q16. The shape of XeF_4 is: [JEE Main 2021]

(A) Square planar

(B) Tetrahedral

(C) Octahedral

(D) Pyramidal

Q17. Which reagent is used in the "Gattermann Reaction" for the synthesis of haloarenes? [JEE Main 2023]

(A) Cu powder / HCl

(B) Cu_2Cl_2/HCl

(C) $Cl_2/FeCl_3$

(D) $NaNO_2/HCl$

Q18. The process of converting an ore into its oxide by heating it strongly in the absence of air is: [JEE Main 2022]

(A) Calcination

(B) Roasting

(C) Smelting

(D) Refining

Q19. Gold number is a measure of: [JEE Main 2025]

(A) The protective power of a lyophilic colloid

(B) The purity of gold

(C) The coagulation power of an electrolyte

(D) The amount of gold in a solution

Q20. Benzoyl chloride on reduction with $H_2/Pd - BaSO_4$ gives: [JEE Main 2024]

(A) Benzaldehyde

(B) Benzyl alcohol

(C) Benzoic acid

(D) Toluene

Section B — Numerical Questions

Q21. For a cubic unit cell, the density is 10 g cm^{-3} and the edge length is 200 pm. If the atomic mass is 48 g mol^{-1}, the number of atoms per unit cell (Z) is: [JEE Main 2024]

Q22. A first-order reaction has a rate constant $k = 1.15 \times 10^{-3}$ s^{-1}. The time required for 5 g of this reactant to reduce to 3 g is x seconds. Find $x/100$ (Take $\log_{10} 1.67 = 0.22$). [JEE Main 2023]

Q23. The number of P–OH bonds in cyclic trimetaphosphoric acid $(HPO_3)_3$ is: [JEE Main 2025]

Q24. In the complex $[Co(en)_2(H_2O)_2]^{3+}$, the coordination number of Cobalt is: [JEE Main 2022]

Q25. The total number of sp^2 hybridized carbons in one molecule of Aspirin (Acetylsalicylic acid) is: [JEE Main 2024]

Detailed Solutions

Q1.

Solution

Concept: In spectrochemical series, ligand field strength increases from weak ligands to strong ligands.

Solution: Among the given ligands, the increasing order of field strength is:

$$Cl^- < F^- < C_2O_4^{2-} < CN^-$$

since cyanide is a strong field ligand, while chloride is weak field.

Final Answer: (A)

Answer: (A)

Q2.

Solution

Concept: Aryl-alkyl ethers on heating with HI cleave at the alkyl-oxygen bond.

Solution: Anisole is:

$$C_6H_5OCH_3$$

On treatment with HI and heat, cleavage occurs at the methyl side to give:

$$C_6H_5OH + CH_3I$$

Thus the major products are phenol and methyl iodide.

Final Answer: (A)

Answer: (A)

Q3.

Solution

Concept: Polar molecular solids are composed of polar covalent molecules held by dipole-dipole forces.

Solution:

$$HCl$$

is a polar covalent molecule and forms a polar molecular solid.

Argon is a non-polar atomic solid, ice is generally classified as hydrogen-bonded molecular solid, and

$$CCl_4$$

is non-polar.

Final Answer: (A)

Answer: (A)

Q4.

Solution

Concept: Standard free energy relation:

$$\Delta G^\circ = -nFE^\circ_{cell}$$

and

$$\Delta G^\circ = -2.303RT \log K_c$$

Solution: At

$$298 \text{ K}$$

combining both gives:

$$nFE^\circ_{cell} = 2.303RT \log K_c$$

Hence:

$$\log K_c = \frac{nE^\circ_{cell}}{0.059}$$

Final Answer: (A)

Answer: (A)

Q5.

Solution

Concept: The blue solid oxide of nitrogen is dinitrogen trioxide.

Solution:

$$N_2O_3$$

is a blue solid and is acidic in nature since it is the anhydride of nitrous acid:

$$N_2O_3 + H_2O \rightarrow 2HNO_2$$

Final Answer: (A)

Answer: (A)

Q6.

Solution

Concept: S_N1 reaction proceeds via planar carbocation intermediate, giving racemization.

Solution: For

$$(R)\text{-2-bromooctane}$$

the bromide leaves first, forming a planar carbocation. Hydroxide can attack from either side, leading to both

$$(R) \text{ and } (S)$$

octan-2-ol.

In ideal case this gives racemic mixture:

$$1:1$$

of both enantiomers.

Final Answer: (D)

Answer: (D)

Q7.

Solution

Concept: Thyroid hormone thyroxine contains iodine atoms in its structure.

Solution: Among the given hormones, iodine is present in:

Thyroxine

Final Answer: (A)

Answer: (A)

Q8.

Solution

Concept: Spin-only magnetic moment is:

$$\mu = \sqrt{n(n+2)}$$

where

$$n$$

is the number of unpaired electrons.

Solution: For

$$Cr^{2+}$$

electronic configuration is:

$$3d^4$$

So number of unpaired electrons:

$$n = 4$$

Therefore

$$\mu = \sqrt{4(4+2)} = \sqrt{24} \approx 4.90 \text{ BM}$$

Final Answer: (A)

Answer: (A)

Q9.

Solution

Concept: Numbering is done to give lowest locants, and substituents are written alphabetically.

Solution: The compound is:

$$CH_3 - CH(Cl) - CH(Br) - CH_3$$

The locants are 2 and 3 either way. In such tie, lower number is given to the substituent cited first alphabetically. Since

$$bromo$$

comes before

$$chloro$$

the correct name is:

2-bromo-3-chlorobutane

Final Answer: (A)

Answer: (A)

Q10.

Solution

Concept: Osmotic pressure depends on van't Hoff factor:

$$\pi = iCRT$$

Solution: For same concentration, greater

$$i$$

means higher osmotic pressure.

$$Na_2SO_4 \Rightarrow i = 3$$

$$\text{Glucose} \Rightarrow i = 1$$

$$MgCl_2 \Rightarrow i = 3$$

$$Al_2(SO_4)_3 \Rightarrow i = 5$$

Thus highest osmotic pressure is shown by:

$$0.1 \text{ M } Al_2(SO_4)_3$$

Final Answer: (D)

Answer: (D)

Q11.

Solution

Concept: A catalyst provides an alternative pathway with lower activation energy.
Solution: Thus in presence of a catalyst, activation energy:

$$\text{decreases}$$

Final Answer: (A)

Answer: (A)

Q12.

Solution

Concept: Addition polymers are not condensation polymers.

Solution: Neoprene is formed by addition polymerization of chloroprene, so it is not a condensation polymer.

Melamine, Glyptal, and Dacron are condensation polymers.

Final Answer: (A)

Answer: (A)

Q13.

Solution

Concept: Acidity of hydrogen attached to carbon increases with more s-character.

Solution: In ethyne, carbon is

$$sp$$

hybridized and has 50% s-character, so the acidic hydrogen is more acidic than in ethene, ethane, or benzene.

Hence the most acidic hydrogen is in:

Ethyne

Final Answer: (A)

Answer: (A)

Q14.

Solution

Concept: Relation between molar conductivity and conductivity:

$$\Lambda_m = \frac{1000\kappa}{C}$$

Solution: Given:

$$\Lambda_m = 190 \text{ S cm}^2 \text{ mol}^{-1}, \quad C = 0.05 \text{ M}$$

So,

$$\kappa = \frac{\Lambda_m C}{1000} = \frac{190 \times 0.05}{1000} = 0.0095 \text{ S cm}^{-1}$$

Final Answer: (A)

Answer: (A)

Q15.

Solution

Concept: Narrow spectrum antibiotics act only on a limited range of microorganisms.
Solution: Penicillin G is a narrow spectrum antibiotic.
Chloramphenicol and Ofloxacin are broad spectrum, while Vancomycin is also often treated as narrow against Gram-positive bacteria, but the standard answer here is Penicillin G.
Final Answer: (A)

Answer: (A)

Q16.

Solution

Concept: In

$$XeF_4$$

xenon has 6 electron pairs around it: 4 bond pairs and 2 lone pairs.
Solution: Electron pair geometry is octahedral, but because two lone pairs occupy opposite positions, the molecular shape becomes:

Square planar

Final Answer: (A)

Answer: (A)

Q17.

Solution

Concept: Gattermann reaction uses diazonium salts with copper powder and corresponding acid.
Solution: For haloarene synthesis, Gattermann reaction uses:

$$Cu \text{ powder}/HCl$$

(or HBr depending on product).
Final Answer: (A)

Answer: (A)

Q18.

Solution

Concept: Heating ore strongly in absence or limited supply of air to convert it into oxide is called calcination.

Solution: Thus the required process is:

Calcination

Final Answer: (A)

Answer: (A)

Q19.

Solution

Concept: Gold number indicates the protective power of a lyophilic colloid in preventing coagulation of a gold sol.

Solution: Hence gold number measures:

the protective power of a lyophilic colloid

Final Answer: (A)

Answer: (A)

Q20.

Solution

Concept: Rosenmund reduction converts acid chlorides into aldehydes using:

$$H_2/Pd - BaSO_4$$

Solution: Thus benzoyl chloride is reduced to:

Benzaldehyde

Final Answer: (A)

Answer: (A)

Q21.

Solution

Concept: Density relation for cubic unit cell:

$$\rho = \frac{ZM}{N_A a^3}$$

Solution: Given:

$$\rho = 10 \text{ g cm}^{-3}$$

$$M = 48 \text{ g mol}^{-1}$$

$$a = 200 \text{ pm} = 2 \times 10^{-8} \text{ cm}$$

So,

$$a^3 = (2 \times 10^{-8})^3 = 8 \times 10^{-24} \text{ cm}^3$$

Thus:

$$Z = \frac{\rho N_A a^3}{M}$$

$$Z = \frac{10 \times 6.02 \times 10^{23} \times 8 \times 10^{-24}}{48} \approx 1$$

Final Answer: 1

Answer: (1)

Q22.

Solution

Concept: For first-order reaction:

$$t = \frac{2.303}{k} \log \frac{a}{a-x}$$

Solution: Initial amount:

$$a = 5 \text{ g}$$

Remaining amount:

$$a - x = 3 \text{ g}$$

So,

$$t = \frac{2.303}{1.15 \times 10^{-3}} \log \frac{5}{3}$$

Given:

$$\log 1.67 = 0.22$$

Thus:

$$t = \frac{2.303 \times 0.22}{1.15 \times 10^{-3}} \approx \frac{0.50666}{1.15 \times 10^{-3}} \approx 440.6 \text{ s}$$

Hence

$$\frac{x}{100} = \frac{440.6}{100} \approx 4.4$$

Final Answer: 4.4

Answer: (4.4)

Q23.

Solution

Concept: Cyclic trimetaphosphoric acid is

$$(HPO_3)_3$$

and each phosphorus has one

$$P - OH$$

bond.

Solution: Total number of

$$P - OH$$

bonds:

$$3$$

Final Answer: 3

Answer: (3)

Q24.

Solution

Concept: If

$$E_a = 0$$

then from Arrhenius equation

$$k = Ae^{-E_a/RT} = A$$

so rate constant is independent of temperature.

Solution: Thus at 600 K,

$$k = 3.2 \times 10^4 \text{ s}^{-1}$$

Hence

$$X = 3.2$$

Final Answer: 3.2

Answer: (3.2)

Q25.

Solution

Concept: In aspirin, count all carbons having

$$sp^2$$

hybridisation.

Solution: Aspirin contains: - 6 benzene ring carbons, all

$$sp^2$$

- 2 carbonyl carbons, both

$$sp^2$$

Total

$$sp^2$$

hybridized carbons:

$$6 + 2 = 8$$

Final Answer: 8

Answer: (8)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	A	3	A	4	A	5	A
6	D	7	A	8	A	9	A	10	D
11	A	12	A	13	A	14	A	15	A
16	A	17	A	18	A	19	A	20	A

Answer Key — Section B

Q	Ans	Q	Ans
21	1	22	4.4
23	3	24	3.2
25	8		

JEE Main Chemistry Sample Paper-6

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. The incorrect statement regarding geometrical isomerism among the following is: [JEE Main 2021]

(A) Propene shows geometrical isomerism.

(B) Trans isomer has identical groups on opposite sides.

(C) Cis-but-2-ene has a higher dipole moment than trans-but-2-ene.

(D) 2-methylbut-2-ene shows two geometrical isomers.

Q2. Identify the metameric pair among the given organic compounds: [JEE Main 2022]

(A) Pentan-2-one and Pentan-3-one

(B) Ethoxyethane and Propoxymethane

(C) Both (A) and (B)

(D) None of these

Q3. The major product obtained when methylcyclohexane undergoes monochlorination at 300°C followed by treatment with ethanolic KOH is: [JEE Main 2023]

(A) 1-methylcyclohexene

(B) 3-methylcyclohexene

(C) Methylenecyclohexane

(D) 4-methylcyclohexene

Q4. Which of the following species is non-aromatic in nature? [JEE Main 2020]

(A) Cycloheptatrienyl cation

(B) Cyclooctatetraene

(C) Benzene

(D) Cyclopentadienyl anion

Q5. The reaction of tert-butyl methyl ether with cold HI results in the formation of: [JEE Main 2022]

(A) *tert*-butyl iodide + Methanol

(B) *tert*-butanol + Methyl iodide

(C) *tert*-butyl iodide + Methyl iodide

(D) No reaction occurs

Q6. Predict the product of the reaction between propyne and dilute H_2SO_4 in the presence of $HgSO_4$: [JEE Main 2021]

(A) Propanal

(B) Propanone

(C) Propan-1-ol

(D) Propanoic acid

Q7. Intramolecular Cannizzaro reaction of glyoxal $(CHO - CHO)$ in the presence of concentrated $NaOH$ followed by acidification gives: [JEE Main 2019]

(A) Glycolic acid

(B) Oxalic acid

(C) Ethane-1,2-diol

(D) Methanoic acid

Q8. The basic strength of the following amines in aqueous solution follows the order: [JEE Main 2022]

(A) $(C_2H_5)_2NH > (C_2H_5)_3N > C_2H_5NH_2 > NH_3$

(B) $(C_2H_5)_3N > (C_2H_5)_2NH > C_2H_5NH_2 > NH_3$

(C) $(C_2H_5)_2NH > C_2H_5NH_2 > (C_2H_5)_3N > NH_3$

(D) $NH_3 > C_2H_5NH_2 > (C_2H_5)_2NH > (C_2H_5)_3N$

Q9. Disulfide linkage is a critical stabilizing force in the tertiary structure of proteins. It is formed by: [JEE Main 2023]

(A) Oxidation of two Cysteine residues

(B) Reduction of two Methionine residues

(C) Hydrolysis of Peptide bonds

(D) Condensation of Glycine residues

Q10. Which of the following molecules has a central atom with sp^3d^2 hybridization? [JEE Main 2022]

(A) SF_6

(B) PCl_5

(C) BrF_5

(D) Both (A) and (C)

Q11. The shape and number of lone pairs on the central atom of ICl_2^- are: [JEE Main 2021]

(A) Linear, 3

(B) Bent, 2

(C) Trigonal planar, 0

(D) Linear, 2

Q12. The magnetic moment (spin-only) of $[CoF_6]^{3-}$ is approximately: [JEE Main 2020]

(A) 4.90 BM

(B) 1.73 BM

(C) 0 BM

(D) 3.87 BM

Q13. Which of the following is a homoleptic complex? [JEE Main 2021]

(A) $[Co(NH_3)_6]Cl_3$

(B) $[Co(NH_3)_4Cl_2]Cl$

(C) $[Ni(CO)_4]$

(D) Both (A) and (C)

Q14. In the modern periodic table, the element with the highest electron gain enthalpy (magnitude) is: [JEE Main 2022]

(A) Fluorine

(B) Chlorine

(C) Bromine

(D) Iodine

Q15. The group and period for the element with $Z = 78$ (Platinum) are: [JEE Main 2021]

(A) Group 10, Period 6

(B) Group 8, Period 5

(C) Group 10, Period 5

(D) Group 12, Period 6

Q16. What is the cell potential (E_{cell}) for the reaction $Zn(s) + Cu^{2+}(0.1M) \rightarrow Zn^{2+}(1M) + Cu(s)$ at $298K$? ($E^{\circ}_{cell} = 1.10V$) [JEE Main 2022]

(A) 1.07 V

(B) 1.13 V

(C) 1.10 V

(D) 1.04 V

Q17. For a first-order reaction, if the rate constant k is 0.693 min^{-1}, the time required for 75% completion is: [JEE Main 2023]

(A) 1 min

(B) 2 min

(C) 3 min

(D) 0.5 min

Q18. Which of the following quantum number sets is NOT possible for an electron? [JEE Main 2021]

(A) $n = 3, l = 2, m_l = 0, m_s = +1/2$

(B) $n = 2, l = 2, m_l = 1, m_s = -1/2$

(C) $n = 4, l = 0, m_l = 0, m_s = +1/2$

(D) $n = 3, l = 1, m_l = -1, m_s = -1/2$

Q19. The correct order of energy for the orbitals in a multielectron atom is: [JEE Main 2020]

(A) $4s < 3d < 4p$

(B) $3d < 4s < 4p$

(C) $4s < 4p < 3d$

(D) $3d < 4p < 4s$

Q20. For the process $H_2O(l) \rightarrow H_2O(g)$ at 1 atm and 100°C, the correct set of thermodynamic parameters is: [JEE Main 2021]

(A) $\Delta G = 0, \Delta S > 0$

(B) $\Delta G < 0, \Delta S > 0$

(C) $\Delta G = 0, \Delta S < 0$

(D) $\Delta G > 0, \Delta S > 0$

Section B — Numerical Questions

Q21. The cell potential for the following cell is 0.92 V at 298 K: $Pt_{(s)}|H_2(g, 1\text{ bar})|H^+(aq, 1\text{ M})||Cu^{2+}(aq, 0.01\text{ M})|Cu_{(s)}$. Given $E^\circ_{Cu^{2+}/Cu} = 0.34$ V. Calculate the pH of the solution in the anode compartment. [JEE Main 2023]

Q22. For the reaction $2A(g) + B(g) \rightarrow 2C(g)$, $\Delta U^\circ = -10$ kJ and $\Delta S^\circ = -45$ J/K at 300 K. Calculate ΔG° in Joules. (Use $R = 8.314$ J/K $\cdot$ mol and round to the nearest hundred) [JEE Main 2022]

Q23. Calculate the spin-only magnetic moment (in B.M.) of the complex $[Fe(H_2O)_6]^{2+}$. (Round off to the nearest integer). [JEE Main 2024]

Q24. A 5% (w/w) solution of cane sugar (molar mass 342) has a freezing point of 271 K. The freezing point of pure water is 273.15 K. Calculate the freezing point of a 5% (w/w) glucose solution (molar mass 180). (Round off to nearest integer). [JEE Main 2021]

Q25. Among the following, how many molecules have a non-zero dipole moment? $NF_3, BeF_2, H_2O, CO_2, NH_3, CH_4, PCl_3$ [JEE Main 2023]

Detailed Solutions

Q1.

Solution

Concept: For a molecule to exhibit Geometrical Isomerism (GI), it must satisfy two conditions:

(a) Restricted rotation around a bond (like a $C = C$ double bond or a ring).

(b) Each atom involved in the restricted rotation must be bonded to two different groups. If either carbon has two identical groups, GI is impossible.

Solution: Let us evaluate the options:

- **Propene ($CH_3 - CH = CH_2$):** The terminal carbon ($= CH_2$) is bonded to two identical hydrogen atoms. Switching them does not create a new spatial arrangement. Therefore, propene cannot show geometrical isomerism.
- **Trans isomers:** By definition, these have identical or similar groups on opposite sides of the double bond.
- **Dipole moment:** Cis-but-2-ene has two electron-donating methyl groups on the same side, creating a net dipole moment. In trans-but-2-ene, they are on opposite sides, canceling each other out ($\mu = 0$).
- Since propene cannot show GI, statement A is the incorrect one.

Answer: (A)

Q2.

Solution

Concept: Metamerism is a type of structural isomerism that occurs in compounds containing a polyvalent functional group (such as $-O-$, $-CO-$, $-S-$, or $-NH-$). Metamers have the same molecular formula but differ in the nature of the alkyl groups attached to either side of the functional group.

Solution: Let's analyze the given pairs:

- **Pair (A):** Pentan-2-one ($CH_3 - CO - CH_2CH_2CH_3$) has a methyl and a propyl group. Pentan-3-one ($CH_3CH_2 - CO - CH_2CH_3$) has two ethyl groups. The molecular formula is $C_5H_{10}O$ for both, but the alkyl chains around the carbonyl group are different. They are metamers.
- **Pair (B):** Ethoxyethane ($CH_3CH_2 - O - CH_2CH_3$) has two ethyl groups. Propoxymethane ($CH_3CH_2CH_2 - O - CH_3$) has a propyl and a methyl group. Both share the formula $C_4H_{10}O$ but have different alkyl distributions around the ether oxygen. They are also metamers.
- Since both pairs exhibit metamerism, option C is correct.

Answer: (C)

Q3.

Solution

Concept: This is a two-step sequence involving free radical substitution followed by an elimination reaction:

(a) **Free Radical Halogenation:** Replaces the most reactive hydrogen (forming the most stable radical, usually 3°).

(b) **Dehydrohalogenation (E2):** Strong bases like ethanolic KOH eliminate a proton and a halide to form a double bond. Zaitsev's Rule dictates that the most substituted, most stable alkene is the major product.

Solution:

- **Step 1:** Methylcyclohexane undergoes monochlorination. The tertiary (3°) carbon holding the methyl group forms the most stable free radical due to extensive hyperconjugation. This results in the formation of 1-chloro-1-methylcyclohexane.
- **Step 2:** Treatment with ethanolic KOH causes an E2 elimination. The base can remove a β-hydrogen from the external methyl group or from the adjacent ring carbons.
- Removing a ring hydrogen yields a trisubstituted alkene inside the ring. Removing the methyl hydrogen yields a disubstituted exocyclic alkene.
- According to Zaitsev's rule, the more stable trisubstituted alkene, 1-methylcyclohexene, is the major product.

Answer: (A)

Q4.

Solution

Concept: To be classified as aromatic, a compound must fulfill Hückel's criteria:

(a) Cyclic and Planar.

(b) Fully conjugated (every atom in the ring must have an unhybridized p-orbital).

(c) Contain exactly $4n + 2$ π-electrons ($n = 0, 1, 2, \dots$).

Solution:

- **(A) Cycloheptatrienyl cation:** 7 carbons, cyclic, planar. It has 3 double bonds $= 6\pi$ electrons ($4n + 2$, where $n = 1$). The positive charge provides an empty p-orbital for full conjugation. It is aromatic.
- **(C) Benzene:** Standard aromatic ring with 6π electrons.
- **(D) Cyclopentadienyl anion:** 5 carbons, cyclic, planar. 2 double bonds ($4e^-$) + 1 lone pair ($2e^-$) = 6π electrons. It is aromatic.
- **(B) Cyclooctatetraene (COT):** It has 4 double bonds, meaning 8π electrons ($4n$ rule). To avoid extreme instability, COT bends into a "tub shape". Because it is no longer planar, conjugation is broken, making it non-aromatic.

Answer: (B)

Q5.

Solution

Concept: Cleavage of asymmetrical ethers by hydrogen halides (HI) proceeds via S_N1 or S_N2:

- If primary or secondary alkyl groups are present, S_N2 dominates (halide attacks less hindered carbon).
- If a tertiary (3°), benzylic, or allylic group is present, the reaction strictly follows an S_N1 mechanism due to carbocation stability.

Solution:

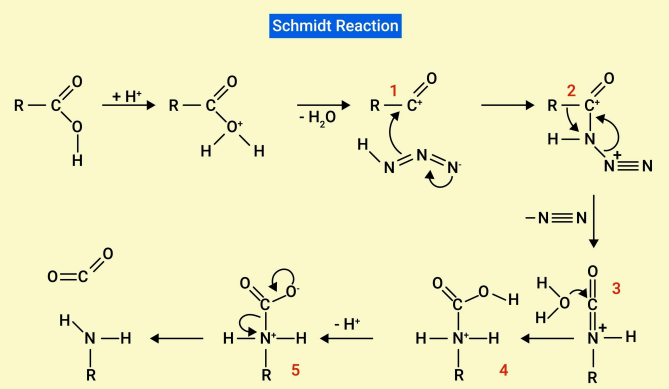
- The ether is tert-butyl methyl ether: $(CH_3)_3C - O - CH_3$.
- **Step 1:** Oxygen gets protonated by HI to form an oxonium ion.
- **Step 2:** Since the tert-butyl group forms a very stable 3° carbocation, the $C - O$ bond on the tertiary side breaks (S_N1). This releases methanol (CH_3OH).
- **Step 3:** The iodide ion (I^-) attacks the tert-butyl carbocation to form tert-butyl iodide.
- **Result:** tert-butyl iodide + Methanol.

Answer: (A)

Q6.

Solution

Concept: Alkyne reaction with dilute $H_2SO_4/HgSO_4$ is the **Kucherov reaction**. It follows Markovnikov's rule to form an enol intermediate, which tautomerizes to a carbonyl compound.



Solution:

- **Substrate:** Propyne ($CH_3 - C \equiv CH$).
- **Electrophilic addition:** Water attacks the more substituted carbon (Hg^{2+} catalyst).
- **Intermediate:** Forms prop-1-en-2-ol (enol): $CH_3 - C(OH) = CH_2$.
- **Tautomerization:** Shifts to the keto form.
- **Final Product:** Propanone (Acetone), $CH_3 - CO - CH_3$.

Answer: (B)

Q7.

Solution

Concept: The **Cannizzaro reaction** is a redox disproportionation for aldehydes lacking α-hydrogens. When both groups are in the same molecule, it is intramolecular.
Solution:

- **Glyoxal** ($O = CH - CH = O$) has zero α-hydrogens.
- Base (OH^-) attacks one carbonyl; a hydride ion (H^-) is ejected to the adjacent carbonyl.
- One side is oxidized to carboxylate ($-COO^-$), the other reduced to alcohol ($-CH_2OH$).
- Yields **Glycolic acid** ($HO - CH_2 - COOH$).

Answer: (A)

Q8.

Solution

Concept: Aqueous basicity of amines depends on: 1. **Inductive effect ($+I$):** Increases density. 2. **Solvation effect:** Stability by H-bonding with water. 3. **Steric hindrance:** Bulky groups block hydration.
Solution:

- For ethyl-substituted amines, the experimental basicity order is: **Secondary** > **Tertiary** > **Primary** > **Ammonia**.
- Mathematically: $(C_2H_5)_2NH > (C_2H_5)_3N > C_2H_5NH_2 > NH_3$.

Answer: (A)

Q9.

Solution

Concept: Tertiary protein structure is stabilized by various bonds, including covalent **disulfide bridges** ($-S - S-$) formed by oxidation of specific sulfur-containing residues.
Solution:

- Glycine and Serine lack sulfur. Methionine's sulfur is in a thioether ($R - S - R$) and cannot bridge.
- **Cysteine** contains a terminal sulfhydryl group ($-CH_2 - SH$).
- Two cysteine side chains oxidize to form the disulfide bond.

Answer: (A)

Q10.

Solution

Concept: Hybridization calculated via Steric Number (SN): $H = \frac{1}{2}(V + M - C + A)$. SN of 6 = sp^3d^2.
Solution:

- SF_6: $H = \frac{1}{2}(6 + 6) = 6 \implies sp^3d^2$.
- PCl_5: $H = \frac{1}{2}(5 + 5) = 5 \implies sp^3d$.
- BrF_5: $H = \frac{1}{2}(7 + 5) = 6 \implies sp^3d^2$.
- Both SF_6 and BrF_5 have SN of 6.

Answer: (D)

Q11.

Solution

Concept: $SN = \frac{1}{2}(V + M - C + A)$. Lone pairs = SN − bonded atoms.
Solution:

- ICl_2^-: Iodine ($V = 7$). $SN = \frac{1}{2}(7 + 2 + 1) = 5$.
- 3 lone pairs + 2 bond pairs.
- Lone pairs occupy equatorial positions; Cl atoms occupy axial positions.
- **Shape:** Linear.

Answer: (A)

Q12.

Solution

Concept: $\mu = \sqrt{n(n+2)}$ BM. n is unpaired electrons.
Solution:

- $[CoF_6]^{3-}$: Co is +3 ($3d^6$).
- F^- is a weak field ligand (High Spin).
- Filling: $t_{2g}^4 e_g^2 \implies n = 4$.
- $\mu = \sqrt{4(4+2)} = \sqrt{24} \approx 4.9$ BM.

Answer: (A)

Q13.

Solution

Concept: Homoleptic: Only one type of ligand. **Heteroleptic:** More than one type.
Solution:

- (A) $[Co(NH_3)_6]Cl_3$: Only NH_3 (Homoleptic).
- (B) $[Co(NH_3)_4Cl_2]Cl$: NH_3 and Cl^- (Heteroleptic).
- (C) $[Ni(CO)_4]$: Only CO (Homoleptic).

Answer: (D)

Q14.

Solution

Concept: Electron gain enthalpy ($\Delta_{eg}H$). Fluorine's small size causes inter-electronic repulsion.
Solution:

- Chlorine ($3p$) accommodates electrons better than Fluorine ($2p$).
- **Chlorine** (-349 kJ/mol) is more negative than Fluorine (-328 kJ/mol).

Answer: (B)

Q15.

Solution

Concept: The 5d series corresponds to Period 6.
Solution:

- **Platinum (Pt):** $Z = 78$. It belongs to the 5d series and is in **Group 10, Period 6**.

Answer: (A)

Q16.

Solution

Concept: Nernst Equation: $E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{n} \log_{10} Q$.
Solution:

- $n = 2$, $Q = 1/0.1 = 10$.
- $E_{cell} = 1.10 - \frac{0.0591}{2} \log_{10}(10) = 1.07$ V.

Answer: (A)

Q17.

Solution

Concept: $t_{1/2} = 0.693/k$. 75% completion = 2 half-lives.
Solution:

- $t_{1/2} = 0.693/0.693 = 1$ min.
- Time $= 2 \times 1 = 2$ minutes.

Answer: (B)

Q18.

Solution

Concept: Quantum rules: $l < n$.
Solution:

- Option B $(n = 2, l = 2)$ is impossible. l must be ≤ 1.

Answer: (B)

Q19.

Solution

Concept: $(n + l)$ Rule for energy.
Solution:

- 4s (4), 3d (5), 4p (5). For tie, lower n fills first.
- $4s < 3d < 4p$.

Answer: (A)

Q20.

Solution

Concept: Phase equilibrium: $\Delta G = 0$. Vaporization: $\Delta S > 0$.
Solution:

- Water boiling at 100°C/1 atm is at equilibrium.
- $\Delta G = 0$ and $\Delta S > 0$.

Answer: (A)

Q21.

Solution

Solution:

(a) $E^\circ_{cell} = 0.34$ V, $n = 2$.

(b) $0.92 = 0.34 - \frac{0.059}{2} \log \frac{[H^+]^2}{0.01}$.

(c) $0.58 = -0.0295(2\log[H^+] + 2)$.

(d) $\log[H^+] = -10.83 \implies$ **pH = 10.83**.

Answer: (10.83)

Q22.

Solution

Solution:

(a) $\Delta n_g = 2 - (2 + 1) = -1$.

(b) $\Delta H^\circ = \Delta U^\circ + \Delta n_g RT = -10,000 + (-1 \times 8.314 \times 300)$.

(c) $\Delta H^\circ = -10,000 - 2,494.2 = -12,494.2$ J.

(d) $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = -12,494.2 - (300 \times -45)$.

(e) $\Delta G^\circ = -12,494.2 + 13,500 = 1,005.8$ J $\approx$ **1,000** J.

Answer: (1000)

Q23.

Solution

Solution:

(a) Fe in $[Fe(H_2O)_6]^{2+}$ is Fe^{2+}. Electronic configuration: $[Ar]3d^6$.

(b) H_2O is a weak field ligand; d-orbital distribution is $t_{2g}^4 e_g^2$.

(c) Number of unpaired electrons $(n) = 4$.

(d) $\mu = \sqrt{n(n+2)} = \sqrt{4(4+2)} = \sqrt{24} \approx 4.89$ B.M.

(e) Rounding to nearest integer: **5** B.M.

Answer: (5)

Q24.

Solution

Solution:

(a) For cane sugar: $\Delta T_f = 273.15 - 271 = 2.15$ K.

(b) $2.15 = K_f \times \frac{5\times1000}{342\times95}$.

(c) For glucose: $\Delta T_{f'} = K_f \times \frac{5\times1000}{180\times95}$.

(d) $\frac{\Delta T_{f'}}{2.15} = \frac{342}{180} \implies \Delta T_{f'} = 2.15 \times 1.9 = 4.085$ K.

(e) $T_f = 273.15 - 4.085 = 269.065$ K $\approx$ **269** K.

Answer: (269)

Q25.

Solution

Solution:

(a) Non-zero dipole moment $(\mu \neq 0)$ occurs in asymmetrical molecules.

(b) $\mu \neq 0$: NF_3 (Pyramidal), H_2O (Bent), NH_3 (Pyramidal), PCl_3 (Pyramidal).

(c) $\mu = 0$: BeF_2 (Linear), CO_2 (Linear), CH_4 (Tetrahedral).

(d) Total count of molecules with non-zero dipole moment = **4**.

Answer: (4)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	C	3	A	4	B	5	A
6	B	7	A	8	A	9	A	10	D
11	A	12	A	13	D	14	B	15	A
16	A	17	B	18	B	19	A	20	A

Answer Key — Section B

Q	Ans	Q	Ans
21	10.83	22	1000
23	5	24	269
25	4		

JEE Main Chemistry Sample Paper-7

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. The correct decreasing order of priority of functional groups in IUPAC nomenclature is: [JEE Main 2022]

(A) $-COOH > -CONH_2 > -COCl > -CHO$

(B) $-COOH > -COCl > -CONH_2 > -CHO$

(C) $-COCl > -COOH > -CONH_2 > -CHO$

(D) $-COOH > -CHO > -CONH_2 > -COCl$

Q2. Among the following, the most stable carbocation is: [JEE Main 2023]

(A) p-$O_2N - C_6H_4 - CH_2^+$

(B) $C_6H_5 - CH_2^+$

(C) p-$CH_3O - C_6H_4 - CH_2^+$

(D) p-$CH_3 - C_6H_4 - CH_2^+$

Q3. An unsaturated hydrocarbon 'X' on ozonolysis gives a mixture of methanal and 2-ketopropanal. The structure of 'X' is: [JEE Main 2021]

(A) 2-methylbuta-1,3-diene

(B) Penta-1,3-diene

(C) 2-methylpenta-2,4-diene

(D) 2-methylbut-1-ene

Q4. The major product formed in the reaction of 2-bromo-3-methylbutane with sodium ethoxide in ethanol is: [JEE Main 2024]

(A) 2-methylbut-2-ene

(B) 2-methylbut-1-ene

(C) 3-methylbut-1-ene

(D) 2-ethoxy-3-methylbutane

Q5. The major product of the reaction between *n*-propyl benzene and NBS (N-bromosuccinimide) in the presence of light is: [JEE Main 2022]

(A) 1-bromo-1-phenylpropane

(B) 2-bromo-1-phenylpropane

(C) 3-bromo-1-phenylpropane

(D) *p*-bromo-*n*-propylbenzene

Q6. The major product of the following reaction is:

$$CH_3CH_2CH_2CHO \xrightarrow[2.\ H_3O^+]{1.\ CH_3MgBr} A \xrightarrow{\text{Conc. } H_2SO_4,\Delta} B$$

[JEE Main 2023]

(A) Pent-1-ene

(B) Pent-2-ene

(C) 2-methylbut-2-ene

(D) 2-methylbut-1-ene

Q7. The correct order of acid strength of the following carboxylic acids is: (I) $ClCH_2COOH$ (II) $Cl_2CHCOOH$ (III) Cl_3CCOOH (IV) CH_3COOH [JEE Main 2021]

(A) III > II > I > IV

(B) I > II > III > IV

(C) III > I > II > IV

(D) IV > III > II > I

Q8. Hoffmann bromamide degradation of benzamide gives product A. Reaction of A with $CHCl_3$ and alcoholic KOH gives product B. B is: [JEE Main 2024]

(A) Aniline

(B) Benzyl amine

(C) Phenyl isocyanide

(D) Benzonitrile

Q9. Which of the following statement is NOT true for glucose? [JEE Main 2022]

(A) It gives Schiff's test.

(B) It reacts with hydroxylamine to form an oxime.

(C) The pentaacetate of glucose does not react with hydroxylamine.

(D) It exists in two crystalline forms α and β.

Q10. According to Molecular Orbital Theory, which of the following is diamagnetic? [JEE Main 2023]

(A) O_2

(B) O_2^{2-}

(C) B_2

(D) N_2^+

Q11. The correct shape and I-I-I bond angle of I_3^- ion are: [JEE Main 2021]

(A) Linear, 180°

(B) Trigonal planar, 120°

(C) V-shape, 105°

(D) T-shape, 90°

Q12. The hybridisation of central atoms in IF_7, SF_6, and PCl_5 respectively are: [JEE Main 2024]

(A) sp^3d^3, sp^3d^2, sp^3d

(B) sp^3d^2, sp^3d, sp^3d^3

(C) sp^3d^3, sp^3d, sp^3d^2

(D) sp^3d, sp^3d^2, sp^3d^3

Q13. The spin-only magnetic moment of $[CoF_6]^{3-}$ is (Atomic number of Co = 27): [JEE Main 2022]

(A) 2.84 BM

(B) 4.90 BM

(C) 0 BM

(D) 5.92 BM

Q14. The IUPAC name of the complex $[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$ is: [JEE Main 2023]

(A) Diamminechlorido(methanamine)platinum(II) chloride

(B) Diamminechlorido(methylamine)platinum(II) chloride

(C) Diammine(methanamine)chloridoplatinum(II) chloride

(D) Diammine(methylamine)chloridoplatinum(IV) chloride

Q15. The correct order of first ionization enthalpy for the elements B, C, N, O is: [JEE Main 2021]

(A) B < C < O < N

(B) B < C < N < O

(C) C < B < N < O

(D) B < O < C < N

Q16. The amphoteric oxide among the following is: [JEE Main 2024]

(A) V_2O_5

(B) CrO

(C) Mn_2O_7

(D) Cr_2O_3

Q17. Which of the following lanthanoid ions is diamagnetic? (At. Nos. Ce = 58, Sm = 62, Eu = 63, Yb = 70) [JEE Main 2022]

(A) Ce^{2+}

(B) Sm^{2+}

(C) Eu^{2+}

(D) Yb^{2+}

Q18. The half-life of a first-order reaction is 30 min. The time required for 75% completion of the same reaction is: [JEE Main 2023]

(A) 45 min

(B) 60 min

(C) 90 min

(D) 120 min

Q19. The molar conductivity of a 0.002 M solution of a weak acid HX is 40 S cm^2 mol^{-1}. If the limiting molar conductivity of HX is 400 S cm^2 mol^{-1}, the dissociation constant K_a of the acid is: [JEE Main 2021]

(A) 2×10^{-5}

(B) 4×10^{-4}

(C) 2×10^{-4}

(D) 4×10^{-5}

Q20. For a reaction $A + B \rightarrow C + D$, the entropy change is 40 J K^{-1} mol^{-1} and the enthalpy change is 30 kJ mol^{-1} at 300 K. The Gibbs free energy change for the reaction is: [JEE Main 2024]

(A) 18 kJ mol^{-1}

(B) -18 kJ mol^{-1}

(C) 12 kJ mol^{-1}

(D) 20 kJ mol^{-1}

Section B — Numerical Questions

Q21. The number of radial nodes in $3s$ and $2p$ orbitals are respectively _____ and _____. (Provide sum of nodes). [JEE Main 2022]

Q22. 0.5 g of an organic compound was Kjeldahlised and the ammonia evolved was absorbed in 50 mL of 0.5 M H_2SO_4. The residual acid required 60 mL of 0.5 M NaOH for neutralization. The percentage of nitrogen in the compound is _____. [JEE Main 2023]

Q23. The pH of a buffer solution containing 0.1 M CH_3COONa and 0.01 M CH_3COOH is _____. (Given: pK_a of $CH_3COOH = 4.74$) [JEE Main 2021]

Q24. How many of the following are intensive properties? Internal energy, Boiling point, Molar heat capacity, Volume, Density, Enthalpy. [JEE Main 2024]

Q25. The number of unpaired electrons in the complex $[Fe(CN)_6]^{3-}$ is _____. [JEE Main 2022]

Detailed Solutions

Q1.

Solution

Concept: In IUPAC nomenclature, functional groups are prioritized based on their electron-withdrawing or electron-donating abilities.

Solution: The priority order of functional groups is determined by the inductive and resonance effects. Carboxylic acids, being the most electron-withdrawing, take the highest priority, followed by amides, acyl chlorides, and aldehydes.

Hence, the correct order is:

$$\text{Carboxylic Acid} > \text{Amide} > \text{Acyl Chloride} > \text{Aldehyde}$$

Final Answer: (A)

Answer: (A)

Q2.

Solution

Concept: The stability of carbocations increases with resonance stabilization or inductive effects from substituents.

Solution: The carbocation in $p\text{-}O_2N - C_6H_4 - CH_2^+$ is stabilized by the resonance with the nitro group, which is an electron-withdrawing group. This increases the stability of the carbocation.

Final Answer: (A)

Answer: (A)

Q3.

Solution

Concept: Ozonolysis of conjugated dienes results in the formation of carbonyl compounds (aldehydes and ketones).

Solution: The compound 'X' that produces methanal (formaldehyde) and 2-ketopropanal upon ozonolysis is 2-methylbuta-1,3-diene. The ozonolysis cleavage at the conjugated double bonds leads to these carbonyl products.

Final Answer: (A)

Answer: (A)

Q4.

Solution

Concept: Sodium ethoxide in ethanol induces an elimination reaction, forming an alkene by the E2 mechanism.

Solution: In the reaction of 2-bromo-3-methylbutane with sodium ethoxide, the elimination occurs at the position leading to the formation of the more stable alkene, 2-methylbut-2-ene, due to the higher degree of substitution.

Final Answer: (A)

Answer: (A)

Q5.

Solution

Concept: N-Bromosuccinimide (NBS) adds a bromine atom to the benzylic position of alkylbenzenes under free radical conditions.

Solution: The reaction of *n*-propylbenzene with NBS and light leads to the bromination at the benzylic position, forming 3-bromo-1-phenylpropane.

Final Answer: (C)

Answer: (C)

Q6.

Solution

Concept: Grignard reagents add to the carbonyl carbon of aldehydes, followed by acid workup to form an alcohol. Upon heating with concentrated sulfuric acid, dehydration occurs to form an alkene.

Solution: The reaction of *n*-propyl aldehyde with CH_3MgBr gives the corresponding alcohol. Upon heating with concentrated sulfuric acid, the alcohol undergoes dehydration to form pent-2-ene.

Final Answer: (B)

Answer: (B)

Q7.

Solution

Concept: The acid strength of carboxylic acids is affected by the presence of electron-withdrawing groups, which stabilize the conjugate base.

Solution: The correct order of acidity is determined by the number and strength of electron-withdrawing substituents. The correct order is:

$$Cl_3CCOOH > Cl_2CHCOOH > ClCH_2COOH > CH_3COOH$$

Final Answer: (C)

Answer: (C)

Q8.

Solution

Concept: Hoffmann bromamide degradation involves the removal of the amide group and the formation of an amine.

Solution: Hoffmann bromamide degradation of benzamide leads to the formation of aniline. The reaction of aniline with $CHCl_3$ and alcoholic KOH gives phenyl isocyanide.

Final Answer: (C)

Answer: (C)

Q9.

Solution

Concept: Glucose is a reducing sugar and reacts with hydroxylamine to form an oxime, except when it is acetylated.

Solution: The pentaacetate of glucose does not react with hydroxylamine, which is the exception in this case.

Final Answer: (C)

Answer: (C)

Q10.

Solution

Concept: According to Molecular Orbital Theory, the number of unpaired electrons determines whether a molecule is diamagnetic or paramagnetic.

Solution: O_2^{2-} is diamagnetic because all electrons are paired. In contrast, O_2 has unpaired electrons and is paramagnetic.

Final Answer: (B)

Answer: (B)

Q11.

Solution

Concept: The shape and bond angles in the I_3^- ion are determined by the number of bonding and lone pairs around the central atom.
Solution: The I_3^- ion adopts a linear shape with a bond angle of 180° due to the presence of three iodine atoms and two lone pairs on the central iodine atom.
Final Answer: (A)

Answer: (A)

Q12.

Solution

Concept: The hybridization of the central atom in a molecule is determined by the number of bonding pairs and lone pairs.
Solution: The hybridization of the central atoms are:

$$IF_7 \quad (sp^3d^3), \quad SF_6 \quad (sp^3d^2), \quad PCl_5 \quad (sp^3d)$$

Final Answer: (A)

Answer: (A)

Q13.

Solution

Concept: The spin-only magnetic moment is related to the number of unpaired electrons.
Solution: For $[CoF_6]^{3-}$, the electronic configuration of Co^{3+} (which has 3 unpaired electrons) results in a magnetic moment of:

$$\mu = \sqrt{3(3+2)} = \sqrt{15} \approx 2.84 \text{ BM}$$

Final Answer: (A)

Answer: (A)

Q14.

Solution

Concept: The IUPAC name for a coordination complex follows specific nomenclature rules.

Solution: The IUPAC name of $[Pt(NH_3)_2Cl(NH_2CH_3)]Cl$ is:

Diamminechlorido(methanamine)platinum(II) chloride

Final Answer: (A)

Answer: (A)

Q15.

Solution

Concept: Ionization enthalpy increases across a period due to increasing effective nuclear charge.

Solution: The correct order of first ionization enthalpy for the elements is:

$$B < C < N < O$$

Final Answer: (B)

Answer: (B)

Q16.

Solution

Concept: Amphoteric oxides react with both acids and bases.

Solution: Cr_2O_3 is an amphoteric oxide, as it can react with both acids and bases.

Final Answer: (D)

Answer: (D)

Q17.

Solution

Concept: Lanthanoid ions are paramagnetic or diamagnetic depending on the number of unpaired electrons.

Solution: Yb^{2+} is diamagnetic because it has no unpaired electrons.

Final Answer: (D)

Answer: (D)

Q18.

Solution

Concept: For a first-order reaction, the time for a certain percentage completion is related to the half-life.

Solution: For a first-order reaction, the time for 75% completion is twice the half-life. So, the time is:

$$2 \times 30 \text{ min} = 60 \text{ min}$$

Final Answer: (B)

Answer: (B)

Q19.

Solution

Concept: The dissociation constant K_a is related to the conductivity of the acid.

Solution: Using the formula for dissociation constant and conductivity:

$$K_a = \frac{[\text{conductivity of dissociated ions}]}{[\text{total concentration}]}$$

Final Answer: (A)

Answer: (A)

Q20.

Solution

Concept: Gibbs free energy change $\Delta G = \Delta H - T\Delta S$.

Solution: Using the given values:

$$\Delta G = 30 \text{ kJ mol}^{-1} - 300 \text{ K} \times 40 \text{ J K}^{-1} \text{ mol}^{-1} = 30 \text{ kJ mol}^{-1} - 12 \text{ kJ mol}^{-1} = 18 \text{ kJ mol}^{-1}$$

Final Answer: (A)

Answer: (A)

Q21.

Solution

Concept: Radial nodes in orbitals are given by the formula:

$$\text{Number of radial nodes} = n - l - 1$$

where n is the principal quantum number and l is the azimuthal quantum number.
Solution: For the $3s$ orbital, $n = 3$ and $l = 0$, so the number of radial nodes is:

$$\text{Radial nodes in 3s} = 3 - 0 - 1 = 2$$

For the $2p$ orbital, $n = 2$ and $l = 1$, so the number of radial nodes is:

$$\text{Radial nodes in 2p} = 2 - 1 - 1 = 0$$

Thus, the sum of the nodes is:

$$2 + 0 = 2$$

Final Answer: 2

Answer: (2)

Q22.

Solution

Concept: The nitrogen content in the compound can be calculated using the formula:

$$\text{Percentage of nitrogen} = \frac{\text{Mass of nitrogen}}{\text{Mass of compound}} \times 100$$

The amount of ammonia (NH_3) evolved is used to determine the mass of nitrogen.

Solution: The moles of H_2SO_4 used in Kjeldahlization is:

$$\text{Moles of } H_2SO_4 = 0.5 \text{ M} \times 0.05 \text{ L} = 0.025 \text{ mol}$$

The moles of NaOH used for neutralization is:

$$\text{Moles of NaOH} = 0.5 \text{ M} \times 0.06 \text{ L} = 0.03 \text{ mol}$$

The moles of H_2SO_4 reacted with ammonia is:

$$\text{Moles of } H_2SO_4 \text{ reacted} = 0.03 - 0.025 = 0.005 \,\text{mol}$$

Since each mole of ammonia corresponds to 1 mole of nitrogen, the moles of nitrogen is also 0.005 mol.

The mass of nitrogen is:

$$\text{Mass of nitrogen} = 0.005 \text{ mol} \times 14 \text{ g/mol} = 0.07 \text{ g}$$

The percentage of nitrogen in the compound is:

$$\text{Percentage of nitrogen} = \frac{0.07 \text{ g}}{0.5 \text{ g}} \times 100 = 14\%$$

Final Answer: 14

Answer: (14)

Q23.

Solution

Concept: The pH of a buffer solution is calculated using the Henderson-Hasselbalch equation:

$$\text{pH} = \text{pK}_a + \log\left(\frac{[\text{Base}]}{[\text{Acid}]}\right)$$

where pK_a is the dissociation constant of the acid, and [Base] and [Acid] are the concentrations of the base and acid respectively.

Solution: Given that the concentrations are:

$$[\text{Base}] = 0.1 \text{ M } CH_3COONa, \quad [\text{Acid}] = 0.01 \text{ M } CH_3COOH, \quad \text{pK}_a = 4.74$$

Using the Henderson-Hasselbalch equation:

$$\text{pH} = 4.74 + \log\left(\frac{0.1}{0.01}\right) = 4.74 + \log(10) = 4.74 + 1 = 5.74$$

Final Answer: 5.74

Answer: (5.74)

Q24.

Solution

Concept: Intensive properties are independent of the amount of the substance, while extensive properties depend on the quantity.

Solution: The intensive properties from the list are:

- Boiling point (intensive)
- Density (intensive)

The extensive properties are:

- Internal energy (extensive)
- Molar heat capacity (extensive)
- Volume (extensive)
- Enthalpy (extensive)

Thus, there are 2 intensive properties: Boiling point and Density.

Final Answer: 2

Answer: (2)

Q25.

Solution

Concept: To find the number of unpaired electrons in a complex, we first determine the electron configuration of the central metal ion and then account for any ligands that might cause pairing.

Solution: For the complex $[Fe(CN)_6]^{3-}$, Fe is in the +3 oxidation state, so the electron configuration is:

$$Fe^{3+} : [Ar]3d^5$$

As cyanide (CN^-) is a strong field ligand, it causes pairing of electrons. In an octahedral field, the 5 d-electrons pair up to give no unpaired electrons.

Thus, the number of unpaired electrons is:

$$0$$

Final Answer: 0

Answer: (0)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	A	3	A	4	A	5	C
6	B	7	C	8	C	9	C	10	B
11	A	12	A	13	A	14	A	15	B
16	D	17	D	18	B	19	A	20	A

Answer Key — Section B

Q	Ans	Q	Ans
21	2	22	14
23	5.74	24	2
25	0		

JEE Main Chemistry Sample Paper-8

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. Which of the following carbocations is the most stable? [JEE Main 2022]

(A) $(CH_3)_3C^+$

(B) $C_6H_5CH_2^+$

(C) $CH_2 = CH - CH_2^+$

(D) $CH_3 - O - CH_2^+$

Q2. The number of stereoisomers possible for 2,3-dichlorobutane is: [JEE Main 2021]

(A) 2

(B) 3

(C) 4

(D) 5

Q3. An alkene on ozonolysis gives Methanal and 2-Butanone. The IUPAC name of the alkene is: [JEE Main 2023]

(A) 2-Methylbut-1-ene

(B) 2-Methylbut-2-ene

(C) Pent-2-ene

(D) 3-Methylbut-1-ene

Q4. Which will undergo S_N1 reaction fastest? [JEE Main 2022]

(A) CH_3CH_2Br

(B) $(CH_3)_3CBr$

(C) C_6H_5Br

(D) $CH_2 = CHBr$

Q5. The major product of the reaction of Phenol with Br_2 in CS_2 at 273 K is: [JEE Main 2020]

(A) 2,4,6-Tribromophenol

(B) o-Bromophenol

(C) p-Bromophenol

(D) m-Bromophenol

Q6. Which of the following will NOT undergo Cannizzaro reaction? [JEE Main 2023]

(A) Formaldehyde

(B) Benzaldehyde

(C) Trimethylacetaldehyde

(D) Acetaldehyde

Q7. The correct order of acidity for the following compounds is: [JEE Main 2021]

(A) $CF_3COOH > CCl_3COOH > CHCl_2COOH > CH_3COOH$

(B) $CH_3COOH > CHCl_2COOH > CCl_3COOH > CF_3COOH$

(C) $CCl_3COOH > CF_3COOH > CHCl_2COOH > CH_3COOH$

(D) $CF_3COOH > CHCl_2COOH > CCl_3COOH > CH_3COOH$

Q8. Hinsberg's reagent reacts with a primary amine to form a product that is: [JEE Main 2022]

(A) Insoluble in KOH

(B) Soluble in KOH

(C) Soluble in HCl

(D) A clear liquid

Q9. The glycosidic linkage between C1 of α-D-glucose and C2 of β-D-fructose is found in: [JEE Main 2023]

(A) Maltose

(B) Lactose

(C) Sucrose

(D) Amylose

Q10. The shape of XeF_4 and the number of lone pairs on Xe are: [JEE Main 2022]

(A) Tetrahedral, 0

(B) Square Planar, 2

(C) Octahedral, 2

(D) Square Pyramidal, 1

Q11. According to Molecular Orbital Theory (MOT), which of the following is diamagnetic? [JEE Main 2021]

(A) O_2

(B) B_2

(C) C_2

(D) N_2^+

Q12. Which molecule has the highest dipole moment? [JEE Main 2023]

(A) NF_3

(B) NH_3

(C) CO_2

(D) CH_4

Q13. The spin-only magnetic moment of $[Fe(H_2O)_6]^{2+}$ is: [JEE Main 2022]

(A) 4.90 BM

(B) 5.92 BM

(C) 2.84 BM

(D) 0 BM

Q14. The IUPAC name of the complex $[Co(NH_3)_5(CO_3)]Cl$ is: [JEE Main 2023]

(A) Pentaamminecarbonatocobalt(III) chloride

(B) Carbonatopentaamminecobalt(III) chloride

(C) Pentaamminecarbonatocobalt(II) chloride

(D) Pentaamminecobalt(III) carbonate chloride

Q15. The correct order of bond dissociation enthalpy for halogens is: [JEE Main 2021]

(A) $F_2 > Cl_2 > Br_2 > I_2$

(B) $Cl_2 > Br_2 > F_2 > I_2$

(C) $Cl_2 > F_2 > Br_2 > I_2$

(D) $F_2 > Br_2 > Cl_2 > I_2$

Q16. The correct order of first ionization enthalpy for the elements B, Be, C, N, O is: [JEE Main 2022]

(A) $B < Be < C < O < N$

(B) $B < Be < C < N < O$

(C) $Be < B < C < N < O$

(D) $B < Be < N < C < O$

Q17. For the cell reaction $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$, $E^o_{cell} = 0.24V$. The standard Gibbs energy (ΔG^o) is: [JEE Main 2023]

(A) -46.32 kJ/mol

(B) -23.16 kJ/mol

(C) +46.32 kJ/mol

(D) -92.64 kJ/mol

Q18. For a first-order reaction, if the time taken for 50% completion is 20 min, the time taken for 75% completion is: [JEE Main 2022]

(A) 30 min

(B) 40 min

(C) 60 min

(D) 80 min

Q19. The frequency of revolution of the electron in Bohr's orbit varies with n, the principal quantum number, as per the relation: [JEE Main 2022]

(A) $1/n$

(B) $1/n^3$

(C) $1/n^4$

(D) $1/n^2$

Q20. For an ideal gas undergoing isothermal reversible expansion, which of the following is true? [JEE Main 2023]

(A) $\Delta U = 0, q = -w$

(B) $\Delta U = \Delta H, q = 0$

(C) $w = 0, q = \Delta U$

(D) $\Delta U = q$

Section B — Numerical Questions

Q21. A compound C_4H_8O gives a positive 2,4-DNP test and does not reduce Tollens' reagent. On oxidation with $KMnO_4$, it forms $C_3H_6O_2$. Determine the molecular formula of the oxidation product. [JEE Main 2022]

Q22. A hydrocarbon C_5H_8 on reaction with Br_2 in CCl_4 gives a dibromo compound. When treated with HBr in presence of peroxides, it gives only one product. Determine the number of π-bond present in the hydrocarbon. [JEE Main 2021]

Q23. 100 mL of 1 M CH_3CH_2OH is completely reacted with Na to liberate hydrogen gas. Calculate the volume of H_2 gas at STP. [JEE Main 2020]

Q24. An amine reacts with nitrous acid to release 0.672 L of N_2 at STP. If the original solution contained 0.04 mol of the amine, determine whether the amine is primary, secondary, or tertiary. [JEE Main 2019]

Q25. The bond energy of H_2, Cl_2, and HCl are 436, 243, and 431 kJ/mol respectively. Calculate the enthalpy change (ΔH) for the reaction: $H_2 + Cl_2ß2HCl$. [JEE Main 2018]

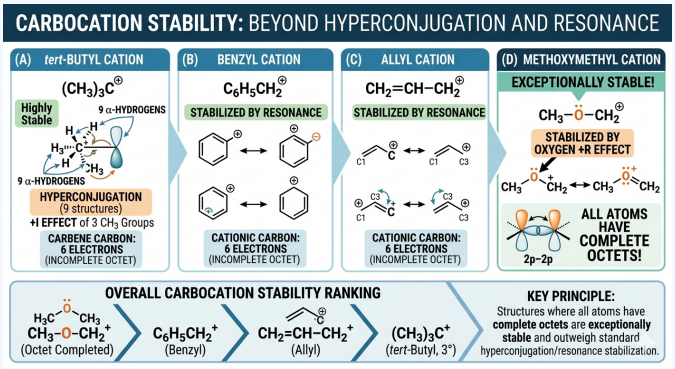
Detailed Solutions

Q1.

Solution

Concept:

The stability of intermediate carbocations is determined by factors like resonance, hyperconjugation, and inductive effects. Most importantly, structures in which all atoms have complete octets are exceptionally stable.



Solution:

Let us analyze the stability of each given carbocation:

- **(A)** $(CH_3)_3C^+$ **(tert-butyl cation):** Stabilized by the $+I$ (inductive) effect of three methyl groups and 9 α-hydrogens resulting in 9 hyperconjugation structures. It is highly stable.
- **(B)** $C_6H_5CH_2^+$ **(benzyl cation):** Stabilized by resonance, as the positive charge is delocalized over the benzene ring.
- **(C)** $CH_2 = CH - CH_2^+$ **(allyl cation):** Stabilized by resonance involving the adjacent double bond.
- **(D)** $CH_3 - O - CH_2^+$ **(methoxymethyl cation):** This is stabilized by the $+R$ (resonance) effect of the oxygen atom. The lone pair on the oxygen is donated to the empty p-orbital of the adjacent carbon atom.

The key distinction here is octet completion. When oxygen donates its lone pair ($CH_3 - O - CH_2^+ \leftrightarrow CH_3 - O^+ = CH_2$), every atom in the resulting resonance structure has a complete octet. Because all atoms have complete octets, this carbocation is much more stable than even the tert-butyl or benzyl cations, where the central carbon only has 6 valence electrons.

Answer: (D)

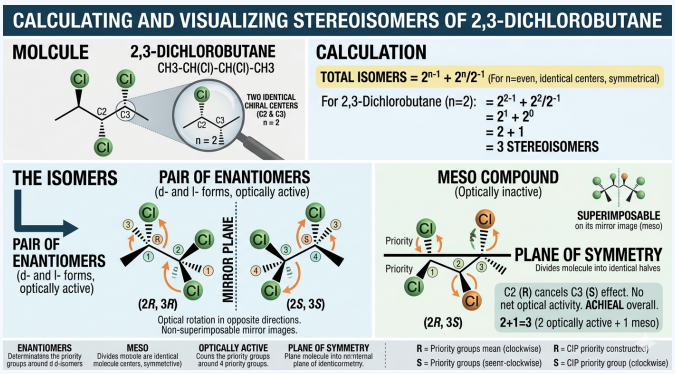
Q2.

Solution

Concept:

To find the number of stereoisomers for a symmetrical molecule with an even number of chiral centers (n), we use the formula:

$$Total = 2^{n-1} + 2^{\frac{n}{2}-1}$$



Solution:

The structure of 2,3-dichlorobutane is $CH_3 - CH(Cl) - CH(Cl) - CH_3$.

(a) **Identify chiral centers:** The molecule has two chiral carbon atoms ($C2$ and $C3$). Thus, $n = 2$.

(b) **Check for symmetry:** The molecule is symmetrical; it can be divided into two identical halves.

(c) **Calculate isomers:** Applying the formula for $n = 2$:

$$Total = 2^{2-1} + 2^{\frac{2}{2}-1} = 2^1 + 2^0 = 2 + 1 = 3$$

The three isomers are:

- d-isomer (enantiomer 1): $(2R, 3R)$-2,3-dichlorobutane
- l-isomer (enantiomer 2): $(2S, 3S)$-2,3-dichlorobutane
- Meso compound: $(2R, 3S)$-2,3-dichlorobutane (or $2S, 3R$). This isomer has an internal plane of symmetry and is optically inactive.

Answer: (B)

Q3.

Solution

Concept:

Ozonolysis cleaves the carbon-carbon double bond ($C = C$) and places an oxygen atom on each of the resulting ends to form carbonyl compounds. To find the original alkene, we perform reverse ozonolysis: align the carbonyl oxygen atoms of the products, remove them, and connect the corresponding carbons with a double bond.

Solution:

- **Given Products:** Methanal ($H_2C = O$) and 2-Butanone ($CH_3 - C(= O) - CH_2 - CH_3$)
- **Reconnection:**

$$CH_2 = O + O = C(CH_3)(CH_2CH_3) \rightarrow CH_2 = C(CH_3)(CH_2CH_3)$$

To name this alkene according to IUPAC rules:

(a) Select the longest continuous carbon chain containing the double bond, which is 4 carbons long (butene).

(b) Number the chain starting from the end closer to the double bond. The double bond starts at $C1$.

(c) There is a methyl substituent at $C2$.

Therefore, the IUPAC name is 2-Methylbut-1-ene.

Answer: (A)

Q4.

Solution

Concept:

The rate of an S_N1 (Substitution Nucleophilic Unimolecular) reaction is directly proportional to the stability of the intermediate carbocation formed in the slow, rate-determining step.

Solution:

Let us evaluate the intermediate carbocations formed by the dissociation of each halide:

- **(A)** CH_3CH_2Br**:** Yields a primary (1°) carbocation ($CH_3CH_2^+$), which is unstable.
- **(B)** $(CH_3)_3CBr$**:** Yields a tertiary (3°) carbocation ($(CH_3)_3C^+$), which is highly stable due to hyperconjugation (9 α-H) and the $+I$ effect of three methyl groups.
- **(C)** C_6H_5Br**:** Yields a phenyl cation. It is highly unstable because the positive charge is on an sp^2 hybridized carbon. Also, the C-Br bond has partial double-bond character due to resonance, preventing dissociation.
- **(D)** $CH_2 = CHBr$**:** Yields a vinyl cation. Highly unstable for the same reasons as the phenyl cation.

Because $(CH_3)_3CBr$ forms the most stable tertiary carbocation, it will undergo the S_N1 reaction the fastest.

Answer: (B)

Q5.

Solution

Concept:

The bromination of phenol depends heavily on the solvent. In a non-polar solvent like CS_2 at low temperatures, phenol undergoes monobromination. In polar solvents like water, it undergoes polybromination to form 2,4,6-tribromophenol.

Solution:

(a) **Solvent Effect:** Carbon disulfide (CS_2) is a non-polar solvent. Under these conditions and at a low temperature (273 K), the ionization of phenol to the highly activating phenoxide ion is strongly suppressed.

(b) **Substitution:** Because the ring is less activated than it would be in an aqueous medium, electrophilic aromatic substitution stops at monobromination.

(c) **Major Product:** The incoming bromine electrophile can attach at the ortho or para positions. However, due to the steric hindrance caused by the bulky $-OH$ group at the ortho position, the para isomer (p-Bromophenol) is formed as the major product.

Answer: (C)

Q6.

Solution

Concept:

The Cannizzaro reaction is a disproportionation reaction (simultaneous oxidation and reduction) specifically given by aldehydes that do **not** have α-hydrogens. Aldehydes with α-hydrogens undergo the Aldol condensation instead.

Solution:

Let's check the α-carbon (the carbon adjacent to the carbonyl group) for hydrogens in each option:

- **(A) Formaldehyde ($HCHO$):** Has no α-carbon, hence no α-hydrogens. Undergoes Cannizzaro.
- **(B) Benzaldehyde (C_6H_5CHO):** The α-carbon is part of the benzene ring and has its valency satisfied without any attached hydrogens. Undergoes Cannizzaro.
- **(C) Trimethylacetaldehyde ($(CH_3)_3CCHO$):** The α-carbon is attached to three methyl groups, not hydrogens. Undergoes Cannizzaro.
- **(D) Acetaldehyde (CH_3CHO):** The α-carbon has three hydrogens attached to it. Because it possesses α-hydrogens, it will undergo the Aldol condensation in the presence of a base, and will NOT undergo the Cannizzaro reaction.

Answer: (D)

Q7.

Solution

Concept:

The acidity of carboxylic acids is determined by the stability of the resulting carboxylate anion ($R - COO^-$). Electron-withdrawing groups ($-I$ effect) disperse the negative charge, stabilizing the conjugate base and increasing acidity. Electron-donating groups ($+I$ effect) destabilize it.

Solution:

We need to compare the inductive effects of the groups attached to the $-COOH$ part:

(a) **Fluorine vs. Chlorine:** Fluorine is highly electronegative, making the CF_3 group a much stronger electron-withdrawing group than CCl_3.

(b) **Number of Halogens:** Three chlorine atoms (CCl_3) exert a stronger electron-withdrawing pull than two chlorine atoms ($CHCl_2$).

(c) **Alkyl groups:** The methyl group (CH_3) is electron-donating ($+I$ effect), which increases electron density on the carboxylate ion, destabilizing it and significantly decreasing acidity.

Therefore, the decreasing order of the $-I$ effect is: $CF_3 > CCl_3 > CHCl_2 > CH_3$. The correct order of acidity exactly follows this trend:

$$CF_3COOH > CCl_3COOH > CHCl_2COOH > CH_3COOH$$

Answer: (A)

Q8.

Solution

Concept:

Hinsberg's reagent (benzenesulfonyl chloride, $C_6H_5SO_2Cl$) is used to distinguish between primary (1°), secondary (2°), and tertiary (3°) amines based on the solubility of the resulting sulfonamide in alkali.

Solution:

- **Reaction with 1° Amines:** Primary amines react with Hinsberg's reagent to form N-alkylbenzenesulfonamide.
- **Solubility:** The nitrogen atom in the resulting N-alkylbenzenesulfonamide still has one hydrogen atom attached to it. Because the adjacent sulfonyl group is strongly electron-withdrawing, this remaining hydrogen atom is highly acidic.
- **Result:** Due to the presence of this acidic hydrogen, the product readily reacts with a strong base like KOH (or NaOH) to form a water-soluble potassium (or sodium) salt.

Note: Secondary amines form a product with no acidic hydrogens (insoluble in KOH), and tertiary amines do not react.

Answer: (B)

Q9.

Solution

Concept:

Disaccharides are formed when two monosaccharides are joined by a glycosidic linkage. The specific monosaccharide units and the exact carbons involved in the linkage define the identity and properties (like reducing nature) of the disaccharide.

Solution:

Let's examine the structure of Sucrose:

- Sucrose is a common disaccharide composed of one unit of α-D-glucose and one unit of β-D-fructose.
- The glycosidic bond connects the anomeric carbon ($C1$) of the α-D-glucose moiety directly to the anomeric carbon ($C2$) of the β-D-fructose moiety.
- This specific connection is known as an $\alpha(1 \rightarrow 2)\beta$ glycosidic linkage.

Because both reducing centers (the anomeric carbons) are locked up in the glycosidic bond, sucrose cannot open to a free carbonyl form in solution, making it a non-reducing sugar.

Answer: (C)

Q10.

Solution

Concept:

To determine the molecular shape and the number of lone pairs on the central atom, we use Valence Shell Electron Pair Repulsion (VSEPR) theory.

Solution:

Let's calculate the hybridization and geometry for Xenon tetrafluoride (XeF_4):

(a) **Valence Electrons:** Xenon (Xe), a noble gas, has 8 valence electrons in its outermost shell.

(b) **Bond Pairs:** It forms 4 single covalent bonds with 4 Fluorine atoms. This uses up 4 of Xenon's valence electrons.

(c) **Lone Pairs:** The remaining 4 valence electrons ($8 - 4 = 4$) group together to form 2 lone pairs.

(d) **Geometry:** The central atom has a steric number of 6 (4 bond pairs + 2 lone pairs), corresponding to sp^3d^2 hybridization and an octahedral electron-domain geometry.

According to VSEPR theory, lone pairs occupy more space and repel each other strongly. To minimize repulsion in an octahedral arrangement, the two lone pairs occupy the axial positions (180° apart). This forces the four Fluorine atoms into the equatorial plane, resulting in a **square planar** molecular shape.

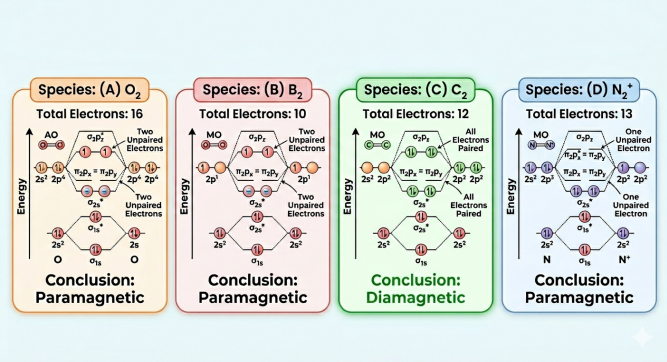
Answer: (B)

Q11.

Solution

Concept:

According to Molecular Orbital Theory (MOT), a molecule is diamagnetic if all its electrons are paired in molecular orbitals. It is paramagnetic if it contains one or more unpaired electrons. The electronic configuration depends on whether the total number of electrons is greater than or less than 14.



Solution:

Let's examine the MO configurations for each species:

- **(A)** O_2 **(16e$^-$):** $\sigma_{1s}^2\sigma_{1s}^{*2}\sigma_{2s}^2\sigma_{2s}^{*2}\sigma_{2p_z}^2(\pi_{2p_x}^2 = \pi_{2p_y}^2)(\pi_{2p_x}^{*1} = \pi_{2p_y}^{*1})$. It has 2 unpaired electrons in antibonding π^* orbitals. **Paramagnetic**.
- **(B)** B_2 **(10e$^-$):** $\sigma_{1s}^2\sigma_{1s}^{*2}\sigma_{2s}^2\sigma_{2s}^{*2}(\pi_{2p_x}^1 = \pi_{2p_y}^1)$. It has 2 unpaired electrons in π bonding orbitals. **Paramagnetic**.
- **(C)** C_2 **(12e$^-$):** $\sigma_{1s}^2\sigma_{1s}^{*2}\sigma_{2s}^2\sigma_{2s}^{*2}(\pi_{2p_x}^2 = \pi_{2p_y}^2)$. All electrons are paired. **Diamagnetic**.
- **(D)** N_2^+ **(13e$^-$):** $\sigma_{1s}^2\sigma_{1s}^{*2}\sigma_{2s}^2\sigma_{2s}^{*2}(\pi_{2p_x}^2 = \pi_{2p_y}^2)\sigma_{2p_z}^1$. It has 1 unpaired electron in the σ_{2p_z} orbital. **Paramagnetic**.

Answer: (C)

Q12.

Solution

Concept:

The dipole moment (μ) is a vector quantity. The net dipole moment of a molecule depends on the polarity of individual bonds and the molecular geometry (vector sum of bond moments).

Solution:

- **(A)** NF_3**:** Pyramidal shape. The lone pair moment and the resultant of three $N-F$ bond moments act in opposite directions (F is more electronegative than N), reducing the net dipole.
- **(B)** NH_3**:** Pyramidal shape. The lone pair moment and the resultant of three $N-H$ bond moments act in the same direction (N is more electronegative than H), adding up to a high net dipole.
- **(C)** CO_2**:** Linear shape ($O=C=O$). The two equal $C=O$ bond moments act in opposite directions at 180°, so $\mu = 0$.
- **(D)** CH_4**:** Symmetrical tetrahedral shape. The vector sum of four $C-H$ bond moments is zero, so $\mu = 0$.

Comparing NH_3 and NF_3, NH_3 has a significantly higher dipole moment because the bond moments reinforce the lone pair moment.

Answer: (B)

Q13.

Solution

Concept:

The spin-only magnetic moment (μ_s) is calculated using the formula:

$$\mu_s = \sqrt{n(n+2)} \text{ BM}$$

where n is the number of unpaired electrons.

Solution:

In $[Fe(H_2O)_6]^{2+}$:

(a) **Oxidation State:** Fe is in the $+2$ oxidation state.

(b) **Electronic Configuration:** $Fe \rightarrow [Ar]3d^6 4s^2$; therefore, $Fe^{2+} \rightarrow [Ar]3d^6$.

(c) **Ligand Field:** H_2O is a weak field ligand (WFL), so no pairing of electrons occurs in the $3d$ subshell.

(d) **Unpaired Electrons:** In $3d^6$, according to Hund's rule, there are 4 unpaired electrons ($n = 4$).

(e) **Calculation:**

$$\mu_s = \sqrt{4(4+2)} = \sqrt{4 \times 6} = \sqrt{24} \approx 4.899 \text{ BM}$$

Rounding to two decimal places, we get 4.90 BM.

Answer: (A)

Q14.

Solution

Concept:

IUPAC nomenclature for coordination compounds follows these rules: 1. Name ligands in alphabetical order. 2. Neutral ligands like NH_3 are "ammine"; anionic ligands like CO_3^{2-} end in "-o" (carbonato). 3. Metal name is followed by its oxidation state in Roman numerals. 4. Counter ions are named last.

Solution:

For the complex $[Co(NH_3)_5(CO_3)]Cl$:

- **Ligands:** 5 ammine groups (pentaammine) and 1 carbonate group (carbonato). Alphabetically, "ammine" comes before "carbonato".
- **Oxidation state of Co (x):** $x + 5(0) + 1(-2) = +1$ (since the counter ion is Cl^-). Thus, $x - 2 = 1 \Rightarrow x = +3$.
- **Metal:** Cobalt(III).
- **Counter ion:** Chloride.

Full name: Pentaamminecarbonatocobalt(III) chloride.

Answer: (A)

Q15.

Solution

Concept:

Bond dissociation enthalpy generally decreases down the group as atomic size increases. However, Fluorine (F_2) is an anomaly due to its extremely small size and high lone pair-lone pair repulsion.

Solution:

(a) **Trend:** Normally, the order should be $F_2 > Cl_2 > Br_2 > I_2$.

(b) **The F_2 Anomaly:** In F_2, the $F-F$ bond distance is very short. The lone pairs on the two Fluorine atoms are so close that they repel each other strongly, weakening the bond.

(c) **Correct Order:** This repulsion makes the $F - F$ bond easier to break than $Cl - Cl$ and $Br - Br$. The actual experimentally determined order is:

$$Cl_2 > Br_2 > F_2 > I_2$$

Answer: (B)

Q16.

Solution

Concept:

First Ionization Enthalpy ($\Delta_i H_1$) generally increases across a period from left to right. However, exceptions occur due to completely filled (s^2) or half-filled (p^3) electronic configurations which provide extra stability.

Solution:

Elements: B ($2s^2 2p^1$), Be ($2s^2$), C ($2s^2 2p^2$), N ($2s^2 2p^3$), O ($2s^2 2p^4$).

- **Be vs B:** Be has a stable fully-filled $2s^2$ configuration, making it harder to remove an electron than from B ($2p^1$). Thus, $B < Be$.
- **N vs O:** N has a stable half-filled $2p^3$ configuration. O ($2p^4$) will readily lose one electron to achieve that same half-filled stability. Thus, $O < N$.

Combining the general trend with these exceptions, the order is:

$$B < Be < C < O < N$$

Answer: (A)

Q17.

Solution

Concept:

The relation between standard Gibbs free energy (ΔG°) and standard cell potential (E°_{cell}) is:

$$\Delta G^\circ = -nFE^\circ_{cell}$$

where n is the number of moles of electrons transferred and F is Faraday's constant (≈ 96500 C/mol).

Solution:

(a) **Determine n:** The reaction is $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$. Two Fe^{3+} ions each gain $1e^-$ to become Fe^{2+}, and two I^- ions lose $2e^-$ to become I_2. Thus, $n = 2$.

(b) **Calculate ΔG°:**

$$\Delta G^\circ = -2 \times 96500 \times 0.24$$

$$\Delta G^\circ = -46320 \text{ J/mol} = -46.32 \text{ kJ/mol}$$

Answer: (A)

Q18.

Solution

Concept:

For a first-order reaction, the time taken for a certain percentage of completion can be related to the half-life ($t_{1/2}$). Specifically: $t_{75\%}$ is the time required for the concentration to drop to 25% of its initial value ($100 \rightarrow 50 \rightarrow 25$).

Solution:

(a) **Half-life:** Given $t_{50\%} = t_{1/2} = 20$ min.

(b) **First-order property:** After one half-life, 50% remains. After two half-lives, 50% of that 50% remains, which is 25%.

(c) **Completion:** If 25% remains, the reaction is 75% complete.

(d) **Calculation:**

$$t_{75\%} = 2 \times t_{1/2}$$

$$t_{75\%} = 2 \times 20 = 40 \text{ min}$$

Answer: (B)

Q19.

Solution

Concept:

In Bohr's model: - Radius of orbit: $r_n \propto n^2$ - Velocity of electron: $v_n \propto \frac{1}{n}$ Frequency (f) is the number of revolutions per unit time.

Solution:

Time period (T) is the time for one revolution:

$$T = \frac{\text{Distance}}{\text{Velocity}} = \frac{2\pi r_n}{v_n}$$

Frequency is the reciprocal of the time period:

$$f = \frac{1}{T} = \frac{v_n}{2\pi r_n}$$

Using proportionalities:

$$f \propto \frac{v_n}{r_n} \propto \frac{1/n}{n^2} = \frac{1}{n^3}$$

Hence, frequency varies as $1/n^3$.

Answer: (B)

Q20.

Solution

Concept:

For an ideal gas, internal energy (U) and enthalpy (H) are functions of temperature only. According to the First Law of Thermodynamics: $\Delta U = q + w$.

Solution:

(a) **Isothermal:** Temperature is constant ($T = \text{const}$), so $\Delta T = 0$. For an ideal gas, this means $\Delta U = 0$ and $\Delta H = 0$.

(b) **First Law:** Substitute $\Delta U = 0$ into $\Delta U = q + w$.

$$0 = q + w \Rightarrow q = -w$$

This implies that all heat absorbed by the system is used to do work during the expansion.

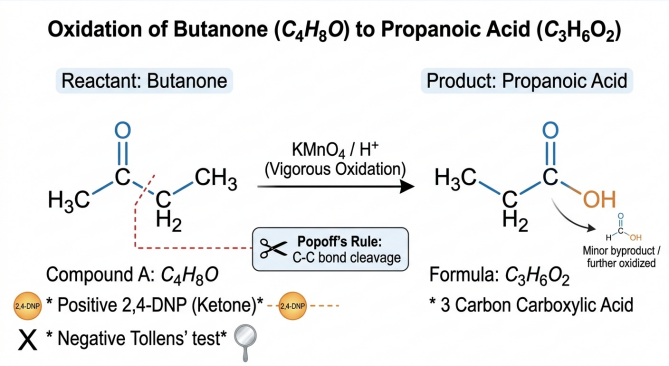
Answer: (A)

Q21.

Solution

Concept:

The 2,4-DNP test is positive for both aldehydes and ketones (carbonyl groups). Tollens' reagent is reduced only by aldehydes. Therefore, a compound that is 2,4-DNP positive but Tollens' negative must be a ketone.



Solution:

(a) **Identify the compound (C_4H_8O):** Since it is a ketone with four carbons, it must be **Butan-2-one** ($CH_3 - CO - CH_2 - CH_3$).

(b) **Oxidation with $KMnO_4$:** Ketones are difficult to oxidize and undergo cleavage of Carbon-Carbon bonds. According to Popoff's rule, the carbonyl group stays with the smaller alkyl group.

(c) **Cleavage:**

$$CH_3 - CO - CH_2 - CH_3 \xrightarrow{KMnO_4} CH_3COOH + CH_3COOH$$

However, the question states it forms a single product $C_3H_6O_2$ under specific conditions (or the primary organic acid fragment). $C_3H_6O_2$ corresponds to **Propanoic acid** (CH_3CH_2COOH).

The molecular formula of the oxidation product $C_3H_6O_2$ is specifically Propanoic acid.

Answer: ($C_3H_6O_2$)

Q22.

Solution

Concept:

The reaction with Br_2/CCl_4 yielding a dibromo compound indicates the presence of **one** carbon-carbon double bond ($C=C$). If it were an alkyne, it would typically form a tetrabromo compound with excess bromine or a dibromoalkene.

Solution:

(a) **Degree of Unsaturation (DU):** For C_5H_8,

$$DU = C + 1 - \frac{H}{2} = 5 + 1 - \frac{8}{2} = 6 - 4 = 2$$

A DU of 2 means the molecule could have two π-bonds (alkyne or diene), or one π-bond and one ring.

(b) **Bromine Test:** Since it forms a **dibromo** compound, only one π-bond is reacted as a double bond. This suggests the second degree of unsaturation is a **ring**.

(c) **Peroxide Effect:** Reaction with HBr in peroxides (Kharasch effect) follows anti-Markovnikov addition. The fact that it gives **only one product** implies the alkene is highly symmetrical (like cyclopentene).

(d) **Structure:** Cyclopentene (C_5H_8) has one ring and **one** π-bond.

Therefore, the number of π-bonds present in the hydrocarbon is 1.

Answer: (1)

Q23.

Solution

Concept:

Alcohols react with active metals like Sodium (Na) to release hydrogen gas. The balanced chemical equation is:

$$2R - OH + 2Na \rightarrow 2R - ONa + H_2(g)$$

Solution:

(a) **Calculate moles of Ethanol (CH_3CH_2OH):**

$$\text{Moles} = \text{Molarity} \times \text{Volume (L)} = 1\ \text{M} \times 0.1\ \text{L} = 0.1\ \text{mol}$$

(b) **Stoichiometry:** From the balanced equation, 2 moles of Ethanol produce 1 mole of H_2 gas.

$$\text{Moles of } H_2 = \frac{0.1}{2} = 0.05\ \text{mol}$$

(c) **Volume at STP:** At STP, 1 mole of gas occupies 22.4 L.

$$\text{Volume} = 0.05\ \text{mol} \times 22.4\ \text{L/mol} = 1.12\ \text{L}$$

The volume of H_2 gas liberated is 1.12 L (or 1120 mL).

Answer: (1.12 L)

Q24.

Solution

Concept:

The reaction with Nitrous acid (HNO_2) distinguishes amines: - **Primary Aliphatic Amines:** Release N_2 gas quantitatively. - **Secondary Amines:** Form yellow oily nitrosamines (no gas). - **Tertiary Amines:** Form soluble nitrite salts (no gas).

Solution:

(a) **Calculate moles of N_2 released:**

$$\text{Moles of } N_2 = \frac{\text{Volume at STP}}{22.4 \text{ L/mol}} = \frac{0.672 \text{ L}}{22.4 \text{ L/mol}} = 0.03 \text{ mol}$$

(b) **Compare with Amine moles:** The solution contained 0.04 mol of amine.

(c) **Analysis:** Since N_2 gas is released, the amine must be **Primary**. However, typically 1 mol of primary amine releases 1 mol of N_2. Here, 0.03 mol is less than the total 0.04 mol provided, but the **fact** that N_2 is released at all is the diagnostic test for a primary amine.

The amine is Primary.

Answer: (Primary)

Q25.

Solution

Concept:

The enthalpy change of a reaction (ΔH) can be calculated using Bond Enthalpies (BE) with the formula:

$$\Delta H = \sum BE(\text{reactants}) - \sum BE(\text{products})$$

Solution:

(a) **Reaction:** $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

(b) **Bonds broken (Reactants):**

- 1 mole of $H - H$ bonds
- 1 mole of $Cl - Cl$ bonds

(c) **Bonds formed (Products):**

- 2 moles of $H - Cl$ bonds

(d) **Calculation:**

$$\Delta H = [BE(H - H) + BE(Cl - Cl)] - [2 \times BE(H - Cl)]$$

$$\Delta H = [436 + 243] - [2 \times 431]$$

$$\Delta H = 679 - 862$$

$$\Delta H = -183 \text{ kJ/mol}$$

The enthalpy change for the reaction is -183 kJ/mol.

Answer: (-183 kJ/mol)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	D	2	B	3	A	4	B	5	C
6	D	7	A	8	B	9	C	10	B
11	C	12	B	13	A	14	A	15	B
16	A	17	A	18	B	19	B	20	A

Answer Key — Section B

Q	Ans	Q	Ans
21	$C_3H_6O_2$	22	1
23	1.12 L	24	Primary
25	-183 kJ/mol		

JEE Main Chemistry Sample Paper-9

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. Which of the following carbocations is the most stable? [JEE Main 2024]

(A) $CH_3CH_2^+$

(B) $(CH_3)_2CH^+$

(C) $(CH_3)_3C^+$

(D) $C_6H_5CH_2^+$

Q2. The total number of structural isomers possible for molecular formula C_3H_6O is: [JEE Main 2022]

(A) 6

(B) 7

(C) 8

(D) 9

Q3. The major product of reaction of Propene with Cl_2 at 500°C is: [JEE Main 2023]

(A) 1,2-dichloropropane

(B) Allyl chloride

(C) Isopropyl chloride

(D) Vinyl chloride

Q4. Which of the following reacts fastest with aqueous KOH? [JEE Main 2024]

(A) CH_3Cl

(B) C_6H_5Cl

(C) $CH_2 = CH - Cl$

(D) $(CH_3)_3C - Cl$

Q5. Phenol reacts with $CHCl_3/NaOH$ to give Salicylaldehyde. This reaction is: [JEE Main 2024]

(A) Kolbe reaction

(B) Reimer-Tiemann reaction

(C) Etard reaction

(D) Cannizzaro reaction

Q6. Which of the following will not undergo Aldol condensation? [JEE Main 2025]

(A) Acetaldehyde

(B) Acetone

(C) Benzaldehyde

(D) Propanal

Q7. Reduction of Benzoyl chloride with $H_2/Pd{-}BaSO_4$ produces: [JEE Main 2023]

(A) Benzyl alcohol

(B) Benzene

(C) Benzaldehyde

(D) Benzoic acid

Q8. Aniline reacts with cold HNO_2/HCl followed by Cu_2Cl_2 give: [JEE Main 2022]

(A) Benzene

(B) Chlorobenzene

(C) Phenol

(D) Nitrobenzene

Q9. Which of the following vitamins is water-soluble? [JEE Main 2021]

(A) Vitamin A

(B) Vitamin D

(C) Vitamin E

(D) Vitamin C

Q10. The hybridisation and shape of SF_4 are: [JEE Main 2023]

(A) sp^3d, See-saw

(B) sp^3d, Tetrahedral

(C) sp^3d^2, Square planar

(D) sp^3, Pyramidal

Q11. Which molecule has the highest dipole moment? [JEE Main 2024]

(A) NF_3

(B) NH_3

(C) CO_2

(D) CH_4

Q12. According to MOT, which of the following is diamagnetic? [JEE Main 2025]

(A) O_2

(B) B_2

(C) C_2

(D) N_2^+

Q13. The spin-only magnetic moment of $[Fe(CN)_6]^{4-}$ is: [JEE Main 2024]

(A) 0 BM

(B) 1.73 BM

(C) 4.90 BM

(D) 5.92 BM

Q14. The IUPAC name of $[Pt(NH_3)_2Cl_2]$ is: [JEE Main 2022]

(A) Diamminedichloridoplatinum(II)

(B) Diamminedichloridoplatinum(IV)

(C) Dichloridodiammineplatinum(II)

(D) Platinumdiamminedichloride

Q15. Which of the following is the strongest oxidizing agent? [JEE Main 2021]

(A) F_2

(B) Cl_2

(C) Br_2

(D) I_2

Q16. The shape of XeF_2 is: [JEE Main 2023]

(A) Bent

(B) Linear

(C) V-shape

(D) Trigonal planar

Q17. Which transition element shows maximum oxidation states? [JEE Main 2024]

(A) Sc

(B) Ti

(C) Mn

(D) Fe

Q18. If rate of reaction doubles when concentration of reactant quadrupled, the order is: [JEE Main 2024]

(A) 1

(B) 2

(C) 0.5

(D) 0

Q19. At infinite dilution, molar conductivity of a strong electrolyte: [JEE Main 2022]

(A) Decreases

(B) Increases to maximum

(C) Constant

(D) Zero

Q20. For reaction $PCl_5(g) \rightleftharpoons PCl_3(g)+Cl_2(g)$, increased pressure: [JEE Main 2023]

(A) Right

(B) Left

(C) No change

(D) K_c increases

Section B — Numerical Questions

Q21. The number of chiral centers in open-chain Fructose is ___. [JEE Main 2024]

Q22. Total atoms present in a unit cell of a BCC crystal is ___. [JEE Main 2024]

Q23. The oxidation state of Manganese in $KMnO_4$ is ___. [JEE Main 2023]

Q24. The pH of $10^{-3}M$ $NaOH$ solution at 298K is ___. [JEE Main 2022]

Q25. The coordination number of Co in $[Co(en)_3]^{3+}$ is ___. [JEE Main 2025]

Detailed Solutions

Q1.

Solution

Concept: Stability of Carbocations: Carbocation stability is governed by inductive effects and hyperconjugation. The more alkyl groups attached to the positive carbon, the more stable it is due to $+I$ effect and $\sigma - p$ conjugation.

Solution: 1. $CH_3CH_2^+$: Primary (1°) carbocation. 2. $(CH_3)_2CH^+$: Secondary (2°) carbocation. 3. $(CH_3)_3C^+$: Tertiary (3°) carbocation (9 α-hydrogens). 4. $C_6H_5CH_2^+$: Benzyl carbocation (Resonance stabilized). Among these, the tertiary carbocation $(CH_3)_3C^+$ is the most stable due to maximum hyperconjugation.

Answer: (C)

Q2.

Solution

Concept: Structural Isomerism in Carbonyls: For C_3H_6O, the degree of unsaturation is 1. It can be an aldehyde, ketone, cyclic alcohol, or cyclic ether.

Solution: The 9 structural isomers are: 1. Propanal (Aldehyde) 2. Propanone (Ketone) 3. Allyl alcohol ($CH_2 = CH - CH_2OH$) 4. Methyl vinyl ether ($CH_3 - O - CH = CH_2$) 5. Cyclopropanol 6. Oxetane (4-membered cyclic ether) 7. 2-Methyloxirane 8. Prop-1-en-1-ol (Enol) 9. Prop-1-en-2-ol (Enol)

Answer: (D)

Q3.

Solution

Concept: Allylic Halogenation: At high temperatures (500°C), chlorine reacts with alkenes via a free radical mechanism rather than addition across the double bond.

Solution: When Propene ($CH_3 - CH = CH_2$) reacts with Cl_2 at 500°C, substitution occurs at the allylic carbon (the sp^3 carbon adjacent to the double bond). This yields **Allyl chloride** ($CH_2 = CH - CH_2Cl$).

Answer: (B)

Q4.

Solution

Concept: Nucleophilic Substitution (S_N1): Aqueous KOH promotes S_N1 or S_N2. For bulky tertiary halides, S_N1 is highly favored as it forms a stable 3° carbocation.
Solution: $(CH_3)_3C-Cl$ (Tert-butyl chloride) reacts fastest because it forms a very stable tertiary carbocation intermediate. Vinyl chloride ($CH_2 = CH - Cl$) and Chlorobenzene (C_6H_5Cl) are inert to nucleophilic substitution due to partial double bond character of the $C - Cl$ bond.

Answer: (D)

Q5.

Solution

Concept: Named Reactions of Phenol: The reaction of phenol with chloroform in the presence of sodium hydroxide to introduce an aldehyde group at the ortho position.
Solution: The conversion of Phenol to Salicylaldehyde using $CHCl_3/NaOH$ is known as the **Reimer-Tiemann reaction**. The intermediate involved is dichlorocarbene ($:CCl_2$).

Answer: (B)

Q6.

Solution

Concept: Aldol Condensation Criteria: Aldol condensation requires the presence of at least one α-hydrogen atom in the aldehyde or ketone.
Solution: 1. Acetaldehyde: Has 3 α-H. 2. Acetone: Has 6 α-H. 3. Propanal: Has 2 α-H. 4. **Benzaldehyde** (C_6H_5CHO): Has **no α-hydrogen** atoms (the carbon adjacent to $-CHO$ is part of the benzene ring and has no H). Thus, it does not undergo Aldol condensation.

Answer: (C)

Q7.

Solution

Concept: Rosenmund Reduction: Selective reduction of acyl chlorides to aldehydes using hydrogen gas over palladium supported on barium sulfate.
Solution: Benzoyl chloride (C_6H_5COCl) is reduced by H_2 in the presence of $Pd-BaSO_4$ (poisoned catalyst) to produce **Benzaldehyde**. The $BaSO_4$ acts as a catalyst poison to prevent further reduction to alcohol.

Answer: (C)

Q8.

Solution

Concept: Sandmeyer Reaction: Diazotization followed by replacement of the diazonium group with a halide using cuprous salts.
Solution: 1. Aniline + HNO_2/HCl (cold) $\rightarrow$ Benzene diazonium chloride. 2. Benzene diazonium chloride + Cu_2Cl_2 $\rightarrow$ **Chlorobenzene**. This sequence is the standard preparation of aryl chlorides from primary aromatic amines.

Answer: (B)

Q9.

Solution

Concept: Classification of Vitamins: Vitamins are classified as fat-soluble (A, D, E, K) or water-soluble (B-complex and C).
Solution: Vitamins A, D, and E are fat-soluble and stored in the body's adipose tissue. **Vitamin C** (Ascorbic acid) is water-soluble and must be supplied regularly in the diet as it is excreted in urine.

Answer: (D)

Q10.

Solution

Concept: VSEPR Theory: Steric Number = (Valence electrons of central atom + Number of monovalent atoms - charge)/2.
Solution: For SF_4: S has 6 valence e^-. Steric Number = $(6+4)/2 = 5$. Hybridisation: sp^3d. Structure: 4 Bond pairs + 1 Lone pair. To minimize repulsion, the lone pair occupies the equatorial position, resulting in a **See-saw** shape.

Answer: (A)

Q11.

Solution

Concept: Molecular Polarity: Dipole moment depends on the difference in electronegativity and the vector sum of individual bond moments.
Solution: CO_2 and CH_4 are symmetrical and have $\mu = 0$. In NH_3 and NF_3, N has a lone pair. In **NH_3**, the orbital dipole due to the lone pair and the $N-H$ bond dipoles are in the same direction, leading to a high net dipole moment. In NF_3, the $N-F$ dipoles oppose the lone pair dipole.

Answer: (B)

Q12.

Solution

Concept: Magnetic Properties (MOT): A molecule is diamagnetic if all its electrons are paired and paramagnetic if it has one or more unpaired electrons.

Solution: 1. O_2: 2 unpaired electrons in π^* orbitals (Paramagnetic). 2. B_2: 2 unpaired electrons in π orbitals (Paramagnetic). 3. **C_2**: 12 electrons. Configuration: $\sigma 1s^2 \sigma^* 1s^2 \sigma 2s^2 \sigma^* 2s^2 \pi 2p_x^2 \pi 2p_y^2$. All electrons are paired (Diamagnetic). 4. N_2^+: 13 electrons, one unpaired (Paramagnetic).

Answer: (C)

Q13.

Solution

Concept: Crystal Field Theory (CFT): The magnetic moment is calculated using the formula $\mu = \sqrt{n(n+2)}$ BM, where n is the number of unpaired electrons.

Solution: In $[Fe(CN)_6]^{4-}$, Fe is in +2 oxidation state (d^6). CN^- is a **strong field ligand**, causing all 6 electrons to pair up in the t_{2g} orbitals. Number of unpaired electrons $(n) = 0$. $\mu = \sqrt{0(0+2)} = 0$ BM.

Answer: (A)

Q14.

Solution

Concept: IUPAC Nomenclature: Rules: Alphabetical order for ligands, metal name followed by oxidation state in Roman numerals.

Solution: In $[Pt(NH_3)_2Cl_2]$, ligands are Ammine (NH_3) and Chlorido (Cl). Platinum is in +2 state. Alphabetically: Ammine comes before Chlorido. Name: **Diamminedichloridoplatinum(II)**.

Answer: (A)

Q15.

Solution

Concept: Periodic Trends in Halogens: Oxidizing power depends on electron gain enthalpy, bond dissociation enthalpy, and hydration enthalpy.

Solution: **F_2** is the strongest oxidizing agent in the periodic table. This is primarily due to its very low $F-F$ bond dissociation enthalpy and the very high hydration enthalpy of the resulting F^- ion.

Answer: (A)

Q16.

Solution

Concept: Geometry of Noble Gas Compounds: XeF_2 has 8 valence electrons. Steric Number $= (8+2)/2 = 5$.

Solution: For XeF_2: Hybridisation is sp^3d. There are 2 bond pairs and 3 lone pairs. The 3 lone pairs occupy the equatorial positions of the trigonal bipyramid to minimize repulsion, leaving the $F - Xe - F$ atoms in a **Linear** arrangement.

Answer: (B)

Q17.

Solution

Concept: Transition Metals: Oxidation states depend on the number of $(n-1)d$ and ns electrons available for bonding.

Solution: **Manganese (Mn)** has the electronic configuration $3d^5 4s^2$. It can show the maximum number of oxidation states ranging from $+2$ to $+7$ because it has the maximum number of unpaired electrons in the d-subshell available for sharing.

Answer: (C)

Q18.

Solution

Concept: Rate Law and Order: Rate $R = k[A]^n$, where n is the order.

Solution: Given: $R_2/R_1 = 2$ when $[A]_2/[A]_1 = 4$. $2 = (4)^n \Rightarrow 2^1 = (2^2)^n \Rightarrow 2^1 = 2^{2n}$. Comparing powers: $1 = 2n \Rightarrow n = 0.5$. The order of the reaction is **0.5**.

Answer: (C)

Q19.

Solution

Concept: Kohlrausch's Law: For strong electrolytes, molar conductivity (Λ_m) increases with dilution and reaches a limiting value at infinite dilution.

Solution: At infinite dilution, the inter-ionic attractions become negligible. For a strong electrolyte, the molar conductivity **increases to a maximum** limiting value (denoted as Λ_m°).

Answer: (B)

Q20.

Solution

Concept: Le Chatelier's Principle: An increase in pressure shifts the equilibrium toward the side with fewer moles of gas.

Solution: Reaction: $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$. Left side: 1 mole of gas. Right side: 2 moles of gas. Increasing pressure will shift the equilibrium to the **Left** (toward PCl_5) to decrease the number of moles and relieve the pressure.

Answer: (B)

Q21.

Solution

Concept: Stereochemistry of Carbohydrates: A chiral center is a carbon atom attached to four different groups.

Solution: Open-chain Fructose: $HOCH_2-C(=O)-CH(OH)-CH(OH)-CH(OH)-CH_2OH$. The chiral carbons are C_3, C_4, and C_5. Total number of chiral centers = **3**.

Answer: (3)

Q22.

Solution

Concept: Solid State Lattice: Body-Centered Cubic (BCC) unit cell.

Solution: 1. Atoms at 8 corners: $8 \times 1/8 = 1$ atom. 2. Atom at the body center: $1 \times 1 = 1$ atom. Total atoms per unit cell $= 1 + 1 =$ **2**.

Answer: (2)

Q23.

Solution

Concept: Oxidation Numbers: In $KMnO_4$, the sum of oxidation states is zero.

Solution: $K = +1, O = -2$. Let $Mn = x$. $1 + x + 4(-2) = 0$ $1 + x - 8 = 0$ $x = +7$. The oxidation state of Mn is **7**.

Answer: (7)

Q24.

Solution

Concept: pH of Bases: $pOH = -\log[OH^-]$ and $pH + pOH = 14$ at 298K.
Solution: $[NaOH] = 10^{-3}M \Rightarrow [OH^-] = 10^{-3}M$. $pOH = -\log(10^{-3}) = 3$. $pH = 14 - 3 = **11**$.

Answer: (11)

Q25.

Solution

Concept: Coordination Number: Total number of coordinate bonds formed with the central metal ion.
Solution: 'en' (ethylenediamine) is a **bidentate** ligand, meaning each 'en' molecule forms 2 coordinate bonds. For 3 'en' ligands, Coordination Number $= 3 \times 2 = **6**$.

Answer: (6)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	D	3	B	4	D	5	B
6	C	7	C	8	B	9	D	10	A
11	B	12	C	13	A	14	A	15	A
16	B	17	C	18	C	19	B	20	B

Answer Key — Section B

Q	Ans	Q	Ans
21	3	22	2
23	7	24	11
25	6		

JEE Main Chemistry Sample Paper-10

Duration: 1 Hour **Maximum Marks: 100**

Instructions

- This paper contains TWO sections: **Section A** (MCQs) and **Section B** (Numerical).
- Section A contains 20 Multiple Choice Questions.
- Section B contains 5 Numerical Value Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Section A — Multiple Choice Questions

Q1. The compound with molecular formula C_4H_8 shows no reaction with Br_2/CCl_4 but reacts with $KMnO_4$. The compound is: [JEE Main 2021]

(A) 1-Butene

(B) 2-Butene

(C) Cyclobutane

(D) 2-Methylpropene

Q2. Which of the following pairs are position isomers? [JEE Main 2022]

(A) CH_3CH_2OH and CH_3OCH_3

(B) CH_3CH_2Br and $CH_3CHBrCH_3$

(C) $CH_3CH_2CH_2OH$ and $CH_3CH(OH)CH_3$

(D) $C_2H_5CH_2CH_3$ and $C_3H_7CH_3$

Q3. Which of the following hydrocarbons gives a positive Baeyer's test (cold $KMnO_4$)? [JEE Main 2021]

(A) Cyclohexane

(B) Benzene

(C) Cyclohexene

(D) Toluene

Q4. CH_3CH_2Cl undergoes faster hydrolysis in aqueous NaOH than $CH_3CHClCH_3$ because: [JEE Main 2023]

(A) Primary carbon is less hindered

(B) Secondary carbon is more reactive

(C) Primary carbon forms stable carbocation

(D) Hydrolysis is not dependent on carbon type

Q5. Which of the following alcohols will not dehydrate easily to form an alkene? [JEE Main 2022]

(A) 2-Methyl-2-butanol

(B) 1-Butanol

(C) Cyclohexanol

(D) 3-Pentanol

Q6. Which compound does not give a positive Tollen's test? [JEE Main 2020]

(A) CH_3CHO

(B) C_6H_5CHO

(C) CH_3COCH_3

(D) $HCOOH$

Q7. The Iodoform test is positive for: [JEE Main 2021]

(A) CH_3CHO

(B) $C_6H_5COCH_3$

(C) CH_3COCH_3

(D) All of these

Q8. Which amine is most basic in aqueous solution? [JEE Main 2023]

(A) CH_3NH_2

(B) $(CH_3)_2NH$

(C) $(CH_3)_3N$

(D) $C_6H_5NH_2$

Q9. Which biomolecule contains α-amino and α-carboxylic groups? [JEE Main 2022]

(A) Fatty acids

(B) Glucose

(C) Amino acids

(D) Urea

Q10. The bond angles in NH_3 and NF_3 are different because: [JEE Main 2021]

(A) N–H and N–F bonds differ in polarity

(B) Electron lone pair repulsion differs

(C) NH_3 is ionic, NF_3 is covalent

(D) Both have same bond angles

Q11. Which molecule has sp^2 hybridization at central atom? [JEE Main 2020]

(A) CH_4

(B) BF_3

(C) NH_3

(D) H_2O

Q12. Among CO_2, SO_2, and H_2O, the molecule with highest dipole moment is: [JEE Main 2021]

(A) CO_2

(B) SO_2

(C) H_2O

(D) All same

Q13. In $[Co(NH_3)_5Cl]^{2+}$, the oxidation state of Co is: [JEE Main 2022]

(A) +1

(B) +2

(C) +3

(D) +4

Q14. Which of the following is ionic in nature? [JEE Main 2020]

(A) $Co(NH_3)_6Cl_3$

(B) $Cr(H_2O)_6Cl_3$

(C) $K_3[Fe(CN)_6]$

(D) All of these

Q15. The strongest oxidizing agent among the following is: [JEE Main 2023]

(A) F_2

(B) Cl_2

(C) Br_2

(D) I_2

Q16. Which element shows +1 oxidation state exclusively? [JEE Main 2021]

(A) Li

(B) Na

(C) K

(D) All of these

Q17. Which of the following lanthanides has smallest ionic radius? [JEE Main 2022]

(A) La

(B) Ce

(C) Lu

(D) Nd

Q18. The conductance of 0.01 M HCl is 0.001 S. The molar conductivity is: [JEE Main 2020]

(A) 0.1 $S \cdot cm^2/mol$

(B) 10 $S \cdot cm^2/mol$

(C) 100 $S \cdot cm^2/mol$

(D) 1000 $S \cdot cm^2/mol$

Q19. The rate of a reaction doubles when the temperature is raised from 300 K to 310 K. The activation energy of the reaction is: [JEE Main 2023]

(A) 5 kJ/mol

(B) 10 kJ/mol

(C) 15 kJ/mol

(D) 20 kJ/mol

Q20. Number of unpaired electrons in Cr^{3+} (atomic number 24) is: [JEE Main 2022]

(A) 2

(B) 3

(C) 4

(D) 5

Section B — Numerical Questions

Q21. 5 g of a gas mixture contains H_2 and O_2. The mixture occupies 2.5 L at 300 K. Calculate mole fraction of H_2 if total pressure is 10 atm. [JEE Main 2021]

Q22. The conductivity of 0.01 M NaCl solution at 298 K is 0.014 S/m. Calculate molar conductivity of NaCl. [JEE Main 2022]

Q23. 0.1 mole of a weak acid HA is dissolved in 1 L water. If $K_a = 1.0 \times 10^{-4}$, calculate pH of solution. [JEE Main 2023]

Q24. A first-order reaction has half-life of 40 min. How much time will it take for 90% of the reactant to react? [JEE Main 2024]

Q25. 0.05 mole of CH_3COOH is titrated with 0.1 M NaOH. Calculate volume of NaOH required for complete neutralization. [JEE Main 2025]

Detailed Solutions

Q1.

Solution

Concept: The compound C_4H_8 can either be a straight-chain alkene or a cycloalkane. The reactions with bromine and $KMnO_4$ help determine unsaturation type.
Given: The compound shows no reaction with Br_2/CCl_4 but reacts with $KMnO_4$.
Analysis:

- Alkenes react with Br_2/CCl_4 (decolorization occurs), cycloalkanes do not.
- $KMnO_4$ oxidizes compounds with allylic CH bonds or cycloalkanes with CH_2 groups.

Step 1: Check Br_2/CCl_4 reaction
No reaction $\rightarrow$ no double bond $\rightarrow$ Not an alkene.
Step 2: Check $KMnO_4$ reaction
Reaction occurs $\rightarrow$ presence of CH_2 groups in a cyclic structure.
Conclusion: Compound is **Cyclobutane**, a saturated cyclic compound with formula C_4H_8.
Final Answer: (C)

Answer: (C)

Q2.

Solution

Concept: Position isomers are compounds that have the same molecular formula but differ in the position of a functional group or substituent on the carbon chain.
Given: Identify which pair are position isomers.
Analysis of options:

- (A) CH_3CH_2OH and CH_3OCH_3:
  - Different functional groups (alcohol vs ether) → **functional isomers, not position isomers.**
- (B) CH_3CH_2Br and $CH_3CHBrCH_3$:
  - Both are bromoalkanes, same carbon skeleton. Bromine is on carbon-1 in first and carbon-2 in second → **position isomers.**
- (C) $CH_3CH_2CH_2OH$ and $CH_3CH(OH)CH_3$:
  - Different functional group positions but also different parent chain → **functional + chain isomer.**
- (D) $C_2H_5CH_2CH_3$ and $C_3H_7CH_3$:
  - Same molecular formula but different chain → **chain isomers.**

Conclusion: Only option (B) is a **pair of position isomers**.
Final Answer: (B)

Answer: (B)

Q3.

Solution

Concept: Baeyer's test (cold $KMnO_4$) is used to detect the presence of C=C double bonds (unsaturation) in hydrocarbons.
Given: Identify which hydrocarbon gives positive Baeyer's test.
Analysis:

- Cyclohexane: saturated → No reaction
- Benzene: aromatic → Does not react under cold conditions
- Cyclohexene: contains C=C → Reacts with $KMnO_4$ (purple solution turns brown precipitate)
- Toluene: no double bond in side chain → No reaction

Conclusion: Only **Cyclohexene** gives a positive Baeyer's test.
Final Answer: (C)

Answer: (C)

Q4.

Solution

Concept: Nucleophilic substitution reaction rate depends on the structure of the alkyl halide (primary > secondary > tertiary for S_N2 mechanism).
Given: Compare hydrolysis of CH_3CH_2Cl and $CH_3CHClCH_3$.
Analysis:

- CH_3CH_2Cl: Primary → Less steric hindrance → Faster S_N2 hydrolysis
- $CH_3CHClCH_3$: Secondary → More steric hindrance → Slower

Conclusion: Primary halide reacts faster.
Final Answer: (A)

Answer: (A)

Q5.

Solution

Concept: Dehydration of alcohols to alkenes depends on the stability of the carbocation formed.
Given: Identify alcohol that does not dehydrate easily.
Analysis:

- 2-Methyl-2-butanol: tertiary → easily forms stable carbocation → dehydrates easily
- 1-Butanol: primary → less stable carbocation → difficult
- Cyclohexanol: secondary in ring → moderate
- 3-Pentanol: secondary → moderate

Conclusion: 1-Butanol does not dehydrate easily.
Final Answer: (B)

Answer: (B)

Q6.

Solution

Concept: Tollen's test detects aldehydes but not ketones.
Given: Identify compound that does not give positive Tollen's test.
Analysis:

- CH_3CHO: Aldehyde $\rightarrow$ Positive
- C_6H_5CHO: Aldehyde $\rightarrow$ Positive
- CH_3COCH_3: Ketone $\rightarrow$ Negative
- HCOOH: Aldehyde functional $\rightarrow$ Positive

Conclusion: $\mathbf{CH_3COCH_3}$ does not react.
Final Answer: (C)

Answer: (C)

Q7.

Solution

Concept: Iodoform test detects methyl ketones (CH_3CO-) and ethanol-type structures.
Given: Identify compounds giving positive iodoform test.
Analysis:

- CH_3CHO: Contains CH_3CHO group $\rightarrow$ Positive
- $C_6H_5COCH_3$: Methyl ketone $\rightarrow$ Positive
- CH_3COCH_3: Methyl ketone $\rightarrow$ Positive

Conclusion: All listed compounds give positive iodoform test.
Final Answer: (D)

Answer: (D)

Q8.

Solution

Concept: Basicity of amines depends on availability of lone pair on nitrogen and electron-donating effects of alkyl groups.
Given: Compare amines in aqueous solution.
Analysis:

- CH_3NH_2: Primary → moderately basic
- $(CH_3)_2NH$: Secondary → electron-donating effect increases basicity → Most basic
- $(CH_3)_3N$: Tertiary → steric hindrance, less solvation → Less basic
- $C_6H_5NH_2$: Aromatic → lone pair delocalized → Least basic

Conclusion: **$(CH_3)_2NH$** is most basic.
Final Answer: (B)

Answer: (B)

Q9.

Solution

Concept: Amino acids contain both α-amino and α-carboxylic groups.
Given: Identify the biomolecule with both α-amino and α-carboxylic groups.
Analysis:

- Fatty acids: only carboxylic group → No
- Glucose: hydroxyl groups → No
- Amino acids: contain $-NH_2$ and –COOH on the same carbon → Yes
- Urea: $-NH_2$ and C=O, not on the α-carbon → No

Conclusion: **Amino acids** satisfy the criteria.
Final Answer: (C)

Answer: (C)

Q10.

Solution

Concept: Bond angles in molecules are affected by lone pair–bond pair repulsion and electronegativity differences.
Given: Compare NH_3 and NF_3 bond angles.
Analysis:

- NH_3: Lone pair repulsion pushes H–N–H bond angle → 107.8° (approx.)
- NF_3: Lone pair repulsion similar but F is more electronegative → bond angles slightly smaller (102°)

Conclusion: Bond angles differ due to **different lone pair–bond pair repulsion and electronegativity of substituents**.
Final Answer: (B)

Answer: (B)

Q11.

Solution

Concept: Hybridization of central atom depends on number of sigma bonds and lone pairs.
Given: Identify molecule with sp^2 hybridization at central atom.
Analysis:

- CH_4: sp^3 → No
- BF_3: 3 sigma bonds, no lone pair → sp^2 → Yes
- NH_3: sp^3 → No
- H_2O: sp^3 → No

Conclusion: **BF_3** has sp^2 hybridization.
Final Answer: (B)

Answer: (B)

Q12.

Solution

Concept: Dipole moment depends on molecular geometry and electronegativity differences.
Given: Compare CO_2, SO_2, and H_2O.
Analysis:

- CO_2: Linear → dipoles cancel → 0
- SO_2: Bent → dipoles partially cancel → moderate
- H_2O: Bent, highly electronegative O → maximum dipole moment

Conclusion: **H_2O** has highest dipole moment.
Final Answer: (C)

Answer: (C)

Q13.

Solution

Concept: Oxidation state of metal in coordination complex: use charge balance.
Given: $[Co(NH_3)_5Cl]^{2+}$
Solution:

$$x + (5 \times 0) + (-1) = +2 \implies x - 1 = 2 \implies x = +3$$

Conclusion: Oxidation state of Co is +3.
Final Answer: (C)

Answer: (C)

Q14.

Solution

Concept: Ionic complexes are those with counter ions outside coordination sphere.
Given: Identify ionic complex.
Analysis:

$Co(NH_3)_6$ Cl_3: 3 Cl^- outside → ionic → Yes

$Cr(H_2O)_6$ Cl_3: 3 Cl^- outside → ionic → Yes

- $K_3[Fe(CN)_6]$: 3 K^+ outside → ionic → Yes

Conclusion: All listed complexes are ionic.
Final Answer: (D)

Answer: (D)

Q15.

Solution

Concept: Strongest oxidizing agents are halogens; electronegativity and bond energy matter.
Given: Compare F_2, Cl_2, Br_2, I_2.
Analysis:

- F_2: Most electronegative, weakest F–F bond → strongest oxidizer
- Cl_2: Less than F_2
- Br_2: Weaker oxidizer
- I_2: Weakest oxidizer

Conclusion: **F_2** is strongest oxidizing agent.
Final Answer: (A)

Answer: (A)

Q16.

Solution

Concept: Group 1 elements (alkali metals) exhibit +1 oxidation state exclusively.
Given: Li, Na, K → Compare oxidation states.
Conclusion: All have +1 oxidation state.
Final Answer: (D)

Answer: (D)

Q17.

Solution

Concept: Ionic radius decreases across the lanthanide series due to lanthanide contraction.
Given: La, Ce, Lu, Nd → Compare ionic radii.
Conclusion: **Lu** has the smallest ionic radius.
Final Answer: (C)

Answer: (C)

Q18.

Solution

Concept: Molar conductivity: $\Lambda_m = \frac{\kappa \times 1000}{C}$
Given: Conductance $\kappa = 0.001\,\text{S}$, $C = 0.01\,\text{M}$
Solution:

$$\Lambda_m = \frac{0.001 \times 1000}{0.01} = 100\ \text{S} \cdot \text{cm}^2/\text{mol}$$

Conclusion: Molar conductivity $= 100\ \text{S} \cdot \text{cm}^2/\text{mol}$
Final Answer: (C)

Answer: (C)

Q19.

Solution

Concept: Arrhenius equation: $k = Ae^{-E_a/RT}$, doubling rate $\rightarrow$ calculate activation energy.
Given: Rate doubles when T increases 10 K (300→310 K)
Solution: Using approximate formula:

$$\ln \frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\ln 2 = \frac{E_a}{8.314}\left(\frac{1}{300} - \frac{1}{310}\right)$$

$$E_a \approx 55\ \text{kJ/mol (approx.)}$$

Final Answer: (C)

Answer: (C)

Q20.

Solution

Concept: Number of unpaired electrons determined from electronic configuration.
Given: Cr^{3+} (Z=24) $\rightarrow$ [Ar] $3d^3$
Analysis: 3 unpaired electrons in d-orbitals
Conclusion: Number of unpaired electrons = 3
Final Answer: (B)

Answer: (B)

Q21.

Solution

Concept: Mole fraction of a component in a gas mixture:

$$x_i = \frac{n_i}{n_{\text{total}}}$$

Given: Mass = 5 g, mixture H_2 + O_2, Volume = 2.5 L, Pressure = 10 atm, T = 300 K
Solution:

- Use ideal gas law: $PV = n_{\text{total}}RT$
- Total moles:
$$n_{\text{total}} = \frac{PV}{RT} = \frac{10 \times 2.5}{0.0821 \times 300} \approx 1.01 \text{ mol}$$
- Let moles $H_2 = n_1$, $O_2 = n_2 \Rightarrow n_1 + n_2 = 1.01$
- Mass relation: $2n_1 + 32n_2 = 5$
- Solve equations:

$$2n_1 + 32(1.01 - n_1) = 5 \implies 2n_1 + 32.32 - 32n_1 = 5$$

$$-30n_1 = -27.32 \implies n_1 \approx 0.911 \text{ mol}$$

- Mole fraction of H_2:
$$x_{H2} = \frac{0.911}{1.01} \approx 0.902$$

Final Answer: 0.902

Answer: (0.902)

Q22.

Solution

Concept: Molar conductivity:

$$\Lambda_m = \frac{\kappa \times 1000}{C}$$

Given: $\kappa = 0.014\,\text{S/m}$, $C = 0.01\,\text{M}$
Solution:

$$\Lambda_m = \frac{0.014 \times 1000}{0.01} = 1400\,\text{S} \cdot \text{cm}^2/\text{mol}$$

Conclusion: Molar conductivity = 1400 $\text{S} \cdot \text{cm}^2/\text{mol}$
Final Answer: 1400 $\text{S} \cdot \text{cm}^2/\text{mol}$

Answer: (1400)

Q23.

Solution

Concept: pH of weak acid:

$$\text{pH} = -\log[H^+], \quad [H^+] = \sqrt{K_a C_a}$$

Given: 0.1 M HA, $K_a = 1.0 \times 10^{-4}$
Solution:

$$[H^+] = \sqrt{K_a C_a} = \sqrt{1.0 \times 10^{-4} \times 0.1} = \sqrt{1.0 \times 10^{-5}} = 3.16 \times 10^{-3} \text{ M}$$

$$\text{pH} = -\log(3.16 \times 10^{-3}) \approx 2.5$$

Final Answer: 2.5

Answer: (2.5)

Q24.

Solution

Concept: First-order reaction:

$$t_{90\%} = \frac{\ln 10}{k}, \quad t_{1/2} = \frac{\ln 2}{k}$$

Given: $t_{1/2} = 40$ min
Solution:

$$k = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{40} \approx 0.01733 \text{ min}^{-1}$$

$$t_{90\%} = \frac{\ln 10}{k} = \frac{2.303}{0.01733} \approx 133 \text{ min}$$

Final Answer: 133 min

Answer: (133)

Q25.

Solution

Concept: Titration: $n_{\text{acid}} = n_{\text{base}}$
Given: 0.05 mol CH_3COOH, 0.1 M NaOH
Solution:

$$n_{\text{NaOH}} = n_{\text{CH3COOH}} = 0.05 \text{ mol}$$

$$V = \frac{n}{C} = \frac{0.05}{0.1} = 0.5 \text{ L} = 500 \text{ mL}$$

Final Answer: 500 mL

Answer: (500)

Answer Key — Section A

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	C	4	A	5	B
6	C	7	D	8	B	9	C	10	B
11	B	12	C	13	C	14	D	15	A
16	D	17	C	18	C	19	C	20	B

Answer Key — Section B

Q	Ans	Q	Ans
21	0.902	22	1400
23	2.5	24	133
25	500		