

# JEE Main Chemistry Sample Paper-16

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 order of stability for the following carbocations is: [\[JEE Main 2021\]](#)
- (A) III > II > I > IV  
(B) II > III > I > IV  
(C) III > II > IV > I  
(D) IV > I > II > III
- Q2.** Which of the following compounds will show geometrical isomerism? [\[JEE Main 2022\]](#)
- (A) 2-Phenylpropene  
(B) 1,1-Diphenyl-1-butene  
(C) 1-Phenyl-2-butene  
(D) 3-Phenyl-1-butene
- Q3.** The major product of the reaction:  $CH_3CH_2CH=CH_2 + HBr \xrightarrow{\text{Peroxide}}$  ... followed by reaction with  $CH_3ONa$  is: [\[JEE Main 2023\]](#)
- (A) 1-methoxybutane  
(B) 2-methoxybutane



(C) 2-bromobutane

(D) 1-butene

**Q4.** In the presence of sunlight, benzene reacts with  $Cl_2$  to give 'X'. The number of hydrogens in 'X' is: [JEE Main 2020]

(A) 0

(B) 3

(C) 6

(D) 12

**Q5.** The reaction of  $HI$  with  $CH_3 - O - CH(CH_3)_2$  yields: [JEE Main 2024]

(A)  $CH_3I + (CH_3)_2CHOH$

(B)  $CH_3OH + (CH_3)_2CHI$

(C)  $CH_3I + (CH_3)_2CHI$

(D)  $CH_3OH + (CH_3)_2CHOH$

**Q6.** Which of the following will not give a yellow precipitate with  $I_2/NaOH$ ? [JEE Main 2021]

(A) Acetophenone

(B) Pentan-2-one

(C) Pentan-3-one

(D) Ethanol

**Q7.** The major product 'P' in the sequence:  $Benzene + Succinic\ anhydride \xrightarrow{AlCl_3} \dots \xrightarrow{Zn-Hg/HCl} P$  is: [JEE Main 2022]

(A) 4-phenylbutanoic acid

(B) 3-phenylpropanoic acid

(C) Benzophenone

(D) Anthracene

**Q8.** Which of the following is a non-reducing sugar? [JEE Main 2021]

(A) Lactose



- (B) Glucose
- (C) Maltose
- (D) Sucrose

**Q9.** Aniline is treated with  $NaNO_2/HCl$  at  $0^\circ C$ , followed by  $CuCN$ . The product is: [JEE Main 2019]

- (A) Benzene
- (B) Benzonitrile
- (C) Chlorobenzene
- (D) Benzylamine

**Q10.** The shape of  $IF_7$  is: [JEE Main 2021]

- (A) Pentagonal bipyramidal
- (B) Octahedral
- (C) Square pyramidal
- (D) Trigonal bipyramidal

**Q11.** Which of the following has the shortest  $C - O$  bond length? [JEE Main 2023]

- (A)  $[Fe(CO)_4]^{2-}$
- (B)  $[Mn(CO)_6]^+$
- (C)  $[Cr(CO)_6]$
- (D)  $CO$

**Q12.** The number of  $P - O - P$  bonds in cyclic trimetaphosphoric acid is: [JEE Main 2022]

- (A) 2
- (B) 3
- (C) 4
- (D) 6

**Q13.** The spin-only magnetic moment of  $[CoF_6]^{3-}$  is (in B.M.): [JEE Main 2020]

- (A) 1.73



- (B) 2.84
- (C) 3.87
- (D) 4.90

**Q14.** Which complex shows optical isomerism?

[JEE Main 2024]

- (A) *cis* –  $[Pt(NH_3)_2Cl_2]$
- (B) *trans* –  $[Co(en)_2Cl_2]^+$
- (C) *cis* –  $[Co(en)_2Cl_2]^+$
- (D)  $[Co(NH_3)_4Cl_2]^+$

**Q15.** Which of the following lanthanoid ions is diamagnetic? (*At. No* : *Ce* = 58, *Sm* = 62, *Eu* = 63, *Yb* = 70)

[JEE Main 2022]

- (A)  $Ce^{2+}$
- (B)  $Sm^{2+}$
- (C)  $Eu^{2+}$
- (D)  $Yb^{2+}$

**Q16.** The correct order of ionic radii is:

[JEE Main 2021]

- (A)  $N^{3-} > O^{2-} > F^- > Na^+ > Mg^{2+}$
- (B)  $Mg^{2+} > Na^+ > F^- > O^{2-} > N^{3-}$
- (C)  $O^{2-} > F^- > N^{3-} > Mg^{2+} > Na^+$
- (D)  $F^- > Na^+ > Mg^{2+} > O^{2-} > N^{3-}$

**Q17.** Which noble gas has the highest boiling point?

[JEE Main 2020]

- (A) He
- (B) Ne
- (C) Ar
- (D) Xe

**Q18.** For a reaction  $A \rightarrow B$ , the rate doubles when the concentration of A is increased 4 times. The order of reaction is:

[JEE Main 2019]

- (A) 1



- (B) 2
- (C) 0.5
- (D) 0

**Q19.** A solution of  $CaCl_2$  has a Van't Hoff factor of 2.8. The degree of dissociation is: [JEE Main 2023]

- (A) 0.7
- (B) 0.8
- (C) 0.9
- (D) 1.0

**Q20.** The ratio of the shortest wavelength of Lyman series to the shortest wavelength of Balmer series for Hydrogen atom is: [JEE Main 2021]

- (A) 1:4
- (B) 4:1
- (C) 1:9
- (D) 9:1



## Section B — Numerical Questions

- Q21.** The work done during isothermal expansion of 2 moles of an ideal gas from 10 L to 100 L at 300 K is  $-x \text{ kJ}$ . Find  $x$ . (Take  $R = 8.314 \text{ J/K}\cdot\text{mol}$ ,  $\ln 10 = 2.303$ ).  
[JEE Main 2022]
- 
- Q22.** For the reaction  $A + B \rightleftharpoons 2C$ , the equilibrium constant  $K_c$  is 100. If initially 1 mole each of A and B are taken in a 10 L flask, the concentration of C at equilibrium is  $x \times 10^{-2} \text{ M}$ . Find  $x$ .  
[JEE Main 2023]
- 
- Q23.** The vapor pressure of pure water at 298 K is 23.8 mm Hg. 50 g of urea ( $\text{NH}_2\text{CONH}_2$ ) is dissolved in 850 g of water. The lowering of vapor pressure is  $x \times 10^{-2} \text{ mm Hg}$ . Find  $x$ .  
[JEE Main 2024]
- 
- Q24.** 10 mL of 2 M NaOH is added to 200 mL of 0.1 M NaOH. The molarity of the resulting solution is \_\_\_\_ M. (Round off to two decimal places).  
[JEE Main 2021]
- 
- Q25.** If the rate constant for a first-order reaction is  $k = 6.93 \times 10^{-3} \text{ s}^{-1}$ , the time required for 90% completion is \_\_\_\_ seconds. (Take  $\log 10 = 1$ ).  
[JEE Main 2025 Trend]
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## Detailed Solutions

Q1.

## Solution

**Concept:** The stability of carbocations is influenced by factors like resonance, hyperconjugation, and inductive effects. The more stable carbocations are those with structures where the central carbon has a complete octet and where the positive charge is stabilized by resonance or inductive effects.

**Solution:** Let's analyze the stability of the given carbocations: - (I)  $C_6H_5CH_2^+$  (benzyl carbocation): This carbocation is stabilized by resonance because the positive charge can be delocalized onto the aromatic ring. - (II)  $C_6H_5CH^+CH_3$  (phenylmethyl cation): This carbocation is also stabilized by resonance, but not as much as the benzyl carbocation since the positive charge is not fully delocalized. - (III)  $C_6H_5C^+(CH_3)_2$  (phenyl tertiary carbocation): This carbocation has no resonance stabilization and the positive charge is destabilized by the electron-donating groups. - (IV)  $C_6H_5CH_2CH_2^+$  (phenyl ethyl cation): This carbocation is not stabilized by resonance, and it is less stable than the others.

**Conclusion:** The correct order of stability is (II) > (III) > (I) > (IV).

Final Answer: (B)

**Answer: (B)**

Q2.

## Solution

**Concept:** Geometrical isomerism occurs when a molecule has a rigid structure and the substituents around a double bond or ring can be arranged differently.

**Solution:** - (A) 2-Phenylpropene: This compound has a double bond and can exhibit cis-trans isomerism. - (B) 1,1-Diphenyl-1-butene: This compound cannot exhibit geometrical isomerism as the double bond is at the terminal position with two identical substituents on one side. - (C) 1-Phenyl-2-butene: This compound has a double bond between the second and third carbon atoms and can exhibit cis-trans isomerism. - (D) 3-Phenyl-1-butene: This compound has a double bond between the first and second carbon atoms and can exhibit cis-trans isomerism.

**Conclusion:** The compound that shows geometrical isomerism is 2-Phenylpropene.

Final Answer: (A)

**Answer: (A)**



Q3.

**Solution**

**Concept:** Peroxide-induced addition of HBr to an alkene follows the anti-Markovnikov rule, where the bromine adds to the carbon with the least number of hydrogen atoms.

**Solution:** - The product will be a bromoalkane. Upon treatment with  $CH_3ONa$ , the bromoalkane undergoes nucleophilic substitution to form a methoxyalkane. - The final product will be 2-methoxybutane.

**Conclusion:** The major product is 2-methoxybutane.

Final Answer: (B)

**Answer: (B)**

Q4.

**Solution**

**Concept:** Benzene reacts with chlorine in the presence of sunlight via a free radical mechanism, leading to the substitution of a hydrogen atom by a chlorine atom.

**Solution:** - The product 'X' formed in the reaction is chlorobenzene with one hydrogen replaced by a chlorine atom. - The number of hydrogens in chlorobenzene is 5, since one hydrogen has been substituted by a chlorine atom.

**Conclusion:** The number of hydrogens in 'X' is 6.

Final Answer: (C)

**Answer: (C)**

Q5.

**Solution**

**Concept:** The reaction of HI with an ether leads to cleavage of the ether bond, followed by the formation of alcohols and alkyl iodides.

**Solution:** - The reaction of HI with  $CH_3 - O - CH(CH_3)_2$  leads to cleavage of the ether bond, forming methyl iodide ( $CH_3I$ ) and isopropyl alcohol ( $CH_3OH + (CH_3)_2CHOH$ ). - This corresponds to option (D).

**Conclusion:** The product is  $CH_3OH + (CH_3)_2CHOH$ .

Final Answer: (D)

**Answer: (D)**



Q6.

**Solution**

**Concept:** The iodoform test (with iodine and NaOH) is given by compounds that contain a methyl ketone group or a structure that can form such a group upon oxidation.

**Solution:** - Acetophenone and pentan-2-one both contain the methyl ketone group and will react with  $I_2/NaOH$  to give a yellow precipitate. - Pentan-3-one does not contain a methyl group at the alpha position, so it will not give the test. - Ethanol will also not give the iodoform test as it does not have a methyl ketone group.

**Conclusion:** Pentan-3-one and ethanol will not give a yellow precipitate.

Final Answer: (D)

**Answer: (D)**

Q7.

**Solution**

**Concept:** In this reaction, benzene reacts with succinic anhydride in the presence of  $AlCl_3$  to form a phenyl derivative. The subsequent reaction with  $Zn-Hg/HCl$  induces a reduction.

**Solution:** - The product 'P' will be a reduced product, 3-phenylpropanoic acid.

**Conclusion:** The major product is 3-phenylpropanoic acid.

Final Answer: (B)

**Answer: (B)**

Q8.

**Solution**

**Concept:** Non-reducing sugars do not undergo reduction when treated with mild reducing agents like Tollen's reagent or Benedict's solution.

**Solution:** - Sucrose is a non-reducing sugar because it does not have a free aldehyde or ketone group.

**Conclusion:** The non-reducing sugar is sucrose.

Final Answer: (D)

**Answer: (D)**



Q9.

**Solution**

**Concept:** The reaction with  $\text{NaNO}_2/\text{HCl}$  forms diazonium salt, which when treated with  $\text{CuCN}$  undergoes nucleophilic substitution to form benzene nitrile.

**Solution:** - The product of this reaction is benzonitrile.

**Conclusion:** The product is benzonitrile.

Final Answer: (B)

Answer: (B)

Q10.

**Solution**

**Concept:** The shape of  $\text{IF}_7$  is determined by the arrangement of the seven fluorine atoms around iodine.

**Solution:** - The molecular geometry of  $\text{IF}_7$  is pentagonal bipyramidal.

**Conclusion:** The shape of  $\text{IF}_7$  is pentagonal bipyramidal.

Final Answer: (A)

Answer: (A)

Q11.

**Solution**

**Concept:** Bond length is influenced by the nature of the bond and the atoms involved.  $\text{CO}$  has the shortest  $\text{C} - \text{O}$  bond length due to its strong triple bond.

**Solution:** - The shortest  $\text{C} - \text{O}$  bond length is found in the molecule  $\text{CO}$ .

**Conclusion:** The shortest  $\text{C} - \text{O}$  bond length is in  $\text{CO}$ .

Final Answer: (D)

Answer: (D)

Q12.

**Solution**

**Concept:** Cyclic trimetaphosphoric acid contains three phosphorus atoms linked by oxygen atoms in the form of a  $\text{P}-\text{O}-\text{P}$  bond.

**Solution:** - The number of  $\text{P} - \text{O} - \text{P}$  bonds in cyclic trimetaphosphoric acid is 3.

**Conclusion:** The number of  $\text{P} - \text{O} - \text{P}$  bonds is 3.

Final Answer: (B)

Answer: (B)



Q13.

**Solution**

**Concept:** The spin-only magnetic moment can be calculated using the formula:

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

where  $n$  is the number of unpaired electrons.

**Solution:** - For  $[CoF_6]^{3-}$ , the number of unpaired electrons is 2. - Therefore, the magnetic moment is  $\sqrt{2(2+2)} = \sqrt{8} = 2.82 \text{ BM}$ .

**Conclusion:** The spin-only magnetic moment is 2.82 B.M.

Final Answer: (B)

**Answer: (B)**

Q14.

**Solution**

**Concept:** Optical isomerism occurs when a compound has a chiral center and lacks any symmetry that would prevent non-superimposability.

**Solution:** - The complex *cis* -  $[Pt(NH_3)_2Cl_2]$  does not show optical isomerism due to its symmetry. - The complex *cis* -  $[Co(en)_2Cl_2]^+$  shows optical isomerism due to the arrangement of the ligands.

**Conclusion:** The complex that shows optical isomerism is *cis* -  $[Co(en)_2Cl_2]^+$ .

Final Answer: (C)

**Answer: (C)**

Q15.

**Solution**

**Concept:** Lanthanoid ions with even numbers of 4f-electrons are typically diamagnetic.

**Solution:** -  $Yb^{2+}$  has an even number of 4f-electrons, making it diamagnetic.

**Conclusion:** The diamagnetic ion is  $Yb^{2+}$ .

Final Answer: (D)

**Answer: (D)**



Q16.

**Solution**

**Concept:** The ionic radii follow the trend of effective nuclear charge and electron repulsion.

**Solution:** - The correct order of ionic radii is:  $N^{3-} > O^{2-} > F^{-} > Na^{+} > Mg^{2+}$ .

**Conclusion:** The correct order is  $N^{3-} > O^{2-} > F^{-} > Na^{+} > Mg^{2+}$ .

Final Answer: (A)

**Answer: (A)**

Q17.

**Solution**

**Concept:** Noble gases with larger atomic sizes tend to have higher boiling points.

**Solution:** - The boiling point increases as the atomic size increases. - The noble gas with the highest boiling point is *Xe*.

**Conclusion:** The noble gas with the highest boiling point is *Xe*.

Final Answer: (D)

**Answer: (D)**

Q18.

**Solution**

**Concept:** The rate law order is determined by the relationship between the rate and concentration.

**Solution:** - If the rate doubles when the concentration of A is increased 4 times, the order of reaction is 2.

**Conclusion:** The order of the reaction is 2.

Final Answer: (B)

**Answer: (B)**

Q19.

**Solution**

**Concept:** Van't Hoff factor is used to calculate the degree of dissociation.

**Solution:** - The degree of dissociation is calculated as:

$$\alpha = \frac{(i - 1)}{(i_0 - 1)}$$

where  $i = 2.8$ .

**Conclusion:** The degree of dissociation is 0.8.

Final Answer: (B)

**Answer: (B)**



Q20.

**Solution**

**Concept:** The ratio of wavelengths in the Lyman and Balmer series can be calculated using the Rydberg formula.

**Solution:** - The shortest wavelength in the Lyman series has a shorter wavelength than the shortest wavelength in the Balmer series. - The ratio of the shortest wavelengths is 4:1.

**Conclusion:** The ratio is 4:1.

Final Answer: (B)

**Answer: (B)**

Q21.

**Solution**

**Concept:** The work done during an isothermal expansion of an ideal gas is given by the equation:

$$W = nRT \ln \frac{V_f}{V_i}$$

where: -  $n$  is the number of moles, -  $R$  is the gas constant, -  $T$  is the temperature, -  $V_f$  and  $V_i$  are the final and initial volumes, respectively.

**Solution:** - Given:  $n = 2$  moles,  $R = 8.314 \text{ J/mol} \cdot \text{K}$ ,  $T = 300 \text{ K}$ ,  $V_i = 10 \text{ L}$ ,  $V_f = 100 \text{ L}$ . - The work done during the isothermal expansion is:

$$W = 2 \times 8.314 \times 300 \ln \frac{100}{10}$$

- First, calculate  $\ln \frac{100}{10} = \ln 10 = 2.303$ :

$$W = 2 \times 8.314 \times 300 \times 2.303 = 11436.6 \text{ J}$$

- Convert  $W$  to kJ:

$$W = 11.4366 \text{ kJ}$$

**Conclusion:** The work done is  $-11.44 \text{ kJ}$ .

Final Answer: 11.44

**Answer: (11.44)**



Q22.

### Solution

**Concept:** The equilibrium constant  $K_c$  for the reaction  $A + B \rightleftharpoons 2C$  is related to the concentrations of the reactants and products at equilibrium.

**Solution:** - Given:  $K_c = 100$ , initial moles of  $A$  and  $B$  are 1 mole each, and the volume is 10 L. - At equilibrium, the change in concentration for  $A$  and  $B$  will be  $-x$ , and the concentration of  $C$  will be  $+2x$ . - The equilibrium concentrations are:

$$[A] = [B] = \frac{1-x}{10}, \quad [C] = \frac{2x}{10}$$

- The equilibrium constant expression is:

$$K_c = \frac{[C]^2}{[A][B]} = \frac{\left(\frac{2x}{10}\right)^2}{\left(\frac{1-x}{10}\right)^2} = 100$$

- Simplify and solve for  $x$ :

$$\frac{4x^2}{(1-x)^2} = 100$$

$$4x^2 = 100(1 - 2x + x^2)$$

$$4x^2 = 100 - 200x + 100x^2$$

$$96x^2 - 200x + 100 = 0$$

- Solve the quadratic equation using the quadratic formula:

$$x = \frac{-(-200) \pm \sqrt{(-200)^2 - 4 \times 96 \times 100}}{2 \times 96}$$

$$x = \frac{200 \pm \sqrt{40000 - 38400}}{192} = \frac{200 \pm \sqrt{1600}}{192}$$

$$x = \frac{200 \pm 40}{192}$$

$$x = \frac{240}{192} = 1.25 \quad \text{or} \quad x = \frac{160}{192} = 0.8333$$

**Conclusion:** The concentration of  $C$  at equilibrium is  $0.83 \times 10^{-2}$  M.

Final Answer: 0.83

**Answer: (0.83)**



Q23.

## Solution

**Concept:** The lowering of vapor pressure ( $\Delta P$ ) can be calculated using Raoult's Law:

$$\Delta P = P_0 \cdot x_{\text{solute}}$$

where  $P_0$  is the vapor pressure of the pure solvent, and  $x_{\text{solute}}$  is the mole fraction of the solute.

**Solution:** - Given:  $P_0 = 23.8$  mm Hg, mass of urea = 50 g, mass of water = 850 g. - Molar mass of urea = 60 g/mol, molar mass of water = 18 g/mol. - Moles of urea =  $\frac{50}{60} = 0.8333$  mol. - Moles of water =  $\frac{850}{18} = 47.22$  mol. - The mole fraction of the solute is:

$$x_{\text{solute}} = \frac{\text{moles of urea}}{\text{moles of water} + \text{moles of urea}} = \frac{0.8333}{47.22 + 0.8333} = 0.017$$

- The lowering of vapor pressure is:

$$\Delta P = 23.8 \times 0.017 = 0.405 \text{ mm Hg}$$

- In the form  $x \times 10^{-2}$ ,  $x = 4.05$ .

**Conclusion:** The lowering of vapor pressure is  $4.05 \times 10^{-2}$  mm Hg.

Final Answer: 4.05

**Answer:** (4.05)

Q24.

## Solution

**Concept:** The molarity of the resulting solution after mixing two solutions can be calculated using the formula:

$$M_{\text{final}} = \frac{M_1 V_1 + M_2 V_2}{V_1 + V_2}$$

where: -  $M_1, M_2$  are the molarities of the two solutions, -  $V_1, V_2$  are the volumes of the two solutions.

**Solution:** - Given:  $M_1 = 2$  M,  $V_1 = 10$  mL,  $M_2 = 0.1$  M,  $V_2 = 200$  mL. - The final molarity is:

$$M_{\text{final}} = \frac{(2 \times 10) + (0.1 \times 200)}{10 + 200} = \frac{20 + 20}{210} = \frac{40}{210} = 0.190 \text{ M}$$

**Conclusion:** The molarity of the resulting solution is 0.19 M.

Final Answer: 0.19

**Answer:** (0.19)



Q25.

**Solution**

**Concept:** For a first-order reaction, the time required for a certain percentage of completion can be calculated using the equation:

$$t = \frac{1}{k} \ln \frac{1}{1-f}$$

where  $f$  is the fraction of the reaction completed, and  $k$  is the rate constant.

**Solution:** - Given:  $k = 6.93 \times 10^{-3} \text{ s}^{-1}$ , and  $f = 0.9$  for 90- The time required is:

$$t = \frac{1}{6.93 \times 10^{-3}} \ln \frac{1}{1-0.9} = \frac{1}{6.93 \times 10^{-3}} \ln 10$$

- Using  $\ln 10 = 1$ :

$$t = \frac{1}{6.93 \times 10^{-3}} \times 1 = 144.5 \text{ seconds}$$

**Conclusion:** The time required for 90

Final Answer: 144.5

**Answer:** (144.5)



## Answer Key — Section A

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

## Answer Key — Section B

Q	Ans	Q	Ans
21	11.44	22	0.83
23	4.05	24	0.19
25	144.5		

