zigyan

PREVIOUS YEAR PAPER · 2023

OLYMPIAD · STAGE I

# NSEC

## National Standard Examination in Chemistry

# 2023

Question paper, answer key and Zigyan solutions

| 60 | 216 | 120 min | 31 |
|---|---|---|---|
| Questions | Maximum marks | Time | Paper code |

Question paper and official answer key: Indian Association of Physics Teachers (IAPT), NSEC 2023, paper code 31.
Solutions and notes: Zigyan. This booklet is not an IAPT publication.

**Prepare for the Olympiads with Zigyan**

www.zigyan.com

zigyan

SCO No. 107, Sector 16, Faridabad, Haryana 121002
0129-4048800 · +91 92115 38800 · info@zigyan.com

zigyan

JEE 2026 RESULTS

OUR TOPPERS

# When talent meets the right guidance.

Saksham Bishnoi and Sulokya Bibhuty - our JEE 2026 toppers from Zigyan, Sector 16 - with the programme they took and the rank they earned.



**Rahul Kaushik Sir**
Founder & Director, Zigyan Eduvision
23 years of teaching



## Saksham Bishnoi

4 YEARS CLASSROOM

| JEE ADVANCED 2026 | JEE MAIN 2026 |
|---|---|
| AIR 168 | AIR 811 |
| | 99.95 percentile |



## Sulokya Bibhuty

3 YEARS CLASSROOM

| JEE ADVANCED 2026 | JEE MAIN 2026 |
|---|---|
| AIR 1,315 | AIR 1,095 |
| | 99.94 percentile |

## OLYMPIAD RESULTS

Above the Minimum Admissible Score - the national band for the subject

**CHEMISTRY**

- Sulokya Bibhuty — 3 Years Classroom
- Anay Gupta — 3 Years Classroom
- Akshat Khator — 3 Years Classroom
- Harshit Goyal — 4 Years Classroom
- Hardik Sharma — 3 Years Classroom
- Aarush Kumar — 1 Year Classroom

**PHYSICS**

- Sulokya Bibhuty — 3 Years Classroom
- Saksham Bishnoi — 4 Years Classroom

**ASTRONOMY**

- Sulokya Bibhuty — 3 Years Classroom

**MATHEMATICS (IOQM)**

- Priyanshi — 4 Years Classroom

**Saksham Bishnoi** qualified the Chemistry Olympiad twice and was selected for the Orientation-cum-Selection Camp at HBCSE, Mumbai.

| 16 selections | 16 of 35 | AIR 168 |
|---|---|---|
| in JEE Advanced 2026 | students of the batch selected | best JEE Advanced rank |

**Start where they started.**

Register for ZEST - ₹200 · www.zigyan.com/scholarship/zest

+91 92115 38800
info@zigyan.com

**Given in the question paper**

## Useful constants

Charge of electron, $e = 1.602 \times 10^{-19}\,C$

Mass of electron, $m_e = 9.1 \times 10^{-31}\,kg$

Planck's constant, $h = 6.63 \times 10^{-34}\,J\,s$

Speed of light, $c = 3.0 \times 10^{8}\,ms^{-1}$

Avogadro constant, $N_A = 6.022 \times 10^{23}\,mol^{-1}$

Faraday constant $F = 96500\,C\,mol^{-1}$

Molar gas constant, $R = 0.082\,L\,atm\,mol^{-1}K^{-1}$

$= 8.314\,J\,mol^{-1}\,K^{-1}$

## PART A-1 · ONE CORRECT OPTION

**Q. 1 – 48 · +3 for a correct answer, –1 for a wrong one**

**1.** The ligand with which the homoleptic octahedral complex of $Co^{3+}$ will be most stable is:

(A) Ethylenediamine tetra acetate ion

(B) Dien (N-(2-aminoethyl)-1,2-ethanediamine)

(C) Ethane-1,2-diamine

(D) Ammonia

**Solution · Q1** **Answer: (A)**

More chelate rings give a more stable complex (chelate effect).

$EDTA^{4-}$ is hexadentate. One ion alone completes the octahedron of $Co^{3+}$ and forms five chelate rings.

Chelate rings in the other complexes:

$[Co(dien)_2]^{3+}$ : 4

$[Co(en)_3]^{3+}$ : 3

$[Co(NH_3)_6]^{3+}$ : none

$\therefore$ the EDTA complex is the most stable.

**IAPT answer:** (A) | **Zigyan answer:** (A)

**2.** Which of the following properties may have positive values of ΔH?

(i) Lattice enthalpy

(ii) Hydration enthalpy

(iii) Electron gain enthalpy for noble gases

(iv) Ionisation enthalpy

(A) (i) and (ii)

(B) (iii) and (iv)

(C) Only (iv)

(D) (ii), (iii) and (iv)

**Solution · Q2** **As per Zigyan: (B)**

(i) Lattice enthalpy, taken for formation of the solid from its gaseous ions: negative.

(ii) Hydration of gaseous ions releases heat: negative.

(iii) In a noble gas the added electron must enter the next higher shell: positive.

(iv) Energy is always needed to remove an electron: positive.

∴ (iii) and (iv)

**Reference:** NCERT Chemistry Class XI (Part I), Unit 3 'Classification of Elements and Periodicity in Properties', section 3.7.1: ionization enthalpies are always positive, and noble gases have large positive electron gain enthalpies.

**IAPT answer:** (B) | **Zigyan answer:** (B)

**3.** The correct IUPAC name of potassium permanganate is:

(A) potassium tetraoxomanganate(VI)
(B) potassium tetraoxidopermanganate(VII)
(C) potassium tetraoxidomanganese(VII)
(D) potassium tetraoxidomanganate(VII)

**Solution · Q3** **Answer: (D)**

In $KMnO_4$ the anion is $[MnO_4]^-$.

Oxidation state of Mn:

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

$$\Rightarrow x = +7$$

The ligand $O^{2-}$ is named oxido, and the metal in a complex anion takes the ending "ate".

∴ potassium tetraoxidomanganate(VII)

**IAPT answer:** (D) | **Zigyan answer:** (D)

**4.** Which of the following statements is true with respect to sodium salts of oxoanions of phosphorus $NaH_2PO_2$ and $Na_2HPO_3$

(A) $NaH_2PO_2$ is reducing and $Na_2HPO_3$ is oxidizing
(B) $NaH_2PO_2$ is more reducing than $Na_2HPO_3$
(C) $NaH_2PO_2$ is more oxidizing than $Na_2HPO_3$
(D) $NaH_2PO_2$ is oxidizing and $Na_2HPO_3$ is reducing

**Solution · Q4** **Answer: (B)**

In these oxoanions the reducing property is due to P–H bonds.

$H_2PO_2^-$ : two P–H bonds, P in +1 state

$HPO_3^{2-}$ : one P–H bond, P in +3 state

∴ $NaH_2PO_2$ is more reducing than $Na_2HPO_3$.

**IAPT answer:** (B) | **Zigyan answer:** (B)

**5.** The fluoride/s of xenon, $XeF_n$ (n = 2 or 4 or 6), which on complete hydrolysis gives back xenon as one of the products, is/are_____.

I. $XeF_2$

II. $XeF_4$

III. $XeF_6$

(A) II only (B) I and II (C) III only (D) I, II and III

**Solution · Q5** **Answer: (B)**

$XeF_2$ and $XeF_4$ give xenon:

$2XeF_2 + 2H_2O \rightarrow 2Xe + 4HF + O_2$

$6XeF_4 + 12H_2O \rightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$

$XeF_6$ gives no xenon:

$XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$

∴ I and II

**IAPT answer:** (B) | **Zigyan answer:** (B)

**6.** If an element after oganesson (Og, atomic number 118 and electronic configuration [Rn] $5f^{14}\ 6d^{10}\ 7s^2\ 7p^6$) was discovered, in which of the following orbital, will the $119^{th}$ electron be accommodated?

(A) 7d (B) 6f (C) 8s (D) 5g

**Solution · Q6** **Answer: (C)**

The 7p subshell is full at Og, so the next electron starts period 8.

By the (n + ℓ) rule, 8s has the value 8, while 5g, 6f and 7d each have 9.

∴ the 119th electron enters 8s.

**IAPT answer:** (C) | **Zigyan answer:** (C)

**7.** The number of 'two-center-two electron' and 'three-center-two electron' bonds in $[Al(BH_4)_3]$ are respectively

(A) twelve and zero (B) twelve and three (C) six and six (D) nine and three

**Solution · Q7** **Answer: (C)**

In $Aℓ(BH_4)_3$ each $BH_4$ unit is joined to Aℓ through two bridging H atoms.

So each unit has two terminal B–H bonds and two Aℓ–H–B bridges.

Two-center-two electron bonds (B–H):

$$3 \times 2 = 6$$

Three-center-two electron bonds (Aℓ–H–B):

$$3 \times 2 = 6$$

Count of valence electrons:

$$3 + 9 + 12 = 24 = 12 \times 2$$

**IAPT answer:** (C) | **Zigyan answer:** (C)

**8.** Identify the correct matching of the following oxides in column **M** with their property in column **N**:

| M | N |
|---|---|
| (i) Aluminium trioxide | (p) Acidic oxide |
| (ii) Calcium oxide | (q) Basic oxide |
| (iii) Arsenic pentoxide | (r) Amphoteric oxide |

(A) (i)-(p), (ii)-(q), (iii)-(r)
(B) (i)-(q), (ii)-(r), (iii)-(p)
(C) (i)-(r), (ii)-(q), (iii)-(p)
(D) (i)-(r), (ii)-(p), (iii)-(q)

**Solution · Q8** **Answer: (C)**

(i) $A\ell_2O_3$ reacts with acids as well as alkalis: amphoteric (r).

(ii) CaO is a metal oxide that gives $Ca(OH)_2$ with water: basic (q).

(iii) $As_2O_5$ gives arsenic acid with water: acidic (p).

$As_2O_5 + 3H_2O \rightarrow 2H_3AsO_4$

$\therefore$ (i)-(r), (ii)-(q), (iii)-(p)

**IAPT answer:** (C) | **Zigyan answer:** (C)

**9.** In each of the following reactions, role of water is:

(i) $H_2O + HCl \rightarrow H_3O^+ + Cl^-$

(ii) $6H_2O + Mg^{2+} \rightarrow [Mg(H_2O)_6]^{2+}$

(iii) $2H_2O + 2F_2 \rightarrow 4\ HF + O_2$

(A) (i) oxidant; (ii) reductant; (iii) base
(B) (i) reductant; (ii) oxidant; (iii) base
(C) (i) base; (ii) base; (iii) reductant
(D) (i) acid; (ii) base; (iii) reductant

**Solution · Q9** **Answer: (C)**

(i) $H_2O$ accepts $H^+$ from $HC\ell$: base.

(ii) $H_2O$ donates a lone pair to $Mg^{2+}$: Lewis base.

(iii) Oxygen of $H_2O$ is oxidised from −2 to 0 in $O_2$: reductant.

**IAPT answer:** (C) | **Zigyan answer:** (C)

**10.** The correct order of the following oxidizing agents in basic aqueous medium is:

$CrO_4^{2-}/ Cr^{3+}$ $E^0 = -0.11$ V

$FeO_4^{2-}/ Fe^{3+}$ $E^0 = +0.72$ V

$MnO_4^{2-}/ Mn^{3+}$ $E^0 = +0.46$ V

(A) $[CrO_4]^{2-} > [FeO_4]^{2-} > [MnO_4]^{2-}$

(B) $[FeO_4]^{2-} > [MnO_4]^{2-} > [CrO_4]^{2-}$

(C) $[CrO_4]^{2-} > [MnO_4]^{2-} > [FeO_4]^{2-}$

(D) $[MnO_4]^{2-} > [FeO_4]^{2-} > [CrO_4]^{2-}$

**Solution · Q10** **Answer: (B)**

A higher reduction potential means a stronger oxidising agent.

$$+0.72 \text{ V} > +0.46 \text{ V} > -0.11 \text{ V}$$

$$\therefore [FeO_4]^{2-} > [MnO_4]^{2-} > [CrO_4]^{2-}$$

**IAPT answer:** (B) | **Zigyan answer:** (B)

**11.** The correct order of ionic radii of $Rb^+$, $Br^-$, $Sr^{2+}$ and $Se^{2-}$ is

(A) $Rb^+ < Br^- < Sr^{2+} < Se^{2-}$

(B) $Sr^{2+} < Rb^+ < Br^- < Se^{2-}$

(C) $Se^{2-} < Br^- < Sr^{2+} < Rb^+$

(D) $Se^{2-} < Sr^{2+} < Rb^+ < Br^-$

**Solution · Q11** **Answer: (B)**

All four ions have 36 electrons (isoelectronic).

For isoelectronic ions, radius decreases as nuclear charge increases.

Order of nuclear charge:

$$Se\ (34) < Br\ (35) < Rb\ (37) < Sr\ (38)$$

$$\therefore Sr^{2+} < Rb^+ < Br^- < Se^{2-}$$

**IAPT answer:** (B) | **Zigyan answer:** (B)

**12.** Consider the following statements:

(i) Calcination is carried out in absence of air below the melting point of the ore

(ii) Roasting and calcination are carried out in presence of flux

(iii) Calcination is carried out in limited supply of air above the melting point of the ore

(iv) Roasting is carried out in air below the melting point of ore

The correct set of statements is

(A) (i) and (iv)

(B) (ii) and (iii)

(C) (i), (iii) and (iv)

(D) (iii) and (iv)

**Solution · Q12** **Answer: (A)**

(i) True: calcination is heating the ore below its melting point in the absence or limited supply of air.

(ii) False: flux is added in smelting, not in these two steps.

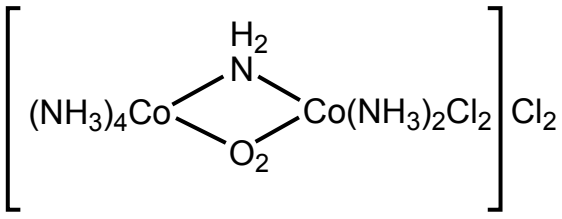
(iii) False: calcination is done below the melting point.

(iv) True: roasting is heating the ore in air below its melting point.

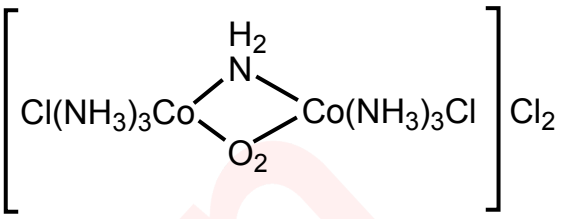
∴ (i) and (iv)

**IAPT answer:** (A) | **Zigyan answer:** (A)

**13.** The cobalt complexes (I) and (II) given below are examples of




(I)




(II)

(A) linkage isomers
(B) coordination isomers
(C) ligand isomers
(D) coordination position isomers

**Solution · Q13** **Answer: (D)**

Both complexes have the same overall formula and the same two bridges:

$[Co_2(NH_3)_6(NH_2)(O_2)C\ell_2]C\ell_2$

Only the placing of the $NH_3$ and $C\ell^-$ ligands on the two Co atoms differs.

(I): 4 $NH_3$ on one Co; 2 $NH_3$ and 2 $C\ell^-$ on the other.

(II): 3 $NH_3$ and 1 $C\ell^-$ on each Co.

∴ they are coordination position isomers.

**IAPT answer:** (D) | **Zigyan answer:** (D)

**14.** The magnetic moment (in units of BM) of copper in $[Cu(H_2O)_4]^{2+}$ and $[Cu(NH_3)_4]^{2+}$ respectively is:

(A) 1.73 and 0 (B) 1.73 and 1.73 (C) 2.83 and 2.83 (D) 0 and 2.83

**Solution · Q14** **Answer: (B)**

In both complexes $Cu^{2+}$ is $3d^9$, with one unpaired electron.

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

$$\Rightarrow \mu = \sqrt{3} = 1.73 \text{ BM}$$

∴ each complex has a moment of 1.73 BM.

**IAPT answer:** (B) | **Zigyan answer:** (B)

**15.** In qualitative inorganic analysis of a water-soluble salt mixture (salt AB + salt XY) both the cations were identified as sulphides. In the tests for anions sodium carbonate extract when treated with $AgNO_3$ gave yellowish precipitate soluble with difficulty in $NH_4OH$ while the other anion can be confirmed with brown ring test. (Given $K_{sp}$ for AS = $1 \times 10^{-44}$ and XS = $1.4 \times 10^{-24}$).

Identify the INCORRECT statement about the analysis.

(A) $H_2S$ can be used under appropriate conditions of pH to separate and identify the cations.

(B) Cation A will be precipitated under acidic condition as the concentration of sulphides ions required is low.

(C) The anions are $NO_3^-$ and $Cl^-$.

(D) Cation X will be precipitated as sulphides under alkaline condition, as the concentration of sulphides ions required is very high.

**Solution · Q15** **Answer: (C)**

A yellowish precipitate with $AgNO_3$, sparingly soluble in $NH_4OH$, is AgBr.

So one anion is $Br^-$; the brown ring test shows $NO_3^-$.

$AgC\ell$ is white and dissolves readily in $NH_4OH$, so $C\ell^-$ is absent.

AS has a very small $K_{sp}$; the low $[S^{2-}]$ in acidic medium precipitates it.

XS has a much larger $K_{sp}$; it needs the higher $[S^{2-}]$ of alkaline medium.

So $H_2S$ can separate the cations by control of pH: (A), (B) and (D) are correct.

$\therefore$ the incorrect statement is (C).

**IAPT answer:** (C) | **Zigyan answer:** (C)

**16.** The correct statement about the solubilities of Group 2 hydroxides is:

(A) The solubilities increase because lattice energy increases as we go down Group 2

(B) The solubilities increase because lattice energy decreases as we go down Group 2

(C) The solubilities decrease because atomic size increases as we go down Group 2

(D) The solubilities decrease because lattice energy decreases as we go down Group 2

**Solution · Q16** **Answer: (B)**

Down Group 2 the cation becomes larger.

So both lattice energy and hydration energy of the hydroxides decrease.

With the small $OH^-$ ion, lattice energy falls faster than hydration energy.

$\therefore$ solubility increases because lattice energy decreases.

**IAPT answer:** (B) | **Zigyan answer:** (B)

**17.** A solution of $CuSO_4.5H_2O$ in methanol has $[Cu^{2+}]$ = 1.00 mg per 1000 g of methanol. The molarity of $Cu^{2+}$ in this solution is $Y \times 10^{-5}$ mol $L^{-1}$.Y is :

(Given- density of methanol = 0.792 g $mL^{-1}$)

(A) 1.57 (B) 5.04 (C) 1.25 (D) 3.99

**Solution · Q17** **Answer: (C)**

Moles of $Cu^{2+}$ in 1000 g of methanol:

$$n = \frac{1.00 \times 10^{-3}}{63.5} = 1.575 \times 10^{-5} \text{ mol}$$

The solution is very dilute, so its volume is taken as that of the methanol.

$$V = \frac{1000}{0.792} \text{ mL}$$

$$\Rightarrow V = 1.263 \text{ L}$$

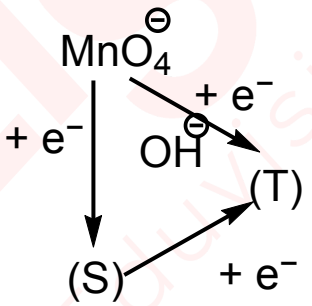
Molarity:

$$M = \frac{1.575 \times 10^{-5}}{1.263} = 1.25 \times 10^{-5} \text{ mol } L^{-1}$$

$$\therefore Y = 1.25$$

**IAPT answer:** (C) | **Zigyan answer:** (C)

**18.** Following is the reaction flow chart for manganese oxidocomplexes under different alkaline pH conditions. Compounds (**S**) and (**T**) respectively are:




(A) S = $MnO(OH)_2$; T = $Mn(OH)_2$ (B) S = $MnO_2$; T = MnO(OH)

(C) S = $MnO_4^{2-}$; T = MnO(OH) (D) S = $MnO_4^{2-}$; T = $MnO_2$

**Solution · Q18** **Answer: (D)**

Each arrow is a reduction.

In strongly alkaline medium, one electron gives green manganate:

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

In weakly alkaline medium, permanganate is reduced to $MnO_2$:

$MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$

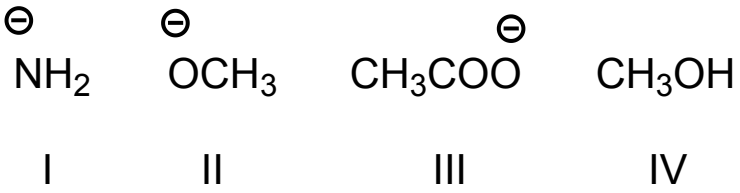
Further reduction of manganate also gives $MnO_2$:

$MnO_4^{2-} + 2H_2O + 2e^- \rightarrow MnO_2 + 4OH^-$

$$\therefore S = MnO_4^{2-} \text{ and } T = MnO_2$$

**IAPT answer:** (D) | **Zigyan answer:** (D)

**19.** The correct order of relative strength for the following nucleophilic species is:




(A) IV > III > II > I
(B) II > III > IV > I
(C) I > II > IV > III
(D) I > II > III > IV

**Solution · Q19** **Answer: (D)**

For these species, nucleophilic strength follows basic strength.

Acid strength of their conjugate acids:

$$NH_3 < CH_3OH < CH_3COOH < CH_3OH_2^+$$

Basic strength follows the reverse order.

Resonance spreads the charge in $CH_3COO^-$, and neutral $CH_3OH$ is the weakest.

$$\therefore I > II > III > IV$$

**IAPT answer:** (D) | **Zigyan answer:** (D)

**20.** The product obtained on reaction of optically pure 1-bromo-1-phenyl ethane with $CH_3OH$, is:

(A) phenyl ethene.
(B) 1-methoxy-1-phenyl ethane with inverted configuration only.
(C) 1-methoxy-1-phenyl ethane with retention of configuration.
(D) a racemic mixture of 1-methoxy-1-phenyl ethane.

**Solution · Q20** **Answer: (D)**

Methanolysis of this benzylic bromide follows the $S_N1$ path.

$C_6H_5CHBrCH_3 \rightarrow C_6H_5C^+HCH_3 + Br^-$

The resonance-stabilised carbocation is planar, so $CH_3OH$ attacks from both faces.

$C_6H_5C^+HCH_3 + CH_3OH \rightarrow C_6H_5CH(OCH_3)CH_3 + H^+$

$\therefore$ a racemic mixture of 1-methoxy-1-phenyl ethane is formed.

**IAPT answer:** (D) | **Zigyan answer:** (D)

**21.** An alkane [X] contains five 1°, two 2°, one 3° and one 4° carbon atoms. The IUPAC name of [X] is:

(A) 2,4,4-trimethylhexane
(B) 3,5-dimethylheptane
(C) 2,4-dimethylheptane
(D) 4,4-dimethylheptane

**Solution · Q21** **Answer: (A)**

Total number of carbon atoms:

$$5 + 2 + 1 + 1 = 9$$

Structure of 2,4,4-trimethylhexane:

$(CH_3)_2CH–CH_2–C(CH_3)_2–CH_2–CH_3$

1° : five $CH_3$ carbons

2° : two $CH_2$ carbons

3° : one CH carbon

4° : one carbon with no H

∴ [X] is 2,4,4-trimethylhexane.

**IAPT answer:** (A) | **Zigyan answer:** (A)

**22.** The number of isomeric alkenes with molecular formula $C_5H_{10}$ is (taking stereoisomers into account):

(A) 4 (B) 5 (C) 6 (D) 7

**Solution · Q22** **Answer: (C)**

The alkenes $C_5H_{10}$ are:

pent-1-ene : 1

pent-2-ene (cis and trans) : 2

2-methylbut-1-ene : 1

3-methylbut-1-ene : 1

2-methylbut-2-ene : 1

∴ there are 6 isomeric alkenes.

**IAPT answer:** (C) | **Zigyan answer:** (C)

**23.** At 0° C, 1 equivalent bromine is added to 2,4-hexadiene to produce 4,5-dibromo-2-hexene and its isomer 'X'. 'X' is:

(A) 5,5-dibromo-2-hexene (B) 2,5-dibromo-3-hexene

(C) 2,2-dibromo-3-hexene (D) 2,3-dibromo-4-hexene

**Solution · Q23** **Answer: (B)**

$Br^+$ adds to an end carbon of the conjugated system, giving an allylic carbocation:

$$CH_3–CHBr–C^+H–CH=CH–CH_3 \leftrightarrow CH_3–CHBr–CH=CH–C^+H–CH_3$$

$Br^-$ can attack either positive carbon.

1,2-addition product:

$$CH_3–CHBr–CHBr–CH=CH–CH_3$$

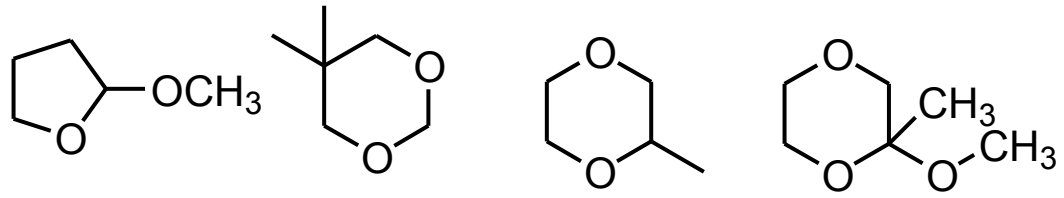
1,4-addition product:

$$CH_3–CHBr–CH=CH–CHBr–CH_3$$

∴ X is 2,5-dibromo-3-hexene.

**IAPT answer:** (B) | **Zigyan answer:** (B)

**24.** Which of the following is/are example/s of an acetal?



I II III IV

(A) I and II (B) III and IV (C) Only IV (D) I, II and III

**Solution · Q24** **Answer: (A)**

An acetal has two –OR groups on one carbon, which also carries the H of the parent aldehyde.

I: C-2 holds the ring O, $OCH_3$ and H, so it is an acetal.

II: the $CH_2$ between the two O atoms makes it an acetal of HCHO.

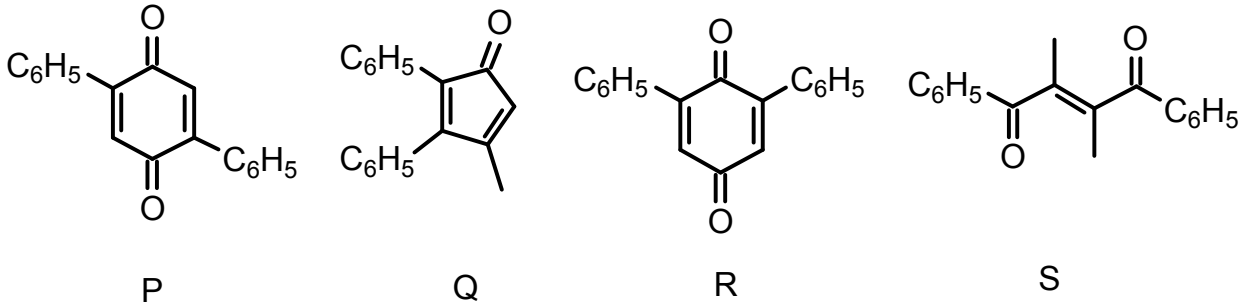
III: no carbon holds two O atoms; it is a cyclic diether.

IV: the carbon with two O atoms has no H; it is a ketal, from a ketone.

∴ I and II are the acetals.

**IAPT answer:** (A) | **Zigyan answer:** (A)

**25.** The compound which can be produced by double aldol condensation of 1-phenyl-1,2-propanedione:



P Q R S

(A) P (B) Q (C) R (D) S

**Solution · Q25** **Answer: (A)**

In each molecule only $CH_3$ has α-hydrogen.

The $CH_3$ carbon of each molecule adds to the C=O next to $C_6H_5$ of the other, closing a six-membered ring. Two molecules of water are then lost.

$2C_6H_5COCOCH_3 \rightarrow C_{18}H_{12}O_2 + 2H_2O$

In the quinone formed, the two C=O groups are para, and the two $C_6H_5$ groups are also para.

∴ The product is 2,5-diphenyl-1,4-benzoquinone, P.

**IAPT answer:** (A) | **Zigyan answer:** (A)

**26.** 2,2-Dimethyl-1,3-propanediol is formed by heating 2-methylpropanal with an excess of formaldehyde and $Ca(OH)_2$. The sequence of reactions taking place in this synthesis is:

(A) dehydrogenation to 2-methyl-2-propenal followed by addition of formaldehyde.

(B) dehydrogenation to penta-2,3-diene followed by addition of formaldehyde.

(C) a crossed aldol reaction followed by a crossed Cannizzaro reaction.

(D) a crossed Cannizzaro reaction followed by a crossed aldol reaction.

**Solution · Q26** **Answer: (C)**

Crossed aldol reaction (only 2-methylpropanal has an α-hydrogen):

$(CH_3)_2CHCHO + HCHO \rightarrow HOCH_2C(CH_3)_2CHO$

The product has no α-hydrogen. With excess HCHO it undergoes crossed Cannizzaro reaction, in which HCHO is oxidised.

$HOCH_2C(CH_3)_2CHO + HCHO + OH^- \rightarrow HOCH_2C(CH_3)_2CH_2OH + HCOO^-$

**IAPT answer:** (C) | **Zigyan answer:** (C)

**27.** Number of different types of dipeptides produced using a mixture of glycine and L-valine, and number of optically active dipeptides formed in this mixture will be:

(A) Four dipeptides, all optically active

(B) Two dipeptides, all optically active

(C) Four dipeptides, three optically active

(D) Two dipeptides, none optically active

**Solution · Q27** **Answer: (C)**

The possible dipeptides are:

Gly–Gly, Gly–Val, Val–Gly, Val–Val

Glycine has no chiral carbon, so Gly–Gly is optically inactive.

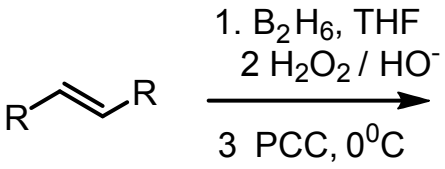
The other three contain L-valine and are optically active.

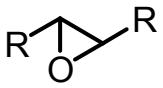
∴ Four dipeptides, three optically active.

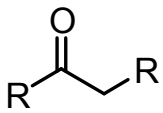
**IAPT answer:** (C) | **Zigyan answer:** (C)

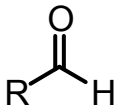
**28.** Predict the major product in the following reaction.

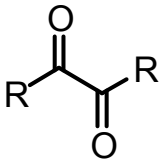
PCC is pyridinium chlorochromate




(A) 


(B) 


(C) 


(D) 


**Solution · Q28** **Answer: (B)**

Hydroboration–oxidation adds H and OH across the double bond.

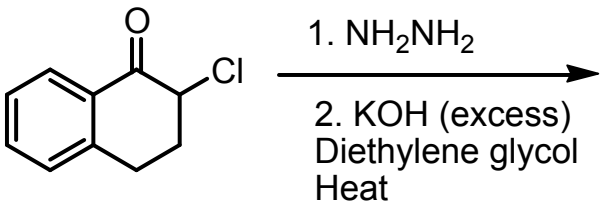
$$R{-}CH{=}CH{-}R \rightarrow R{-}CH_2{-}CH(OH){-}R$$

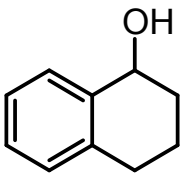
PCC oxidises this secondary alcohol to a ketone.

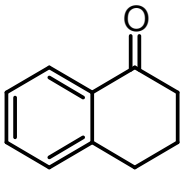
$R{-}CH_2{-}CH(OH){-}R \rightarrow R{-}CH_2{-}CO{-}R$

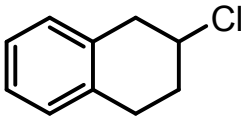
**IAPT answer:** (B) | **Zigyan answer:** (B)

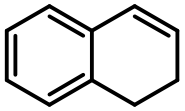
**29.** Find out the product in the following reaction.




(A) 


(B) 


(C) 


(D) 

**Solution · Q29** **Answer: (D)**

Hydrazine converts C=O into a hydrazone. As the α-carbon carries Cℓ, base removes HCℓ instead of giving the usual $CH_2$ (Kishner elimination).

$$C(=N{-}NH_2){-}CHC\ell \rightarrow C(-N{=}NH){=}CH + HC\ell$$

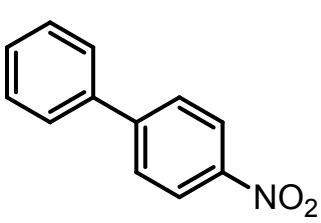
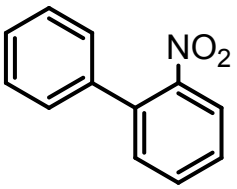
The diazene then loses $N_2$, and the vinylic anion takes a proton.

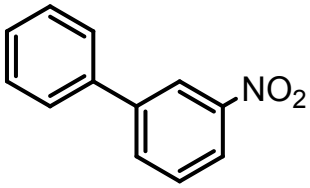
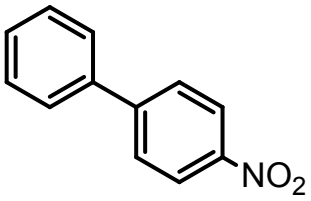
$$C(-N{=}NH){=}CH \rightarrow CH{=}CH + N_2$$

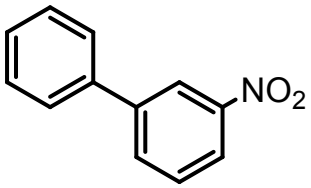
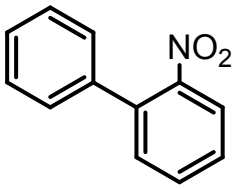
∴ The product is 1,2-dihydronaphthalene.

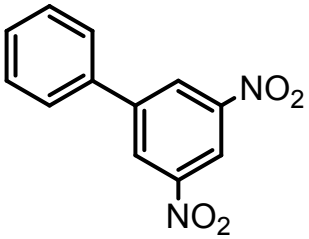
**IAPT answer:** (D) | **Zigyan answer:** (D)

**30.** The product/s obtained on reaction of biphenyl (Ph-Ph) with nitrating mixture ($HNO_3 + H_2SO_4$) is/are:

(A)  and 

(B)  and 

(C)  and 

(D) 

**Solution · Q30** **Answer: (A)**

In biphenyl each phenyl group activates the other ring and is ortho, para directing.

So $NO_2^+$ enters the para and ortho positions.

Biphenyl → 4-nitrobiphenyl + 2-nitrobiphenyl

**IAPT answer:** (A) | **Zigyan answer:** (A)

**31.** Chlorination of propane gives four dichloro products. One of them is optically active. The number of trichloro products possible from the optically active dichloro product is (excluding stereoisomers):

(A) 1 (B) 2 (C) 3 (D) 4

**Solution · Q31** **Answer: (C)**

The optically active dichloro product is 1,2-dichloropropane.

$CH_3–CHCl–CH_2Cl$

Replacing one H on each of the three carbons by Cl gives:

$CH_3–CHCl–CHCl_2$

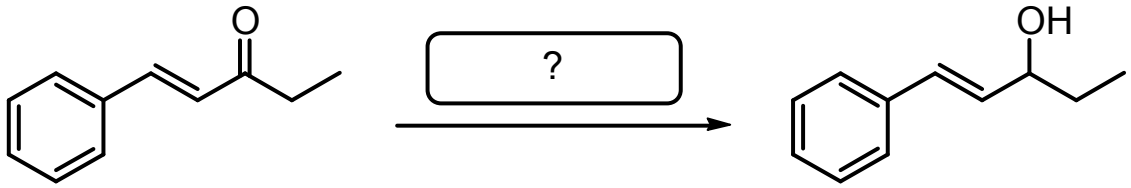
$CH_3–CCl_2–CH_2Cl$

$CH_2Cl–CHCl–CH_2Cl$

∴ Three trichloro products are possible.

**IAPT answer:** (C) | **Zigyan answer:** (C)

**32.** The suitable reagent for the following transformation is:




(A) Na / liq. $NH_3$ (B) $H_2$, Pd/C (C) $LiAlH_4$ (D) Zn-Hg, HCl, heat

**Solution · Q32** **Answer: (C)**

Only C=O is to be reduced and C=C must remain. $LiA\ell H_4$, used under mild conditions, transfers hydride to the carbonyl carbon (1,2-addition).

$$C_6H_5CH{=}CHCOC_2H_5 \rightarrow C_6H_5CH{=}CHCH(OH)C_2H_5$$

$H_2$, Pd/C and Na / liq. $NH_3$ reduce the conjugated C=C. Zn–Hg, $HC\ell$ converts C=O into $CH_2$.

**IAPT answer:** (C) | **Zigyan answer:** (C)

**33.** Column **A** represents a set of functional groups and Column **B** their respective electronic effects.
[EDG: Electron donating group and EWG: Electron withdrawing group]
The correct match is:
Column **A** Column **B**

(A) $-NH_2$, -COCl, $-SO_3H$, -COOH ; *m*-directing, EWG, activating, *o/p*-directing

(B) -X, $-NHCOCH_3$, -CHO, $-CH_3$ ; *o/p* directing, EDG, *m*-directing, activating

(C) -COCl, $-COCH_3$, $-NH_2$, -CN ; EDG, EWG, deactivating, *m*-directing

(D) $-SO_3H$, $-NH_2$, $-OCH_3$, $-CONH_2$ ; activating, deactivating, EWG, EWG

**Solution · Q33** **Answer: (B)**

–X is o/p directing.

$-NHCOCH_3$ is electron donating through the lone pair on N.

–CHO is m-directing.

$-CH_3$ is activating.

All four match in order only in (B). In (A) $-NH_2$ is not m-directing, in (C) $-COC\ell$ is not electron donating, and in (D) $-SO_3H$ is not activating.

**IAPT answer:** (B) | **Zigyan answer:** (B)

**34.** The correct order of reactivity of -CHO, -COR, -COOR, $-CONR_2$ groups toward MeMgI in ether is:

(A) $-CONR_2$ > -COOR > -COR > -CHO (B) -CHO > -COR > -COOR > $-CONR_2$

(C) $-CONR_2$ > -CHO > -COR > -COOR (D) -CHO > $-CONR_2$ > -COOR > -COR

**Solution · Q34** **Answer: (B)**

Nucleophilic addition is faster when the carbonyl carbon is more electron deficient and less crowded.

An aldehyde is better than a ketone, which has two electron-releasing, bulkier alkyl groups.

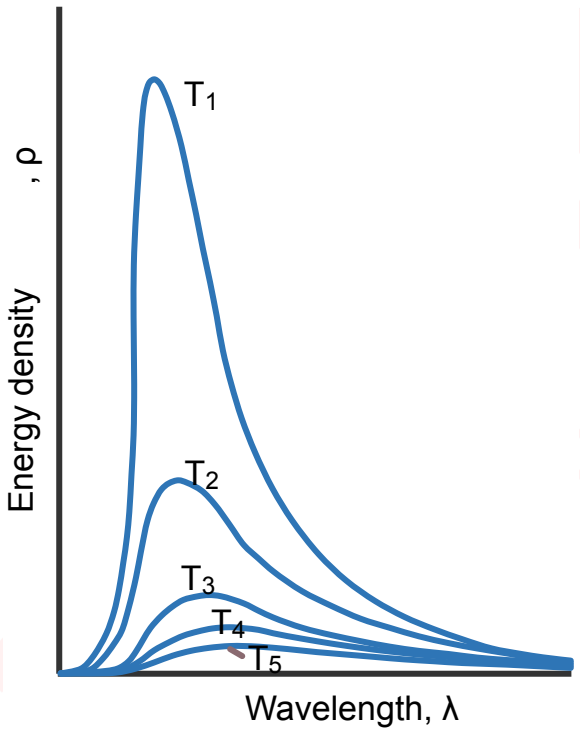
In esters and amides, the lone pair on O or N is donated to C=O. N donates more strongly than O.

$$\therefore -CHO > -COR > -COOR > -CONR_2$$

**IAPT answer:** (B) | **Zigyan answer:** (B)

**35.** The plots of energy density (energy per unit area) vs wavelength for blackbody radiation at various temperatures is given below.

The correct option among the following is:




(i) $T_1 > T_2 > T_3 > T_4 > T_5$

(ii) As temperature increases, the wavelength at which the intensity is maximum shifts towards the higher energy regions of the electromagnetic spectrum.

(iii) Radiations of all wave lengths are emitted, absorbed, reflected, and refracted by the black body.

(iv) The total energy density increases as the temperature is decreased.

(A) (i) and (ii)
(B) (ii) and (iii)
(C) (i), (iii) and (iv)
(D) (ii), (iii) and (iv)

**Solution · Q35** **Answer: (A)**

(i) The curve of a hotter body lies higher at every wavelength: true.

(ii) By Wien's displacement law,

$$\lambda_{max} T = b$$

A higher temperature gives a smaller wavelength at the peak, that is, higher energy: true.

(iii) A black body absorbs and emits all wavelengths but does not reflect or refract them: false.

(iv) The area under the curve, the total energy density, falls when temperature is lowered: false.

**IAPT answer:** (A) | **Zigyan answer:** (A)

**36.** A student adds 'x' g of iron (Fe) powder to dil. HCl and measures the work done by the reaction between HCl and the added Fe to be 1000 J. If the experiment was conducted at a constant pressure of 1 atm at 27°C, mass of Fe powder added is:

(A) 22.4 g (B) 2.24 g (C) 11.2 g (D) 1.12 g

**Solution · Q36** **Answer: (A)**

$Fe(s) + 2HC\ell(aq) \rightarrow FeC\ell_2(aq) + H_2(g)$

The hydrogen formed does expansion work against constant pressure.

$$w = p\Delta V = nRT$$

$$n = \frac{1000}{8.314 \times 300}$$

$$\Rightarrow n = 0.401 \text{ mol}$$

Moles of Fe and of $H_2$ are equal.

$$\Rightarrow x = 0.401 \times 55.85$$

$$\Rightarrow x \approx 22.4 \text{ g}$$

**IAPT answer:** (A) | **Zigyan answer:** (A)

**37.** Antacids are medicines that temporarily neutralize the acid in the stomach and prevent heartburns. The volume of an antacid syrup containing 2.9 g of $Mg(OH)_2$ per 100 mL to be given to a patient whose stomach contains 2 L of gastric juice with HCl concentration of $6.0 \times 10^{-3}$ M is :

(Molar mass of $Mg(OH)_2 = 58.0 \text{ g mol}^{-1}$)

(A) 4.0 mL (B) 7.8 mL (C) 12.0 mL (D) 120 mL

**Solution · Q37** **Answer: (C)**

Neutralisation reaction:

$Mg(OH)_2 + 2HC\ell \rightarrow MgC\ell_2 + 2H_2O$

$$n(HC\ell) = 2 \times 6.0 \times 10^{-3} = 0.012 \text{ mol}$$

$$\Rightarrow n[Mg(OH)_2] = 0.006 \text{ mol}$$

$$\Rightarrow m = 0.006 \times 58.0 = 0.348 \text{ g}$$

Volume of syrup containing this mass:

$$\therefore V = \frac{0.348 \times 100}{2.9} = 12.0 \text{ mL}$$

**IAPT answer:** (C) | **Zigyan answer:** (C)

**38.** A half-cell reaction represented by (i) as given below

$Fe(OH)_2(s) + 2e^- \rightarrow Fe(s) + 2OH^-(aq)\ E^\ominus = -0.9\ V$ (i)

takes place in two different electrochemical cells, I and II, in which the other half cell reactions are (ii) and (iii) respectively:

$Al^{3+}(aq) + 3e^- \rightarrow Al(s)\ E^\ominus = -1.7\ V$ (ii)

$AgBr(s) + e^- \rightarrow Ag(s) + Br^-(aq)\ E^\ominus = -0.07\ V$ (iii)

The correct option that represents the redox reactions in cells I and II is:

(A) Fe is oxidised in cell I; Fe is oxidised in cell II

(B) Fe is oxidised in cell I; Fe is reduced in cell II

(C) Fe is reduced in cell I; Fe is reduced in cell II

(D) Fe is reduced in cell I; Fe is oxidised in cell II

**Solution · Q38** **Answer: (D)**

The couple with the higher reduction potential forms the cathode.

For cell I:

$$E^\ominus(i) = -0.9\ V > E^\ominus(ii) = -1.7\ V$$

$\therefore$ $Fe(OH)_2$ is reduced to Fe, and Aℓ is oxidised.

For cell II:

$$E^\ominus(iii) = -0.07\ V > E^\ominus(i) = -0.9\ V$$

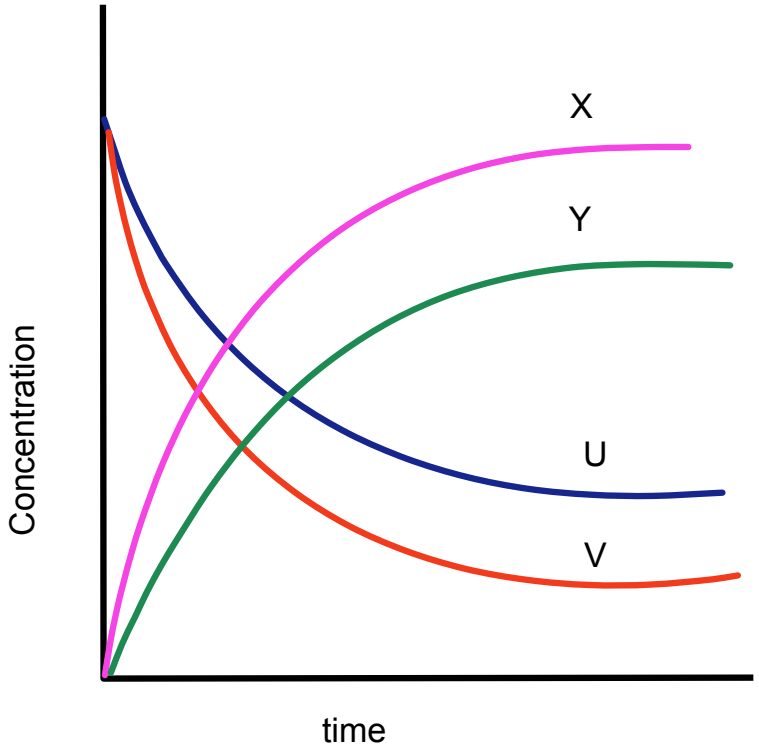
$\therefore$ AgBr is reduced, and Fe is oxidised to $Fe(OH)_2$.

**IAPT answer:** (D) | **Zigyan answer:** (D)

**39.** The following are the concentration vs time plots of the reactants and products represented by the reaction

$L(g) + 2\,M(g) \rightarrow N(g) + 3\,O(g)$

The curves that represent M(g) and N(g) qualitatively are respectively




(A) X, Y (B) Y, U (C) V, Y (D) U, X

**Solution · Q39** **Answer: (C)**

The falling curves U and V belong to the reactants. M is used up twice as fast as L, so it falls more.

∴ M is V.

The rising curves X and Y belong to the products. N forms at one-third the rate of O, so it rises less.

∴ N is Y.

**IAPT answer:** (C) | **Zigyan answer:** (C)

**40.** The current produced due to photoelectric effect

(A) increases with the increase of frequency of the incident radiation.

(B) increases with the increase in intensity of the incident radiation.

(C) decreases with time of irradiation.

(D) is independent of the intensity of incident radiation.

**Solution · Q40** **Answer: (B)**

Above the threshold frequency, higher intensity means more photons per second. So more photoelectrons are emitted per second.

∴ The photocurrent increases with the intensity of the incident radiation.

**IAPT answer:** (B) | **Zigyan answer:** (B)

**41.** The property of radiation that is not different at various regions of the electromagnetic spectrum is:

(A) energy (B) frequency (C) velocity (D) wavelength

**Solution · Q41** **Answer: (C)**

In vacuum, all electromagnetic radiations travel with the same velocity.

$$c = 3.0 \times 10^{8}\ m\ s^{-1}$$

Energy, frequency and wavelength differ from one region to another.

**IAPT answer:** (C) | **Zigyan answer:** (C)

**42.** Among the following, the correct statements about the compressibility factor (Z) of real gases are:

(i) If Z < 1, intermolecular repulsive forces are more dominant.

(ii) If Z < 1, intermolecular attractive forces are more dominant.

(iii) If Z > 1, intermolecular repulsive forces are more dominant.

(iv) If Z >1, intermolecular attractive forces are more dominant.

(A) (i) and (iv) (B) (i) and (iii) (C) (ii) and (iv) (D) (ii) and (iii)

**Solution · Q42** **Answer: (D)**

$$Z = \frac{pV_m}{RT}$$

$$Z < 1$$

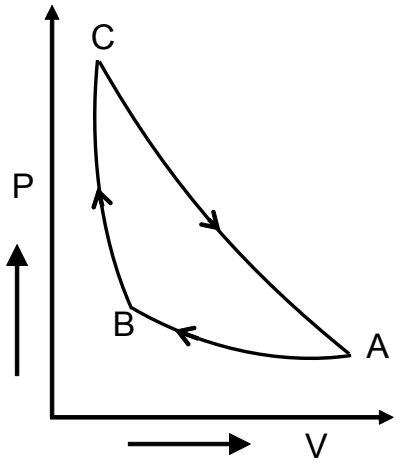
The gas is compressed more easily than an ideal gas, so attractive forces dominate. (ii) is correct.

$$Z > 1$$

The gas is harder to compress than an ideal gas, so repulsive forces dominate. (iii) is correct.

**IAPT answer:** (D) | **Zigyan answer:** (D)

**43.** The figure represents the processes AB, BC and CA undertaken by a certain mass of an ideal gas. Along the path AB, the gas is isothermally compressed with release of 800 J heat to the surroundings. It is then compressed adiabatically along the path BC and the work done is 500 J. The gas then returns to the state A along path CA and absorbs 100 J heat from the surroundings. The work done by the gas along the path CA is:




(A) – 300 J (B) – 900 J (C) – 600 J (D) – 400 J

**Solution · Q43** **As per Zigyan: (C)**

Take w as the work done on the gas.

Along AB (isothermal, ideal gas):

$$\Delta U_{AB} = 0$$

Along BC (adiabatic compression):

$$\Delta U_{BC} = w = +500 \text{ J}$$

For the complete cycle:

$$\Delta U_{AB} + \Delta U_{BC} + \Delta U_{CA} = 0$$

$$\Rightarrow \Delta U_{CA} = -500 \text{ J}$$

Along CA:

$$\Delta U_{CA} = q + w$$

$$-500 = 100 + w$$

$$\Rightarrow w = -600 \text{ J}$$

The negative sign shows that the gas does 600 J of work.

**Check:** over the whole cycle the heats add to −700 J, and the work terms +800 J, +500 J and −600 J done on the gas add to +700 J, so the internal energy returns to its starting value.

**IAPT answer:** (C) | **Zigyan answer:** (C)

**44.** Two flasks I and II of equal volume are evacuated and connected by a tube of negligible volume fitted with a stopcock. They are then placed in two different constant temperature baths of 250 K and 750 K respectively. 20 moles of an ideal gas are introduced into the system of these flasks through the stopcock. When the system reaches equilibrium, the ratio of the moles of the gas in flasks I and II is:

(A) 1 : 1 (B) 2 : 1 (C) 3 : 1 (D) 4 : 1

**Solution · Q44** **Answer: (C)**

At equilibrium, both flasks have the same pressure. Their volumes are also equal.

$$pV = nRT$$

$$\Rightarrow n_I \times 250 = n_{II} \times 750$$

$$\therefore n_I : n_{II} = 3 : 1$$

**IAPT answer:** (C) | **Zigyan answer:** (C)

**45.** When a certain amount of a univalent salt AB (molar mass = 54 g $mol^{-1}$) was dissolved in 0.1 $dm^3$ of water, the relative lowering of the vapour pressure was found to be 3.55%. The molality of the resulting solution is:

(Assume complete dissociation of the salt under given condition. Density of water = 1 g $cm^{-3}$)

(A) 0.5 m (B) 1.0 m (C) 2.0 m (D) 4.0 m

**Solution · Q45** **Answer: (B)**

AB dissociates completely into two ions.

$$i = 2$$

Moles of water in 100 g:

$$n(H_2O) = 100/18 = 5.556 \text{ mol}$$

For n mol of AB, relative lowering equals the mole fraction of the ions:

$$\frac{2n}{2n + 5.556} = 0.0355$$

$$\Rightarrow n = 0.102 \text{ mol}$$

Mass of water is 0.1 kg.

$$\therefore m = \frac{0.102}{0.1} = 1.02 \approx 1.0 \text{ m}$$

**IAPT answer:** (B) | **Zigyan answer:** (B)

**46.** The rate constant values for the decay of radioisotopes X and Y, used in radio-medicine are 0.05 $h^{-1}$ and 0.025 $h^{-1}$ respectively. In a hospital, at a time '$t_0$' the activity of a sample of X was found to be twice that of Y. The activities of the two radioisotopes will be approximately equal when the time elapsed is:

(A) twice the half-life of Y
(B) twice the half-life of X
(C) equal to the half-life of X
(D) equal to ½ the half-life of Y

**Solution · Q46** **Answer: (B)**

At $t_0$, let the activity of Y be a and that of X be 2a.

When the two activities become equal:

$$2a\, e^{-0.05t} = a\, e^{-0.025t}$$

$$\Rightarrow e^{0.025t} = 2$$

$$\Rightarrow t = \frac{\ln 2}{0.025} = 27.7\ \text{h}$$

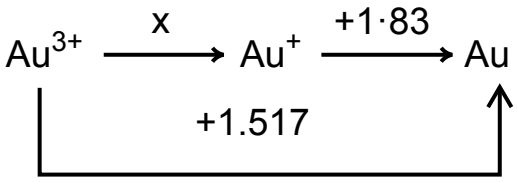
Half-life of X:

$$t_{1/2} = \frac{\ln 2}{0.05} = 13.86\ \text{h}$$

∴ The time elapsed is twice the half-life of X.

**IAPT answer:** (B) | **Zigyan answer:** (B)

**47.** Latimer diagrams are the compact representations of electrochemical equilibria in substances of multiple oxidation states. The value of the potential, x, in the Latimer diagram of gold (at pH = 1.0) is:




(A) 2.72 V (B) 3.18 V (C) −3.18 V (D) 1.36 V

**Solution · Q47** **Answer: (D)**

Free energy changes are additive:

$$\Delta G°(Au^{3+}/Au) = \Delta G°(Au^{3+}/Au^{+}) + \Delta G°(Au^{+}/Au)$$

For each step:

$$\Delta G° = -nFE°$$

Substituting the values:

$$-3F \times 1.517 = -2F \times x - F \times 1.83$$

$$\Rightarrow x = \frac{3 \times 1.517 - 1.83}{2} = 1.36\ \text{V}$$

**IAPT answer:** (D) | **Zigyan answer:** (D)

**48.** Electrolysis of aqueous $CuSO_4$ (0.1 M) was carried out in two cells I and II. In I, the electrodes are of Cu and in II they were of Pt. As the electrolysis proceeds pH of the electrolyte solution will:

(A) decrease in II and remain the same in I (B) remain the same in both I and II
(C) increase in both I and II (D) increase in I and decrease in II

**Solution · Q48** **Answer: (A)**

Cell I (Cu electrodes), at the anode:

$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

At the cathode:

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

No $H^+$ is produced or used up, so the pH remains the same.

Cell II (Pt electrodes): $Cu^{2+}$ is deposited at the cathode, and water is oxidised at the anode.

$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

$H^+$ builds up, so the pH decreases.

**IAPT answer:** (A) | **Zigyan answer:** (A)

## PART A-2 · ONE OR MORE CORRECT OPTIONS

**Q. 49 – 60 · 6 marks only if all correct options are marked · no negative marking**

**49.** Choose the correct statement(s) regarding zeolites:

(A) Silicon atoms are replaced by aluminium atoms in the zeolites.

(B) The pores and cavities of the zeolites as well as size and shape of reactant decides the reactions taking place in the zeolites.

(C) The cracking of hydrocarbons and isomerisation reactions are catalyzed by zeolites in the petrochemical industries.

(D) Zeolites act as molecular sieves and can separate the molecules of different sizes.

**Solution · Q49** **Answer: (A), (B), (C), (D)**

(A) Zeolites are aluminosilicates in which some Si atoms of the silicate framework are replaced by Aℓ atoms ⇒ true.

(B) They are shape-selective: pore and cavity size, with the size and shape of the molecules, control the reaction ⇒ true.

(C) They are widely used petrochemical catalysts for cracking and isomerisation of hydrocarbons ⇒ true.

(D) Their pores of fixed size admit small molecules and hold back larger ones ⇒ true.

**IAPT answer:** (A), (B), (C), (D) | **Zigyan answer:** (A), (B), (C), (D)

**50.** Crystalline iron(III) nitrate nonahydrate, $Fe(NO_3)_3.9H_2O$, has a very pale violet colour. When added to water, the crystals dissolve to form a brown solution. Treatment of this brown solution with concentrated nitric acid yields a very pale violet solution while treatment with HCl yields a yellow solution.

Identify the correct statements regarding the above observations.

(A) The brown colour is due to $[Fe(OH)(H_2O)_5]^{2+}$, $[Fe(OH)_2(H_2O)_4]^+$

(B) Violet colour is due to $[Fe(H_2O)_6]^{3+}$ and yellow colour due to $[FeCl_4]^-$

(C) Addition of $HNO_3$ shifts the equilibrium $[Fe(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Fe(OH)(H_2O)_5]^{2+} + H_3O^+$ to left giving pale violet colour

(D) Addition of $HNO_3$ shifts the equilibrium $[Fe(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Fe(OH)(H_2O)_5]^{2+} + H_3O^+$ to right giving violet colour

**Solution · Q50** **Answer: (A), (B), (C)**

In water the pale violet aqua ion is hydrolysed:

$[Fe(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Fe(OH)(H_2O)_5]^{2+} + H_3O^+$

$[Fe(OH)(H_2O)_5]^{2+} + H_2O \rightleftharpoons [Fe(OH)_2(H_2O)_4]^+ + H_3O^+$

(A) These hydroxo species give the brown colour ⇒ true.

(B) The aqua ion is violet. With HCℓ the yellow chloro complex forms:

$[Fe(H_2O)_6]^{3+} + 4C\ell^- \rightleftharpoons [FeC\ell_4]^- + 6H_2O$

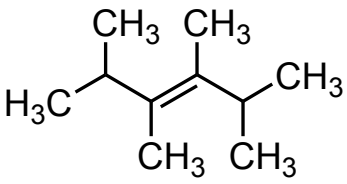
⇒ true.

(C) $HNO_3$ adds $H_3O^+$, so the equilibrium shifts left to the violet ion ⇒ (C) true, (D) false.

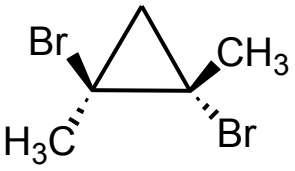
**IAPT answer:** (A), (B), (C) | **Zigyan answer:** (A), (B), (C)

**51.** The optically active compounds from the following are:

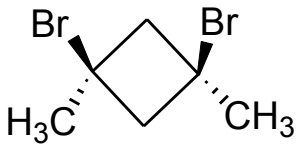
(A)



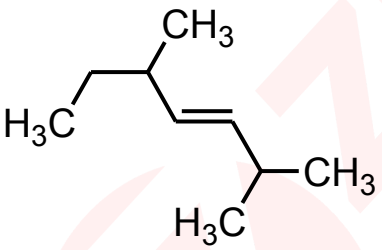
(B)



(C)



(D)



**Solution · Q51** **Answer: (B), (D)**

(A) 2,3,4,5-Tetramethylhex-3-ene: each side CH carbon has two $CH_3$ groups, so there is no stereocentre ⇒ inactive.

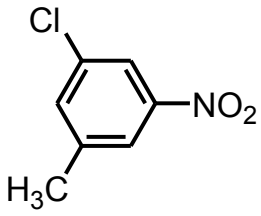
(B) The two Br atoms are on opposite faces (trans). The molecule has a $C_2$ axis but no plane or centre of symmetry ⇒ active.

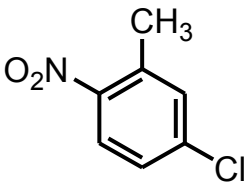
(C) This 1,3-disubstituted cyclobutane has a symmetry plane through C-1 and C-3 ⇒ inactive.

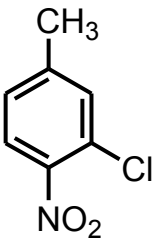
(D) In 2,5-dimethylhept-3-ene, C-5 carries four different groups: H, $CH_3$, $C_2H_5$ and the alkenyl chain ⇒ chiral, so active.

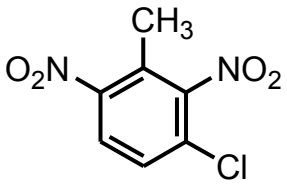
**IAPT answer:** (B), (D) | **Zigyan answer:** (B), (D)

**52.** 3-chlorotoluene is reacted with a mixture of conc. $H_2SO_4$ and $HNO_3$. The product/s formed is/are:

(A) 


(B) 


(C) 


(D) 


**Solution · Q52** **As per Zigyan: (B), (C)**

With $CH_3$ at C-1 and C$\ell$ at C-3, both groups direct to C-2, C-4 and C-6. C-2, between them, is crowded.

The nitrating mixture gives the mononitro products:

3-chlorotoluene → 3-chloro-4-nitrotoluene + 5-chloro-2-nitrotoluene

These are (C) and (B).

(A) Here $NO_2$ is meta to both groups ⇒ not formed.

(D) It needs a second nitration, with one $NO_2$ at the crowded C-2 ⇒ not formed.

Why Zigyan differs from IAPT: (D) has $NO_2$ between the $CH_3$ and C$\ell$ groups, a hindered site that is rarely substituted.

**Reference:** NCERT Chemistry Class XI (Part II), Unit 9 'Hydrocarbons', section 9.5.6: $CH_3$ is activating and, like halogens, directs ortho and para; a deactivating nitro group makes further substitution difficult.

**Reference:** OpenStax Organic Chemistry, section 16.5 'Trisubstituted Benzenes: Additivity of Effects': further substitution rarely occurs between the two groups of a meta-disubstituted compound, because that site is too hindered.

**IAPT answer:** (B), (C), (D) | **Zigyan answer:** (B), (C)

**53.** 2,4,6-trinitrophenol is more acidic than phenol. Identify the correct statement(s)

(A) $pK_a$ for 2,4,6-trinitrophenol is less than that of phenol.

(B) phenol is stabilized by intramolecular π hydrogen bonding.

(C) The conjugate base of 2,4,6-trinitrophenol delocalizes the negative charge on the oxygen atom to a very large extent.

(D) The conjugate base of phenol delocalizes the negative charge to a greater extent than the conjugate base of 2,4,6-trinitrophenol.

**Solution · Q53** **Answer: (A), (C)**

(A) A stronger acid has a smaller $pK_a$, and picric acid is far stronger than phenol ⇒ true.

(B) The O–H of phenol cannot bend back to its own ring, so there is no intramolecular π hydrogen bond ⇒ false.

(C) In picrate the charge on oxygen is delocalised by –M and –I effects of three $NO_2$ groups (two ortho, one para) ⇒ true.

(D) Phenoxide spreads the charge only over the ring, much less than picrate ⇒ false.

**IAPT answer:** (A), (C) | **Zigyan answer:** (A), (C)

**54.** The correct statements for 1,3-butadiene from following are:

(A) Molar addition of $Br_2$ yields only 1,4-dibromo-2-butene as the major product when the reaction is performed for longer time period

(B) Molar addition of $Br_2$ yields only 1,2-dibromo-2-butene for longer time period

(C) $C_1 - C_2$ and $C_3 - C_4$ bonds are slightly longer than a C=C bond

(D) $C_2 - C_3$ single bond is slightly shorter than a C – C bond

**Solution · Q54** **Answer: (A), (C), (D)**

(A) Long reaction time gives thermodynamic control. The more substituted alkene, the 1,4-adduct, is the major product:

$$CH_2{=}CH{-}CH{=}CH_2 + Br_2 \rightarrow BrCH_2{-}CH{=}CH{-}CH_2Br$$

⇒ true.

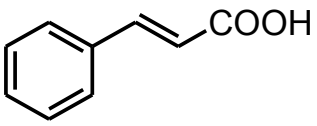
(B) The 1,2-adduct is 3,4-dibromobut-1-ene, not 1,2-dibromo-2-butene, and it is not favoured on standing ⇒ false.

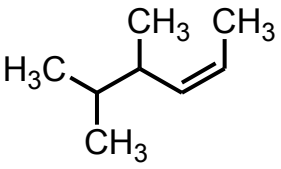
(C), (D) Delocalisation gives C1–C2 and C3–C4 some single bond character and C2–C3 some double bond character.

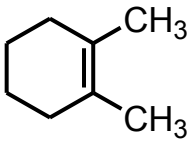
Hence C1–C2 is slightly longer than C=C, and C2–C3 is shorter than C–C ⇒ both true.

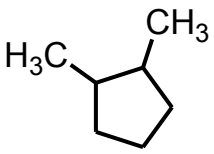
**IAPT answer:** (A), (C), (D) | **Zigyan answer:** (A), (C), (D)

**55.** Which of the following representations will exhibit *cis-trans* isomerism?

(A) 


(B) 


(C) 


(D) 


**Solution · Q55** **Answer: (A), (B), (D)**

(A) The side chain carbons carry H and $C_6H_5$, and H and COOH ⇒ shows cis-trans isomerism.

(B) Each carbon of CH=CH has two different groups (H and an alkyl group) ⇒ shows it.

(C) The double bond lies in a six-membered ring, which permits only the cis arrangement ⇒ does not show it.

(D) The two $CH_3$ groups can be on the same side or on opposite sides of the ring ⇒ shows it.

**IAPT answer:** (A), (B), (D) | **Zigyan answer:** (A), (B), (D)

**56.** For an elementary dimerization reaction of the type $2R \rightarrow R_2$, the value of the steric factor was found to be 2.5. This indicates that

(A) the experimentally obtained rate is 2.5 times faster than the theoretical rate.

(B) ratio of the number of collisions calculated from collision theory and that actually take place is 1: 2.5.

(C) the activation energy of the reaction is the same for both the experimental and calculated values.

(D) the molecules of reactant R may be of some complex structure.

**Solution · Q56** **As per Zigyan: (A), (C)**

With the steric factor,

$$k_{exp} = PZe^{-E_a/RT}$$

From simple collision theory,

$$k_{calc} = Ze^{-E_a/RT}$$

$$\therefore k_{exp} = 2.5\, k_{calc}$$

(A) At the same temperature and concentration, the observed rate is 2.5 times the calculated one ⇒ true.

(C) Both expressions carry the same $E_a$ ⇒ true.

(B) Collision theory itself gives the number of collisions Z; P is a separate correction ⇒ false.

(D) Complex shape limits proper orientation and lowers the rate, which cannot explain P above 1 ⇒ false.

Why Zigyan differs from IAPT: P of 2.5 multiplies the calculated rate by 2.5, so (A) holds; restricted orientation cannot raise it, so (D) does not follow.

**Reference:** NCERT Chemistry Class XII (Part I), Unit 3 'Chemical Kinetics', section 3.5: the collision theory rate, made of collision frequency and activation energy factor, is multiplied by the steric factor P, which accounts for proper orientation; for complex molecules deviations arise, possibly because not all collisions form products.

**IAPT answer:** (C), (D) | **Zigyan answer:** (A), (C)

**57.** The correct statement/s among the following is/are:

(A) The charge on the diffused layer of AgI colloidal solution by the addition of few drops of dilute aqueous solution of KI to an aqueous solution of $AgNO_3$ is negative.

(B) The charge on the diffused layer of AgI colloidal solution by the addition of few drops of dilute aqueous solution of $AgNO_3$ to an aqueous solution of KI is positive.

(C) When the ionic strength of a colloidal solution is increased, thickness of the double layer is increased, and the colloid gets precipitated.

(D) When the ionic strength of a colloidal solution is increased, thickness of the double layer is decreased, and the colloid gets precipitated.

**Solution · Q57** **Answer: (A), (B), (D)**

(A) A few drops of KI in $AgNO_3$: excess $Ag^+$ is adsorbed on AgI, with $NO_3^-$ as counter ions.

The particle is positive and the diffused layer negative ⇒ true.

(B) A few drops of $AgNO_3$ in KI: excess $I^-$ is adsorbed, with $K^+$ as counter ions.

The diffused layer is positive ⇒ true.

(C), (D) Higher ionic strength compresses the double layer, lowers the zeta potential and the sol coagulates ⇒ (D) true, (C) false.

**IAPT answer:** (A), (B), (D) | **Zigyan answer:** (A), (B), (D)

**58.** In reverse osmosis the flow of solvent across semi permeable membrane occurs

(A) when hydrostatic pressure is greater than osmotic pressure

(B) when hydrostatic pressure is lower than osmotic pressure

(C) from higher concentrated solution to lower concentrated solution

(D) from lower concentrated solution to higher concentrated solution

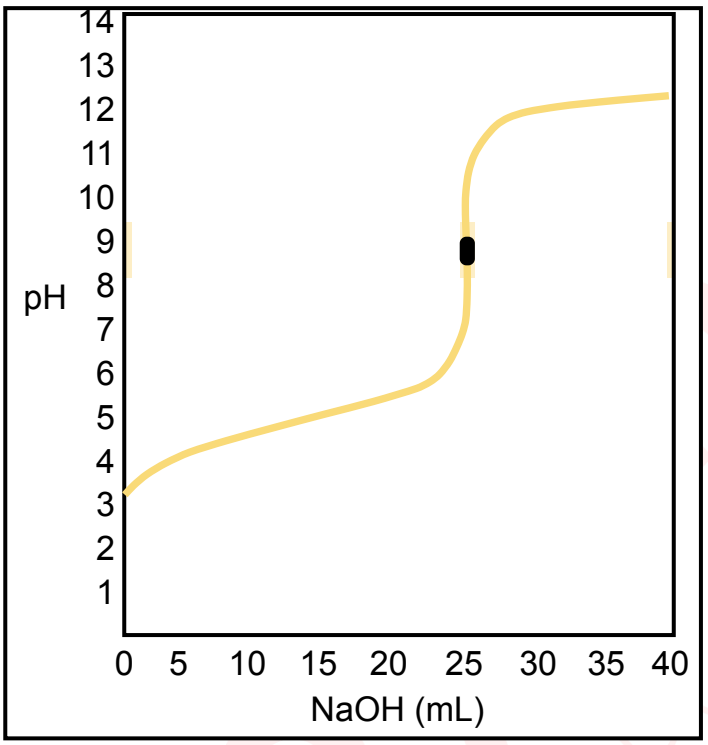
**Solution · Q58** **Answer: (A), (C)**

Reverse osmosis occurs when the pressure applied on the solution exceeds its osmotic pressure ⇒ (A) true, (B) false.

Solvent is then forced through the membrane from the more concentrated to the less concentrated side ⇒ (C) true, (D) false.

**IAPT answer:** (A), (C) | **Zigyan answer:** (A), (C)

**59.** Given below is the plot of pH vs volume of NaOH added in an acid-base titration. The correct statement/s among the following is/are:




(A) Before the equivalence point, a series of buffer solutions determine the pH.

(B) The graph represents the titration of a strong acid with NaOH.

(C) At the equivalence point, hydrolysis of the anion of the acid determines the pH.

(D) After the equivalence point acid/salt buffer solution determines the pH.

**Solution · Q59** **Answer: (A), (C)**

The curve starts near pH 3 and its equivalence point (25 mL) lies above pH 7. So a weak acid HA is titrated with NaOH.

(A) Before equivalence, HA and $A^-$ form a buffer:

$$pH = pK_a + \log([A^-]/[HA])$$

$\Rightarrow$ true.

(B) A strong acid would give equivalence at pH 7 $\Rightarrow$ false.

(C) At equivalence the salt anion hydrolyses:

$A^- + H_2O \rightleftharpoons HA + OH^-$

$\Rightarrow$ true.

(D) Beyond equivalence, excess NaOH fixes the pH $\Rightarrow$ false.

**IAPT answer:** (A), (C) | **Zigyan answer:** (A), (C)

**60.** The correct statement/s among the following is/are:

(A) The probability density ($\psi^2$) for a hydrogen atom is zero at r = 0.

(B) In an atom, orbitals with the same quantum number have different energies.

(C) The energy of a given orbital with same principal quantum number decreases as the atomic number 'Z', increases.

(D) For a given atomic number, the configuration having the maximum number of parallel spins is of the lowest energy than any other arrangement arising from the same configuration.

**Solution · Q60** **Answer: (C), (D)**

(A) For the 1s electron $\psi^2$ is maximum at the nucleus; it is the radial probability $4\pi r^2\psi^2$ that vanishes there ⇒ false.

(B) Orbitals such as $2p_x$, $2p_y$ and $2p_z$ of a free atom have equal energy ⇒ false.

(C) A larger nuclear charge holds the same orbital more strongly:

$$E_{2s}(H) > E_{2s}(Li) > E_{2s}(Na) > E_{2s}(K)$$

⇒ true.

(D) By Hund's rule, maximum parallel spins give the most exchange energy and the lowest energy ⇒ true.

**IAPT answer:** (C), (D) | **Zigyan answer:** (C), (D)

**Given in the question paper**

# PERIODIC TABLE OF ELEMENT

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H Hydrogen 1 | | | | | | | | | | | | | | | | | 2 He Helium 4 |
| 2 Li Lithium 3 | 3 Be Beryllium 9 | | | | | | | | | | | 5 B Boron 11 | 6 C Carbon 12 | 7 N Nitrogen 14 | 8 O Oxygen 16 | 9 F Fluorine 19 | 10 Ne Neon 20 |
| 11 Na Sodium 23 | 12 Mg Magnesium 24 | | | | | | | | | | | 13 Al Aluminum 27 | 14 Si Silicon 28 | 15 P Phosphorus 31 | 16 S Sulfur 32 | 17 Cl Chlorine 35.5 | 18 H Argon 40 |
| 19 K Potassium 39 | 20 Ca Calcium 40 | 21 Sc Scandium 45 | 22 Ti Titanium 48 | 23 V Vanadium 51 | 24 Cr Chromium 52 | 25 Mn Manganese 55 | 26 Fe Iron 56 | 27 Co Cobalt 59 | 28 Ni Nickel 59 | 29 Cu Copper 64 | 30 Zn Zinc 65 | 31 Ga Gallium 70 | 32 Ge Germanium 73 | 33 As Arsenic 75 | 34 Se Selenium 79 | 35 Br Bromine 80 | 36 Kr Krypton 84 |
| 37 Rb Rubidium 86 | 38 Sr Strontium 88 | 39 Y Yttrium 89 | 40 Zr Zirconium 91 | 41 Nb Niobium 93 | 42 Nb Niobium 96 | 43 Tc Technetium 98 | 44 Ru Ruthenium 101 | 45 Rh Rhodium 103 | 46 Pd Palladium 106 | 47 Ag Silver 108 | 48 Cd Cadmium 112 | 49 In Indium 115 | 50 Sn Tin 119 | 51 Sb Antimony 122 | 52 Te Tellurium 128 | 53 I Iodine 127 | 54 Xe Xenon 131 |
| 55 Cs Cesium 133 | 56 Ba Barium 137 | 57 La Lanthanum 139 | 72 Hf Hafnium 179 | 73 Ta Tantalum 181 | 74 W Tungsten 184 | 75 Re Rhenium 186 | 76 Os Osmium 190 | 77 Ir Iridium 192 | 78 Pt Platinum 195 | 79 Au Gold 197 | 80 Hg Mercury 201 | 81 Ti Thallium 204 | 82 Pb Lead 207 | 83 Bi Bismuth 209 | 84 Po Polonium 210 | 85 At Astatine 210 | 86 Rn Radon 222 |
| 87 Fr Francium 223 | 88 Ra Radium 226 | 89 Ac Actinium 227 | 104 Unq Unilquadium 257 | 105 Unp Unilpentium 260 | 106 Unh Unilhexium 263 | 107 Uns Unilseptium 262 | 108 Uno Unioctium 265 | 109 Une Unienium 266 | | | | | | | | | |

← Proton number
← Symbol
← Name of element
← Relative atomic mass

| 2 He Helium 4 |
|---|

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 58 Ce Cerium 140 | 59 Pr Praseodymium 141 | 60 Nd Neodymium 144 | 61 Pm Promethium 147 | 62 Sm Samarium 150 | 63 Eu Europium 152 | 64 Gd Gadolinium 157 | 65 Tb Terbium 159 | 66 Dy Dysprosium 136 | 67 Ho Holmium 165 | 68 Er Erbium 167 | 69 Tm Thulium 169 | 70 Yb Ytterbium 173 | 71 Lu Lutetium 175 |
| 90 Th Thorium 232 | 91 Pa Protactinium 231 | 92 U Uranium 238 | 93 Np Neptunium 237 | 94 Pu Plutonium 244 | 95 Am Americium 243 | 96 Cm Curium 247 | 97 Bk Berkelium 247 | 98 Cf Californium 249 | 99 Es Einsteinium 254 | 100 Fm Fermium 253 | 101 Md Mendelevium 256 | 102 No Nobelium 254 | 103 Lr Lawrencium 257 |

# ANSWER KEY

NSEC 2023 · PAPER CODE 31

**60**
QUESTIONS · 216 MARKS

IAPT final answer key for paper code 31. ★ marks an answer given as per Zigyan.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | (A) | 2 | (B)★ | 3 | (D) | 4 | (B) | 5 | (B) |
| 6 | (C) | 7 | (C) | 8 | (C) | 9 | (C) | 10 | (B) |
| 11 | (B) | 12 | (A) | 13 | (D) | 14 | (B) | 15 | (C) |
| 16 | (B) | 17 | (C) | 18 | (D) | 19 | (D) | 20 | (D) |
| 21 | (A) | 22 | (C) | 23 | (B) | 24 | (A) | 25 | (A) |
| 26 | (C) | 27 | (C) | 28 | (B) | 29 | (D) | 30 | (A) |
| 31 | (C) | 32 | (C) | 33 | (B) | 34 | (B) | 35 | (A) |
| 36 | (A) | 37 | (C) | 38 | (D) | 39 | (C) | 40 | (B) |
| 41 | (C) | 42 | (D) | 43 | (C)★ | 44 | (C) | 45 | (B) |
| 46 | (B) | 47 | (D) | 48 | (A) | 49 | (A), (B), (C), (D) | 50 | (A), (B), (C) |
| 51 | (B), (D) | 52 | (B), (C)★ | 53 | (A), (C) | 54 | (A), (C), (D) | 55 | (A), (B), (D) |
| 56 | (A), (C)★ | 57 | (A), (B), (D) | 58 | (A), (C) | 59 | (A), (C) | 60 | (C), (D) |

**★ Answers as per Zigyan**

- **Q2** — As per Zigyan: (B); IAPT key (B).
- **Q43** — As per Zigyan: (C); IAPT key (C).
- **Q52** — As per Zigyan: (B), (C); IAPT key (B), (C), (D).
- **Q56** — As per Zigyan: (A), (C); IAPT key (C), (D).

zigyan

OLYMPIADS · 2026

# Olympiad results



TOP ACHIEVEMENT · CHEMISTRY

## Qualified the Chemistry Olympiad twice, and selected for the HBCSE camp.

**Saksham Bishnoi** reached the national stage of the Chemistry Olympiad in two consecutive years and was selected for the Orientation-cum-Selection Camp at HBCSE, Mumbai. 4 Years Classroom - the same student who took AIR 168 in JEE Advanced 2026.

Qualified twice | HBCSE selection camp | Only student from Faridabad

**Above MAS** means above the **Minimum Admissible Score**: clearing it puts a student in the national band for their subject. It is a real threshold, not a participation marker.

## CHEMISTRY · ABOVE MAS



**Sulokya Bibhuty**
Class XII
3 Years Classroom
Above MAS



**Anay Gupta**
Class XI
3 Years Classroom
Above MAS



**Akshat Khator**
Class XI
3 Years Classroom
Above MAS



**Harshit Goyal**
Class XII
4 Years Classroom
Above MAS



**Hardik Sharma**
Class XI
3 Years Classroom
Above MAS



**Aarush Kumar**
Class XII
1 Year Classroom
Above MAS

## PHYSICS · ASTRONOMY · MATHEMATICS

PHYSICS



**Sulokya Bibhuty**
Class XII
3 Years Classroom
Above MAS

PHYSICS



**Saksham Bishnoi**
Class XII
4 Years Classroom
Above MAS

ASTRONOMY



**Sulokya Bibhuty**
Class XI
3 Years Classroom
Above MAS

MATHEMATICS · IOQM



**Priyanshi**
Class XI
4 Years Classroom
IOQM Qualifier

## OLYMPIADS WE PREPARE STUDENTS FOR

| NSEP | NSEC | NSEB | NSEA | IOQM | NSEJS |
|---|---|---|---|---|---|
| Physics | Chemistry | Biology | Astronomy | Mathematics | Class X and below |

## The olympiad pathway starts in Class 8.

NSEJS is open to Class 10 and below - the habit of staying with one hard problem is the one JEE Advanced rewards.



Zigyan Eduvision Pvt. Ltd. · SCO No. 107, Sector 16, Faridabad 121002
0129-4048800 · +91 92115 38800 · info@zigyan.com

zigyan

RESULTS · 2021 – 2026

# Our toppers, year by year

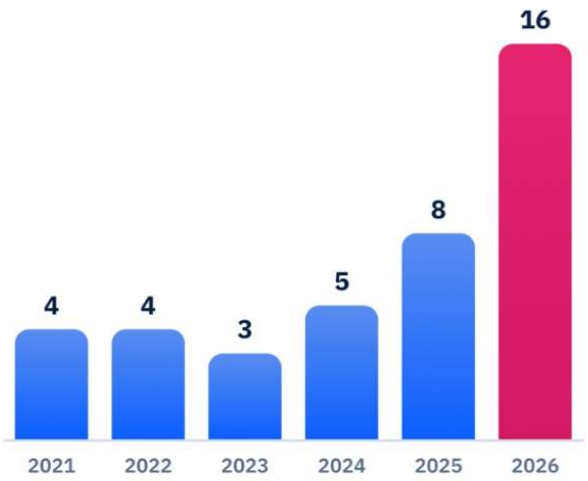
**40**
JEE Advanced selections in 6 years

**AIR 168**
best rank — Saksham Bishnoi, 2026

**16 of 35**
students selected, JEE Advanced 2026

**14 of 35**
above 98 percentile, JEE Main 2026

## JEE ADVANCED SELECTIONS PER YEAR




## BEST RANK EACH YEAR

| YEAR | JEE ADVANCED | JEE MAIN |
|---|---|---|
| 2026 | **Saksham Bishnoi**<br>AIR 168 · 4 Years Classroom | **Saksham Bishnoi**<br>AIR 811 · 99.95 %ile |
| 2025 | **Chakshu**<br>AIR 4,233 · 2 Years Classroom | **Chakshu**<br>AIR 8,538 · 99.44 %ile |
| 2024 | **Harshit**<br>AIR 777 · 2 Years Classroom | **Harshit**<br>AIR 1,473 · 99.91 %ile |
| 2023 | **Aditya Jain**<br>AIR 2,373 · 2 Years Classroom | **Aditya Jain**<br>AIR 2,503 · 99.79 %ile |
| 2022 | **Rachit Sharma**<br>AIR 698 · 1 Year Classroom | **Rachit Sharma**<br>AIR 1,016 · 99.90 %ile |
| 2021 | **Sparsh Mittal**<br>AIR 2,237 · 1 Year Classroom | **Sparsh Mittal**<br>AIR 1,562 |

## JEE ADVANCED 2026 — THIRTEEN NAMED SELECTIONS



**Saksham Bishnoi**
AIR 168
4 Years Classroom



**Sulokya Bibhuty**
AIR 1,315
3 Years Classroom



**Aarush**
AIR 2,699
1 Year Classroom



**Manishka**
AIR 2,869
4 Years Classroom



**Oojit Kumar**
AIR 5,765
4 Years Classroom



**Harshit Goyal**
AIR 6,407
4 Years Classroom



**Pranab Sharma**
AIR 6,750
3 Years Classroom



**Aditya Dhar**
AIR 15,183
3 Years Classroom



**Arpit Anshuman**
AIR 19,308
4 Years Classroom



**Lokesh**
AIR 22,857
3 Years Classroom



**Arjun**
AIR 24,674
3 Years Classroom



**Sanyam Gulyani**
AIR 25,123
1 Year Classroom



**Saket**
AIR 27,628
3 Years Classroom

Sixteen students of the 2026 batch were selected in JEE Advanced; the thirteen above are named with their All India Rank.

## JEE MAIN 2026 — TOP SIX, WITH PERCENTILE



**Saksham Bishnoi**
AIR 811
99.95 %ile
4 Years Classroom



**Sulokya Bibhuty**
AIR 1,095
99.94 %ile
3 Years Classroom



**Harshit Goyal**
AIR 2,662
99.83 %ile
4 Years Classroom



**Manishka**
AIR 4,817
99.70 %ile
4 Years Classroom



**Oojit Kumar**
AIR 5,040
99.69 %ile
4 Years Classroom



**Aarush**
AIR 5,276
99.67 %ile
1 Year Classroom

14 of the 35 students in the 2026 batch scored above the 98th percentile in JEE Main.



Zigyan Eduvision Pvt. Ltd. · SCO No. 107, Sector 16, Faridabad 121002
0129-4048800 · +91 92115 38800 · info@zigyan.com