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PREVIOUS YEAR PAPER · 2021-22

OLYMPIAD · STAGE I

IOQC

Indian Olympiad Qualifier in Chemistry (Part I)

2021-22

Question paper, answer key and Zigyan solutions

32	120	75 min	31
Questions	Maximum marks	Time	Paper code

Question paper and official answer key: Indian Association of Physics Teachers (IAPT), IOQC 2021-22, paper code 31.
Solutions and notes: Zigyan. This booklet is not an IAPT publication.

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AIR 168	AIR 811
	99.95 percentile



Sulokya Bibhuty

3 YEARS CLASSROOM

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- Anay Gupta — 3 Years Classroom
- Akshat Khator — 3 Years Classroom
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- Hardik Sharma — 3 Years Classroom
- Aarush Kumar — 1 Year Classroom

PHYSICS

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

ASTRONOMY

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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
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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, $h = 6.626 \times 10^{-34} J\,s$
Speed of light, $c = 3.0 \times 10^{8}\ ms^{-1}$
Avogadro constant, $N_A = 6.022 \times 10^{23}\ mol^{-1}$
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 – 24 · +3 for a correct answer, –1 for a wrong one

1. The correct order of CFSE of the following complex ions is

$[Zn(NH_3)_4]^{2+}$, $[Co(NH_3)_6]^{2+}$, $[Co(NH_3)_6]^{3+}$, $[Ir(NH_3)_6]^{3+}$

(A) $[Ir(NH_3)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Co(NH_3)_6]^{2+} > [Zn(NH_3)_4]^{2+}$

(B) $[Zn(NH_3)_4]^{2+} > [Co(NH_3)_6]^{2+} > [Co(NH_3)_6]^{3+} > [Ir(NH_3)_6]^{3+}$

(C) $[Ir(NH_3)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Zn(NH_3)_4]^{2+} > [Co(NH_3)_6]^{2+}$

(D) $[Co(NH_3)_6]^{3+} > [Ir(NH_3)_6]^{3+} > [Co(NH_3)_6]^{2+} > [Zn(NH_3)_4]^{2+}$

Solution · Q1 **Answer: (A)**

Zn^{2+} is $3d^{10}$, so its CFSE is zero.

Co^{2+} in $[Co(NH_3)_6]^{2+}$ is high spin $3d^7$:

$$CFSE = -0.8\Delta_o$$

Co^{3+} and Ir^{3+} complexes here are low spin d^6:

$$CFSE = -2.4\Delta_o$$

Δ_o increases with oxidation state and from 3d to 5d metals.

$$\therefore [Ir(NH_3)_6]^{3+} > [Co(NH_3)_6]^{3+} > [Co(NH_3)_6]^{2+} > [Zn(NH_3)_4]^{2+}$$

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

2. Solvents are classified as polar and nonpolar based on their dipole moments.

Given below are some solvents.

(p)1,2-dibromobenzene

(q) diisopropylether

(r) trans-1,2-dichloroethene

(s) 1,2-dichloroethane

(t) N-ethyl-N-methylpropan-1-amine

The set in which all solvents are polar is

(A) p, s, t (B) p, q, r (C) r, s, t (D) q, r, t

Solution · Q2 **Answer: (A)**

In trans-1,2-dichloroethene (r), the two C–Cℓ bond dipoles cancel:

$$\mu = 0$$

So every set containing r is rejected.

In p, the two C–Br dipoles are at about 60° and do not cancel.

s has a net dipole due to its gauche conformers, and the pyramidal amine t is also polar.

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

3. Which of the following statement/s is/are correct?

I. Half-life is 50 % of the total time taken for the completion of a reaction

II. Collision frequency (Z), which is the number of collisions per second per unit volume, is same as the rate constant of the reaction

III. A change in the activation energy of a reaction at a particular temperature will result in a proportional change in the rate and rate constant of the reaction at the same temperature

IV. All first order reactions are not unimolecular

V. For a zero order reaction, slope of a plot of $t_{1/2}$ Vs. initial concentration will be zero

(A) I, IV (B) II only (C) IV only (D) II, III,V

Solution · Q3 **Answer: (C)**

I: Half-life is the time for 50 % reaction, not half of the total time. False.

II: Only a fraction of the collisions leads to reaction, so Z is not the rate constant. False.

III: By the Arrhenius equation, k changes exponentially with E_a:

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

So the change is not proportional. False.

IV: A first order reaction need not be unimolecular, e.g. hydrolysis of an ester in excess water. True.

V: For a zero order reaction,

$$t_{1/2} = \frac{[A]_0}{2k}$$

So the slope of the plot against $[A]_0$ is 1/2k, not zero. False.

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

4. The orange colour of $K_2Cr_2O_7$ and yellow colour of K_2CrO_4 are, respectively, due to

(A) charge transfer transitions and d-d transitions

(B) d-d transitions and charge transfer transitions

(C) charge transfer transitions in both

(D) d-d transitions in both

Solution · Q4 **Answer: (C)**

Cr is in the +6 state in both $K_2Cr_2O_7$ and K_2CrO_4.

Cr(VI) is $3d^0$, so a d-d transition is not possible.

Both colours are due to ligand to metal (O → Cr) charge transfer.

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

5. One mole of neon (atomic mass = 20 g mol^{-1}) and one mole of argon (atomic mass = 40 g mol^{-1}) are stored in two separate containers I and II, at temperature T and 2T respectively. If both the gases are assumed to behave ideally

(A) K.E. and average velocity of the gas molecules will be the same in both I and II

(B) K.E. and average velocity of the gas molecules in II will be twice that of the gas molecules in I

(C) K.E. of the gas molecules in II will be twice that in I and average velocity of the gas molecules in both I and II will be the same

(D) Both K.E. and average velocity of the gas molecules in I will be twice that of the gas molecules in II

Solution · Q5 **Answer: (C)**

Average kinetic energy per molecule:

$$\mathrm{KE} = \frac{3}{2}\mathrm{kT}$$

So the K.E. in II (2T) is twice that in I (T).

Average speed:

$$v_{av} = \sqrt{\frac{8RT}{\pi M}}$$

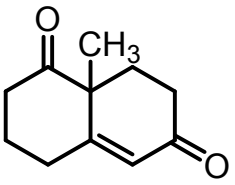
For Ne and Ar, the ratio T/M is the same:

$$\frac{T}{20} = \frac{2T}{40}$$

∴ The average velocity is the same in I and II.

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

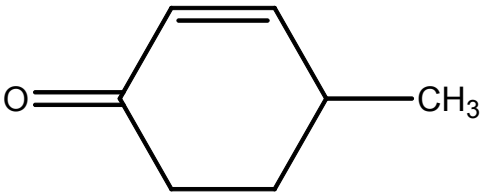
6. An aldehyde/ketone in the presence of a base forms a carbanion at the α-position which can react with a carbonyl group in an Aldol type of reaction. It can also react with an olefinic double bond which is activated by groups like CO, CN, NO_2 attached to the double bond. The latter reaction is an addition reaction across the double bond. Wieland-Miescher ketone is an important synthetic intermediate used to synthesize many compounds

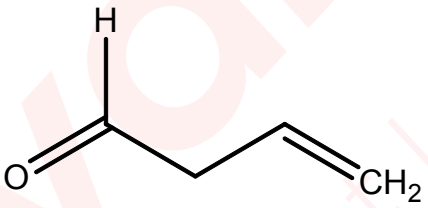


Wieland-Miescher Ketone

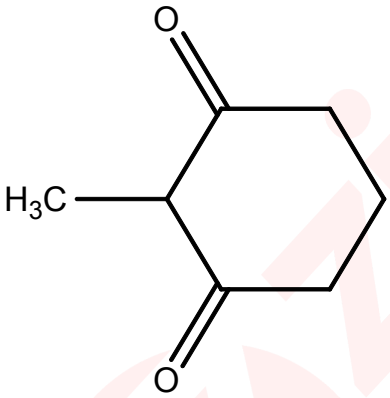
The pair of starting materials suitable for preparation of Wieland-Miescher ketone through a base catalysed reaction is

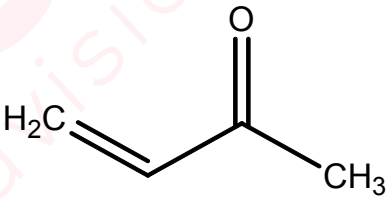
(A)



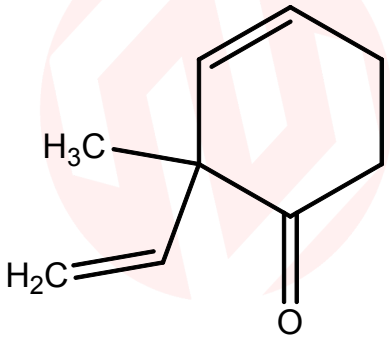


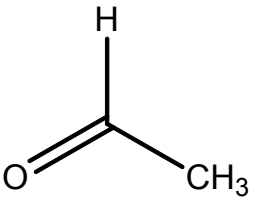
(B)



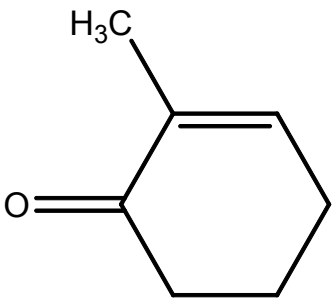


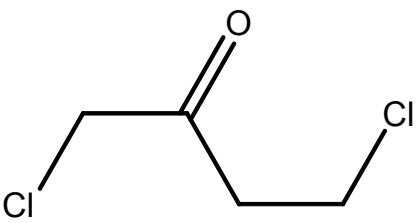
(C)





(D)





Solution · Q6 **Answer: (B)**

The base removes the acidic C-2 hydrogen of 2-methylcyclohexane-1,3-dione.

This carbanion undergoes Michael addition to but-3-en-2-one:

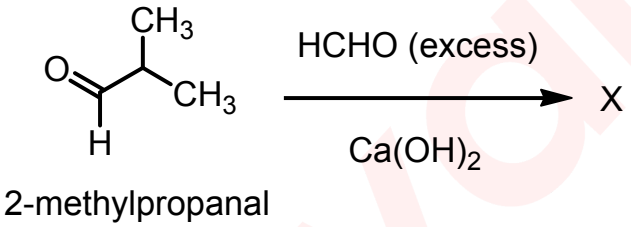
$$CH_2{=}CHCOCH_3$$

In the triketone formed, the side-chain CH_3 carbon attacks one ring C=O (intramolecular aldol), closing a six-membered ring.

Dehydration then gives the Wieland-Miescher ketone.

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

7. '**X**' in the following reaction is



2-methylpropanal

(A) 2,2-Dimethyl-1,3-propanediol (B) 2-Methylpropan-1-ol

(C) iso-butyric acid (D) 3-Hydroxy-2,2-dimethylpropanal

Solution · Q7 **Answer: (A)**

Crossed aldol addition with HCHO at the α-carbon:

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

This aldehyde has no α-H. With excess HCHO, a crossed Cannizzaro reaction follows:

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

X is 2,2-dimethyl-1,3-propanediol.

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

8. When 0.805 g of the potassium salt $(CH_2)_n(COOK)_2$ of a dibasic organic acid was reduced, 0.323 g of potassium was obtained. Molar mass of the acid is

(A) 194 (B) 116 (C) 118 (D) 156

Solution · Q8 **Answer: (C)**

One mole of the salt contains two moles of K. By POAC on K:

$$2 \times \frac{0.805}{M} = \frac{0.323}{39}$$

$$\Rightarrow M \approx 194 \text{ g mol}^{-1}$$

In the acid, 2 H replace the 2 K:

$$M_{acid} = 194 - 2 \times 39 + 2 \times 1$$

$$\Rightarrow M_{acid} = 118 \text{ g mol}^{-1}$$

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

9. Among (i) HCl, (ii) HOClO, (iii) $HOClO_2$ and (iv) $HOClO_3$, which cannot undergo a disproportionation reaction?

(A) Only (i) (B) (ii) and (iii)

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

Solution · Q9 **Answer: (C)**

An element in its lowest or highest oxidation state cannot disproportionate.

Oxidation state of Cℓ:

HCℓ: −1, HOCℓO: +3, $HOC\ell O_2$: +5, $HOC\ell O_3$: +7

−1 is the lowest and +7 is the highest state of chlorine.

∴ (i) and (iv) cannot disproportionate.

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

10. The electronic transition in He^+ ion that will occur at the same wavelength as that of the n = 2 to n = 1 transition in H atom is

(A) n = 2 to n = 1 (B) n = 3 to n = 1 (C) n = 3 to n = 2 (D) n = 4 to n = 2

Solution · Q10 **Answer: (D)**

For a one-electron species:

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

For He^+, Z is twice that of H.

So λ is the same when each quantum number of the H transition is doubled:

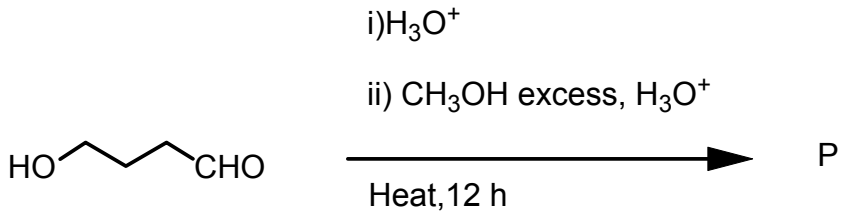
$n_1 = 2 \times 1 = 2$

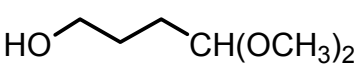
$n_2 = 2 \times 2 = 4$

∴ n = 4 to n = 2

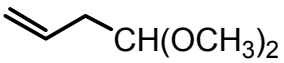
IAPT answer: (D) | **Zigyan answer:** (D)

11. '**P**' in the following reaction is

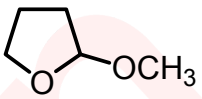




A



B



C



D

(A) A (B) B (C) C (D) D

Solution · Q11 **Answer: (C)**

In acid, the OH group of 4-hydroxybutanal adds to its own CHO group.

This gives a five-membered cyclic hemiacetal, tetrahydrofuran-2-ol.

With excess CH_3OH and acid, the hemiacetal loses water to form an oxocarbenium ion.

CH_3OH adds to this ion, giving the cyclic acetal 2-methoxytetrahydrofuran.

So P is structure C.

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

12. The number of stereoisomers is maximum for (ox = $C_2O_4^{2-}$)

(A) $[Co(ox)_3]^{3-}$ (B) $[Co(ox)_2ClBr]^{3-}$

(C) $[Co(ox)Cl_2Br_2]^{3-}$ (D) $[CoCl_3Br_3]^{3-}$

Solution · Q12 **Answer: (C)**

$[Co(ox)_3]^{3-}$: d and l forms only (2).

$[Co(ox)_2C\ell Br]^{3-}$: one trans form and a cis d, l pair (3).

$[Co(ox)C\ell_2Br_2]^{3-}$: trans $C\ell$, trans Br, and a d, l pair with both pairs cis.

Number of stereoisomers:

$$1 + 1 + 2 = 4$$

$[CoC\ell_3Br_3]^{3-}$: fac and mer (2).

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

13. Maximum number of electrons with $m_s = ½$ which can be accommodated in subshells having total three nodes is

(A) 10 (B) 16 (C) 20 (D) 32

Solution · Q13 **Answer: (B)**

Total nodes in an orbital:

$$(n - l - 1) + l = n - 1 = 3$$

$$\Rightarrow n = 4$$

The subshells are 4s, 4p, 4d and 4f.

Number of orbitals:

$$1 + 3 + 5 + 7 = 16$$

Each orbital takes only one electron of a given spin.

$\therefore$ 16 electrons

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

14. The Hinsberg test of the compound **X** produces a solid compound **Y** that is insoluble in 10 % aq. NaOH. **Y** dissolves in 10 % aq. sulphuric acid. The compound **X** is

(A) $NH_2CH_2CH_2CH_2N(CH_3)_2$ (B) $(CH_3)_2NCH_2CH_2NHCH_3$

(C) $NH_2CH_2C(CH_3)_2CH_2NH_2$ (D) $(CH_3)_2NCH_2N(CH_3)_2$

Solution · Q14 **Answer: (B)**

Y does not dissolve in NaOH, so it has no N–H. Hence X reacts as a secondary amine.

Y dissolves in dilute acid, so it still has a basic tertiary N.

Only (B) has both:

$(CH_3)_2NCH_2CH_2NHCH_3 + C_6H_5SO_2C\ell + NaOH \rightarrow (CH_3)_2NCH_2CH_2N(CH_3)SO_2C_6H_5 + NaC\ell + H_2O$

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

15. An ionic species, M^{3+}, is isoelectronic with $CuCl_2$ and has (Z+2) neutrons. The molar mass of M^{3+} is

(A) 128 (B) 62 (C) 68 (D) 134

Solution · Q15 **Answer: (D)**

Electrons in $CuC\ell_2$:

$$29 + 2 \times 17 = 63$$

M^{3+} also has 63 electrons.

$$\Rightarrow Z = 63 + 3 = 66$$

Number of neutrons:

$$Z + 2 = 68$$

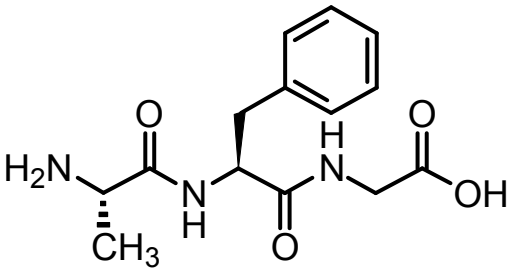
Mass number:

$$66 + 68 = 134$$

$\therefore$ The molar mass is 134 g mol^{-1}.

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

16. In compound **X,** the number of chiral centres and the number of peptide linkages are, respectively



X

(A) 2,3 (B) 3,2 (C) 2,2 (D) 3,3

Solution · Q16 **Answer: (C)**

X is the tripeptide Ala–Phe–Gly.

The α-carbons of the alanine and phenylalanine units are chiral (2).

The glycine CH_2 carries two H atoms, so it is not chiral.

There are two –CO–NH– peptide linkages.

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

17. Which of the following reactions is *NOT* an example of Lewis acid-Lewis base reaction?

(A) $Zn + I_3^- \rightarrow Zn^{2+} + 3I^-$ (B) $I_2 + I_3^- \rightarrow I_5^-$

(C) $CoCl_3 + Cl^- \rightarrow CoCl_4^-$ (D) $SO_3 + H_2O \rightarrow H^+ + HSO_4^-$

Solution · Q17 **Answer: (A)**

(A) is a redox reaction, with transfer of electrons:

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

$I_3^- + 2e^- \rightarrow 3I^-$

In the others, an electron pair is accepted by a Lewis acid from a Lewis base:

(B) acid I_2, base I_3^-

(C) acid $CoC\ell_3$, base $C\ell^-$

(D) acid SO_3, base H_2O

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

18. A student intended to prepare 1000 mL of a 10 ppm solution of K^+ from KCl. He made appropriate calculations, weighed the salt accordingly and prepared the solution. However, after making the solution, he realized that the salt he used was KNO_3 and not KCl. The concentration of K^+ (ppm) in this prepared solution is

(A) 7.37 (B) 10.00 (C) 13.55 (D) 3.86

Solution · Q18 **Answer: (A)**

A 10 ppm solution of volume 1000 mL needs 10 mg of K^+.

Mass of KCℓ calculated, in mg:

$$w = \frac{10 \times 74.55}{39.1}$$

This mass of KNO_3 was weighed. Mass of K^+ in it, in mg:

$$m = w \times \frac{39.1}{101.1}$$

$$\Rightarrow m = \frac{10 \times 74.55}{101.1} \approx 7.37$$

∴ The solution has 7.37 ppm of K^+.

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

19. Oxide A is soluble in NaOH, oxide B in HCl and oxide C in both. The correct set of A, B and C is

A B C

(A) CO_2 SO_2 PbO_2 (B) CO_2 Na_2O ZnO (C) SO_2 ZnO SnO_2 (D) SO_2 BaO Na_2O

Solution · Q19 **As per Zigyan: (B)**

A must be an acidic oxide, B a basic oxide and C an amphoteric oxide.

CO_2 is acidic:

$CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$

Na_2O is basic:

$Na_2O + 2HC\ell \rightarrow 2NaC\ell + H_2O$

ZnO is amphoteric:

$ZnO + 2HC\ell \rightarrow ZnC\ell_2 + H_2O$

$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

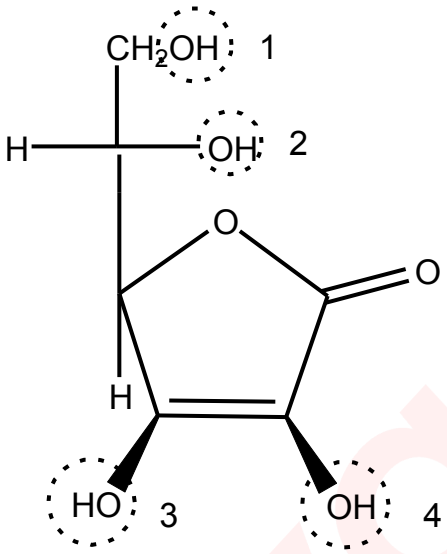
Being amphoteric, ZnO cannot serve as the basic oxide B in (C).

Reference: NCERT Chemistry Class XI (Part I), Unit 3 'Classification of Elements and Periodicity in Properties', section 3.7.3: Na_2O, from the far left of its period, is the example of a most basic oxide; an amphoteric oxide reacts like an acid with a base and like a base with an acid.

Reference: NCERT Science Class X, Chapter 3 'Metals and Non-metals', section 3.2.1: zinc oxide reacts with acids as well as bases, so it is amphoteric.

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

20. Ascorbic acid (Vitamin C), a naturally occurring water soluble vitamin and abundantly found in lemon, shows antioxidant properties. In ascorbic acid, the OH with the lowest pKa is



Ascorbic Acid

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

Solution · Q20 **Answer: (C)**

Removing H^+ from OH group 3 gives an anion whose charge is delocalised through the C=C bond onto the C=O oxygen:

$$^{-}O{-}C{=}C{-}C{=}O \leftrightarrow O{=}C{-}C{=}C{-}O^{-}$$

So the negative charge is shared by two oxygen atoms.

The anion from OH group 4 cannot pass its charge to the C=O oxygen. Groups 1 and 2 are ordinary alcohol groups.

∴ OH group 3 is the most acidic and has the lowest pK_a.

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

21. Compound **'X'** ($C_7H_{12}O_2$) gives - i) a positive silver mirror test and ii) a yellow precipitate on treatment with I_2/NaOH. The compound **'X'** is

(A) 2-hydroxy-3,3-dimethylcyclopentanone (B) 2,5-heptanedione
(C) 2,2-dimethyl-3-oxopentanal (D) 2,2-dimethyl-4-oxopentanal

Solution · Q21 **Answer: (D)**

The silver mirror test needs a –CHO group or an α-hydroxy ketone unit.

A yellow precipitate of CHI_3 with I_2/NaOH needs a $CH_3CO–$ or $CH_3CH(OH)–$ group.

Both are present in 2,2-dimethyl-4-oxopentanal:

$CH_3COCH_2C(CH_3)_2CHO$

(A) and (C) lack the iodoform group. (B) does not give the silver mirror test.

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

22. If the ratio of the concentrations of the oxidized and reduced forms of a species in an electrochemical reaction can be given as [Ox]/[Red] = 1.0×10^{-3}, the correct expression among the following at 25°C is

(A) $E = E^{o} + \frac{1}{3}(0.0592 / n)$

(B) $E - E^{o} = 3 \times (0.0592/ n)$

(C) $E = E^{o} - \frac{1}{3}(0.0592 / n)$

(D) $E - E^{o} = (0.0592/n)^{1/3}$

Solution · Q22 **As per Zigyan: no option is correct**

For the electrode reaction:

$Ox + ne^{-} \rightarrow Red$

At 25 °C,

$$E = E^{\circ} - \frac{0.0592}{n}\log\frac{[Red]}{[Ox]}$$

$$\Rightarrow E = E^{\circ} + \frac{0.0592}{n}\log\frac{[Ox]}{[Red]}$$

$$\Rightarrow E = E^{\circ} + \frac{0.0592}{n}\log\left(10^{-3}\right)$$

$$\therefore E - E^{\circ} = -3 \times \frac{0.0592}{n}$$

No option shows this value.

Why Zigyan differs from IAPT: (B) makes E larger than E°. Here the oxidised form is only one thousandth of the reduced form, so the electrode potential must be lower than E°.

Reference: NCERT Chemistry Class XII (Part I), Unit 2 'Electrochemistry', section 2.3 'Nernst Equation': for the reduction of M^{n+} to M, the electrode potential is E° minus (RT/nF) times the natural logarithm of the reduced form divided by the oxidised ion.

IAPT answer: (B) | **Zigyan answer:** none of the options is correct

23. Among the following numbers, the one in which all the zeros are significant is

(A) 0.0004 (B) 0.0400 (C) 40.000 (D) 0.0040

Solution · Q23 **Answer: (C)**

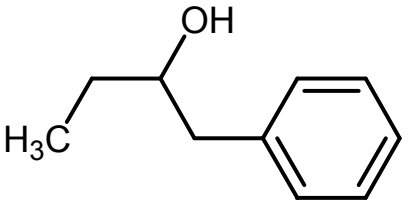
Zeros before the first non-zero digit are not significant.

0.0004, 0.0400 and 0.0040 all begin with such zeros.

In 40.000, every zero comes after 4 and the number has a decimal point, so it has five significant figures.

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

24. Among the following sets of compounds, the one in which a reaction between them followed by hydrolysis that *does not* lead to the formation of 1-phenyl-2- butanol is



1-phenyl-2-butanol

(A) phenylacetaldehyde and ethylmagnesium bromide

(B) butanal and phenylmagnesium bromide

(C) propanal and benzylmagnesium bromide

(D) 1-phenyl-2-butanone and $NaBH_4$

Solution · Q24 **Answer: (B)**

The required alcohol is

$PhCH_2CH(OH)CH_2CH_3$

Grignard additions (followed by hydrolysis) in (A) and (C):

$PhCH_2CHO + C_2H_5MgBr \rightarrow PhCH_2CH(OH)C_2H_5$

$C_2H_5CHO + PhCH_2MgBr \rightarrow PhCH_2CH(OH)C_2H_5$

In (D), $NaBH_4$ reduces the ketone to the same alcohol.

In (B):

$CH_3CH_2CH_2CHO + PhMgBr \rightarrow PhCH(OH)CH_2CH_2CH_3$

This product is 1-phenylbutan-1-ol.

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

PART A-2 · ONE OR MORE CORRECT OPTIONS

Q. 25 – 32 · 6 marks only if all correct options are marked · no negative marking

25. At room temperature, NaCl(s) and KCl(s) were taken in equal masses and dissolved in equal volumes of water in two separate closed containers I and II respectively.

Of the following, correct option/s is/are

(A) To compare molarities in (I) and (II), masses of both the solutions need to be known

(B) Molalities cannot be compared without measuring the mass of water added in each case

(C) If (I) and (II) are completely transferred into another container (III), $[Cl^-]$ in (III) will be sum of that in (I) and (II)

(D) Information given is sufficient to compare the vapour pressures in (I) and (II)

Solution · Q25 **Answer: (D)**

(A) Molarity needs the moles of solute and the volume of solution. Measured volumes serve this, so masses of the solutions are not required. False.

(B) Equal volumes of water at the same temperature have equal masses, so molalities can be compared. False.

(C) Concentrations do not add on mixing:

$$[C\ell^-] = \frac{n_1 + n_2}{V_1 + V_2}$$

False.

(D) For equal masses, NaCℓ (58.5 g mol^{-1}) gives more moles than KCℓ (74.5 g mol^{-1}). Each gives two ions, and the mass of water is the same.

So I has the greater lowering and the lower vapour pressure. True.

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

26. In a pair of isomers of molecular formula C_5H_8, both the compounds undergo catalytic hydrogenation to form compounds of molecular formula C_5H_{10}. On ozonolysis followed by oxidative workup (H_2O_2), one of the isomers gives a diacid ($C_5H_8O_4$) while the other isomer gives a ketoacid ($C_5H_8O_3$). The pair/s which give/s above set of reactions is/are

(A) 3-ethylcyclopropene and 1-pentyne

(B) cyclopentene and 1-methylcyclobutene

(C) 1-methylcyclobutene and 3-methylcyclobutene

(D) 1,2-dimethylcyclopropene and 3-methylcyclobutene

Solution · Q26 **Answer: (B), (C)**

Uptake of only one H_2 suggests a cycloalkene.

A ring CH=CH bond gives a diacid; a ring $C(CH_3)$=CH bond gives a keto acid.

Cyclopentene (diacid):

$HOOC(CH_2)_3COOH$

1-Methylcyclobutene (keto acid):

$CH_3COCH_2CH_2COOH$

3-Methylcyclobutene (diacid):

$HOOCCH_2CH(CH_3)COOH$

So (B) and (C) fit.

(A) 1-Pentyne gives butanoic acid, not a keto acid.

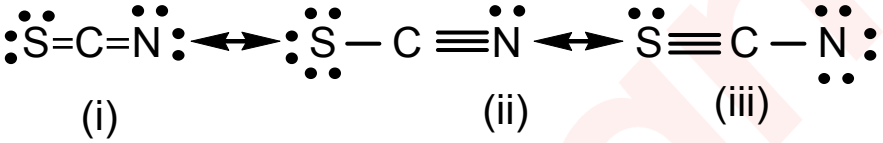
(D) 1,2-Dimethylcyclopropene gives a diketone:

$CH_3COCH_2COCH_3$

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

27. The resonance structures of SCN^- are given below along with the S-C and C-N bond lengths

	S-C (in pm)	C-N (in pm)
SCN^-	165	117
Single bond	181	147
Double bond	155	128
Triple bond	-----	116



(i) (ii) (iii)

Among the following, the *incorrect* statement/s is/ are

(A) The contribution from resonance structures (i) and (ii) is more important than that from structure (iii)

(B) The formal charge on S in structure (iii) is zero

(C) The degree of contribution of these structures is in the order: i > ii > iii

(D) The formal charge on N in structure (ii) is zero

Solution · Q27 **As per Zigyan: (B), (C)**

Formal charge (valence electrons V, lone-pair electrons L, bonding electrons B):

$$FC = V - L - B/2$$

S in (iii):

$$FC = 6 - 2 - 3 = +1$$

So (B) is incorrect.

N in (ii):

$$FC = 5 - 2 - 3 = 0$$

So (D) is correct.

N in (iii):

$$FC = 5 - 6 - 1 = -2$$

These large charges make (iii) the least important, so (A) is correct.

The observed C–N length, 117 pm, is almost the triple bond value (116 pm) and far from the double bond value (128 pm).

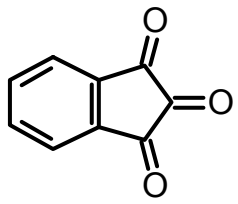
So (ii) contributes more than (i), and the order in (C) is incorrect.

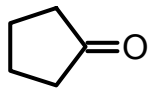
Reference: NCERT Chemistry Class XI (Part I), Unit 4 'Chemical Bonding and Molecular Structure', section 4.1.4: formal charge is the free atom's valence electrons minus its lone-pair electrons minus half its bonding electrons; the lowest energy structure generally has the smallest formal charges.

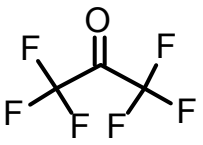
Reference: The same unit, section 4.3.5, Problem 4.4: a measured bond length is compared with standard multiple-bond lengths to describe the resonance hybrid.

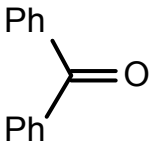
IAPT answer: (B) or (B), (C) | **Zigyan answer:** (B), (C)

28. The compound/s which form/s stable hydrate/s is/are


(a)


(b)


(c)


(d)

(A) a (B) b (C) c (D) d

Solution · Q28 **Answer: (A), (C)**

A stable hydrate is favoured when the C=O carbon is strongly electron deficient.

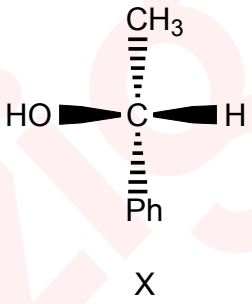
(a) Ninhydrin: the middle C=O lies between two C=O groups. Its hydrate also has intramolecular H-bonding.

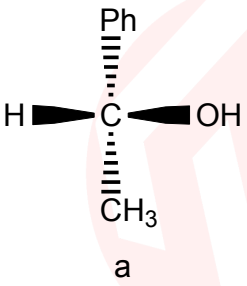
(c) Hexafluoroacetone: two CF_3 groups (strong –I effect) make the carbonyl carbon highly electrophilic.

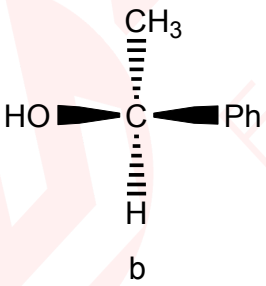
(b) and (d) have no such activation, so the ketone is favoured.

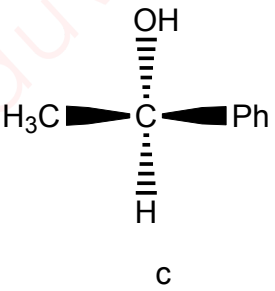
IAPT answer: (A), (C) | **Zigyan answer:** (A), (C)

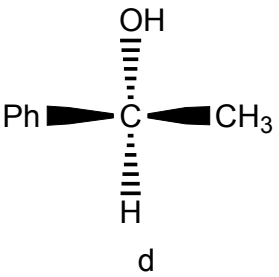
29. The formula/e which also represent/s a compound with formula **X** is/are


X


a


b


c


d

(A) a (B) b (C) c (D) d

Solution · Q29 **Answer: (A), (C)**

Priority order:

$$OH > Ph > CH_3 > H$$

Horizontal bonds point towards the viewer and vertical bonds away, as in a Fischer projection.

In X, H is horizontal and 1 → 2 → 3 is anticlockwise. Reversing this, X is R.

(a) H horizontal, anticlockwise: R.

(b) H vertical, anticlockwise: S.

(c) H vertical, clockwise: R.

(d) H vertical, anticlockwise: S.

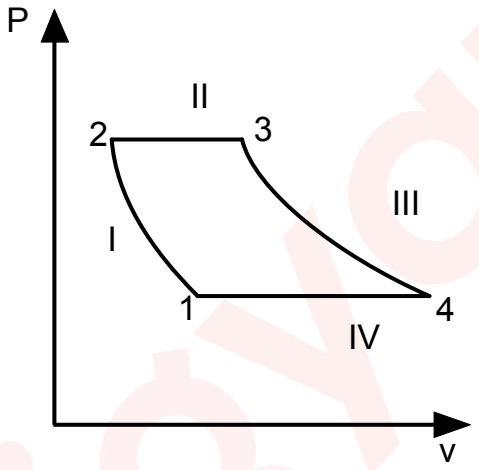
So a and c represent X.

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

30. Following is the P vs V plot of a cyclic process 1 → 2, 2 → 3, 3 → 4, 4 → 1, denoted as I, II, III and IV respectively for a system of one mole of an ideal gas.

Assume that there is heat exchange between the system and surroundings only in II and IV.

Which of the following is/are correct?



(A) In II and IV ΔS is zero

(B) In I and III, ΔS is zero

(C) I and III are isothermal and reversible

(D) In II and IV, change in internal energy of the gas (ΔU) is zero

Solution · Q30 **Answer: (B)**

I and III have no heat exchange, so they are adiabatic. Taken as reversible paths:

$$q_{rev} = 0$$

$$\Rightarrow \Delta S = 0$$

So (B) is true. An isothermal volume change of an ideal gas needs heat, so (C) is false.

II and IV are constant pressure steps in which V, and hence T, changes:

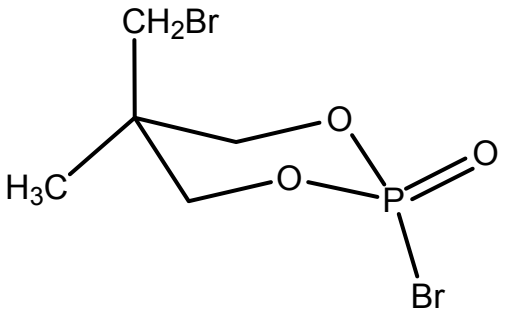
$$\Delta U = C_V \Delta T \neq 0$$

$$\Delta S = C_P \ln(T_f/T_i) \neq 0$$

So (A) and (D) are false.

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

31. For the given compound, % s character of phosphorous hybrid orbitals which contribute to various bonds are given in the table below.



Bond	% s character
P=O	40
P-Br	< 20
P-O	20

This difference in % 's' character of various phosphorous bonds could be due to

(A) The large size of bromine atom

(B) The large electronegativity difference between P and O

(C) Increased overlap of σ-orbitals of terminal P-O bond

(D) Stronger covalent character of P-O in cyclic oxygen atoms

Solution · Q31 **Answer: (A), (C)**

By Bent's rule and orbital overlap, P shares its 3s character unequally among its four σ bonds.

(A) Large, diffuse Br orbitals overlap poorly with P, so P uses mainly p character in P–Br. True.

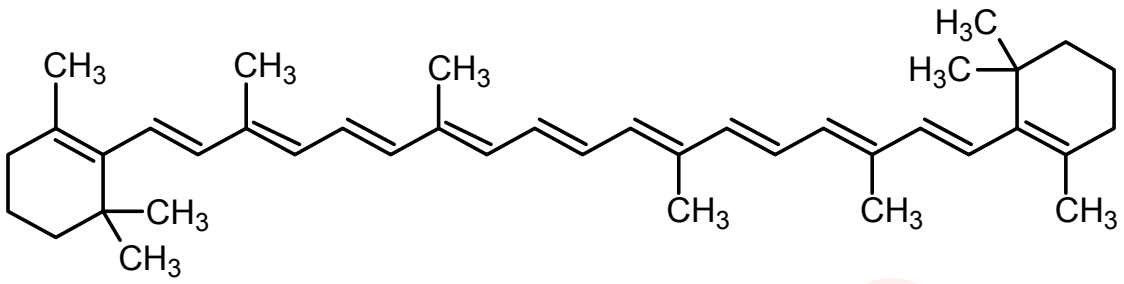
(B) The P and O electronegativity difference is common to both kinds of P–O bond, so it cannot explain 40 and 20. Electronegativity alone would also give P–Br more s character than ring P–O. False.

(C) The short terminal P–O bond has greater σ overlap, favouring more s character. True.

(D) The ring P–O bonds are single bonds; they are not more strongly covalent than the terminal P=O bond. False.

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

32. β-carotene and related compounds are plant pigments that give red, orange and yellow vegetables their vibrant colour. The structure of β-carotene is given below.



It is approved as a food additive in many countries. The correct statement/s that describe/s β-carotene is/are

(A) It is a strong oxidizing agent

(B) It reacts with singlet oxygen, an excited form of O_2, to produce an epoxide

(C) It absorbs red/yellow light of electromagnetic spectrum

(D) It comes in the oil phase when carrots are cooked in oil and water in a curry

Solution · Q32 **As per Zigyan: (D)**

(A) β-Carotene is easily oxidised and acts as an antioxidant. False.

(B) It removes singlet oxygen mainly by physical quenching. In chemical attack, O_2 can add across a diene to form the 5,8-endoperoxide, which has an O–O bridge. It is not an epoxide. False.

(C) Its long conjugated system absorbs blue light (about 450 nm), so it looks orange. False.

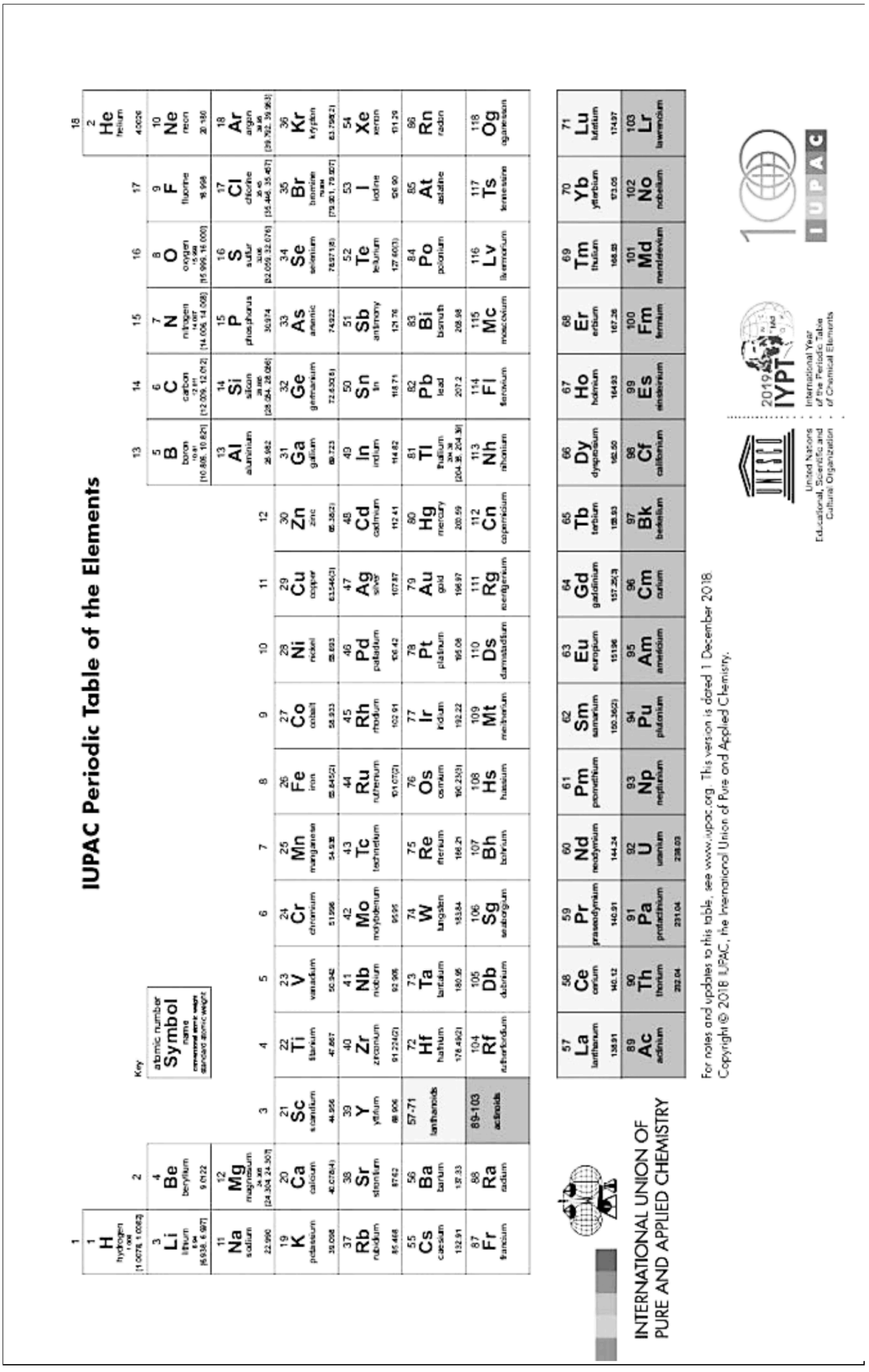
(D) It is a non-polar hydrocarbon, $C_{40}H_{56}$, so it dissolves in oil rather than water. True.

Why Zigyan differs from IAPT: an epoxide has one oxygen atom in a three-membered ring, whereas the ring product identified from singlet oxygen is the 5,8-endoperoxide with two oxygen atoms.

Reference: Stratton, Schaefer and Liebler, Chemical Research in Toxicology 6 (1993) 542, abstract: the singlet oxygen oxidation products of β-carotene were identified as β-ionone, three β-apo-carotenals and β-carotene 5,8-endoperoxide.

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

Given in the question paper



ANSWER KEY

IOQC 2021-22 · PAPER CODE 31

32
QUESTIONS · 120 MARKS

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

1	(A)	2	(A)	3	(C)	4	(C)	5	(C)
6	(B)	7	(A)	8	(C)	9	(C)	10	(D)
11	(C)	12	(C)	13	(B)	14	(B)	15	(D)
16	(C)	17	(A)	18	(A)	19	(B)★	20	(C)
21	(D)	22	–★	23	(C)	24	(B)	25	(D)
26	(B), (C)	27	(B), (C)★	28	(A), (C)	29	(A), (C)	30	(B)
31	(A), (C)	32	(D)★						

★ Answers as per Zigyan

- **Q19** — As per Zigyan: (B); IAPT key (B) or (C).
- **Q22** — As per Zigyan: no option is correct; IAPT key (B).
- **Q27** — As per Zigyan: (B), (C); IAPT key (B) or (B), (C).
- **Q32** — As per Zigyan: (D); IAPT key (B), (D).

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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

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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

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PHYSICS



Sulokya Bibhuty
Class XII
3 Years Classroom
Above MAS

PHYSICS



Saksham Bishnoi
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RESULTS · 2021 – 2026

Our toppers, year by year

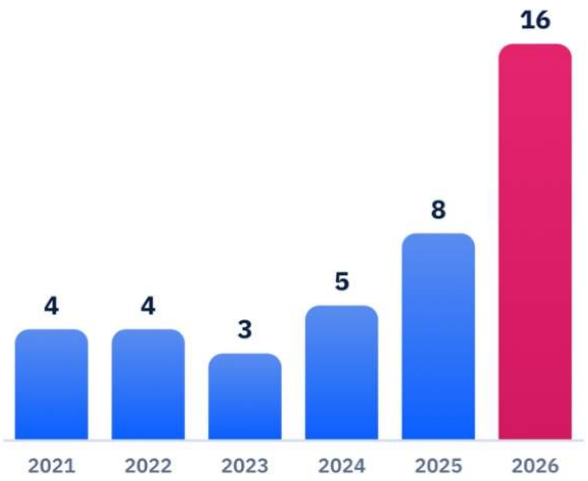
40
JEE Advanced selections in 6 years

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** AIR 168 · 4 Years Classroom	**Saksham Bishnoi** AIR 811 · 99.95 %ile
2025	**Chakshu** AIR 4,233 · 2 Years Classroom	**Chakshu** AIR 8,538 · 99.44 %ile
2024	**Harshit** AIR 777 · 2 Years Classroom	**Harshit** AIR 1,473 · 99.91 %ile
2023	**Aditya Jain** AIR 2,373 · 2 Years Classroom	**Aditya Jain** AIR 2,503 · 99.79 %ile
2022	**Rachit Sharma** AIR 698 · 1 Year Classroom	**Rachit Sharma** AIR 1,016 · 99.90 %ile
2021	**Sparsh Mittal** AIR 2,237 · 1 Year Classroom	**Sparsh Mittal** 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.

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