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PREVIOUS YEAR PAPER · 2025

OLYMPIAD · STAGE I

NSEC

National Standard Examination in Chemistry

2025

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 2025, 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

JEE ADVANCED 2026	JEE MAIN 2026
AIR 1,315	AIR 1,095
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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
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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, $h = 6.63 \times 10^{-34}\,Js$

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. Among Ca, V, Cr and Mn, the second Ionization Energy is the highest for

(A) V (B) Ca (C) Cr (D) Mn

Solution · Q1 **Answer: (C)**

Configurations of the M^+ ions:

Ca^+: $[Ar]4s^1$

V^+: $[Ar]3d^4$

Cr^+: $[Ar]3d^5$

Mn^+: $[Ar]3d^5 4s^1$

In Cr^+, the electron has to leave the stable half-filled $3d^5$ subshell.

∴ The second ionisation energy is highest for Cr.

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

2. Among the given compounds, the permanent dipole moment is exhibited by

(A) BF_3 (B) XeF_4 (C) SiF_4 (D) SF_4

Solution · Q2 **Answer: (D)**

BF_3 (trigonal planar), XeF_4 (square planar) and SiF_4 (tetrahedral) are symmetrical, so their bond dipoles cancel.

SF_4 has one lone pair on S and is see-saw shaped.

∴ SF_4 has a permanent dipole moment.

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

3. Choose the correct statement

(A) XeO_4 and XeO_2F_2 have tetrahedral geometry with no lone pairs

(B) XeO_2F_2 is trigonal planar with two oxygen atoms in the trigonal plane

(C) XeO_4 has square planar geometry with no lone pair of electrons

(D) XeO_2F_2 is distorted tetrahedral and XeO_4 is square planar

Solution · Q3 **As per Zigyan: no option is correct**

XeO_4: four Xe–O double bonds and no lone pair on Xe.

⇒ It is tetrahedral.

XeO_2F_2: two double bonds, two single bonds and one lone pair on Xe.

⇒ Trigonal bipyramidal electron arrangement and see-saw (distorted tetrahedral) shape.

Both O atoms and the lone pair are equatorial; the F atoms are axial.

(A) XeO_2F_2 has a lone pair, ∴ false.

(B) XeO_2F_2 is not trigonal planar, ∴ false.

(C) and (D): XeO_4 is not square planar, ∴ false.

∴ Each of the four options contains a wrong statement.

Reference: NCERT Chemistry Class XI (Part I), Unit 4 'Chemical Bonding and Molecular Structure', section 4.4: VSEPR counts a multiple bond as one pair; AB_4 molecules are tetrahedral, and AB_4E molecules are see-saw (distorted tetrahedron) with the lone pair equatorial.

IAPT answer: question dropped by IAPT | **Zigyan answer:** none of the options is correct

4. $HClO_4$ is used in etching of liquid crystal displays whereas $H_2C_2O_4$ is present in vegetables like spinach which causes itching to throat. Consider the following statements for these compounds

(i) $HClO_4$ is a stronger acid than $H_2C_2O_4$

(ii) $HClO_4$ is a weaker acid than $H_2C_2O_4$

(iii) $H_2C_2O_4$ is reducing agent and $HClO_4$ is oxidizing agent

(iv) The conjugate base of $HClO_4$ is stronger than the conjugate base of $H_2C_2O_4$

The correct statements are

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

Solution · Q4 **Answer: (A)**

$HC\ell O_4$ is a very strong acid, while $H_2C_2O_4$ is a weak acid.

⇒ (i) is true and (ii) is false.

$C\ell$ in $HC\ell O_4$ is in its highest state (+7), so $HC\ell O_4$ is an oxidising agent.

C in $H_2C_2O_4$ (+3) can be oxidised to CO_2 (+4), so it is a reducing agent.

⇒ (iii) is true.

A stronger acid has a weaker conjugate base, ∴ (iv) is false.

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

5. Compounds A, B, C and D are solid trihalides, all containing the same central atom. Compounds A, B, C are pale lilac (pale purple) in colour but compound D is dark green. Compound A is insoluble in water and alcohol but rest of the three are soluble in both the solvents.

The correct statement indicating the central atom and halides present in each of the compounds is

(A) Central atom is As, halides are F^-, Cl^-, Br^-, I^- respectively

(B) Central atom is Co, halides are F^-, Cl^-, Br^-, I^- respectively

(C) Central atom is Cr, halides are F^-, Cl^-, Br^-, I^- respectively

(D) Central atom is Nd, halides are F^-, Cl^-, Br^-, I^- respectively

Solution · Q5 **Answer: (D)**

AsF_3 is not a solid.

For Co(III), CoF_3 is the only stable trihalide.

CrF_3 is green, not lilac.

Neodymium fits all the observations:

NdF_3, $NdC\ell_3$ and $NdBr_3$ are pale lilac to violet, and NdI_3 is green.

Only NdF_3 is insoluble in water and alcohol.

$\therefore$ A, B, C and D contain F^-, $C\ell^-$, Br^- and I^- respectively.

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

6. You are given a set of oxides: SrO, MoO_3 and ZrO_2. All the three show different reactions with water. Two of these oxides react with water whereas the third one is insoluble in water at room temperature (25-30 ^{o} C). The statement that is correct about these oxides is

(A) MoO_3 is insoluble in water, SrO gives a basic solution and ZrO_2 gives an acidic solution in water.

(B) MoO_3 is insoluble in water, SrO gives an acidic solution and ZrO_2 gives a basic solution in water.

(C) ZrO_2 is insoluble in water, SrO gives a basic solution and MoO_3 gives an acidic solution in water.

(D) ZrO_2 is insoluble in water, MoO_3 gives a basic solution and SrO gives an acidic solution in water.

Solution · Q6 **Answer: (C)**

SrO is a basic oxide:

$SrO + H_2O \rightarrow Sr(OH)_2$

MoO_3 (Mo in +6 state) is an acidic oxide. It dissolves slightly to give an acidic solution:

$MoO_3 + H_2O \rightarrow H_2MoO_4$

ZrO_2 is insoluble in water.

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

7. The complex that shows maximum number of isomers is (where gly = glycine, PEt_3= triethylphosphine)

(A) $[Pt(ox)(NH_3)_2]$ (B) $[Pd(PEt_3)_2BrCl]$

(C) $[Pd(gly)(ox)]$ (D) $[Pt(NH_3)(NO_2)(PEt_3)_2]^+$

Solution · Q7 **Answer: (D)**

$[Pt(ox)(NH_3)_2]$: ox can only occupy cis positions, so there is one form.

$[Pd(PEt_3)_2BrC\ell]$: cis and trans forms, 2 isomers.

$[Pd(gly)(ox)]$: type M(AB)(AA), one form.

$[Pt(NH_3)(NO_2)(PEt_3)_2]^+$: cis and trans forms, each with nitro ($-NO_2$) and nitrito ($-ONO$) linkage isomers.

$$\Rightarrow 2 \times 2 = 4$$

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

8. The spin-only magnetic moment for $[Ni(H_2O)_6](ClO_4)_2$ should be

(A) 3.87 (B) 2.83 (C) 1.72 (D) 5.92

Solution · Q8 **Answer: (B)**

Ni^{2+} is $3d^8$ in an octahedral field:

$t_{2g}^6\, e_g^2$

So the number of unpaired electrons is two.

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

$$\Rightarrow \mu = \sqrt{8} = 2.83\ BM$$

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

9. The correct order of Δ_o for the following given transition metal complexes is

(A) $Rh(CN)_6^{3-} > Rh(NH_3)_6^{3+} > RhCl_6^{3-}$ (B) $Rh(NH_3)_6^{3+} > RhCl_6^{3-} > Rh(CN)_6^{3-}$

(C) $RhCl_6^{3-} > Rh(CN)_6^{3-} > Rh(NH_3)_6^{3+}$ (D) $Rh(CN)_6^{3-} > RhCl_6^{3-} > Rh(NH_3)_6^{3+}$

Solution · Q9 **Answer: (A)**

All are octahedral Rh(III) complexes, so Δ_o depends on the ligand field strength:

$$CN^- > NH_3 > C\ell^-$$

$$\therefore Rh(CN)_6^{3-} > Rh(NH_3)_6^{3+} > RhC\ell_6^{3-}$$

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

10. The correct rank of bond order for O_2^+, O_2^-, CO and O_2^{2-} is

(A) 3, 1.5, 3, 1 (B) 2, 5, 1, 1 (C) 1.5, 2.5, 3, 2 (D) 2.5, 1.5, 3, 1

Solution · Q10 **Answer: (D)**

By molecular orbital theory,

$$\text{B.O.} = \frac{N_b - N_a}{2}$$

O_2^+ (15 e^-): (10 – 5)/2 = 2.5

O_2^- (17 e^-): (10 – 7)/2 = 1.5

CO (14 e^-): (10 – 4)/2 = 3

O_2^{2-} (18 e^-): (10 – 8)/2 = 1

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

11. The correct basicity order in water for the following is

(A) $NMe_3 > NH_3 > NH_2NH_2 > NF_3$ (B) $NH_2OH > NH_3 > NF_3 > NMe_3$

(C) $NH_3 < NF_3 < NMe_3 < NH_2NH_2$ (D) $NMe_3 < NH_2OH < NH_3 < NF_3$

Solution · Q11 **Answer: (A)**

NMe_3: the +I effect of three methyl groups makes it a stronger base than NH_3.

NH_2NH_2: the –I effect of the second NH_2 group makes it weaker than NH_3.

NF_3: the strong –I effect of three F atoms makes it almost non-basic.

$$\therefore NMe_3 > NH_3 > NH_2NH_2 > NF_3$$

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

12. A 1.25 g Shelcal 500 tablet contains 1250 mg of $CaCO_3$. A student dissolved one tablet in water to make 1.0 L solution(X). 10.0 mL of solution(X) was titrated with 0.0198 M EDTA-MgEDTA mixture in the burette and found the $CaCO_3$ content matched the label claim. (Molar mass of $CaCO_3$ = 100.0 g/mol).

The correct option is

(A) The burette reading is 6.31 mL and molarity of Shelcal solution is 0.125 M

(B) The burette reading is 10.00 mL and molarity of Shelcal solution is 0.0125 M

(C) The burette reading is 6.31 mL and molarity of Shelcal solution is 0.0125 M

(D) The burette reading is 10.00 mL and molarity of Shelcal solution is 0.125 M

Solution · Q12 **Answer: (C)**

Molarity of solution X:

$$M = 1.250/(100.0 \times 1.0) = 0.0125 \text{ mol } L^{-1}$$

Ca^{2+} reacts with EDTA in a 1 : 1 ratio.

$$10.0 \times 0.0125 = V \times 0.0198$$

$$\Rightarrow V = 6.31 \text{ mL}$$

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

13. When 10 mL of 0.01 M HCl was added to a mixture of 0.5 M NH_3 and 0.5 M NH_4Cl, the pH of the resultant solution will be (pK_b of NH_3 is 4.75)

(A) 9.07 (B) 9.75 (C) 9.25 (D) 8.75

Solution · Q13 **As per Zigyan: (C)**

For the basic buffer before adding the acid,

$$pOH = pK_b + \log([NH_4^+]/[NH_3])$$

$$\Rightarrow pOH = 4.75 + \log(0.5/0.5) = 4.75$$

$$\Rightarrow pH = 14 - 4.75 = 9.25$$

The added HCℓ is only 0.1 mmol.

The buffer volume is not given. Taking it as large enough, the ratio of salt to base hardly changes.

$$\therefore pH \approx 9.25$$

Reference: NCERT Chemistry Class XI (Part I), Unit 6 'Equilibrium', section 6.12 'Buffer Solutions': a buffer resists a change of pH when a little acid or alkali is added, and an ammonium chloride and ammonium hydroxide buffer works near pH 9.25.

Check: with an assumed 100 mL of buffer, the base to salt ratio only changes from 50 : 50 to 49.9 : 50.1, so the pH stays 9.25.

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

14. The correct order of CO triple bond character in the given metal carbonyl complexes is

(A) $[Fe(CO)_4]^{-2} > [Co(CO)_4]^{-1} > [Mn(CO)_6]^+ > Ni(CO)_4$

(B) $Ni(CO)_4 > [Mn(CO)_6]^+ > [Co(CO)_4]^{-1} > [Fe(CO)_4]^{-2}$

(C) $[Mn(CO)_6]^+ > [Fe(CO)_4]^{-2} > [Co(CO)_4]^{-1} > Ni(CO)_4$

(D) $[Mn(CO)_6]^+ > Ni(CO)_4 > [Co(CO)_4]^{-1} > [Fe(CO)_4]^{-2}$

Solution · Q14 **Answer: (D)**

More negative charge on the metal gives more back donation into the π* orbital of CO.

This lowers the C–O bond order, so the triple bond character falls.

Oxidation states of the metals:

Mn(+1), Ni(0), Co(−1), Fe(−2)

∴ order of CO triple bond character:

$$[Mn(CO)_6]^+ > Ni(CO)_4 > [Co(CO)_4]^- > [Fe(CO)_4]^{2-}$$

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

15. Consider the following statements for the square planar complex $[Pt(en)(NCS)_2]$. Identify the correct statements

I. It is thermodynamically more stable than $[Pt(NH_3)_2(NCS)_2]$

II. It can exhibit stereoisomerism.

III. It can exhibit structural isomerism.

IV. It is not easily soluble in polar solvents.

The correct option is

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

Solution · Q15 **Answer: (C)**

I. True: en forms a chelate ring (chelate effect).

II. False: en can join only *cis* positions, so the two NCS ligands are fixed *cis*; the planar complex is also optically inactive.

III. True: NCS^- is ambidentate, so linkage isomers (N-bonded and S-bonded) are possible.

IV. Neutral, non-ionic complex, so it is sparingly soluble in polar solvents.

∴ I, III and IV (the only option without II).

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

16. Which of the following molecules is odd one out in its bonding properties?

(A) CO_3^{2-} (B) SO_3 (C) CH_4 (D) BF_3

Solution · Q16 **Answer: (C)**

CO_3^{2-}, SO_3 and BF_3 are sp^2, trigonal planar, and have π bonding along with σ bonds (in BF_3 by back bonding).

CH_4 is sp^3, tetrahedral, and has only σ bonds.

∴ CH_4 is the odd one.

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

17. Which one of the following reactions will give a product that has zero net dipole moment?

(A) Hex-3-yne with H_2-Pd/C (B) Hex-3-yne with Na in liquid ammonia

(C) Hex-2-yne with H_2-Pd/C (D) Hex-2-yne with Na in liquid ammonia

Solution · Q17 **As per Zigyan: (B)**

Na in liquid NH_3 reduces hex-3-yne to *trans*-hex-3-ene:

$$CH_3CH_2C{\equiv}CCH_2CH_3 + 2[H] \rightarrow CH_3CH_2CH{=}CHCH_2CH_3$$

The two ethyl groups are on opposite sides, so their bond moments cancel.

∴ net dipole moment is zero for this symmetrical *trans* alkene.

Reference: NCERT Chemistry Class XI (Part II), Unit 9 'Hydrocarbons', sections 9.3.3 and 9.3.4: Na in liquid ammonia gives *trans* alkenes; the symmetrical *trans*-but-2-ene has zero dipole moment.

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

18. Which of the following statements is ***not*** correct regarding the aromatic electrophilic substitution reactions of aniline or its derivatives under standard laboratory conditions?

(A) A*niline*, when subjected to bromination with Br_2/H_2O, undergoes rapid tribromination to form 2,4,6-tribromoaniline as the major product.

(B) During direct nitration of aniline with a nitrating mixture, meta-substitution is observed predominantly due to protonation of the amino group under acidic conditions.

(C) The acetamido group ($-NHCOCH_3$), being less basic than $-NH_2$, shows stronger +M (mesomeric) effect and thus activates the ring more than the free amino group.

(D) Acetylation of aniline reduces its reactivity towards electrophilic substitution and facilitates controlled monosubstitution at ortho and para positions.

Solution · Q18 **As per Zigyan: (C)**

In $-NHCOCH_3$, the N lone pair is also in resonance with the C=O group.

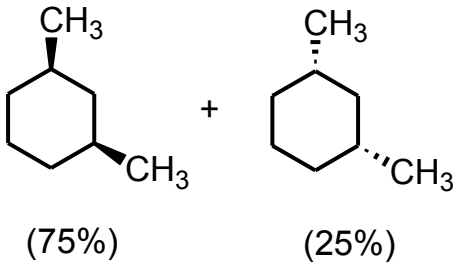
So it is less available to the ring: the +M effect and activation are weaker than for $-NH_2$.

$\therefore$ statement (C) is not correct.

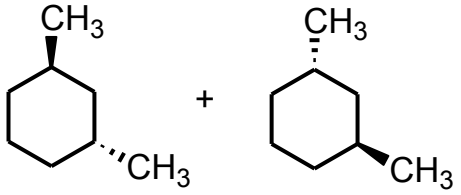
Reference: NCERT Chemistry Class XII (Part II), Unit 9 'Amines', section 9.6, electrophilic substitution: $-NHCOCH_3$ activates the ring less than $-NH_2$.

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

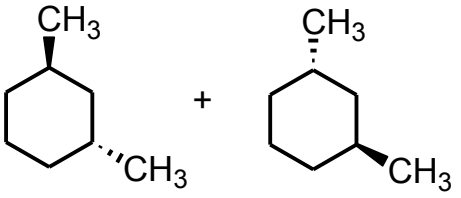
19. The optically active mixtures from the following is:

(A) 

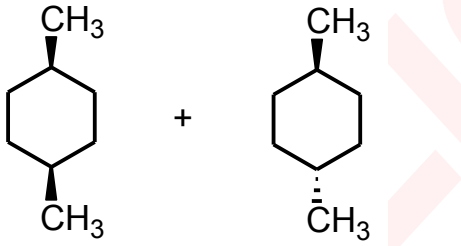
(75%) (25%)

(B) 

(50%) (50%)

(C) 

(75%) (25%)

(D) 

(75%) (25%)

Solution · Q19 **Answer: (C)**

(A) Both drawings are *cis*-1,3-dimethylcyclohexane (meso), so the mixture is inactive.

(B) The two *trans* forms are enantiomers in equal amounts: racemic, inactive.

(C) The same enantiomers are in the ratio 75 : 25, so one is in excess: active.

(D) Both *cis* and *trans* 1,4-dimethylcyclohexane are achiral: inactive.

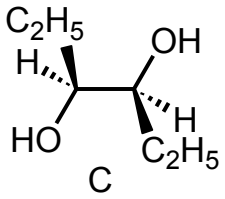
IAPT answer: (C) | **Zigyan answer:** (C)

20. Alkenes can be converted to *cis*-diols using OsO_4 + $NaHCO_3$ and *trans*-diols via the epoxide followed by acid hydrolysis.

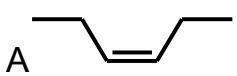
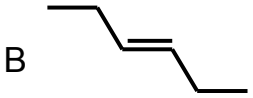
Compound **C** given below is formed from:

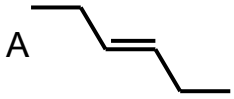
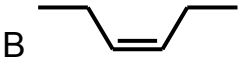
(i) alkene **A** by treatment with OsO_4 + $NaHCO_3$

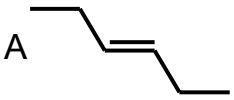
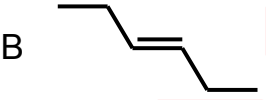
(ii) the epoxide of alkene **B** followed by acid hydrolysis.

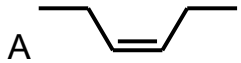


The structures of **A** and **B** are:

(A)  

(B)  

(C)  

(D)  

Solution · Q20 **Answer: (B)**

In C, both stereocentres are S (3S,4S), so it is the chiral diol, not the meso form.

It is obtained as a racemic mixture from either route:

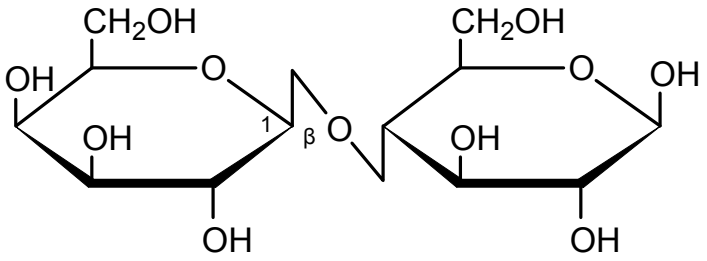
OsO_4 (*syn* addition): *trans* alkene → (±)-diol

Epoxide, then H_3O^+ (*anti* addition): *cis* alkene → (±)-diol

∴ A is *trans*-hex-3-ene and B is *cis*-hex-3-ene.

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

21. The disaccharide shown below undergoes enzymatic hydrolysis. The monosaccharide units formed upon complete hydrolysis of the disaccharide are



(A) Glucose and Glucose
(B) Glucose and Galactose
(C) Galactose and Fructose
(D) Galactose and Galactose

Solution · Q21 **Answer: (B)**

Left ring (–OH groups: C-2 down, C-3 up, C-4 up): D-galactose.

Right ring (–OH groups: C-2 down, C-3 up; C-4 oxygen down): D-glucose.

The sugar is lactose (β-1,4 link), so hydrolysis gives glucose and galactose.

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

22. The correct order of the isoelectric points (pI) of Alanine (Ala), Arginine (Arg), and Glutamic acid (Glu) is:

(A) Ala > Arg > Glu (B) Arg > Ala > Glu (C) Glu > Arg > Ala (D) Glu > Ala > Arg

Solution · Q22 **Answer: (B)**

Arg has a basic side chain, Ala a neutral one and Glu an acidic one.

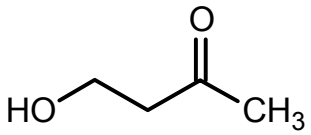
Approximate pI values:

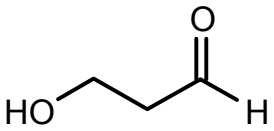
Arg 10.8, Ala 6.0, Glu 3.2

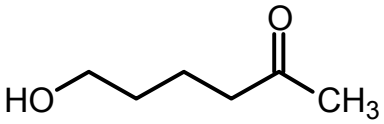
∴ Arg > Ala > Glu

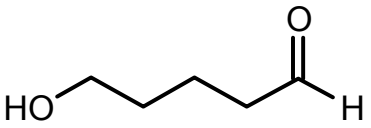
IAPT answer: (B) | **Zigyan answer:** (B)

23. Which of the following most readily forms a cyclic hemiacetal in the presence of an acid catalyst?

(A) 

(B) 

(C) 

(D) 

Solution · Q23 **Answer: (D)**

An aldehyde is more reactive than a ketone, and a six-membered ring forms readily.

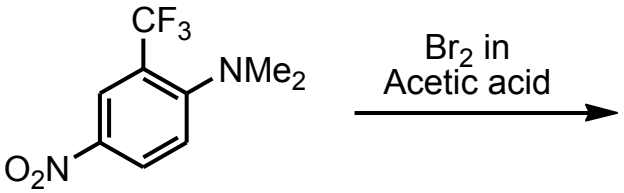
(A) and (B) would give strained four-membered rings.

(C) can give a six-membered ring, but it is a less reactive ketone.

(D) 5-Hydroxypentanal easily gives a six-membered cyclic hemiacetal.

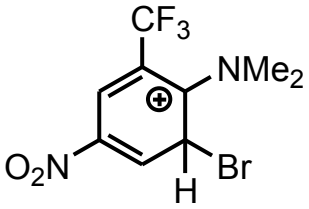
IAPT answer: (D) | **Zigyan answer:** (D)

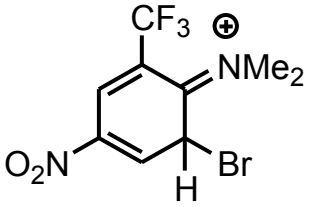
24. A medicinal chemist is exploring halogenated aromatic compounds as potential precursors for drug molecules. In one experiment, she attempts bromination of a substituted aromatic ring in the presence of acetic acid, a typical aromatic electrophilic substitution (AES) condition.

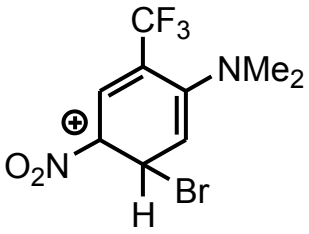


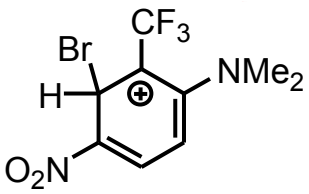
The chemist proposed an intermediate for the above reaction with the following resonance structures.

Which of the following structures contributes the most to the stability of the intermediate?

(A)


(B)


(C)


(D)


Solution · Q24 **Answer: (B)**

The Br adds *ortho* to the activating $-NMe_2$ group, giving an arenium ion.

In (B), the N lone pair forms a $C{=}N^+$ bond, so every C and N atom has a complete octet.

It also has one more covalent bond than the carbocation forms.

In (A), (C) and (D), a carbon atom has only six electrons; in (C) and (D) that carbon also carries a strongly electron-withdrawing group.

∴ (B) contributes the most.

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

25. Which sequence of reagents, when used in the correct order, will convert benzene to *m*-nitro-n-propylbenzene?

(A) (i) $CH_3COCl/AlCl_3$, (ii) HNO_3/H_2SO_4, (iii) Zn/Hg, HCl

(B) (i) HNO_3/H_2SO_4, (ii) $CH_3CH_2CH_2Cl/AlCl_3$

(C) (i) HNO_3/H_2SO_4, (ii) $CH_3CH_2COCl/AlCl_3$, (iii) $H_2NNH_2/NaOH$

(D) (i) $CH_3CH_2COCl/AlCl_3$, (ii) HNO_3/H_2SO_4, (iii) $H_2NNH_2/NaOH$

Solution · Q25 **Answer: (D)**

The acyl group goes in first, as it does not rearrange and is meta-directing.

With $CH_3CH_2COC\ell$ and $A\ell C\ell_3$:

$C_6H_6 \rightarrow C_6H_5COCH_2CH_3$

With HNO_3/H_2SO_4:

$C_6H_5COCH_2CH_3 \rightarrow m\text{-}O_2NC_6H_4COCH_2CH_3$

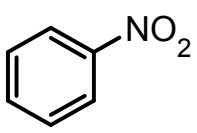
Wolff–Kishner reduction ($H_2NNH_2/NaOH$) converts C=O into CH_2:

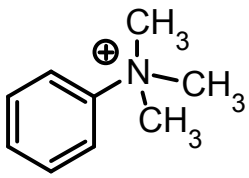
$m\text{-}O_2NC_6H_4COCH_2CH_3 \rightarrow m\text{-}O_2NC_6H_4CH_2CH_2CH_3$

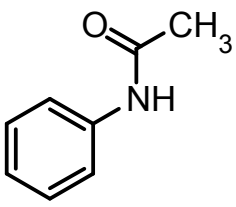
Zn/Hg, $HC\ell$ would also reduce NO_2, and nitrobenzene does not undergo Friedel–Crafts reactions.

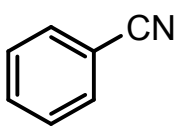
IAPT answer: (D) | **Zigyan answer:** (D)

26. Which of the following compounds predominantly gives the *para*-nitro product as the major isomer upon nitration using a nitrating mixture (HNO_3 + H_2SO_4)?

(A) 

(B) 

(C) 

(D) 

Solution · Q26 **Answer: (C)**

$-NO_2$, $-N^+(CH_3)_3$ and –CN withdraw electrons and are meta-directing.

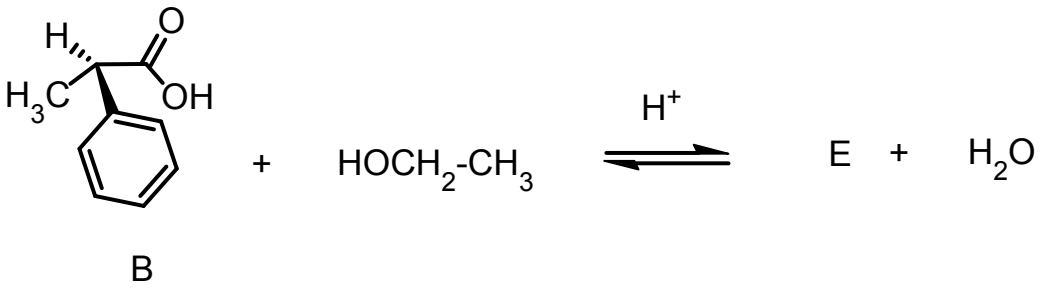
In $-NHCOCH_3$, the lone pair on N is donated to the ring, so it is ortho/para-directing.

Its bulk hinders the ortho positions.

∴ Acetanilide gives mainly the para-nitro product.

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

27. Product **E** formed in the following chemical reaction will



B

(A) have the same configuration as **B**

(B) have inverted configuration as compared to **B**

(C) be a racemic mixture

(D) be optically inactive

Solution · Q27 **Answer: (A)**

In Fischer esterification, the acyl C–OH bond breaks:

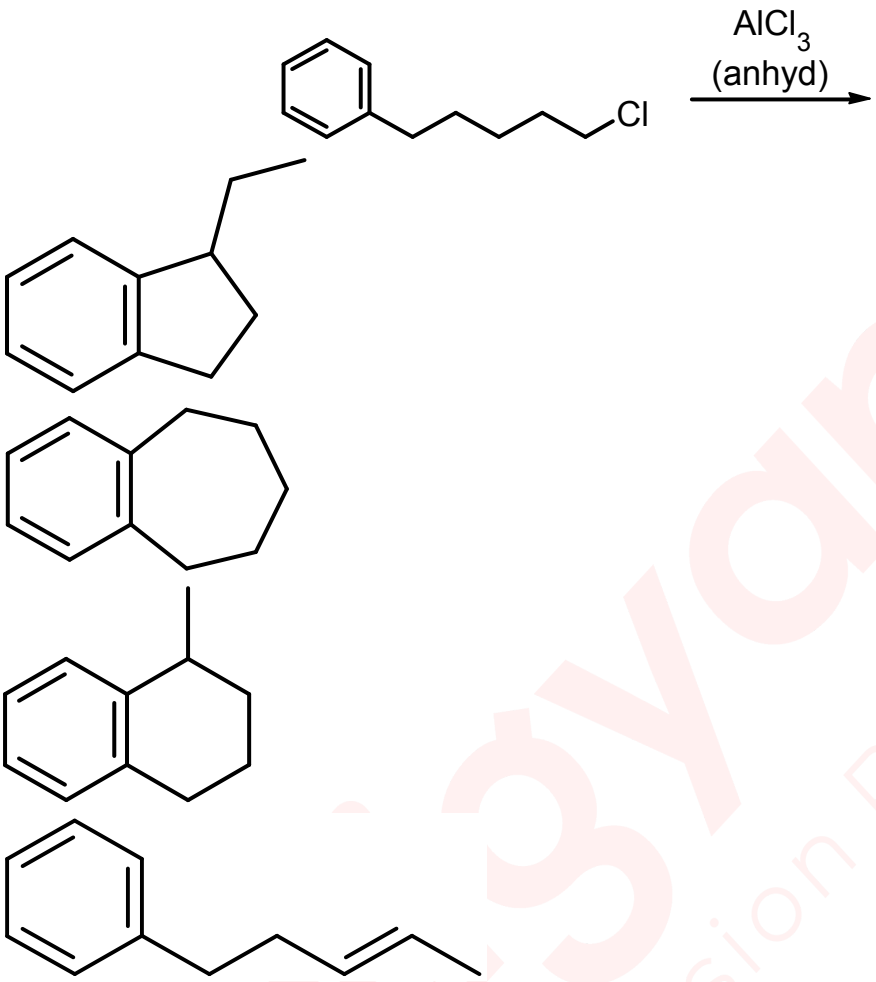
$RCOOH + C_2H_5OH \rightleftharpoons RCOOC_2H_5 + H_2O$

No bond to the chiral carbon is broken.

∴ E has the same configuration as B.

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

28. The most predominant product of the following reaction will be:



Solution · Q28 **Answer: (C)**

$A\ell C\ell_3$ removes $C\ell^-$, and a 1,2-hydride shift gives a more stable secondary carbocation:

$Ph(CH_2)_4CH_2^+ \rightarrow Ph(CH_2)_3CH^+CH_3$

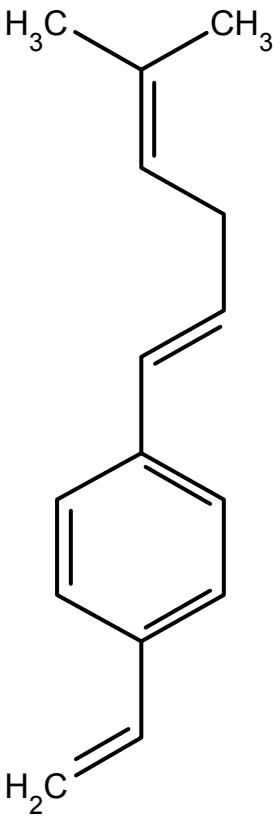
This cation attacks the ortho carbon of the ring, closing a six-membered ring.

∴ The major product is 1-methyl-1,2,3,4-tetrahydronaphthalene.

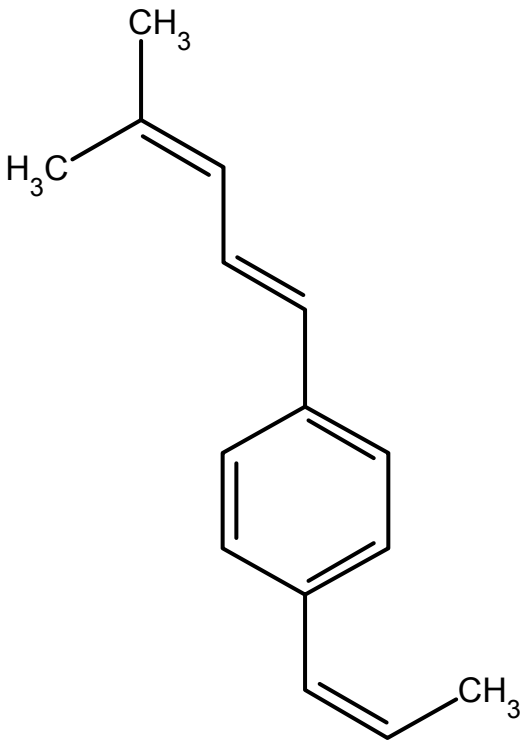
IAPT answer: (C) | **Zigyan answer:** (C)

29. Which of the following molecules will react with ozone and hydrogen peroxide to form 1,4-benzene dicarboxylic acid, formic acid, oxalic acid and acetone?

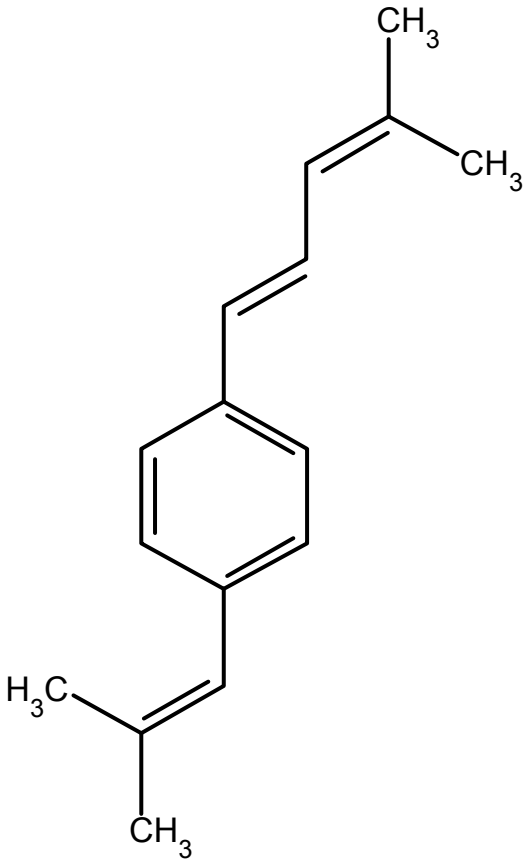
(A)



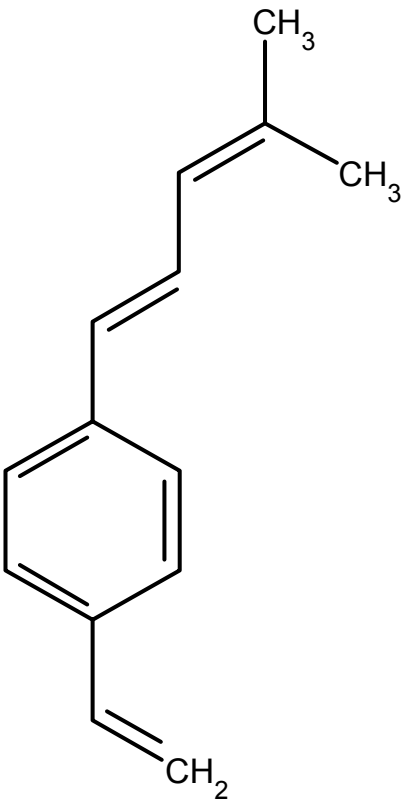
(B)



(C)



(D)



Solution · Q29 **Answer: (D)**

Ozone followed by H_2O_2 cleaves each side-chain C=C, giving acids or ketones.

For (D):

$$(CH_3)_2C{=}CH{-}CH{=}CH{-}C_6H_4{-}CH{=}CH_2$$

The products are:

$(CH_3)_2CO$, HOOC–COOH, HOOC–C_6H_4–COOH and HCOOH

(A) gives HOOC–CH_2–COOH in place of oxalic acid.

(B) gives CH_3COOH in place of formic acid.

(C) gives no formic acid.

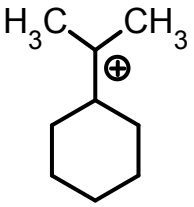
IAPT answer: (D) | **Zigyan answer:** (D)

30. The correct numerical answers for the following is:

(i) The number of NOT-aromatic compounds from the following is

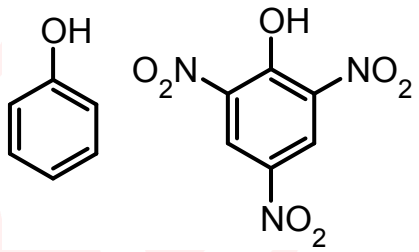


(ii) The number of α hydrogen atoms in the following structure is



(iii) The number of geometrical isomers possible in $CH_3CH{=}CH{-}CH{=}CH_2$

(iv) The number of compounds more acidic than CH_3COOH from:



CF_3COOH CH_3SO_3H C_2H_5OH

(A) (i) = 3 ; (ii) = 6; (iii) = 2; (iv) = 3

(B) (i) = 2 ; (ii) = 6; (iii) = 2; (iv) = 3

(C) (i) = 2 ; (ii) = 7; (iii) = 4; (iv) = 2

(D) (i) = 3 ; (ii) = 7; (iii) = 2; (iv) = 3

Solution · Q30 **Answer: (D)**

(i) Cyclobutadiene and 1,2-diazete are antiaromatic, and cyclopentadiene is non-aromatic.

Furan and pyridazine are aromatic, so the number is 3.

(ii) α-Hydrogens on the carbons next to C^+:

$$3 + 3 + 1 = 7$$

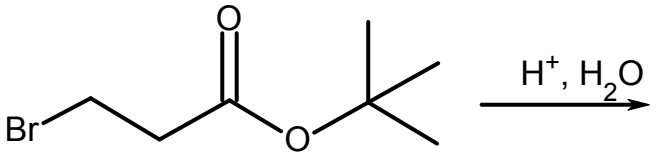
(iii) Only the C2=C3 bond shows geometrical isomerism, so there are 2 isomers.

(iv) Picric acid, CF_3COOH and CH_3SO_3H are stronger acids than CH_3COOH.

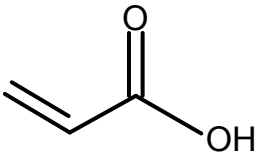
Phenol and ethanol are weaker, so the number is 3.

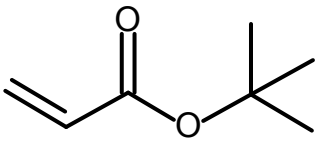
IAPT answer: (D) | **Zigyan answer:** (D)

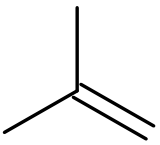
31. The following reaction is performed and multiple products are observed.

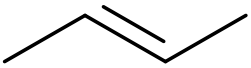


One of the products (X) can decolourize Br_2 water. The product (X) is

(A)


(B)


(C)


(D)


Solution · Q31 **Answer: (C)**

A tert-butyl ester is hydrolysed in acid by alkyl–oxygen cleavage.

After protonation:

$BrCH_2CH_2COOC(CH_3)_3 + H^+ \rightarrow BrCH_2CH_2COOH + (CH_3)_3C^+$

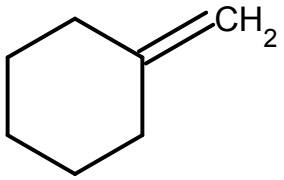
The tertiary carbocation loses a proton:

$$(CH_3)_3C^+ \rightarrow (CH_3)_2C{=}CH_2 + H^+$$

$\therefore$ X is 2-methylpropene, which decolourises Br_2 water.

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

32. Compound **A** can be prepared from a suitable alkyl halide and appropriate reagent and conditions. The most appropriate combination of the requirements to give the highest yield is:

Compound A 

(A) 1-bromo-1-methylcyclohexane, CH_3O^-, CH_3OH

(B) 1-fluoro-1-methylcyclohexane, CH_3O^-, CH_3OH

(C) 1-bromo-1-methylcyclohexane, $(CH_3)_3CO^-$, $(CH_3)_3COH$

(D) 1-fluoro-1-methylcyclohexane, $(CH_3)_3CO^-$, $(CH_3)_3COH$

Solution · Q32 **As per Zigyan: (C)**

A is the less substituted (exocyclic) alkene, formed by E2 removal of a methyl hydrogen.

The bulky base $(CH_3)_3CO^-$ prefers this exposed hydrogen.

Br^- is a much better leaving group than F^-, as the C–F bond is very strong.

A fluoride reacts very sluggishly, so it is a poor choice for yield.

∴ Use 1-bromo-1-methylcyclohexane with $(CH_3)_3CO^-$ in $(CH_3)_3COH$.

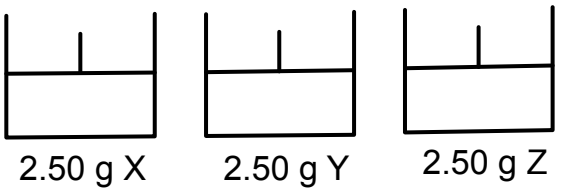
Reference: NCERT Chemistry Class XII (Part II), Unit 6 'Haloalkanes and Haloarenes', Table 6.2: the C–F bond is much stronger than C–Br (452 against 293 kJ mol^{-1} in methyl halides).

Reference: Same unit, section 6.7.1: a bulky base favours proton removal, and fluorides are far the least reactive in substitution.

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

33. Consider three cylinders of capacity 2.24 L each fitted with piston. Each containing 2.50 g of an ideal gas (X, Y and Z) as specified below at 273 K. The pressure is not specified.

Given: Molar mass (in g mol^{-1}) as X = 40, Y = 80 and Z = 20.



The correct set of statement(s) is/are

(i) The number of molecules in each cylinder is the same.

(ii) The average velocity of the molecules in each cylinder is the same.

(iii) The pressure of gas Z is the highest.

(iv) If the pressure in each cylinder is adjusted to one atmosphere at constant temperature, the volume of the gas Z will increase and those of the other two will decrease.

(A) (i) and (ii) are correct

(B) (i) and (iii) are correct

(C) (ii) and (iv) are correct

(D) (iii) and (iv) are correct

Solution · Q33 **Answer: (D)**

Moles of each gas:

$$n_X = 2.50/40 = 0.0625$$

$$n_Y = 2.50/80 = 0.03125$$

$$n_Z = 2.50/20 = 0.125$$

(i) The numbers of molecules differ, ∴ false.

(ii) At the same temperature, the average speed depends on M:

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

∴ false.

(iii) At the same V and T:

$$P = nRT/V$$

$$P_X \approx 0.625 \text{ atm}$$

$$P_Y \approx 0.31 \text{ atm}$$

$$P_Z \approx 1.25 \text{ atm}$$

So Z has the highest pressure, ∴ true.

(iv) At 1 atm, Z expands, while X and Y are compressed, ∴ true.

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

34. A sample(X) of MCl_2 was found to contain a small quantity of $M(OH)_2$ as an impurity, both of the compounds are soluble in water. In an experiment 30 g of the above sample (X) was dissolved in 60 mL of 0.4 M HCl to give solution (Y). 20 mL of 0.4 M NaOH was required to neutralise the excess HCl in solution(Y). The percentage of $M(OH)_2$ in sample(X) is:

Given: Molar mass of $M(OH)_2$ = 65 g mol^{-1}

(A) 1.7 (B) 3.5 (C) 0.17 (D) 0.35

Solution · Q34 **Answer: (A)**

HCℓ taken:

$$60 \times 0.4 = 24 \text{ mmol}$$

Excess HCℓ, from the NaOH used:

$$20 \times 0.4 = 8 \text{ mmol}$$

HCℓ used by $M(OH)_2$:

$$24 - 8 = 16 \text{ mmol}$$

$M(OH)_2 + 2HC\ell \rightarrow MC\ell_2 + 2H_2O$

Hence $M(OH)_2$ present:

$$16/2 = 8 \text{ mmol}$$

Its mass:

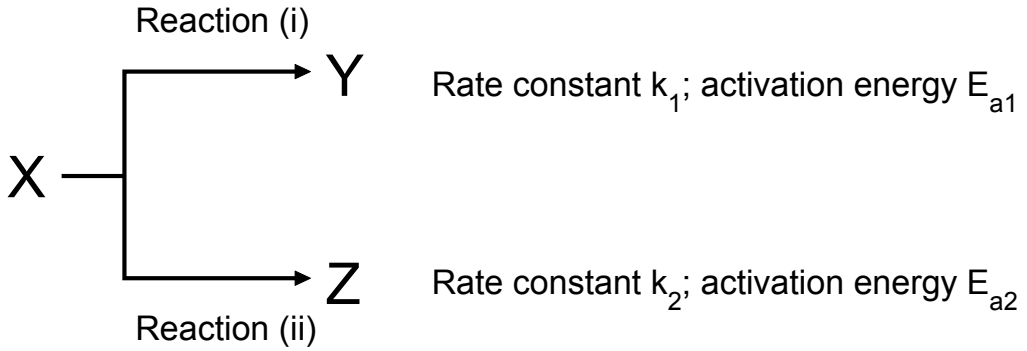
$$8 \times 10^{-3} \times 65 = 0.52 \text{ g}$$

Percentage in the sample:

$$(0.52/30) \times 100 \approx 1.7$$

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

35. Consider the following reactions (i) and (ii) occurring at 298 K, such that $E_{a2} = 3E_{a1}$ and the Arrhenius constant A has the same value for both the reactions. The relation between k_1 and k_2 is



(A) $k_1 = 3k_2e^{E_{a2}/RT}$ (B) $k_1 = k_2e^{2E_{a1}/RT}$

(C) $k_2 = k_1e^{2E_{a1}/RT}$ (D) $k_2 = k_1e^{3E_{a1}/RT}$

Solution · Q35 **Answer: (B)**

By the Arrhenius equation:

$$k_1 = Ae^{-E_{a1}/RT}$$

$$k_2 = Ae^{-3E_{a1}/RT}$$

Dividing:

$$k_1/k_2 = e^{2E_{a1}/RT}$$

$$\Rightarrow k_1 = k_2 e^{2E_{a1}/RT}$$

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

36. In the spacecrafts of NASA, the oxygen required for the astronauts is obtained from the following chemical reaction.

$$KClO_3(s) + Fe(s) \rightarrow O_2(g) + KCl(s) + FeO(s)$$

The requirement of O_2 per astronaut per day is 500 L as measured at 1 atm and 300 K. The minimum mass of $KClO_3$ (Molar mass of $KClO_3$ = 122.5 g mol^{-1}) needed for two astronauts to be in the spacecraft for ten days in a space mission is:

(A) 49.8 kg (B) 426 g (C) 213 g (D) 498.0 kg

Solution · Q36 **Answer: (A)**

The given equation is balanced:

$KC\ell O_3 + Fe \rightarrow O_2 + KC\ell + FeO$

So one mole of $KC\ell O_3$ gives one mole of O_2.

Volume of O_2 needed:

$$V = 500 \times 2 \times 10 = 10000 \text{ L}$$

By the ideal gas equation:

$$n = PV/RT$$

$$\Rightarrow n = (1 \times 10000)/(0.082 \times 300) \approx 406.5 \text{ mol}$$

Mass of $KC\ell O_3$:

$$406.5 \times 122.5 \approx 49800 \text{ g}$$

$\therefore$ The mass needed is about 49.8 kg.

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

37. When 15.0 g of steam at 373 K is passed in 250.0 g of H_2O (l) in closed container at 298 K at constant pressure of 1 bar, then the correct statement, if this is isolated system, will be:

(Assume that the final state is liquid water)

(A) Both the volume and entropy will increase.

(B) Both the volume and entropy will decrease.

(C) The volume will increase and the entropy will decrease.

(D) The volume will decrease and the entropy will increase.

Solution · Q37 **As per Zigyan: (D)**

Insulated vessel, volume free to change at 1 bar.

Heat released if all the steam condenses:

$$q_1 = \frac{15.0}{18} \times 40.79 \approx 34 \text{ kJ}$$

Heat needed to warm the water to 373 K:

$$q_2 = 250.0 \times 4.18 \times 75 \text{ J} \approx 78 \text{ kJ}$$

$$q_2 > q_1$$

So no steam is left, and the final temperature is below 373 K (about 333 K).

About 26 L of steam becomes only about 15 mL of liquid, so the volume decreases.

For a spontaneous change in an isolated system, by the second law,

$$\Delta S > 0$$

∴ The volume decreases and the entropy increases.

Why Zigyan differs from IAPT: reaching 373 K needs about 78 kJ, but condensation gives only about 34 kJ.

Reference: NCERT Chemistry Class XI (Part I), Unit 5 'Thermodynamics', section 5.6, 'Entropy and Second Law of Thermodynamics': in an isolated system, a spontaneous change goes towards higher entropy.

Reference: Same unit, section 5.2.2, 'Enthalpy, H': liquids change volume very little on heating, unlike systems with gases.

Check: the entropy changes of condensing steam, cooling condensate and warming water add to about $+17.5 \text{ J K}^{-1}$.

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

38. Consider the given equilibrium reaction at 473 K

$$Li_3N(s) + 2H_2(g) \rightleftharpoons LiNH_2(s) + 2\,LiH\,(s)\ \Delta H_{rxn}^{\circ} = -200 \text{ kJ/mol}$$

The number of moles of $H_2(g)$ present at equilibrium can be maximised by

	Temperature	Pressure
(A)	increasing	increasing
(B)	increasing	decreasing
(C)	decreasing	increasing
(D)	decreasing	decreasing

Solution · Q38 **Answer: (B)**

For more moles of H_2, the equilibrium must shift backward.

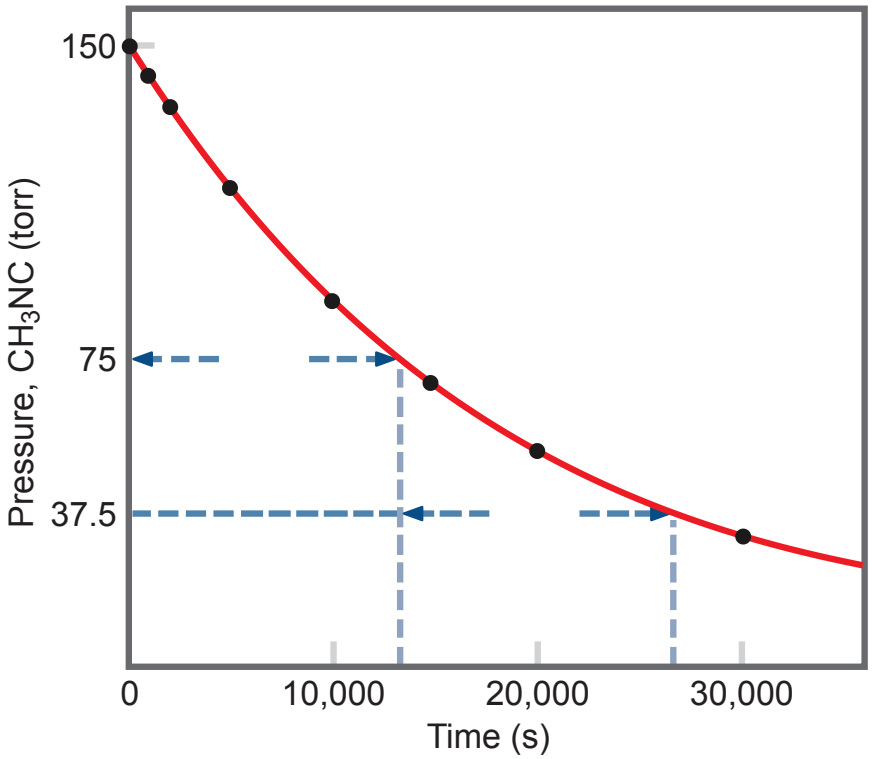
The forward reaction is exothermic, so raising the temperature favours the backward reaction.

H_2 is the only gas and is on the reactant side, so lowering the pressure also favours the backward reaction.

∴ Increase the temperature and decrease the pressure.

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

39. The following concentration vs time plot represents the conversion of $CH_3NC(g)$ to $CH_3CN(g)$. Which of the following statements (I to IV) is/are true?



I. The reaction is of zero order

II. Unit of rate constant of this reaction is s^{-1}

III. Unit of rate constant of the reaction is torr s^{-1}

IV. Unit of rate of the reaction is torr s^{-1}

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

Solution · Q39 **Answer: (D)**

From the plot, the fall from 150 torr to 75 torr takes

$$t_{1/2} \approx 1.33 \times 10^4 \text{ s}$$

The fall from 75 torr to 37.5 torr takes nearly the same time.

The half-life is constant, so the reaction is of first order. (I) is false.

The unit of a first order rate constant is s^{-1}, so (II) is true and (III) is false.

Rate is the change of pressure per unit time, in torr s^{-1}, so (IV) is true.

∴ II and IV are true.

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

40. Consider the chemical reaction A → C + D

The observations for kinetic study of the above unimolecular elementary reaction at 298 K are given in the table below:

Time (minute)	[A] (M)
0	0.35
10	0.035
t	0.00035

The value of time t (minute) is

(A) 20 (B) 30 (C) 40 (D) 35

Solution · Q40 **Answer: (B)**

A unimolecular elementary reaction is of first order.

$$kt = \ln\frac{[A]_0}{[A]_t}$$

For the first 10 min:

$$10k = \ln\frac{0.35}{0.035} = \ln 10$$

At time t:

$$kt = \ln\frac{0.35}{0.00035}$$

$$\Rightarrow kt = 3 \ln 10$$

$$\Rightarrow t = 3 \times 10 = 30 \text{ min}$$

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

41. Propanoic acid (PA) is an organic acid. At 298 K, the pH of a 50.0 mL sample of 0.20 M of it is 3.0. The pH of solution formed by mixing 25.0 mL 0.2 M sodium propanoate solution with 25.0 mL 0.1 M propanoic acid will be:

(A) 3.3 (B) 5.3 (C) 5.6 (D) 6.3

Solution · Q41 **Answer: (C)**

For 0.20 M propanoic acid:

$$[H^+] = 10^{-3} \text{ M}$$

$$K_a \approx \frac{\left(10^{-3}\right)^2}{0.20} = 5 \times 10^{-6}$$

$$\Rightarrow pK_a = 5.30$$

In the 50.0 mL mixture:

$$[C_2H_5COO^-] = 0.10 \text{ M}$$

$$[C_2H_5COOH] = 0.05 \text{ M}$$

$$pH = pK_a + \log\frac{0.10}{0.05}$$

$$\Rightarrow pH = 5.30 + 0.30 = 5.6$$

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

42. M is an alkaline earth metal. 1.0 M solution of MCl_2 is added dropwise to a solution that is 0.01 M each in fluoride, sulfite, and phosphate ions. The order of precipitation of corresponding salts is

Solid	Ksp
MSO_3	7×10^{-7}
MF_2	5×10^{-9}
$M_3(PO_4)_2$	1×10^{-25}

(A) $M_3(PO_4)_2$, MF_2, MSO_3

(B) $M_3(PO_4)_2$, MSO_3, MF_2

(C) MSO_3, MF_2, $M_3(PO_4)_2$

(D) MF_2, MSO_3, $M_3(PO_4)_2$

Solution · Q42 **Answer: (A)**

$[M^{2+}]$ needed to start each precipitate:

For MSO_3:

$$[M^{2+}] = \frac{7 \times 10^{-7}}{0.01} = 7 \times 10^{-5}\ M$$

For MF_2:

$$[M^{2+}] = \frac{5 \times 10^{-9}}{(0.01)^2} = 5 \times 10^{-5}\ M$$

For $M_3(PO_4)_2$:

$$[M^{2+}]^3 = \frac{1 \times 10^{-25}}{(0.01)^2} = 10^{-21}$$

$$\Rightarrow [M^{2+}] = 10^{-7}\ M$$

The salt needing the lowest $[M^{2+}]$ precipitates first.

$\therefore$ The order is $M_3(PO_4)_2$, MF_2, MSO_3.

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

43. $CrCl_3.xNH_3$ can exist as an octahedral complex (P). 0.1 molal aqueous solution of this complex (P) shows a depression in freezing point of 0.558 °C. The molecular formula of the complex (P) is:

(Given K_f for water = 1.86 K Kg mol^{-1})

(Assuming 100% ionization of the complex)

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

(B) $[Cr(NH_3)_5Cl]Cl_2$

(C) $[Cr(NH_3)_4Cl_2]Cl$

(D) $[Cr(NH_3)_3Cl_3]$

Solution · Q43 **Answer: (B)**

$$\Delta T_f = iK_f m$$

$$i = \frac{0.558}{1.86 \times 0.1} = 3$$

With 100% ionisation, the complex gives 3 ions: one complex cation and two $C\ell^-$ ions.

$\therefore$ P is $[Cr(NH_3)_5C\ell]C\ell_2$.

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

44. Aspirin ($C_9H_8O_4$) is produced by the reaction between salicylic acid ($C_7H_6O_3$) and acetic anhydride ($C_4H_6O_3$) as per the reaction $C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + C_2H_4O_2$

In the reaction of 155 g salicylic acid and 105 g acetic anhydride, assuming 80% conversion of the limiting reactant, the mass of aspirin formed is:

Given molar mass in g mol^{-1} salicylic acid = 138, acetic anhydride = 102 and aspirin = 180

(A) 148 g (B) 162 g (C) 202 g (D) 184 g

Solution · Q44 **Answer: (A)**

Moles of salicylic acid:

$$155/138 = 1.12 \text{ mol}$$

Moles of acetic anhydride:

$$105/102 = 1.03 \text{ mol}$$

They react in the ratio 1 : 1, so acetic anhydride is the limiting reactant.

Mass of aspirin at 80% conversion:

$$m = 0.80 \times 1.029 \times 180 \approx 148 \text{ g}$$

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

45. A voltaic cell is constructed as shown below

$Ni(s)|\ Ni^{2+}(aq)\ ||\ Ag^+(aq)\ |Ag(s)$

$E°_{Ni2+(aq)/Ni(s)} = -0.236$ V , $E°_{Ag+(aq)/Ag(s)} = 0.799$ V. The initial concentration of $Ag^+(aq)$ in the $Ag^+(aq)/Ag(s)$ half-cell is 0.005 M and the corresponding cell voltage is +0.95 V at 298 K. Identify the correct option from the following

(A) Initial $[Ni^{2+}](aq) = 0.019$ M; it will increase with time

(B) Initial $[Ni^{2+}](aq) = 0.120$ M; it will increase with time

(C) Initial $[Ni^{2+}](aq) = 0.019$ M; it will decrease with time

(D) Initial $[Ni^{2+}](aq) = 0.120$ M; it will decrease with time

Solution · Q45 **Answer: (A)**

Cell reaction:

$Ni(s) + 2Ag^+(aq) \rightarrow Ni^{2+}(aq) + 2Ag(s)$

$$E°_{cell} = 0.799 - (-0.236) = 1.035 \text{ V}$$

By the Nernst equation,

$$0.95 = 1.035 - \frac{0.0591}{2}\log\frac{[Ni^{2+}]}{[Ag^+]^2}$$

$$\Rightarrow \log\frac{[Ni^{2+}]}{(0.005)^2} = 2.876$$

$$\Rightarrow [Ni^{2+}] \approx 0.019\ M$$

As the cell works, Ni is oxidised to Ni^{2+}, so its concentration increases with time.

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

46. A certain quantity of a hydrocarbon fuel sample ($C_X H_Y$) is burnt in excess $O_2(g)$ to ensure complete combustion. The combustion produced 11.93 g $CO_2(g)$, 2.19 g $H_2O(g)$, and 311 kJ of heat. Mass of the fuel burnt in this combustion is

(A) 3.493 g (B) 14.02 g (C) 11.93 g (D) 3.250 g

Solution · Q46 **Answer: (A)**

All the C of the fuel is in CO_2 and all its H is in H_2O. The heat value is not needed.

Mass of C:

$$11.93 \times \frac{12}{44} = 3.254\ g$$

Mass of H:

$$2.19 \times \frac{2}{18} = 0.243\ g$$

Mass of the fuel:

$$3.254 + 0.243 = 3.497\ g$$

∴ The nearest option is 3.493 g; the small gap is due to rounding.

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

47. The photon with the longest wavelength required for the electronic transition in an atom of hydrogen is:

(A) n = 1 → n = 3 (B) n = 2 → n = 6 (C) n = 3 → n = 1 (D) n = 1 → n = 6

Solution · Q47 **Answer: (B)**

Longest wavelength means the smallest energy gap.

$$\Delta E = 13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\ eV$$

For 1 → 3:

$$\Delta E = 12.09\ eV$$

For 2 → 6:

$$\Delta E = 3.02\ eV$$

For 1 → 6:

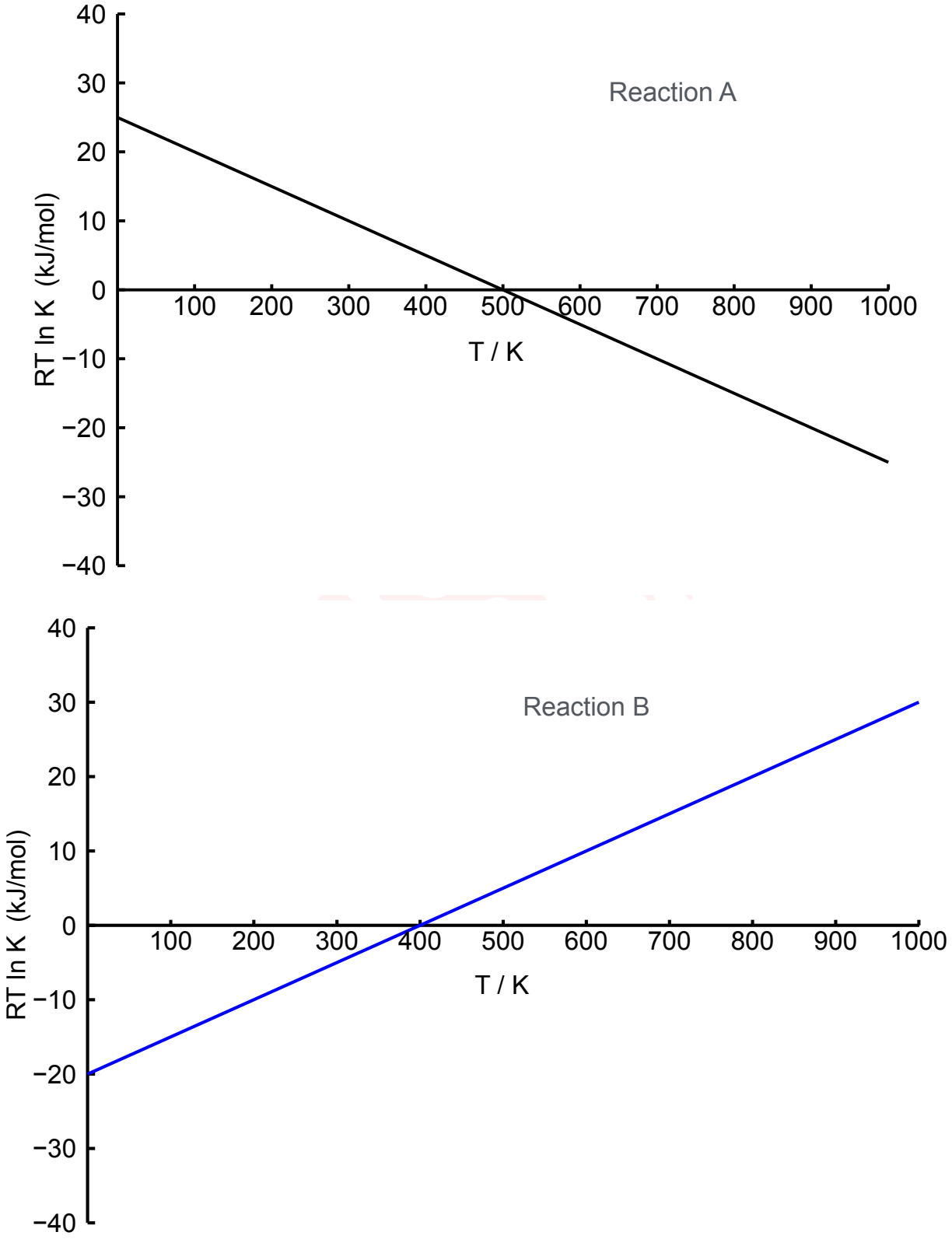
$$\Delta E = 13.22\ eV$$

3 → 1 is an emission, also with a large gap.

∴ The longest wavelength belongs to the 2 → 6 transition.

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

48. Consider two reactions A and B for which the variation of RT ln K with temperature is given in the plots below. If the enthalpy change for the reactions are –25 kJ/mol and 20 kJ/mol, respectively for A and B, the correct statement is:



(A) The equilibrium constant for Reaction B decreases as temperature increases.

(B) The entropy change for Reaction A is 50 kJ/mol.

(C) Reaction A remains spontaneous only at temperatures less than 500K

(D) At 400 K, reaction B changes from exothermic to endothermic reaction.

Solution · Q48 **Answer: (C)**

$$RT \ln K = -\Delta G^\circ = T\Delta S^\circ - \Delta H^\circ$$

So the slope of each line is ΔS°.

(A) B is endothermic, so its K increases with temperature: false.

(B) From the slope of line A,

$$\Delta S^\circ = \frac{0 - 25000}{500} = -50 \text{ J K}^{-1} \text{ mol}^{-1}$$

The stated sign and unit are wrong: false.

(C) For A, RT ln K is positive ($\Delta G^\circ < 0$) only below 500 K: true.

(D) B stays endothermic. At 400 K only the sign of ΔG° changes: false.

∴ Only (C) is correct.

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

PART A-2 · ONE OR MORE CORRECT OPTIONS

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

49. Alkyl lithium compounds are of interest in organic synthesis as efficient alkylating agents. Consider the following two reactions

(i) $C_4H_9Li + C_6H_6 \rightarrow C_6H_5Li + C_4H_{10}$

(ii) $C_5H_5Li + C_6H_6 \rightarrow C_6H_5Li + C_5H_6$

The CORRECT statement(s) for the above two reactions is/are:

(A) Reaction (i) will proceed because the more acidic hydrocarbon will react with the Li-derivative of less acidic hydrocarbon to liberate less acidic hydrocarbon.

(B) Reaction (ii) will proceed because the less acidic hydrocarbon will react with the Li-derivative of more acidic hydrocarbon to liberate more acidic hydrocarbon.

(C) Both the reactions will proceed because the more acidic hydrocarbon will react with the Li-derivative of more acidic hydrocarbon to liberate less acidic hydrocarbon.

(D) Both the reactions proceed because the less acidic hydrocarbon will react with the Li-derivative of more acidic hydrocarbon to liberate less acidic hydrocarbon.

Solution · Q49 **Answer: (A)**

An acid-base exchange goes forward only towards the weaker acid.

Acid strength (cyclopentadienide ion is aromatic):

$$C_5H_6 > C_6H_6 > C_4H_{10}$$

(i) Benzene, the stronger acid, sets free the weaker acid butane. It proceeds, so (A) is true.

(ii) It would set free the stronger acid C_5H_6, so it does not proceed.

Hence (B), (C) and (D) are false.

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

50. A mixture gave light yellow precipitate with silver nitrate which did not dissolve completely with ammonia solution. It gave positive chromyl chloride test. When organic layer test was performed with addition of excess of concentrated nitric acid, a violet coloured organic layer first formed which then changed to orange colour. Brown ring test was positive but brown coloured gas was not intensified on heating the mixture with copper turnings and concentrated sulphuric acid. Which of the anions were present?

(A) Chloride, bromide, iodide
(B) Chloride, nitrate, iodide
(C) Fluoride, nitrate, bromide
(D) Chloride, iodide, nitrite

Solution · Q50 **Answer: (A)**

Positive chromyl chloride test: $C\ell^-$ is present.

Violet organic layer: I^- is present.

Excess HNO_3 removes the violet colour by oxidising iodine:

$$I_2 + 10HNO_3 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$$

The orange layer left is due to Br_2, so Br^- is present.

This also fits the light yellow, partly soluble silver halide precipitate.

Copper turnings do not increase the brown vapour, so NO_3^- is absent.

The brown ring is a false positive caused by Br^- and I^-.

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

51. Consider the following half-cell reactions

$$H^+_{(aq)} + e^- \rightleftharpoons 1/2H_{2(g)}\ E^0 = 0.00\ V$$

$$V^{3+}_{(aq)} + e^- \rightleftharpoons V^{2+}_{(aq)}\ E^0 = -0.255\ V$$

$$VO^{2+} + e^- + 2H^+ \rightleftharpoons V^{3+}_{(aq)} + H_2O_{(l)}\ E^0 = +0.337\ V$$

$$1/2O_{2(g)} + 2e^- + 2H^+ \rightleftharpoons H_2O_{(l)}\ E^0 = +1.23\ V$$

Using above equations, the correct statement(s) is/are

(A) Oxidation of $V^{2+}_{(aq)}$ to $V^{3+}_{(aq)}$ by H^+ is a spontaneous reaction.

(B) Oxidation of $V^{3+}_{(aq)}$ to $V^{4+}_{(aq)}$ by H^+ is a nonspontaneous reaction.

(C) H^+ is a better oxidizing agent than O_2.

(D) O_2 will be able to oxidize $V^{2+}_{(aq)}$ to $V^{3+}_{(aq)}$.

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

A positive cell potential means a spontaneous reaction.

$$E°_{cell} = E°_{cathode} - E°_{anode}$$

(A) For V^{2+} with H^+:

$$E°_{cell} = 0.00 - (-0.255) = +0.255\ V$$

It is spontaneous, so (A) is true.

(B) Here V(+4) is VO^{2+}.

$$E°_{cell} = 0.00 - 0.337 = -0.337\ V$$

It is not spontaneous, so (B) is true.

(C) O_2 has the higher reduction potential, so it is the better oxidant. (C) is false.

(D) For V^{2+} with O_2:

$$E°_{cell} = 1.23 - (-0.255) = +1.485\ V$$

So (D) is true.

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

52. The suitable combinations of physico-chemical methods that can be used to assign the correct formula to the compound $CoCl_3.4NH_3$ are

(A) Addition of Ag^+ ions

(B) Electrical conductance of aqueous solution

(C) Depression in freezing point

(D) Thermal decomposition of the complex under controlled conditions

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

The complex is $[Co(NH_3)_4C\ell_2]C\ell$.

(A) Only the outer chloride ion is precipitated:

$$[Co(NH_3)_4C\ell_2]^+ + C\ell^- + Ag^+ \rightarrow [Co(NH_3)_4C\ell_2]^+ + AgC\ell\downarrow$$

(B) Molar conductance shows a 1 : 1 electrolyte.

(C) Freezing point depression counts the particles. For complete ionisation,

$$i = 2$$

(D) Controlled heating can show whether any NH_3 is loosely held outside the coordination sphere. Along with the other results, it helps to assign the formula.

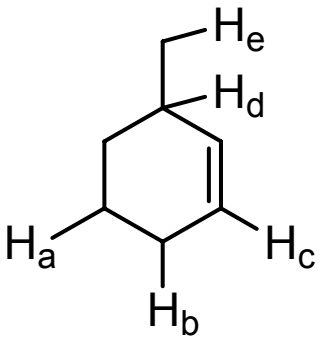
Reference: NCERT Chemistry Class XII (Part I), Unit 5 'Coordination Compounds', section 5.1: precipitated chloride and solution conductivity show that $CoC\ell_3.4NH_3$ is a 1 : 1 electrolyte; this supports (A) and (B).

Reference: NCERT Chemistry Class XII (Part I), Unit 1 'Solutions', sections 1.6 and 1.7: freezing point depression depends on the number of solute particles, which ionisation raises; this supports (C).

Check: for (D), a form $[Co(NH_3)_3C\ell_3].NH_3$ could also give two particles if the free NH_3 separates in water; loosely held NH_3 should leave early on heating.

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

53. Given below is the structure of a compound **X**. Identify the correct statement(s) from below.



X

(A) Compound X has two vinylic protons, and two allylic protons.

(B) Compound X (9.6 gram) will react with excess of bromine to give a dibromide (25.6 gram).

(C) The carbon radical that generated by cleavage of C-H_d bond will be more stable than that generated by cleavage of C-H_b bond.

(D) Compound X on ozonolysis followed by treatment with Zn/H_2O will give a dial.

Solution · Q53 **Answer: (B), (C), (D)**

X is 3-methylcyclohexene, C_7H_{12}.

(A) Allylic H: one is H_d and two are on the carbon carrying H_b. There are three, so (A) is false.

(B) With molar masses 96 for X and 256 for the dibromide:

$$n = \frac{9.6}{96} = 0.1 \text{ mol}$$

$$m = 0.1 \times 256 = 25.6 \text{ g}$$

So (B) is true.

(C) Losing H_d gives a tertiary allylic radical, but losing H_b gives a secondary allylic one. (C) is true.

(D) Ozonolysis opens the ring to a dialdehyde:

OHC–CH(CH_3)–$CH_2CH_2CH_2$–CHO

So (D) is true.

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

54. Which of the following statement(s) is/are incorrect for sugars?

(A) If a disaccharide is dextrorotatory, it means both its monosaccharides will also be essentially dextrorotatory.

(B) The designations (+) and (–) can also be referred to as D- and L- respectively

(C) The predominant hemiacetal form of glucose is formed by bond formation between C_1 and C_6

(D) All nucleic acids contain 2-deoxy-D-ribose as the aldopentose

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

All four statements are wrong.

(A) Sucrose is dextrorotatory, but its fructose unit is laevorotatory.

(B) (+) and (–) give the direction of optical rotation, while D and L give configuration.

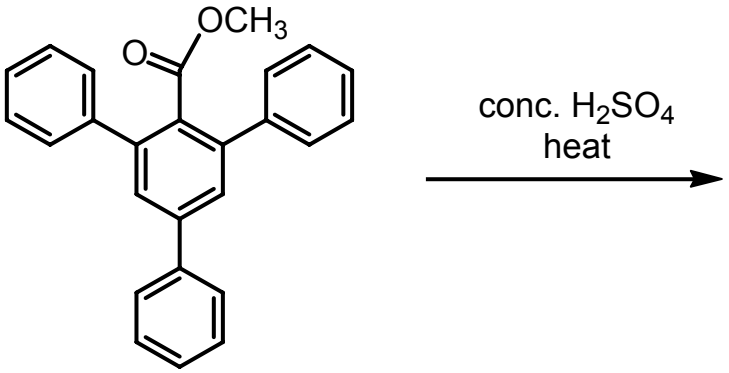
(C) Glucose mainly forms a pyranose ring, in which the C-5 hydroxyl group adds to C-1.

(D) RNA contains D-ribose. Only DNA has 2-deoxy-D-ribose.

So each statement is incorrect.

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

55. When the following reaction was performed, the product obtained gave a bright orange red precipitate with 2, 4-dinitrophenylhydrazine and does not react with saturated solution of $NaHCO_3$.



This implies:

(A) hydrolysis has taken place

(B) intramolecular Friedal Crafts reaction has been favoured

(C) intermolecular Friedal Crafts reaction has taken place

(D) the product has a carbonyl functional group

Solution · Q55 **Answer: (B), (D)**

In hot conc. H_2SO_4, this crowded ester loses methanol and forms an acylium ion.

With Ar as the triphenylphenyl group:

$Ar–COOCH_3 + H^+ \rightarrow Ar–CO^+ + CH_3OH$

The cation attacks a neighbouring ortho phenyl ring (intramolecular Friedel-Crafts acylation).

The product is the ketone 1,3-diphenylfluoren-9-one.

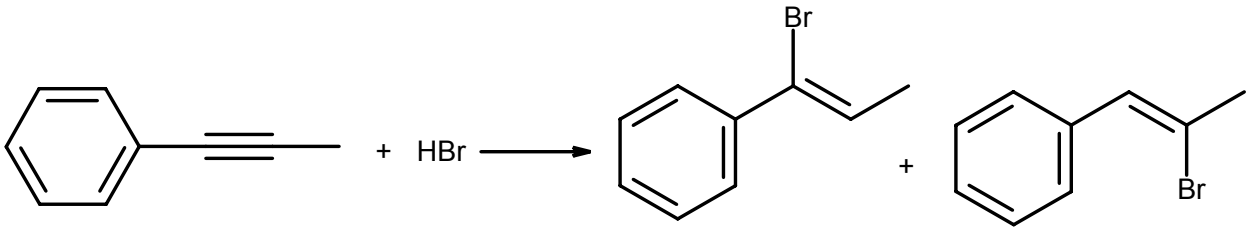
It gives the 2,4-DNP test and does not react with $NaHCO_3$.

No carboxylic acid is formed as product, so (A) is not implied.

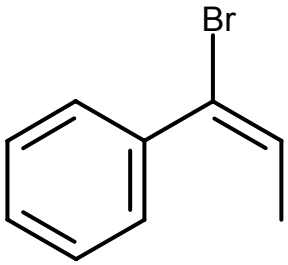
(B) and (D) are true, while (C) is false.

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

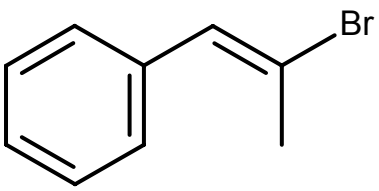
56. The following reaction was performed.



However, on investigation it was discovered that there were additional product(s) in the reaction mixture. The additional product(s) is/are

(A) 

(B) a vicinal dibromide

(C) 

(D) a geminal dibromide

Solution · Q56 **Answer: (A), (B), (C), (D)**

The two products shown are Z isomers, formed by anti addition.

The reaction can pass through a vinyl cation, which Br^- can attack from either side.

So the E isomers in (A) and (C) can also form.

A second HBr molecule can add. From the first bromoalkene:

$$C_6H_5{-}CBr{=}CH{-}CH_3 + HBr \rightarrow C_6H_5{-}CBr_2{-}CH_2CH_3$$

This is a geminal dibromide, so (D) is true.

The other bromoalkene can form a benzylic cation:

$$C_6H_5{-}CH{=}CBr{-}CH_3 + H^+ \rightarrow C_6H_5{-}CH^+{-}CHBr{-}CH_3$$

Attack of Br^- gives $C_6H_5{-}CHBr{-}CHBr{-}CH_3$.

This is a vicinal dibromide, so (B) is true.

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

57. Two open beakers A and B are kept inside a sealed box. Initially, beaker A contains 30 mL of 0.050 M glucose solution and beaker B contains 30 mL of 0.035 M fructose solution. Enough time was given to ensure that the water vapour in the system is in equilibrium. Under the equilibrium conditions,

Assume density of solution to be 1 gm/cm^3

(A) Volume of solution in A decreased to 25 mL

(B) Volume of solution in B decreased to 25 mL

(C) Volume of solution in A increased to 35 mL

(D) Volume of solution in B increased to 35 mL

Solution · Q57 **Answer: (B), (C)**

Water vapour moves until both solutions have the same concentration. The solutes stay in their beakers.

$$n_A = 30 \times 0.050 = 1.5 \text{ mmol}$$

$$n_B = 30 \times 0.035 = 1.05 \text{ mmol}$$

The total volume remains 60 mL.

$$c = \frac{1.5 + 1.05}{60} = 0.0425 \text{ M}$$

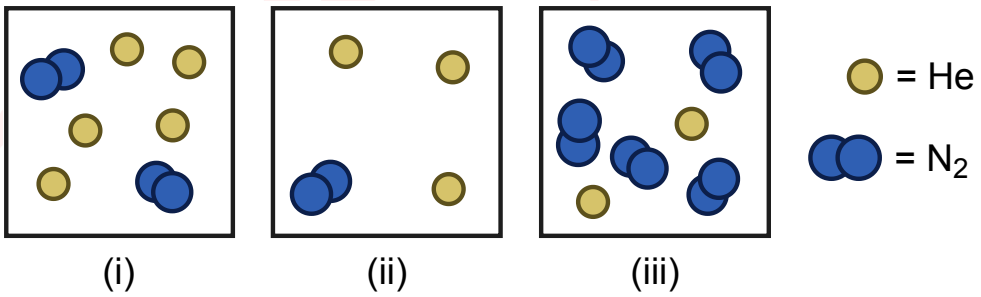
$$V_A = \frac{1.5}{0.0425} \approx 35.3 \text{ mL}$$

$$V_B = \frac{1.05}{0.0425} \approx 24.7 \text{ mL}$$

So A rises to about 35 mL and B falls to about 25 mL.

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

58. Three different gaseous mixtures (i), (ii) and (iii) of helium and nitrogen are placed in boxes of equal volume as shown below:



The true statement(s) from the following is/are

(A) Box (ii) has the lowest pressure

(B) Box (ii) has the lowest partial pressure of helium

(C) Box (ii) has the lowest density

(D) Pressure of box (iii) is less than pressure of box (i)

Solution · Q58 **Answer: (A), (C)**

Count the particles in the boxes:

(i) 5 He and 2 N_2, total 7

(ii) 3 He and 1 N_2, total 4

(iii) 2 He and 5 N_2, total 7

Taking the same temperature, pressure follows the total number of particles.

(A) Box (ii) has the fewest, so (A) is true.

(B) Helium is least in box (iii), so (B) is false.

(C) The relative masses of the contents are:

(i) 76, (ii) 40, (iii) 148

The volumes are equal, so box (ii) is least dense. (C) is true.

(D) Boxes (i) and (iii) have equal pressure, so (D) is false.

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

59. Identify the isotonic solution(s) from the following mixtures of aqueous solutions at 298 K. (Assume complete dissociation of the electrolytes in water)

(A) 100 mL 0.5 M glucose solution and 110 mL 0.2 M $CuSO_4$ solution

(B) 200 mL 0.5 M acetamide solution and 300 mL 0.1 M NaCl solution

(C) 400mL 0.1 M $BaCl_2$ solution and 100 mL 0.2 M KCl solution

(D) 200mL 0.13 M $CaCl_2$ solution and 200mL 0.125 M HCl solution

Solution · Q59 **Answer: (B), (C), (D)**

Compare the total molarity of particles, using van't Hoff factors.

(A)

$$c = \frac{0.5 \times 100 + 2 \times 0.2 \times 110}{210} \approx 0.45\ \text{M}$$

(B)

$$c = \frac{0.5 \times 200 + 2 \times 0.1 \times 300}{500} = 0.32\ \text{M}$$

(C)

$$c = \frac{3 \times 0.1 \times 400 + 2 \times 0.2 \times 100}{500} = 0.32\ \text{M}$$

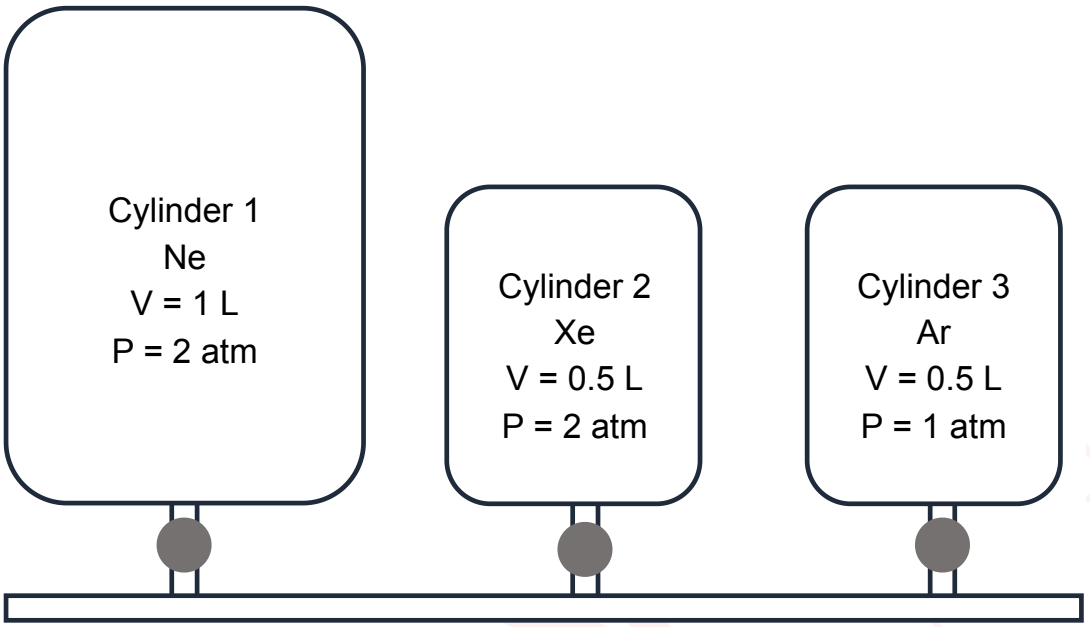
(D)

$$c = \frac{3 \times 0.13 \times 200 + 2 \times 0.125 \times 200}{400} = 0.32\ \text{M}$$

So (B), (C) and (D) are isotonic with one another.

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

60. Three cylinders connected with valves are shown in the diagram. All the cylinders are at same temperature. Which of the following statement(s) is/are true once the valves are opened and the system is allowed to reach equilibrium?



NOTE: Volume of connecting tubes may be neglected.

(A) Total pressure of the system will be 1.75 atm

(B) The partial pressure of Ne in cylinder 1 will be higher than that in cylinder 2 and 3

(C) The correct order of partial pressures will be p(Ne) > p(Xe) > p(Ar)

(D) Number of moles of gas in cylinder 2 will be lower than its initial value.

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

At one temperature, moles are proportional to PV.

The PV values in atm L for Ne, Xe and Ar are 2, 1 and 0.5. The total volume is 2 L.

(A)

$$P = \frac{2 + 1 + 0.5}{2} = 1.75 \text{ atm}$$

So (A) is true.

(B) Each gas spreads evenly, so (B) is false.

(C) The partial pressures are:

p(Ne) = 1 atm

p(Xe) = 0.5 atm

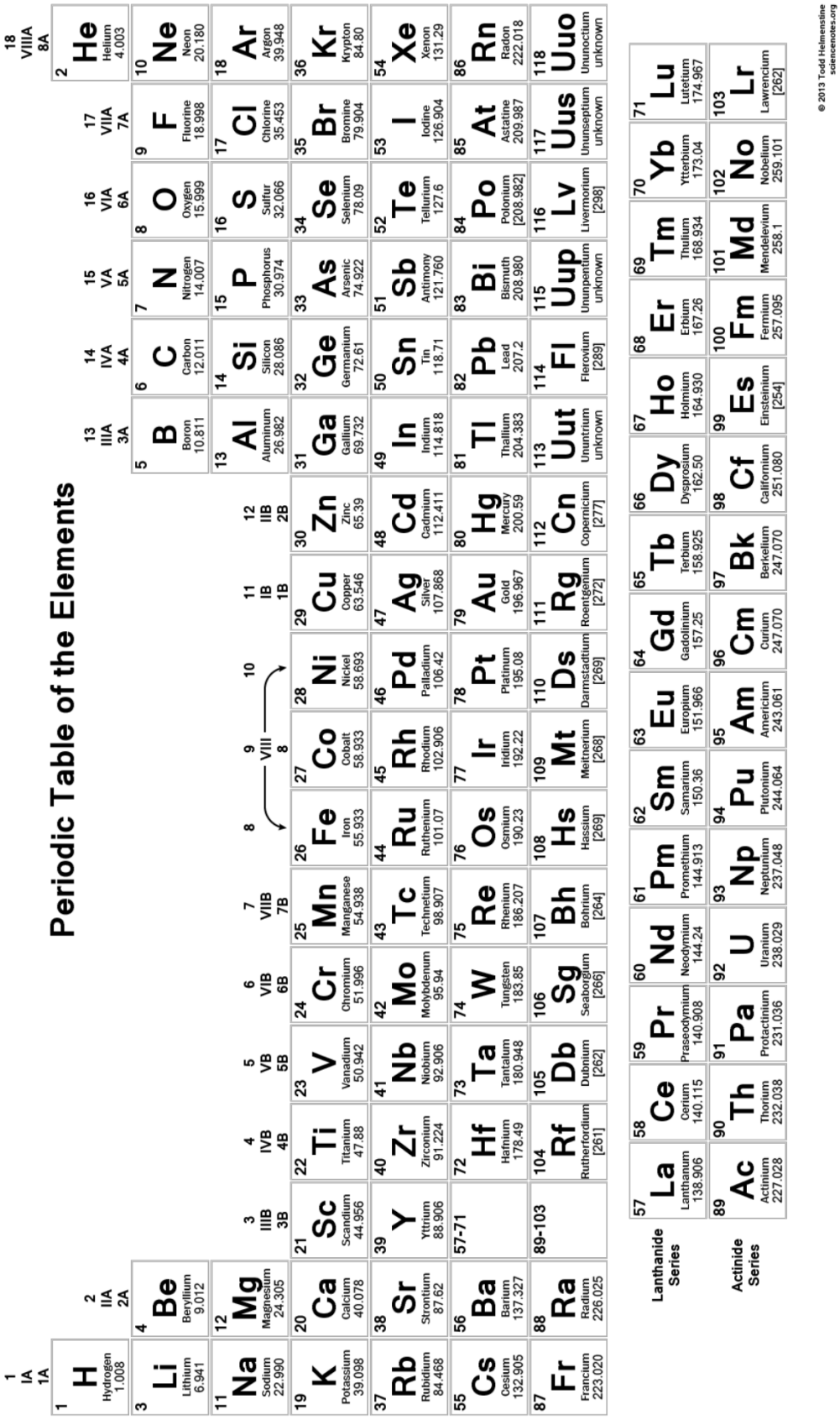
p(Ar) = 0.25 atm

So (C) is true.

(D) Cylinder 2 keeps its volume, but its pressure falls from 2 atm to 1.75 atm. It holds fewer moles, so (D) is true.

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

Given in the question paper



ANSWER KEY

NSEC 2025 · PAPER CODE 31

60
QUESTIONS · 216 MARKS

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

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

★ Answers as per Zigyan

- **Q3** — As per Zigyan: no option is correct; dropped by IAPT.
- **Q13** — As per Zigyan: (C); IAPT key (C).
- **Q17** — As per Zigyan: (B); IAPT key (B).
- **Q18** — As per Zigyan: (C); IAPT key (C).
- **Q32** — As per Zigyan: (C); IAPT key (C).
- **Q37** — As per Zigyan: (D); IAPT key (A).
- **Q52** — As per Zigyan: (A), (B), (C), (D); IAPT key (A), (B), (C), (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

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.

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RESULTS · 2021 – 2026

Our toppers, year by year

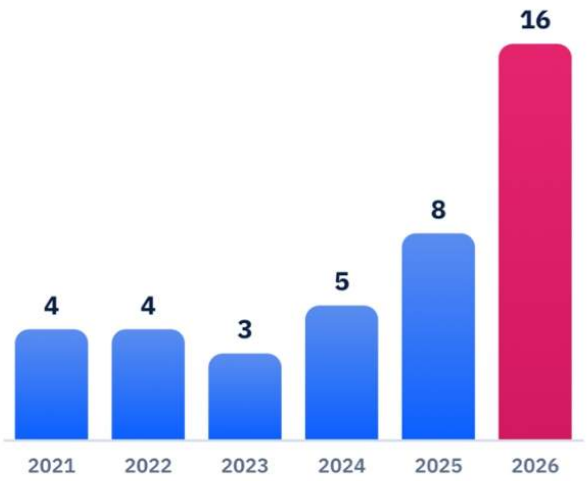
40
JEE Advanced selections in 6 years

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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