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PREVIOUS YEAR PAPER · 2022

OLYMPIAD · STAGE I

NSEC

National Standard Examination in Chemistry

2022

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 2022, 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
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- Anay Gupta — 3 Years Classroom
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- 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.

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Given in the question paper

Constants you may need….

Charge of electron,	$e = 1.602 \times 10^{-19}$ C	Speed of light,	$c = 3.0 \times 10^{8}$ ms^{-1}
Mass of electron,	$m_e = 9.1 \times 10^{-31}$ kg	Avogadro constant,	$N_A = 6.022 \times 10^{23}$ mol^{-1}
Planck's constant,	$h = 6.63\ 10^{-34}$ Js	Faraday	$F = 96500$ C mol^{-1}
		Molar gas constant,	$R = 0.082$ L atm mol^{-1} K^{-1} $= 8.314$ J mol^{-1} K^{-1}

PART A-1 · ONE CORRECT OPTION

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

1. The results obtained by four students, each performing a set of four titrations with the same solution under identical conditions, are given below. If the expected titre value is 20.0 mL, the set of data (mL) with good accuracy and poor precision is

(A) 19.9, 20.0, 20.1, 19.9
(B) 18.1, 18.2, 18.0, 18.1
(C) 17.9, 18.1, 21.5, 21.0
(D) 20.0, 19.8, 19.4, 20.2

Solution · Q1 **Answer: (D)**

Accuracy is judged against 20.0 mL; precision is judged by the spread of the readings.

(A) Mean 19.98 mL, range 0.2 mL: accurate and precise.

(B) Mean 18.10 mL, range 0.2 mL: precise, not accurate.

(C) Mean 19.63 mL, range 3.6 mL: every reading is 1 mL or more away from 20.0 mL, so not accurate.

(D) Mean 19.85 mL, range 0.8 mL: good accuracy, poor precision.

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

2. The statement that is NOT correct about atomic spectra is

(A) Electric discharges through gases produce line spectra
(B) Each element in the gaseous state has a unique line spectrum
(C) The number of lines in the spectrum is same as the number of electrons in the atom
(D) Atoms can emit photons with wavelengths lower than that of visible light

Solution · Q2 **Answer: (C)**

Spectral lines arise from electronic transitions between energy levels, so their number is not fixed by the number of electrons.

A hydrogen atom has only one electron, but hydrogen gives many lines.

∴ statement (C) is not correct.

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

3. A closed 2.0 L container initially holds 3.0 mol of O_2 (g) and 2.0 mol of N_2(g) at room temperature, T. If the pressure remains constant when 1.0 mol of O_2 (g) is added, the final temperature of the system is- (Assume ideal gas behaviour throughout)

(A) (3/5) T (B) (5/6) T (C) 2T (D) (6/5) T

Solution · Q3 **Answer: (B)**

The container is closed, so V is constant. P is also constant.

By the ideal gas equation:

$$n_1T_1 = n_2T_2$$

Total moles change from 5.0 to 6.0.

$$\Rightarrow 5.0 \times T = 6.0 \times T_2$$

$$\Rightarrow T_2 = (5/6)\ T$$

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

4. The equilibrium constant (K_c) for trimerization of phenyl acetylene to triphenyl benzene is 3.0 at 310 K. If at equilibrium, 0.9 mol dm^{-3} of triphenyl benzene is present, concentration of phenyl acetylene at equilibrium is:

(A) 1/3 mol dm^{-3} (B) 3.0 mol dm^{-3} (C) 1.732 mol dm^{-3} (D) 0.67 mol dm^{-3}

Solution · Q4 **Answer: (D)**

$3C_6H_5C{\equiv}CH \rightleftharpoons C_6H_3(C_6H_5)_3$

Let the equilibrium concentration of phenyl acetylene be x mol dm^{-3}.

$$3.0 = \frac{0.9}{x^3}$$

$$\Rightarrow x^3 = 0.30$$

$$\Rightarrow x = 0.67 \text{ mol dm}^{-3}$$

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

5. At 298 K, the standard free energies of formation of *cis*- and *trans*-1,2-dichloroethene are 41.549 kJ and 33.235 kJ respectively. The most appropriate mol ratio of *trans*- and *cis*- isomers at equilibrium at 298 K is

(A) 10:3 (B) 3:10 (C) 28:1 (D) 1:28

Solution · Q5 **Answer: (C)**

For cis → trans:

$$\Delta G^\circ = 33.235 - 41.549 = -8.314 \text{ kJ mol}^{-1}$$

At equilibrium,

$$\Delta G^\circ = -RT \ln K$$

$$\Rightarrow \ln K = \frac{8314}{8.314 \times 298}$$

$$\Rightarrow \ln K = 3.356$$

$$\Rightarrow K \approx 28.7$$

The nearest ratio of trans to cis is 28:1.

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

6. The pH of the solution produced by complete consumption of 10 mL of 0.4 M NaOH to 'x' mL of 0.5M CH_3COOH was found to be 4.57. The value of 'x' (mL) is (Given-K_a of $CH_3COOH = 1.8 \times 10^{-5}$).

(A) 12.0 (B) 10.4 (C) 19.8 (D) 6.5

Solution · Q6 **Answer: (C)**

NaOH is used up completely, forming a buffer.

$$n(CH_3COONa) = 10 \times 0.4 = 4 \text{ mmol}$$

$$n(CH_3COOH) = (0.5x - 4) \text{ mmol}$$

$$pK_a = -\log(1.8 \times 10^{-5}) \approx 4.74$$

By the Henderson equation:

$$4.57 = 4.74 + \log\frac{4}{0.5x - 4}$$

$$\Rightarrow \frac{4}{0.5x - 4} = 0.676$$

$$\Rightarrow x \approx 19.8 \text{ mL}$$

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

7. The correct order of concentrations of the ions/molecules present in 1.0 L of 1.0 M H_2SO_4 (aq) solution is

(A) $OH^- < SO_4^{2-} < HSO_4^- < H_3O^+ < H_2O$

(B) $OH^- < HSO_4^- < SO_4^{2-} < H_3O^+ < H_2O$

(C) $H_2O < HSO_4^- < OH^- < SO_4^{2-} < H_3O^+$

(D) $H_2O < OH^- < SO_4^{2-} < HSO_4^- < H_3O^+$

Solution · Q7 **Answer: (A)**

The first ionisation is complete.

$$H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^-$$

The second is only slight (K_{a2} is about 10^{-2}).

$$HSO_4^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{2-}$$

Approximate molarities: H_2O above 50, H_3O^+ 1.01, HSO_4^- 0.99, SO_4^{2-} 0.01, OH^- about 10^{-14}.

$$\therefore OH^- < SO_4^{2-} < HSO_4^- < H_3O^+ < H_2O$$

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

8. The pOH of the solution obtained by mixing 30 mL of a strong monobasic acid of pH 3.0 and 70 mL of a strong monoacidic base of pH 12.0 at 298 K is

(A) 3.17 (B) 2.17 (C) 5.17 (D) 0.17

Solution · Q8 **Answer: (B)**

For the acid, pH is 3.0:

$$n(H^+) = 30 \times 10^{-3} = 0.03 \text{ mmol}$$

For the base, pOH is 2.0:

$$n(OH^-) = 70 \times 10^{-2} = 0.70 \text{ mmol}$$

Excess base is present in 100 mL.

$$[OH^-] = \frac{0.70 - 0.03}{100}$$

$$\Rightarrow [OH^-] = 6.7 \times 10^{-3} \text{ M}$$

$$\Rightarrow \text{pOH} = 2.17$$

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

9. If refractive index, density, pressure, volume, heat capacity and surface tension are represented respectively as η, ρ, P, V, Q and γ, the set that contains only intensive properties is

(A) η, ρ, γ, Q (B) ρ, P, Q, γ (C) V, Q, η, ρ (D) η, ρ, P, γ

Solution · Q9 **Answer: (D)**

Intensive properties do not depend on the amount of matter.

Intensive: η, ρ, P and γ.

Extensive: V and Q.

∴ only the set η, ρ, P, γ is fully intensive.

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

10. Heat of reaction and heat of formation will be the same in

I. $1/2\ N_2(g) + O_2(g) \rightarrow NO_2(g)$

II. $Xe\ (g) + 2F_2(g) \rightarrow XeF_4\ (g)$

III. $N_2\ (g) + O_3\ (g) \rightarrow N_2O_3\ (g)$

IV. $C\ (\text{diamond}) + O_2\ (g) \rightarrow CO_2\ (g)$

(A) Only I (B) Only I and II

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

Solution · Q10 **Answer: (B)**

The two heats are the same when 1 mol of a compound is formed from its elements in their reference states.

I: 1 mol $NO_2(g)$ is formed from $N_2(g)$ and $O_2(g)$. ∴ same.

II: 1 mol $XeF_4(g)$ is formed from $Xe(g)$ and $F_2(g)$. ∴ same.

III: O_3 is not the reference state of oxygen. ∴ not same.

IV: The reference state of carbon is graphite, not diamond. ∴ not same.

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

11. From the following data

$2CH_6N_2\,(\ell) + 5O_2\,(g) \rightarrow 2N_2\,(g) + 2CO_2\,(g) + 6H_2O\,(g)$ $(\Delta H^0_r = -2606\ kJ)$ and

$H_2O\,(\ell) \rightarrow H_2O\,(g)$ $(\Delta H^{\mathbf{0}}_{\mathbf{v}} = 44\ kJ\ mol^{-1})$

Heat of combustion of CH_6N_2 at 298K can be calculated as

(A) $-1567\ kJ\ mol^{-1}$ (B) $-1435\ kJ\ mol^{-1}$ (C) $-1171\ kJ\ mol^{-1}$ (D) $-2342\ kJ\ mol^{-1}$

Solution · Q11 **Answer: (B)**

In the heat of combustion at 298 K, water is liquid.

Add six times the reverse of the vaporisation step:

$$\Delta H = -2606 + 6 \times (-44)$$

$$\Rightarrow \Delta H = -2870\ kJ$$

This is for 2 mol of CH_6N_2.

$$\Delta_c H = \frac{-2870}{2}$$

$$\Rightarrow \Delta_c H = -1435\ kJ\ mol^{-1}$$

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

12. When 100 g each of the salts NaCl, $MgSO_4$, $Ca(NO_3)_2$, K_2CO_3, were dissolved separately in 1.0 kg of water, the solution with the highest boiling point will be of

(A) $Ca\,(NO_3)_2$ (B) $MgSO_4$ (C) NaCl (D) K_2CO_3

Solution · Q12 **Answer: (C)**

Elevation in boiling point is proportional to i × m. Complete dissociation is assumed.

With 1.0 kg of water, i × m for each salt is:

$NaC\ell$: 2 × (100/58.5) = 3.42

$MgSO_4$: 2 × (100/120) = 1.67

$Ca(NO_3)_2$: 3 × (100/164) = 1.83

K_2CO_3: 3 × (100/138) = 2.17

∴ the $NaC\ell$ solution has the highest boiling point.

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

13. When the pH of the system is increased by 2.0 units, maximum decrease in half cell potential for the reaction will be observed in

(A) $V^{2+}(aq) \rightarrow V^{3+}(aq) + e^-$

(B) $VO_3^- + 2H^+ \rightarrow VO_2^+ + H_2O$

(C) $VO^{2+} + 2H^+ + e^- \rightarrow V^{3+} + H_2O$

(D) $VO^{2+} + H_2O \rightarrow VO_2^+ + 2H^+ + e^-$

Solution · Q13 **Answer: (C)**

(A) involves no H^+, so its potential does not change.

(B) is not a redox change; V stays +5.

For (C), by the Nernst equation:

$$E = E^\circ - 0.059\log\frac{[V^{3+}]}{[VO^{2+}][H^+]^2}$$

$$\Rightarrow E = E^\circ - 0.059\log\frac{[V^{3+}]}{[VO^{2+}]} - 0.118\ pH$$

$$\Rightarrow \Delta E = -0.118 \times 2 = -0.236\ V$$

(D) is written as an oxidation, so its potential rises.

$\therefore$ the maximum decrease is in (C).

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

14. The reaction that takes place during charging of the lead storage cell is given below

$2PbSO_4(s) + 2H_2O(\ell) \rightarrow Pb(s) + PbO(s) + 2H_2SO_4(aq)$

If a current of 10.0 A is passed for 1.50 h for charging, the amount of $PbSO_4$ reacted is

(A) 25.0 g (B) 56.0 g (C) 120.5 g (D) 170.0 g

Solution · Q14 **As per Zigyan: (D)**

PbO(s) in the printed equation is to be read as $PbO_2(s)$. On charging:

$2PbSO_4 + 2H_2O \rightarrow Pb + PbO_2 + 2H_2SO_4$

2 mol electrons convert 2 mol $PbSO_4$.

$$Q = 10.0 \times 1.50 \times 3600 = 54000\ C$$

$$n(PbSO_4) = n(e^-) = 54000/96500$$

$$\Rightarrow n(PbSO_4) = 0.5596\ mol$$

$$\Rightarrow m = 0.5596 \times 303 \approx 170.0\ g$$

Reference: NCERT Chemistry Class XII (Part I), Unit 2 'Electrochemistry', section 2.6.2: on charging the lead storage battery, $PbSO_4$ on the two electrodes is converted into Pb and PbO_2 respectively.

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

15. A sample of water from a water tank has a resistance of 100 Ω at 298 K, when placed in a conductivity cell of cell constant 0.2 m^{-1}. On dissolving 58.5 g of NaCl in the water tank, a sample of this solution gave a resistance of 40 Ω . The molar conductivity of NaCl at this concentration is 10 $\Omega^{-1}m^2mol^{-1}$. The volume of water in the water tank is

(A) 3.33×10^6 L (B) 3333.3 L (C) 363.5 L (D) 4.2×10^5L

Solution · Q15 **As per Zigyan: (A)**

For the tank water:

$$\kappa_1 = 0.2/100 = 0.002 \text{ S m}^{-1}$$

For the salt solution:

$$\kappa_2 = 0.2/40 = 0.005 \text{ S m}^{-1}$$

Due to NaCℓ alone:

$$\kappa = \kappa_2 - \kappa_1 = 0.003 \text{ S m}^{-1}$$

$$c = \kappa/\Lambda_m = 0.003/10 = 3 \times 10^{-4} \text{ mol m}^{-3}$$

Moles of NaCℓ:

$$n = 58.5/58.5 = 1 \text{ mol}$$

$$V = \frac{n}{c} = \frac{1}{3 \times 10^{-4}} = 3333.3 \text{ m}^3$$

$$\Rightarrow V = 3.33 \times 10^6 \text{ L}$$

Reference: NCERT Chemistry Class XII (Part I), Unit 2 'Electrochemistry', section 2.4.1: conductivity is the cell constant divided by the resistance, and molar conductivity is conductivity divided by concentration (mol m^{-3} in SI units).

Check: 1 mol in 3333.3 m^3, times 10 S m^2 mol^{-1}, returns 0.003 S m^{-1}, the observed rise in conductivity.

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

16. Initial concentrations of the reactants and the corresponding half-lives for the reaction P + Q → R are given below. The rate law for the reaction is

Entry	$[P_0]$ (mol $dm^{-3} \times 10^{-6}$)	$[Q_0]$ (mol $dm^{-3} \times 10^{-6}$)	$t_{1/2}$ (s)
1	500	10	30
2	500	20	60
3	10	500	60
4	20	500	60

(A) dR/dt = k[P] (B) dR/dt = k[P]/[Q]

(C) dR/dt = k[Q] (D) −d[P]/dt = k[P]/[Q]

Solution · Q16 **As per Zigyan: (A)**

The reactant in large excess stays nearly constant, so $t_{1/2}$ refers to the other one. For order n in it:

$$t_{1/2} \propto [A_0]^{1-n}$$

Entries 1 and 2: doubling $[Q_0]$ doubles $t_{1/2}$.

$\therefore$ order in Q is zero.

Entries 3 and 4: doubling $[P_0]$ leaves $t_{1/2}$ unchanged.

$\therefore$ order in P is one.

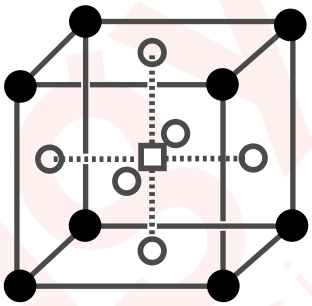
$$dR/dt = k[P][Q]^0$$

$$\Rightarrow dR/dt = k[P]$$

Reference: NCERT Chemistry Class XII (Part I), Unit 3 'Chemical Kinetics', section 3.3.3: half-life is directly proportional to the initial concentration for zero order, and independent of it for first order.

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

17. The unit cell structure of a mineral perovskite crystallizes in cubic unit cell wherein calcium (filled circles) and oxide (hollow circles) constitute a cubic close packing (ccp) arrangement and titanium ion (hollow square) occupies an interstitial hole as shown below. (Charges are omitted for simplicity). The empirical formula of this compound is



(A) Ca_2TiO_3 (B) Ca_4TiO_6 (C) $CaTiO_3$ (D) Ca_8TiO_6

Solution · Q17 **Answer: (C)**

Ca at 8 corners:

$$8 \times 1/8 = 1$$

O at 6 face centres:

$$6 \times 1/2 = 3$$

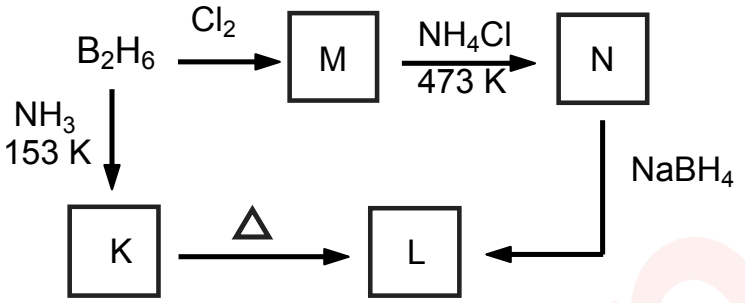
Ti at the body centre:

$$1 \times 1 = 1$$

$\therefore$ the formula is $CaTiO_3$.

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

18. Study the sequence of reactions of diborane (B_2H_6) given below and identify the products K, L, M and N. (The shown reagents are taken in excess).



(A) **K** = BNH_6; **L** = (BN)x; **M** = B_2H_5Cl; **N** = $B_3N_3H_3Cl_3$

(B) **K** = $[B_2H_6.2NH_3]$; **L** = $B_3N_3H_6$; **M** = B_2H_5Cl; **N** = $B_3N_3Cl_6$

(C) **K** = BNH_6; **L** = (BN)x; **M** = BCl_3; **N** = $B_3N_3Cl_6$

(D) **K** = $[B_2H_6.2NH_3]$; **L** = $B_3N_3H_6$; **M** = BCl_3; **N** = $B_3N_3H_3Cl_3$

Solution · Q18 **Answer: (D)**

At low temperature, K is the diammoniate of diborane:

$B_2H_6 + 2NH_3 \rightarrow [B_2H_6 \cdot 2NH_3]$

On heating, K gives borazine L:

$3[B_2H_6 \cdot 2NH_3] \rightarrow 2B_3N_3H_6 + 12H_2$

With excess $C\ell_2$, M is $BC\ell_3$:

$B_2H_6 + 6C\ell_2 \rightarrow 2BC\ell_3 + 6HC\ell$

N is trichloroborazine:

$3BC\ell_3 + 3NH_4C\ell \rightarrow B_3N_3H_3C\ell_3 + 9HC\ell$

$NaBH_4$ reduces N to L:

$2B_3N_3H_3C\ell_3 + 6NaBH_4 \rightarrow 2B_3N_3H_6 + 3B_2H_6 + 6NaC\ell$

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

19. During extraction of gold, the gold ore is treated with aqueous KCN solution as shown by the equations (not balanced) below to get compound X which is further reduced by Zn to obtain compound Y and metallic gold. Identify X and Y.

Gold ore + $CN^- + H_2O + O_2 \rightarrow [X] + OH^-$ ..... (i)

$[X] + Zn \rightarrow [Y] + Au$ ..... (ii)

(A) X = $[Au(CN)_2]^-$, Y = $[Zn(CN)_2]^{2-}$

(B) X = $[Au(CN)_2]^-$, Y = $[Zn(CN)_4]^{2-}$

(C) X = $[Au(CN)_4]^{3-}$, Y = $[Zn(CN)_4]^{2-}$

(D) X = $[Au(CN)_2]^-$, Y = $[Zn(CN)_4]^{4-}$

Solution · Q19 **Answer: (B)**

Cyanide leaching dissolves gold:

$4Au + 8CN^- + 2H_2O + O_2 \rightarrow 4[Au(CN)_2]^- + 4OH^-$

Zinc then displaces gold:

$2[Au(CN)_2]^- + Zn \rightarrow [Zn(CN)_4]^{2-} + 2Au$

$\therefore$ X is $[Au(CN)_2]^-$ and Y is $[Zn(CN)_4]^{2-}$.

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

20. The correct IUPAC name for the complex $[Au(en)_2(H_2O)_2]\,[Au(ox)_3]$ is (en = ethylenediamine and ox = oxalate)

(A) Bisaquobisethylenediaminegold (III) trioxalatoaurate (III)
(B) Diaquobisethylenediamineaurate (III) trisoxalatogold (III)
(C) Bisaquodiethylenediamineaurate (III) trisoxalatogold (III)
(D) Diaquobisethylenediaminegold (III) trioxalatoaurate (III)

Solution · Q20 **Answer: (D)**

The ions are $[Au(en)_2(H_2O)_2]^{3+}$ and $[Au(ox)_3]^{3-}$; Au is +3 in both.

Cation: aqua is cited before ethylenediamine, and the metal is named gold.

Anion: the metal is named aurate.

$\therefore$ Diaquobisethylenediaminegold(III) trioxalatoaurate(III).

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

21. Addition of dil. HCl to an aqueous solution of a mixture of two inorganic salts yielded white precipitate **E** and filtrate **F**. Precipitate **E** dissolved in hot water. **F** in alkaline alizarin gives a positive red lake test. The cations present in the precipitate **E** and solution **F** respectively are

(A) Ag^+; Fe^{3+} (B) Hg^{2+}; Ba^{2+} (C) Pb^{2+}; Al^{3+} (D) Pb^{2+}; Zn^{2+}

Solution · Q21 **Answer: (C)**

A white chloride that dissolves in hot water is $PbC\ell_2$:

$Pb^{2+} + 2C\ell^- \rightarrow PbC\ell_2\downarrow$

In alkaline medium, $A\ell(OH)_3$ adsorbs alizarin and forms a red lake.

$\therefore$ E contains Pb^{2+} and F contains $A\ell^{3+}$.

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

22. Br_2 disproportionates to Br^- and BrO_3^- in a hot alkaline solution as

$3Br_2 + 6OH^- \rightarrow 5Br^- + BrO_3^- + 3H_2O$

The equivalent weight of Br_2 is: (M = molar mass of Br_2)

(A) M/5 (B) M/6 (C) 3M/5 (D) 5M/3

Solution · Q22 **Answer: (C)**

Reduction to Br^- needs 2 electrons per Br_2:

$$E_1 = M/2$$

Oxidation to BrO_3^- releases 10 electrons per Br_2:

$$E_2 = M/10$$

For disproportionation:

$$E = E_1 + E_2$$

$$\Rightarrow E = M/2 + M/10$$

$$\Rightarrow E = 3M/5$$

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

23. The number of all the possible geometrical isomers for trigonal bipyramidal $OsO_2F_3^+$ cation is:

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

Solution · Q23 **Answer: (B)**

Os(VIII) has no lone pair. The two O atoms in the trigonal bipyramid can be:

(i) both axial

(ii) one axial and one equatorial

(iii) both equatorial

∴ there are 3 geometrical isomers.

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

24. The correct order for the wavelength of absorption in the following complex ions is

(A) $[Ni(NO_2)_6]^{4-} < [Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+}$

(B) $[Ni(NO_2)_6]^{4-} < [Ni(H_2O)_6]^{2+} < [Ni(NH_3)_6]^{2+}$

(C) $[Ni(H_2O_6]^{2+} < [Ni(NH_3)_6]^{2+} < [Ni(NO_2)_6]^{4-}$

(D) $[Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+} < [Ni(NO_2)_6]^{4-}$

Solution · Q24 **Answer: (A)**

Ligand field strength:

$$NO_2^- > NH_3 > H_2O$$

Δ_o follows the same order, and

$$\lambda = \frac{hc}{\Delta_o}$$

∴ increasing order of wavelength absorbed:

$$[Ni(NO_2)_6]^{4-} < [Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+}$$

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

25. Mixing of an aqueous salt solution containing nitrate ion with ferrous ion followed by gentle addition of conc. sulphuric acid from the sides of the test tube, results in brown coloration at the interface is due to

(A) interaction of ferrous ion with nitric oxide
(B) interaction between the resulting nascent oxygen, ferrous ion and nitrate ion
(C) formation of ferrous ion and nitrogen dioxide
(D) complex formation between ferrous ion and nitrate ion

Solution · Q25 **Answer: (A)**

Brown ring test for nitrate ion.

In acid, Fe^{2+} reduces nitrate to nitric oxide:

$$NO_3^- + 3Fe^{2+} + 4H^+ \rightarrow NO + 3Fe^{3+} + 2H_2O$$

NO then combines with the remaining ferrous ion:

$$[Fe(H_2O)_6]^{2+} + NO \rightarrow [Fe(H_2O)_5(NO)]^{2+} + H_2O$$

This nitrosyl complex gives the brown ring.

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

26. Aqueous solutions of hydrogen sulphide and sulphur dioxide when mixed together gives

(A) bisulphite ion and water
(B) hydrogen and sulphurous acid
(C) sulphur and water
(D) hydrogen peroxide and sulphur

Solution · Q26 **Answer: (C)**

H_2S reduces SO_2 and is itself oxidised. Both give sulphur.

$$2H_2S + SO_2 \rightarrow 3S\downarrow + 2H_2O$$

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

27. The ion with least coagulation value for arsenous sulphide sol is

(A) SO_4^{2-} (B) PO_4^{3-} (C) Al^{3+} (D) Ba^{2+}

Solution · Q27 **Answer: (C)**

As_2S_3 sol is negatively charged, so cations coagulate it.

By the Hardy–Schulze rule, coagulating power increases with the charge on the cation:

$$A\ell^{3+} > Ba^{2+}$$

Higher coagulating power means lower coagulation value, so it is least for $A\ell^{3+}$.

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

28. The correct order of catenation property among the following is

(A) Pb > Si > Ge > Sn (B) Pb > Sn > Ge > Si

(C) Si > Sn > Ge > Pb (D) Si > Ge > Sn > Pb

Solution · Q28 **Answer: (D)**

Catenation depends on the strength of the bond between two like atoms.

Down group 14, atomic size increases and this bond becomes weaker:

$$\text{Si–Si} > \text{Ge–Ge} > \text{Sn–Sn}$$

Lead hardly shows catenation.

$$\therefore \text{Si} > \text{Ge} > \text{Sn} > \text{Pb}$$

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

29. An agriculturist wants to use different concentrations of phosphorus as a fertilizer using P_4O_{10}. The correct expression to calculate P from P_4O_{10} is

(A) $P_4O_{10} \times 2.29$ (B) $P \times 0.44$ (C) $P \times 2.29$ (D) $P_4O_{10} \times 0.44$

Solution · Q29 **Answer: (D)**

Molar mass of P_4O_{10}:

$$4 \times 31 + 10 \times 16 = 284 \text{ g mol}^{-1}$$

Mass fraction of phosphorus:

$$\frac{4 \times 31}{284} \approx 0.44$$

$$\therefore P = P_4O_{10} \times 0.44$$

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

30. Given below are some names of the compounds.

(p) Acetals; (q) silicones; (r) ferrocene; (s) glyoxal, (t) ethyl acetate, (u) gammaxene

The set which is **NOT** having a double bond between an element and O(E=O where E is any element in the periodic table) as a functional group is

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

Solution · Q30 **Answer: (D)**

(p) Acetals have only C–O single bonds.

(q) Silicones have Si–O–Si single bonds.

(r) Ferrocene, $Fe(C_5H_5)_2$, has no oxygen.

(u) Gammaxene, $C_6H_6C\ell_6$, has no oxygen.

(s) Glyoxal and (t) ethyl acetate contain C=O.

$\therefore$ The required set is p, q, r, u.

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

31. Hybridization of S in CH_3SH molecule is

(A) dsp^3 (B) sp^2 (C) sp^3 (D) sp^3d

Solution · Q31 **Answer: (C)**

Sulphur in CH_3SH has 2 bond pairs and 2 lone pairs.

Steric number:

$$2 + 2 = 4$$

$\therefore$ sp^3

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

32. Using different reaction conditions nickel reacts with (p) Cl^-, (q) CN^-, (r) CO and (s) small amount of Al. Choose **incorrect** statement.

(A) (p), (q), and (r) respectively can result in tetrahedral, octahedral and square planar geometries around nickel

(B) Ligand (p) and (q) leads to homoleptic complex formation wherein final electronic configuration shows maximum multiplicity in case of (p)

(C) Ligand (r) reacts only in reducing medium to form organometallic compound

(D) In case of (s) formation of spongy product with large surface drive reduction reaction of C=C compounds

Solution · Q32 **Answer: (A)**

(A) CN^- gives square planar $[Ni(CN)_4]^{2-}$; CO gives tetrahedral $Ni(CO)_4$. $\therefore$ incorrect.

(B) Tetrahedral $[NiC\ell_4]^{2-}$ has 2 unpaired electrons; $[Ni(CN)_4]^{2-}$ has none. $\therefore$ correct.

(C) $Ni(CO)_4$ contains Ni(0), so nickel must be in the reduced state. $\therefore$ correct.

(D) NaOH leaches $A\ell$ from Ni–$A\ell$ alloy, leaving spongy Raney nickel, a hydrogenation catalyst. $\therefore$ correct.

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

33. Optically pure 2-butanol has a specific rotation of +13.52 degrees. A synthesized and purified sample of 2-butanol has the observed specific rotation of +6.76 degrees. The correct statement based on this observation is

(A) the sample is completely racemized (B) 25% of the sample is racemic

(C) 50% of the sample is racemic (D) 6.76% of the sample is racemic

Solution · Q33 **Answer: (C)**

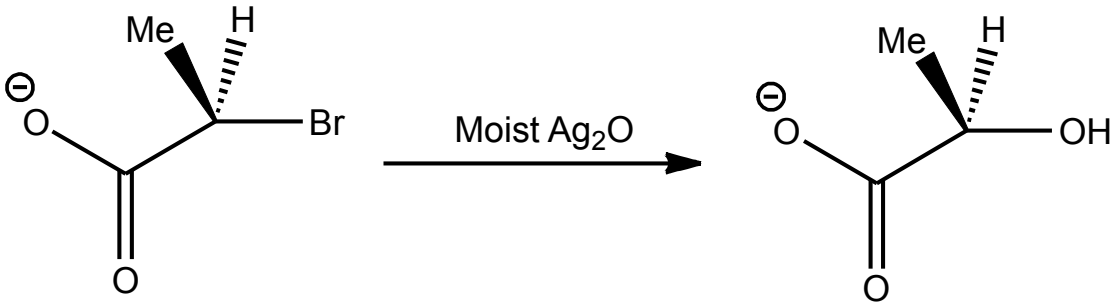
Optical purity of the sample, in per cent:

$$\frac{6.76}{13.52} \times 100 = 50$$

So 50% is excess (+) isomer and the remaining 50% is racemic.

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

34. Certain organic reactions proceed through formation of intermediates which are highly strained and reactive. Given the following reaction, the correct statement about the mechanism of the reaction is



(A) Intramolecular S_N2 attack by -COO^- to form an intermediate followed by the attack by HO^-via S_N2 pathway on the intermediate

(B) Intramolecular S_N2 attack by -COO^- to form an intermediate followed by the attack by HO^- via S_N1 pathway on the intermediate

(C) HO^- attacks via S_N1 pathway on the reactant

(D) HO^- attacks via S_N2 pathway on the reactant

Solution · Q34 **Answer: (A)**

The product keeps the configuration of the reactant.

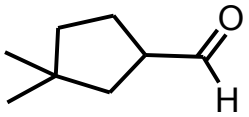
First, the COO^- group displaces Br^- from the back side (intramolecular S_N2), assisted by Ag^+. A strained α-lactone forms with inversion.

HO^- then opens the α-lactone at the same carbon by S_N2, giving a second inversion.

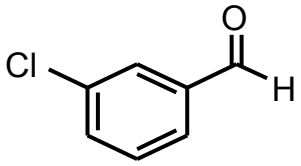
Two inversions give net retention.

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

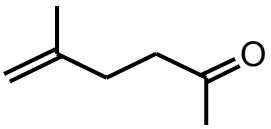
35. Which of the following compound is **NOT** named correctly according to the IUPAC nomenclature?

(A) 

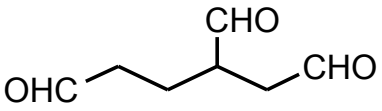
3,3 - Dimenthyl cyclopentanecar baldehyde

(B) 

3 - Chlorobenzaldehyde

(C) 

2 - Methy1-1-penten-4-one

(D) 

Butane - 1,2,4-tricarbaldehyde

Solution · Q35 **As per Zigyan: (C)**

In (C), the longest chain with both C=O and C=C has six carbon atoms.

Numbering starts from the end nearer to C=O.

Correct name: 5-methylhex-5-en-2-one.

In (A), "Dimenthyl" is a misprint of dimethyl: 3,3-dimethylcyclopentanecarbaldehyde.

(A), (B) and (D) are then correctly named.

Reference: NCERT Chemistry Class XII (Part II), Unit 8 'Aldehydes, Ketones and Carboxylic Acids', section 8.1.1: ketone chains are numbered from the end nearer the carbonyl group; an aldehyde group on a ring takes the suffix carbaldehyde.

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

36. Which of the following compounds contains the maximum number of sp^2 hybridized carbon atoms?

(A) 1, 4-Cyclohexadiene
(B) 2, 5-dimethyl -2, 3, 4-hexatriene
(C) Benzaldehyde
(D) 1, 1-diallyl -3, 3-divinylcyclopentane

Solution · Q36 **Answer: (D)**

Count the sp^2 carbon atoms.

(A) 1,4-Cyclohexadiene: 4

(B) $CH_3–C(CH_3)=C=C=C(CH_3)–CH_3$: 2, as the two middle carbons are sp.

(C) Benzaldehyde, ring and CHO carbons:

$$6 + 1 = 7$$

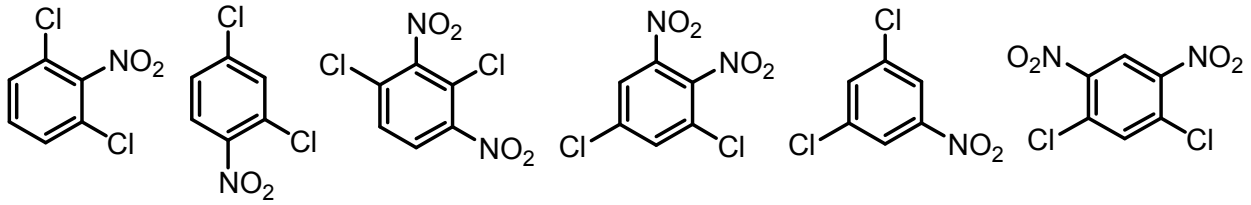
(D) Two allyl and two vinyl groups, two each:

$$4 \times 2 = 8$$

∴ (D) has the maximum number.

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

37. The number of products from the following, which cannot be formed on nitration of 1, 3-dichlorobenzene with a mixture of concentrated nitric acid and sulfuric acid is



(A) Four (B) Three (C) Two (D) One

Solution · Q37 **Answer: (C)**

Both Cℓ atoms direct the first $-NO_2$ group to C4 (major) or C2 (minor).

A second $-NO_2$ group enters meta to the first one.

So (i), (ii), (iii) and (vi) can form, (i) and (iii) as minor products.

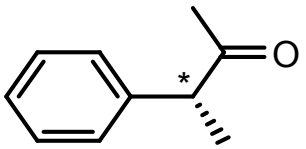
(v) has $-NO_2$ meta to both Cℓ atoms.

(iv) has two $-NO_2$ groups ortho to each other, one of them also meta to both Cℓ atoms.

∴ (iv) and (v), that is two products, cannot be formed.

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

38. Optically pure 3-Phenyl-2-butanone (X) with the following structure is treated with methyl magnesium iodide in anhydrous ether. The product formed after acidic hydrolysis is



[X]

3-phenyl-2-butanone

(A) diastereomeric mixture of alcohols (B) optically pure alcohol

(C) racemic mixture of alcohols (D) optically inactive alcohol

Solution · Q38 **Answer: (B)**

CH_3MgI adds a methyl group to the carbonyl carbon.

$C_6H_5CH(CH_3)COCH_3 + CH_3MgI \rightarrow C_6H_5CH(CH_3)C(CH_3)_2OMgI$

On acidic hydrolysis,

$C_6H_5CH(CH_3)C(CH_3)_2OMgI \rightarrow C_6H_5CH(CH_3)C(CH_3)_2OH$

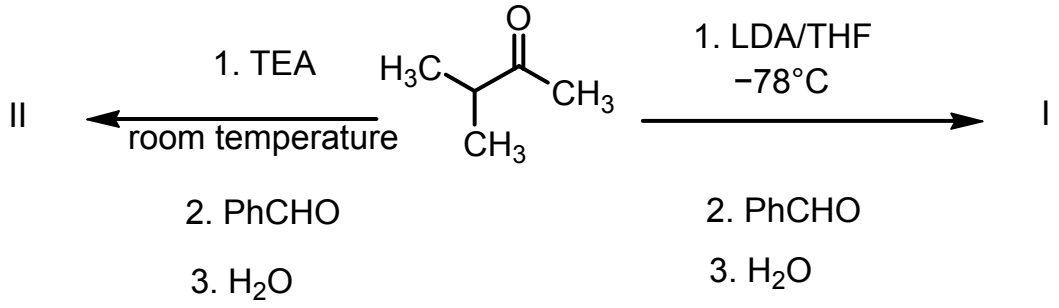
The carbinol carbon carries two methyl groups, so it is not a stereocentre.

No bond at the original stereocentre is touched.

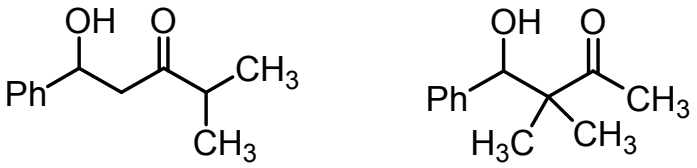
∴ the alcohol is a single enantiomer.

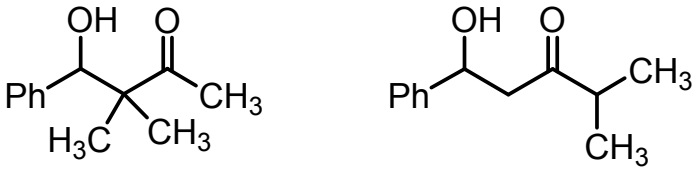
IAPT answer: (B) | **Zigyan answer:** (B)

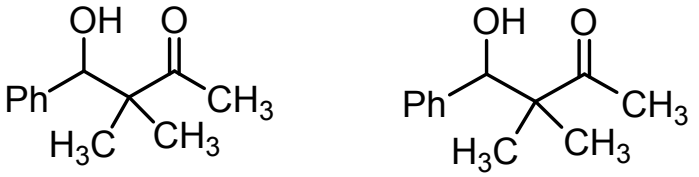
39. Aldehydes react with carbonyl compounds in the presence of bases by a mechanism similar to aldol condensation. Given below is the reaction of benzaldehyde with 3-methyl-2-butanone in the presence of lithium diisopropylamide (LDA), a strong bulky base and triethyl amine (TEA), a weak base. The correct structures of the major products, **I** and **II** formed in the following reactions are respectively

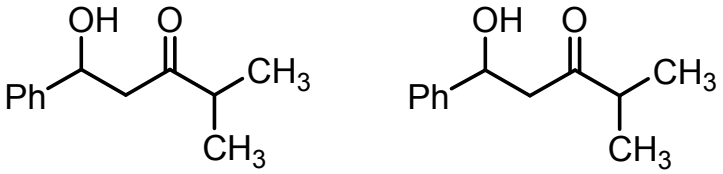


I **II**

(A) 

(B) 

(C) 

(D) 

Solution · Q39 **Answer: (A)**

LDA at −78 °C removes the more accessible methyl proton (kinetic enolate).

$$(CH_3)_2CHCOCH_3 \rightarrow (CH_3)_2CHC(O^-)=CH_2$$

After PhCHO and water, product I is:

$PhCH(OH)CH_2COCH(CH_3)_2$

With TEA at room temperature, thermodynamic control favours the more substituted enolate.

$$(CH_3)_2CHCOCH_3 \rightarrow (CH_3)_2C=C(O^-)CH_3$$

Product II is:

$PhCH(OH)C(CH_3)_2COCH_3$

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

40. The correct order of the given reagents to convert benzene to m-Chlorobromobenzene is

(1) sulfuric acid (conc.) and heat	(2) Cl_2 + $FeCl_3$ and heat	(3) $NaNO_2$ + H_3O^+ 0 °C	(4) H_2 Pt catalyst	(5) Mg in ether
(6) PBr_3	(7) H_3PO_2 (aqueous)	(8) HNO_3 (conc.) + H_2SO_4 (conc.) and heat	(9) Cu_2Br_2 + HBr	(10) $(CH_3CO)_2O$ + pyridine

(A) 1, 2, 5, 7 and 6
(B) 2, 8, 4, 3 and 9
(C) 8, 4, 10, 2, 3 and 9
(D) 8, 2, 4, 3 and 9

Solution · Q40 **Answer: (D)**

Nitrate first (8), as $-NO_2$ is meta directing.

$C_6H_6 \rightarrow C_6H_5NO_2$

Chlorination (2):

$C_6H_5NO_2 \rightarrow$ m-$C\ell C_6H_4NO_2$

Reduction (4):

m-$C\ell C_6H_4NO_2 \rightarrow$ m-$C\ell C_6H_4NH_2$

Diazotisation (3):

m-$C\ell C_6H_4NH_2 \rightarrow$ m-$C\ell C_6H_4N_2^+$

Sandmeyer reaction (9):

m-$C\ell C_6H_4N_2^+ \rightarrow$ m-$C\ell C_6H_4Br$

$\therefore$ the order is 8, 2, 4, 3 and 9.

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

41. A chiral hydrocarbon (Molecular Formula C_6H_{12}) undergoes catalytic hydrogenation to yield an achiral product (Molecular Formula C_6H_{14}). The chiral hydrocarbon is

(A) *cis*-2-hexene
(B) 3-methyl-2-pentene
(C) 4-methyl-2-pentene
(D) 3-methyl-1-pentene

Solution · Q41 **Answer: (D)**

In 3-methyl-1-pentene, C3 carries four different groups:

H, CH_3, C_2H_5 and CH_2=CH–

On hydrogenation,

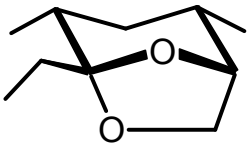
$$CH_2=CHCH(CH_3)C_2H_5 + H_2 \rightarrow CH_3CH(C_2H_5)_2$$

3-Methylpentane has two identical ethyl groups on C3, so it is achiral.

The other three alkenes have no chiral carbon.

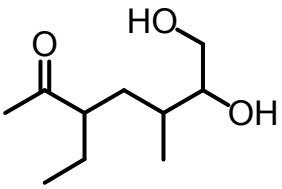
IAPT answer: (D) | **Zigyan answer:** (D)

42. The structure of multistriatin, a pheromone of the elm bark beetle, is shown beside. The open chain ketodiol that on dehydrative cyclization gives multistriatin, bicyclic ketal (ignore stereo chemical aspects) is

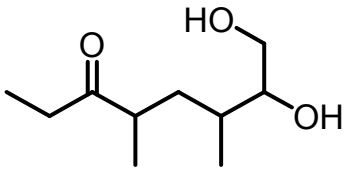


multistriatin

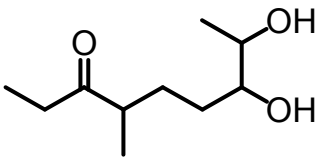
(A)



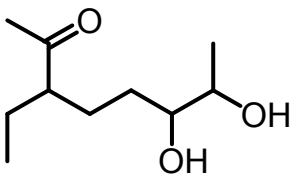
(B)



(C)



(D)



Solution · Q42 **Answer: (B)**

The ketal carbon, bonded to both ring oxygens, was the C=O carbon of the ketodiol.

Opening its two C–O bonds gives back the ketone and two –OH groups.

These –OH groups are on a terminal CH_2 and the adjacent CH.

$CH_3CH_2COCH(CH_3)CH_2CH(CH_3)CH(OH)CH_2OH$

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

43. A monobasic acid (0.100 g) on complete combustion gave 0.252 g of CO_2 and 0.044 g of H_2O. For complete neutralization of 0.122 g of the acid, 10.0 mLof 0.1M NaOH solution was required. Molecular formula of the acid is

(A) $C_7H_6O_2$ (B) $C_6H_7O_2$ (C) $C_7H_7O_2$ (D) $C_6H_6O_2$

Solution · Q43 **Answer: (A)**

The acid is monobasic, so moles of acid equal moles of NaOH.

$$M = \frac{0.122}{0.0100 \times 0.1}$$

$$\Rightarrow M = 122 \text{ g mol}^{-1}$$

For the 0.100 g sample:

$$n_C = \frac{0.252}{44}$$

$$\Rightarrow n_C = 0.00573 \text{ mol}$$

$$n_H = \frac{2 \times 0.044}{18}$$

$$\Rightarrow n_H = 0.00489 \text{ mol}$$

$$m_O = 0.100 - (0.00573 \times 12) - (0.00489 \times 1)$$

$$\Rightarrow m_O = 0.0264 \text{ g}$$

$$\Rightarrow n_O = 0.00165 \text{ mol}$$

$$C : H : O = 0.00573 : 0.00489 : 0.00165$$

$$\Rightarrow C : H : O \approx 3.5 : 3 : 1$$

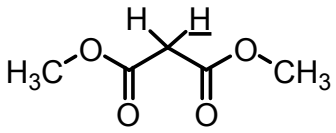
$$\Rightarrow C : H : O \approx 7 : 6 : 2$$

$\therefore$ $C_7H_6O_2$, of molar mass 122 g mol^{-1}.

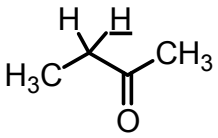
IAPT answer: (A) | **Zigyan answer:** (A)

44. Acidity of acidic compounds depend on the stability of their conjugate bases. The correct order of acidity of the underlined H in the following compounds is

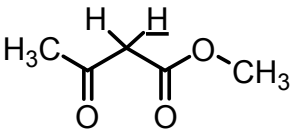
(Note: Assume that all the compounds exist in the keto form)



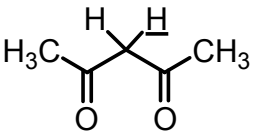
(i)



(ii)



(iii)



(iv)

(A) (ii) > (iii) > (iv) > (i)

(B) (iv) > (iii) > (i) > (ii)

(C) (iii) > (ii) > (iv) > (i)

(D) (i) > (iii) > (iv) > (ii)

Solution · Q44 **Answer: (B)**

A more stable carbanion means a more acidic H.

Two C=O groups spread the negative charge far better than one, so (ii) is the weakest acid.

In an ester, the $-OCH_3$ oxygen donates a lone pair to its own C=O.

So an ester group stabilises the carbanion less than a ketone group.

(iv) has two ketone groups, (iii) one ketone and one ester, and (i) two ester groups.

$\therefore$ (iv) > (iii) > (i) > (ii)

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

45. Reaction of *para*-Chloroaniline with acetic anhydride in pyridine gave a crude mixture of 94% of *para*-chloroacetanilide and 6% unreacted amine.

From the following, the best treatment suitable for purification of *para*-chloroacetanilide is

(A) treating the reaction mixture with methyl iodide

(B) washing an ether solution of the crude product with concentrated brine (aq. NaCl)

(C) washing an ether solution of the crude product with 5% cold aqueous sulfuric acid

(D) washing an ether solution of the crude product with 5% aqueous sodium carbonate

Solution · Q45 **Answer: (C)**

The leftover p-chloroaniline is basic, while the amide is practically neutral.

Cold dilute H_2SO_4 converts the amine into its salt:

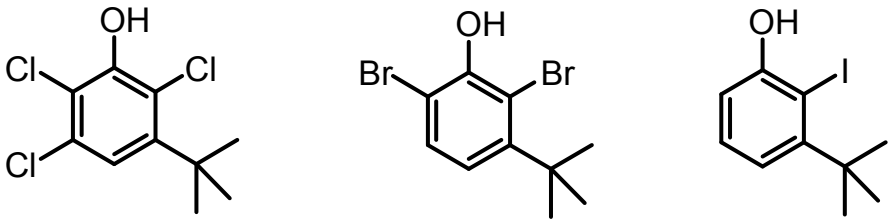
$2C\ell C_6H_4NH_2 + H_2SO_4 \rightarrow (C\ell C_6H_4NH_3)_2SO_4$

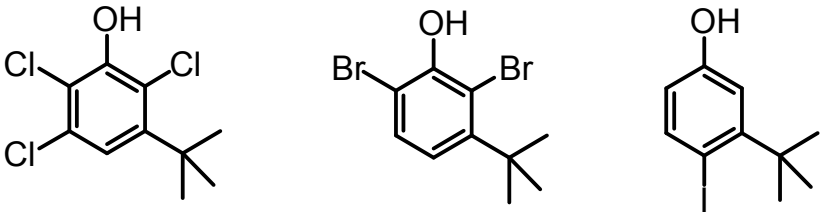
The salt leaves the ether layer for water, and p-chloroacetanilide stays in ether.

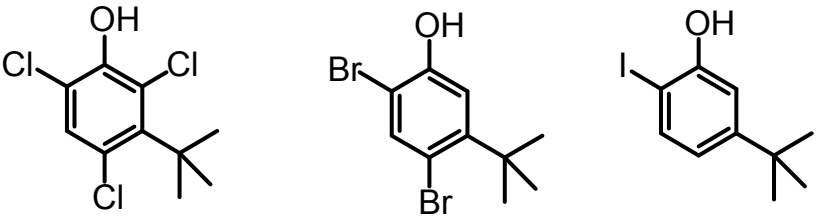
Cold, dilute acid does not appreciably hydrolyse the amide.

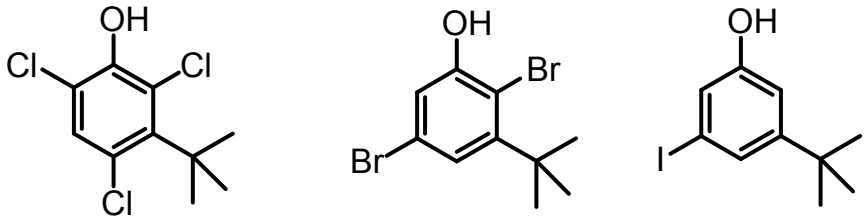
IAPT answer: (C) | **Zigyan answer:** (C)

46. 3-tert-butylphenol when reacted separately with excess chlorine, bromine and iodine gave trichloro, di-bromo and mono-iodo derivatives of 3-tert-butylphenol respectively. The correct structures of the respective halogen derivatives are

(A) 

(B) 

(C) 

(D) 

Solution · Q46 **Answer: (C)**

The –OH group activates C2, C4 and C6.

C2 lies between –OH and tert-butyl, C4 is next to tert-butyl, and C6 is the least crowded.

Small, reactive chlorine enters all three positions:

2,4,6-trichloro derivative

The larger bromine leaves C2 free:

4,6-dibromo derivative

Bulky, weakly reactive iodine enters only C6:

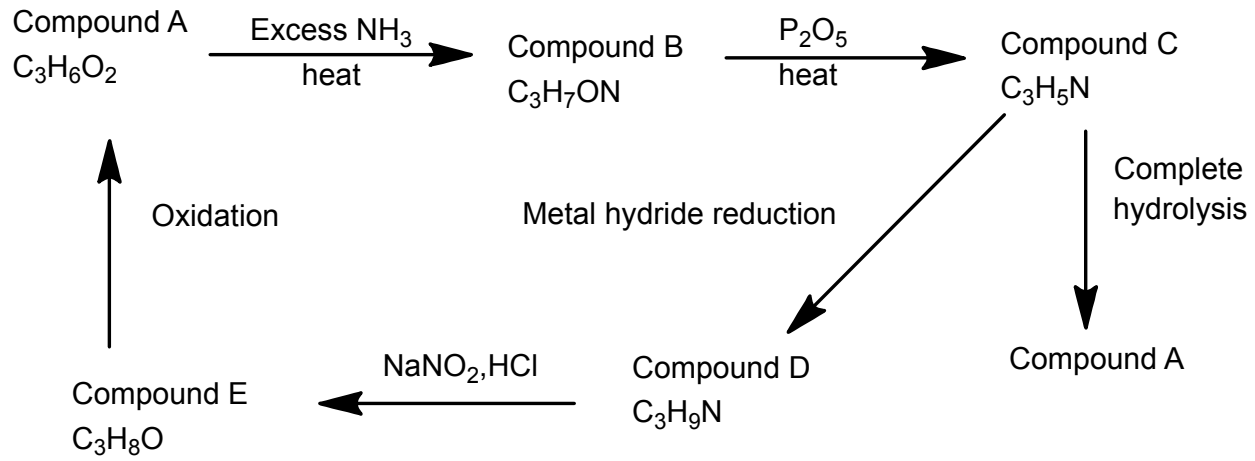
6-iodo derivative

These positions match option (C).

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

47. Consider the following sequence of reactions:

The functional groups undergoing change in the conversion of A to E respectively are



(A) -COOH, -NC, $-CONH_2$, $-NH_2$, $-CH_2OH$

(B) -COOH, -CN, $-CONH_2$, $-NH_2$, $-CH_2OH$

(C) -COOH, $-CONH_2$, -CN, $-CH_2NH_2$, $-CH_2OH$

(D) $-CONH_2$, -COOR, -NC, -NHR, >CHOH

Solution · Q47 **Answer: (C)**

A is propanoic acid.

Excess NH_3 with heat, then P_2O_5:

$C_2H_5COOH \rightarrow C_2H_5CONH_2 \rightarrow C_2H_5CN$

Reduction, then $NaNO_2$ with $HC\ell$:

$C_2H_5CN \rightarrow C_2H_5CH_2NH_2 \rightarrow C_2H_5CH_2OH$

So the groups in A to E are:

$-COOH$, $-CONH_2$, $-CN$, $-CH_2NH_2$, $-CH_2OH$

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

48. The correct sequence of reagents which would convert p-Nitrotoluene to p-Iodobenzoic acid is

(A) (i) Br_2 + $FeBr_2$, (ii) Mg in ether, then CO_2, (iii) 3 H_2 and Pt or Ni catalyst, (iv) HNO_2, 0°C, (v) KI solution

(B) (i) Br_2 in CCl_4 and heat, (ii) NaI in acetone, (iii) 3 H_2 and Pt or Ni catalyst, (iv) HNO_2, 0 °C, (v) H_3PO_2

(C) (i) 3 H_2 and Pt or Ni catalyst, (ii) HNO_2, 0 °C, (iii) Cu_2Br_2 + HBr, (iv) $KMnO_4$ and heat, (v) KI solution

(D) (i) $KMnO_4$ and heat, (ii) 3 H_2 and Pt or Ni catalyst, (iii) HNO_2, 0 °C, (iv) KI solution

Solution · Q48 **Answer: (D)**

Oxidise $-CH_3$ first, then change $-NO_2$ into $-I$ through the diazonium salt.

With $KMnO_4$ and heat:

$p\text{-}O_2NC_6H_4CH_3 \rightarrow p\text{-}O_2NC_6H_4COOH$

With H_2 and Pt or Ni:

$p\text{-}O_2NC_6H_4COOH \rightarrow p\text{-}H_2NC_6H_4COOH$

With HNO_2 at 0 °C:

$p\text{-}H_2NC_6H_4COOH \rightarrow p\text{-}HOOCC_6H_4N_2^+$

With KI solution:

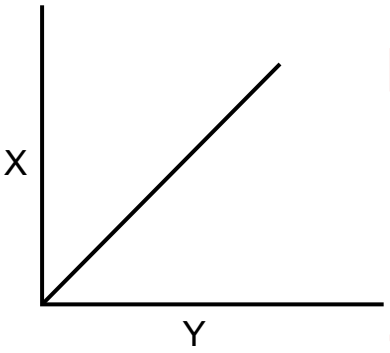
$p\text{-}HOOCC_6H_4N_2^+ \rightarrow p\text{-}IC_6H_4COOH$

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

PART A-2 · ONE OR MORE CORRECT OPTIONS

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

49. Following is a qualitative plot that can represent kinetic data obtained with a reactant R where $[R]_0$ and [R] represent the concentrations of R, at t = 0 and t = t respectively. 'Y' and 'X' are suitable parameters on the x- and y- axes.



The correct representation of the curve is

	X	Y	order	X	Y	order
(A)	$[R]_0 - [R]$	time	Zero	Rate	time	First
(B)	$[R]_0 - [R]$	time	Zero	Initial rate	$[R]_0$	First
(C)	Rate	[R]	Zero	$t_{1/2}$	[R]	First
(D)	$t_{1/2}$	[R]0	Zero	$\ln\{[R]_0/[R]\}$	t	First

Solution · Q49 **Answer: (B), (D)**

The line passes through the origin, so $X \propto Y$.

Zero order:

$$[R]_0 - [R] = kt$$

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

Both give such a line, but rate against [R] is horizontal.

First order:

$$r_0 = k[R]_0$$

$$\ln([R]_0/[R]) = kt$$

These two also give such a line.

For rate against time:

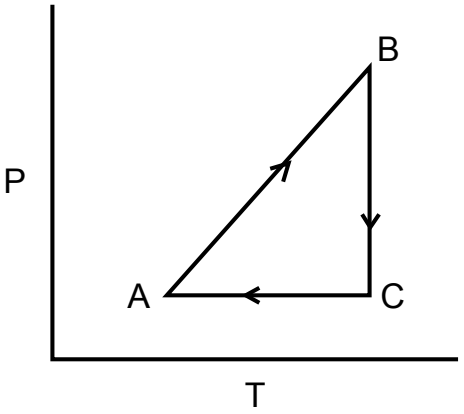
$$r = k[R]_0 e^{-kt}$$

This is a decay curve, and first order $t_{1/2}$ is constant.

∴ both pairs are right only in (B) and (D).

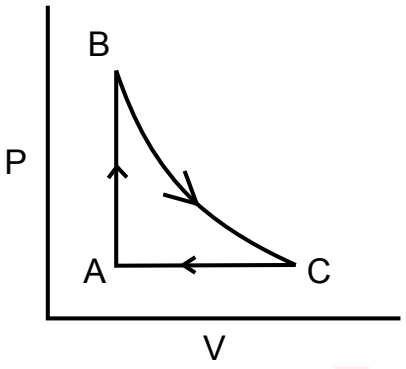
IAPT answer: (B), (D) | **Zigyan answer:** (B), (D)

50. A given amount of an ideal gas undergoes the cyclic process ABCA as given below.

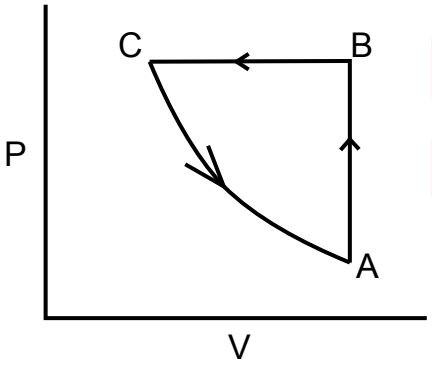


The equivalent representation/s of the same process is/are

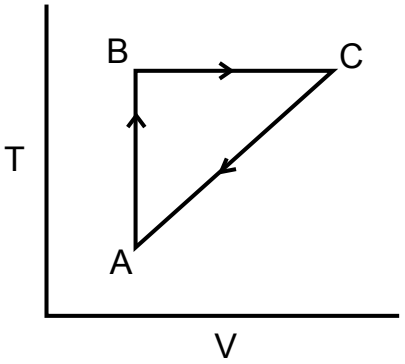
(A)



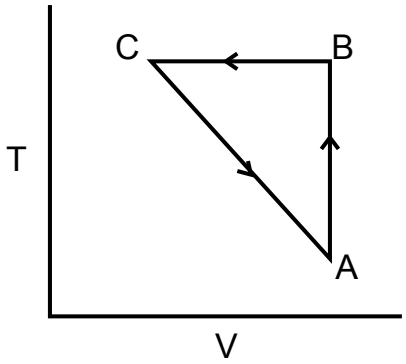
(B)



(C)



(D)



Solution · Q50 **Answer: (A), (C)**

A → B (taken as a line through the origin):

$$P \propto T$$

∴ V is constant while P rises.

B → C: T is constant and P falls, so V increases (isothermal curve on P–V).

C → A: P is constant and T falls.

$$V \propto T$$

(A) shows these three steps on P–V axes, and (C) on T–V axes.

In (B), P is constant from B to C; in (D), V falls from B to C.

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

51. The correct statements among the following is /are

(A) When equal volumes of a solution containing Sr^{2+} (0.01M) and another containing F^- (0.001M) are mixed at 25°C, SrF_2 will be precipitated (K_{sp} of $SrF_2 = 8.0 \times 10^{-10}$ at 25°C)

(B) When equal volumes of a solution containing Ba^{2+} (1.0×10^{-4} M) and another containing F^- (1.0×10^{-2}M) are mixed at 25°C, BaF_2 will be precipitated (K_{sp} of $BaF_2 = 1.0 \times 10^{-6}$ at 25°C)

(C) The solubility product (K_{sp}) and the molar solubility (s) of $La(IO_3)_3$ are related as $K_{sp} = 27s^4$

(D) The solubility product and the molar solubility of $Ca_3(PO_4)_2$ are related as $27s^4$

Solution · Q51 **Answer: (A), (C)**

Mixing equal volumes halves each concentration.

For (A):

$$Q = [Sr^{2+}][F^-]^2$$

$$\Rightarrow Q = (5 \times 10^{-3})(5 \times 10^{-4})^2$$

$$\Rightarrow Q = 1.25 \times 10^{-9} > K_{sp}$$

∴ SrF_2 precipitates.

For (B):

$$Q = (5 \times 10^{-5})(5 \times 10^{-3})^2$$

$$\Rightarrow Q = 1.25 \times 10^{-9} < K_{sp}$$

∴ no precipitate.

For (C):

$$K_{sp} = s(3s)^3$$

$$\Rightarrow K_{sp} = 27s^4$$

For (D):

$$K_{sp} = (3s)^3(2s)^2$$

$$\Rightarrow K_{sp} = 108s^5$$

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

52. For the phenomenon of adsorption, the correct statement/s among the following is /are

(A) According to Freundlich model, mass of N_2 gas adsorbed per g of silica surface will increase with temperature of adsorption

(B) If S is the surface area of an adsorbent, and 'A', 'm' and 'M' are the cross-sectional area, mass adsorbed and molar mass of the adsorbate respectively, then $S = \left(\frac{m}{M}\right)AN_A$ (N_A-Avogadro's number)

(C) The number of gas molecules physisorbed on unit mass of an adsorbent will be the same for two different gases at the same temperature.

(D) Adsorption of H_2 on Ni surface with E_a = 96 kJ mol^{-1} can be termed as chemisorption

Solution · Q52 **Answer: (B), (D)**

(A) Physical adsorption is exothermic, so the amount adsorbed falls as temperature rises. False.

(B) For a monolayer, number of adsorbed molecules:

$$N = \frac{m}{M}N_A$$

$$\Rightarrow S = N \times A$$

$$\Rightarrow S = \frac{m}{M}AN_A$$

True.

(C) The extent of physisorption depends on the nature of the gas. False.

(D) Physisorption needs practically no activation energy; 96 kJ mol^{-1} indicates chemisorption. True.

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

53. When excess $KMnO_4$ is added to concentrated H_2SO_4, an oily green colored covalent compound **Y** is formed. Which of the following statements is/ are true for the above reaction.

(A) Compound **Y** is formed by a dehydration reaction

(B) In compound **Y** Mn is octahedrally surrounded by oxygen atoms

(C) **Y** is the highest oxide of Manganese

(D) Compound **Y** has Mn-O-Mn bridge

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

With excess $KMnO_4$:

$2KMnO_4 + H_2SO_4 \rightarrow Mn_2O_7 + K_2SO_4 + H_2O$

Mn_2O_7 is the dehydration product of $HMnO_4$:

$2HMnO_4 \rightarrow Mn_2O_7 + H_2O$

∴ (A) is true.

Structure: two MnO_4 tetrahedra share one oxygen.

$O_3Mn–O–MnO_3$

∴ (B) is false and (D) is true.

Mn is in its highest state, +7, so (C) is true.

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

54. Read carefully all the three statements on defects in solids:

(i) In Frenkel defect, interstitial Ag^+ site is surrounded tetrahedrally by four Cl^- ions and four Ag^+ ions, where interstitial Ag^+ and Cl^- interaction is covalent

(ii) Addition of small amount of $SrCl_2$ in NaCl yields solid solution with a formula of $Na_{1-2x}Sr_xV_{Nax}Cl$, where V = valency

(iii) In general, Schottky defect increases the density of the substance

Choose the correct alternative(s).

(A) Statement (i) is correct

(B) Statements (ii) and (iii) are correct

(C) Statements (i) and (ii) are correct

(D) Statements (i) and (iii) are correct

Solution · Q54 **As per Zigyan: (A), (C)**

In (ii), V is a vacant Na^+ site ("valency" is a misprint for vacancy).

(i) In $AgC\ell$ the interstitial Ag^+ occupies a tetrahedral void with four $C\ell^-$ and four Ag^+ neighbours; covalent Ag–Cℓ interaction stabilises it. True.

(ii) One Sr^{2+} replaces two Na^+: one site holds Sr^{2+}, the other stays vacant.

Total cation charge per $C\ell^-$:

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

So the formula is correct. True.

(iii) Schottky vacancies lower the density. False.

∴ statements (i) and (ii) are correct.

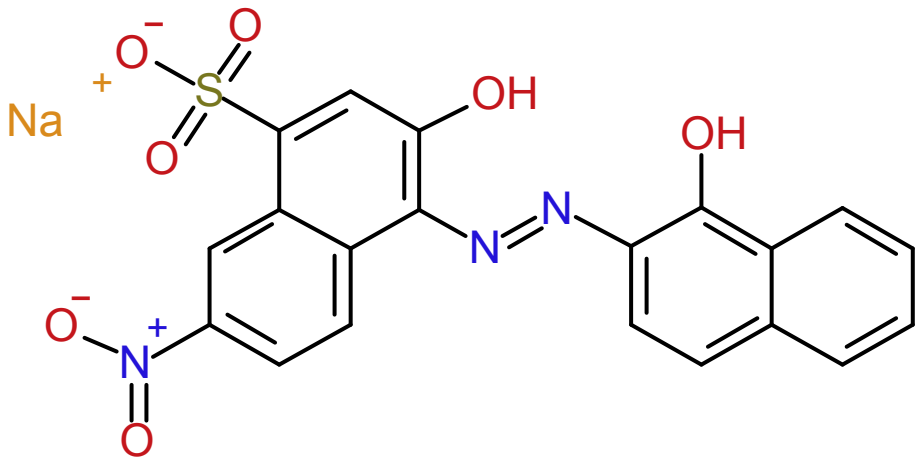
Reference: NPTEL course 'Defects, Diffusion and Conduction in Ceramics', Module 3, section 3.3.1: when $CdC\ell_2$ enters $NaC\ell$, each Cd^{2+} on a Na site creates one sodium vacancy.

Reference: Kiel University online course 'Defects in Crystals' (H. Föll), section 2.4.2, Kröger-Vink notation: V denotes a vacancy and its subscript names the site.

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

55. Eriochrome black T (EBT) is an indicator in titrimetric estimation of calcium at pH 10.0 giving pink colour to the solution. It has structure as shown below. Considering that the pH of solution is 10.0, which statement(s) describe(s) the complexation of EBT with Ca(II) correctly

EBT



$pK_{a2} = 6.3$, $pK_{a3} = 11.5$

(A) On dissociation of EBT, Ca(II) binds at SO_3^- to form 1:2 complex

(B) Both sulphonate and nitro groups are involved in 1:1 complexation with Ca(II)

(C) EBT acts as a bidentate ligand to form a dianionic species, with deprotonation of one – OH, where Ca(II) binds to azide nitrogen and phenolic oxygen *trans* to – NO_2 group in 1:2 ratio

(D) There is a mixture of complexes of Ca(II) with EBT acting as a bidentate and tridentate ligand

Solution · Q55 **As per Zigyan: (C), (D)**

pH 10 lies between the two given values:

$$pK_{a2} < pH < pK_{a3}$$

∴ EBT is mainly HIn^{2-} (SO_3^- and one phenoxide).

(C) HIn^{2-} chelates through an azo N and the phenoxide O as a bidentate ligand, giving a 1:2 dianionic complex. True.

$Ca^{2+} + 2HIn^{2-} \rightleftharpoons [Ca(HIn)_2]^{2-}$

(D) If the second –OH also loses H^+ on binding, O, N and O coordinate (tridentate):

$Ca^{2+} + HIn^{2-} \rightleftharpoons [CaIn]^- + H^+$

So both kinds of complex are present. True.

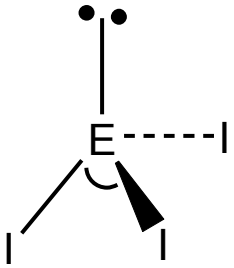
(A), (B) SO_3^- and NO_2 lie far from the azo group and cannot join this chelate. False.

Reference: University of Texas chemistry course CH 455, laboratory handout 'Determination of Water Hardness using Complexometric titration': at pH 10, Eriochrome Black T is predominantly in the form HIn^{2-}.

Check: pH 10 is 3.7 units above pK_{a2} and 1.5 units below pK_{a3}, so about 97% of the free dye is HIn^{2-}.

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

56. The correct statement(s) regarding three EI_3 molecules (where E = P, As or Sb) is/are:



(A) These compounds are formed by mutual sharing of electrons and hence considered as covalent compounds

(B) PI_3 is most susceptible towards hydrolysis in water to give phosphorous acid

(C) SbI_3 has highest boiling point amongst all

(D) In AsI_3, there is least repulsion between bond pair and lone pair and thus has the largest I-E-I angle

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

(A) E and I share electron pairs in these molecular halides. True.

(B) PI_3 hydrolyses most readily, giving phosphorous acid:

$PI_3 + 3H_2O \rightarrow H_3PO_3 + 3HI$

Hydrolysis becomes less complete from P to Sb. True.

(C) AsI_3 boils at 424 °C and SbI_3 at 400 °C. False.

(D) The I–E–I angle is largest in PI_3, not in AsI_3. False.

Why Zigyan differs from IAPT: water attacks PI_3 violently, and only this iodide of the three can give phosphorous acid. So (B) is correct along with (A).

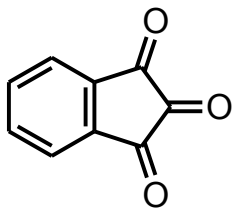
Reference: A. R. Barron, 'Chemistry of the Main Group Elements' (LibreTexts), section 8.5: phosphorus triiodide reacts violently with water.

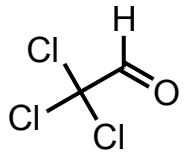
Reference: University of Missouri course text (LibreTexts), section 22.8: the trihalides react rapidly with water; those of P and As give H_3PO_3 and H_3AsO_3.

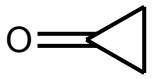
Reference: PubChem, U.S. National Library of Medicine, boiling points: arsenic triiodide 424 °C, antimony triiodide 400 °C.

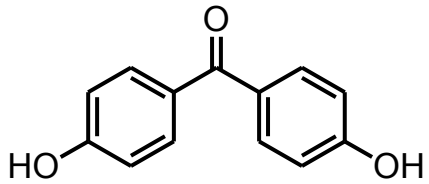
IAPT answer: (A) | **Zigyan answer:** (A), (B)

57. Aldehydes and ketones can react with water in the presence of an acid or base to yield an equilibrium mixture of the aldehyde/ketone and the corresponding hydrates (geminal diol). Among the following, the aldehyde/ketones which will have a greater percentage of the hydrate at equilibrium are

(A) 

(B) 

(C) 

(D) 

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

A hydrate is favoured when the carbonyl compound is destabilised.

(A) The middle C=O is flanked by two C=O groups, so it is highly electrophilic. High hydrate.

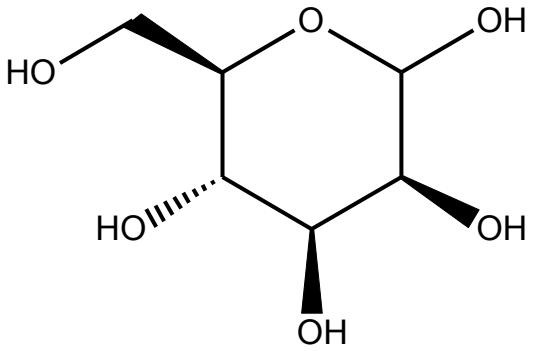
(B) The $CC\ell_3$ group withdraws electrons strongly (stable chloral hydrate). High hydrate.

(C) The sp^2 carbon makes the three-membered ring very strained; the sp^3 hydrate relieves strain. High hydrate.

(D) The two 4-hydroxyphenyl rings stabilise C=O by resonance and crowd it. Very little hydrate.

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

58. The correct statement/s about the pyranose form of a sugar (X) given below is/are:



(X)

(A) It exists in two anomeric pyranose forms

(B) It reacts with Tollens' reagent to give a silver mirror

(C) The penta-O-methyl derrvative of (X) is non reducing.

(D) It resists reduction with aqueous sodium borohydride

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

X is an aldohexose pyranose; C-1 is a hemiacetal carbon.

(A) The –OH at C-1 gives α and β anomers. True.

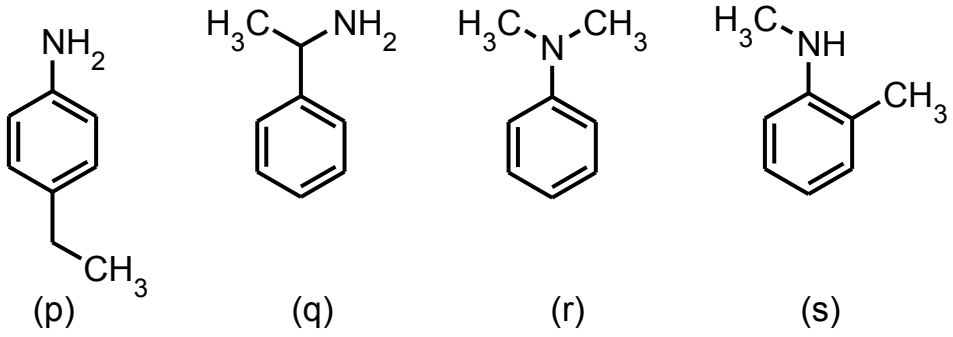
(B) The hemiacetal opens to the aldehyde, which reduces Tollens' reagent. True.

(C) In the penta-O-methyl derivative, C-1 is part of a methyl glycoside (acetal). It does not open in the basic reagent: non-reducing. True.

(D) $NaBH_4$ reduces the open-chain aldehyde to an alditol. False.

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

59. Given below are isomeric amines. The **incorrect** statement/s about them from the following is/are



(p) (q) (r) (s)

(A) (p) and (q) both will give unstable products respectively with $NaNO_2$ in HCl at 268 K

(B) Reaction of all amines with HCl is exothermic

(C) Reaction of benzene sulphonyl chloride with (s) gives a solid product that is soluble in NaOH

(D) (q) has the highest basicity among these

Solution · Q59 **Answer: (A), (C)**

(A) At 268 K, aromatic (p) gives a diazonium salt that is stable in the cold; only alkyl (q) gives an unstable one. Incorrect.

(B) Salt formation with HCℓ is an acid–base reaction and releases heat. Correct.

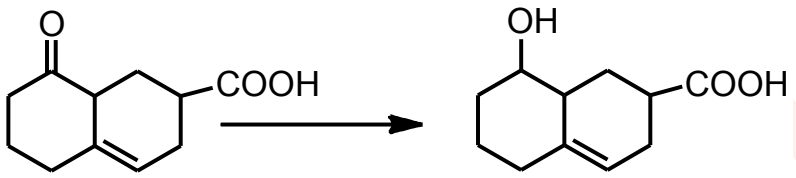
(C) (s) is a secondary amine. Its sulphonamide has no H on N, so it does not dissolve in NaOH. Incorrect.

(D) The lone pair of (q) is not delocalised into the ring, so it is the strongest base. Correct.

∴ the incorrect statements are (A) and (C).

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

60. Which one/s of the reduction techniques mentioned below is/are **NOT** suitable for the following chemical transformation



(A) $NaBH_4$ based reduction

(B) $LiAlH_4$ based reduction

(C) DIBAL-H based reduction

(D) B_2H_6 based reduction

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

Only the ketone has to be reduced; COOH and C=C must survive.

(A) $NaBH_4$ reduces the ketone and leaves COOH (as its salt until work-up) and C=C. Suitable.

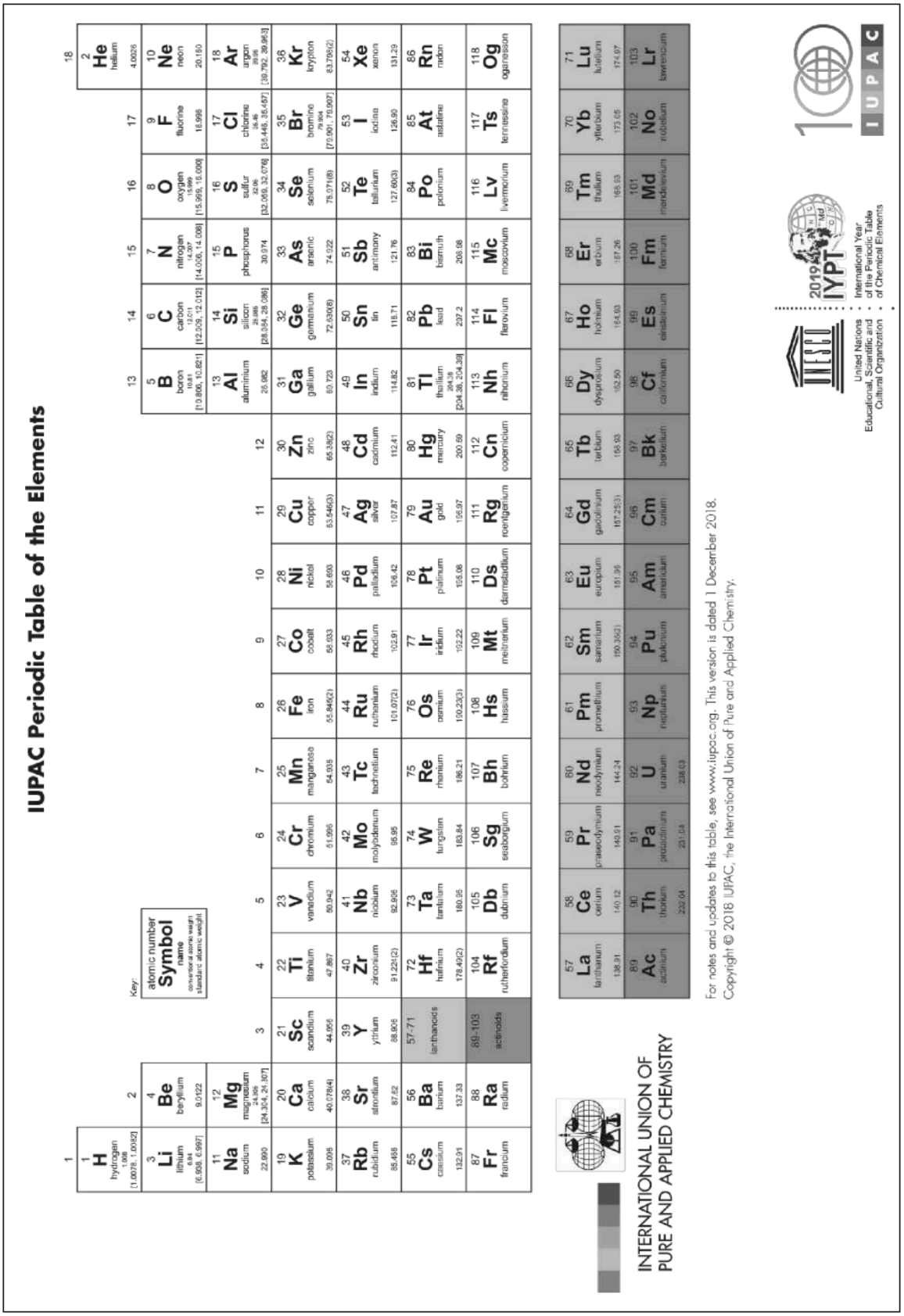
(B) $LiA\ell H_4$ also reduces COOH to CH_2OH. Not suitable.

(C) DIBAL-H also reduces the COOH group. Not suitable.

(D) B_2H_6 reduces COOH readily and adds to C=C. Not suitable.

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

Given in the question paper



ANSWER KEY

NSEC 2022 · PAPER CODE 31

60
QUESTIONS · 216 MARKS

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

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

★ Answers as per Zigyan

- **Q14** — As per Zigyan: (D); IAPT key (D).
- **Q15** — As per Zigyan: (A); IAPT key (A).
- **Q16** — As per Zigyan: (A); IAPT key (A).
- **Q35** — As per Zigyan: (C); IAPT key (C).
- **Q54** — As per Zigyan: (A), (C); IAPT key (A), (C).
- **Q55** — As per Zigyan: (C), (D); IAPT key (C), (D).
- **Q56** — As per Zigyan: (A), (B); IAPT key (A).

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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

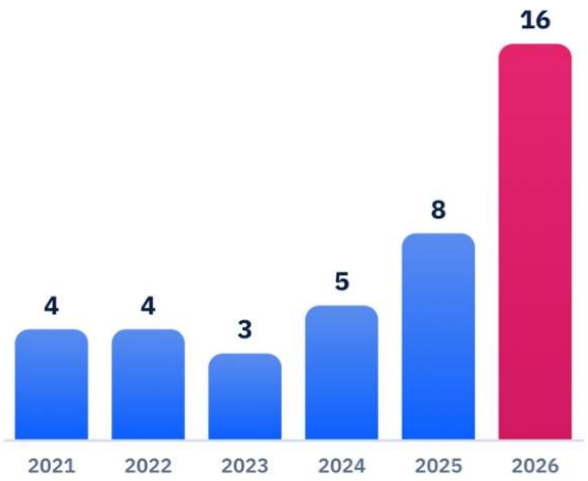
40
JEE Advanced selections in 6 years

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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