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PREVIOUS YEAR PAPER · 2020-21

OLYMPIAD · STAGE I

IOQC

Indian Olympiad Qualifier in Chemistry (Part I)

2020-21

Question paper, answer key and Zigyan solutions

32	120	60 min	31
Questions	Maximum marks	Time	Paper code

Question paper and official answer key: Indian Association of Physics Teachers (IAPT), IOQC 2020-21, paper code 31.
Solutions and notes: Zigyan. This booklet is not an IAPT publication.

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- Aarush Kumar — 1 Year Classroom

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- Priyanshi — 4 Years Classroom

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Given in the question paper

Useful constants

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

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

Planck's constant, $h = 6.626 \times 10^{-34} J\,s$

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

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

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

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

PART A-1 · ONE CORRECT OPTION

Q. 1 – 24 · +3 for a correct answer, –1 for a wrong one

1. Reaction of ammonia with diborane gives an ionic product ($B_2H_6.2NH_3$).

The hybridization of boron in the cation and anion of this product are respectively

(A) sp^3 in both (B) sp^3 and sp^2 (C) sp^2 and sp^3 (D) sp^2 in both

Solution · Q1 **Answer: (A)**

Ammonia splits diborane unsymmetrically:

$B_2H_6 + 2NH_3 \rightarrow [BH_2(NH_3)_2]^+ + [BH_4]^-$

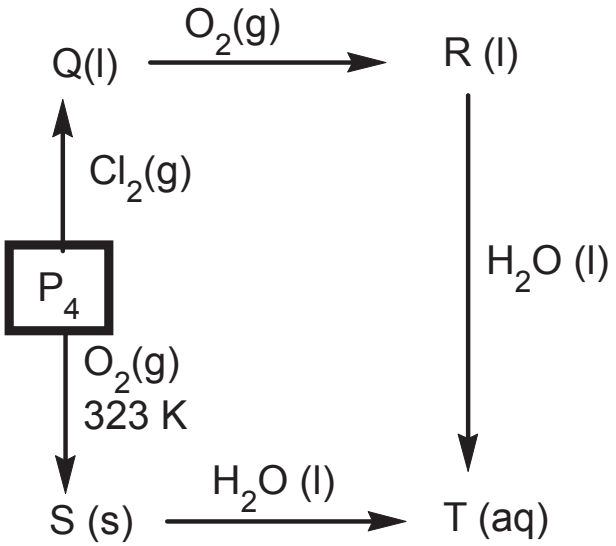
In each ion, boron has four σ bonds and no lone pair.

$\therefore$ boron is sp^3 in both ions.

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

2. A sequence of reactions of phosphorous (P_4) is given below

The correct set of products (Q, R, S and T) among the following is



(A) Q = PCl_3; R = $POCl_3$; S = P_2O_3; T = H_3PO_3

(B) Q = PCl_5; R = P_2O_5; S = P_4O_6; T = H_3PO_3

(C) Q = PCl_3; R = $POCl_3$; S = P_4O_{10}; T = H_3PO_4

(D) Q = PCl_5; R = P_4O_{10}; S = P_4O_{10}; T = H_3PO_4

Solution · Q2 **Answer: (C)**

Q is a liquid, so it is $PC\ell_3$ ($PC\ell_5$ is a solid).

$P_4 + 6C\ell_2 \rightarrow 4PC\ell_3$

$2PC\ell_3 + O_2 \rightarrow 2POC\ell_3$

Hydrolysis of R:

$POC\ell_3 + 3H_2O \rightarrow H_3PO_4 + 3HC\ell$

So T is H_3PO_4, and the solid S must also give it.

$P_4 + 5O_2 \rightarrow P_4O_{10}$

$P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$

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

3. In the gaseous state of $Fe(CO)_5$, the 'd' orbital that would participate in hybridization is

(A) $d_{x^2-y^2}$ (B) d_{z^2}

(C) d_{xz} (D) any one of the 'd' orbitals

Solution · Q3 **Answer: (B)**

$Fe(CO)_5$ is trigonal bipyramidal.

CO is a strong field ligand. The eight valence electrons of Fe pair up in four 3d orbitals.

The fifth 3d orbital, d_{z^2}, takes part in dsp^3 hybridisation.

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

4. Among the following, the *correct* statement/s about 'p' block elements is/are

I. The valence shell electronic configuration of all of them is $ns^2\ np^{1\text{-}6}$

II. Only in p block, metals, nonmetals and metalloids are present

III. Halogens have the lowest negative electron gain enthalpy in the respective periods

IV. Noble gases have no tendency to accept an electron and hence they have large negative values of electron gain enthalpy

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

Solution · Q4 **Answer: (D)**

I: He ($1s^2$), a group 18 element of the p block, has no p electron. ∴ false.

II: Only the p block has metals, non-metals and metalloids together. ∴ true.

III: In a period, halogens have the most negative electron gain enthalpy, not the least negative. ∴ false.

IV: Noble gases have large positive electron gain enthalpy. ∴ false.

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

5. A chemical reaction is carried out at two different temperatures T_1 and T_2 ($T_2 > T_1$) and also with and without a catalyst.

The statement that is correct among the following is

(A) Lowering in the activation energy of the reaction due to catalyst would be higher at T_2 than at T_1

(B) Lowering in the activation energy of the reaction due to catalyst would be higher at T_1 than at T_2

(C) The factor by which the rate of the reaction is increased by the catalyst would be lower at T_2 than at T_1

(D) The factor by which the rate of the reaction is increased by the catalyst would be higher at T_2 than at T_1

Solution · Q5 **Answer: (C)**

A catalyst lowers the activation energy by ΔE_a, taken as independent of temperature, with the same pre-exponential factor.

By the Arrhenius equation,

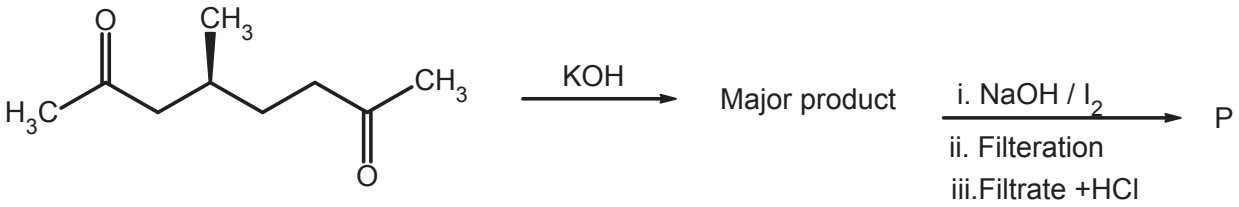
$$\frac{k_{cat}}{k} = e^{\Delta E_a / RT}$$

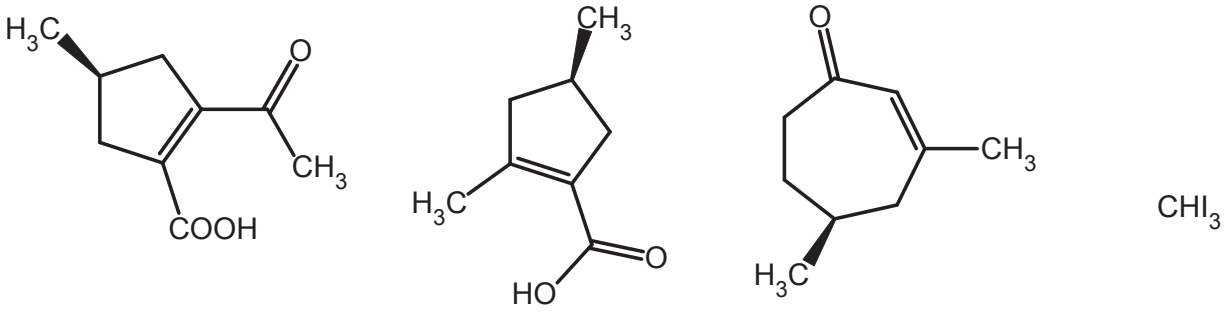
This factor decreases as T increases.

As $T_2 > T_1$, the rate is raised by a smaller factor at T_2.

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

6. The product **'P'** in the following sequence of reactions is





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

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

Solution · Q6 **Answer: (B)**

The reactant is 4-methyloctane-2,7-dione.

With KOH, it undergoes intramolecular aldol condensation to a five-membered ring. On the less hindered path, C-6 attacks the C-2 carbonyl and water is lost.

The major product is the methyl ketone 1-(2,4-dimethylcyclopent-1-en-1-yl)ethanone.

$NaOH/I_2$ (iodoform reaction) changes its $COCH_3$ group into COO^-Na^+ and gives CHI_3.

CHI_3 is filtered off. HCℓ on the filtrate gives P, 2,4-dimethylcyclopent-1-ene-1-carboxylic acid, which is structure (B).

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

7. Among the following, maximum number of resonance structures is possible for

(A) PO_4^{-3} (B) SO_4^{-2} (C) CO_3^{-2} (D) MnO_4^-

Solution · Q7 **Answer: (B)**

Equivalent structures with the least formal charge are counted.

PO_4^{3-}: one P=O among four O atoms gives 4.

SO_4^{2-}: two S=O among four O atoms give ${}^4C_2$, that is 6.

CO_3^{2-}: one C=O among three O atoms gives 3.

MnO_4^-: three Mn=O among four O atoms give 4.

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

8. A mixture of sodium (Na) and potassium (K) metals weighing 32 g was reacted with water and the solution obtained could be neutralized with 517.3 mL of 1.0 M H_2SO_4 (aq).

The mass of sodium that was present in the mixture is

(A) 20 g (B) 16 g (C) 10 g (D) 12 g

Solution · Q8 **Answer: (D)**

Moles of OH^- neutralised:

$$n = 2 \times 0.5173 \times 1.0$$

$$\Rightarrow n = 1.0346 \text{ mol}$$

Let the mass of Na be x g. Each Na or K atom gives one OH^-.

$$\frac{x}{23} + \frac{32 - x}{39} = 1.0346$$

$$\Rightarrow 16x = 192$$

$$\Rightarrow x = 12 \text{ g}$$

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

9. The mass ratio of steam and hydrogen is found to be 1:1.5 at equilibrium in the following reaction

$3Fe\,(s) + 4H_2O\,(g) \rightleftharpoons Fe_3O_4(s) + 4H_2\,(g)$

The value of the equilibrium constant **(K_c)** of the above reaction is

(A) 3.0×10^{-5} (B) 3.3×10^{4} (C) 3.3×10^{6} (D) 1.3×10^{3}

Solution · Q9 **Answer: (B)**

Only the gases enter K_c, and both occupy the same volume.

$$K_c = \left(\frac{n_{H_2}}{n_{H_2O}}\right)^4$$

Take 1 g of steam with 1.5 g of hydrogen.

$$\frac{n_{H_2}}{n_{H_2O}} = \frac{1.5/2}{1/18}$$

$$\Rightarrow \frac{n_{H_2}}{n_{H_2O}} = 13.5$$

$$\therefore K_c = (13.5)^4$$

$$\Rightarrow K_c \approx 3.3 \times 10^4$$

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

10. Two students did a set of experiments on ketones **'X'** and **'Y'** independently and obtained the following results.

Reaction /Experiment	**X**	**Y**
Optical rotation	Yes	Yes
Optical rotation after treatment with a base	Zero	Yes
NH_2NH_2, KOH, Heat	Formation of an optically inactive hydrocarbon C_6H_{12}	Formation of an optically inactive hydrocarbon C_6H_{12}

The ketones **'X'** and **'Y'** are respectively

(A) 2-ethylcyclobutanone and 3-ethylcyclobutanone

(B) 2-methylcyclopentanone and 3-methylcyclopentanone

(C) 3-methylcyclopentanone and 2-methylcyclopentanone

(D) 3-methyl-4-penten-2-one and 4-methyl-1-penten-3-one

Solution · Q10 **Answer: (B)**

Wolff–Kishner reduction changes C=O into CH_2. Both 2- and 3-methylcyclopentanone give achiral methylcyclopentane, C_6H_{12}.

X loses its rotation in base, so its stereocentre is an α carbon carrying H. It racemises through the enolate.

∴ X is 2-methylcyclopentanone.

Y keeps its rotation, so its stereocentre is not an α carbon.

∴ Y is 3-methylcyclopentanone.

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

11. Glycine ($C_2H_5O_2N$) is the simplest of amino acids. Molecular formula of the linear oligomer synthesized by linking *ten* glycine molecules together via a condensation reaction would be

(A) $C_{20}H_{32}O_{11}N_{10}$ (B) $C_{20}H_{68}O_{29}N_{10}$

(C) $C_{20}H_{40}O_{10}N_{10}$ (D) $C_{20}H_{50}O_{20}N_{10}$

Solution · Q11 **Answer: (A)**

A linear chain of ten glycine units has nine peptide bonds, so nine H_2O are lost.

$10 \times C_2H_5O_2N - 9 \times H_2O$

$= C_{20}H_{32}O_{11}N_{10}$

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

12. If Ni^{2+} is replaced by Pt^{2+} in the complex ion $[NiCl_2Br_2]^{2-}$, which of the following would change?

I. Magnetic moment

II. Geometry

III. Geometrical isomerism

IV. Optical isomerism

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

Solution · Q12 **Answer: (A)**

In $[NiC\ell_2Br_2]^{2-}$, Ni^{2+} is $3d^8$ and the halide ligands are weak.

$\Rightarrow sp^3$, tetrahedral, 2 unpaired electrons

In $[PtC\ell_2Br_2]^{2-}$, Pt^{2+} is $5d^8$ with a large splitting, so all electrons pair up.

$\Rightarrow dsp^2$, square planar, diamagnetic

Square planar Ma_2b_2 has cis and trans forms; tetrahedral Ma_2b_2 does not.

Neither complex shows optical isomerism.

$\therefore$ I, II and III change.

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

13. An inorganic compound **'X'** of an alkali metal on heating gives a reddish-brown gas **'Y'** and a binary solid **'Z'**. This solid is less soluble in water and its solution is basic. **'X'** does not give a positive silver nitrate test. **'X'** can be identified as

(A) KIO_3 (B) $LiNO_3$ (C) $NaNO_3$ (D) KNO_2

Solution · Q13 **Answer: (B)**

The reddish-brown gas Y is NO_2.

$4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$

The binary solid Z is Li_2O. In water it gives a basic solution:

$Li_2O + H_2O \rightarrow 2LiOH$

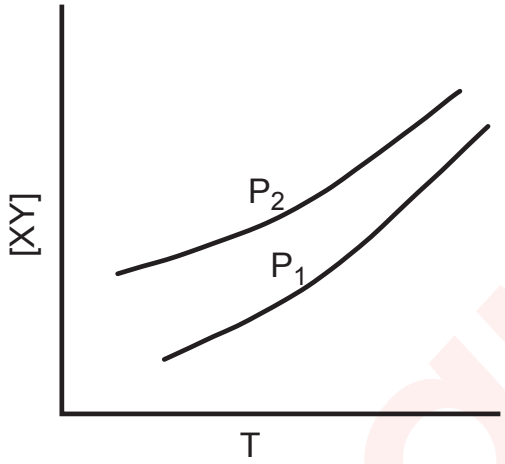
The nitrate ion gives no precipitate with $AgNO_3$.

$\therefore$ X is $LiNO_3$.

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

14. The qualitative plots given represent the yield of the product, [XY], at equilibrium in the reaction X(g) + Y(g) ⇌ XY(g), as a function of temperature, at total pressures P_1 and P_2.

The reaction is



(A) endothermic and $P_1 < P_2$

(B) endothermic and $P_2 < P_1$

(C) exothermic and $P_1 > P_2$

(D) exothermic and $P_2 > P_1$

Solution · Q14 **Answer: (A)**

On each curve, [XY] rises as T increases.

∴ the forward reaction is endothermic.

For X(g) + Y(g) ⇌ XY(g),

$$\Delta n_g = 1 - 2 = -1$$

So a higher pressure gives more XY.

At the same T, the P_2 curve lies higher.

$$\therefore P_1 < P_2$$

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

15. When 6.8 g of $AgNO_3$ completely reacts with H_3PO_2, metallic silver produced (g) and H_3PO_2 consumed (mole) are respectively

(A) 4.32 and 0.1 (B) 1.08 and 0.01 (C) 4.32 and 0.01 (D) 2.16 and 0.01

Solution · Q15 **Answer: (C)**

$4AgNO_3 + H_3PO_2 + 2H_2O \rightarrow 4Ag + H_3PO_4 + 4HNO_3$

$$n(AgNO_3) = \frac{6.8}{170} = 0.04 \text{ mol}$$

Moles of Ag formed are also 0.04.

Mass of Ag:

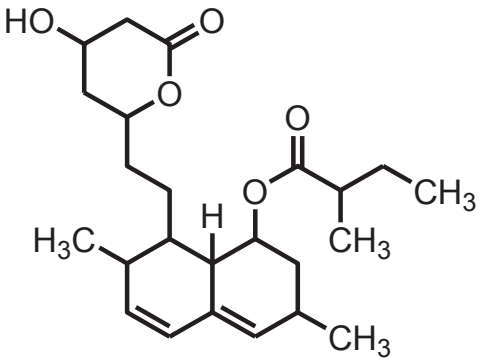
$$0.04 \times 108 = 4.32 \text{ g}$$

H_3PO_2 consumed:

$$n(H_3PO_2) = \frac{0.04}{4} = 0.01 \text{ mol}$$

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

16. Lovastatin, a drug used to reduce the risk of cardio vascular diseases has the following structure



Lovastatin

The number of stereogenic centers present in lovastatin is

(A) 8 (B) 3 (C) 4 (D) 6

Solution · Q16 **Answer: (A)**

Count the sp^3 carbons that carry four different groups.

Lactone ring: the carbon bearing OH and the CH joined to ring oxygen (2).

Fused rings: the two carbons bearing CH_3, the ring-junction CH, the CH bearing the CH_2CH_2 chain and the CH bearing the ester oxygen (5).

Ester side chain: the CH bearing CH_3 (1).

Number of stereogenic centres:

$$2 + 5 + 1 = 8$$

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

17. Among the following sets, the one in which all the molecules are non polar is

(A) XeF_4, XeO_3, XeO_4 (B) XeF_2, XeO_4, $XeOF_4$

(C) XeF_2, XeF_4, XeO_4 (D) XeF_2, XeO_3, $XeOF_4$

Solution · Q17 **Answer: (C)**

XeF_2 is linear, XeF_4 is square planar and XeO_4 is tetrahedral.

In each, the bond dipoles cancel, so all three are non-polar.

XeO_3 (pyramidal) and $XeOF_4$ (square pyramidal) are polar.

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

18. Gas phase reactions (i) and (ii) are of first and second order respectively

$2N_2O_5 \rightarrow 4NO_2 + O_2$ ..... (i)

$2NO + O_2 \rightarrow 2NO_2$..... (ii)

Under certain conditions, the rate constants (k_1, k_2) of (i) and (ii) respectively, have the same numerical value, when the concentrations of the reactants are expressed in mol/dm^3.

If the concentrations are expressed in mol/mL, the correct relationship between k_1 and k_2 is

(A) $k_2 \times 10^{-3} = k_1$

(B) $k_2 \times 10^{3} = k_1$

(C) $k_1 = k_2$

(D) $k_1 \times 10^{6} = k_2$

Solution · Q18 **As per Zigyan: (A)**

With the orders as stated, (i) is first order and (ii) is second order.

The unit of k_1 is s^{-1}, so its value does not change.

The unit of k_2 is $dm^3\ mol^{-1}\ s^{-1}$, and

$$1\ dm^3 = 1000\ mL$$

Let the common value in mol/dm^3 units be N. In mol/mL units:

$$k_1 = N$$

$$k_2 = 1000N$$

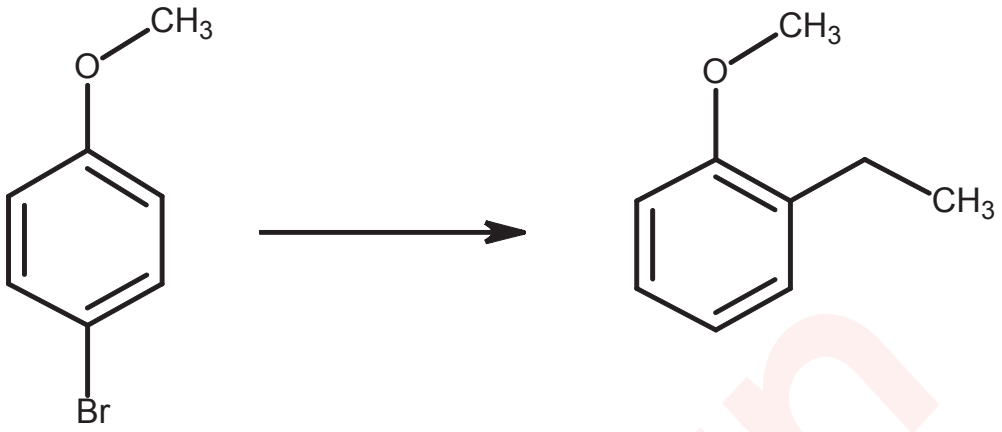
$$\Rightarrow k_2 = 1000k_1$$

$$\therefore k_2 \times 10^{-3} = k_1$$

Reference: NCERT Chemistry Class XII (Part I), Unit 3 'Chemical Kinetics', section 3.2.3, Table 3.3: a first order rate constant has the unit s^{-1}, free of concentration, while a second order rate constant has the unit $L\ mol^{-1}\ s^{-1}$.

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

19. The correct sequence of reactions to get **'Q'** as the *only* product from **'P'** is



P Q

(A) (i) H_2 & Pt catalyst (ii) C_2H_5Cl & $AlCl_3$

(B) (i) Mg in ether (ii) aqueous alcohol (iii) C_2H_5Cl & $AlCl_3$

(C) (i) Mg in ether (ii) C_2H_5Cl & $AlCl_3$

(D) (i) C_2H_5Cl & $AlCl_3$ (ii) Mg in ether (iii) aqueous alcohol

Solution · Q19 **Answer: (D)**

In P, Br blocks the para position, so alkylation goes ortho to the OCH_3 group.

(i) $C_2H_5C\ell$ with $A\ell C\ell_3$ puts ethyl next to OCH_3.

(ii) Mg in ether changes C–Br into C–MgBr.

(iii) Aqueous alcohol protonates the Grignard reagent; H replaces MgBr, giving Q.

Removing Br first gives anisole, whose alkylation gives a mixture of ortho and para products.

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

20. The Galvanic cell can be represented as Zn / Zn^{2+} (0.1M) // Cu^{2+} (0.1M)/Cu.

Among the following, the cell that can produce an EMF more than that of the Galvanic cell is

(E^0 of Zn^{2+}/Zn and Cu^{2+}/Cu are −0.763V and 0.337V respectively)

(A) Zn / Zn^{2+} (0.1M) // Cu^{2+} (0.01M)/Cu

(B) Zn / Zn^{2+} (1M) // Cu^{2+} (0.01M)/Cu

(C) Zn / Zn^{2+} (0.01M) // Cu^{2+} (1M)/Cu

(D) Zn / Zn^{2+} (0.01M) // Cu^{2+} (0.01M)/Cu

Solution · Q20 **Answer: (C)**

For this cell, at 298 K,

$$E = E^{\circ} - \frac{0.059}{2}\log\frac{[Zn^{2+}]}{[Cu^{2+}]}$$

$$E° = 0.337 - (-0.763) = 1.100\ V$$

Given cell: the concentration ratio is 1, so its EMF equals E°.

A larger EMF needs a ratio below 1.

The ratio is 10 in (A), 100 in (B) and 1 in (D).

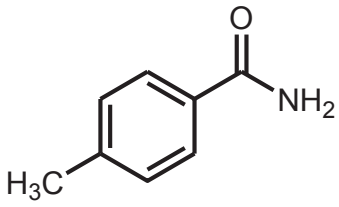
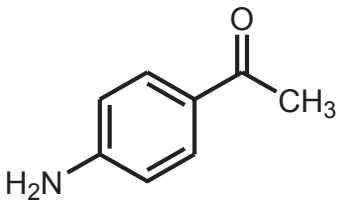
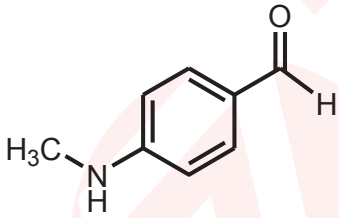
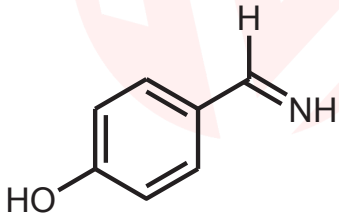
In (C),

$$\frac{[Zn^{2+}]}{[Cu^{2+}]} = \frac{0.01}{1} = 10^{-2}$$

$$\Rightarrow E = 1.100 + 0.059 = 1.159\ V$$

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

21. The correct match of the molecules in column I and reactions in column II is

Column I	Column II
i) 	(L) Coloration with $FeCl_3$
ii) 	(M) Effervescence with $NaHCO_3$
iii) 	(N) Yellow precipitate with NaOH and I_2
iv) 	(O) Yellow oil with $NaNO_2$, HCl at 0 ^oC (P) Heating with NaOH gives out a gas that turns moist turmeric paper brown

(A) i)-N ii)-L iii)-O iv)-M
(B) i)-O ii)-N iii)-L iv)- P
(C) i)-P ii)-O iii)-L iv)-M
(D) i)-P ii)-N iii)-O iv)-L

Solution · Q21 **Answer: (D)**

(i) An amide: hot NaOH releases NH_3, which turns turmeric paper brown → P.

(ii) The $COCH_3$ group gives yellow CHI_3 with NaOH and $I_2 \rightarrow$ N.

(iii) A secondary amine gives a yellow oily N-nitrosamine with $NaNO_2$ and $HC\ell \rightarrow$ O.

(iv) The phenolic OH gives a colour with $FeC\ell_3 \rightarrow$ L.

∴ i-P, ii-N, iii-O, iv-L

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

22. While doing titration, a student recorded a burette reading of 10.0 mL for the neutralization of 10.0 mL $NaHC_2O_4$ (aq) with 0.1 M NaOH (aq). In a separate experiment, 10.0 mL of this $NaHC_2O_4$ (aq) solution could be completely oxidized by 10.0 mL of $KMnO_4$ in an acidic medium.

What would be the molarity of $KMnO_4$ used by this student?

(A) 0.02 M (B) 0.04 M (C) 0.1 M (D) 0.2 M

Solution · Q22 **Answer: (B)**

With NaOH, $NaHC_2O_4$ gives one H^+. The burette reading is the volume of NaOH used.

$$c_1 \times 10.0 = 0.1 \times 10.0$$

$$\Rightarrow c_1 = 0.1 \text{ M}$$

In the redox titration, the n-factor is 2 for oxalate (to CO_2) and 5 for permanganate (to Mn^{2+}).

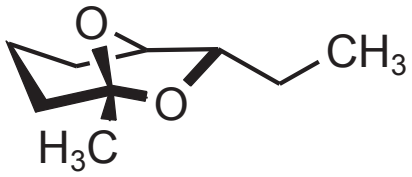
Equating equivalents,

$$c_2 \times 5 \times 10.0 = 0.1 \times 2 \times 10.0$$

$$\Rightarrow c_2 = 0.04 \text{ M}$$

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

23. Pheromones are chemicals that animals produce for social response. The structure of brevicomin, a pheromone, is shown below. The open chain ketodiol that would form brevicomin is



Brevicomin

(A) 7,8-dihydroxynonan-3-one (B) 6,7-dihydroxynonan-3-one

(C) 7,8-dihydroxynonan-2-one (D) 6,7-dihydroxynonan-2-one

Solution · Q23 **Answer: (D)**

Brevicomin is a cyclic ketal.

The carbon carrying CH_3 is joined to two O atoms, so it comes from the C=O group. Both C–O bonds at this carbon are broken, and the two O atoms become OH groups.

The open chain ketodiol is

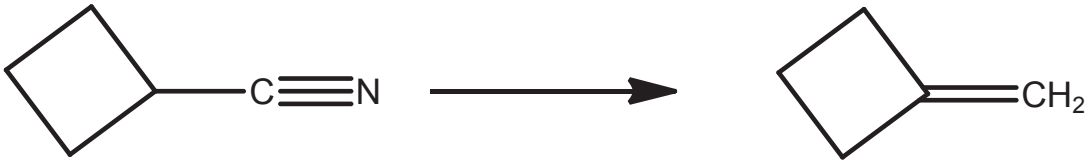
$CH_3–CO–CH_2–CH_2–CH_2–CH(OH)–CH(OH)–CH_2–CH_3$

The C=O carbon is C-2, and the OH groups are on C-6 and C-7.

∴ 6,7-dihydroxynonan-2-one

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

24. The best reagents and conditions to accomplish the following conversion is



(A) (i) $LiAlH_4$ in ether, (ii) 3 moles of CH_3I followed by heating with AgOH

(B) (i) $LiAlH_4$ in ether; (ii) P_2O_5 and heat

(C) (i) 20 % H_2SO_4 & heat, (ii) P_2O_5 and heat

(D) H_2 and Lindlar catalyst

Solution · Q24 **Answer: (A)**

Reduction with $LiA\ell H_4$ in ether:

$C_4H_7–CN \rightarrow C_4H_7–CH_2NH_2$

Exhaustive methylation with 3 moles of CH_3I:

$C_4H_7–CH_2NH_2 \rightarrow C_4H_7–CH_2N^+(CH_3)_3\ I^-$

AgOH replaces I^- by OH^-. On heating, Hofmann elimination removes the ring H next to the CH_2 group:

$$C_4H_7–CH_2N^+(CH_3)_3\ OH^- \rightarrow C_4H_6{=}CH_2 + (CH_3)_3N + H_2O$$

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

PART A-2 · ONE OR MORE CORRECT OPTIONS

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

25. The correct statement/s among the following is/are

(A) Intermolecular forces in n-heptane are stronger than those in 2-methylheptane

(B) Boiling point of 2,2-dimethylpentane is higher than that of 2, 2-dimethylbutane

(C) Both hydrogen bonding and van der Waals forces exist between molecules of 2-methylbutan-2-ol

(D) In 2,2-dimethylbutane, 1°, 2° and 3° types of carbon atoms are present

Solution · Q25 **Answer: (B), (C)**

(A) 2-methylheptane has one carbon more than n-heptane, so its intermolecular forces are stronger. ∴ false.

(B) 2,2-dimethylpentane is the larger molecule, so it boils higher. ∴ true.

(C) The OH group gives hydrogen bonding and the carbon chain gives van der Waals forces. ∴ true.

(D) The structure is

$(CH_3)_3C–CH_2–CH_3$

It has 1°, 2° and 4° carbons, but no 3° carbon. ∴ false.

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

26. Which of the following aqueous solution/s will have a pH value between 4.0 and 5.0 at 25 °C?

(A) 0.01 M solution of benzoic acid (K_a= 6.6 x 10^{-5} at 25 °C)

(B) 0.02 mol benzoic acid and 0.05 mol sodium benzoate dissolved in appropriate amount of water to make a solution of 1L

(C) A mixture of 999 mL water and 1mL 0.2 M HCl

(D) 499 mL of 0.01M NaOH and 501 mL of 0.01 M HCl mixed together

Solution · Q26 **Answer: (B), (D)**

(A) For the weak acid,

$$[H^+] \approx \sqrt{6.6 \times 10^{-5} \times 0.01}$$

$$\Rightarrow [H^+] \approx 8 \times 10^{-4}\ M$$

$$\Rightarrow pH \approx 3.1$$

(B) For the buffer, with the same K_a,

$$pH = 4.18 + \log\frac{0.05}{0.02}$$

$$\Rightarrow pH = 4.58$$

(C) After dilution to 1000 mL,

$$[H^+] = 2 \times 10^{-4}\ M$$

$$\Rightarrow pH = 3.7$$

(D) HCl left after neutralisation:

$$(501 - 499) \times 0.01 = 0.02\ mmol$$

$$\Rightarrow [H^+] = 2 \times 10^{-5}\ M$$

$$\Rightarrow pH = 4.7$$

∴ (B) and (D) lie in the range.

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

27. The energy required to remove an electron from a gaseous species 'X' to form 'X^+' is known as first ionization energy (IE) of X. The energy required to remove an electron from a gaseous species 'X^+' to form 'X^{++}' is called the second IE of X. Similarly, the energy required to remove an electron from a gaseous species X^- to form X is called the IE of X^-.

Identify the correct statement/s from the following

(A) The second IE of the He atom is *four times* that of the (first) IE of the H atom.

(B) The first IEs of F, Ne and Na atoms follow the order IE(Na) < IE(Ne) < IE(F)

(C) The second IE of the H^- ion is much less than the (first) IE of the H atom.

(D) The IEs of Li, Na and K atoms follow the order IE(K) < IE(Na) < IE (Li)

Solution · Q27 **Answer: (A), (D)**

(A) The second electron of He leaves He^+, a one-electron species.

$$IE(He^+) = 2^2 \times IE(H)$$

∴ true.

(B) Ne has a complete octet. The order is Na < F < Ne. ∴ false.

(C) H^- first gives H. Its second ionisation removes the electron of this H atom.

$$IE_2(H^-) = IE(H)$$

∴ false.

(D) Atomic size increases from Li to K, so IE decreases down the group. ∴ true.

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

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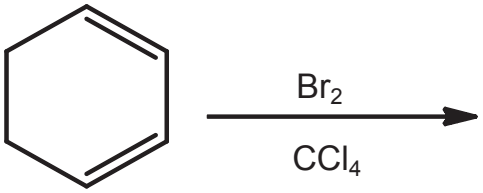
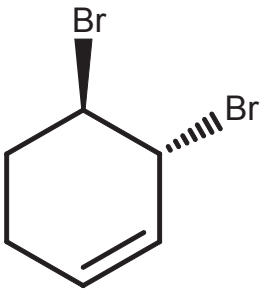
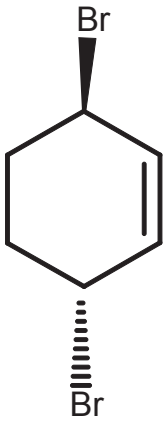
28. The product/s formed in the following reaction is/are



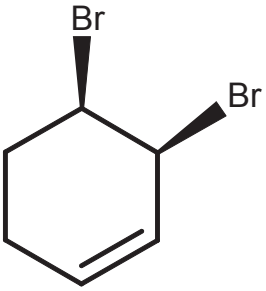
(A)



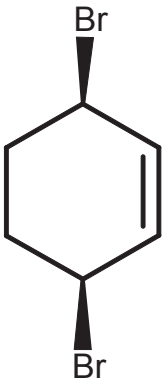
(B)



(C)



(D)



Solution · Q28 **Answer: (A), (B), (D)**

Br_2 attacks one double bond of the conjugated diene. The cation formed is allylic, with Br holding one face of the neighbouring carbon.

1,2-addition: Br^- attacks the neighbouring carbon from the side opposite to Br (anti addition). This gives the trans product (A), not the cis product (C).

1,4-addition: Br^- attacks the far end of the allylic system. This carbon is away from the first Br, so attack on either face is possible.

$\therefore$ both the trans product (B) and the cis product (D) are formed.

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

29. Which of the following option/s is /are correct?

(A) C_2 is paramagnetic

(B) He_2^+ has the same energy as that of two isolated He atoms

(C) S_2 is paramagnetic and S_2^{2-} is diamagnetic

(D) N_2^+ and N_2^- have the same bond order

Solution · Q29 **Answer: (C), (D)**

(A) All electrons of C_2 are paired, including four in the π2p orbitals. $\therefore$ false.

(B) He_2^+ has one electron less than two He atoms, so their energies are not the same. $\therefore$ false.

(C) Like O_2, S_2 has two unpaired electrons in its π* orbitals. In S_2^{2-} they are all paired. $\therefore$ true.

(D) Bond orders:

$$N_2^+: (9 - 4)/2 = 2.5$$

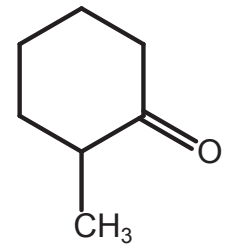
$$N_2^-: (10 - 5)/2 = 2.5$$

$\therefore$ true.

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

30. Nitromethane undergoes an aldol type reaction with a racemic mixture of 2-methylcyclohexanone in presence of aqueous NaOH in two steps (I, II) to give the product '**P**'. The statement/s *NOT* correct among the following is/are

I $\ominus OH$ + $H\text{-}CH_2\text{-}NO_2$ (Nitromethane, pKa 10.2) ⇌ H_2O (pKa 14.0) + $\ominus CH_2NO_2$ (Carbanion)

II  + $\ominus CH_2NO_2$ → product 'P'

(A) The equilibrium in step I will be more towards the right as water is a stronger acid than nitromethane

(B) The carbanion formed in reaction I can be stabilized due to resonance

(C) The product formed will be a mixture of four stereoisomers in the form of two pairs of enantiomers

(D) The mixture of products formed can be readily dehydrated to give a single product

Solution · Q30 **Answer: (A), (D)**

(A) A lower pK_a means a stronger acid. Nitromethane is stronger than water, and that is why step I lies to the right. ∴ not correct.

(B) The negative charge moves on to the nitro group:

$$^{-}CH_2\text{–}N^{+}(=O)O^{-} \leftrightarrow CH_2=N^{+}(O^{-})_2$$

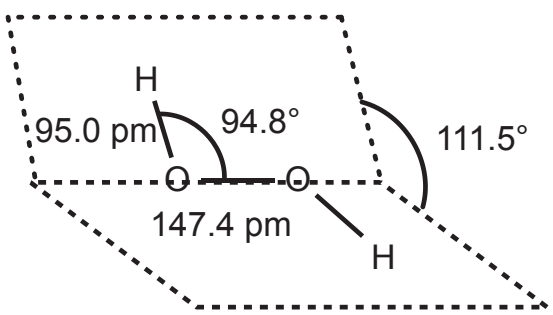
∴ correct.

(C) P is 2-methyl-1-(nitromethyl)cyclohexan-1-ol. It has two stereocentres, giving four stereoisomers as two pairs of enantiomers. ∴ correct.

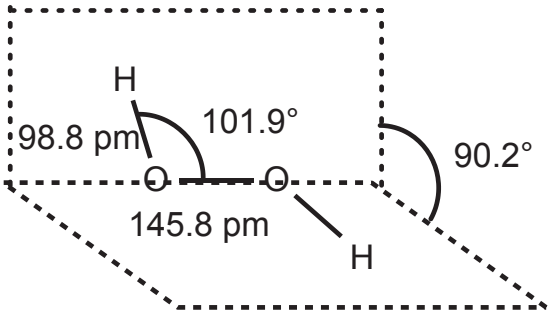
(D) Water can be lost towards the CH_2NO_2 carbon, C-2 or C-6, giving a mixture of alkenes. ∴ not correct.

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

31. The structures of hydrogen peroxide (H_2O_2) in the solid and gaseous states are given below. H_2O_2 (l) is slightly more viscous than H_2O (l). The correct option/s among the following is/are



Gas



Solid (Crystal)

(A) Both O atoms are near enough to cause repulsion between the electron lone pairs thus making the O-O bond susceptible for cleavage

(B) The strong intermolecular H-bonding along with restricted rotation present in the liquid state of H_2O_2 make it more viscous than H_2O (l)

(C) The molecule gets twisted to minimize the repulsion between the lone pair and bond pair of electrons

(D) The difference in the dihedral angles in the solid and gaseous states is a consequence of hydrogen bonding between the molecules

Solution · Q31 **As per Zigyan: (A), (B), (C), (D)**

(A) The lone pairs on the two bonded O atoms repel each other. This weakens the O–O bond. ∴ true.

(B) Each molecule has two OH groups, so the liquid is extensively hydrogen bonded. With restricted rotation, this makes it more viscous than water. ∴ true.

(C) The non-planar shape reduces the repulsion of lone pairs with other electron pairs, including the O–H bond pairs. ∴ true.

(D) Hydrogen bonding is very weak in the gas but strong in the crystal. It changes the dihedral angle from 111.5° to 90.2°. ∴ true.

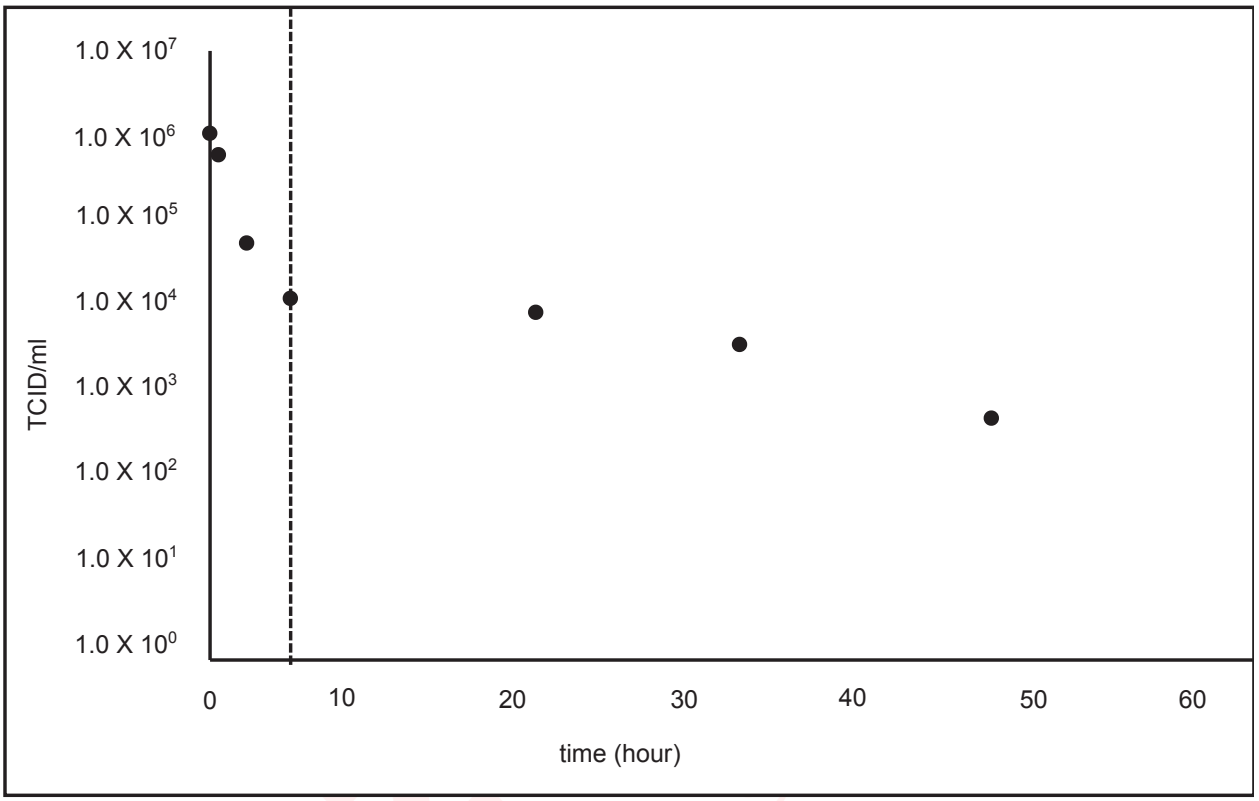
Reference: NCERT Chemistry Class XI (Part I), Unit 4 'Chemical Bonding and Molecular Structure', section 4.4: valence shell electron pairs take positions of least repulsion; lone pair–bond pair repulsion is stronger than bond pair–bond pair repulsion.

Reference: Same unit, section 4.9.1: hydrogen bonding is greatest in the solid state and least in the gas, and it strongly affects the structure and properties of compounds.

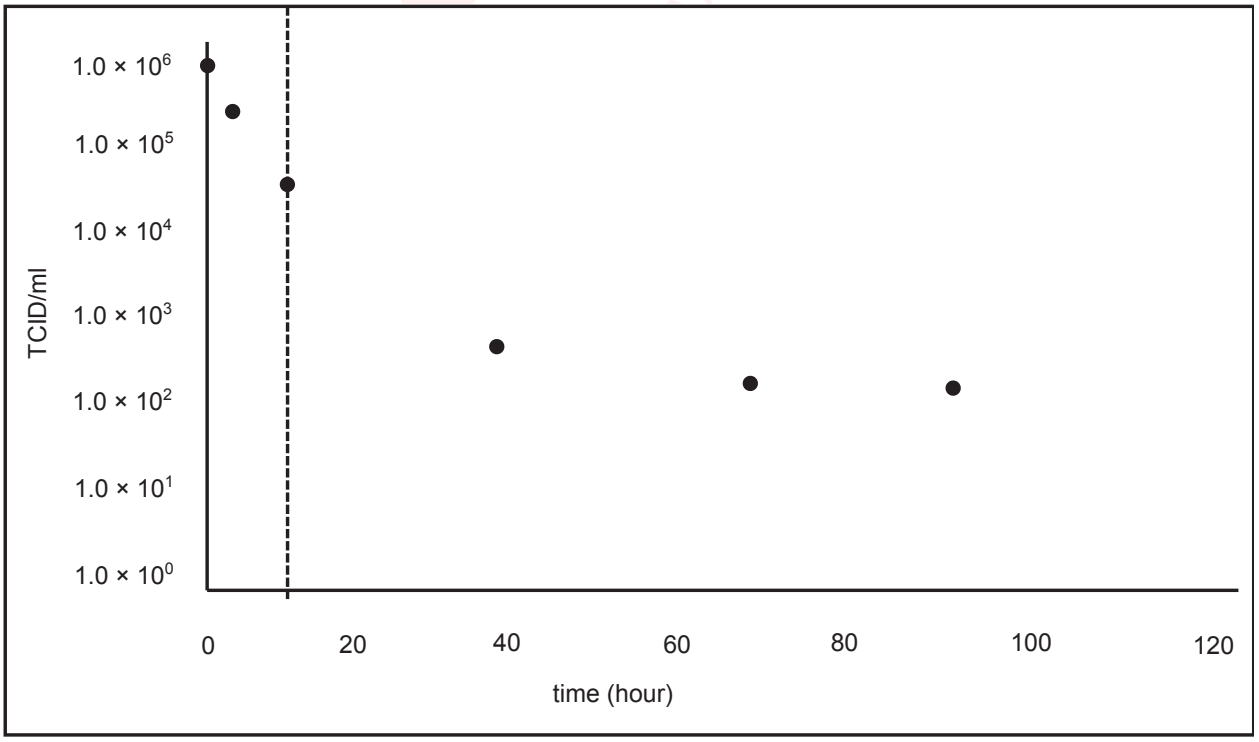
IAPT answer: (A), (B), (C), (D) | **Zigyan answer:** (A), (B), (C), (D)

32. Viruses are nonliving complex chemical entities. They undergo inactivation and hence lose the ability to infect a host, with time. Concentration (expressed as 'median tissue culture infectious dose', TCID/ml, a unit used in expressing virus concentrations) vs. time plots of a corona virus on the surfaces of a paper currency note and a plastic currency note are shown below. Both these plots have two separate regions (shown by vertical lines in the plots), indicating two time zones.

I. Paper currency note



II. Plastic currency note



The correct option/s among the following is/are

(A) Inactivation of the virus follows zero order kinetics in 1st zone and first order kinetics in 2nd zone

(B) The rate of inactivation is independent of the surface material

(C) The virus reacts with different chemical entities/substances in 1st zone and 2nd zone

(D) On both the surfaces, at least 95 % of the virus is inactivated within 10 h

Solution · Q32 **As per Zigyan: (C), (D)**

(A) In the first zone the amount of virus lost per hour falls steeply with time, so it is not zero order. ∴ false.

(B) The paper note falls to about 10^4 TCID/ml sooner than the plastic note falls even to about 3.5×10^4. ∴ false.

(C) On both notes the slope changes sharply at the dividing line. This change of rate indicates that the virus reacts with different substances in the two zones. ∴ true.

(D) For 95% inactivation, the amount left is at most

$$0.05 \times 10^6 = 5 \times 10^4 \text{ TCID/ml}$$

By 10 h, paper is near 10^4. The third plastic point, at about 10 h, is near 3.5×10^4. ∴ true.

Check: On paper, the logarithm of TCID/ml falls by about 2 units in the first few hours, but by only about 1.4 units over roughly the next 40 h. On plastic, it falls by about 1.5 units in about the first 10 h, then by about 2.4 units over roughly the next 80 h.

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

Given in the question paper

IUPAC Periodic Table of the Elements

1																	18
1 H hydrogen 1.008 [1.0078, 1.0082]	2		Key: atomic number **Symbol** name conventional atomic weight standard atomic weight									13	14	15	16	17	2 He helium 4.0026
3 Li lithium 6.94 [6.938, 6.997]	4 Be beryllium 9.0122											5 B boron 10.81 [10.806, 10.821]	6 C carbon 12.011 [12.009, 12.012]	7 N nitrogen 14.007 [14.006, 14.008]	8 O oxygen 15.999 [15.999, 16.000]	9 F fluorine 18.998	10 Ne neon 20.180
11 Na sodium 22.990	12 Mg magnesium 24.305 [24.304, 24.307]	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 26.982	14 Si silicon 28.085 [28.084, 28.086]	15 P phosphorus 30.974	16 S sulfur 32.06 [32.059, 32.076]	17 Cl chlorine 35.45 [35.446, 35.457]	18 Ar argon 39.95 [39.792, 39.963]
19 K potassium 39.098	20 Ca calcium 40.078(4)	21 Sc scandium 44.956	22 Ti titanium 47.867	23 V vanadium 50.942	24 Cr chromium 51.996	25 Mn manganese 54.938	26 Fe iron 55.845(2)	27 Co cobalt 58.933	28 Ni nickel 58.693	29 Cu copper 63.546(3)	30 Zn zinc 65.38(2)	31 Ga gallium 69.723	32 Ge germanium 72.630(8)	33 As arsenic 74.922	34 Se selenium 78.971(8)	35 Br bromine 79.904 [79.901, 79.907]	36 Kr krypton 83.798(2)
37 Rb rubidium 85.468	38 Sr strontium 87.62	39 Y yttrium 88.906	40 Zr zirconium 91.224(2)	41 Nb niobium 92.906	42 Mo molybdenum 95.95	43 Tc technetium	44 Ru ruthenium 101.07(2)	45 Rh rhodium 102.91	46 Pd palladium 106.42	47 Ag silver 107.87	48 Cd cadmium 112.41	49 In indium 114.82	50 Sn tin 118.71	51 Sb antimony 121.76	52 Te tellurium 127.60(3)	53 I iodine 126.90	54 Xe xenon 131.29
55 Cs caesium 132.91	56 Ba barium 137.33	57-71 lanthanoids	72 Hf hafnium 178.49(2)	73 Ta tantalum 180.95	74 W tungsten 183.84	75 Re rhenium 186.21	76 Os osmium 190.23(3)	77 Ir iridium 192.22	78 Pt platinum 195.08	79 Au gold 196.97	80 Hg mercury 200.59	81 Tl thallium 204.38 [204.38, 204.39]	82 Pb lead 207.2	83 Bi bismuth 208.98	84 Po polonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium	89-103 actinoids	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganesson

57 La lanthanum 138.91	58 Ce cerium 140.12	59 Pr praseodymium 140.91	60 Nd neodymium 144.24	61 Pm promethium	62 Sm samarium 150.36(2)	63 Eu europium 151.96	64 Gd gadolinium 157.25(3)	65 Tb terbium 158.93	66 Dy dysprosium 162.50	67 Ho holmium 164.93	68 Er erbium 167.26	69 Tm thulium 168.93	70 Yb ytterbium 173.05	71 Lu lutetium 174.97
89 Ac actinium	90 Th thorium 232.04	91 Pa protactinium 231.04	92 U uranium 238.03	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

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2019 IYPT International Year of the Periodic Table of Chemical Elements

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ANSWER KEY

IOQC 2020-21 · PAPER CODE 31

32
QUESTIONS · 120 MARKS

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

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

★ Answers as per Zigyan

- **Q18** — As per Zigyan: (A); IAPT key (A).
- **Q31** — As per Zigyan: (A), (B), (C), (D); IAPT key (A), (B), (C), (D).
- **Q32** — As per Zigyan: (C), (D); IAPT key (C), (D).

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Above MAS



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Harshit Goyal
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Above MAS



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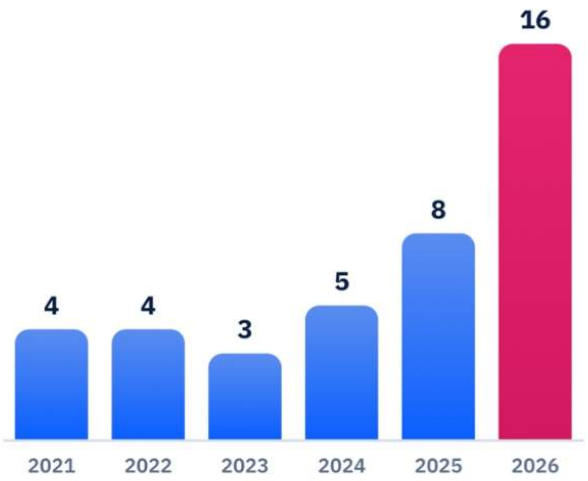
above 98 percentile, JEE Main 2026

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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