CHEMISTRY (CODE – 043)

Chapter-wise Test: Aldehydes, Ketones and Carboxylic Acids

(NCERT Class XII Chemistry, Unit 8: Aldehydes, Ketones and Carboxylic Acids)

SOLUTIONS AND MARKING SCHEME

CLASS XII (2026-27)

Time: 1½ hours **Max. Marks: 35**

Step-by-step solutions with the distribution of marks. Marks for each step are shown in square brackets [ ]. Any other correct method or answer should be given full credit.

Quick answer key – Section A

Q.	1	2	3	4	5	6	7	8
Ans.	B	A	C	D	B	C	A	D

SECTION A

Questions 1 to 8 are multiple choice questions. Only one of the choices is correct. Select and write the correct choice as well as the answer to these questions. Each question carries 1 mark.

1	**Answer: B** The principal functional group, the ketone (C=O), gets the lowest locant, so the chain is numbered from the CH_3CO end: C-1 (CH_3), C-2 (C=O), C-3 (=CH), C-4 (=C(CH_3)). The double bond starts at C-3 and the methyl group is on C-4: **4-methylpent-3-en-2-one**.	1
2	**Answer: A. Row 1** Ammonia (Z = –H) gives an **imine**, not an oxime. An oxime (>C=N–OH) is formed from hydroxylamine (Z = –OH), a hydrazone from hydrazine (Z = –NH_2), and a semicarbazone from semicarbazide (Z = –$NHCONH_2$).	1
3	**Answer: C. sp^2 to sp^3** The carbonyl carbon is sp^2 hybridised and planar (bond angles about 120°). The nucleophile attacks it from a direction approximately perpendicular to the plane; the carbon becomes sp^3 hybridised in the tetrahedral alkoxide intermediate X, which then captures H^+ to give the neutral product.	1
4	**Answer: D** DIBAL-H selectively reduces nitriles to imines, which are hydrolysed to aldehydes ($CH_3CN \rightarrow CH_3CH{=}NH \rightarrow CH_3CHO$). ($SnCl_2$/HCl, Stephen reaction, also works.) H_2/Pd–$BaSO_4$ is the Rosenmund reagent for acyl chlorides; $LiAlH_4$ would reduce the nitrile to an amine; Zn–Hg/HCl (Clemmensen) reduces C=O to CH_2.	1
5	**Answer: B. benzaldehyde** This is the Gatterman–Koch reaction (formylation): CO and HCl generate the electrophile HCO^+ (formyl chloride type species), which substitutes in the benzene ring to give benzaldehyde (C_6H_5CHO).	1
6	**Answer: C. 2,2-Dimethylbutanal** Only aldehydes with **no α-hydrogen** undergo the Cannizzaro reaction (self oxidation–reduction to the alcohol and the carboxylate salt). 2,2-Dimethylbutanal, $CH_3CH_2C(CH_3)_2CHO$, has a quaternary α-carbon. Propanal, 2-methylpentanal and butanal have α-hydrogens and undergo aldol condensation instead.	1
7	**Answer: A. ethane** This is decarboxylation: $CH_3CH_2COONa + NaOH \rightarrow^{(CaO,\ heat)} CH_3CH_3 + Na_2CO_3$. The hydrocarbon has one carbon atom less than the acid salt.	1

8	**Answer: D. A is false but R is true.** Aldehydes are more reactive than ketones in nucleophilic addition, for steric and electronic reasons: the two relatively large alkyl groups in ketones hinder the approach of the nucleophile and, being electron releasing, reduce the electrophilicity of the carbonyl carbon more than the single alkyl group in aldehydes. A is false, R is true.	1

SECTION B

Question Nos. 9 to 11 are very short answer questions carrying 2 marks each.

9	**(A)** (i) The carbonyl group is highly polar, so aldehydes and ketones have weak molecular association through dipole–dipole interactions; ethers are only weakly polar. Hence the boiling points of carbonyl compounds are higher than those of ethers of comparable mass. [1] (ii) Propan-1-ol molecules are associated through extensive intermolecular hydrogen bonding, which is absent in aldehydes, ketones and ethers. [1] **(B)** $CH_3CH_2CH_3 < CH_3OCH_3 < CH_3CHO < CH_3CH_2OH$. [1] Reason: propane has only weak van der Waals forces; the ether is weakly polar; ethanal has strong dipole–dipole attraction; ethanol has intermolecular hydrogen bonding. [1]	1 + 1
10	**(A)** (i) $CH_3COCH_3 + HCN \rightarrow (CH_3)_2C(OH)CN$ (propanone cyanohydrin). The reaction with pure HCN is very slow; a base generates the cyanide ion (CN^-), a much stronger nucleophile, which readily adds to the carbonyl carbon. [1] (ii) The hydrogensulphite addition compound is water soluble (and crystalline), so the aldehyde can be separated from non-carbonyl impurities and regenerated by treating it with dilute mineral acid or alkali. [1] **(B)** (i) A hemiacetal (alkoxyalcohol) is the intermediate formed when an aldehyde adds one molecule of a monohydric alcohol in the presence of dry HCl, e.g. $CH_3CH(OH)OCH_3$ from ethanal and methanol. [1] (ii) A ketal is formed when a ketone reacts with ethylene glycol (or two molecules of alcohol) in the presence of dry HCl; it is a cyclic gem-dialkoxy compound, e.g. the ethylene glycol ketal of propanone. [1]	1 + 1
11	**(A)** (i) **Iodoform test**: pentan-2-one (a methyl ketone, $CH_3CO–$) gives a yellow precipitate of CHI_3 on warming with I_2/NaOH; pentan-3-one does not. [1] (ii) **$NaHCO_3$ test**: benzoic acid gives brisk effervescence of CO_2 with sodium hydrogencarbonate; phenol does not (it is too weak an acid). [1] **(B)** (i) Methylcyclohexane (Clemmensen reduction converts –CHO to $–CH_3$). [1] (ii) The diethyl acetal, cyclohexyl–$CH(OC_2H_5)_2$ (via the hemiacetal). [1]	1 + 1

SECTION C		
Question Nos. 12 to 15 are short answer questions carrying 3 marks each.		
12	**(A)** (i) **2-Methylpentanal** and **cyclohexanone** (they have α-hydrogen atoms). [1] (ii) **Methanal, benzaldehyde and 2,2-dimethylbutanal** (aldehydes with no α-hydrogen). [1] (iii) **Benzophenone**: it is a ketone with no α-hydrogen, so it cannot give aldol condensation, and the Cannizzaro reaction is a reaction of aldehydes only. [1] **(B)** (i) $2HCHO + \text{conc. } NaOH \rightarrow (\text{heat}) CH_3OH + HCOONa$ [1] (ii) $2CH_3CH_2CHO \rightarrow (\text{dil. } NaOH) CH_3CH_2CH(OH)CH(CH_3)CHO$ (3-hydroxy-2-methylpentanal, the aldol), which on heating loses water to give $CH_3CH_2CH{=}C(CH_3)CHO$ (2-methylpent-2-enal). [1] (iii) Benzaldehyde has no α-hydrogen atom (the –CHO is attached directly to the ring), so no carbanion/enolate can form. [1]	1 + 1 + 1
13	**(A)** (i) **P = C_2H_5MgBr** (ethylmagnesium bromide); **Q = CH_3CH_2COOH** (propanoic acid); **R = CH_3CH_2CN** (propanenitrile); **S = $CH_3CH_2CONH_2$** (propanamide). [1] (ii) One more carbon atom (the carbon of CO_2 or of CN). Both methods convert alkyl halides into carboxylic acids having one carbon atom more (ascending the series). [1] (iii) The Grignard reagent reacts with any source of proton (even traces of water), forming the hydrocarbon (C_2H_6) instead; so moisture must be excluded. [1] **(B)** (i) $C_6H_5CH_2CH_3 \rightarrow (KMnO_4/KOH, \text{heat; then } H^+) C_6H_5COOH$ (the whole side chain is oxidised). [1] (ii) $C_6H_5Br \rightarrow (Mg, \text{dry ether}) C_6H_5MgBr \rightarrow (CO_2;\ H_3O^+) C_6H_5COOH$. [1] (iii) $C_6H_5COCl + H_2O \rightarrow C_6H_5COOH + HCl$ (hydrolysis of the acid chloride). [1]	1 + 1 + 1
14	**(A)** (i) Aldol condensation. **A = 3-hydroxybutanal** (aldol, $CH_3CH(OH)CH_2CHO$); **B = but-2-enal** ($CH_3CH{=}CHCHO$, the α,β-unsaturated aldehyde obtained by loss of water). [1] (ii) The carbonyl group is strongly electron withdrawing, and the carbanion (enolate) formed by loss of an α-hydrogen is stabilised by resonance (negative charge shared with oxygen). [1] (iii) No: methanal has no α-hydrogen, so it cannot form the carbanion and does not undergo aldol condensation (it undergoes the Cannizzaro reaction with concentrated alkali). [1] **(B)** (1 mark each; nucleophile = the aldehyde that loses its α-H) • 3-Hydroxybutanal, $CH_3CH(OH)CH_2CHO$ (ethanal nucleophile + ethanal electrophile). [1] • 3-Hydroxy-2-methylpentanal, $CH_3CH_2CH(OH)CH(CH_3)CHO$ (propanal + propanal). [1] • 3-Hydroxypentanal, $CH_3CH_2CH(OH)CH_2CHO$ (ethanal nucleophile, propanal electrophile). [1] • 3-Hydroxy-2-methylbutanal, $CH_3CH(OH)CH(CH_3)CHO$ (propanal nucleophile, ethanal electrophile). [1]	1 + 1 + 1

15	**(A)** (i) $CH_3CH_2CH_2CH_2OH$ →(alkaline $KMnO_4$, heat; then H^+) $CH_3CH_2CH_2COOH$. [1] (ii) $CH_3COOH + SOCl_2 \rightarrow CH_3COCl + SO_2 + HCl$ ($SOCl_2$ is preferred, since the by-products are gases). [1] (iii) $CH_3COOH + C_2H_5OH$ ⇌(conc. H_2SO_4) $CH_3COOC_2H_5 + H_2O$ (esterification). [1] **(B)** (i) Hell–Volhard–Zelinsky reaction: $CH_3CH_2COOH + Cl_2$ →(red P) $CH_3CHClCOOH + HCl$. [1] (ii) Kolbe electrolysis: $2CH_3COONa + 2H_2O \rightarrow CH_3–CH_3 + 2CO_2 + H_2 + 2NaOH$ (hydrocarbon with twice the number of carbons of the alkyl group). [1] (iii) Amide formation: CH_3COONH_4 →(heat) $CH_3CONH_2 + H_2O$. [1]	1 + 1 + 1

SECTION D

Question No. 16 is a case-based/data-based question carrying 4 marks.

16	(i) 4-Methoxybenzoic acid < benzoic acid < 4-nitrobenzoic acid (pK_a 4.46 > 4.19 > 3.41; the smaller the pK_a, the stronger the acid). The electron withdrawing $–NO_2$ group stabilises the carboxylate ion (conjugate base) and increases the acidity, while the electron donating $–OCH_3$ group destabilises it and decreases the acidity. [1] (ii) **CF_3COOH** (pK_a = 0.23), the strongest carboxylic acid: the three highly electronegative fluorine atoms exert a strong electron withdrawing (–I) effect, which strongly stabilises the trifluoroacetate ion. [1] (iii) **(A)** On ionisation, the carboxylate ion is stabilised by two *equivalent* resonance structures in which the negative charge is on the electronegative oxygen atoms, so it is delocalised over two oxygen atoms. In the phenoxide ion the resonance structures are non-equivalent, with the negative charge on the less electronegative carbon atoms, so the delocalisation is less effective. The carboxylate ion is therefore more stabilised and carboxylic acids are more acidic. [2] **(B)** (a) **CH_2FCOOH**: the electron withdrawing F atom stabilises the carboxylate ion and increases the acidity. (b) **CH_2FCOOH**: fluorine is more electronegative than chlorine and has the larger –I effect (the order of effect is I < Br < Cl < F). [2]	1 + 1 + 2

SECTION E

Question No. 17 is a long answer question carrying 5 marks.

17	**(A)** (i) A = **2-ethylbenzaldehyde** (*o*-ethylbenzaldehyde), *o*-C_2H_5–C_6H_4–CHO. [1] (ii) (a) Forms a 2,4-DNP derivative: it contains a carbonyl group (aldehyde or ketone). (b) Reduces Tollens' reagent: it is an aldehyde. [1] (c) Undergoes the Cannizzaro reaction: an aldehyde with no α-hydrogen; so the –CHO group is attached directly to the benzene ring. (d) Formula $C_9H_{10}O$ has 5 degrees of unsaturation = benzene ring (4) + C=O (1). [1] (e) Vigorous oxidation gives benzene-1,2-dicarboxylic acid: the ring has two substituents in ortho positions, one is –CHO (→ –COOH) and the other is an alkyl group (→ –COOH). The remaining C_2H_5 group is ethyl. [1] (iii) *o*-$C_2H_5C_6H_4CHO + 2[Ag(NH_3)_2]^+ + 3OH^- \rightarrow$ *o*-$C_2H_5C_6H_4COO^- + 2Ag\downarrow + 4NH_3 + 2H_2O$ (silver mirror). [1] **(B)** (i) % O = 100 − (69.77 + 11.63) = 18.60. Moles: C = 69.77/12 = 5.81; H = 11.63/1 = 11.63; O = 18.60/16 = 1.16. Ratio C : H : O = 5 : 10 : 1. Empirical formula = **$C_5H_{10}O$** (mass 86); molecular mass = 86, so the molecular formula is also **$C_5H_{10}O$**. [2] (ii) Does not reduce Tollens' reagent: not an aldehyde, so a **ketone**. Forms a bisulphite addition compound: a carbonyl compound (a methyl ketone, sterically unhindered). Positive iodoform test: contains the CH_3CO– group. [2: ½ for each inference, 1 for the structure] A methyl ketone $C_5H_{10}O$ whose oxidation gives CH_3COOH and CH_3CH_2COOH is **pentan-2-one**, $CH_3COCH_2CH_2CH_3$ (vigorous oxidation cleaves the C–C bond between the carbonyl carbon and the propyl group, giving CH_3COOH and CH_3CH_2COOH). [1]	5

Topic coverage of the paper

Topic (NCERT section)	Questions
Nomenclature and structure of the carbonyl group (8.1)	Q1, Q3 (figure)
Preparation of aldehydes and ketones (8.2)	Q4, Q5, Q11 (B)
Physical properties (8.3, 8.8)	Q9 (table)
Nucleophilic addition and addition–elimination reactions, Table 8.2 (8.4)	Q2 (table), Q3, Q8, Q10, Q11 (B)
Aldol, cross aldol and Cannizzaro reactions (8.4)	Q6, Q12 (table), Q14 (figure)
Tests for carbonyl compounds and identification (8.4)	Q11 (A), Q17
Preparation of carboxylic acids (8.7)	Q13 (figure), Q15 (A)
Acidity and reactions of carboxylic acids (8.9)	Q7, Q15, Q16 (table)

Figure/table-based questions (7): Q2, Q3, Q9, Q12, Q13, Q14 and Q16.