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Organic Compounds Containing Oxygen — JEE (Main) Pattern Topic Test

FREE SAMPLE TEST · CHEMISTRY · PATTERN OF JEE (MAIN)

DURATION	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
60 minutes	100	25 (20 + 5)	

GENERAL INSTRUCTIONS

1. This question paper has two sections, A and B. All 25 questions are compulsory.
2. Section A has TWENTY (20) multiple-choice questions. Each has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Section B has FIVE (05) questions whose answer is a numerical value. Enter the value rounded off to the nearest integer.
4. Marking scheme for both sections: +4 for a correct answer, −1 for an incorrect answer, 0 if the question is not attempted.
5. Use of a calculator, log tables or any other aid is not allowed.
6. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 60 minutes before you look at them.

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Topics covered: Alcohols · Phenols · Ethers · Aldehydes and ketones: preparation · Nucleophilic addition · Reactions involving α-hydrogen · Reduction and oxidation · Aldehydes and ketones: tests · Carboxylic acids

SECTION A (Q1–20) · Multiple choice · +4 / 0 / −1

Each question has FOUR options. ONLY ONE of them is correct.

1. The correct order of acid strength of the following is

(1) 4-nitrophenol > 2,4,6-trinitrophenol > 3-nitrophenol > phenol

(2) 2,4,6-trinitrophenol > 4-nitrophenol > 3-nitrophenol > phenol

(3) 2,4,6-trinitrophenol > 3-nitrophenol > 4-nitrophenol > phenol

(4) phenol > 3-nitrophenol > 4-nitrophenol > 2,4,6-trinitrophenol

2. The correct order of acid strength of the following benzoic acids is

(1) 4-methoxybenzoic acid > 4-methylbenzoic acid > benzoic acid > 4-nitrobenzoic acid

(2) 4-nitrobenzoic acid > 4-methylbenzoic acid > benzoic acid > 4-methoxybenzoic acid

(3) benzoic acid > 4-nitrobenzoic acid > 4-methoxybenzoic acid > 4-methylbenzoic acid

(4) 4-nitrobenzoic acid > benzoic acid > 4-methylbenzoic acid > 4-methoxybenzoic acid

3. The correct order of acid strength of the following alcohols (in the liquid state or in solution) is

(1) $CH_3OH > CH_3CH_2OH > (CH_3)_2CHOH > (CH_3)_3COH$

(2) $(CH_3)_3COH > (CH_3)_2CHOH > CH_3CH_2OH > CH_3OH$

(3) $CH_3CH_2OH > CH_3OH > (CH_3)_2CHOH > (CH_3)_3COH$

(4) all four are equally acidic

4. But-2-en-1-ol, $CH_3CH{=}CHCH_2OH$, is treated with pyridinium chlorochromate (PCC) in CH_2Cl_2. The product is

(1) butanoic acid

(2) butanal

(3) but-2-enoic acid

(4) but-2-enal

5. 2-Ethoxypropane, $CH_3CH_2{-}O{-}CH(CH_3)_2$, is treated with one equivalent of HI at 373 K. The products are

(1) iodoethane and propan-2-ol

(2) ethanol and 2-iodopropane

(3) iodoethane and 2-iodopropane

(4) ethanol and propan-2-ol

6. Phenol is treated with bromine in CS_2 at 273 K. The main product is

(1) 2,4,6-tribromophenol

(2) 3-bromophenol

(3) 4-bromophenol

(4) bromobenzene

7. The correct order of reactivity of the following towards nucleophilic addition of HCN is

(1) $CH_3COCH_3 > CH_3CHO > HCHO > (CH_3)_3CCOC(CH_3)_3$

(2) $HCHO > CH_3CHO > CH_3COCH_3 > (CH_3)_3CCOC(CH_3)_3$

(3) $(CH_3)_3CCOC(CH_3)_3 > CH_3COCH_3 > CH_3CHO > HCHO$

(4) $HCHO > CH_3COCH_3 > CH_3CHO > (CH_3)_3CCOC(CH_3)_3$

8. Which of the following does NOT undergo aldol condensation with dilute NaOH?

(1) ethanal

(2) propanone

(3) 2,2-dimethylpropanal

(4) phenylethanal, $C_6H_5CH_2CHO$

9. Propanone is converted into propane by heating with

(1) $NaBH_4$ in ethanol

(2) $LiAlH_4$ in ether, then water

(3) hydrazine, then KOH in ethylene glycol

(4) H_2 and a Pd catalyst at room temperature

10. Fehling's solution can be used to distinguish between

(1) propanal and butanal

(2) propanone and butanone

(3) benzaldehyde and acetophenone

(4) ethanal and benzaldehyde

11. 4-Oxopentanoic acid, $CH_3COCH_2CH_2COOH$, is treated with $NaBH_4$ and the mixture is acidified. The product is

(1) 4-hydroxypentanoic acid

(2) pentane-1,4-diol

(3) pentanoic acid

(4) 5-hydroxypentan-2-one

12. Anisole (methoxybenzene) reacts with ethanoyl chloride in the presence of anhydrous $AlCl_3$. The main product is

(1) phenyl ethanoate

(2) 3-methoxyacetophenone

(3) 4-methoxyacetophenone

(4) acetophenone and methanol

13. Ethanoic acid is esterified with ethanol in which the oxygen is labelled with ^{18}O ($CH_3CH_2–^{18}OH$), in the presence of a little concentrated H_2SO_4. The ^{18}O is found

(1) in the water formed

(2) in the ester, as the oxygen joining the ethyl group

(3) in the ester, as the C=O oxygen

(4) divided equally between the ester and the water

14. Which of the following gives a chiral product (as a racemic mixture) when it adds HCN?

(1) methanal

(2) ethanal

(3) propanone

(4) pentan-3-one

15. Ethyl methanoate, $HCOOC_2H_5$, is treated with an excess of methylmagnesium bromide, and the product is hydrolysed. The alcohol obtained (besides ethanol) is

(1) 2-methylpropan-2-ol

(2) propan-1-ol

(3) ethanol only

(4) propan-2-ol

16. Propanenitrile, CH_3CH_2CN, is treated with diisobutylaluminium hydride (DIBAL-H) and then with water. The product is

(1) propan-1-amine

(2) propanal

(3) propanoic acid

(4) propan-1-ol

17. Statement I: Diethyl ether can be made by heating ethanol with concentrated H_2SO_4 at 413 K.
Statement II: Di-tert-butyl ether can be made by heating 2-methylpropan-2-ol with concentrated H_2SO_4 in the same way.
In the light of the above statements, choose the correct answer from the options given below:

(1) Both Statement I and Statement II are true

(2) Statement I is true but Statement II is false

(3) Statement I is false but Statement II is true

(4) Both Statement I and Statement II are false

18. 4-Methylphenol (p-cresol) is heated with chloroform and aqueous NaOH, and the mixture is then acidified. The main product is

(1) 2-hydroxy-4-methylbenzaldehyde

(2) 4-hydroxybenzaldehyde

(3) 2-hydroxy-5-methylbenzoic acid

(4) 2-hydroxy-5-methylbenzaldehyde

19. Assertion A: Propanone gives a positive iodoform test, but ethanoic acid does not, although both contain a CH_3–C=O group.
Reason R: In ethanoic acid the –OH group donates electrons to the carbonyl carbon by resonance, so the α-hydrogens of the CH_3 group are far less acidic than in propanone.
In the light of the above statements, choose the correct answer from the options given below:

(1) Both A and R are true and R is the correct explanation of A

(2) Both A and R are true but R is NOT the correct explanation of A

(3) A is true but R is false

(4) A is false but R is true

20. Which of the following reagents reduces a carboxylic acid to a primary alcohol?

(1) $NaBH_4$

(2) Zn–Hg and conc. HCl

(3) $LiAlH_4$, then water

(4) Tollens' reagent

SECTION B (Q21–25) · Numerical value · +4 / 0 / −1

The answer to each question is a NUMERICAL VALUE. Enter it rounded off to the nearest integer.

21. The number of the following compounds that give a positive iodoform test is _____.
ethanol, methanol, propan-2-ol, propan-1-ol, butan-2-one, pentan-3-one, acetophenone, ethanal, propanal, butan-2-ol, ethanoic acid, pentan-3-ol

Answer: _____

22. 1.2 g of methanal is warmed with an excess of Tollens' reagent. The mass of silver deposited (in g, to the nearest integer) is _____. (H = 1, C = 12, O = 16, Ag = 108; methanal is oxidised all the way to CO_2.)

Answer: _____

23. The number of structurally isomeric aldehydes and ketones with the molecular formula $C_5H_{10}O$ is _____.

Answer: _____

24. For $CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$, K = 4.0. When 1.0 mol of ethanoic acid is heated with 3.0 mol of ethanol until equilibrium is reached, the percentage of the acid converted into the ester (to the nearest integer) is _____.

Answer: _____

25. 0.30 g of a saturated monohydric alcohol $C_nH_{2n+1}OH$ reacts completely with sodium to give 56 mL of hydrogen at STP. The value of n is _____. (H = 1, C = 12, O = 16; molar volume 22.4 L)

Answer: _____

END OF THE QUESTION PAPER

ANSWER KEY

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
(2)	(4)	(1)	(4)	(1)	(3)	(2)	(3)	(3)	(4)

Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
(1)	(3)	(2)	(2)	(4)	(2)	(2)	(4)	(1)	(3)

Q21	Q22	Q23	Q24	Q25
6	17	7	90	3

WORKED SOLUTIONS

Q1. Answer (2). A nitro group ortho or para to –OH takes the negative charge of the phenoxide ion on to its oxygens by resonance (−R and −I); a meta nitro group acts only by −I. Three o/p nitro groups make picric acid almost as strong as a mineral acid. pKa: 0.42 < 7.15 < 8.36 < 10.0.

Q2. Answer (4). Electron-withdrawing groups stabilise the carboxylate ion and raise acidity; electron-donating groups lower it. $–NO_2$ withdraws; $–CH_3$ donates by +I and hyperconjugation; at the para position $–OCH_3$ donates strongly by +R. pKa: 3.41 < 4.20 < 4.37 < 4.47.

Q3. Answer (1). Each alkyl group on the carbinol carbon pushes electrons towards oxygen (+I), making the O–H bond less polar and the alkoxide ion less stable (and less well solvated). So the more alkyl groups, the weaker the acid: methanol > primary > secondary > tertiary.

Q4. Answer (4). PCC is a mild oxidising agent: it stops a primary alcohol at the aldehyde stage and does not attack the C=C bond. $CH_3CH{=}CHCH_2OH \rightarrow CH_3CH{=}CHCHO$ (but-2-enal).

Q5. Answer (1). HI protonates the ether oxygen; then I^- attacks by SN2 at the less hindered carbon (the CH_2 of the ethyl group rather than the secondary carbon). So the C–O bond to ethyl breaks: $CH_3CH_2I + (CH_3)_2CHOH$. (Only with a tertiary group does the reaction switch to SN1 and put iodine on that group.)

Q6. Answer (3). In a non-polar solvent at low temperature, phenol is not ionised and Br_2 is less polarised, so the reaction stops at monosubstitution, mainly at the less hindered para position: 4-bromophenol. (In water, phenol partly ionises and all three o/p positions are brominated.)

Q7. Answer (2). Alkyl groups on the carbonyl carbon both lower its positive charge (+I) and crowd the approach of the nucleophile. Methanal has none, ethanal one, propanone two small ones and di-tert-butyl ketone two very bulky ones.

Q8. Answer (3). Aldol condensation needs an α-hydrogen, which the base removes to form the enolate. In $(CH_3)_3C–CHO$ the α-carbon is quaternary and has no hydrogen (it undergoes the Cannizzaro reaction instead). The other three have 3, 6 and 2 α-hydrogens.

Q9. Answer (3). Wolff–Kishner reduction: the hydrazone $(CH_3)_2C{=}N–NH_2$ formed from hydrazine loses N_2 when heated with KOH in a high-boiling solvent, giving $(CH_3)_2CH_2$, propane. $NaBH_4$ and $LiAlH_4$ only reduce C=O to CH–OH (propan-2-ol).

Q10. Answer (4). Fehling's solution is reduced (red Cu_2O) by aliphatic aldehydes but not by aromatic aldehydes or by ketones. Ethanal gives a red precipitate and benzaldehyde does not. In each of the other pairs both compounds behave the same way.

Q11. Answer (1). $NaBH_4$ reduces aldehydes and ketones but not carboxylic acids ($LiAlH_4$ would reduce both). Only the ketone becomes CH–OH: $CH_3CH(OH)CH_2CH_2COOH$, 4-hydroxypentanoic acid.

Q12. Answer (3). $-OCH_3$ activates the ring and directs ortho/para by its +R effect. In Friedel–Crafts acylation the bulky acylium ion goes mainly to the para position, giving 1-(4-methoxyphenyl)ethanone.

Q13. Answer (2). The alcohol oxygen attacks the protonated carbonyl carbon of the acid (nucleophilic acyl substitution), and the acid loses its –OH as water. So the C–O bond of the acid breaks (acyl–oxygen cleavage), and the labelled oxygen stays in $CH_3CO{-}^{18}O{-}CH_2CH_3$.

Q14. Answer (2). HCN adds across C=O to give $R_2C(OH)CN$. The carbon is chiral only if the two groups already on the carbonyl carbon are different: ethanal gives $CH_3CH(OH)CN$ (H, CH_3, OH, CN). Methanal (H, H), propanone (CH_3, CH_3) and pentan-3-one (C_2H_5, C_2H_5) do not. Attack from either face gives a racemic mixture.

Q15. Answer (4). The first CH_3MgBr replaces the $-OC_2H_5$ group, giving ethanal (CH_3CHO); the second adds to ethanal. After hydrolysis: $(CH_3)_2CHOH$, propan-2-ol. Esters of other acids give tertiary alcohols, but the H of a methanoate ester stays on the carbon, so the alcohol is secondary.

Q16. Answer (2). DIBAL-H transfers only one hydride to the nitrile, giving an imine–aluminium complex, which water hydrolyses to the aldehyde: $CH_3CH_2CN \rightarrow CH_3CH_2CHO$. $LiAlH_4$ would reduce the nitrile all the way to the amine.

Q17. Answer (2). I is true: a protonated ethanol molecule is attacked by a second ethanol molecule (SN2). II is false: a tertiary alcohol forms a carbocation that loses H^+ to give 2-methylpropene, so acidic dehydration makes ethers only from primary alcohols.

Q18. Answer (4). This is the Reimer–Tiemann reaction. $CHCl_3$ and NaOH give dichlorocarbene, $:CCl_2$, which attacks the phenoxide ion at a position ortho to O^- (the para position is taken by CH_3, which stays). The $-CHCl_2$ group is hydrolysed to –CHO. Numbering from the CHO carbon, the OH is at C-2 and the CH_3 at C-5: 2-hydroxy-5-methylbenzaldehyde. (CCl_4 in place of $CHCl_3$ would give the acid.)

Q19. Answer (1). The haloform reaction starts with removal of an α-hydrogen by the base. In the acid (and in the carboxylate ion that the base forms at once) the lone pair on oxygen is delocalised into C=O, so the CH_3 hydrogens are not removed and the CH_3 group is not iodinated. Both statements are true and R explains A.

Q20. Answer (3). $LiAlH_4$ (or diborane) reduces –COOH to $-CH_2OH$. $NaBH_4$ is too weak for acids, Clemmensen conditions do not reduce –COOH, and Tollens' reagent is an oxidising agent.

Q21. Answer 6. Positive: compounds with CH_3CO- or $CH_3CH(OH)-$ (H or C on the other side): ethanol, propan-2-ol, butan-2-one, acetophenone, ethanal and butan-2-ol: 6. Methanol, propan-1-ol, pentan-3-one, propanal, pentan-3-ol and ethanoic acid are negative.

Q22. Answer 17. $HCHO \rightarrow HCOOH \rightarrow CO_2$: carbon goes from 0 to +4, so each HCHO reduces 4 Ag^+. 1.2/30 = 0.040 mol HCHO gives 0.16 mol Ag = 0.16 × 108 = 17.28 g, i.e. 17.

Q23. Answer 7. Aldehydes (4): pentanal, 2-methylbutanal, 3-methylbutanal and 2,2-dimethylpropanal. Ketones (3): pentan-2-one, pentan-3-one and 3-methylbutan-2-one. Total 7.

Q24. Answer 90. $x^2/[(1-x)(3-x)] = 4$ gives $3x^2 - 16x + 12 = 0$, so $x = (16 - \sqrt{112})/6 = 0.903$ (the other root exceeds 1). Percentage converted = 90.3, i.e. 90. (With 1 mol of ethanol only 67% would react: an excess of alcohol drives the reaction forward.)

Q25. Answer 3. $2ROH + 2Na \rightarrow 2RONa + H_2$. $H_2 = 0.056/22.4 = 0.0025$ mol, so ROH = 0.0050 mol and M = 0.30/0.0050 = 60 g/mol. 14n + 18 = 60 gives n = 3 (propanol).

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every answer in this paper was checked independently by computer: structures were built as graphs; the iodoform test, α-hydrogens, chirality of cyanohydrins, ether cleavage, Grignard products and isomer counts were worked out on the graphs, acid strengths from measured pKa values, and the equilibrium and stoichiometry questions by calculation.