Aldehydes, Ketones and Carboxylic Acids

Standard difficulty · 20 questions · 40 marks · Time: 40 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer 8 × 1 = 8 marks

1. The carbonyl carbon is:

(a) sp hybridised **(b)** tetrahedral

(c) sp^3 hybridised **(d)** sp^2 hybridised and trigonal planar

2. The IUPAC name of CH_3COCH_3 (acetone) is:

(a) propanone **(b)** butanal

(c) diphenylmethanone **(d)** pentan-3-one

3. Which of these gives a positive result with Tollens' test (silver mirror)?

(a) pentan-3-one **(b)** diphenylmethanone

(c) methanal **(d)** propanone

4. Which of these undergoes the aldol reaction with dilute alkali?

(a) pentan-3-one **(b)** 2,2-dimethylpropanal

(c) benzaldehyde **(d)** diphenylmethanone

5. The correct order of increasing acid strength is:

(a) $CF_3COOH < FCH_2COOH < C_6H_5COOH$ **(b)** $FCH_2COOH < CF_3COOH < C_6H_5COOH$

(c) $FCH_2COOH < C_6H_5COOH < CF_3COOH$ **(d)** $C_6H_5COOH < FCH_2COOH < CF_3COOH$

6. 1-phenylethanone is treated with NH_2NH_2 then KOH in ethylene glycol. The main product is:

(a) benzyl alcohol and sodium benzoate **(b)** ethylbenzene

(c) benzaldehyde **(d)** 3-nitrobenzoic acid

7. Benzoic acid is heated with ethanol and a little conc. H_2SO_4. The ester formed is:

(a) propyl benzoate **(b)** phenyl ethanoate

(c) ethyl methanoate **(d)** ethyl benzoate

8. Assertion (A): Benzaldehyde (C_6H_5CHO) does not give a silver mirror with Tollens' reagent.
Reason (R): Aldehydes are oxidised by Tollens' reagent, while ketones are not.

(a) Both A and R are true, and R is the correct explanation of A.

(b) Both A and R are true, but R is not the correct explanation of A.

(c) A is true, but R is false.

(d) A is false, but R is true.

Section B — Short answer 8 × 2 = 16 marks

9. Why do aldehydes and ketones have lower boiling points than alcohols of similar mass?

10. Name the ester formed from butanoic acid and methanol, and give its molecular formula and molar mass. (C = 12, H = 1, O = 16)

11. Give a chemical test to tell propanone from 2,2-dimethylpropanal.

12. What is formed when benzoic acid reacts with conc. HNO_3 and conc. H_2SO_4? Name the reaction.

13. Arrange in increasing order of acid strength, and give a reason: CF_3COOH, CH_3CH_2COOH, 4-nitrobenzoic acid.

14. What hydrocarbon is formed when sodium propanoate is heated with soda lime? Name the reaction.

15. Does 1-phenylethanone ($C_6H_5COCH_3$) give (a) Tollens' test, (b) Fehling's test, (c) the iodoform test, (d) the aldol reaction?

16. 97.6 g of benzoic acid is heated with excess propan-1-ol. If the yield is 80%, what mass of propyl benzoate is obtained? (C = 12, H = 1, O = 16)

Section C — Word problems — 4 × 4 = 16 marks

17. Describe the nucleophilic addition reactions of aldehydes and ketones, with the mechanism.

18. Identify the compounds in: ethanenitrile —$SnCl_2$, HCl, then H_2O→ A —Tollens'→ observation.

19. How would you tell apart diphenylmethanone, propanone, propanal using Tollens', Fehling's and iodoform tests? Give the result of each test for each compound.

20. Arrange in increasing order of acid strength, and explain the effect of each substituent: HCOOH, CH_3CH_2COOH, CH_3COOH, FCH_2COOH.

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Answer key

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Q	Answer	Working
1	**(d) sp^2 hybridised and trigonal planar**	—
2	**(a) propanone**	—
3	**(c) methanal**	methanal: is an aldehyde
4	**(a) pentan-3-one**	it has an α-hydrogen
5	**(d) C_6H_5COOH < FCH_2COOH < CF_3COOH**	pKa: FCH_2COOH 2.59, CF_3COOH 0.23, C_6H_5COOH 4.19 (lower pKa, stronger acid)
6	**(b) ethylbenzene**	—
7	**(d) ethyl benzoate**	name the alkyl group of the alcohol, then the -oate of the acid
8	**(d) A is false, but R is true.**	A is false: benzaldehyde is an aldehyde. R is true.
9	**They have polar C=O groups but cannot form intermolecular hydrogen bonds with each other, unlike alcohols.**	—
10	**methyl butanoate; $C_5H_{10}O_2$; 102 g/mol**	acid + alcohol → ester + water
11	**the iodoform test (yellow precipitate): propanone gives a positive result, 2,2-dimethylpropanal does not**	the iodoform test needs a $CH_3CO–$ group
12	**3-nitrobenzoic acid; nitration (meta)**	—
13	**CH_3CH_2COOH < 4-nitrobenzoic acid < CF_3COOH**	electron-withdrawing groups stabilise the carboxylate ion; pKa: CF_3COOH 0.23, CH_3CH_2COOH 4.87, 4-nitrobenzoic acid 3.41
14	**ethane; decarboxylation (one carbon is lost as Na_2CO_3)**	$RCOONa + NaOH \rightarrow RH + Na_2CO_3$
15	**(a) no; (b) no; (c) yes; (d) yes**	aldehydes reduce Tollens'; aliphatic aldehydes reduce Fehling's; $CH_3CO–$ gives iodoform; aldol needs an α-H
16	**104.96 g**	0.8 mol of acid; ester M = 164
17	**A nucleophile attacks the positive carbonyl carbon from above or below the plane, giving a tetrahedral alkoxide intermediate, which takes up a proton. Examples: HCN gives cyanohydrins; $NaHSO_3$ gives bisulphite addition products; Grignard reagents then water give alcohols; alcohols give hemiacetals and acetals.**	—
18	**A = ethanal (Stephen reduction); a silver mirror**	follow each reagent in turn

Q	Answer	Working
19	**diphenylmethanone: Tollens −, Fehling −, iodoform −; propanone: Tollens −, Fehling −, iodoform +; propanal: Tollens +, Fehling +, iodoform −**	Tollens: aldehydes; Fehling: aliphatic aldehydes; iodoform: $CH_3CO–$ compounds
20	**$CH_3CH_2COOH < CH_3COOH < HCOOH < FCH_2COOH$**	halogens and nitro groups withdraw electrons (−I) and stabilise the carboxylate ion; the more of them and the closer they are, the stronger the acid; alkyl groups (+I) weaken the acid. pKa: HCOOH 3.75, CH_3CH_2COOH 4.87, CH_3COOH 4.76, FCH_2COOH 2.59