Alcohols, Phenols and Ethers

Standard difficulty · 20 questions · 40 marks · Time: 38 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. Alcohols have higher boiling points than ethers of similar mass because of:

(a) ionic bonding **(b)** lower molar mass

(c) van der Waals forces only **(d)** hydrogen bonding

2. The IUPAC name of $(CH_3)_2CHOH$ is:

(a) propan-2-ol **(b)** butan-2-ol

(c) 2-methylpropan-2-ol **(d)** 2-methylpropan-1-ol

3. Which alcohol gives turbidity at once with the Lucas reagent?

(a) propan-1-ol **(b)** butan-1-ol

(c) ethanol **(d)** 2-methylpropan-2-ol

4. Ethanol is treated with pyridinium chlorochromate (PCC). The product is:

(a) no reaction (tertiary) **(b)** butanal

(c) ethanal **(d)** methanal

5. The correct order of increasing acid strength is:

(a) 2-methylphenol < 2,4,6-trinitrophenol < ethanol

(b) 2-methylphenol < ethanol < 2,4,6-trinitrophenol

(c) ethanol < 2-methylphenol < 2,4,6-trinitrophenol

(d) 2,4,6-trinitrophenol < 2-methylphenol < ethanol

6. Phenol reacts with NaOH, then CO_2 under pressure, then acid (Kolbe). The product is:

(a) benzene

(b) benzoquinone

(c) salicylic acid (2-hydroxybenzoic acid)

(d) a mixture of 2-nitrophenol and 4-nitrophenol

7. 2-methoxypropane ($(CH_3)_2CHOCH_3$) is heated with HI. The products are:

(a) CH_3I and propan-2-ol

(b) phenol and C_2H_5I

(c) 2-iodo-2-methylpropane and CH_3OH (SN1 at the tertiary carbon)

(d) CH_3I and CH_3OH (CH_3I with excess HI)

8. Assertion (A): Methanol gives turbidity at once with the Lucas reagent.
Reason (R): Alcohols react with the Lucas reagent through carbocations, so the order is tertiary > secondary > primary.

(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 is phenol acidic? Why is 4-nitrophenol more acidic than phenol?

10. What is the main product when cyclohexanol is heated with concentrated H_2SO_4? Which alcohols dehydrate most easily?

11. Give the IUPAC name and the common name of $C_6H_5CH_2OCH_3$.

12. 96.2 g of 2-methylpropan-2-ol reacts completely with sodium. What volume of hydrogen is given off at STP? (C = 12, H = 1, O = 16; 1 mol of gas = 22.4 L at STP)

13. Arrange in increasing order of boiling point, and explain: pentane, methoxyethane, butan-1-ol.

14. What is formed when 2-methylpropan-2-ol is oxidised with (a) PCC, (b) alkaline $KMnO_4$, then acid?

15. Write the product when phenol is treated with $Na_2Cr_2O_7$ with H_2SO_4.

16. Which alkoxide and which alkyl halide would you use to make tert-butyl methyl ether by the Williamson synthesis? Explain your choice.

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

17. Describe three methods of preparing alcohols, with equations.

18. Identify the compounds in: methanal —CH_3MgBr, then H_2O→ A —PCC→ B.

19. Arrange in increasing order of acid strength, and explain the effect of each substituent: 4-nitrophenol, 3-nitrophenol, phenol, 2-methylphenol.

20. An alcohol of formula C_4H_9OH is butan-2-ol. Classify it, state what you see with the Lucas reagent, give its products with PCC and with acidified $KMnO_4$, and find the volume of hydrogen at STP when 14.8 g of it reacts with sodium. (C = 12, H = 1, O = 16; 1 mol of gas = 22.4 L at STP)

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Answer key

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Q	Answer	Working
1	**(d) hydrogen bonding**	—
2	**(a) propan-2-ol**	the longest chain containing the –OH carbon; –ol ending
3	**(d) 2-methylpropan-2-ol**	2-methylpropan-2-ol is a tertiary (3°) alcohol
4	**(c) ethanal**	PCC stops a primary alcohol at the aldehyde
5	**(c) ethanol < 2-methylphenol < 2,4,6-trinitrophenol**	pKa: 2,4,6-trinitrophenol 0.5, 2-methylphenol 10.2, ethanol 15.9 (lower pKa, stronger acid)
6	**(c) salicylic acid (2-hydroxybenzoic acid)**	—
7	**(a) CH_3I and propan-2-ol**	the C–O bond to the smaller (or tertiary, by SN1) group breaks
8	**(d) A is false, but R is true.**	A is false: it is a primary (1°) alcohol. R is true.
9	**The phenoxide ion formed by losing H^+ is stabilised by resonance over the ring. A nitro group at the para position withdraws electrons and spreads the negative charge further, stabilising the ion even more.**	—
10	**cyclohexene; tertiary > secondary > primary**	acid-catalysed dehydration through a carbocation
11	**(methoxymethyl)benzene; benzyl methyl ether**	the larger group is the parent; the smaller is alkoxy
12	**14.56 L**	$2ROH + 2Na \rightarrow 2RONa + H_2$; 1.3 mol of alcohol gives 0.65 mol of H_2
13	**methoxyethane < pentane < butan-1-ol**	alcohols and phenols form hydrogen bonds, ethers and alkanes do not; data (°C): pentane 36, methoxyethane 7, butan-1-ol 117
14	**(a) no reaction (tertiary); (b) no reaction under mild conditions**	PCC is mild; alkaline $KMnO_4$ takes a primary alcohol to the acid
15	**benzoquinone**	the –OH group activates the ring at the ortho and para positions
16	**$(CH_3)_3CONa$ and CH_3Br; CH_3ONa with $(CH_3)_3CBr$ would give mainly 2-methylpropene by elimination**	Williamson synthesis is SN2: use the less hindered halide

Q	Answer	Working
17	**From alkenes by acid-catalysed hydration (Markovnikov): $CH_3CH{=}CH_2 + H_2O \rightarrow CH_3CH(OH)CH_3$. By hydroboration–oxidation (anti-Markovnikov): propene → propan-1-ol. From carbonyl compounds by reduction (H_2/Pd, $NaBH_4$, $LiAlH_4$) or with Grignard reagents: HCHO gives a 1° alcohol, other aldehydes 2°, ketones 3°.**	—
18	**A = ethanol, B = ethanal**	follow each reagent in turn
19	**2-methylphenol < phenol < 3-nitrophenol < 4-nitrophenol**	nitro groups (especially ortho and para) withdraw electrons and stabilise the phenoxide ion; methyl groups release electrons and destabilise it; ethanol is weakest. pKa: 4-nitrophenol 7.1, 3-nitrophenol 8.3, phenol 10, 2-methylphenol 10.2
20	**secondary (2°); turbidity in about five minutes; butan-2-one; butan-2-one; 2.24 L of H_2 (M = 74 g/mol)**	Lucas order 3° > 2° > 1°