Organic Chemistry – Some Basic Principles and Techniques

Standard difficulty · 20 questions · 40 marks · Time: 36 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 ability of carbon to form long chains by bonding to itself is called:

(a) isomerism **(b)** resonance **(c)** hybridisation **(d)** catenation

2. The IUPAC name of $CH_2{=}CHCH_3$ is:

(a) 2-methylpropene **(b)** propan-1-amine
(c) propene **(d)** 2-methylpropan-1-ol

3. CH_3CH_2CHO belongs to the class:

(a) ether **(b)** alkane **(c)** ketone **(d)** aldehyde

4. How many structural isomers are possible for C_4H_8 (open-chain alkenes (ignoring cis–trans))?

(a) 5 **(b)** 2 **(c)** 3 **(d)** 4

5. Propanal and propanone are:

(a) functional group isomers **(b)** metamers
(c) chain isomers **(d)** position isomers

6. Which of these is an electrophile?

(a) NO_2^+ **(b)** Cl^- **(c)** CH_3O^- **(d)** OH^-

7. Which shows the correct order of increasing acid strength?

(a) $BrCH_2COOH < ICH_2COOH < ClCH_2COOH$ **(b)** $ClCH_2COOH < ICH_2COOH < BrCH_2COOH$
(c) $BrCH_2COOH < ClCH_2COOH < ICH_2COOH$ **(d)** $ICH_2COOH < BrCH_2COOH < ClCH_2COOH$

8. Assertion (A): $Cl_2CHCOOH$ is a stronger acid than Cl_3CCOOH.
Reason (R): Electron-withdrawing groups stabilise the carboxylate ion by the −I effect; the effect grows with more, closer and more electronegative substituents.

(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. What is the difference between homolytic and heterolytic cleavage?

10. 3 g of an organic compound gave 6.6 g of CO_2 and 3.6 g of H_2O on complete combustion. Find the percentages of carbon and hydrogen in it. (2 decimal places where needed.)

11. In a Kjeldahl estimation, the ammonia from 0.6 g of a compound neutralised 35 mL of 0.25 M H_2SO_4. Find the percentage of nitrogen. (2 decimal places where needed.)

12. In a Dumas estimation, 0.25 g of a compound gave 83 mL of nitrogen at STP. Find the percentage of nitrogen. (2 decimal places where needed.)

13. In a Carius estimation, 0.3 g of a compound gave 0.75 g of AgCl. Find the percentage of chlorine. (AgCl = 143.5 g/mol; Cl = 35.5) (2 decimal places where needed.)

14. 0.5 g of an organic compound gave 1.45 g of $BaSO_4$ in the estimation of sulphur. Find the percentage of sulphur. ($BaSO_4$ = 233 g/mol) (2 decimal places where needed.)

15. In thin-layer chromatography a spot moved 6.4 cm while the solvent front moved 8 cm. Find the Rf value.

16. Write the condensed structural formula of methoxyethane, and name its class of compound.

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

17. Explain the inductive effect, resonance effect, electromeric effect and hyperconjugation, with one example each.

18. 3.52 g of an organic compound containing C, H and O gave 7.04 g of CO_2 and 2.88 g of H_2O. (a) Find the percentages of C, H and O. (b) Find its empirical formula. (c) Its molar mass is 88 g/mol; find its molecular formula. (2 decimal places where needed.)

19. (a) Classify as electrophile or nucleophile: NO_2^+, H^+, $AlCl_3$, CH_3^+, Br^+. (b) Arrange these carbanions in order of increasing stability, and give the reason: $(CH_3)_3C^-$, $(CH_3)_2CH^-$, $CH_3CH_2^-$.

20. Write the structures and IUPAC names of all the structural isomers of C_2H_6O (alcohols and ethers). How many are there?

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Answer key

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Q	Answer	Working
1	**(d) catenation**	—
2	**(c) propene**	longest chain, lowest locants, functional group as suffix
3	**(d) aldehyde**	look at the functional group
4	**(c) 3**	but-1-ene, but-2-ene, 2-methylpropene
5	**(a) functional group isomers**	—
6	**(a) NO_2^+**	it is electron-deficient and accepts an electron pair
7	**(d) $ICH_2COOH < BrCH_2COOH < ClCH_2COOH$**	electron-withdrawing groups (more, closer, more electronegative) stabilise the carboxylate ion
8	**(d) A is false, but R is true.**	A is false: Cl_3CCOOH is the stronger. R is true.
9	**In homolytic cleavage each atom keeps one electron of the bond, giving free radicals. In heterolytic cleavage one atom takes both electrons, giving a cation and an anion (for carbon, a carbocation or a carbanion).**	—
10	**C 60%; H 13.33% (it is propan-1-ol)**	%C = 12 × mass CO_2 × 100/(44 × mass); %H = 2 × mass H_2O × 100/(18 × mass)
11	**40.83%**	%N = 1.4 × molarity × 2 × volume of acid ÷ mass = 1.4 × 0.25 × 2 × 35 ÷ 0.6
12	**41.5%**	%N = 28 × 83 × 100/(22400 × 0.25)
13	**61.85%**	%X = 35.5 × 0.75 × 100/(143.5 × 0.3)
14	**39.83%**	%S = 32 × 1.45 × 100/(233 × 0.5)
15	**0.8**	Rf = distance moved by substance ÷ distance moved by solvent
16	**$CH_3CH_2OCH_3$ (ether)**	the root gives the chain length; suffix and locants give the group and its position

Q	Answer	Working
17	**Inductive: permanent σ-electron shift towards an electronegative atom; in CH_3CH_2Cl, chlorine pulls electrons from carbon. Resonance: delocalisation of π electrons or lone pairs through conjugation; in phenol the O lone pair spreads into the ring (+R). Electromeric: temporary complete π-electron shift when a reagent attacks a C=C or C=O. Hyperconjugation: delocalisation of C–H σ electrons into an adjacent empty p orbital or π bond; it makes $(CH_3)_3C^+$ more stable than CH_3^+.**	—
18	**(a) C 54.55%, H 9.09%, O 36.36%; (b) C_2H_4O; (c) $C_4H_8O_2$ (ethyl ethanoate)**	%O by difference; divide each % by its atomic mass and by the smallest; (Atomic masses: H = 1 u, C = 12 u, O = 16 u)
19	**(a) NO_2^+ electrophile; H^+ electrophile; $AlCl_3$ electrophile; CH_3^+ electrophile; Br^+ electrophile. (b) $(CH_3)_3C^- < (CH_3)_2CH^- < CH_3CH_2^-$: alkyl groups (+I) push electron density onto the negative carbon, so more alkyl groups destabilise it.**	—
20	**2: ethanol, methoxymethane**	—