# Unit 9 · Organic Compounds

**ANSWER KEY · FOR TEACHERS**

Full marks 49

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

## 1 Key words

1. tetracovalency → **g.** carbon's property of forming four covalent bonds
2. catenation → **a.** carbon atoms joining to each other in chains and rings
3. alkyl group → **f.** what is left of an alkane when one hydrogen atom is taken off
4. functional group → **c.** the atom or group of atoms that decides a compound's chemical properties
5. homologous series → **b.** compounds with the same group, each differing from the next by $CH_2$
6. saturated → **d.** having only single bonds between its carbon atoms

K · 3

Each carries 0.5 mark.

## 2 Multiple choice

**i.** **b.** Wöhler — K · 1

Friedrich Wöhler made urea from ammonium cyanate in 1828. Berzelius had proposed that organic compounds need a vital force; Kekulé and van 't Hoff worked out carbon's four bonds and their shape later.

**ii.** **b.** $C_nH_{2n}$ — K · 1

An alkene has one C=C, so it has two hydrogens fewer than the alkane: $C_nH_{2n}$. $C_nH_{2n-2}$ is the alkynes', and $C_nH_{2n+1}$ an alkyl group.

**iii.** **c.** $Na_2CO_3$ — U · 1

Sodium carbonate is a carbonate, and carbonates, like the oxides of carbon, cyanides and carbides, are counted as inorganic.

**iv.** **b.** propanoic acid — U · 1

Methanoic (1 carbon), ethanoic (2), propanoic (3): the –COOH carbon counts.

**v.** **a.** ethanol and methoxymethane — A · 1

Ethanol, $CH_3CH_2OH$, and methoxymethane, $CH_3OCH_3$, are both $C_2H_6O$. Ethanal is $C_2H_4O$; propanone $C_3H_6O$ and propan-2-ol $C_3H_8O$; ethene $C_2H_4$ and ethyne $C_2H_2$.

## 3 Label the diagram

1. ethane $H_3C–CH_3$
2. ethene $H_2C=CH_2$
3. ethyne $HC\equiv CH$
4. single 347 kJ/mol
5. double 614 kJ/mol
6. triple 839 kJ/mol

K · 3

Each carries 0.5 mark.

## 4 Very short answers

**a.** MARKING SCHEME — K · 1

✓ Ammonium cyanate.

**b.** MARKING SCHEME — K · 1

✓ Ethyl.

**c.** MARKING SCHEME — U · 1

✓ Ketone.

**d.** MARKING SCHEME — U · 1

✓ 14.



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## 5 Short answers

**a.** MARKING SCHEME U · 2

- ✓ To make an ion with a full shell it would have to gain or lose 4 electrons, which needs far too much energy.
- ✓ So it shares its 4 outer electrons, making four covalent bonds.

**b.** MARKING SCHEME U · 2

- ✓ Its carbon has only one bond left for the chain, so it must be at the end of the chain.
- ✓ The chain is numbered from it, so it is always carbon 1.

**c.** MARKING SCHEME A · 2

- ✓ A double bond is less than twice as strong as a single bond: its second bond is weaker.
- ✓ The extra bond opens easily, and other atoms add on there.

**d.** MARKING SCHEME U · 2

- ✓ Propanal, an aldehyde.
- ✓ Propanone, a ketone.

## 6 Long answers

**a.** ANSWER U · 4

**Catenation** is the property of an element's atoms to join to one another by covalent bonds in long chains, branched chains and rings.
Carbon catenates more than any other element because the C–C bond is strong (about 347 kJ/mol) and about as strong as carbon's bonds to hydrogen and oxygen, so carbon chains stay stable in air and water. The bonds of other elements to themselves are much weaker than their bonds to oxygen (N–N about 160, O–O about 146 kJ/mol; silicon's bonds to itself are weaker than Si–O, 452 kJ/mol), so their chains break up or react with air. Carbon's four bonds also leave room for hydrogen and other atoms along the chain.

MARKING SCHEME

- ✓ Catenation is an element's atoms joining to one another in chains, branches and rings.
- ✓ The C–C bond is strong (about 347 kJ/mol), about as strong as carbon's bonds to hydrogen and oxygen.
- ✓ So carbon chains stay stable in air and water.
- ✓ Other elements' bonds to themselves are weaker (N–N about 160, O–O about 146 kJ/mol; silicon's much weaker than Si–O), so their chains break up or react with air.

**b.** ANSWER K · 4

A **homologous series** is a series of organic compounds with the same functional group, in which each member differs from the next by a $-CH_2-$ group.
Characteristics, with the alcohols:

1. All have the same functional group (–OH) and similar chemical properties: methanol, ethanol and propanol all react with sodium to give hydrogen.
2. All fit one general formula: $C_nH_{2n+1}OH$.
3. Neighbors differ by $CH_2$ and by 14 in molecular mass: $CH_3OH$ (32), $C_2H_5OH$ (46), $C_3H_7OH$ (60).
4. Physical properties change gradually: the boiling point rises from 65 °C (methanol) to 78 °C (ethanol) and 97 °C (propan-1-ol).

They can also be made by similar methods.

MARKING SCHEME

- ✓ A series of compounds with the same functional group, each differing from the next by a $-CH_2-$ group.
- ✓ Same functional group (–OH) and similar chemical properties.
- ✓ One general formula ($C_nH_{2n+1}OH$), or neighbors differ by $CH_2$ and 14 in mass (32, 46, 60).
- ✓ Physical properties change gradually: boiling points 65, 78, 97 °C.


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## 7 Names and formulas

**a.** MARKING SCHEME — A · 1

✓ 2-methylpentane.

**b.** MARKING SCHEME — A · 1

✓ But-1-yne.

**c.** MARKING SCHEME — A · 2

✓ $CH_2$=CH–CH($CH_3$)–$CH_3$.

✓ $CH_3$–C($CH_3$)$_2$–$CH_2$–$CH_3$.

**d.** ANSWER — A · 4

a. Numbered from the wrong end: the methyl should get the lower number. **2-methylbutane.**

b. The ethyl group makes a longer chain: $CH_3$–CH($CH_2CH_3$)–$CH_3$ has a chain of 4, with a methyl on carbon 2. **2-methylbutane.**

c. Numbered from the wrong end: the double bond is at carbon 1 from the other end. **But-1-ene.**

d. A methyl on an end carbon just makes the chain longer: $CH_3$–$CH_2$–$CH_2$–$CH_3$ is **butane.**

MARKING SCHEME

✓ a. Numbered from the wrong end: 2-methylbutane.

✓ b. The ethyl group makes the chain longer: 2-methylbutane.

✓ c. Numbered from the wrong end: but-1-ene.

✓ d. A methyl on an end carbon only lengthens the chain: butane.

## 8 Numerical problems

**a.** ANSWER — A · 2

14n + 2 = 58, so 14n = 56 and n = 4: **$C_4H_{10}$**. It could be **butane**, $CH_3CH_2CH_2CH_3$, or **2-methylpropane**, $CH_3CH(CH_3)CH_3$.

MARKING SCHEME

✓ 14n + 2 = 58, so n = 4: $C_4H_{10}$.

✓ $CH_3CH_2CH_2CH_3$ and $CH_3CH(CH_3)CH_3$.

**b.** ANSWER — A · 2

2n + 2 = 22, so n = 10: $C_{10}H_{22}$, **decane**, mass 120 + 22 = **142**.

MARKING SCHEME

✓ 2n + 2 = 22, so n = 10.

✓ Decane, mass 120 + 22 = 142.

**c.** ANSWER — A · 3

From the first to the fifth member there are 4 steps of $CH_2$: 46 + 4 × 14 = **102**. Two series start at 46: the carboxylic acids, whose first member, methanoic acid, HCOOH, is 2 + 12 + 32 = 46 (the fifth is pentanoic acid, $C_4H_9COOH$, 102), and the ethers, whose first member, methoxymethane, $CH_3OCH_3$ ($C_2H_6O$), is also 46 (the fifth is $C_6H_{14}O$, 102). (Ethanol has a mass of 46 too, but it is the second alcohol, not the first.)

MARKING SCHEME

✓ 4 steps of $CH_2$: 4 × 14 = 56.

✓ 46 + 56 = 102.

✓ The carboxylic acids (methanoic acid, 46) or the ethers (methoxymethane, 46).



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## 9 Think

**ANSWER** HA · 3

No. The double bond outranks a branch: the chain must be numbered so that the **double bond** gets the lowest number, and only then are the branches numbered. From the left, the double bond starts at carbon 1, and the methyl is then on carbon 4: **4-methylpent-1-ene.** The student's numbering gives the double bond the number 4, which is not the lowest possible.

**MARKING SCHEME**

- ✓ No.
- ✓ The double bond must get the lowest number before any branch.
- ✓ 4-methylpent-1-ene.

## 10 Activity: In water and in kerosene

(not marked)

**WHAT STUDENTS SHOULD FIND**

Salt, copper sulphate and washing soda (inorganic, ionic) dissolve in water, and the copper sulphate turns it blue; they don't dissolve in kerosene. Wax, naphthalene and oil (organic) stay undissolved in water and dissolve in kerosene. "Like dissolves like": water's polar molecules pull ions apart, while the molecules of wax, naphthalene and oil aren't polar and mix only with liquids like themselves.

| Marks by level | Knowledge | Understanding | Application | Higher ability | Total |
|---|---|---|---|---|---|
| **Marks** | 14 | 14 | 18 | 3 | **49** |



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