Unit 9 · Organic Compounds

HARDER PRACTICE QUESTIONS · ANSWER KEY

Full marks 45

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

1 Spot the errors

ANSWER U · 3

1. "1-methylpentane" is hexane: a methyl on carbon 1 only lengthens the chain.
2. "4-methylpentane" is 2-methylpentane, counted from the other end.
   So C_6H_{14} has **5** isomers: hexane, 2-methylpentane, 3-methylpentane, 2,2-dimethylbutane and 2,3-dimethylbutane.

MARKING SCHEME

✓ 1-methylpentane is hexane.
✓ 4-methylpentane is 2-methylpentane.
✓ 5 isomers in all.

2 Two bottles

ANSWER A · 4

i. $14n = 42$, so $n = 3$: $\mathbf{C_3H_6}$.
ii. **A is propene**, which has a C=C. **B is cyclopropane**, a ring with no double bond.
iii. $CH_2{=}CHCH_3 + Br_2 \rightarrow CH_2BrCHBrCH_3$, **1,2-dibromopropane**.
iv. **Functional** isomerism: an alkene and a cycloalkane.

MARKING SCHEME

✓ C_3H_6.
✓ A is propene, B cyclopropane.
✓ The equation, with 1,2-dibromopropane.
✓ Functional isomers.

3 Aromatic, antiaromatic or neither?

ANSWER A · 4

i. $2 + 0 = \mathbf{2}$ π electrons. $4n + 2 = 2$ gives $n = 0$: **aromatic**.
ii. $4 + 0 = \mathbf{4}$ π electrons, a 4n number ($n = 1$): **antiaromatic**.
iii. The CH_2 has four single bonds and breaks the ring of π electrons: **non-aromatic**, even though its 6 π electrons would fit the count.
iv. $4 + 2 = \mathbf{6}$ π electrons, $n = 1$: **aromatic**.

MARKING SCHEME

✓ $C_3H_3^+$: 2, $n = 0$, aromatic.
✓ $C_5H_5^+$: 4, antiaromatic.
✓ C_7H_8: the CH_2 breaks the ring, non-aromatic.
✓ Furan: 6, $n = 1$, aromatic.

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4 Read the boiling points

ANSWER A · 4

i. **Butane and 2-methylpropane**: they boil below 5 °C. (2,2-dimethylpropane, at 9.5 °C, is still a liquid.)
ii. **2-methylpropane**, which boils at −12 °C. Butane, at −0.5 °C, is now a liquid.
iii. Even the most branched C_5, at **9.5 °C**, boils higher than the unbranched C_4, at −0.5 °C.
iv. A more branched molecule is more nearly round, so it has less surface to touch its neighbors, holds them more weakly and boils lower.

MARKING SCHEME

✓ Butane and 2-methylpropane.
✓ 2-methylpropane.
✓ The most branched C_5 (9.5 °C) is still above the unbranched C_4 (−0.5 °C).
✓ More branched, less surface in contact, weaker attraction.

5 Which structure fits the evidence?

ANSWER HA · 4

i. Prashant predicts three bonds of 154 pm and three of 134 pm. The result supports **Shruti**.
ii. Prashant predicts the color goes at once, as with an alkene. The result supports **Shruti**.
iii. Prashant predicts $3 \times 120 = 360$ kJ. The measured value is about 150 kJ less, so the ring is that much more stable: **Shruti**.
iv. Prashant predicts a lopsided hexagon. A regular one supports **Shruti**.

MARKING SCHEME

✓ Three long and three short bonds predicted.
✓ The color predicted to go at once.
✓ 360 kJ predicted; about 150 kJ more stable than that.
✓ A lopsided hexagon predicted; a regular one found.

6 Plan a route

ANSWER A · 4

i. $CH_3CH_2OH \rightarrow CH_2{=}CH_2 + H_2O$ (conc. H_2SO_4, 170 °C): **elimination**. $CH_2{=}CH_2 + H_2 \rightarrow CH_3CH_3$ (Ni, heat): **addition**.
ii. $CH_3CH_2Br + KOH$ (alc) $\rightarrow CH_2{=}CH_2 + KBr + H_2O$ (heat): **elimination**. $CH_2{=}CH_2 + Br_2 \rightarrow CH_2BrCH_2Br$ (room temperature): **addition**.

MARKING SCHEME

✓ Ethanol to ethene, elimination, with conditions.
✓ Ethene to ethane, addition, with nickel.
✓ Bromoethane to ethene with alcoholic KOH, elimination.
✓ Ethene to 1,2-dibromoethane, addition.

7 Work backward

ANSWER HA · 3

i. $1.6 \div 160 = 0.01$ mol of Br_2, so 0.01 mol of alkene: $0.7 \div 0.01 =$ **70 g/mol**.
ii. $14n = 70$, so $n = 5$: $\mathbf{C_5H_{10}}$.
iii. **Pent-1-ene** and **pent-2-ene**.

MARKING SCHEME

✓ 70 g/mol.
✓ C_5H_{10}.
✓ Pent-1-ene and pent-2-ene.

8 Alkene or alkyne?

ANSWER

$n(Br_2) = 16 \div 160 = 0.1$ mol.
If an alkene: 0.1 mol of it, so $M = 1.3 \div 0.1 = 13$ g/mol. The smallest alkene, ethene, is 28, so this is

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impossible. HA · 3

If an alkyne: 0.05 mol of it, so M = 1.3 ÷ 0.05 = 26 g/mol. 14n − 2 = 26 gives n = 2: **ethyne**, C_2H_2. Richa is right.

MARKING SCHEME

- ✓ 0.1 mol of Br_2.
- ✓ An alkene would have M = 13, impossible.
- ✓ An alkyne has M = 26: ethyne.

9 All the way to the end

ANSWER A · 4

i. $\mathbf{CH_4 + 4Cl_2 \rightarrow CCl_4 + 4HCl.}$

ii. 8 ÷ 16 = 0.5 mol of CH_4 needs 2 mol of Cl_2: 2 × 71 = **142 g**.

iii. CCl_4 = 154 g/mol: 0.5 × 154 = **77 g**. HCl = 36.5 g/mol: 2 × 36.5 = **73 g**.

iv. 8 + 142 = 150 g, and 77 + 73 = 150 g.

MARKING SCHEME

- ✓ $CH_4 + 4Cl_2 \rightarrow CCl_4 + 4HCl$.
- ✓ 142 g of chlorine.
- ✓ 77 g of CCl_4 and 73 g of HCl.
- ✓ 150 g on each side.

10 Count every bond

MARKING SCHEME U · 3

- ✓ 12 σ, 3 π.
- ✓ 16 σ, 1 π.
- ✓ 9 σ, 2 π.

11 Correct the misconceptions

ANSWER U · 3

1. Aromatic means a flat, specially stable ring of delocalized π electrons. Many aromatic compounds have no smell, and plenty of compounds with a smell are not aromatic.
2. "Straight" means unbranched. The bonds at each carbon are 109.5° apart, so a real chain zigzags.
3. The solvent decides: aqueous KOH gives ethanol (substitution), and alcoholic KOH gives ethene (elimination).

MARKING SCHEME

- ✓ Aromatic means the stable ring, not the smell.
- ✓ A straight chain is unbranched and zigzags.
- ✓ Aqueous gives ethanol, alcoholic gives ethene.

12 Think

ANSWER HA · 4

Five. Alkenes: but-1-ene, but-2-ene and 2-methylpropene. Cycloalkanes: cyclobutane and methylcyclopropane.

With but-1-ene: 2-methylpropene is a **chain** isomer, but-2-ene a **position** isomer, and the two cycloalkanes **functional** isomers.

MARKING SCHEME

- ✓ The three alkenes.
- ✓ The two cycloalkanes.
- ✓ But-2-ene position; 2-methylpropene chain.
- ✓ The cycloalkanes functional.

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13 Make your own

HA · 2

ANSWER

For example: "$CH_3CH_2CH_2OH \rightarrow ? \rightarrow CH_3CH_2CH_3$." Propan-1-ol loses water to give propene (conc. H_2SO_4, heat), which adds hydrogen (Ni, heat) to give propane.

MARKING SCHEME

- ✓ A correct elimination and addition, with conditions.
- ✓ The correct missing compound.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	0	9	20	16	**45**

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