Unit 9 · Organic Compounds

HARDER PRACTICE QUESTIONS · ANSWER KEY

Full marks 41

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

1 Spot the error

ANSWER U · 4

a. Numbered from the wrong end: the branch must get the lower number. **2-methylpentane.**

b. She missed the longest chain. Going through the ethyl group gives 5 carbons with a methyl on the middle one: **3-methylpentane.**

c. The –CHO carbon is always carbon 1, so the name needs no number: **propanal.**

d. A C=O on the end carbon is an aldehyde, not a ketone: **butanal.**

MARKING SCHEME

✓ a. Wrong end: 2-methylpentane.

✓ b. Not the longest chain: 3-methylpentane.

✓ c. No number is needed: propanal.

✓ d. It is an aldehyde: butanal.

2 Hunt them all

ANSWER A · 4

There are **seven**.

Alcohols: butan-1-ol, $CH_3CH_2CH_2CH_2OH$; butan-2-ol, $CH_3CH_2CH(OH)CH_3$; 2-methylpropan-1-ol, $CH_3CH(CH_3)CH_2OH$; 2-methylpropan-2-ol, $CH_3C(CH_3)(OH)CH_3$.

Ethers: 1-methoxypropane, $CH_3OCH_2CH_2CH_3$; 2-methoxypropane, $CH_3OCH(CH_3)CH_3$; ethoxyethane, $CH_3CH_2OCH_2CH_3$.

MARKING SCHEME

✓ The two straight-chain alcohols: butan-1-ol and butan-2-ol.

✓ The two branched alcohols: 2-methylpropan-1-ol and 2-methylpropan-2-ol.

✓ The three ethers: 1-methoxypropane, 2-methoxypropane and ethoxyethane.

✓ Seven in all, so Lochan is wrong.

3 Check the claim

ANSWER A · 4

a. The rises are 73, 47, 41.5 and 36.5 °C. They fall at every step, so the first rise can't be used for the next one. The boiling point climbs by less each time.

b. The last rises fell by 5.5 and 5 °C, so the next rise should be about 32 °C: hexane should boil at about 36 + 32 = **68 °C**, far below 109 °C. (Anything from about 65 to 72 °C, with this reason, is fine.)

MARKING SCHEME

✓ The rises: 73, 47, 41.5, 36.5 °C.

✓ They get smaller, so her claim is wrong: the same CH_2 doesn't add the same amount.

✓ The next rise is smaller than 36.5 °C, about 32 °C.

✓ Hexane about 68 °C (65 to 72 °C accepted).

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4 Which explanation fits the evidence?

ANSWER U · 3

Srijana's. Ethanol and methoxymethane have the same mass, yet ethanol boils 103 °C higher, and only ethanol has an –OH. Methanol (32) is lighter than butane (58), yet boils far higher, and only methanol has an –OH. If mass alone decided, the lighter one could never boil higher.

MARKING SCHEME

- ✓ Srijana's explanation.
- ✓ Ethanol and methoxymethane: same mass, but only ethanol has –OH, and it boils 103 °C higher.
- ✓ Methanol boils higher than the heavier butane, and only methanol has –OH.

5 Work backwards

ANSWER A · 4

X is a carboxylic acid: $14n + 32 = 74$, so $n = 3$: $C_3H_6O_2$, CH_3CH_2COOH, **propanoic acid**.
Y is an alcohol: $14n + 18 = 74$, so $n = 4$: C_4H_9OH. With an unbranched chain and the –OH on carbon 2: $CH_3CH(OH)CH_2CH_3$, **butan-2-ol**.
Z is an ether, with the same general formula: $C_4H_{10}O$. Two identical alkyl groups with 4 carbons between them are two ethyl groups: $CH_3CH_2OCH_2CH_3$, **ethoxyethane**.

MARKING SCHEME

- ✓ The families: acid, alcohol, ether.
- ✓ X: $14n + 32 = 74$, $n = 3$: propanoic acid.
- ✓ Y: $14n + 18 = 74$, $n = 4$: butan-2-ol.
- ✓ Z: $C_4H_{10}O$ with two ethyl groups: ethoxyethane.

6 What if?

ANSWER A · 4

a. Second bond: $614 - 347 =$ **267 kJ/mol**. Third bond: $839 - 614 =$ **225 kJ/mol**. Each extra bond is weaker than the one before.
b. $2 \times 347 =$ **694 kJ/mol**.
c. No. Alkenes react readily because their extra bond is weaker than a single bond and opens easily, letting other atoms add on. If it were as strong as the first, it would open less easily, and alkenes would be less ready to react.

MARKING SCHEME

- ✓ 267 kJ/mol.
- ✓ 225 kJ/mol.
- ✓ 694 kJ/mol.
- ✓ Less ready to react: the extra bond would no longer open so easily.

7 Estimate

ANSWER A · 4

a. 20,000 carbons make 10,000 units of C_2H_4, each $24 + 4 = 28$: $10{,}000 \times 28 =$ **280,000**.
b. $20{,}000 \times 154$ pm $\approx 3.1 \times 10^6$ pm $= 3.1 \times 10^6 \times 10^{-12}$ m $\approx$ **3×10^{-6} m**.
c. 1 mm $= 10^{-3}$ m, and $10^{-3} \div (3 \times 10^{-6}) \approx$ **300** chains (about 325 with 3.08×10^{-6} m).

MARKING SCHEME

- ✓ 10,000 units × 28 = 280,000.
- ✓ $20{,}000 \times 154$ pm $\approx 3.1 \times 10^6$ pm.
- ✓ About 3×10^{-6} m.
- ✓ About 300 chains.

8 Design a fair test

ANSWER

Change: the liquid. **Measure:** the time until a drop has gone. **Keep the same:** the size of the drop (the same dropper, the same number of drops), the surface (the same glass plate), the room, and no fan or sun on one and not another. Repeat each a few times and take the average.

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Support: propanone gone first, then ethanol, then water. HA · 4
Safety: propanone and ethanol catch fire easily, so keep them away from any flame.

MARKING SCHEME

✓ Change the liquid; measure the time for a drop to go.
✓ Keep the same: drop size, surface, room and air; repeat.
✓ Her idea is supported if propanone goes first, then ethanol, then water.
✓ Keep them away from any flame.

9 Correct the misconceptions

ANSWER U · 3

a. Organic means a compound of carbon, nearly always with hydrogen, wherever it was made. Polythene and polypropene are organic, and Wöhler made urea in a flask.
b. Its –OH is joined to carbon by a covalent bond and doesn't break off in water: it is not the hydroxide ion, so ethanol isn't alkaline.
c. A family shares its chemical properties, not its effects on the body. The body turns methanol into methanal and methanoic acid, and even a small amount can cause blindness or death.

MARKING SCHEME

✓ a. Organic means carbon compounds, wherever they are made.
✓ b. The –OH is covalently bonded and doesn't leave as a hydroxide ion.
✓ c. The body turns methanol into poisons; a small amount can blind or kill.

10 Predict, then explain

ANSWER A · 3

a. **Ethanol.** All alcohols react with sodium to give hydrogen, through their –OH. Ethoxyethane has no –OH: its oxygen is between two carbons, with no hydrogen on it.
b. **Ethanoic acid.** Carboxylic acids react with carbonates and hydrogencarbonates to give carbon dioxide. Propanal is an aldehyde, not an acid.
c. **Yes.** A chain of six carbons closed into a ring uses up one more bond between carbons, so it holds two hydrogens fewer than hexane: cyclohexane, C_6H_{12}.

MARKING SCHEME

✓ a. Ethanol, because it has an –OH and the ether has none.
✓ b. Ethanoic acid, because only the acid gives carbon dioxide with baking soda.
✓ c. Yes: a ring, as in cyclohexane.

11 Prove the formula

ANSWER HA · 4

a. n carbons are joined by $\mathbf{n - 1}$ C–C bonds. Each uses one bond from each of its two carbons, so $\mathbf{2(n - 1)}$ of the carbons' bonds are used.
b. The carbons have 4n bonds in all. What is left goes to hydrogen: $4n - 2(n - 1) = 4n - 2n + 2 = \mathbf{2n + 2}$. A branch doesn't change the count, since n carbons still need $n - 1$ bonds to join them.
c. The double bond's second bond uses up two more of the carbons' bonds: $2n + 2 - 2 = \mathbf{2n}$.

MARKING SCHEME

✓ $n - 1$ C–C bonds, using $2(n - 1)$ of the carbons' bonds.
✓ $4n - 2(n - 1) = 2n + 2$.
✓ A branch changes nothing, since n carbons still need $n - 1$ bonds.
✓ The second bond of C=C uses two more: 2n.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	0	10	23	8	**41**

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