Unit 12 · Ethers

ANSWER KEY · FOR TEACHERS

Full marks 36

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

1 Key words

U · 3

i. ✓ **True**

ii. ✗ **False**: An ether has no O–H, so its molecules can't hydrogen-bond to each other; ethoxyethane (34.6 °C) boils about as pentane (36.1 °C) does.

iii. ✗ **False**: The alkoxide, a strong base, eliminates with a tertiary haloalkane: the product is 2-methylpropene.

iv. ✓ **True**

v. ✗ **False**: The ring–oxygen bond never breaks: anisole gives phenol and iodomethane.

vi. ✓ **True**

Each carries 0.5 mark.

2 Label the diagram

K · 2

1. conc. H2SO4
2. 413 K
3. H2O
4. ethoxyethane

Each carries 0.5 mark.

3 Multiple choice

i. **b.** 1-methoxypropane — K · 1

The larger group is the parent alkane, propane, and the smaller group with the oxygen is the alkoxy prefix: 1-methoxypropane. Methyl propyl ether is its common name.

ii. **b.** ethene — U · 1

At the higher temperature each ethanol molecule loses water by elimination, giving ethene.

iii. **b.** 2-iodo-2-methylpropane and methanol — A · 1

A tertiary group leaves as a stable carbocation (SN1), which takes up I^-: the tertiary group becomes the iodide, and the methyl stays on oxygen as methanol.

iv. **c.** peroxides — K · 1

Peroxides oxidize Fe^{2+} to Fe^{3+}, which gives a blood-red complex with thiocyanate. Such ether must not be distilled.

v. **b.** para position, because $-OCH_3$ pushes electrons into the ring — U · 1

The oxygen's lone pairs push electrons into the ring (+R), activating it and directing ortho and para; the para product is usually the major one.

4 Short answers

a. MARKING SCHEME — A · 2

✓ $C_2H_5Cl + CH_3ONa \xrightarrow{\Delta} C_2H_5OCH_3 + NaCl$ (or $CH_3I + C_2H_5ONa$).

✓ $C_6H_5ONa + CH_3I \rightarrow C_6H_5OCH_3 + NaI$

b. MARKING SCHEME — U · 2

✓ The ring's C–Cl bond is partly double, by resonance of chlorine's lone pair with the ring.

✓ So it can't be attacked from behind by SN2; the halogen must be on the alkyl group (phenoxide + CH_3I).

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c. MARKING SCHEME U · 2

- ✓ Ethers are among the least reactive organic compounds: bases, sodium, dilute acids and cold oxidizing agents don't break them.
- ✓ So the ether dissolves the reactants without taking part in the reaction.

d. MARKING SCHEME A · 2

- ✓ $C_2H_5OC_2H_5 + HI \xrightarrow{\Delta} C_2H_5OH + C_2H_5I$
- ✓ $C_2H_5OC_2H_5 + 2\,HI \xrightarrow{\Delta} 2\,C_2H_5I + H_2O$

e. MARKING SCHEME U · 3

- ✓ Air and light slowly form explosive peroxides, concentrated when old ether is distilled.
- ✓ Test: $FeSO_4$ + KSCN turns red.
- ✓ Prevention: dark closed bottles, used soon, iron or copper inside.

5 Long answer

ANSWER A · 4

A haloalkane heated with a sodium alkoxide gives an ether and a sodium halide: R–X + R′O$^-$Na$^+$ → R–O–R′ + NaX. The alkoxide attacks the carbon holding the halogen from the side opposite the halogen (SN2).

With a tertiary haloalkane, three alkyl groups block the back of that carbon, and the alkoxide, a strong base, takes a hydrogen from a neighboring carbon instead (E2), giving an alkene; heat favors this.

So put the tertiary group on the alkoxide and use a methyl halide:

$(CH_3)_3CONa + CH_3I \rightarrow (CH_3)_3COCH_3 + NaI$.

The other way round, 2-chloro-2-methylpropane and sodium methoxide, gives 2-methylpropene by elimination, not the ether.

MARKING SCHEME

- ✓ The reaction, with its general equation (SN2).
- ✓ A tertiary haloalkane: steric hindrance and a strong base give elimination.
- ✓ Sodium tert-butoxide with iodomethane (or another methyl halide), with the equation.
- ✓ The reverse pair gives 2-methylpropene.

6 Numerical problems

a. ANSWER A · 4

i. $(CH_3)_2CHONa + CH_3I \rightarrow (CH_3)_2CHOCH_3 + NaI$: **2-methoxypropane**.

ii. CH_3I = 142 g/mol: 7.10 ÷ 142 = 0.0500 mol. $C_4H_{10}O$ = 74 g/mol: **3.70 g** at 100%; 0.75 × 3.70 = **2.78 g** at 75%.

iii. **Iodomethane and propan-2-ol**: both groups are methyl or secondary, so I$^-$ attacks by SN2 at the less crowded carbon, the methyl.

MARKING SCHEME

- ✓ The balanced equation, 2-methoxypropane.
- ✓ 3.70 g.
- ✓ 2.78 g.
- ✓ Iodomethane and propan-2-ol, by SN2 at the methyl carbon.

b. ANSWER A · 4

i. $2\,C_2H_5OH \xrightarrow[413\ K]{\text{conc. } H_2SO_4} C_2H_5OC_2H_5 + H_2O$

ii. Ethanol 46 g/mol: 46.0 ÷ 46 = 1.00 mol, giving 0.500 mol of ether × 74 g/mol = **37.0 g**.

iii. 0.80 × 37.0 = **29.6 g**; 29.6 ÷ 0.71 = **41.7 cm^3**.

iv. 6 g × 50/100 = **about 3 g** stays dissolved in the water.

MARKING SCHEME

- ✓ The balanced equation.
- ✓ 37.0 g.
- ✓ 29.6 g and 41.7 cm^3.
- ✓ About 3 g lost.

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7 Think

ANSWER HA · 3

Dehydration joins any two alcohol molecules, so a mixture of two alcohols gives three ethers at once: ethoxyethane (two ethanols), 1-propoxypropane (two propanols) and 1-ethoxypropane (one of each), hard to separate. Dehydration is good for symmetrical ethers only. Methoxypropane is unsymmetrical, so it is made by Williamson's synthesis: sodium propoxide with iodomethane, $CH_3CH_2CH_2ONa + CH_3I \rightarrow CH_3CH_2CH_2OCH_3 + NaI$.

MARKING SCHEME

- ✓ Two alcohols give a mixture of three ethers (named).
- ✓ Dehydration suits symmetrical ethers only.
- ✓ Williamson's synthesis: sodium propoxide + iodomethane, with the equation.

8 Activity: Two layers

(not marked)

WHAT STUDENTS SHOULD FIND

The oil, less dense than water, floats as the top layer; a water-soluble food coloring stays in the water. Ether too is less dense and only slightly soluble in water, so it floats. A chemist shakes the water solution with ether in a separating funnel: the organic compound, more soluble in ether, moves into the upper ether layer; the water is run out through the stopcock, and the ether is evaporated (away from any flame) to leave the compound.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	4	12	17	3	**36**

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