

Reactions of Organic Compounds

Answer key with worked solutions

A. Understanding

1. Reaction types.

(a) **Addition:** two molecules form one, e.g. ethene + Br₂ → 1,2-dibromoethane. (b) **Substitution:** an atom or group is replaced, e.g. CH₄ + Cl₂ → CH₃Cl + HCl. (c) **Elimination:** a small molecule is removed and C=C forms, e.g. ethanol → ethene + H₂O. (d) **Oxidation:** gain of O or loss of H, e.g. ethanol → ethanal. (e) **Condensation:** two molecules join and release water, e.g. acid + alcohol → ester + water.

B. Reaction types and products

2. Classification.

(a) **addition** (b) **substitution** (c) **elimination** (d) **oxidation** (e) **condensation** (f) **substitution**

3. Products.

(a) **butane** (b) **2,3-dibromobutane**, CH₃CHBrCHBrCH₃ (c) **ethanol** (d) **propanoic acid** (reflux takes the oxidation all the way) (e) **butanone** (secondary alcohol → ketone)

C. Tests and selectivity

4. Tests.

(a) Shake with **bromine water**: hex-1-ene turns it from **orange-brown to colourless**; hexane leaves it orange. (b) Warm with **acidified potassium dichromate**: propan-1-ol (primary) turns it from **orange to green**; 2-methylpropan-2-ol (tertiary) leaves it **orange**.

5. Aldehyde or acid.

To get **propanal**, use a limited amount of oxidizing agent and **distil** the aldehyde off as it forms (it boils lower than the alcohol), so it is not oxidized further. To get **propanoic acid**, use excess oxidizing agent and **heat under reflux**, so the aldehyde stays in the flask and is oxidized to the acid.

6. Propene + HBr.

(a) **1-bromopropane** and **2-bromopropane**. (b) **2-bromopropane** is the major product (Markovnikov's rule): the H adds to the end carbon, which already has more hydrogens, and Br adds to the middle carbon.

D. Calculations

7. Ethanol from ethene.

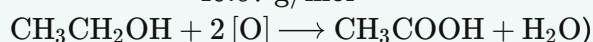
$$n(\text{C}_2\text{H}_4) = \frac{1.40 \times 10^4 \text{ g}}{28.05 \text{ g/mol}} = 499.1 \text{ mol}; 1 : 1 \text{ ratio, so } n(\text{ethanol}) = 499.1 \text{ mol}$$

$$\text{Theoretical yield} = 499.1 \text{ mol} \times 46.07 \text{ g/mol} = 2.299 \times 10^4 \text{ g} = \mathbf{23.0 \text{ kg}}$$

$$\text{Percent yield} = \frac{21.2 \text{ kg}}{22.99 \text{ kg}} \times 100 \% = \mathbf{92.2 \%}$$

8. Ethanoic acid.

$$n(\text{ethanol}) = \frac{9.21 \text{ g}}{46.07 \text{ g/mol}} = 0.1999 \text{ mol}; 1 : 1 \text{ ratio (}$$



$$m = 0.1999 \text{ mol} \times 60.05 \text{ g/mol} = \mathbf{12.0 \text{ g}}$$

E. Challenge

9. Synthesis of ethyl ethanoate.

1. Ethene + steam, acid catalyst → **ethanol** (**addition**, hydration). 2. Oxidize part of the ethanol with **excess acidified potassium dichromate, heated under reflux** → **ethanoic acid** (**oxidation**). 3. Warm ethanoic acid with the rest of the ethanol and a few drops of **concentrated sulfuric acid** → **ethyl ethanoate** + water (**condensation**, esterification).