7.2 Alkenes, alcohols and carboxylic acids

Name: _____ Class: _____ Date: _____ **Total: 35 marks**

KEY WORDS functional group • fermentation • carboxylic acid

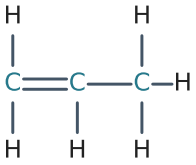
Objective

Describe alkenes, alcohols and carboxylic acids by functional group. Chemistry only. Original questions for spec statements 4.7.2.1–4.7.2.4.

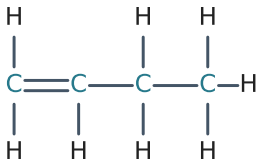
1 Key knowledge and worked examples

Ethene · C_2H_4

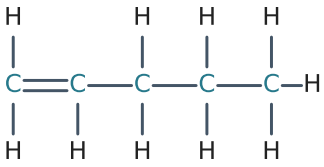
Propene · C_3H_6



Butene · C_4H_8



Pentene · C_5H_{10}



Alkenes C_nH_{2n} – the **C=C** double bond makes them **unsaturated**: ethene, propene, butene, pentene. React by addition: + H_2 (Ni catalyst) → alkane; + H_2O (steam, phosphoric acid) → alcohol; + Br_2 → dibromo compound (bromine water test). Tend to burn in air with **smoky flames** (incomplete combustion); sufficient oxygen gives complete combustion.

Alcohols –OH – methanol, ethanol, propanol, butanol. With **sodium** → hydrogen; **burn** cleanly (fuels); **mix** with water, with limited solubility for longer members; the taught primary forms are **oxidised** → carboxylic acid. **Fermentation**: sugar + **yeast**, warm and **oxygen-free**, gives ethanol solution.

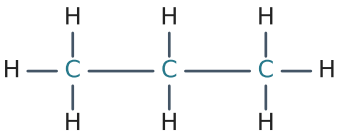
Carboxylic acids –COOH – methanoic, ethanoic, propanoic, butanoic. With **carbonates** → CO_2 fizz; dissolve in water – **weak** acids (HT: partially ionised → higher

pH than strong acids); with **alcohols → esters** (ethyl ethanoate) + water.

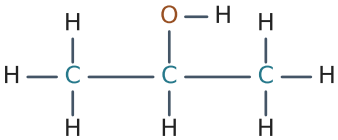
Worked example (3 marks). Describe a test to distinguish ethene from ethane.

Add bromine water to each sample; ethene decolourises the orange bromine water; ethane leaves it orange – no double bond to add across.

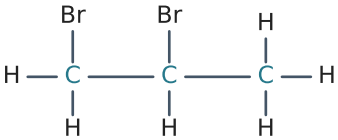
Propene + H_2 → propane · heated nickel



Propene + steam → shown OH-position product · acid catalyst



Propene + Br_2 → dibromo product · no H removed



Worked ethanol combustion. Two C atoms require two CO_2, and six H atoms require three H_2O. The products need seven oxygen atoms; ethanol already supplies one, leaving six from three O_2:

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

2 Practice

2.1 Give the general formula of the alkenes. [1]

2.2 Name the alcohol made by fermenting sugar solution. [1]

2.3 *(HT)* Why is ethanoic acid a weak acid? [2]

3 Exam-style questions

3.1 For hydrogen addition, hydration and bromine addition to ethene, name the other reactant and the product for each reaction. [6]

3.2 Describe the conditions for fermentation and the process by which ethanol solution forms. [4]

3.3 Ethanoic acid reacts with ethanol. Name the products and the type of reaction, and write the functional groups present in the reactants. [4]

3.4 Draw a fully displayed propene molecule and its bromine-addition product. State the bromine-water colour change. Explain why $CH_2Br–CHBr–CH_3$ is addition rather than replacement of hydrogen. [5]

3.5 State what happens when the taught primary ethanol reacts with sodium and with an oxidising agent. Write the balanced equation for ethanol's complete combustion. [5]

3.6 Two warm sugar solutions have equal volumes and sugar concentrations. A contains yeast; B contains no yeast. Both use approved airlocks. A produces much more gas. Explain the purpose of B, why the vessel needs an escaping-gas path, and why gas volume alone does not establish the purity of the ethanol solution. [4]

3.7 *(HT)* Equal-concentration solutions of a strong monoprotic acid and ethanoic acid have different pH values. Which has the lower pH? Explain using ionisation, and state why the word "weak" does not mean "dilute". [3]

Solutions

2.1 C_nH_{2n}.

2.2 Ethanol.

2.3 It is only partially ionised in water; so few H^+ ions form relative to a strong acid of equal concentration.

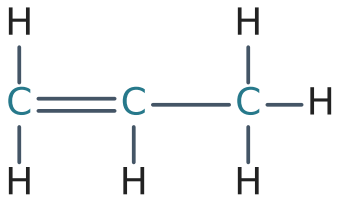
3.1 + hydrogen (nickel catalyst) → ethane; + water/steam (phosphoric acid catalyst) → ethanol; + bromine → dibromoethane, decolourising bromine water.

3.2 Mix sugar solution with yeast; keep warm – around body temperature; exclude oxygen – anaerobic conditions; the yeast's enzymes convert the sugar to ethanol and carbon dioxide, giving a dilute ethanol solution.

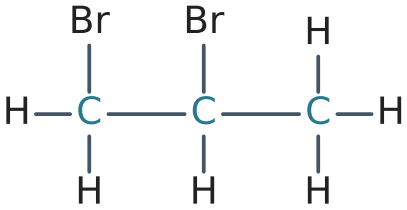
3.3 Ester – ethyl ethanoate + water; condensation/esterification reaction; ethanol carries –OH and ethanoic acid carries –COOH.

3.4

Propene: starting molecule



Bromine-addition product: all hydrogens retained



Correct displayed starting structure, C=C becomes C–C, one Br on each former C=C carbon with all H retained and valid carbon valencies. Orange → colourless. Two Br atoms have been added without removing hydrogen atoms.

3.5 Sodium gives fizzing/hydrogen; oxidation of the taught primary ethanol gives ethanoic acid.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

Correct products, C/H balanced, O balanced including ethanol's oxygen. The shown hydration product from propene is not primary ethanol and must not be assigned this oxidation rule blindly.

3.6 B is a yeast-free control to compare gas formation without yeast. Carbon dioxide must escape to prevent pressure build-up in a tightly sealed vessel. Gas measurement

does not measure the proportions of ethanol and water or establish ethanol purity. Other conditions must remain matched.

3.7 The strong acid has lower pH at the same stated concentration, because it ionises more completely and gives more H^+; ethanoic acid is partially ionised. Weak describes ionisation, while dilute describes amount per volume.