

Making and reacting esters and acyl chlorides

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems cover naming, reactions of carboxylic acids, esterification equilibrium, ester hydrolysis, soap making and the chemistry of acyl chlorides. They suit A Level, IB Chemistry and Class 11-12 students.

Levels 1 and 2 build naming, equations and short calculations; level 3 asks for equilibrium algebra, graph reading, back titration and mechanism checking. Show formulae and units throughout.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.3.9

Problem 1 Names of acids and esters (easy)

Kofi in Accra is naming organic compounds.

1. Name $\text{CH}_3\text{CH}_2\text{COOH}$.
2. Name $\text{CH}_3\text{CH}_2\text{COOCH}_3$.
3. Name HCOOC_2H_5 .

Problem 2 Acid reactions (easy)

Complete and balance the equations for ethanoic acid.

1. with magnesium
2. with sodium carbonate
3. with sodium hydroxide

Problem 3 Making methyl propanoate (easy)

Wanjiru in Nairobi makes an ester from propanoic acid and methanol.

1. Write the equation.
2. State the catalyst and the type of heating.
3. Give the molecular formula of the ester.

Problem 4 Hydrolysis products (easy)

Ethyl methanoate is hydrolysed.

1. Name the products with dilute sulfuric acid.
2. Name the products with aqueous sodium hydroxide.
3. State which hydrolysis is irreversible.

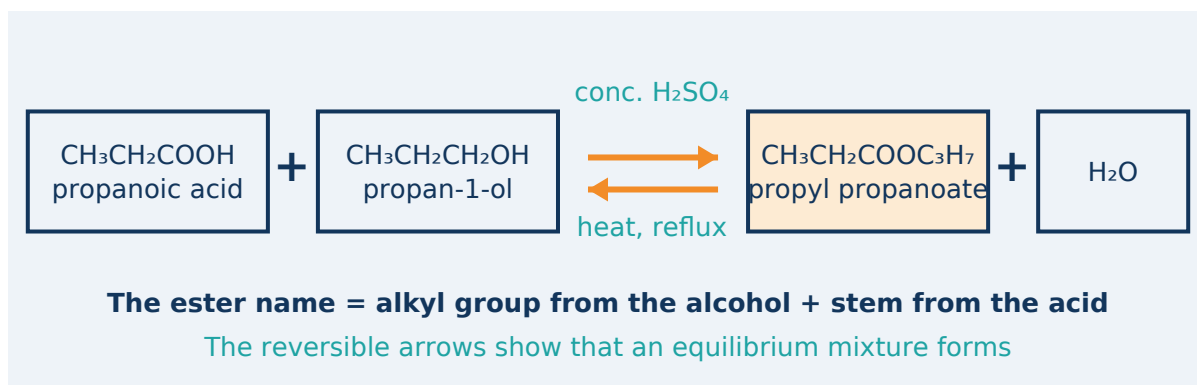
Problem 5 Making an acyl chloride (easy)

Propanoic acid reacts with thionyl chloride, SOCl_2 .

1. Write the balanced equation.
2. Name the organic product.
3. Explain why the by-products make purification easy.

Problem 6 Reading an esterification scheme (easy)

Aarav in Pune studies this scheme.



Esterification is a reversible reaction: reactants and products coexist at equilibrium.

1. Identify the ester linkage in the product.
2. State the part of the name that comes from the alcohol.
3. Give the molecular formula of the ester.

Problem 7 Carbon dioxide from vinegar (medium)

Emma in Leeds adds 6.0 g of ethanoic acid ($M = 60.0 \text{ g/mol}$) to excess sodium hydrogencarbonate.

1. Write the equation.
2. Calculate the amount of acid.
3. Calculate the volume of CO_2 at room temperature and pressure ($24.0 \text{ dm}^3/\text{mol}$).

Problem 8 Calculating K_c (medium)

0.500 mol of ethanoic acid and 0.500 mol of ethanol reach equilibrium, with 0.333 mol of ester present at the end.

1. State the amounts of acid and water at equilibrium.
2. Write the expression for K_c .
3. Calculate K_c .

Problem 9 Raising the yield (medium)

Mei in Singapore wants a better yield of ethyl ethanoate.

1. Suggest two ways to increase the yield.

2. Explain the effect of adding more catalyst.
3. State what happens to K_c if the temperature stays constant.

Problem 10 Making soap (medium)

Diego in Texas heats 8.90 g of glyceryl tristearate ($M = 890 \text{ g/mol}$) with excess sodium hydroxide: $(\text{C}_{17}\text{H}_{35}\text{COO})_3\text{C}_3\text{H}_5 + 3\text{NaOH} \rightarrow 3\text{C}_{17}\text{H}_{35}\text{COONa} + \text{C}_3\text{H}_5(\text{OH})_3$.

1. Calculate the amount of fat.
2. Calculate the mass of NaOH reacting ($M = 40.0 \text{ g/mol}$).
3. Calculate the maximum mass of sodium stearate ($M = 306 \text{ g/mol}$).

Problem 11 Banana flavour (medium)

Chiamaka in Lagos makes pentyl ethanoate ($M = 130 \text{ g/mol}$) from 6.0 g of ethanoic acid and excess pentan-1-ol. The yield is 70 %.

1. Write the equation.
2. Calculate the theoretical mass of ester.
3. Calculate the actual mass.

Problem 12 Why alkaline hydrolysis finishes (medium)

Compare the hydrolysis of an ester by dilute acid and by sodium hydroxide.

1. State which is reversible.
2. Explain why the other reaction goes to completion.
3. Name the organic product containing sodium when methyl ethanoate reacts with NaOH.

Problem 13 Acylation equations (medium)

Ethanoyl chloride reacts with different nucleophiles.

1. Write the equation with water.
2. Write the equation with ethanol.
3. Write the equation with excess ammonia.

Problem 14 Why acyl chlorides are reactive (medium)

Explain.

1. Why is the carbonyl carbon in ethanoyl chloride more positive than in ethanoic acid?
2. Why is chloride a good leaving group?
3. State one disadvantage of using acyl chlorides.

Problem 15 Atom economy of the acyl chloride route (medium)

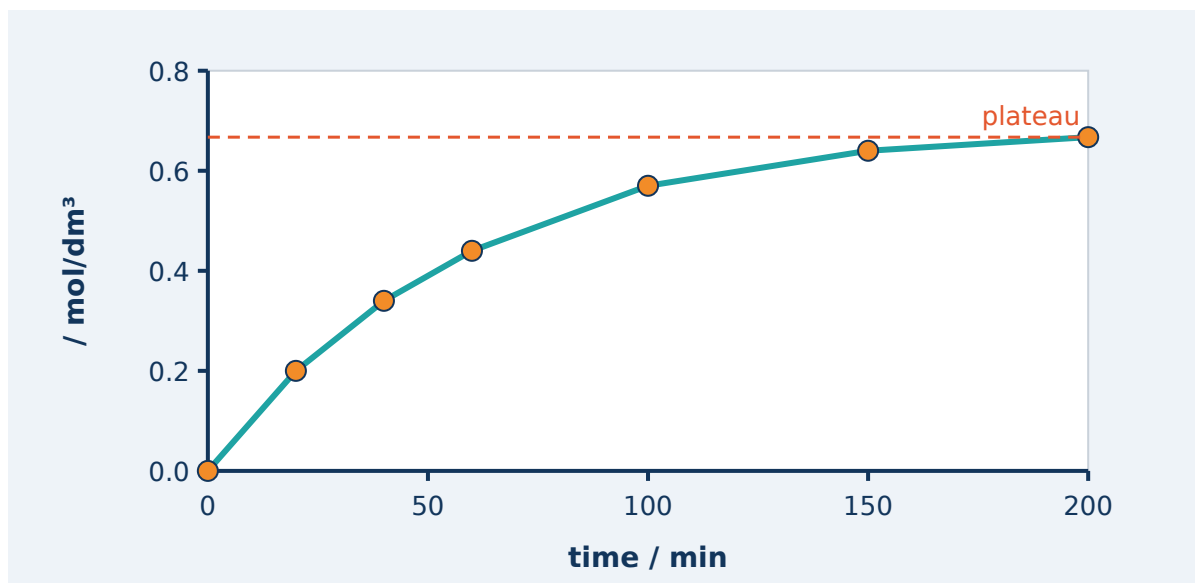
Propanoic acid ($M = 74.0$) reacts with SOCl_2 ($M = 119.0$) to give propanoyl chloride ($M = 92.5$).

1. Write the balanced equation.

2. Calculate the atom economy for making the acyl chloride.
3. Name the two other products.

Problem 16 Rise to equilibrium (hard)

Bilal in Lahore follows the formation of ethyl ethanoate from 1.00 mol/dm^3 acid and 1.00 mol/dm^3 alcohol.



Ester concentration against time for 1.00 mol/dm^3 acid and 1.00 mol/dm^3 alcohol.

1. Read the equilibrium concentration of ester.
2. Calculate K_c .
3. Estimate the average rate over the first 20 minutes.

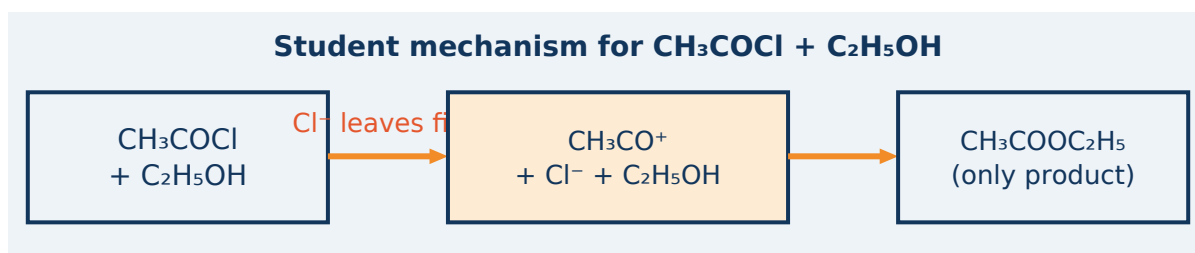
Problem 17 Excess alcohol (hard)

1.00 mol of ethanoic acid is mixed with 3.00 mol of ethanol ($K_c = 4.0$).

1. Write an expression for K_c in terms of x , the amount of ester at equilibrium.
2. Solve for x .
3. Calculate the percentage of the acid converted.

Problem 18 Find the errors (hard)

A student wrote this mechanism.



A student scheme for ethanoyl chloride and ethanol. It contains errors to find.

1. Identify the main error in the mechanism.
2. Describe the correct first step.
3. Explain why HCl, not Cl^- alone, is a product.

Problem 19 Back titration of an ester (hard)

Kofi in Accra warms 0.880 g of an ester with 50.0 cm³ of 0.400 mol/dm³ NaOH. The excess alkali needs 20.0 cm³ of 0.500 mol/dm³ HCl.

1. Calculate the amount of NaOH added.
2. Calculate the amount that reacted with the ester.
3. Calculate the molar mass of the ester (1 : 1 ratio) and deduce its formula.

Problem 20 Making aspirin (hard)

Salicylic acid ($\text{C}_7\text{H}_6\text{O}_3$, $M = 138.0$) is acylated with ethanoic anhydride ($\text{C}_4\text{H}_6\text{O}_3$, $M = 102.0$):
 $\text{C}_7\text{H}_6\text{O}_3 + \text{C}_4\text{H}_6\text{O}_3 \rightarrow \text{C}_9\text{H}_8\text{O}_4 + \text{C}_2\text{H}_4\text{O}_2$. Aspirin has $M = 180.0$.

1. Show that the equation is balanced.
2. Calculate the theoretical yield from 2.76 g of salicylic acid.
3. Calculate the percentage yield if 2.52 g is obtained, and the atom economy.