47th National Chemistry Olympiad

Utrecht University

PRACTICAL TEST

Marking Scheme

Tuesday 9th June 2026

SCHEIKUNDE OLYMPIADE

Universiteit Utrecht

58th International Chemistry Olympiad Uzbekistan 2026

Experiment 1 The synthesis of the ester 1-pentylpropanoate 40 points

Maximum score 10
The following practical skills are assessed:
- safety, neatness and independent working
- handling of glassware

Maximum score 5
Assessment of 1-pentylpropanoate yield:

The score for yield is determined by comparing the yield (calculated by the organization) with the yield of an experiment carried out by the organization.

Maximum score 5
Assessment of 1-pentylpropanoate purity:
The purity of the product is determined by using an NMR spectrum.
The score is determined by comparing the measured purity with a completely pure sample.
Optionally, an IR spectrum is also recorded.

▫1 Maximum score 3

- propanoyl chloride 2
- triethylammonium chloride 1

Note:
If the answer „propanoic acid, hydrogen chloride and triethylammonium chloride" is given, count this as correct.

▫2 Maximum score 1

Sulphuric acid reacts with the excess triethylamine (to triethylammonium chloride, which is thus removed from the reaction mixture)

▫3 Maximum score 1

Magnesium sulphate is a desiccant, and that ensures that the last bit of water is removed.

▫4 Maximum score 2

- number of mL stated 1
- correct accuracy 1

▫5 Maximum score 4

- calculation of the number of grams of alcohol and acid chloride 1
- calculation of the number of moles of alcohol and acid chloride 1
- determining the maximum number of moles of ester that can be formed 1
- calculation of the maximum number of grams of ester that can be formed 1

▫6 Maximum score 3

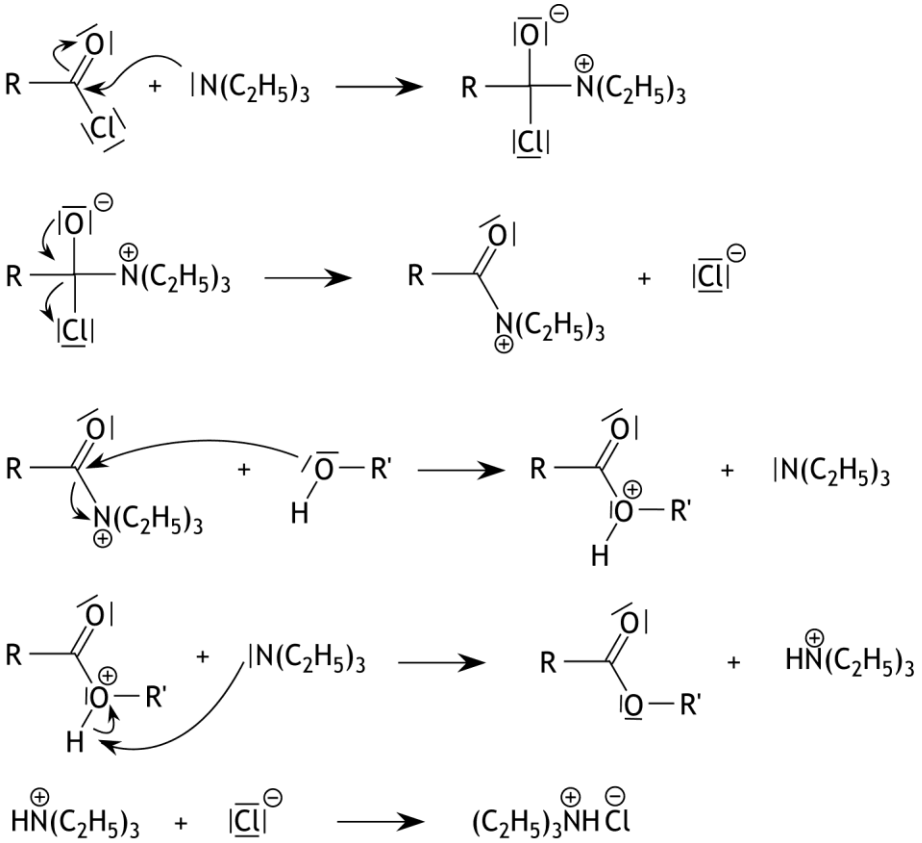
- masses noted 1
- correct units 1
- correct accuracy 1

▫7 Maximum score 2

· yield calculated in grams 1
· percentage yield calculated 1

▫8 Maximum score 4

An example of a correct answer is:



· a plausible mechanism drawn 1
· in each step all non-bonding electron pairs drawn 1
· in every step the charges in the correct place 1
· in every step all curly arrows drawn correctly 1

Note:
If the last step is not listed, do not penalize.

Experiment 2 The determination of the acetic acid content in vinegar using a titration curve. 40 points

Maximum score 10
The following practical skills are assessed:
- safety, neatness and independent working
- handling of the glassware

□9 Maximum score 0

correct molarity stated

□10 Maximum score 7

· total number of mL sodium hydroxide correctly recorded	1
· corresponding pH values	1
· the second titration performed more efficiently than the first	5

□11 Maximum score 5

· grid optimally used	1
· title vertical axis	1
· title horizontal axis	1
· points displayed correctly	1
· smooth line drawn	1

Note:
If one or more of the above sub-scores are not met in the titration curve for the first titration, do not penalize this.

□12 Maximum score 10

· equivalence point correctly determined	1
· calculation of the number of mmol sodium hydroxide and the number of mmol acetic acid in 5.00 mL vinegar	1
· calculation of the number of mg of acetic acid in 5.00 mL of vinegar	1
· calculation of the mass of 5.00 mL vinegar	1
· calculation of the mass percentage and conclusion	1
· result	5

□13 Maximum score 2

Examples of a correct answer are:
The use of a volumetric pipette is not necessary, because the 20 mL of water play no role in the calculation.

And

The use of a volumetric pipette is not necessary, because only the amount of acetic acid in the 5.00 mL of vinegar is important.

· correct explanation	1
· corresponding conclusion	1

▫14 Maximum score 6

An example of a correct answer is:
After adding 5.0 mL of sodium hydroxide, half the number of moles of acetic acid is converted to acetate. Then a buffer solution is formed in which [HAc] = [Ac $^-$], so

$$\mathrm{pH} = \mathrm{p}K_\mathrm{a} + \log\frac{[\mathrm{Ac}^-]}{[\mathrm{HAc}]} = 4.76\,.$$

At the equivalence point, a 0.050 M solution of sodium acetate was formed. In this

$K_\mathrm{b} = \dfrac{[\mathrm{HAc}][\mathrm{OH}^-]}{[\mathrm{Ac}^-]} = \dfrac{[\mathrm{OH}^-]^2}{0.050 - [\mathrm{OH}^-]} = 5.8 \cdot 10^{-10}$. This gives [OH $^-$] = $5.4 \cdot 10^{-6}$ mol L^{-1},
so pH = 14.00 − (−log$5.4 \cdot 10^{-6}$) = 8.73.

· after adding 5.0 mL of sodium hydroxide solution, [HAc] = [Ac$^-$] 1
· calculation of the pH of the solution after adding 5.0 mL sodium hydroxide 1
· at the equivalence point a 0.050 M solution of sodium acetate was formed 1
· notion that [HAc] = [OH$^-$] and [Ac$^-$] = 0.050 − [OH$^-$] 1
· calculation of the [OH$^-$] in the solution formed at the equivalence point 1
· calculation of the pH in the solution formed at the equivalence point 1

Note:
If [OH$^-$] is neglected compared to 0.050 in the calculation of the pH of the solution formed at the equivalence point, count this as correct.