

5.5.1 Choose carbon-building routes and purification methods

Name: _____ Class: _____ Date: _____ **Total: 18 marks**

KEY WORDS evidence • conditions

Objective

Choose carbon-building routes and purification methods. All questions and marking guidance are original.

1 Key knowledge and worked examples

Make RMgX from a halogenoalkane and Mg in dry ether. Carbonyl addition is followed by separate acidic work-up. Methanal gives a primary alcohol, another aldehyde a secondary alcohol, and a ketone a tertiary alcohol. CO₂ gives a carboxylic acid after work-up.

■ Worked method

Ethylmagnesium bromide plus ethanal then acid gives butan-2-ol. The two-carbon ethyl fragment bonds to the two-carbon aldehyde fragment. Water added early destroys the Grignard reagent, forming ethane. For aspirin, 1.38 g salicylic acid / 138 g mol⁻¹ = 0.0100 mol; theoretical aspirin = 0.0100 × 180 = 1.80 g. Purification losses reduce recovery; wet crystals can falsely raise yield.

2 Practice

2.1 State how ethylmagnesium bromide is made and why the solvent must be dry. [2]

2.2 Identify the product after propylmagnesium bromide reacts with CO₂ then acid. Count carbon atoms. [2]

2.3 Select the carbonyl reagent that gives propan-2-ol with methylmagnesium bromide then acid. [2]

3 Exam-style questions

3.1 Plan four organic conversions from bromoethane to butan-2-one using ethanol, ethanal and butan-2-ol as intermediates. Give conditions for every arrow. [4]

3.2 Salicylic acid, 2.76 g at M = 138 g mol⁻¹, is limiting in aspirin synthesis. Aspirin M = 180 g mol⁻¹, ratio 1:1, dry product 2.52 g. Find theoretical mass and percentage yield. Explain why wet product could mislead. [4]

3.3 An organic liquid contains acidic impurities and water. Explain carbonate washing and drying; identify one safety control in extraction and one reason the organic layer may be lower. [4]

Solutions

Original marking guidance: M1 method, A1 accuracy, B1 explanation.

2.1 Bromoethane with Mg in dry ether; water reacts with/destroys Grignard reagent.

2.2 Butanoic acid, four carbons: three from propyl plus one from CO₂.

2.3 Ethanal, CH₃CHO; its carbonyl carbon gains CH₃ and becomes bonded to two methyl groups and OH.

3.1 Bromoethane → ethanol: aqueous OH[−], heat. Ethanol → ethanal: controlled oxidation, distil. Ethanal → butan-2-ol: ethylmagnesium bromide/dry ether then acidic work-up. Butan-2-ol → butan-2-one: acidified dichromate oxidation. Grignard reagent is prepared separately.

3.2 Amount = $2.76/138 = 0.0200$ mol; theoretical mass = 3.60 g; yield = $2.52/3.60 \times 100 = 70.0\%$. Water adds mass that is not aspirin.

3.3 Carbonate removes acidic impurity by reaction; anhydrous drying agent removes remaining water. Vent separating funnel to release CO₂/pressure away from people. A dense organic solvent can form the lower layer.