Solutions

Each answer shows the steps, then the **result**.

2.1

- an alcohol and a carboxylic acid; concentrated sulfuric acid catalyst

2.2

- water

3.1 B

- Esterification is a condensation reaction

3.2 B

- Alkaline hydrolysis gives the carboxylate salt (plus the alcohol)

3.3

(a)

- $CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$

(b)

- ethanoic acid and ethanol

3.4

- with alkali the carboxylic acid is converted to its carboxylate salt, which does not react back, so the reaction goes to completion; with acid the products are the acid and alcohol, which can re-esterify, so it is reversible

3.5

(a)

- $CH_3COOH + CH_3CH_2OH \rightleftharpoons CH_3COOCH_2CH_3 + H_2O$; the sulfuric acid is a **catalyst** — it protonates the carbonyl and speeds both directions equally, and it also removes water, which shifts the position of equilibrium

(b)

- Use an excess of one reactant — by Le Chatelier the system shifts right to oppose the increase; remove the water (or distil off the ester) as it forms, so the system again shifts right to replace it

(c)

- $CH_3COOCH_2CH_3 + NaOH \rightarrow CH_3COO^-Na^+ + CH_3CH_2OH$; the products are **sodium ethanoate** and **ethanol**

(d)

- The alkali converts the carboxylic acid to its **anion**, which is not attacked by the alcohol; the reverse reaction is therefore impossible and the hydrolysis goes to completion, whereas acid hydrolysis leaves both products free to re-esterify