Solutions

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

2.1

- an ion with both a positive ($–NH_3^+$) and a negative ($–COO^-$) charge but no overall charge

2.2

- a peptide bond (an amide link)

2.3

- they exist as zwitterions, held together by strong ionic attractions between the charged groups

2.4

- the pH at which the amino acid exists as a zwitterion with no overall charge

3.1 A

- Below the isoelectric point, extra H^+ gives an overall positive charge

3.2 B

- A negative ion is attracted to the positive electrode

3.3

- at low pH the $–COO^-$ is protonated to –COOH, giving $H_3N^+CH_2COOH$, overall positive; at high pH the $–NH_3^+$ loses H^+ to give $H_2NCH_2COO^-$, overall negative; between them lies the zwitterion $H_3N^+CH_2COO^-$ at the isoelectric point

3.4

- the amino acid at its isoelectric point is a neutral zwitterion, so it does not move; the other amino acid is charged at that pH; so it migrates towards the oppositely charged electrode, separating the two

3.5

(a)

- $H_2NCH_2CONHCH(CH_3)COOH$ (Gly–Ala), or $H_2NCH(CH_3)CONHCH_2COOH$ (Ala–Gly)
- with the peptide link drawn as $-C(=O)-N(H)-$

(b)

- **two** (Gly–Ala and Ala–Gly)

3.6

- the peptide bond is broken, giving the two amino acids (as their protonated forms in acid)
- **hydrolysis**