

The  $pK_a$  values of tyrosine are  $pK_{a1} = 2.20$  ( $\alpha$ -COOH),  $pK_{a2} = 9.11$  ( $\alpha$ -NH<sub>3</sub><sup>⊕</sup>) and  $pK_{a3} = 10.07$  (-CH<sub>2</sub>C<sub>6</sub>H<sub>4</sub>OH). Draw the structure of the zwitterionic form of tyrosine.

**Marks**  
**4**

At what pH will this be the predominant species in aqueous solution?

The naturally occurring isomer of phenylalanine is (L)-phenylalanine. Draw the zwitterionic structure of (L)-phenylalanine and indicate the stereogenic centre with an asterisk (\*). Determine whether this amino acid has the (*R*) or (*S*) configuration. Show your working.

**THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.**