Question 29 **(15 marks)**

Wines and other alcoholic drinks can spoil when the alcohol (ethanol) they contain oxidises to acetic acid (ethanoic acid). An acidity regulator, monosodium citrate, is often added to drinks to prevent the formation of acetic acid. The monosodium citrate does this by acting as a buffer.

A citric acid/dihydrogen citrate ion buffer can be prepared from citric acid, $H_3C_6H_5O_7$ and monosodium citrate, $NaH_2C_6H_5O_7$.

(a) Write an equation for the buffer system ($H_3C_6H_5O_7$ / $H_2C_6H_5O_7^-$) containing citric acid, $H_3C_6H_5O_7$ and monosodium citrate, $NaH_2C_6H_5O_7$. (2 marks)

Buffers that contain equal concentrations of both components are most effective. This buffer solution is prepared by mixing 100.0 mL of citric acid solution with 100.0 mL of monosodium citrate solution. The citric acid solution, $H_3C_6H_5O_7(aq)$, has a concentration of 0.200 mol L^{-1}.

(b) Calculate the mass of sodium citrate, $NaH_2C_6H_5O_7$, that would need to be dissolved in 100.0 mL of distilled water to make the most effective buffer solution. (3 marks)

(c) If a citric acid buffer was prepared to a pH of 3.5, what would be the concentration of the hydroxide ion at 25.0 °C? (3 marks)

(d) Explain why only a small change in pH is observed in this buffer solution when a small amount of sodium hydroxide solution is added, compared to adding a similar amount of sodium hydroxide solution to a system that is not a buffer solution. Your answer should refer to the buffer equilibrium in part (a). (4 marks)

(e) Increasing the concentration of this buffer solution will increase its buffering capacity. Explain this statement. (3 marks)