Oxford Cambridge and RSA

A Level Chemistry A

H432/03 Unified chemistry

Question Set 10

1 A student carries out two experiments in the laboratory based on succinic acid (butanedioic acid), $(CH_2COOH)_2$.

(a) Aqueous succinic acid can be neutralised by aqueous sodium hydroxide, NaOH(aq):

$$(CH_2COOH)_2(aq) + 2NaOH(aq) \rightarrow (CH_2COONa)_2(aq) + 2H_2O(l)$$

This reaction can be used to determine a value for the enthalpy change of neutralisation, $\Delta_{neut}H$.

The student follows this method:

- Add 50.0 cm^3 of 0.400 mol dm^{-3} succinic acid to a polystyrene cup.
- Measure out 50.0 cm^3 of 1.00 mol dm^{-3} NaOH(aq), which is in excess.
- Measure the temperature of both solutions.
- Add the NaOH(aq) to the aqueous succinic acid in the polystyrene cup, stir the mixture, and record the maximum temperature.

Temperature readings

Maximum temperature of mixture/°C	26.5
Initial temperature of both solutions/°C	21.5

Calculate a value for the enthalpy change of neutralisation, $\Delta_{neut}H$, in kJ mol^{-1}.

Assume that the density of all solutions and the specific heat capacity, *c*, of the reaction mixture are the same as for water. **[4]**

(b) Succinic acid is esterified by ethanol, C_2H_5OH, in the presence of an acid catalyst to form an equilibrium mixture.

The equilibrium constant, K_c, for this equilibrium can be calculated using the amounts, in moles, of the components in the equilibrium mixture, using **expression 5.1**.

$$K_c = \frac{n((CH_2COOC_2H_5)_2) \times n(H_2O)^2}{n((CH_2COOH)_2) \times n(C_2H_5OH)^2}$$ **Expression 5.1**

A student carries out an experiment to determine the value of K_c for this equilibrium.

- The student mixes together 0.0500 mol of succinic acid and 0.150 mol of ethanol,with a small amount of an acid catalyst.
- The mixture is allowed to reach equilibrium.
- The student determines that 0.0200 mol of succinic acid are present in the equilibrium mixture.

(i) Which technique could be used to determine the equilibrium amount of succinic acid? **[1]**

(ii) Write the equation for the equilibrium reaction that takes place. **[1]**

(iii) Draw the skeletal formula of the ester present in the equilibrium mixture. **[1]**

(iv) K_c is the equilibrium constant in terms of equilibrium concentrations.

Why can **expression 5.1** be used to calculate K_c for this equilibrium? **[1]**

(v) Calculate the value of K_c for this reaction.

Show your working. **[3]**

Total Marks for Question Set 10: 11