Q1. In this question, give all values of pH to two decimal places.

Calculating the pH of aqueous solutions can involve the use of equilibrium constants such as K_w and K_a

K_w is the ionic product of water. The value of K_w is 5.48×10^{-14} mol^2 dm^{-6} at 50 °C.

(a) (i) Write an expression for pH.

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(1)

(ii) Write an expression for K_w

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(1)

(b) (i) Calculate the pH of pure water at 50 °C.

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(2)

(ii) Suggest why this pure water is **not** acidic.

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(1)

(iii) Calculate the pH of 0.140 mol dm^{-3} aqueous sodium hydroxide at 50 °C.

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(3)

(c) Calculate the pH of the solution formed when 25.0 cm^3 of 0.150 mol dm^{-3} aqueous sulfuric acid are added to 30.0 cm^3 of 0.200 mol dm^{-3} aqueous potassium hydroxide at 25 °C. Assume that the sulfuric acid is fully dissociated.

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(6)
(Total 14 marks)

Q2. In this question, give all values of pH to 2 decimal places.

(a) (i) Write an expression for the term pH.

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(1)

(ii) Calculate the concentration, in mol dm^{-3}, of an aqueous solution of sulfuric acid that has a pH of 0.25

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(2)

(b) A student carried out a titration by adding an aqueous solution of sodium hydroxide from a burette to an aqueous solution of ethanoic acid. The end-point was reached when 22.60 cm^3 of the sodium hydroxide solution had been added to 25.00 cm^3 of 0.410 mol dm^{-3} ethanoic acid.

(i) Write an equation for the reaction between sodium hydroxide and ethanoic acid.

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(1)

(ii) Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide solution used.

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(2)

(iii) A list of indicators is shown below.

Indicator	pH range
thymol blue	1.2–2.8
bromophenol blue	3.0–4.6
litmus	5.0–8.0
cresol purple	7.6–9.2

Select from the list the most suitable indicator for the end-point of this titration.

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(1)

(iv) Suggest why the concentration of sodium hydroxide in a solution slowly decreases when left open to air.

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(1)

(c) At 298 K, the value of the acid dissociation constant, K_a, for ethanoic acid in aqueous solution is 1.74×10^{-5} mol dm^{-3}

(i) Write an expression for the acid dissociation constant, K_a, for ethanoic acid.

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(1)

(ii) Calculate the pH of 0.410 mol dm^{-3} ethanoic acid at this temperature.

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(3)

(iii) Calculate the pH of the buffer solution formed when 10.00 cm^3 of 0.100 mol dm^{-3} potassium hydroxide are added to 25.00 cm^3 of 0.410 mol dm^{-3} ethanoic acid.

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(6)
(Total 18 marks)

Q3. In this question, give all pH values to 2 decimal places.

(a) (i) Write expressions for the ionic product of water, K_w, and for pH.

K_w = ……

pH = ...

(ii) At 318 K, the value of K_w is 4.02×10^{-14} mol^2 dm^{-6} and hence the pH of pure water is 6.70
State why pure water is not acidic at 318 K.

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(iii) Calculate the number of moles of sodium hydroxide in 2.00 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide.

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(iv) Use the value of K_w given above and your answer to part (a)(iii) to calculate the pH of the solution formed when 2.00 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide are added to 998 cm^3 of pure water at 318 K.

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(6)

(b) At 298 K, the acid dissociation constant, K_a, for propanoic acid, CH_3CH_2COOH, has the value 1.35×10^{-5} mol dm^{-3}.

(i) Write an expression for K_a for propanoic acid.

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(ii) Calculate the pH of 0.125 mol dm^{-3} aqueous propanoic acid at 298 K.

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(4)

(c) Sodium hydroxide reacts with propanoic acid as shown in the following equation.

$$NaOH + CH_3CH_2COOH \rightarrow CH_3CH_2COONa + H_2O$$

A buffer solution is formed when sodium hydroxide is added to an excess of aqueous propanoic acid.

(i) Calculate the number of moles of propanoic acid in 50.0 cm^3 of 0.125 mol dm^{-3} aqueous propanoic acid.

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(ii) Use your answers to part (a)(iii) and part (c)(i) to calculate the number of moles of propanoic acid in the buffer solution formed when 2.00 cm^3 of 0.500 mol dm^{-3} aqueous sodium hydroxide are added to 50.0 cm^3 of 0.125 mol dm^{-3} aqueous propanoic acid.

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(iii) Hence calculate the pH of this buffer solution at 298 K.

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(6)
(Total 16 marks)

Q4. Use the information below to answer this question.

A saturated solution of magnesium hydroxide, $Mg(OH)_2$, contains 0.1166 g of $Mg(OH)_2$ in 10.00 dm^3 of solution. In this solution the magnesium hydroxide is fully dissociated into ions.

Which one of the following is the pH of a solution of magnesium hydroxide containing 4.0×10^{-5} mol dm^{-3} of hydroxide ions at 298 K?
($K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6} at 298 K)

A 9.6

B 9.5

C 8.6

D 8.3

(Total 1 mark)