Q1.

At 40 °C the ionic product of water, $K_w = 2.92 \times 10^{-14}$ mol^2 dm^{-6}

(a) Give the expression for K_w

Calculate the pH of pure water at 40 °C
Give your answer to 2 decimal places.

K_w

pH _____

(3)

(b) 35.0 cm^3 of 0.150 mol dm^{-3} aqueous sodium hydroxide are mixed with 20.0 cm^3 of a 0.100 mol dm^{-3} solution of hydrochloric acid.
The temperature of the solution formed is 40 °C

Calculate the pH of the solution formed.
Give your answer to 2 decimal places.

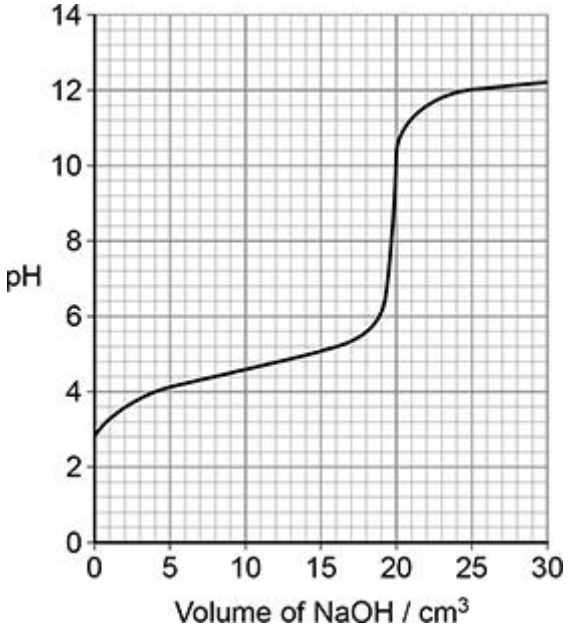
pH _____

(5)

(Total 8 marks)

Q2.

The figure below shows how the pH changes as 0.100 mol dm^{-3} sodium hydroxide solution is added to 25.0 cm^3 of 0.0800 mol dm^{-3} aqueous propanoic acid at 298 K



(a) Propanoic acid is a weak acid.

State the meaning of weak in this context.

_____

_____

_____

(1)

(b) Suggest why a student doing an experiment to produce the curve in the figure above would add the sodium hydroxide solution dropwise around the equivalence point.

_____

_____

_____

(1)

(c) Give an expression for K_a for propanoic acid (CH_3CH_2COOH).

Use this expression to show that pH = pK_a when half of the propanoic acid has reacted with sodium hydroxide.

K_a

(3)

(d) Use the pH from the figure above, when half of the propanoic acid has reacted, to calculate K_a at 298 K

K_a _____ mol dm^{-3}

(2)

(e) When sodium hydroxide solution is added to aqueous propanoic acid, the solution formed acts as a buffer when between 5 cm^3 and 15 cm^3 have been added.

Explain why the pH stays approximately constant during this part of the experiment.

_____

_____

_____

_____

_____

_____

(2)

(f) Methyl orange and universal indicator are **not** suitable indicators for the titration of solutions of propanoic acid with sodium hydroxide.

State the reason why each indicator is **not** suitable.

Methyl orange _____

_____

Universal indicator _____

_____

(2)

(Total 11 marks)

Q3.

This question is about weak acids.

(a) The table below shows the pH ranges of some indicators.

Indicator	pH range
Bromocresol green	3.8 – 5.4
Bromothymol blue	6.0 – 7.6
Thymol blue	8.0 – 9.6

Identify the indicator that is most suitable for use in a titration between propanoic acid and sodium hydroxide.

_____

(1)

(b) Give the expression for the acid dissociation constant (*K*a) for propanoic acid ($CH3CH_2COOH$).

*K*a

(1)

(c) Calculate the pH of a 0.100 mol dm^{-3} propanoic acid solution.
Give your answer to 2 decimal places.

For propanoic acid, $pK_a = 4.87$

pH _____

(4)

(d) For butanoic acid, $K_a = 1.51 \times 10^{-5}$ mol dm^{-3}

20.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution are added to 25.0 cm^3 of 0.100 mol dm^{-3} butanoic acid solution.

Calculate the pH of the solution formed.

pH _____

(5)

(e) A student plans to titrate butanoic acid solution with a solution of ethylamine.

Explain why this titration could **not** be done using an indicator.

_____

_____

_____

_____

(2)

(Total 13 marks)

Q4.

Calcium hydroxide is almost insoluble in water, but it reacts with dilute hydrochloric acid.

$$Ca(OH)_2(s) + 2\ HCl(aq) \rightarrow CaCl_2(aq) + 2\ H_2O(l)$$

A student adds 100 cm^3 of 0.100 mol dm^{-3} hydrochloric acid to 0.600 g of solid calcium hydroxide.

(a) Show, by calculation, that the calcium hydroxide is in excess.

(2)

(b) The final mixture contains a saturated solution of $Ca(OH)_2$ at 293 K

At 293 K

- the solubility of $Ca(OH)_2$ in this solution is 0.400 g dm^{-3}
- $K_w = 6.80 \times 10^{-15}$ mol^2 dm^{-6}

Calculate the pH of this solution.
Give your answer to two decimal places.

pH _____

(5)

(Total 7 marks)

Q5.

This question is about acids and bases.

(a) Calculate the pH of a 0.150 mol dm^{-3} solution of ethanoic acid at 25 °C
Give your answer to 2 decimal places.

For ethanoic acid, K_a = 1.74 x 10^{-5} mol dm^{-3} at 25 °C

pH _____

(3)

(b) Strontium is an element in Group 2.

Calculate the pH of a 0.0100 mol dm^{-3} solution of strontium hydroxide at 10 °C
You may assume that strontium hydroxide is completely dissociated in this solution.

At 10 °C the ionic product of water, K_w = 2.93 x 10^{-15} mol^2 dm^{-6}

pH _____

(3)

(c) The pH of a barium hydroxide solution is lower at 50 °C than at 10 °C

At 50 °C a 25 cm^3 sample of this barium hydroxide solution was neutralised by 22.45 cm^3 of hydrochloric acid added from a burette.

Deduce the volume of this hydrochloric acid that should be added from a burette to neutralise another 25 cm^3 sample of this barium hydroxide solution at 10 °C

Circle (⬭) the correct answer.

> 22.45 cm^3 = 22.45 cm^3 < 22.45 cm^3

Explain your answer _____

_____

_____

_____

(2)

(d) State how a buffer solution can be made from solutions of potassium hydroxide and ethanoic acid.

Give an equation for the reaction between potassium hydroxide and ethanoic acid.

State how this buffer solution resists changes in pH when a small amount of acid is added.

How buffer solution is made _____

_____

_____

_____

Equation

_____

How buffer solution resists pH change _____

_____

_____

_____

(3)

(e) A buffer solution is made by adding 2.00 g of sodium hydroxide to 500 cm^3 of 1.00 mol dm^{-3} ethanoic acid solution.

Calculate the pH of this buffer solution at 25 °C

Give your answer to 2 decimal places.

For ethanoic acid, K_a = 1.74 x 10^{-5} mol dm^{-3} at 25 °C

pH _____

(5)

(Total 16 marks)