AS 91392 Demonstrate understanding of equilibrium principles in aqueous systems

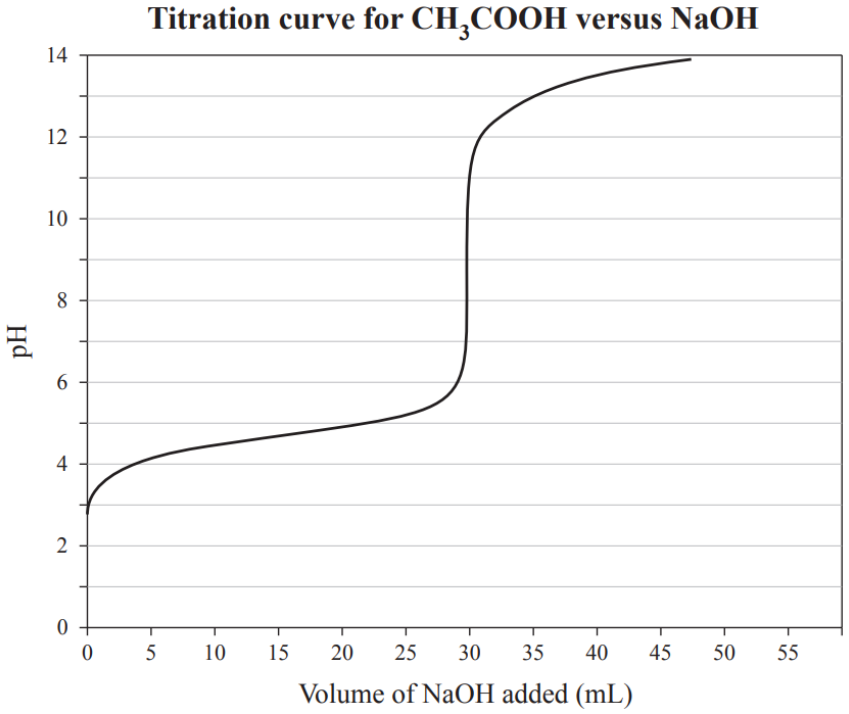
Collated Titration & Titration Curve Questions

2017:3

A titration was carried out by adding 0.112 mol L^{-1} sodium hydroxide solution, NaOH(aq), to 20.0 mL of ethanoic acid solution, $CH_3COOH(aq)$.

The equation for the reaction is:

$$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l) \quad K_a\ (CH_3COOH) = 1.74 \times 10^{-5}.$$



(a) With reference to the titration curve above, put a tick next to the indicator most suited to identify the equivalence point.

Indicator	pKa	Tick ONE
Methyl yellow	3.1	
Bromocresol purple	6.3	
Phenolphthalein	9.6	

(b) (i) The ethanoic acid solution, $CH_3COOH(aq)$, has a pH of 2.77 before any NaOH is added. Show by calculation that the concentration of the CH_3COOH solution is 0.166 mol L^{-1}.

(ii) Calculate the pH of the solution in the flask after 10.0 mL of 0.112 mol L^{-1} NaOH has been added to 20.0 mL of ethanoic acid solution, $CH_3COOH(aq)$.

(c) The equivalence point pH for the titration of ethanoic acid with sodium hydroxide is 8.79.

(i) Identify the chemical species present at the equivalence point, other than water.

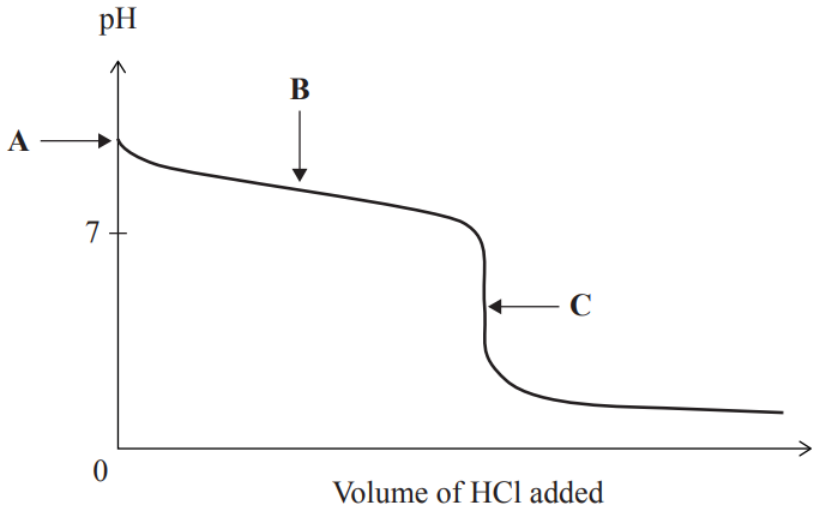
(ii) In a second titration, a 0.166 mol L^{-1} methanoic acid solution, HCOOH(aq), is titrated with the NaOH solution. The equivalence point pH for this titration is 8.28.
The equivalence point pH for the CH_3COOH titration is 8.79.
Compare and contrast the pH values at the equivalence point for both titrations.
K_a (HCOOH) = 1.82×10^{-4} K_a (CH_3COOH) = 1.74×10^{-5}
No calculations are necessary.

2016:3

20.00 mL of 0.320 mol L^{-1} ammonia, NH_3, is titrated with 0.640 mol L^{-1} hydrochloric acid, HCl.

The equation for this reaction is: $NH_3 + HCl \rightarrow NH_4^+ + Cl^-$ pK_a (NH_4^+) = 9.24

The curve for this titration is given below.



(a) Explain why the pH at the equivalence point (point C) is not 7.

(b) Show, by calculation, that the pH at the equivalence point (point C) is 4.96.

(c) Explain, in terms of the species present, why the pH at B (half way to the equivalence point) is 9.24.

(d) Explain, in terms of the species present, why the pH of the solution at point C is 4.96. No calculations are necessary.

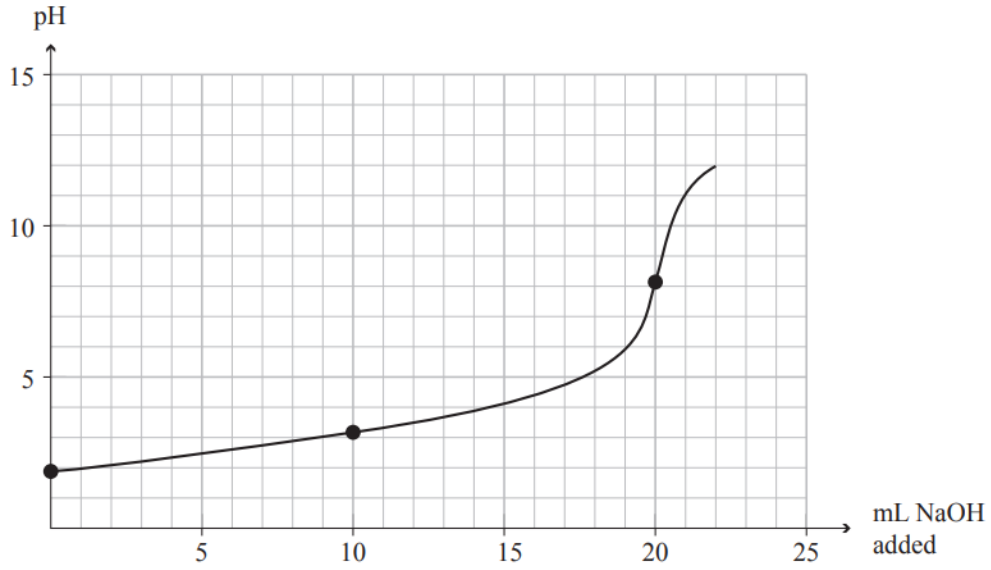
2015:3

20.0 mL of 0.258 mol L^{-1} hydrofluoric acid, HF, solution is titrated with a sodium hydroxide, NaOH, solution. The equation for the reaction is:

$$HF + NaOH \rightarrow NaF + H_2O$$

$$pK_a\ (HF) = 3.17$$

The titration curve is given below:



(a) (i) Identify the species in solution at the equivalence point.

(ii) Explain why the pH at the equivalence point is greater than 7. Include an equation in your answer.

(iii) After a certain volume of NaOH solution has been added, the concentration of HF in the solution will be twice that of the F^-.
Calculate the pH of this solution, and evaluate its ability to function as a buffer.

(iv) Determine by calculation, the pH of the solution after 24.0 mL of 0.258 mol L^{-1} NaOH solution has been added.

(b) In a second titration, a 0.258 mol L^{-1} ethanoic acid, CH_3COOH, solution was titrated with the NaOH solution. Contrast the expected pH at the equivalence point with the HF titration. pKa (CH_3COOH) = 4.76
No calculations are necessary.

2014:3

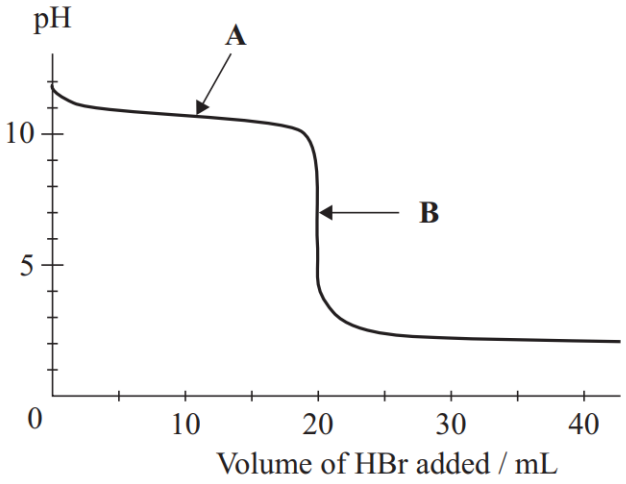
A titration was carried out by adding hydrobromic acid, HBr, to 20.0 mL of aqueous methylamine, CH_3NH_2, solution.

The equation for the reaction is:

$$CH_3NH_2 + HBr \rightarrow CH_3NH_3 + + Br^-$$

$$K_a\ (CH_3NH_3^+) = 2.29 \times 10^{-11}$$

The curve for this titration is given below:



(a) Explain why the pH does not change significantly between the addition of 5 to 15 mL of HBr (around point A on the curve). Include any relevant equation(s) in your answer.

(b) The aqueous methylamine, CH_3NH_2, solution has a pH of 11.8 before any HBr is added. Show by calculation that the concentration of this solution is 0.0912 mol L^{-1}.

(c) (i) Write the formulae of the four chemical species, apart from water and OH^-, that are present at the point marked B on the curve.

2013:3

20.0 mL of 0.0896 mol L^{-1} ethanoic acid is titrated with 0.100 mol L^{-1} sodium hydroxide. $pK_a\ (CH_3COOH) = 4.76$

(a) Calculate the pH of the ethanoic acid before any NaOH is added.

(b) Halfway to the equivalence point of the titration, the pH = pKa of the ethanoic acid.

Discuss the reason for this.

(c) (i) Discuss the change in the concentration of species in solution, as the first 5.00 mL of NaOH is added to the 20.0 mL of ethanoic acid. Your answer should include chemical equations. No calculations are required.

(ii) Calculate the pH of the titration mixture after 5.00 mL of NaOH has been added.