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Level 3 Chemistry, 2018

91392 Demonstrate understanding of equilibrium principles in aqueous systems

2.00 p.m. Thursday 15 November 2018
Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of equilibrium principles in aqueous systems.	Demonstrate in-depth understanding of equilibrium principles in aqueous systems.	Demonstrate comprehensive understanding of equilibrium principles in aqueous systems.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

A periodic table and relevant formulae are provided in the Resource Booklet L3–CHEMR.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–8 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

TOTAL

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QUESTION ONE

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(a) When sodium ethanoate, CH_3COONa, is dissolved in water, the resulting solution has a pH greater than 7 due to the production of hydroxide ions, OH^-, as shown in the equation below.

$$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$$

$pK_a(CH_3COOH) = 4.76$ $\quad$ $K_a(CH_3COOH) = 1.74 \times 10^{-5}$

Calculate the pH of a 0.420 mol L^{-1} CH_3COONa solution.

(b) (i) Write the equation for the equilibrium occurring in a saturated solution of calcium fluoride, CaF_2.

(ii) Calculate the solubility of CaF_2 in water at 25°C.

$K_s(CaF_2) = 3.20 \times 10^{-11}$

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(c) Explain the effect of the following on the solubility of iron(III) hydroxide, $Fe(OH)_3$, in water.
Include relevant equation(s) in your answer.
No calculations are necessary.

(i) pH lowered below 4

(ii) Potassium thiocyanate, KSCN, solution added

QUESTION TWO

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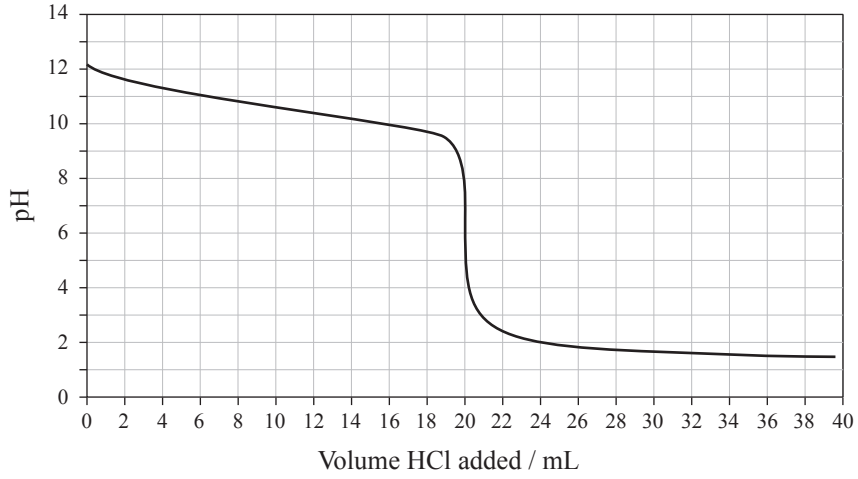
A titration was carried out by adding 0.210 mol L^{-1} hydrochloric acid, HCl, to 25.0 mL of 0.168 mol L^{-1} methanamine, CH_3NH_2.

The equation for the reaction is:

$$HCl + CH_3NH_2 \rightarrow CH_3NH_3^+ + Cl^-$$

$pK_a(CH_3NH_3^+) = 10.6$ $\quad$ $K_a(CH_3NH_3^+) = 2.51 \times 10^{-11}$

Titration Curve for CH_3NH_2 versus HCl



(a) Between pH 9.60 – 11.6, the solution is a buffer.

(i) From the titration curve, estimate the volume of the HCl solution that must be added to the CH_3NH_2 solution above to make a buffer solution of pH 10.0.

(ii) Explain how the buffer solution resists large changes in pH as the HCl solution is added between a pH of 9.60 – 11.6.

Include an appropriate equation in your answer.

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(b) (i) List all the species present in the solution at the equivalence point in order of decreasing concentration.

Do not include water.

(ii) Calculate the pH at the equivalence point.

(c) Why is the solution at the equivalence point a better electrical conductor than the initial solution of methanamine?

Your answer should include relevant equation(s) and elaborate on the relative concentrations of the different species in each solution.

No calculations are necessary.

QUESTION THREE

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(a) (i) Write the solubility product expression, K_s, for silver chloride, AgCl.

(ii) Why does the solubility of AgCl decrease when a small volume of silver nitrate, $AgNO_3$, solution is added to a saturated solution of AgCl?

Explain your answer.

(iii) Show by calculation whether a precipitate of AgCl will form when 70.0 mL of 0.0220 mol L^{-1} $AgNO_3$ is added to 50.0 mL of 0.0550 mol L^{-1} sodium chloride, NaCl.

$K_s(AgCl) = 1.80 \times 10^{-10}$

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(b) 5.11 g of sodium methanoate, HCOONa, was added to 125 mL of 0.105 mol L^{-1} methanoic acid, HCOOH, to make a buffer solution.

Assume there is no change in the total volume.

$pK_a(HCOOH) = 3.74$ $K_a(HCOOH) = 1.82 \times 10^{-4}$

(i) Give the pH range over which the resulting solution will function as a buffer.

(ii) Show, by calculation, that the pH of this buffer solution is 4.50.

$M(HCOONa) = 68.0$ g mol^{-1}

(iii) Evaluate whether this buffer solution will be more effective at neutralising small volumes of strong acid or strong base.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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