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Level 3 Chemistry 2020

91392 Demonstrate understanding of equilibrium principles in aqueous systems

2.00 p.m. Friday 27 November 2020
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 2–12 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) An aqueous solution containing a mixture of ammonium chloride, NH_4Cl, and ammonia, NH_3, can act as a buffer solution.

$K_a(NH_4^+) = 5.75 \times 10^{-10}$ $\quad$ $pK_a(NH_4^+) = 9.24$

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

(ii) Explain why the addition of a small volume of nitric acid, HNO_3, to this buffer solution will not result in a significant change in pH.

Your answer should include relevant equation(s).

(b) (i) Calculate the mass of NH_4Cl that must be added to 200 mL of 0.0500 mol L^{-1} NH_3 to give a buffer solution with a pH of 8.75.

Assume there is no change in volume when the solid is added.

$M(NH_4Cl) = 53.5$ g mol^{-1}

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(ii) Explain whether the buffer in part (i) will be more effective at neutralising strong acid or strong base.

(c) (i) Solutions of equal concentration were prepared for each of the following:

HBr CH_3NH_2 NH_4Cl

Rank the solutions in order of decreasing pH in the box below:

Order of decreasing pH:

Justify the order.

Your answer should include:

- relative concentrations of hydronium ions
- relevant equation(s).

(ii) If the NH_4Cl solution has a pH of 4.70, calculate its concentration.

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QUESTION TWO

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(a) (i) Write the equation for the equilibrium occurring in a saturated solution of lead bromide, $PbBr_2$.

(ii) Write the expression for $K_s(PbBr_2)$.

(iii) Calculate the solubility of $PbBr_2$ in water at 25 °C.

$K_s(PbBr_2) = 2.10 \times 10^{-6}$

(b) Determine whether a precipitate of lead bromide, $PbBr_2$, will form when 125 mL of 0.0365 mol L^{-1} lead nitrate, $Pb(NO_3)_2$, is added to 175 mL of 0.00262 mol L^{-1} magnesium bromide, $MgBr_2$.

(c) (i) Explain the effect of the following on the solubility of nickel hydroxide, $Ni(OH)_2$, in water.

Include relevant equation(s) in your answer.

No calculations are necessary.

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- Ammonia solution, $NH_3(aq)$, is added:

- The pH is decreased below 4:

(ii) Calculate the solubility of a saturated solution of nickel hydroxide at pH 8.25.

$K_s(Ni(OH)_2) = 6.00 \times 10^{-16}$

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QUESTION THREE

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A titration was carried out by adding 0.280 mol L^{-1} hydrochloric acid, HCl, to 25.0 mL of 0.224 mol L^{-1} sodium ethanoate solution, CH_3COONa.

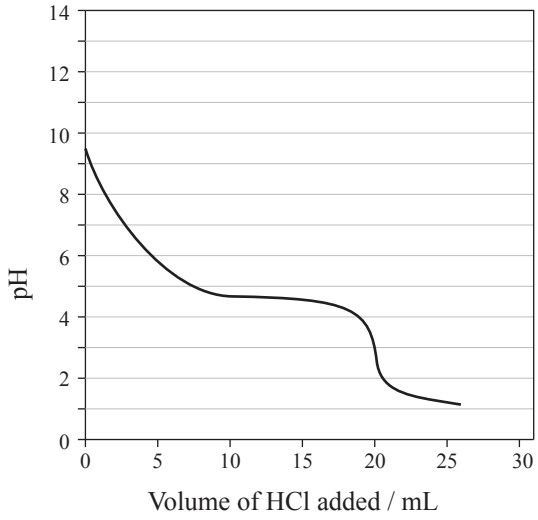
The equation for the reaction is:

$$CH_3COONa + HCl \rightarrow CH_3COOH + NaCl$$

$pK_a\ (CH_3COOH) = 4.76$

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

Titration curve for CH_3COONa versus HCl



(a) (i) List all the species present in a solution of sodium ethanoate.

Do not include water.

(ii) Calculate the pH of the 0.224 mol L^{-1} sodium ethanoate solution before any hydrochloric acid is added.

(b) Why are hydrochloric acid and sodium ethanoate solutions both good electrical conductors? Justify your answer, including any relevant equation(s).

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(c) (i) Calculate the pH at the equivalence point.

Question Three continues on the following page.

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(ii) In a second titration, 25.0 mL of 0.224 mol L^{-1} methanamine, CH_3NH_2, is titrated with the same 0.280 mol L^{-1} hydrochloric acid.

K_a ($CH_3NH_3^+$) = 2.29×10^{-11} K_a (CH_3COOH) = 1.74×10^{-5}

For this second titration, circle how the pH at the equivalence point will compare to the pH at the equivalence point in the titration of sodium ethanoate.

Lower pH **Same pH** **Higher pH**

Explain your answer.

No calculations are necessary.

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

QUESTION NUMBER

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