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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Chemistry 2025

91392 Demonstrate understanding of equilibrium principles in aqueous systems

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 other reference material 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.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

Do not write in the margins (⁝⁝⁝). This area will be cut off when the booklet is marked.

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

QUESTION ONE

(a) (i) Write the equation for the equilibrium occurring in a saturated solution of iron(II) hydroxide, $Fe(OH)_2$.

(ii) Write the expression for $K_s(Fe(OH)_2)$.

(iii) Calculate the solubility product, K_s, of $Fe(OH)_2$ in water at 25 °C, given $Fe(OH)_2$ has a solubility of 1.01×10^{-5} mol L^{-1}.

(iv) Some dilute hydrochloric acid, HCl(*aq*), is added to a saturated solution of $Fe(OH)_2$.

Justify what will happen to the solubility of the $Fe(OH)_2$ in solution.

Include relevant equation(s) in your answer.

No calculations are necessary.

(b) Nickel hydroxide, $Ni(OH)_2$, is another sparingly soluble solid.

(i) A student makes a green precipitate of $Ni(OH)_2$ in a test tube by mixing sodium hydroxide, NaOH(*aq*), and nickel chloride, $NiCl_2$(*aq*). When the student then adds excess sodium cyanide, NaCN(*aq*), the green precipitate dissolves.

Explain why the green precipitate of $Ni(OH)_2$ dissolves, using equilibrium principles and any relevant equation(s).

(ii) Determine whether a precipitate of $Ni(OH)_2$ will form when 55.0 mL of 0.130 mol L^{-1} nickel sulfate, $NiSO_4$, is added to 35.0 mL of potassium hydroxide, KOH, solution of pH 11.7.

$K_s(Ni(OH)_2) = 6 \times 10^{-16}$

QUESTION TWO

Methylammonium chloride, CH_3NH_3Cl, is an acidic salt.

(a) List all the species present in a solution of CH_3NH_3Cl in order of decreasing concentration.

Do not include water.

	>	$CH_3NH_3^+$	>		=	H_3O^+	>	

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(b) If CH_3NH_3Cl and methanamine, CH_3NH_2, are mixed in the appropriate quantities, a buffer solution is formed.

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

(i) When a small volume of dilute sodium hydroxide, NaOH, is added to the buffer, the following reaction occurs:

$$CH_3NH_3^+ + OH^- \rightarrow CH_3NH_2 + H_2O$$

Describe the function of a buffer solution, and explain the significance of this equation in terms of the function of the buffer solution.

(ii) Calculate the mass of CH_3NH_3Cl that should be added to 600 mL of 0.840 mol L^{-1} CH_3NH_2 to produce a solution of pH 12.1.

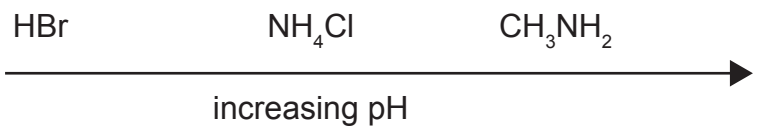
$M(CH_3NH_3Cl) = 67.5$ g mol^{-1}

(iii) Explain why the solution prepared in part (ii) will not function as a buffer.

Outline how the solution could be modified in the laboratory to make it a buffer.

No calculations are necessary.

(c) The pH of three solutions of equal concentration were ranked in order of increasing pH.



Justify the order in terms of the degree of dissociation and the relative concentration of hydronium ions in each solution.

Include relevant equation(s) in your answer.

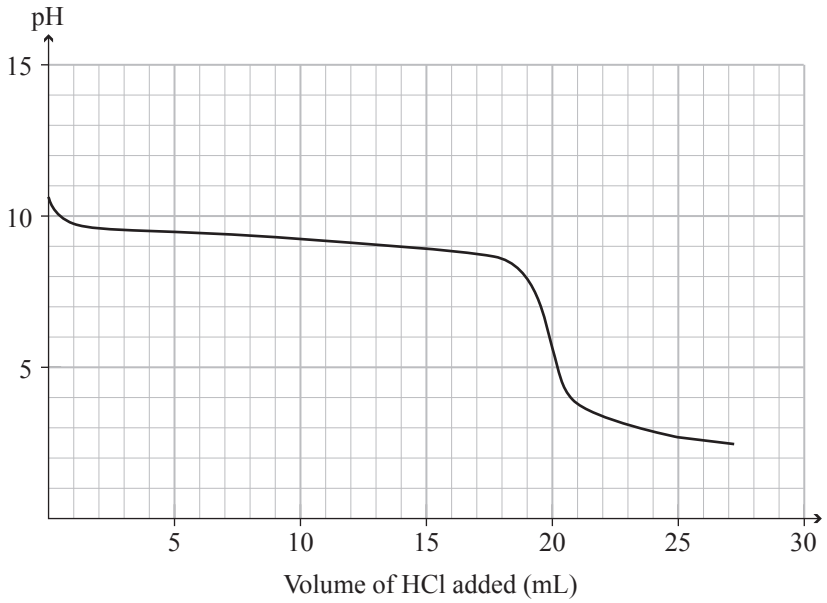
QUESTION THREE

A titration was carried out by adding 0.0174 mol L^{-1} hydrochloric acid, HCl(*aq*), to 25.0 mL of 0.0139 mol L^{-1} ammonia, $NH_3(aq)$, in a conical flask.

The equation for the reaction is:

$$NH_3 + HCl \rightarrow NH_4^+ + Cl^-$$

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



(a) Explain, with reference to the titration curve, why methyl red (pK_a 5.1) would be a better indicator to detect the equivalence point than thymol blue (pK_a 1.7).

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

(ii) Compare the electrical conductivity of the solution in the conical flask before HCl is added, and after 20 mL of HCl is added.

Include relevant equation(s) in your answer.

(c) (i) Calculate the pH in the conical flask after 25.0 mL of 0.0174 mol L^{-1} HCl has been added.

(ii) The 0.0174 mol L^{-1} HCl in the burette has a pH of 1.76.

Explain why the pH calculated in part (i) is higher than 1.76.

No calculations are necessary.

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