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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Chemistry 2024

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 any cross-hatched area (▨). 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 silver sulfate, Ag_2SO_4.

(ii) Write the expression for $K_s(Ag_2SO_4)$.

(iii) Calculate the solubility of Ag_2SO_4 in water at 25 °C, and give $[Ag^+]$ and $[SO_4^{2-}]$.

$K_s(Ag_2SO_4) = 1.20 \times 10^{-5}$

(b) Below is a list of solutions of the same concentration available for a student to add to a saturated solution of Ag_2SO_4:

$HNO_3(aq)$, $Na_2SO_4(aq)$, $NH_3(aq)$, $KNO_3(aq)$

Select and justify, including any relevant equations, an appropriate solution the student could add to:

(i) increase the solubility of Ag_2SO_4

(ii) decrease the solubility of Ag_2SO_4

(c) Predict, by calculation, whether a precipitate of silver sulfate, Ag_2SO_4, will form when 20.0 mL of 0.0188 mol L^{-1} silver nitrate, $AgNO_3$, is added to 30.0 mL of 0.0146 mol L^{-1} aluminium sulfate, $Al_2(SO_4)_3$.

$K_s(Ag_2SO_4) = 1.20 \times 10^{-5}$

QUESTION TWO

(a) (i) List all the species present in a solution of sodium ethanoate, CH_3COONa, in order of decreasing concentration. Do not include water.

Na^+	>		>		=	OH^-	>	

(ii) Sodium ethanoate can be mixed with ethanoic acid, CH_3COOH, to form a buffer solution.

Explain how this buffer solution would react upon the addition of a small volume of hydrobromic acid, HBr, including a balanced equation(s) to support your answer.

(iii) Calculate the mass of sodium ethanoate that must be added to 250 mL of 0.354 mol L^{-1} CH_3COOH to give a buffer solution with a pH of 4.11.

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

$K_a(CH_3COOH) = 1.74 \times 10^{-5}$ $\quad pK_a(CH_3COOH) = 4.76$ $\quad M(CH_3COONa) = 82.0$ g mol^{-1}

(b) Three colourless 0.110 mol L^{-1} solutions of CH_3NH_2, CH_3COOH, and NH_4Cl have lost their labels. The solutions are randomly labelled A, B, and C. The electrical conductivity of each solution, and the colour of the solution when the acid-base indicator bromothymol blue ($pK_a = 7.2$) was added, are shown in the table below.

Solution	Electrical conductivity	Colour with bromothymol blue
A	Poor	Yellow
B	Poor	Blue
C	Good	Yellow

Identify the three solutions.

Justify your identification in terms of the degree of dissociation and the relative concentration of ions in each solution, including relevant equations.

No calculations are necessary.

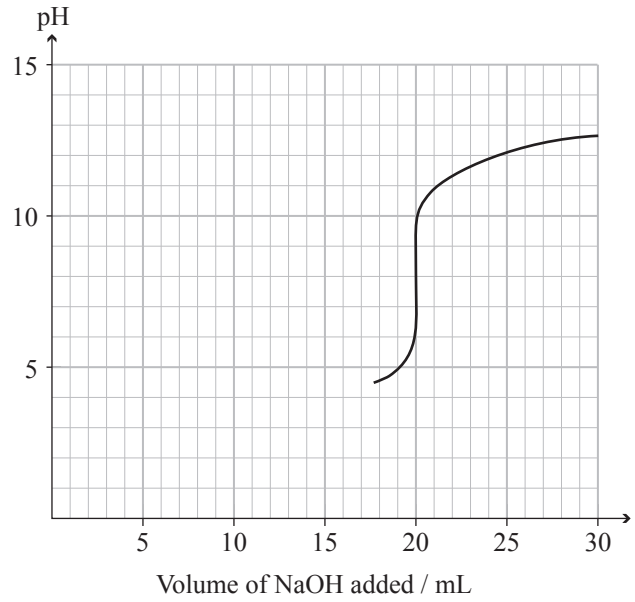
QUESTION THREE

A titration was carried out by adding 0.169 mol L^{-1} sodium hydroxide, NaOH, to 25.0 mL of 0.135 mol L^{-1} hydrofluoric acid, HF.

The equation for the reaction is:

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

$K_a(HF) = 6.76 \times 10^{-4}$ $\quad$ $pK_a(HF) = 3.17$



(a) (i) Show, by calculation, that the initial pH of the HF solution is 2.02.

(ii) Sketch the missing portion of the titration curve between 0 and 17.5 mL to complete the curve provided above.

Consider the initial pH, the pH after 10.0 mL of NaOH has been added, and the shape of the curve.

If you need to redraw your curve, use the graph on page 9.

(b) (i) After a certain volume of NaOH has been added, the HF and NaF are present in a 1:9 ratio in the solution.

Calculate the pH of this solution, and evaluate its buffering ability.

(ii) Justify why the pH increases rapidly between 18.0 mL and 22.0 mL.

No calculations are necessary.

Question Three continues on the next page.

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

(ii) In a second titration, 25.0 mL of 0.135 mol L^{-1} ethanoic acid, CH_3COOH, is titrated with the 0.169 mol L^{-1} NaOH solution.

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

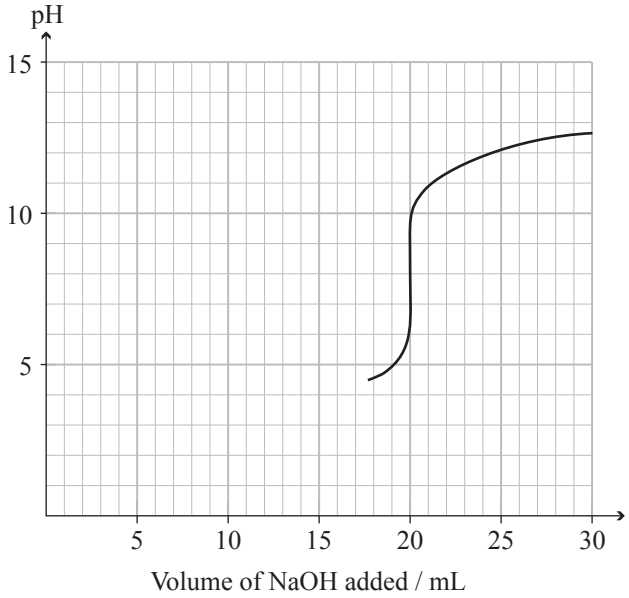
Predict how the pH at the equivalence point will compare to the titration with HF by circling one answer below:

Lower pH $\quad$ **Same pH** $\quad$ **Higher pH**

Explain your choice.

SPARE DIAGRAM

If you need to redraw your response to Question Three (a)(ii), use the graph below. Make sure it is clear which answer you want marked.



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