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Level 3 Chemistry 2022

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 – 11 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (▨). This area may 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 chromate, Ag_2CrO_4.

(ii) Write the expression for $K_s(Ag_2CrO_4)$.

(iii) Calculate the solubility product, K_s, of Ag_2CrO_4 in water at 25 °C, given Ag_2CrO_4 has a solubility of 6.50×10^{-5} mol L^{-1}.

(b) Explain, using equilibrium principles, the effect of the following on the solubility of Ag_2CrO_4 in water.

Include relevant equation(s) in your answer.

No calculations are necessary.

(i) Dilute silver nitrate, $AgNO_3(aq)$, is added:

(ii) Dilute sodium cyanide, NaCN(*aq*), is added:

(c) Show, by calculation, that a precipitate of silver chloride, AgCl, will form when 30.0 mL of 0.0686 mol L^{-1} calcium chloride, $CaCl_2$, is added to 50.0 mL of 0.00154 mol L^{-1} silver nitrate, $AgNO_3$.

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

QUESTION TWO

Sodium hypochlorite, NaOCl, is the active ingredient in bleach. The hypochlorite ion, OCl^-, is a weak base.

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

(ii) Hypochlorous acid, HOCl, is the conjugate acid of the hypochlorite ion.

If a hypochlorous acid solution has a pH of 4.80, calculate its concentration.

$K_a(HOCl) = 2.95 \times 10^{-8}$ $pK_a(HOCl) = 7.53$

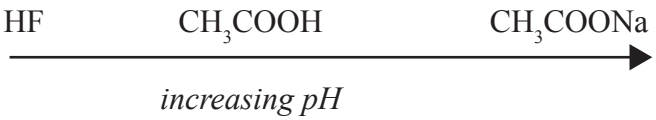
(iii) Compare the electrical conductivity of HOCl and NaOCl solutions of equal concentration.
Use relevant equation(s) in your answer.

(b) When a small volume of hydrochloric acid, HCl, is added to a buffer solution made from HOCl and NaOCl, the following reaction occurs:

$$OCl^- + H_3O^+ \rightarrow HOCl + H_2O$$

Explain the significance of this reaction in terms of the function of the buffer solution.

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



Justify the order.

Your answer should include:

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

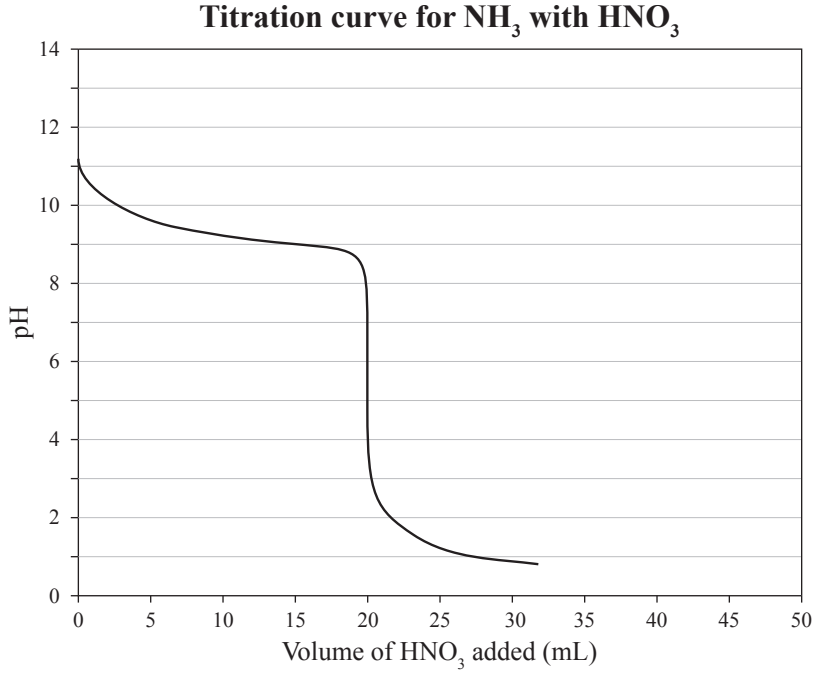
QUESTION THREE

A titration was carried out by adding 0.155 mol L^{-1} nitric acid, HNO_3, to 25.0 mL of 0.124 mol L^{-1} ammonia, NH_3.

The equation for the reaction is:

$$NH_3 + HNO_3 \rightarrow NH_4^+ + NO_3^-$$

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



(a) Calculate the pH of the 0.124 mol L^{-1} ammonia solution before any nitric acid is added.

(b) As HNO_3 is added to the NH_3 solution, the NH_3 reacts to form ammonium ions, NH_4^+.

(i) After a certain volume of HNO_3 has been added, NH_3 and NH_4^+ are present in a 5:2 ratio in the solution.

Calculate the pH of this solution and evaluate its effectiveness as a buffer.

(ii) Explain the significance of the pH of the solution in the flask halfway to the equivalence point of this titration.

Your answer should refer to the relative concentrations of the species present.

No calculations are necessary.

(c) In a second titration, 25.0 mL of 0.124 mol L^{-1} sodium ethanoate, CH_3COONa, is titrated with the 0.155 mol L^{-1} HNO_3 solution.

The equation for the reaction is:

$$CH_3COONa + HNO_3 \rightarrow NaNO_3 + CH_3COOH$$

$K_a(CH_3COOH) = 1.74 \times 10^{-5}$ $K_a(NH_4^+) = 5.75 \times 10^{-10}$

(i) Predict how the initial pH will compare to the titration with NH_3 by circling one answer:

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

Explain your choice.

(ii) Predict how the pH at the equivalence point will compare to the titration with NH_3 by circling one answer:

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

Explain your choice.

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

QUESTION NUMBER

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

QUESTION NUMBER