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Level 3 Chemistry, 2015

91392 Demonstrate understanding of equilibrium principles in aqueous systems

2.00 p.m. Wednesday 11 November 2015

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 is provided on the Resource Sheet 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 2–11 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

ASSESSOR'S USE ONLY

QUESTION ONE

Methylammonium chloride, $\text{CH}_3\text{NH}_3\text{Cl}$, dissolves in water to form a weakly acidic solution.

$$K_a(\text{CH}_3\text{NH}_3^+) = 2.29 \times 10^{-11}$$

- (a) (i) Write an equation to show $\text{CH}_3\text{NH}_3\text{Cl}$ dissolving in water.

- (ii) Write an equation to show the reaction occurring in an aqueous solution of $\text{CH}_3\text{NH}_3\text{Cl}$.

- (iii) List all the species present in an aqueous solution of $\text{CH}_3\text{NH}_3\text{Cl}$, in order of decreasing concentration.

Do not include water.

- (iv) Calculate the pH of $0.0152 \text{ mol L}^{-1}$ $\text{CH}_3\text{NH}_3\text{Cl}$ solution.

- (b) The table shows the pH and electrical conductivity of three solutions. The concentrations of the solutions are the same.

Solution	NaOH	CH_3NH_2	CH_3COONa
pH	13.2	11.9	8.98
Electrical conductivity	good	poor	good

Compare and contrast the pH and electrical conductivity of these three solutions.

Include appropriate equations in your answer.

pH: _____

Electrical conductivity: _____

QUESTION TWO

Sufficient calcium carbonate, $\text{CaCO}_3(s)$, is dissolved in water to make a saturated solution.

- (a) (i) Write the equation for the equilibrium occurring in a saturated solution of CaCO_3 .

- (ii) Write the expression for $K_s(\text{CaCO}_3)$.

- (iii) Calculate the solubility product of CaCO_3 , $K_s(\text{CaCO}_3)$.

The solubility of CaCO_3 is $5.74 \times 10^{-5} \text{ mol L}^{-1}$.

- (b) Some marine animals use calcium carbonate to form their shells. Increased acidification of the oceans poses a problem for the survival of these marine animals.

Explain why the solubility of CaCO_3 is higher in an acidic solution.

Use an equation to support your explanation.

- (c) Show, by calculation, that a precipitate of lead(II) hydroxide, Pb(OH)_2 , will form when 25.0 mL of a sodium hydroxide solution, NaOH , at pH 12.6 is added to 25.0 mL of a 0.00421 mol L^{-1} lead(II) nitrate, $\text{Pb(NO}_3)_2$, solution.

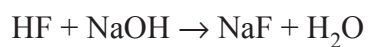


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QUESTION THREE

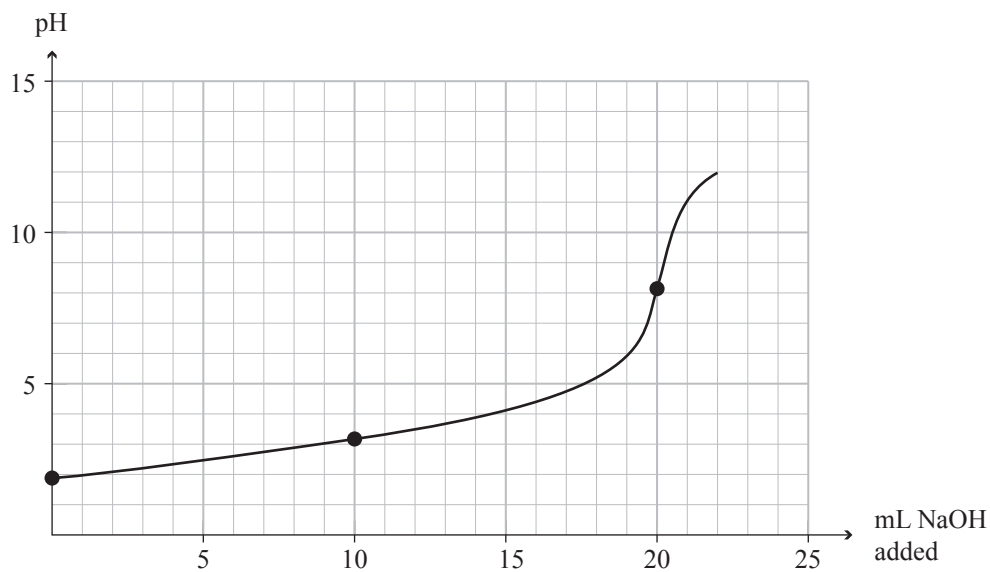
20.0 mL of 0.258 mol L⁻¹ hydrofluoric acid, HF, solution is titrated with a sodium hydroxide, NaOH, solution.

The equation for the reaction is:



$$\text{p}K_{\text{a}}(\text{HF}) = 3.17$$

The titration curve is given below:



- (a) (i) Identify the species in solution at the equivalence point.

- (ii) Explain why the pH at the equivalence point is greater than 7.

Include an equation in your answer.

- (iii) After a certain volume of NaOH solution has been added, the concentration of HF in the solution will be twice that of the F^- .

Calculate the pH of this solution, and evaluate its ability to function as a buffer.

- (iv) Determine by calculation, the pH of the solution after 24.0 mL of 0.258 mol L^{-1} NaOH solution has been added.

**Question Three continues
on the following page.**

- (b) In a second titration, a 0.258 mol L^{-1} ethanoic acid, CH_3COOH , solution was titrated with the NaOH solution.

Contrast the expected pH at the equivalence point with the HF titration.

$$\text{p}K_{\text{a}}(\text{CH}_3\text{COOH}) = 4.76$$

No calculations are necessary.

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