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Level 3 Chemistry, 2019

91392 Demonstrate understanding of equilibrium principles in aqueous systems

2.00 p.m. Thursday 14 November 2019
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 2–11 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

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QUESTION ONE

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

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

(iii) Calculate the solubility of $Zn(OH)_2$ in water at 25°C, and give the $[Zn^{2+}]$ and $[OH^-]$ in the solution.

$K_s(Zn(OH)_2) = 3.80 \times 10^{-17}$

(iv) The presence of a common ion decreases the solubility of a sparingly soluble solid, such as $Zn(OH)_2$.

Calculate the concentration of the hydroxide ions, OH^-, in solution after 25.0 mL of 0.210 mol L^{-1} zinc chloride, $ZnCl_2$, solution was added to 25.0 mL of a saturated $Zn(OH)_2$ solution.

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(b) Use equilibrium principles to explain why the solubility of $Zn(OH)_2$ increases when an excess of dilute sodium hydroxide, NaOH, is added.

Include relevant equation(s) in your answer.

(c) Determine whether a precipitate of $Zn(OH)_2$ will form when 30.0 mL of sodium hydroxide solution, NaOH, at pH 13.1 is added to 20.0 mL of 0.0242 mol L^{-1} zinc nitrate, $Zn(NO_3)_2$.

QUESTION TWO

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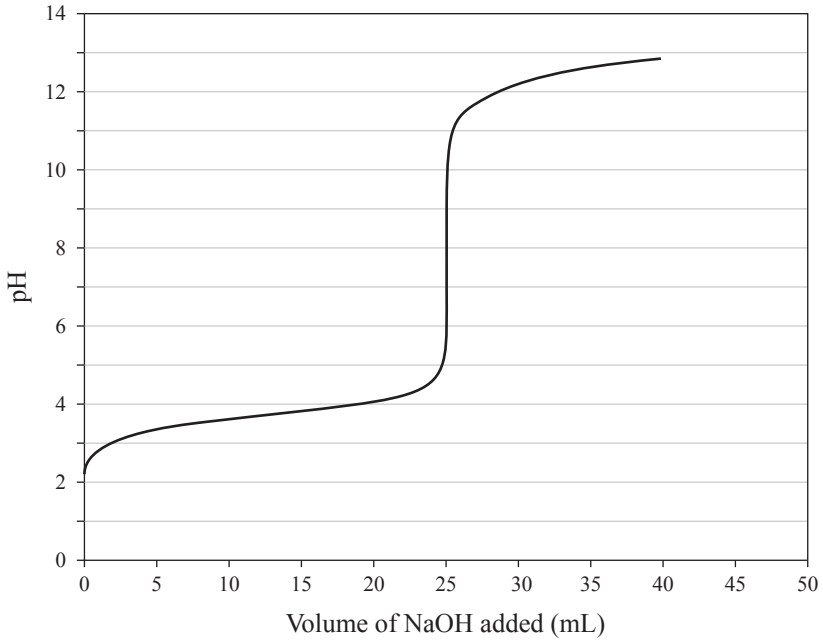
A titration was carried out by adding 0.140 mol L^{-1} sodium hydroxide, NaOH, to 20.0 mL of 0.175 mol L^{-1} methanoic acid, HCOOH.

The equation for the reaction is:

$$HCOOH + NaOH \rightarrow HCOONa + H_2O$$

$pK_a(HCOOH) = 3.74$
$K_a(HCOOH) = 1.82 \times 10^{-4}$



(a) (i) List ALL the species in solution after 12.5 mL of NaOH solution has been added.

Do not include water.

(ii) After 12.5 mL of NaOH has been added, the solution has a pH of 3.74.

Explain the significance of this pH with reference to the relative concentrations of the species present.

No calculations are necessary.

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(b) (i) With reference to the titration curve, put a tick next to the indicator most suited to identify the equivalence point.

Indicator	**pK_a**	**Tick ONE box below**
Thymol blue	1.70	
Bromocresol green	4.70	
Cresol red	8.30	

Explain your choice, including the consequences of choosing the other indicators.

(ii) Calculate the pH at the equivalence point.

(c) Calculate the pH of the solution after 28.0 mL of 0.140 mol L^{-1} NaOH has been added.

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QUESTION THREE

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(a) Two solutions of equal concentration were prepared: one of ethanoic acid, CH_3COOH, and one of ammonium chloride, NH_4Cl.

$pK_a(CH_3COOH) = 4.76$ $pK_a(NH_4^+) = 9.24$

(i) Explain which solution would have the lower pH.

Your answer should refer to the concentration of relevant ion(s) in each solution.

No calculations are necessary.

(ii) Evaluate the electrical conductivity of the CH_3COOH and NH_4Cl solutions.

Include relevant equation(s) in your answer.

Question Three continues on the following page.

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(iii) The ethanoic acid solution has a $[H_3O^+]$ of 1.78×10^{-3} mol L^{-1}.

Calculate the concentration of the ethanoic acid solution.

(b) (i) Dilute hydrochloric acid, HCl, is added to a solution of sodium ethanoate, CH_3COONa, until the ratio of CH_3COONa to ethanoic acid, CH_3COOH, in the solution is two to five (2:5).

Calculate the pH of this buffer solution.

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(ii) Explain why this buffer solution would be more effective at resisting a change in pH when a small volume of strong base is added, rather than strong acid.

Your answer should include an equation to show how the buffer neutralises added strong base.

(iii) How would the pH of this buffer solution be affected when it is diluted with water?

Explain your answer.

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

QUESTION NUMBER

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91392