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NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3 Chemistry, 2014

91392 Demonstrate understanding of equilibrium principles in aqueous systems

2.00 pm Tuesday 11 November 2014
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 space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–10 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.

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QUESTION ONE

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When chlorine gas is added to water, the equation for the reaction is:

$$Cl_2(g) + H_2O(\ell) \rightleftharpoons HCl(aq) + HOCl(aq)$$

(a) (i) Write an equation for the reaction of the weak acid, hypochlorous acid, HOCl, with water.

(ii) List all the species present when HOCl reacts with water, in order of decreasing concentration.

Order of decreasing concentration:

Justify your order.

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(b) Hypochlorous acid has a pK_a of 7.53. Another weak acid, hydrofluoric acid, HF, has a pK_a of 3.17.

A 0.100 mol L^{-1} solution of each acid was prepared by dissolving it in water.

Compare the pHs of these two solutions.

No calculations are necessary.

(c) An aqueous solution containing a mixture of HF and sodium fluoride, NaF, can act as a buffer solution.

Calculate the mass of NaF that must be added to 150 mL of 0.0500 mol L^{-1} HF to give a buffer solution with a pH of 4.02.

Assume there is no change in volume.

M(NaF) = 42.0 g mol^{-1} pK_a(HF) = 3.17

QUESTION TWO

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A flask contains a saturated solution of $PbC1_2$ in the presence of undissolved $PbC1_2$.

(a) (i) Write the equation for the dissolving equilibrium in a saturated solution of $PbC1_2$.

(ii) Write the expression for $K_s(PbC1_2)$.

(iii) Calculate the solubility (in mol L^{-1}) of lead(II) chloride in water at 25°C, and give the $[Pb^{2+}]$ and $[Cl^-]$ in the solution.

$K_s(PbC1_2) = 1.70 \times 10^{-5}$ at 25°C

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(b) A sample of seawater has a chloride ion concentration of 0.440 mol L^{-1}.

Determine whether a precipitate of lead(II) chloride will form when a 2.00 g sample of lead(II) nitrate is added to 500 mL of the seawater.

$K_s(PbCl_2) = 1.70 \times 10^{-5}$ $M(Pb(NO_3)_2) = 331$ g mol^{-1}

(c) The solubility of zinc hydroxide, $Zn(OH)_2$, can be altered by changes in pH. Some changes in pH may lead to the formation of complex ions, such as the zincate ion, $[Zn(OH)_4]^{2-}$.

Use equilibrium principles to explain why the solubility of zinc hydroxide increases when the pH is less than 4 or greater than 10.

No calculations are necessary.

QUESTION THREE

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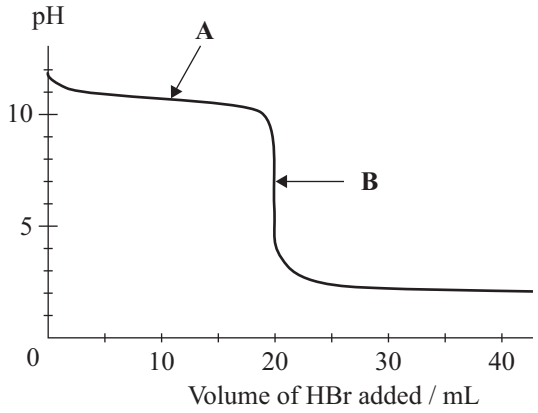
A titration was carried out by adding hydrobromic acid, HBr, to 20.0 mL of aqueous methylamine, CH_3NH_2, solution.

The equation for the reaction is:

$$CH_3NH_2 + HBr \rightarrow CH_3NH_3^+ + Br^-$$

$$K_a(CH_3NH_3^+) = 2.29 \times 10^{-11}$$

The curve for this titration is given below:



(a) Explain why the pH does not change significantly between the addition of 5 to 15 mL of HBr (around point **A** on the curve).

Include any relevant equation(s) in your answer.

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(b) The aqueous methylamine, CH_3NH_2, solution has a pH of 11.8 before any HBr is added.

Show by calculation that the concentration of this solution is 0.0912 mol L^{-1}.

(c) (i) Write the formulae of the four chemical species, apart from water and OH^-, that are present at the point marked **B** on the curve.

(ii) Compare and contrast the solution at point **B** with the initial aqueous methylamine solution.

In your answer you should include:

- a comparison of species present AND their relative concentrations
- a comparison of electrical conductivity linked to the relevant species present in each solution
- equations to support your answer.

There is more space for your answer to this question on the following page.

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

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