Chemistry

Higher level

Paper 2

Practice paper

Topic: Acid/Base Chemistry

Chemistry

Higher level

Paper 2

Specimen paper

2 hours 15 minutes

Instructions to candidates

- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is [65 marks].

1. Ammonia, $NH_3(aq)$, is a weak base. A 20.0 cm^3 sample of 0.150 mol dm^{-3} aqueous ammonia is titrated with 0.100 mol dm^{-3} hydrochloric acid, HCl(aq), at 298 K. The pK_b of ammonia is 4.75.

(a) Calculate the volume of HCl(aq) required to reach the equivalence point. **[2]**

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(b) Determine the pH of the initial 0.150 mol dm^{-3} ammonia solution. **[3]**

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(c) Calculate the pH of the solution after the addition of exactly 15.0 cm^3 of HCl(aq). **[4]**

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2. Aqueous solutions of salts can be acidic, basic, or neutral depending on the hydrolysis of their constituent ions.

(a) Identify whether a 0.1 mol dm^{-3} solution of ammonium chloride, $NH_4Cl(aq)$, is acidic, neutral, or basic. Justify your answer using a relevant ionic equation. **[2]**

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(b) Calculate the pH of a 0.20 mol dm^{-3} solution of sodium ethanoate, $CH_3COONa(aq)$, at 298 K. The pK_a of ethanoic acid is 4.76. **[4]**

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3. An acidic buffer is prepared by dissolving 0.050 moles of propanoic acid (C_2H_5COOH, $K_a = 1.34 \times 10^{-5}$) and 0.050 moles of sodium propanoate (C_2H_5COONa) in water to make 1.00 dm^3 of solution.

(a) Calculate the pH of this original buffer solution. **[1]**

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(b) Calculate the new pH of the buffer solution if 0.0050 moles of solid sodium hydroxide, NaOH(s), is added, assuming the total volume remains 1.00 dm^3. **[3]**

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(c) Calculate the total amount, in moles, of strong acid that would need to be added to completely destroy the buffering action of this specific mixture. **[1]**

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4. An indicator, HIn, is a weak acid that changes color according to the equilibrium:
$HIn(aq)$ [yellow] $\rightleftharpoons H^+(aq) + In^-(aq)$ [red]

(a) The K_a of this indicator is 2.5×10^{-5}. Calculate the pH at which the indicator will appear distinctly orange (the exact end-point). **[2]**

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(b) State Le Chatelier's principle and use it to explain why the indicator appears yellow in a solution of pH 2.0. **[2]**

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5. The concept of Lewis acids and bases encompasses a wider range of reactions than the Brønsted-Lowry theory.

(a) Define a Lewis base. **[1]**

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(b) In the reaction between boron trifluoride, BF_3, and ammonia, NH_3, identify the Lewis acid and the Lewis base, justifying your answer. **[2]**

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(c) Explain the connection between Lewis acid-base theory and the terms nucleophile and electrophile as used in organic chemistry. **[2]**

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6. A student measures the electrical conductivity of a solution during a titration of $Ba(OH)_2(aq)$ with $H_2SO_4(aq)$.

(a) Formulate the word and symbol equation for this continuous titration. **[1]**

(b) Describe and explain the shape of the conductivity curve from the start of the titration until the equivalence point is reached. **[3]**

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7. The autoionization of water is an endothermic process: $H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$

(a) At 313 K (40 °C), the value of the ionic product of water, K_w, is 2.92×10^{-14}. Calculate the pH of pure water at 313 K. **[2]**

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(b) State and explain whether water at 313 K is neutral, predicting the effect of temperature on the neutrality of water. **[2]**

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