Chemistry
Paper 2

Time allowed
• Perusal time — 10 minutes
• Working time — 90 minutes

General instructions
• Answer all questions in this question and response book.
• Write using black or blue pen.
• QCAA-approved calculator permitted.
• QCAA formula and data book provided.
• Planning paper will not be marked.

Section 1 (60 marks)
• 5 short response questions
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Section 1

Instructions

• If you need more space for a response, use the additional pages at the back of this book.
  – On the additional pages, write the question number you are responding to.
  – Cancel any incorrect response by ruling a single diagonal line through your work.
  – Write the page number of your alternative/additional response, i.e. See page …
  – If you do not do this, your original response will be marked.
QUESTION 1 (12 marks)

When zinc metal was placed into a blue solution of copper(II) nitrate, the solution became colourless and a red-brown deposit of copper formed on the bottom of the beaker.

a) Identify if the reaction that occurred can be classified as a redox reaction. Explain your reasoning. [3 marks]

b) When the copper deposited in the reaction was collected and reacted with concentrated nitric acid, copper(II) nitrate solution and nitrogen dioxide gas formed.

\[ \text{Cu(s)} + 4\text{HNO}_3(\text{aq}) \rightarrow \text{Cu(NO}_3)_2(\text{aq}) + 2\text{NO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \]  \[ E^\circ = +0.46 \text{ V} \]

i) Determine the reduction half-equation for this reaction. [2 marks]

ii) Determine the standard reduction potential, \( E^\circ \), for the reduction half-equation. [1 mark]
c) Apply your understanding of standard reduction potentials to explain why:

i) copper can dissolve in concentrated nitric acid, but does not dissolve in concentrated hydrochloric acid.  

[3 marks]

ii) NO\textsubscript{2} is the gaseous product, rather than H\textsubscript{2}, when copper dissolves in nitric acid.  

[3 marks]
QUESTION 2 (12 marks)

Salicylic acid reacts with ethanoic anhydride in an aqueous solution to produce acetylsalicylic acid, as shown in the equation. Acetylsalicylic acid is commonly known as aspirin.

\[
\text{salicylic acid (C}_7\text{H}_6\text{O}_3) + \text{ethanoic anhydride (C}_4\text{H}_6\text{O}_3) \xrightleftharpoons{H^+} \text{acetylsalicylic acid (C}_9\text{H}_8\text{O}_4) + \text{ethanoic acid (C}_2\text{H}_4\text{O}_2)
\]

a) Identify the type of chemical reaction used to produce aspirin. [1 mark]

b) Write the equilibrium expression, \(K_c\), for the reaction. [1 mark]

c) At 20 °C, the equilibrium constant \(K_c\) for the reaction is \(2 \times 10^{-3}\). Determine whether the concentration of the reactants or products is greater at equilibrium at this temperature. [2 marks]
d) Calculate the minimum mass of salicylic acid required to produce 500.0 mg of aspirin if the yield of aspirin is 45.0%. Show your working. [4 marks]

\[
\text{Mass} = \underline{\text{mg (to three significant figures)}}
\]

e) When the reaction is heated to 40 °C and equilibrium is re-established, the concentration of acetylsalicylic acid and ethanoic acid increases. Apply Le Châtelier’s principle to predict if the forward reaction is exothermic or endothermic. Explain your reasoning. [4 marks]
QUESTION 3 (9 marks)

Ethanol can be produced by the fermentation of glucose or the hydration of ethene.

a) Describe the production of ethanol by fermentation of glucose by writing a balanced equation and indicating if a catalyst is required. [3 marks]

b) Calculate the atom economy for the production of ethanol by fermentation of glucose. [2 marks]

\[ \text{Atom economy} = \frac{\text{actual yield}}{\text{possible yield}} \times 100\% \]

c) In terms of atom economy, determine which process for the production of ethanol (i.e. hydration of ethene or fermentation of glucose) is greener. [2 marks]
d) Identify two principles of green chemistry, other than atom economy, that make the production of ethanol by fermentation greener than by hydration. [2 marks]
QUESTION 4 (10 marks)
Consider the organic molecule shown.

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{C} \quad \text{C} \quad \text{H}_2 \\
\text{H}_3\text{C} & \quad \text{C} \quad \text{CH}_2
\end{align*}
\]

a) Identify the molecule as saturated or unsaturated. [1 mark]

b) Apply IUPAC rules to name this molecule. [1 mark]

c) Write an equation to show the products formed by the hydration of this molecule. [2 marks]

d) Predict which is the major product formed in c). [1 mark]
e) Identify a physical property and experimental technique that could be used to separate products formed by hydration in c). Explain your reasoning. [5 marks]
QUESTION 5 (17 marks)

Compound A reacts with water to produce compound B and hydroxide ions.

\[ \text{CH}_3\text{CH}_2\text{NH}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{C}_2\text{H}_5\text{NH}_3^+ (\text{aq}) + \text{OH}^- (\text{aq}) \]

A \hspace{2cm} B

a) Apply IUPAC rules to name compound A. [1 mark]

b) Identify the Brønsted-Lowry acids in the equation. [2 marks]

c) A small amount of hydrochloric acid is added to the equilibrium mixture. Predict the effect of this on the concentration of compound A in the mixture. Explain your reasoning. [3 marks]

d) Calculate the pH of a 2.0 M solution of compound A. State any assumptions.

Show your working. \((K_b = 5.6 \times 10^{-4})\) [6 marks]
e) Describe, using a balanced chemical equation, how Compound A could be made from bromomethane. Include relevant conditions and reagents in your response. [5 marks]
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