LUI | | | | | | | | | | School code | | | |

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Attach your barcode ID label here

Book of books used

External assessment 2021

Question and response book

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 (51 marks)

- 5 short response questions

Queensland Government | QCAA Queensland Curriculum & Assessment Authority

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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.

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QUESTION 1 (11 marks)

Phosphoric acid (H_3PO_4) is a common triprotic acid that dissociates fully in three stages. The dissociation equations are shown in the table.

Stage	Dissociation equation	K_a
1	$H_3PO_4(aq) + H_2O(l) \rightleftharpoons H_2PO_4^-(aq) + H_3O^+(aq)$	7.1×10^{-3}
2	$H_2PO_4^-(aq) + H_2O(l) \rightleftharpoons HPO_4^{2-}(aq) + H_3O^+(aq)$	6.5×10^{-8}
3	$HPO_4^{2-}(aq) + H_2O(l) \rightleftharpoons PO_4^{3-}(aq) + H_3O^+(aq)$	4.5×10^{-13}

a) Use the information to determine the strongest Brønsted-Lowry acid and its conjugate base. Explain your reasoning. *[3 marks]*

Acid: ____________________ Conjugate base: ____________________

Reasoning: ____________________

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b) Identify an amphiprotic species from the dissociation reactions. Explain your reasoning. *[2 marks]*

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c) Determine the K_b value for the strongest conjugate base formed when H_3PO_4 has fully dissociated. Show your working. *[2 marks]*

K_b = ________________ (to two significant figures)

d) Calculate the pH of a 0.05 M solution of dihydrogen phosphate ($H_2PO_4^-$). Show your working and state any assumptions made. *[4 marks]*

pH = ________________ (to one decimal place)

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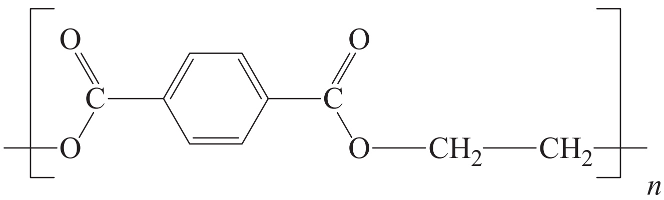
QUESTION 2 (10 marks)

Polypropene (PP) is a polymer formed from propene. Polyethylene terephthalate (PET) is a polymer formed from monomers of carboxylic acid and alcohol. A section of the PET polymer is shown.



a) Draw the structural formulas of the monomers used to form PET. *[2 marks]*

i) Carboxylic acid monomer

ii) Alcohol monomer

Note: If you make a mistake in the drawing, cancel it by ruling a single diagonal line through your work and use the additional response space on page 16 of this question and response book.

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b) Determine the type of polymerisation used to form PET. *[1 mark]*

c) Identify the functional group formed by the reaction of the monomers in PET. *[1 mark]*

d) Determine the type of polymerisation used to form PP. *[1 mark]*

e) Explain how the position of the methyl group on the polymer chain affects the strength of isotactic PP, relative to syntactic PP. *[5 marks]*

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QUESTION 3 (11 marks)

Four colourless liquids, A, B, C and D, are known to be butane, 1-butene, 2-butanol and 1-propanol. Reactions are carried out to identify the liquids. The results are shown.

Test 1	A	B	C	D
Bromine (Br_2) water	No reaction	No reaction	No reaction	Decolourised

Test 2	A	B	C
Excess acidified potassium manganate(VII) ($KMnO_4$) solution, heated gently	Decolourised, Compound X formed	Decolourised, Compound Y formed	No reaction

Test 3	Compound X	Compound Y
Ethanol and concentrated sulfuric acid solution, heated gently and refluxed	Fruity smell produced, Compound Z formed	No apparent reaction

a) Identify Compound D. Explain your reasoning. *[2 marks]*

b) Write a balanced equation to describe the decolourisation of bromine (Br_2) water by Compound D. Apply IUPAC rules to name the product formed. *[2 marks]*

IUPAC name: ____________________

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c) Identify Compound C. Explain your reasoning. *[3 marks]*

d) Draw the structural formula of Compound Y. *[1 mark]*

Note: If you make a mistake in the drawing, cancel it by ruling a single diagonal line through your work and use the additional response space on page 17 of this question and response book.

e) Identify Compound B. *[1 mark]*

f) Draw the structural formula of Compound Z. *[1 mark]*

Note: If you make a mistake in the drawing, cancel it by ruling a single diagonal line through your work and use the additional response space on page 17 of this question and response book.

g) Apply IUPAC rules to name Compound Z. *[1 mark]*

IUPAC name: ____________________

QUESTION 4 (9 marks)

5.00×10^{-4} moles of hydrogen gas is mixed with 1.00×10^{-3} moles of iodine vapour in a sealed 1.00 L vessel at 455.0 °C. The concentration of hydrogen iodide gas formed at equilibrium is 9.30×10^{-4} M.

The balanced equation for the reaction is shown.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

a) Write the equilibrium law expression for the reaction. *[1 mark]*

b) Calculate the equilibrium constant (K_c) for the reaction at 455.0 °C.
Show your working. *[5 marks]*

K_c = ____________ (to three significant figures)

Do not write outside this box.

c) Predict the effect that adding a catalyst would have on the reaction rates, position of the equilibrium and value of K_c. *[3 marks]*

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QUESTION 5 (10 marks)

A sample of iron ore was tested for its iron content using the experimental procedure outlined.

$$\boxed{\text{8.00 g of iron ore sample}} \xrightarrow{\textit{Reacted with } H_2SO_4(aq)} \boxed{Fe^{2+}(aq)} \xrightarrow{\textit{Titrated with } KMnO_4(aq)} \boxed{Fe^{3+}(aq)}$$

All the iron (Fe) in the sample was converted to $Fe^{2+}(aq)$ by reacting it with $H_2SO_4(aq)$, forming hydrogen gas. The solution made up to a final volume of 500.0 mL. A 25.00 mL aliquot of the Fe^{2+} aqueous solution was titrated with a standardised solution of 0.0500 M $KMnO_4$. An average titre of 16.40 mL was obtained.

a) Write a balanced chemical equation for the reaction between the iron (Fe) in the ore sample and sulfuric acid. *[1 mark]*

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b) Identify the species oxidised in the reaction in Question 5a). Explain your reasoning. *[2 marks]*

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c) Apply your understanding of half-equations to balance the redox equation. *[2 marks]*

$$MnO_4^-(aq) + \_\_\_\_ H^+(aq) + \_\_\_\_ Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + \_\_\_\_ H_2O(l) + \_\_\_\_ Fe^{3+}(aq)$$

d) Calculate the percentage of iron (Fe) in the ore sample. Show your working. *[5 marks]*

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Percentage iron (Fe) in ore sample = ______________ % (to one decimal place)

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ADDITIONAL PAGE FOR STUDENT RESPONSES

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ADDITIONAL RESPONSE SPACE FOR QUESTION 2a)

If you want this drawing to be marked, rule a single diagonal line through the drawing on page 4.

i) Carboxylic acid monomer

ii) Alcohol monomer

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ADDITIONAL RESPONSE SPACE FOR QUESTION 3d)

If you want this drawing to be marked, rule a single diagonal line through the drawing on page 7.

ADDITIONAL RESPONSE SPACE FOR QUESTION 3f)

If you want this drawing to be marked, rule a single diagonal line through the drawing on page 7.

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