External assessment 2023

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 (54 marks)

- 9 short response questions

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.

DO NOT WRITE ON THIS PAGE

THIS PAGE WILL NOT BE MARKED

QUESTION 1 (2 marks)

Polylactic acid (PLA) and low-density polyethylene (LDPE) are both used to produce plastic wrapping film.

Plastic	Composition	Density (g/cm^3)	Tensile stress (MPa)	Elongation (%)	Degradation rate
PLA	plant-based	1.24	60	6	slow
LDPE	petrochemical-based	0.92	12	148	none

Analyse the data to discuss one advantage and one disadvantage of using PLA rather than LDPE to produce plastic wrapping film.

Advantage: _____

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Disadvantage: _____

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QUESTION 2 (3 marks)

Compare the structure of α-helix and β-pleated sheets in the secondary structure of proteins.

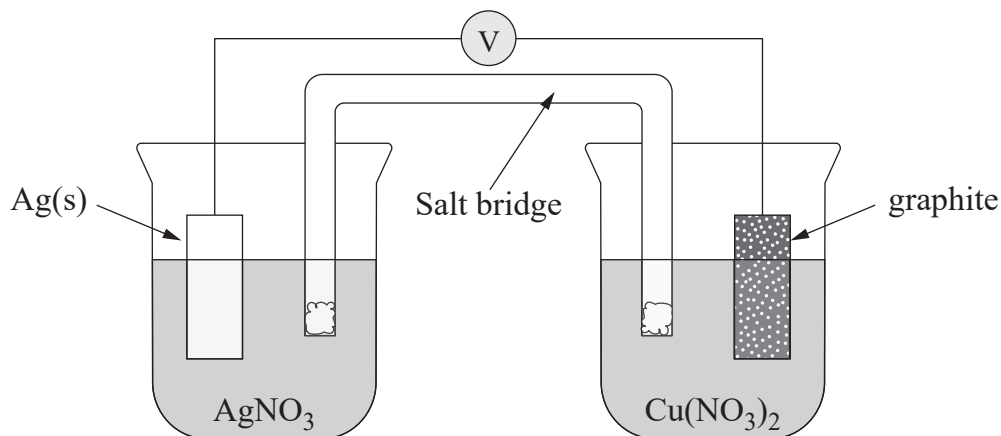Similarity: _____

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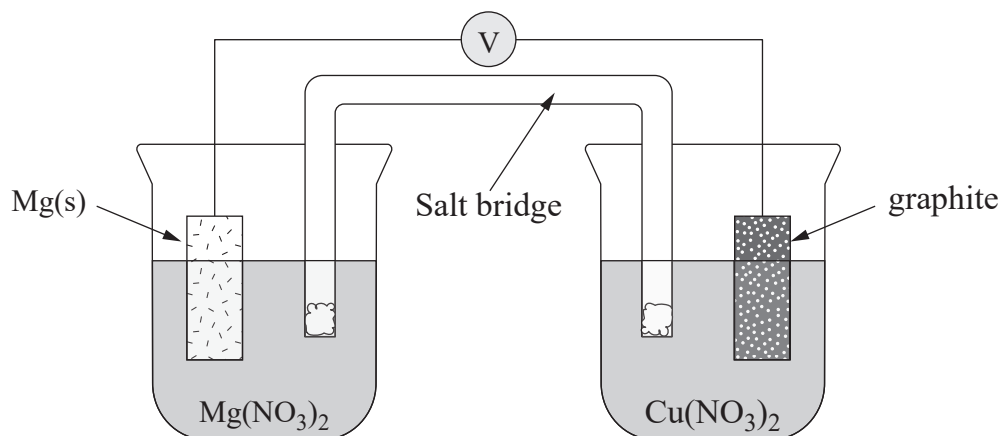Difference: _____

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Significance: _____

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QUESTION 3 (7 marks)

An experiment was conducted at standard state conditions to investigate the potential difference (V) produced by different galvanic cells. The three cells used in the experiment are shown.
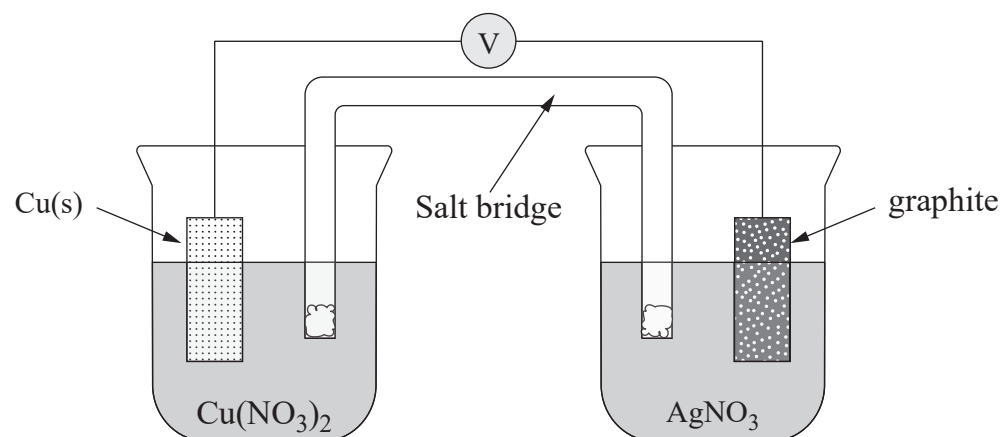
Cell 1

Ag(s)

Salt bridge

graphite

$AgNO_3$

$Cu(NO_3)_2$

Cell 2

Mg(s)

Salt bridge

graphite

$Mg(NO_3)_2$

$Cu(NO_3)_2$

Cell 3

Cu(s)

Salt bridge

graphite

$Cu(NO_3)_2$

$AgNO_3$

(a) Predict which cell produced the highest voltage. Explain your reasoning.   *[3 marks]*

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(b) Determine the maximum voltage that could be produced by a fourth galvanic cell constructed from any of the components used in the first three cells. Use oxidation and reduction half-equations to justify your answer.   *[4 marks]*

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QUESTION 4 (8 marks)

Compound C has the molecular formula $C_4H_{10}O$ and is either an alcohol, an aldehyde or a carboxylic acid.

Compound C infrared spectrum
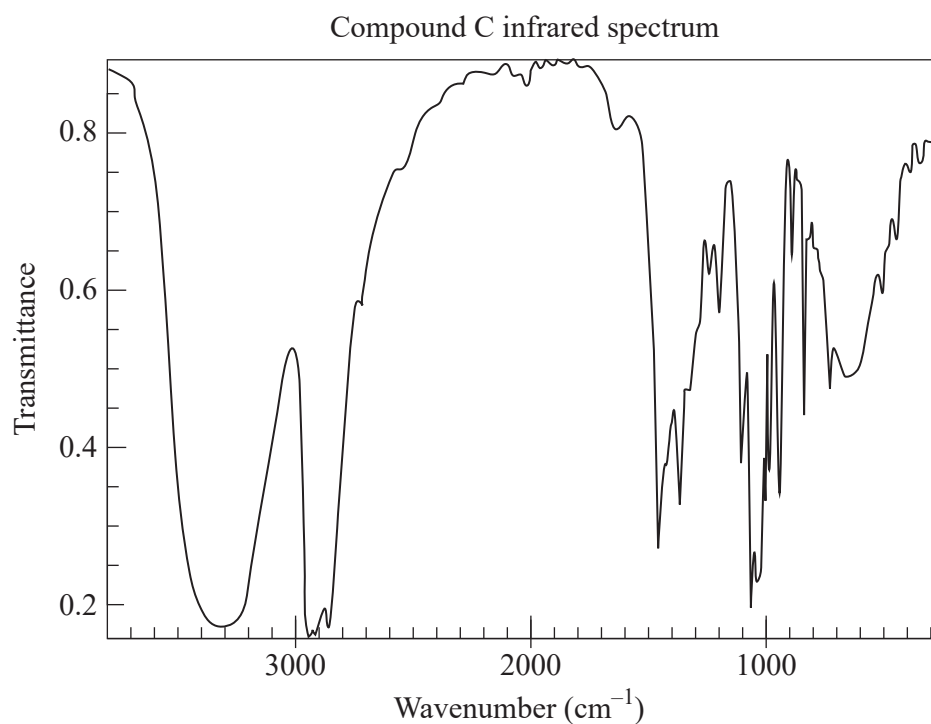
(a) Deduce the class of compound C. Explain your reasoning.   *[4 marks]*

(b) Deduce the structural formula and IUPAC name of two isomers of compound C. *[2 marks]*

Isomer 1:

IUPAC name: _____

Isomer 2:

IUPAC name: _____

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 at the back of this question and response book.

(c) Distinguish between structural and geometric isomers. *[2 marks]*

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QUESTION 5 (13 marks)

The table gives the properties of four monoprotic acids.

Acid	Concentration (mol L^{-1})	[H$^+$] (mol L^{-1})	pH	K_a
1	0.200	7.90×10^{-5}		
2	0.100	4.20×10^{-3}	2.34	1.80×10^{-4}
CH$_3$COOH(aq)	0.100			1.78×10^{-5}
HCl(aq)	0.010	1.00×10^{-2}	2.00	>1

(a) Determine the relative strength of acids 1 and 2 by contrasting their K_a values.　　　*[3 marks]*

(b) Write a balanced chemical equation for the dissociation of ethanoic acid (CH$_3$COOH) in water.　　　*[2 marks]*

(c) Identify whether the conjugate base of ethanoic acid (CH$_3$COOH(aq)) is amphiprotic. Explain your reasoning.　　　*[2 marks]*

(d) Calculate the pH of the aqueous solution of ethanoic acid (CH₃COOH). Show your working. *[3 marks]*

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(e) Determine the volume of water that would need to be added to 100.0 mL of HCl(aq) to change the pH from 2.00 to 3.00. Explain your reasoning. *[3 marks]*
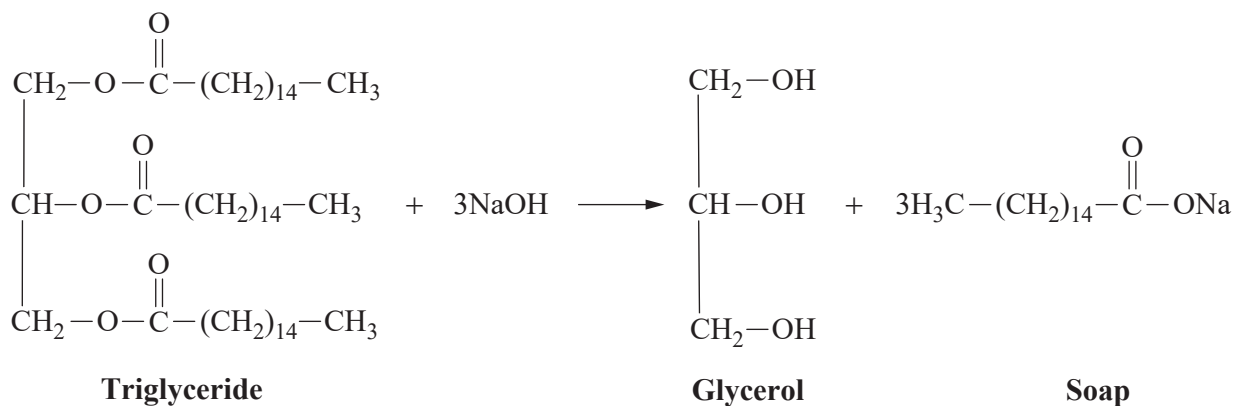
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QUESTION 6 (6 marks)

The reaction shows the base hydrolysis (saponification) of a triglyceride to produce glycerol and a soap.

$$
\begin{array}{cccc}
\underset{\textbf{Triglyceride}}{
\begin{array}{l}
CH_2-O-\overset{\displaystyle O}{\overset{\|}{C}}-(CH_2)_{14}-CH_3 \\[2pt]
CH-O-\overset{\displaystyle O}{\overset{\|}{C}}-(CH_2)_{14}-CH_3 \\[2pt]
CH_2-O-\overset{\displaystyle O}{\overset{\|}{C}}-(CH_2)_{14}-CH_3
\end{array}}
& +\ 3NaOH\ \longrightarrow
& \underset{\textbf{Glycerol}}{
\begin{array}{l}
CH_2-OH \\[2pt]
CH-OH \\[2pt]
CH_2-OH
\end{array}}
& +\ \underset{\textbf{Soap}}{3H_3C-(CH_2)_{14}-\overset{\displaystyle O}{\overset{\|}{C}}-ONa}
\end{array}
$$

(a) Identify which compound in the reaction is an ester.   *[1 mark]*

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(b) Contrast the structure of saturated and unsaturated fatty acids.   *[1 mark]*

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(c) Explain how the cleaning action of soap is related to its structure.   *[4 marks]*

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QUESTION 7 (4 marks)

When heated in a sealed container, solid mercury(II) oxide (HgO) decomposed to form metallic mercury (Hg) and oxygen gas (O_2).

$$2HgO(s) \rightleftharpoons 2Hg(l) + O_2(g)$$

Orange   Silver   Colourless
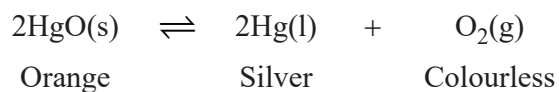
(a) Identify whether the reaction occurs in an open or closed system.   *[1 mark]*

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(b) Explain why the colour of the system does not change once equilibrium is established.   *[3 marks]*

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QUESTION 8 (7 marks)

Two experiments were conducted to investigate the effect of temperature on the equilibrium formed during the decomposition of hydrogen iodide (HI).

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g) \qquad \Delta H = +53.6 \text{ kJ mol}^{-1}$$

Experiment	Initial concentration (mol L^{-1})			Equilibrium concentration (mol L^{-1})			K_c
	[HI]	[H$_2$]	[I$_2$]	[HI]	[H$_2$]	[I$_2$]	
1	0.08	0.00	0.00		0.01		2.78×10^{-2}
2	0.00	0.06	0.06	0.06	0.03	0.03	

(a) Determine the concentration of HI(g) and I$_2$(g) at equilibrium for experiment 1.   *[2 marks]*

[HI]: _____

[I$_2$]: _____

(b) Calculate the equilibrium constant (K_c) for experiment 2. Show your working.   *[2 marks]*

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(c) Determine which experiment was conducted at a higher temperature.
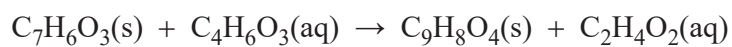Explain your reasoning.   *[3 marks]*

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QUESTION 9 (4 marks)

Aspirin ($C_9H_8O_4$) can be produced from a reaction between salicylic acid ($C_7H_6O_3$) and acetic anhydride ($C_4H_6O_3$) with ethanoic acid being a minor product.

$$C_7H_6O_3(s) + C_4H_6O_3(aq) \rightarrow C_9H_8O_4(s) + C_2H_4O_2(aq)$$

Calculate the mass of salicylic acid required to produce 8.25 g of aspirin if the percentage yield of the reaction is 60%. Show your working.

END OF PAPER

ADDITIONAL PAGE FOR STUDENT RESPONSES

Write the question number you are responding to.

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Write the question number you are responding to.

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References

Question 4

Minor adaptation from Coblentz Society, Inc., 2-Butanol 2018, in NIST Chemistry WebBook, NIST Standard Reference Database Number 69, Nist.gov, National Institute of Standards and Technology, U.S. Secretary of Commerce https://webbook.nist.gov/cgi/cbook.cgi?ID=C78922&Type=IR-SPEC&Index=1