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

School name

Given name/s

Family name

Attach your barcode ID label here

Book of books used

External assessment 2025

Question and response book

Chemistry

Paper 1

Time allowed

- Perusal time — 10 minutes
- Working time — 90 minutes

General instructions

- Answer all questions in this question and response book.
- QCAA-approved calculator permitted.
- QCAA formula and data book provided.
- Planning paper will not be marked.

Section 1 (20 marks)

- 20 multiple choice questions

Section 2 (35 marks)

- 9 short response questions

Clear zone — margin trimmed off after completion of assessment

Queensland Government | QCAA Queensland Curriculum & Assessment Authority

DO NOT WRITE ON THIS PAGE

THIS PAGE WILL NOT BE MARKED

Section 1

Instructions

- This section has 20 questions and is worth 20 marks.
- Use a 2B pencil to fill in the A, B, C or D answer bubble completely.
- Choose the best answer for Questions 1–20.
- If you change your mind or make a mistake, use an eraser to remove your response and fill in the new answer bubble completely.

	A	B	C	D
Example:	●	○	○	○

	A	B	C	D
1.	○	○	○	○
2.	○	○	○	○
3.	○	○	○	○
4.	○	○	○	○
5.	○	○	○	○
6.	○	○	○	○
7.	○	○	○	○
8.	○	○	○	○
9.	○	○	○	○
10.	○	○	○	○
11.	○	○	○	○
12.	○	○	○	○
13.	○	○	○	○
14.	○	○	○	○
15.	○	○	○	○
16.	○	○	○	○
17.	○	○	○	○
18.	○	○	○	○
19.	○	○	○	○
20.	○	○	○	○

Ensure you have filled an answer bubble for each question.

Do not write outside this box.

Section 2

Instructions

- Write using black or blue pen.
- 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.
- This section has nine questions and is worth 35 marks.

QUESTION 21 (2 marks)

An unknown acid, HA, undergoes 1.3% ionisation in an aqueous solution.

$$HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$$

a) Classify HA as a strong or weak acid. *[1 mark]*

b) Explain whether HA is a monoprotic or polyprotic acid. *[1 mark]*

QUESTION 22 (2 marks)

Determine the oxidation state of manganese in Mn_2O_3 and name the ionic compound.

Oxidation state (Mn): _____

Name of ionic compound (Mn_2O_3): _____

Do not write outside this box.

QUESTION 23 (2 marks)

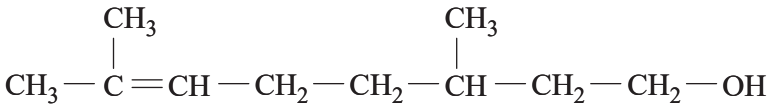
Identify two limitations associated with standard electrode (reduction) potentials ($E°$).

1: _____

2: _____

QUESTION 24 (4 marks)

Citronellol is a common ingredient used in the fragrance industry and a component of citronella oil, an insect repellant. Its structure is shown.



a) Classify citronellol as saturated or unsaturated. Explain your reasoning. *[2 marks]*

b) Describe a chemical test that could be used to confirm whether citronellol is saturated or unsaturated. *[2 marks]*

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QUESTION 25 (4 marks)

But-2-ene can form structural isomers and geometric isomers.

a) Draw one structural isomer of but-2-ene and apply IUPAC rules to name this isomer. *[2 marks]*

IUPAC name: _____

b) Draw one geometric isomer of but-2-ene and apply IUPAC rules to name this isomer. *[2 marks]*

IUPAC name: _____

Note: If you make a mistake, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this book.

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QUESTION 26 (3 marks)

One step of the contact process involves reacting sulfur dioxide (SO_2) and oxygen (O_2) to produce sulfur trioxide (SO_3), as shown.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The equilibrium constant (K_c) for the forward reaction is 5.6×10^4 at 350 °C and 9.2×10^1 at 800 °C.

a) Determine whether the forward reaction is exothermic or endothermic. *[1 mark]*

b) Apply Le Châtelier's principle to explain how changing pressure could be used to increase the production of SO_3 gas. *[2 marks]*

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QUESTION 27 (4 marks)

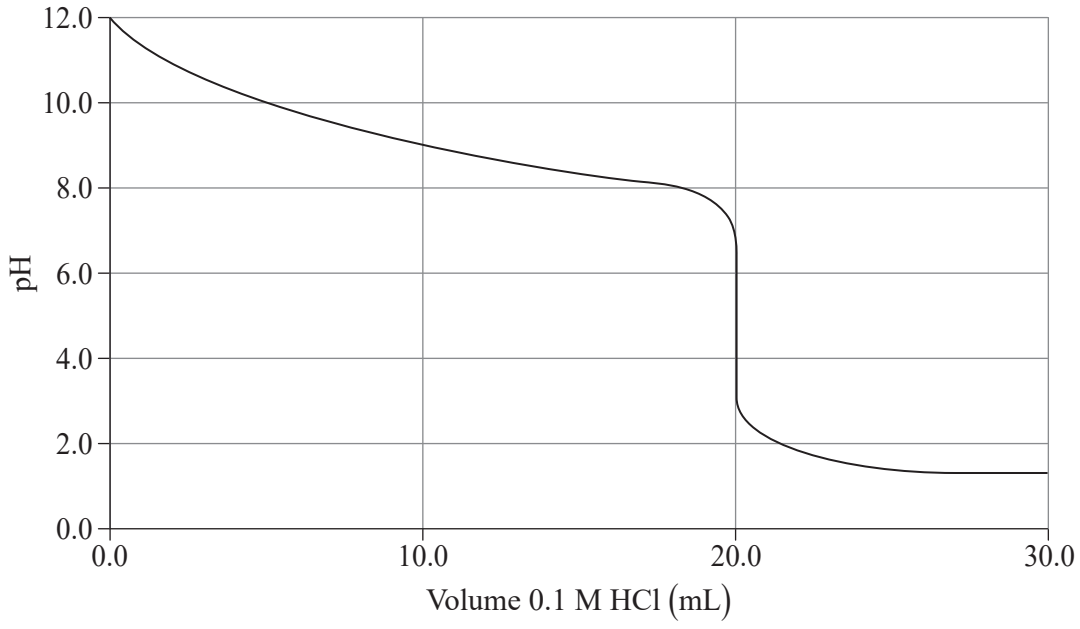
Determine the product formed at the cathode and the oxidation half-equation that occurs when various NaCl electrolytes undergo electrolysis using inert electrodes. Include states of matter in your response.

Electrolyte	Cathode product	Oxidation half-equation
concentrated (25%) $NaCl(aq)$		
molten $NaCl(l)$		

QUESTION 28 (8 marks)

A 10.0 mL volume of a weak monoprotic base (BOH) was pipetted into a volumetric flask and diluted to a final volume of 50.0 mL using distilled water. A 25.0 mL aliquot of the BOH solution was then titrated with 0.1 M hydrochloric acid (HCl). The reaction and titration curve are shown.

$$BOH(aq) + HCl(aq) \rightarrow BCl(aq) + H_2O(l)$$



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a) Determine the pK_b of BOH. *[1 mark]*

b) Calculate the concentration of BOH in the original 10.0 mL solution. Show your working. *[3 marks]*

c) Determine whether the following features of the titration curve would change if 10.0 mL of 0.2 M sodium hydroxide (NaOH) was titrated with 0.1 M hydrochloric acid (HCl). Explain your reasoning. *[4 marks]*

The pH of the equivalence point:

The volume of HCl required to reach the equivalence point:

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QUESTION 29 (6 marks)

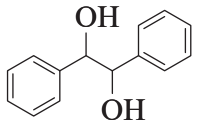
The oxidation of *meso*-hydrobenzoin $(C_{14}H_{14}O_2)$ to produce benzaldehyde (C_7H_6O) was carried out via three different reaction pathways to evaluate atom economy and E-factor.

Atom economy is a measure of reaction efficiency based on the percentage of the total mass of reactants successfully converted to the desired product.

E-factor is a measure of environmental impact based on the mass of waste generated per kilogram of desired product.

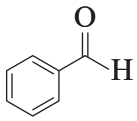
$$\text{Atom economy} = \frac{\text{molecular weight (desired product)}}{\text{molecular weight (reactants)}} \qquad \text{E-factor} = \frac{\text{mass (waste) kg}}{\text{mass (desired product) kg}}$$

meso-hydrobenzoin



$C_{14}H_{14}O_2$
(molecular weight = 214.28 g mol^{-1})

benzaldehyde



C_7H_6O
(molecular weight = 106.13 g mol^{-1})

Reactants	Reaction pathway	Products	Benzaldehyde produced (kg)	E-factor
$C_{14}H_{14}O_2 + \frac{1}{2}O_2$	$\xrightarrow{\text{Na-MnO}_x\text{ catalyst}}$	$2C_7H_6O + H_2O$	1	5.2
$C_{14}H_{14}O_2 + NaIO_4$	$\xrightarrow{\text{Malaprade oxidation}}$	$2C_7H_6O + NaIO_3 + H_2O$	1	13.9
$C_{14}H_{14}O_2 + Pb(OAc)_4$	$\xrightarrow{\text{Criegee oxidation}}$	$2C_7H_6O + Pb(OAc)_2 + 2AcOH$	1	3.2

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a) Identify one principle of green chemistry, other than atom economy, that could be used in the production of benzaldehyde from *meso*-hydrobenzoin. Explain your reasoning. *[2 marks]*

b) Evaluate the production of benzaldehyde from *meso*-hydrobenzoin in terms of atom economy and E-factor. Provide evidence for your reasoning. *[4 marks]*

END OF PAPER

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ADDITIONAL PAGE FOR STUDENT RESPONSES

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References

Question 29

Table adapted from Chun Ho Lam, Vincent Escande, Karolina E. Mellor, Julie B. Zimmerman, and Paul T. Anastas 2019, 'Teaching Atom Economy and E-Factor Concepts through a Green Laboratory Experiment: Aerobic Oxidative Cleavage of *meso*-Hydrobenzoin to Benzaldehyde Using a Heterogeneous Catalyst', *Journal of Chemical Education,* 96 (4), 761-765, DOI: 10.1021/acs.jchemed.8b00058

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