Chemistry marking guide and response

External assessment 2023

Combination response (111 marks)

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

1. describe and explain chemical equilibrium systems, oxidation and reduction, properties and structure of organic materials, and chemical synthesis and design
2. apply understanding of chemical equilibrium systems, oxidation and reduction, properties and structure of organic materials, and chemical synthesis and design
3. analyse evidence about chemical equilibrium systems, oxidation and reduction, properties and structure of organic materials, and chemical synthesis and design to identify trends, patterns, relationships, limitations or uncertainty
4. interpret evidence about chemical equilibrium systems, oxidation and reduction, properties and structure of organic materials, and chemical synthesis and design to draw conclusions based on analysis.

Note: Objectives 5, 6 and 7 are not assessed in this instrument.

Queensland Government
Queensland Curriculum & Assessment Authority
For all Queensland schools

Purpose

This document consists of a marking guide and a sample response.

The marking guide:

- provides a tool for calibrating external assessment markers to ensure reliability of results
- indicates the correlation, for each question, between mark allocation and qualities at each level of the mark range
- informs schools and students about how marks are matched to qualities in student responses.

The sample response demonstrates the qualities of a high-level response.

Mark allocation

Where a response does not meet any of the descriptors for a question or a criterion, a mark of ‘0’ will be recorded.

Where no response to a question has been made, a mark of ‘N’ will be recorded.

Allow FT mark/s — refers to ‘follow through’, where an error in the prior section of working is used later in the response, a mark (or marks) for the rest of the response can still be awarded so long as it still demonstrates the correct conceptual understanding or skill in the rest of the response.

Marking guide

Multiple choice

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

Paper 1: Short response

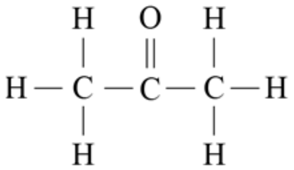
Q	Sample response	The response:
21	Increasing the concentration of O_2 increases the number of O_2 molecules. This increases the frequency of collisions between O_2 and CO. Therefore, the rate of the forward reaction increases and equilibrium shifts to the right (products) to increase the concentration of CO_2.	• identifies that increasing concentration of O_2 increases the number of O_2 molecules **[1 mark]** • explains that an increase in $[O_2]$ increases collisions between O_2 and CO **[1 mark]** • explains that the rate of forward reaction increases **[1 mark]** • identifies that equilibrium shifts to the right and concentration of CO_2 increases **[1 mark]**

Q	Sample response	The response:
22a)	$nF_2C=CF_2 \rightarrow [F_2C-CF_2]_n$	• describes formulas for tetrafluorethene monomer and polytetrafluorethene polymer **[1 mark]** • provides a balanced equation **[1 mark]**
22b)	Addition polymer The double bond in tetrafluorethene is broken to allow the monomers to join.	• identifies addition polymer **[1 mark]** • explains double bond in monomer is broken to allow the formation of polymer **[1 mark]**

Q	Sample response	The response:
23a)	Anode half-equation: $2H_2(g) \rightarrow 4H^+(aq) + 4e^-$ Cathode half-equation: $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$	• identifies anode half-equation **[1 mark]** • identifies cathode half-equation **[1 mark]**
23b)	Product Z is water.	• identifies product Z is water **[1 mark]**
23c)	Similarity: Electrons and hydrogen ions move from the anode towards the cathode. Difference: Hydrogen ions move through the proton exchange membrane while electrons move through the wire. Significance: Flow of electrons creates the potential difference.	• identifies electrons and hydrogen ions move from the anode to the cathode **[1 mark]** • identifies hydrogen ions move through the proton exchange membrane while electrons flow through the wire **[1 mark]** • identifies that movement of electrons creates potential difference **[1 mark]**

Q	Sample response	The response:
24	Metal R displaces Zn ions from solution but not Mg ions, therefore metal R is more reactive than Zn but less reactive than Mg. Therefore, metal R is manganese. Metal Q displaces Cu ions and Ag ions from solution but not Zn ions, therefore metal Q is more reactive than Cu but less reactive than Zn. $E^{o}_{cell} = E_{red} - E_{ox}$ $= +0.94 + (-1.18) = -0.24\ V$ Therefore, metal Q is Ni.	• uses the data to explain that metal R is more reactive than Zn and less reactive than Mg **[1 mark]** • identifies metal R is manganese **[1 mark]** • uses the data to explain that metal Q must be Ni, Co, Fe or Cr **[1 mark]** • uses the electrochemical data to determine $E^{o}_{metal\ Q} = -0.24V$ **[1 mark]** • identifies metal Q is Ni **[1 mark]**

Q	Sample response	The response:
25a)	+4	• determines that the oxidation state of vanadium is +4 **[1 mark]**
25b)	Vanadium in $V_2O_5(s)$ is acting as an oxidising agent in reaction 1 as the oxidation state decreased from $+5$ to $+4$ in $V_2O_4(s)$.	• determines that vanadium in $V_2O_5(s)$ is an oxidising agent **[1 mark]** • explains that oxidation state of vanadium decreases from $+5$ to $+4$ **[1 mark]**
25c)	Reaction 1: $V_2O_5(s)$ is converted to $V_2O_4(s)$ to allow SO_2 to be converted to SO_3. Reaction 2: $V_2O_4(s)$ is converted back to $V_2O_5(s)$ by reacting with O_2. Therefore, $V_2O_5(s)$ acts as a catalyst because it undergoes a temporary chemical change during the reaction but remains chemically unchanged at the end.	• identifies that $V_2O_5(s)$ is involved in the chemical reaction **[1 mark]** • uses data from reaction 1 to support chemical change to $V_2O_4(s)$ **[1 mark]** • uses data from reaction 2 to support chemical change to $V_2O_5(s)$ **[1 mark]** • explains that $V_2O_5(s)$ remains unchanged at the end of the reaction **[1 mark]**

Q	Sample response	The response:
26a)	IUPAC name: propene	• determines compound A is propene **[1 mark]**
26b)	Compound B (2-propanol) is a secondary alcohol. Propanol is a primary alcohol. The OH group is attached to the second carbon atom in compound B and the terminal carbon atom in propanol.	• identifies compound B is a secondary alcohol and propanol is a primary alcohol **[1 mark]** • explains that the OH group in propanol is attached to a terminal carbon while the OH group in compound B is attached to the second C in the parent chain **[1 mark]**
26c)	IUPAC name: propanone 	• deduces the structural formula for propanone **[1 mark]**
26d)	The purple colour of $KMnO_4$ would become lighter.	• describes a qualitative observation **[1 mark]**

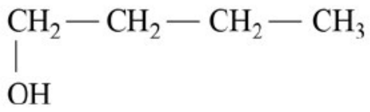
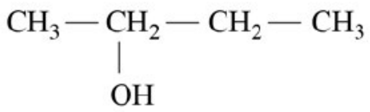
Q	Sample response	The response:
27a)	$HIn(aq) \rightleftharpoons In^{-}(aq) + H^{+}(aq)$ Phenolphthalein is colourless in its acidic form. Adding hydroxide ions removes hydrogen ions and shifts the equilibrium for the indicator towards the coloured anion, turning the indicator pink. The pH of the equivalence point lies within the pH range for the colour change for phenolphthalein, thus making it a suitable indicator for this titration.	• explains phenolphthalein is colourless in its acidic form **[1 mark]** • explains adding $OH^{-}(aq)$ removes $H^{+}(aq)$ **[1 mark]** • explains equilibrium shifts toward the coloured anion **[1 mark]** • explains pH equivalence point lies within the pH range of the colour change **[1 mark]**
27b)	The pH of the equivalence would remain the same. However, the volume of $NaOH$ required to reach the equivalence point would be halved to 2.5 mL because the $[OH^{-}]$ has doubled.	• determines the pH of the equivalence point would remain the same **[1 mark]** • determines the volume of $NaOH$ required to reach the equivalence would be halved **[1 mark]**

Paper 2: Short response

Q	Sample response	The response:
1	Advantage: An advantage is that PLA is plant based, therefore it uses (renewable) natural resources while LDPE is produced from non-renewable fossil fuels. Disadvantage: PLA has less % elongation than LDPE, therefore PLA would stretch less.	• identifies an advantage of using PLA using data **[1 mark]** • identifies a disadvantage of using PLA using data **[1 mark]**

Q	Sample response	The response:
2	Similarity: α-helix structure and β-pleated sheets both form H-bonds between two peptide bonds on polypeptide chains. Difference: α-helix structure contains intra-chain H-bonds while β-pleated sheets contain inter-chain H-bonds. Significance: α-helix structure produces a regular coiled configuration, whereas β-pleated structure produces a sheet.	• identifies both contain H-bonds between peptide bonds in the polypeptide chain **[1 mark]** • identifies α-helix structure contains intra-chain H-bonds while β-pleated sheets contain inter-chain H-bonds **[1 mark]** • explains α-helix is coiled and β-pleated forms sheets **[1 mark]**

Q	Sample response	The response:
3a)	Cell 1 is not spontaneous. Cell 2 is spontaneous and would produce voltage of 2.70 V. Cell 3 is spontaneous and would produce 0.46 V. Cell 2 would produce the highest voltage of the three cells.	• determines that cell 1 is not spontaneous **[1 mark]** • determines voltage of cells 2 and 3 **[1 mark]** • predicts which cell produces maximum voltage **[1 mark]**
3b)	The new cell would be constructed using Mg as the anode and Ag as the cathode. Anode half-equation: $\mathrm{Mg} \rightarrow \mathrm{Mg}^{2+} + 2\mathrm{e}^-$ (+2.36 V) Cathode half-equation: $\mathrm{Ag}^+ + \mathrm{e}^- \rightarrow \mathrm{Ag}$ (+0.80 V) $E^o_{cell} = 3.16\ \mathrm{V}$	• determines cell 4 constructed using Mg and Ag **[1 mark]** • identifies oxidation half-equation **[1 mark]** • identifies reduction half-equation **[1 mark]** • determines E^o_{cell} is 3.16 **[1 mark]**

Q	Sample response	The response:
4a)	Compound C is an alcohol which can be inferred from the broad peak between 3200–3600 cm^{-1} on infrared spectrum which indicates the presence of an OH functional group. Compound C cannot be an aldehyde as there is no peak at 1700–1750 cm^{-1} on infrared spectrum, therefore the compound does not contain a C=O functional group. Compound C cannot be a carboxylic acid since the molecular formula only contains one oxygen atom, therefore the compound does not contain a COOH functional group.	• determines that compound C is an alcohol **[1 mark]** • explains that the peak at 3200–3600 indicates OH functional group **[1 mark]** • explains that no peak at 2500–3000 indicates that compound C is not a carboxylic acid **[1 mark]** • explains that no peak at 1700–1750 indicates that compound C is not an aldehyde **[1 mark]**
4b)	Isomer 1:  IUPAC name: 1-butanol Isomer 2:  IUPAC name: 2-butanol	• deduces the structural formula and IUPAC name for – an isomer **[1 mark]** – a second isomer **[1 mark]**
4c)	Structural isomers have the same molecular formula but different structures. Geometric isomers have the same order of atom bonding but the atoms are arranged differently in space.	• explains structural isomers have the same molecular formula but different structure **[1 mark]** • explains geometric isomers have the same bonding of atoms, but the atoms are arranged differently in space **[1 mark]**

Q	Sample response	The response:
5a)	Acid 1: $K_a = \frac{[H^+][A^-]}{[HA]} = \frac{(7.90 \times 10^{-5})^2}{0.200} = 3.12 \times 10^{-8}$ Acid 2 has a larger K_a than acid 1. Therefore, acid 2 is a stronger acid.	• calculates K_a for acid 1 as 3.12×10^{-8} **[1 mark]** • identifies the K_a for acid 2 is greater than acid 1 **[1 mark]** • determines acid 2 is stronger **[1 mark]**
5b)	$CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$	• states balanced equation **[1 mark]** • uses an equilibrium arrow **[1 mark]**
5c)	Conjugate base of ethanoic acid, CH_3COO^-, is not amphiprotic as it can accept a H^+ ion but cannot donate one.	• identifies the conjugate base, CH_3COO^-, is not amphiprotic **[1 mark]** • explains that CH_3COO^- can accept but not donate a H^+ ion **[1 mark]**
5d)	$1.78 \times 10^{-5} = \frac{[H^+][A^-]}{[HA]} = \frac{x^2}{0.100}$ $x = [H^+] = \sqrt{(1.78 \times 10^{-5}) \times 0.1} = 1.33 \times 10^{-3}\ M$ $pH = -\log(1.33 \times 10^{-3}) = 2.87$	• identifies $[CH_3COO^-]$ equals $[H^+]$ **[1 mark]** • determines $[H^+]$ is 1.33×10^{-3} **[1 mark]** • calculates pH **[1 mark]**
5e)	$[H^+]$ is 10x greater at pH 2.0 than at pH 3.0. Therefore, final volume needs to be 1 L (0.1000 L x 10 = 1.000 L). Therefore, 1.000 – 0.1000 = 0.900 L of water is needed.	• identifies $[H^+]$ at pH 2.0 is 10 times greater than pH 3.0 **[1 mark]** • determines final volume would be 1 L **[1 mark]** • determines 0.900 L of water needs to be added **[1 mark]**

Q	Sample response	The response:
6a)	The triglyceride is an ester.	• identifies the triglyceride is an ester **[1 mark]**
6b)	Unsaturated fatty acids contain at least one double bond while saturated fatty acids contain only single bonds.	• identifies saturated fatty acids contain only single bonds and unsaturated fatty acids contain at least one double bond **[1 mark]**
6c)	Soap contains a non-polar, hydrophobic group and a polar, hydrophilic group. The ionic salt is attracted to the polar water, allowing the soap to dissolve in water while the non-polar fatty acid chain is attracted to non-polar oils allowing the soap to dissolve in the oils. Thus, soap can form a bridge between polar water and non-polar oils that water can't dissolve.	• identifies soap contains a polar and non-polar region **[1 mark]** • explains that fatty acid group is non-polar and dissolves in oil **[1 mark]** • explains ionic salt group is polar and dissolves in water **[1 mark]** • explains how soap acts as a bridge to remove oils from water **[1 mark]**

Q	Sample response	The response:
7a)	Closed system	• identifies closed system **[1 mark]**
7b)	At equilibrium there is no net change in the concentration of the reactants and the products. The forward and reverse reactions are still occurring. As the forward reaction is equal to the rate of the reverse reaction the colour of the system at equilibrium remains constant.	• identifies the concentration of the reactants and products remain constant at equilibrium **[1 mark]** • explains that the forward and reverse reactions are occurring simultaneously **[1 mark]** • explains forward reaction is equal to reverse reaction and therefore there is no colour change **[1 mark]**

Q	Sample response	The response:
8a)	$[HI]: 0.06\ mol\ L^{-1}$ $[I_2]: 0.01\ mol\ L^{-1}$	• determines $[HI]$ is 0.06 **[1 mark]** • determines $[I_2]$ is 0.01 **[1 mark]**
8b)	$K_c = \frac{[H_2][I_2]}{[HI]^2}$ $K_c = \frac{(0.03)^2}{(0.06)^2} = 0.25$	• uses appropriate substitution **[1 mark]** • calculates K_c is 0.25 **[1 mark]**
8c)	Temperature was higher for experiment 2. The K_c value was larger for experiment 2, indicating that the equilibrium shifted towards the products (endothermic direction) to compensate for the increase in temperature.	• determines experiment 2 was conducted at a higher temperature **[1 mark]** • explains that K_c value for experiment 2 is larger **[1 mark]** • explains higher K_c value indicates equilibrium shifts to the right **[1 mark]**

Q	Sample response	The response:
9	1:1 Aspirin : salicylic acid (SA) $n(\text{aspirin}) = \frac{8.25}{(9\times12.01)+(8\times1.01)+(4\times16.00)} = \frac{8.25}{180.17} = 0.0458\text{ mol}$ $n(\text{SA}) = \frac{0.0458}{0.60} = 0.0763\text{ mol}$ $m(\text{SA}) = 0.0763\times138.13 = 10.5\text{ g}$	• determines molar mass aspirin is 180.17 **[1 mark]** • determines moles aspirin **[1 mark]** • determines moles salicylic acid **[1 mark]** • calculates mass salicylic acid **[1 mark]**