Chemistry marking guide and solution

Sample external assessment 2020

Science (125 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. analysis 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.

Queensland Government

Queensland Curriculum & Assessment Authority

Introduction

The Queensland Curriculum and Assessment Authority (QCAA) has developed mock external assessments for each General senior syllabus subject to support the introduction of external assessment in Queensland.

An external assessment marking guide (EAMG) has been created specifically for each mock external assessment.

The mock external assessments and their marking guides were:

- developed in close consultation with subject matter experts drawn from schools, subject associations and universities
- aligned to the external assessment conditions and specifications in General senior syllabuses
- developed under secure conditions.

Purpose

This document consists of an EAMG and an annotated response.

The EAMG:

- 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.

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.

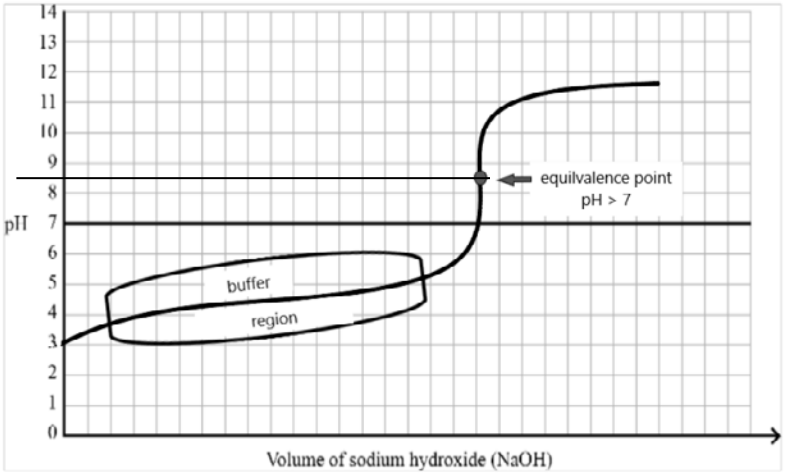
External assessment marking guide

Paper 1 — Section 1: Multiple choice

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

Paper 1 — Section 2: Short response

Question		Sample response	The response
26	a)	D	• determines structure with tertiary carbon is D [1 mark]
	b)	propan-2-ol	• determines name is propan-2-ol [1 mark]
27		Ethane is insoluble in water because it contains only a non-polar hydrocarbon chain. The inter-molecular forces are dispersion forces only. Ethanol and ethanoic acid are both soluble in water as the hydroxyl (R-OH) and carboxyl (R-COOH) groups forms H-bonds with water molecules The non-polar hydrocarbon chains in ethanol and ethanoic acid are small and have weak dispersion forces which do not interfere with the H-bonding and their solubility in water.	• identifies that ethane is insoluble due to dispersion forces [1 mark] • identifies that ethanol is soluble due to H-bonds between the hydroxyl group and water [1 mark] • identifies that ethanoic acid is soluble due to H-bonding between the carboxyl group and water [1 mark]

Question		Sample response	The response
28			• correctly identifies equivalence point > 7 [1 mark] • correctly identifies buffer region [1 mark] • identifies initial pH 3 [1 mark]
29	a)	Stage 2 Because it's a reversible reaction where all the products and reactants are gases.	• identifies stage 2 [1 mark] • indicates stage 2 is affected by pressure because it is reversible, and all of the reactants and products are gases [1 mark]
	b)	$n\mathrm{H_2SO_4}$ required = 1 100 000/98.08 = 11 215 mol $n\mathrm{SO_3}$ required = 11 215/0.97 = 11 562 mol $n\mathrm{SO_3}{:}n\mathrm{S}$ = 1:1 = 11 562 mol mass S = 11 562 × 32.06 = 370 678 g Mass = 371 kg	• correctly determines $n\mathrm{H_2SO_4} = 11\ 215$ [1 mark] • determines $n\mathrm{SO_3} = 11\ \ 562$ [1 mark] • determines $n\mathrm{SO_3}{:}n\mathrm{S}$ = 11 562 [1 mark] • determines mass S = 371 [1 mark]

Question		Sample response	The response
30	a)	O_2	• identifies O_2 produced [1 mark]
	b)	Cu	• identifies Cu formed [1 mark]
		The E^o value for $Cu^{2+}(aq)$ is greater than the E^o value for $H^+(aq)$.	• indicates E^o value for Cu^{2+} > E^o value for H^+ [1 mark]
		Therefore, Cu^{2+} is easier to reduce than H^+.	• concludes Cu^{2+} is easier to reduce than H^+ [1 mark]
	c)	A limitation of the use of standard reduction potentials is that they assume that a 1.0 mol dm^{-3} concentration is being used. OR A limitation of the use of standard reduction potentials is that the experiment is conducted at 100 kPa. OR A limitation of the use of standard reduction potentials is that the experiment is conducted at 298 K (25 °C).	• identifies one limitation [1 mark]
31	a)	$H_2In(aq) \leftrightharpoons 2H^+(aq) + In^{2-}(aq)$	• determines correct balanced equilibrium equation for indicator [1 mark]

Question		Sample response	The response
	b)	In^{2-} (aq)	• identifies In^{2-} as conjugate base [1 mark]
	c)	H^+(aq) reacts with the OH^-(aq) added. Decrease in concentration of H^+(aq) causes the equilibrium to shift to the right (products). H_2In(aq) is a weak acid that dissociates to produce more H^+(aq). Shift in equilibrium means the solution remains acidic and there is no colour change.	• identifies OH^- added is consumed by reacting with H^+ [1 mark] • indicates equilibrium shifts to the right, counteracting decrease in $[H^+]$ [1 mark] • indicates H_2In dissociates to produce H^+ [1 mark] • explains solution is still acidic [1 mark]
32	a)	pOH = 14.0 – 12.3 = 1.7 $[OH^-] = 10^{-1.7} = 2.0 \times 10^{-2}$ mol/L	• correctly determines pOH = 1.7 [1 mark] • determines $[OH^-] = 0.02$ [1 mark]
	b)	$nNaOH = 0.10 \times 0.01555 = 1.555 \times 10^{-3}$ $nH_2SO_4 = \frac{1.555 \times 10^{-3}}{2} = 7.775 \times 10^{-4}$	• correctly determines $nNaOH = 1.555 \times 10^{-3}$ [1 mark] • determines $nH_2SO_4 = 7.775 \times 10^{-4}$ [1 mark]

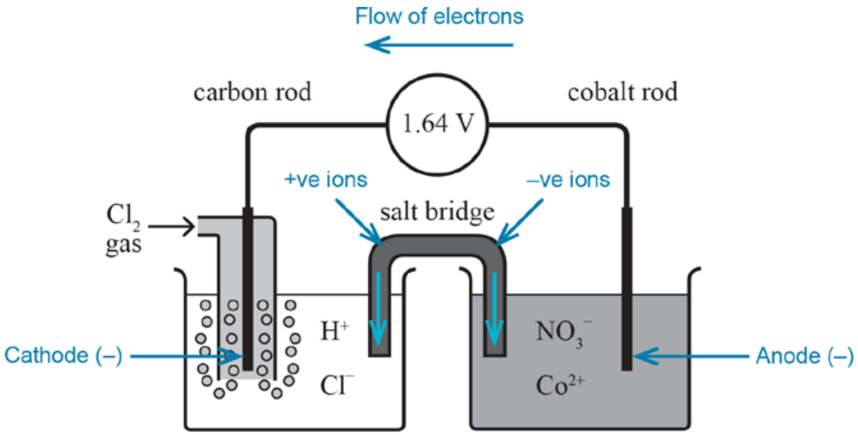
Question		Sample response	The response
		$[H_2SO_4] = \frac{7.775 \times 10^{-4}}{0.01000} = 0.07775 = 7.775 \times 10^{-2}$ Concentration = 0.078 mol/L	• determines $[H_2SO_4] = 7.8 \times 10^{-2}$ [1 mark]
33	a)	Acid B is the strongest	• provides B [1 mark]
	b)	Acid B dissociates more than Acid A because it is a stronger acid. Therefore, Acid B has a higher concentration of ions in solution and a higher conductivity. Therefore, the bulb glows brighter for acid B.	• identifies that a strong acid dissociates more than a weak acid [1 mark] • identifies that the stronger acid has a higher concentration of ions in solution [1 mark] • explains that the solution with a higher concentration of ions has higher conductivity [1 mark] • explains that higher conductivity leads to a brighter bulb [1 mark]

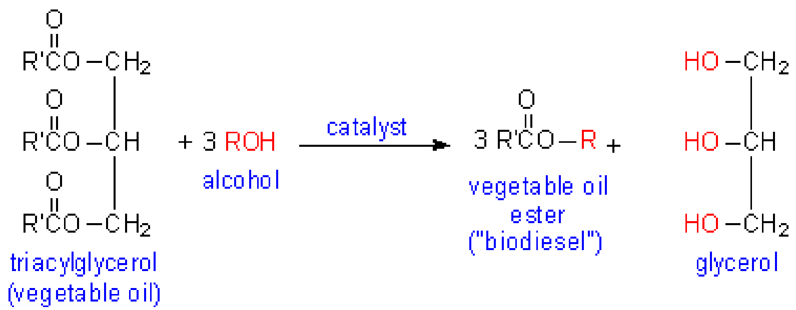
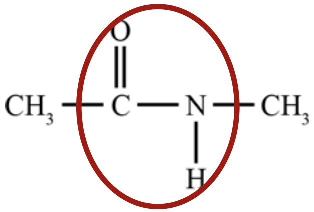
Paper 2 — Section 1: Short response

Question		Sample response	The response
1	a)	3	• identifies equilibrium reached 3 times [1 mark]
	b)	No effect on the position of equilibrium. Because the number of gaseous molecules for reactants and products are the same.	• states no effect on position of equilibrium [1 mark] • identifies reactants and products as gases and the number of molecules of reactants and products is the same [1 mark]
	c)	The reaction is endothermic. Therefore, an increase in temperature will shift the equilibrium in the endothermic direction, towards the products. The value of K_c will increase.	• indicates reaction is endothermic [1 mark] • identifies equilibrium will shift towards products [1 mark] • predicts K_c will increase [1 mark]
	d)	$K_c = \frac{(0.3)^2}{(0.2)(0.2)} = \frac{0.09}{0.04}$ K_c = 2.25 ≈ 2	• shows substitution correctly performed [1 mark] • determines K_c = 2.25 [1 mark]
2	a)	$CH_3COOH + CH_3OH \rightleftharpoons CH_3OCOCH_3 + H_2O$	• provides correct formula for both reactants [1 mark] • provides correct formula for both products [1 mark] • indicates reaction is reversible with ⇌ and reaction balanced [1 mark]

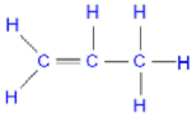
Question		Sample response	The response
	b)	let $x = [\text{ester}_{\text{eq}}] = [\text{water}_{\text{eq}}]$ $\therefore$ $[\text{carboxylic acid}_{\text{eq}}]$ = $[\text{alcohol}_{\text{eq}}]$ = 0.25 – x $4.0 = \frac{(x)(x)}{(0.25-x)(0.25-x)}$ $2 = \frac{x}{(0.25-x)}$ 2(0.25 – x) = x 0.5 = 3x $\therefore$ x = 0.17 mol L^{-1} = [ester$_{eq}$] = [water$_{eq}$] [ethanol$_{eq}$] = [ethanoic acid$_{eq}$] = 0.25 – 0.17 = 0.08 mol L^{-1}	• indicates assumption for equilibrium concentrations [1 mark] • shows substitution correctly performed [1 mark] • shows correct transposition [1 mark] • correctly determines $[\text{ester}_{\text{eq}}] = [\text{water}_{\text{eq}}]$ = 0.17 mol L^{-1} [1 mark] • determine $[\text{carboxylic acid}_{\text{eq}}]$ = $[\text{alcohol}_{\text{eq}}]$ = 0.08 mol L^{-1} [1 mark]
3	a)	oxygen gas	• correctly determines $O_2(g)$ is produced [1 mark]
	b)	Because hydrogen ions (H^+) are positively charged, they move towards the negatively charged cathode.	• states H^+ have a positive charge [1 mark]
	c)	zone A_1: $H_2(g)$ is fed into the fuel cell. zone A_2: $O_2(g)$ is fed into the fuel cell. zone B: Hydrogen gas is oxidised at the anode.	• correctly determines $H_2(g)$ enters via zone A_1 and $O_2(g)$ enters via zone A_2 [1 mark] • correctly determines $H_2(g)$ is oxidised [1 mark]

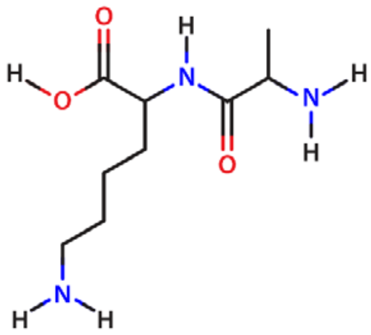
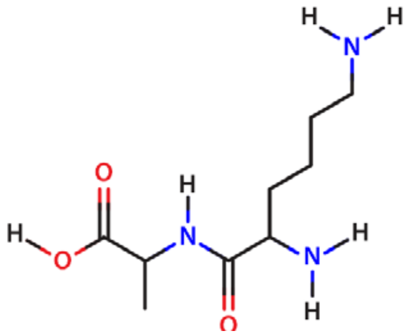
Question		Sample response	The response
		zone C: Hydroxide ions (OH^-) migrate through membrane towards zone B (anode). zone D: Oxygen gas (O_2) is reduced at the cathode.	• identifies $OH^-(aq)$ migrates towards zone B [1 mark] • determines $O_2(g)$ is reduced [1 mark]
	d)	Oxidation half-equation: $2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$ Reduction half-equation: $2H_2O(l) + O_2(g) + 4e^- \rightarrow 4OH^-(aq)$ Overall reaction: $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$	• correctly determines oxidation half-equation [1 mark] • correctly determines reduction half-equation [1 mark] • determines correct overall reaction [1 mark]
4	a)		• correctly labels cathode (+) and anode (–) [1 mark] • correctly identifies the direction electrons flow through wire [1 mark]

Question		Sample response	The response
			• correctly identifies the movement of anions and cations in the salt bridge [1 mark]
	b)	Co^{2+}/Co half-cell undergoes oxidation and Cl_2/Cl^- half-cell undergoes reduction. $Cl_2 + 2e^- \leftrightharpoons 2Cl^- = 1.36\ V$ $E^o(ox) = E^o(red) - E^o(cell) = 1.36 - (1.64)$ $E^o(ox) = -0.28\ V$	• correctly identifies Co^{2+} is oxidised and Cl_2 is reduced [1 mark] • selects correct E^o for reduction of Cl_2 = +1.36 V from formula and data book [1 mark] • shows correct transposition [1 mark] • determines $E^o(ox) = -0.28$ V for Co^{2+}/Co half-cell [1 mark]
5	a)	Enzymes act as biological catalysts because they increase the rate of reaction without undergoing chemical change. They form an enzyme–substrate complex that lowers the activation energy by providing an alternative pathway for the reaction of substrate to product.	• describes any three characteristics [3 marks] • describes any two characteristics [2 marks] • describes any one characteristic [1 mark]

Question		Sample response	The response
	b)		• correctly determines formula for both reactants [1 mark] • correctly determines formula for both products [1 mark] • indicates catalyst required [1 mark] • shows chemical equation is balanced [1 mark]
6	a)		• correctly identifies peptide bond in secondary amide on the diagram [1 mark]
	b)	acidic conditions: $CH_3CONH_2 + H_2O + HCl \rightarrow CH_3COOH + NH_4Cl$	• correctly determines formula for ethanoic acid as a product [1 mark]

Question		Sample response	The response
		basic conditions: $CH_3CONH_2 + NaOH \rightarrow CH_3COONa + NH_3$	• correctly determines formula for ammonium ion as a product [1 mark] • correctly determines formula for ethanoate ion as a product [1 mark] • correctly determines formula for ammonia as a product [1 mark]
	c)	Ethanol is oxidised completely to ethanoic acid by heating with acidified $KMnO_4(aq)$ under reflux. Ethanoic acid reacts with methanamine to produce N-methylethanamide and water.	• identifies ethanol is oxidised to ethanoic acid [1 mark] • identifies reagents and conditions required to oxidise ethanol to ethanoic acid [1 mark] • identifies ethanoic acid and methanamine as reactants [1 mark] • identifies N-methylethanamide and water as products [1 mark]
7	a)	$W + O_2 \rightarrow CO_2 + H_2O$ Therefore, W contains C and H and maybe O. $W + HBr \rightarrow W + (H^+ + Br^-) \rightarrow X$ (1W:1HBr) Therefore, W contains a double bond. W = molar mass of 42 g = C_3H_6 Structural formula:	• identifies W contains C and H [1 mark] • correctly identifies W contains a double bond [1 mark] • determines structural formula of W [1 mark]

Question		Sample response	The response
			
	b)	Alkenes (C_3H_6) decolourise bromine water.	• identifies correct confirmation test for alkenes [1 mark]
	c)	$W = C_3H_6$ $C_3H_6 + HBr \rightarrow C_3H_7Br$ = X $C_3H_7Br + NaOH \rightarrow C_3H_7OH + NaBr$ Therefore $C_3H_7OH = Y$ $C_3H_7OH + CH_3COOH \rightarrow CH_3COOC_3H_7 + H_2O$ Therefore $CH_3COOC_3H_7 = Z$	• uses correct equation to show formation X from W [1 mark] • uses correct equation to show formation Y from X [1 mark] • uses correct equation to show formation Z from Y [1 mark]
8	a)	Mixture of amino acids placed onto gel (polyacrylamide) and potential difference (voltage) applied. Isoelectric point of Ala < pH of buffer, so it is negatively charged. Isoelectric point of Lys > pH of buffer, so it is positively charged. Therefore, Ala moves towards the anode, which is the positive electrode, and Lys moves towards the cathode, which is the negative electrode.	• indicates amino acid mixture applied to gel and voltage applied [1 mark] • correctly determines Ala is negatively charged and Lys is positively charged [1 mark] • indicates Ala (–ve) moves towards anode (+ve electrode) and Lys (+ve) moves towards the cathode (–ve electrode) to be separated [1 mark]

Question	Sample response	The response
b)	 (Ala-Lys) OR  (Lys-Ala)	• correctly determines the structural formula for Ala-Lys or Lys-Ala dipeptide [1 mark]
c)	Properties due to α-helix structure: Elastic H-bonds form between C=O group of one peptide bond and the N-H group of another peptide bond further along the peptide chain. These intra-chain H-bonds are easily broken and allow the molecule to stretch.	• correctly identifies proteins with an α-helix secondary structure as elastic [1 mark] • indicates α-helix structure results in H-bonding between C=O and N-H groups along the amino acid chain [1 mark] • indicates properties are related to intra-chain H-bonding, which is easily broken and reformed [1 mark]
	Properties due to β-pleated sheets structure: Inelastic H-bonding forms between C=O group and N-H group on adjacent/side-by-side peptide chains. Inter-chain H-bonding creates cross-links, which are stronger than intra-chain H-bonds and not easily broken.	• correctly identifies secondary proteins with a β-pleated sheet structure are inelastic [1 mark] • indicates β-pleated sheet structure results in H-bonding between C=O and N-H group on adjacent peptide chains [1 mark] • indicates properties are related to inter-chain H-bonding, which

Question		Sample response	The response
			is stronger and therefore harder to break than intra-chain H-bonding [1 mark]