Chemistry marking guide and response

External assessment 2024

Combination response (110 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
- has been annotated using the marking guide.

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

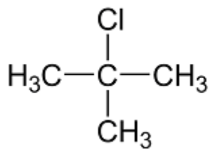
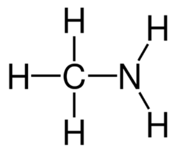
Multiple choice

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

Short response: Paper 1

Q	Sample response	The response:
21a)	The reversible arrow indicates that the reaction occurs in both directions (forward and reverse) simultaneously.	• explains that forward and reverse reactions occur simultaneously **[1 mark]**
21b)	K_c is greater than 1, therefore the equilibrium for the reaction lies towards the products.	• deduces the equilibrium lies towards the products **[1 mark]** • explains that K_c is greater than 1 **[1 mark]**
22a)	A condensation reaction occurs when amino acid monomers are joined to form a peptide bond and water is removed.	• identifies condensation reaction **[1 mark]** • describes that water is removed when the amino acids are joined to form polypeptides **[1 mark]**
22b)	A peptide bond is formed.	• identifies peptide bond **[1 mark]**
23a)	KHP is a weak acid. The titration curve contains a buffer region.	• determines KHP is a weak acid **[1 mark]** • identifies the buffer region **[1 mark]**
23b)	KHP does not absorb water from the air; therefore, an accurate concentration can be determined for KHP.	• explains that [KHP] does not change due to absorption of water from the air **[1 mark]**
23c)	$n\text{KHP} = 0.03 \times 0.012 = 0.00036 \text{ mol}$ $n\text{KHP} = n\text{NaOH}$ $[\text{NaOH}] = \frac{0.00036}{0.025} = 0.0144 \text{ mol L}^{-1}$	• provides suitable substitution **[1 mark]** • calculates [NaOH] **[1 mark]**
24	As temperature increases, pK_w decreases (K_w increases), indicating that equilibrium shifts towards the products. Therefore, the forward reaction is endothermic and increasing the temperature increases $[H^+]$ and decreases pH.	• identifies that pK_w decreases as temperature increases **[1 mark]** • determines that the forward reaction is endothermic **[1 mark]** • explains that increasing temperature shifts the equilibrium toward products **[1 mark]** • explains that increasing temperature decreases pH **[1 mark]**

Q	Sample response	The response:
25a)	Glucose is an aldose monosaccharide.	• identifies that glucose is an aldose monosaccharide **[1 mark]**
25b)	α-glucose has its OH group attached on the opposite side of the carbon ring (*trans*) to the CH_2OH group, while β-glucose has its OH group attached on the same side of the ring (*cis*) as the CH_2OH group.	• identifies that α-glucose has its OH group and CH_2OH group attached to opposite sides of ring (*trans*) for **[1 mark]** • identifies that β-glucose has its OH group and CH_2OH group attached on the same side of the ring (*cis*) **[1 mark]**
26a)	$I^-(aq)$ in KI is the reducing agent because it loses an electron to be oxidised to $I_2(s)$.	• identifies that the iodide ion (I^-) in KI is the reducing agent **[1 mark]** • explains I^- is oxidised by losing an electron **[1 mark]**
26b)	Reduction half-equation: $2IO_3^-(aq) + 12H^+(aq) + 10e^- \rightarrow I_2(s) + 6H_2O(l)$	• determines IO_3^- + H^+ + e^- are reactants **[1 mark]** • determines I_2 + H_2O are products **[1 mark]** • determines the balanced reduction half-equation **[1 mark]**
27a)	Catalyst concentration (%): 4 Ethanol to seed oil ratio (g/g): 10:1 Temperature (°C): 45	• identifies optimal reaction conditions are 4% catalyst concentration, 10:1 ethanol to seed oil ratio and 45 °C **[1 mark]**
27b)	In esterification, free fatty acids (FFAs) react with an alcohol to produce esters and water. In transesterification, esters react with an alcohol to produce fatty acid alkyl esters (FAAEs) (biodiesel) and glycerol. A two-step process maximises the conversion of FFAs to biodiesel (FAAE).	• explains that esterification converts free fatty acids to esters **[1 mark]** • explains that transesterification converts esters to fatty acid alkyl esters **[1 mark]** • explains that a two-step process maximises the production of biodiesel **[1 mark]**

Q	Sample response	The response:
27c)	Increasing the catalyst concentration from 0% to 4% resulted in ~1.8% increase in biodiesel yield from ~91.0% to ~92.8%. Increasing the ethanol–oil ratio from 10:1 g/g to 18:1 g/g resulted in a ~1.9% decrease in biodiesel yield from ~93.2% to ~91.3%. Increasing temperature from 45 °C to 75 °C has minimal effect, decreasing biodiesel yield by ~0.4% from ~92.3% to ~92.0%.	• determines that increasing catalyst concentration increases biodiesel yield **[1 mark]** • determines that increasing ethanol to seed oil ratio decreases biodiesel yield **[1 mark]** • determines that increasing temperature results in a slight decrease in biodiesel yield **[1 mark]** • identifies data from the graphs to support reasoning **[1 mark]**
28a)	The isomer is a saturated compound because it contains only single bonds.	• identifies that the compound is saturated because it contains only single bonds **[1 mark]**
28b)	Primary haloalkane	• identifies compound is a primary haloalkane **[1 mark]**
28c)	 IUPAC name: 2-chloro-2-methylpropane	• determines structural formula **[1 mark]** • determines IUPAC name **[1 mark]**
29a)		• describes the structural formula for methylamine **[1 mark]**
29b)	Added OH^- would react and accept a proton from $CH_3NH_3^+$ to form water and CH_3NH_2 (weak base). Thus, equilibrium would shift to the left (reactants) and resist a change in pH.	• explains $CH_3NH_3^+$ reacts with excess OH^- ions **[1 mark]** • explains equilibrium would shift to the left and resist a change in pH **[1 mark]**

Paper 2

Q	Sample response	The response:
1a)	$[H^+]=10^{(-pH)}$ $[H^+]=10^{-2}=0.01\text{ mol L}^{-1}$	• determines $[H^+]$ is 0.01 mol L^{-1} **[1 mark]**
1b)	$C_1V_1=C_2V_2$ Let $C_2=[H^+]$ $[H^+]=\frac{0.01\text{ M}\times 30\text{ mL}}{3000\text{ mL}}=0.0001\text{ mol L}^{-1}$ $pH=-\log_{10}[10^{-4}]$ $pH=4$	• determines $[H^+]$ **[1 mark]** • calculates pH **[1 mark]**
2a)	Conjugate base is In^-.	• identifies conjugate base is In^- **[1 mark]**
2b)	$K_a=10^{-pK_a}$ $K_a=10^{-7.9}=1.26\times10^{-8}$	• determines K_a is 1.26×10^{-8} **[1 mark]**
2c)	Phenol red changes colour when the concentration of the yellow weak acid form (HIn) equals the concentration of the red conjugate base form (In^-). When [HIn] = [In^-], the K_a of phenol red equals [H^+] and pH equals the pK_a (7.9). However, the colour change of phenol red occurs over a pH range equal to pK_a ±1, because visible colour change can be observed when the [HIn] : [In^-] changes by a ratio of 1:10.	• identifies that colour change occurs when the [HIn] = [In^-] **[1 mark]** • explains that when [HIn] = [In^-], the K_a of phenol red equals [H^+], and therefore pH equals the pK_a **[1 mark]** • identifies that the pH range of colour change is pK_a ±1 **[1 mark]** • explains that the pH range of colour change occurs either side of pK_a because colour change is detected when the [HIn] : [In^-] changes **[1 mark]**

Q	Sample response	The response:
3a)	Similarity: both weak acids Difference: ethanoic acid (CH_3COOH) is weaker than acid I Significance: Ethanoic acid dissociates less to produce a lower $[H^+]$	• identifies that both acids are weak acids **[1 mark]** • identifies that ethanoic acid is weaker than acid I **[1 mark]** • explains that ethanoic acid dissociates less to produce a lower $[H^+]$ **[1 mark]**
3b)	Acid II has a K_a greater than 1 and is therefore a strong acid, while acid I is a weak acid due to small K_a. Acid II dissociates to produce more ions in an aqueous solution than acid I. Therefore, acid II has a higher electrical conductivity than acid I.	• identifies that acid II is stronger than acid I **[1 mark]** • explains that acid II dissociates to produce more ions in solution **[1 mark]** • determines that the electrical conductivity of acid II will be greater than acid I **[1 mark]**
3c)	$[H_3O^+] = [CH_3COO^-] = x$ $[CH_3COOH] = \frac{[H_3O^+][CH_3COO^-]}{K_a}$ $0.2 = \frac{(x)^2}{1.8\times10^{-5}}$ $[H_3O^+] = 1.9\times10^{-3}$ M $pH = -\log_{10}[H_3O^+]$ $pH = 3$	• identifies $[H_3O^+] = [CH_3COO^-]$ **[1 mark]** • determines $[H_3O^+]$ **[1 mark]** • calculates pH **[1 mark]**
4a)	Enzymes convert starch into glucose via hydrolysis that breaks the glycosidic bond.	• identifies that enzymes break glycosidic bonds in starch to form glucose **[1 mark]** • explains that enzymes convert starch to glucose via hydrolysis **[1 mark]**

<table>
<tr><th>Q</th><th>Sample response</th><th>The response:</th></tr>
<tr><td>4b)</td><td>
<table>
<tr><th></th><th>Amylose</th><th>Amylopectin</th></tr>
<tr><td>Monomer</td><td>α-glucose</td><td>α-glucose</td></tr>
<tr><td>Glycosidic bonds</td><td>1,4-glycosidic bonds</td><td>both 1,4 and 1,6-glycosidic bonds</td></tr>
<tr><td>Chain structure</td><td>Linear</td><td>Branched</td></tr>
<tr><td>Shape</td><td>Helix</td><td>Spherical</td></tr>
</table>
</td><td>

describes that the monomer for amylose and amylopectin is α-glucose [1 mark]
describes that amylose contains 1,4-glycosidic bonds and amylopectin contains 1,4 and 1,6-glycosidic bonds [1 mark]
describes that amylose has a straight chain structure and that amylopectin has a branched chain structure [1 mark]
describes that amylose is helical in shape and that amylopectin forms spheres [1 mark]

</td></tr>
<tr><td>4c)</td><td>
$$\overset{0}{C}_6\overset{+1}{H}_{12}\overset{-2}{O}_6 \rightarrow 2(\overset{-2}{C}_2\overset{+1}{H}_5\overset{-2}{O}\overset{+1}{H}) + 2\overset{+4}{C}\overset{-2}{O}_2$$
Carbon in glucose is oxidised to CO_2. Oxidation number increases from 0 to +4.
Carbon in glucose is reduced to C_2H_5OH. Oxidation number decreases from 0 to –2.
</td><td>

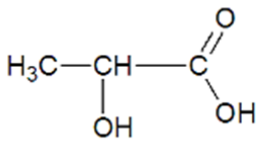
determines fermentation is a redox reaction [1 mark]
explains carbon in glucose is oxidised to CO_2; oxidation number increases from 0 to +4 [1 mark]
explains carbon in glucose is reduced to C_2H_5OH; oxidation number decreases from 0 to –2 [1 mark]

</td></tr>
<tr><td>4d)</td><td>
Molar mass glucose = 180
Molar mass ethanol = 2(46)
(C = 12, H = 1, O = 16) =92
$$\text{atom economy} = \frac{92}{180} \times \frac{100}{1} = 51\%$$
</td><td>

determines the molar mass of glucose is 180 and molar mass of ethanol is 92 [1 mark]
calculates atom economy [1 mark]

</td></tr>
</table>

Q	Sample response	The response:
5a)	Magnesium is the anode and is being oxidised, i.e. it loses electrons. Thus, electrons move from the magnesium electrode through the wire towards metal Q.	• identifies that the magnesium electrode is oxidised **[1 mark]** • describes the movement of electrons through the wire **[1 mark]** • identifies that Q^{2+} ions are reduced **[1 mark]**
5b)	Metal Q is reduced. $Q^{2+}(aq) + 2e^- \rightleftharpoons Q(s)$ $E_{cell} = E_{red} - E_{ox}$ $2.55 = Q - (-2.36)$ $Q = 2.55 - 2.36 = 0.19\ V$	• determines the half-equation is $Q^{2+}(aq) + 2e^- \rightleftharpoons Q(s)$ **[1 mark]** • determines standard electrode potential is +0.19 V **[1 mark]**
5c)	All solutions must have a concentration of 1.0 M.	• identifies a limitation **[1 mark]**
5d)	$Q^{2+}(aq) + 2e^- \rightleftharpoons Q(s) = +0.19\ V$ $Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s) = +0.34V$ Q is less positive that Cu, therefore metal Q is a stronger reducing agent than metallic Cu.	• determines metal Q is a stronger reducing agent **[1 mark]** • explains that the lower the standard reduction potential, the stronger the reducing agent **[1 mark]**
6a)	Molecule 1	• identifies molecule 1 or molecule 2 **[1 mark]**
6b)	*cis*-1-chloropropene	• determines the IUPAC name of a geometric isomer **[1 mark]**

Q	Sample response	The response:
6c)	$CH_3CN(l) + 2H_2(g) \xrightarrow{Pt} CH_3CH_2NH_2(g)$	• determines balanced chemical equation **[1 mark]** • identifies appropriate catalyst **[1 mark]**
6d)	Type of reaction: elimination IUPAC name of product X: propene IUPAC name of product Y: propan-2-ol Oxidising agent: $K_2Cr_2O_7/H^+$ Propanol forms molecule 2 and propan-2-ol forms molecule 1.	• identifies type of reaction is elimination **[1 mark]** • determines product X is propene **[1 mark]** • determines product Y is propan-2-ol **[1 mark]** • identifies oxidising agent **[1 mark]** • determines that propanol forms molecule 2 **and** propan-2-ol forms molecule 1 **[1 mark]**
7a)	Polylactic acid contains an ester linkage. Microorganisms produce enzymes that can hydrolyse the ester linkage to decompose PLA into CO_2 and water.	• explains that polylactic acid contains an ester linkage **[1 mark]** • explains that the ester linkage can be hydrolysed **[1 mark]**
7b)		• describes the location of COOH group **[1 mark]** • describes the location of the OH group **[1 mark]**
8	At equilibrium, the forward reaction rate equals the reverse reaction rate. Therefore, yellow chromate ions and orange dichromate ions are re-formed at the same rate at which they are broken down, so the colour remains constant because the $[CrO_4^{2-}]$ and $[Cr_2O_7^{2-}]$ remain constant.	• identifies that the forward reaction rate equals the reverse reaction rate at equilibrium **[1 mark]** • explains that the colour remains constant because the $[CrO_4^{2-}]$ and $[Cr_2O_7^{2-}]$ remain constant **[1 mark]**