Chemistry marking guide and response

External assessment 2022

Combination response (100 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 EAMG.

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.

Allowing for FT error — 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 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	D
3	B
4	B
5	D
6	A
7	D
8	D
9	A
10	B
11	D
12	D
13	C
14	C
15	A
16	C
17	C
18	C
19	A
20	A

Paper 1: Short response

Q	Sample response	The response:
21a)	2-bromopropane is saturated because it contains only single bonds.	• identifies 2-bromopropane is satured **[1 mark]** • indicates 2-bromopropane contains only single bonds **[1 mark]**
21b)	2-bromopropane is a secondary halogenoalkane, because the carbon that the bromine is attached to two carbon atoms.	• determines 2-bromopropane is a secondary halogenoalkane **[1 mark]** • explains that the bromine (halogen) is bonded to a carbon that is attached to two other carbon atoms **[1 mark]**

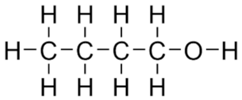
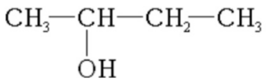
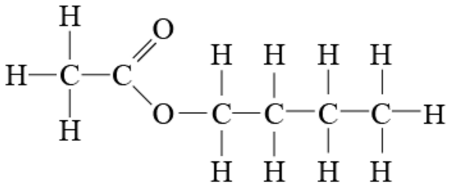
Q	Sample response	The response:
22	$[H_3O^+] = 10^{-4}$ and $[F^-] = 10^{-4}$ $[HF] = \frac{[H_3O^+][F^-]}{K_a}$ $[HF] = \frac{10^{-4} \times 10^{-4}}{7.2 \times 10^{-4}}$ $[HF] = 1.4 \times 10^{-5}$ mol L^{-1}	• uses correct substitution [1 mark] • calculates [HF] = 1.4 x 10^{-5} [1 mark]
23	Process 1: atom economy = 206.0/514.5 x 100 = 40.04% Process 2: atom economy = 206.0/266.0 x 100 = 77.44% Process 2 has 37.4% better atom economy than process 1 Economic impact: Process 2 has a better atom economy than process 1 (fewer reagents are required). Environmental impact: Process 2 is greener than process 1 because fewer waste products (atoms) are produced.	• calculates atom economy for – Process 1 as 40% **[1 mark]** – Process 2 as 77% **[1 mark]** • concludes process 2 is – cheaper as fewer reagent atoms are required **[1 mark]** – greener as fewer waste atoms are produced **[1 mark]**

Q	Sample response	The response:
24a)	Similarity: Both the Pt and Cu half-cells have a positive standard reduction potential compared to SHE. Difference: Pt half-cell is more positive than Cu half-cell. Significance: Cu electrode is oxidised (loses electrons) and the $Fe^{3+}(aq)$ is reduced.	• Similarities: identifies that both half-cells have positive standard reduction potential **[1 mark]** • Differences: identifies that Pt half-cell is more positive than Cu half-cell **[1 mark]** • Significance: explains that Cu electrode is oxidised and Fe^{3+} is reduced **[1 mark]**
24b)	Balance redox equation: $2Fe^{3+} + Cu \rightarrow Cu^{2+} + 2Fe^{2+}$	• provides correct balanced redox equation **[1 mark]**
24c)	Cell potential = 0.77 + (−0.34) = +0.43 V	• determines cell potential is +0.43 **[1 mark]**
24d)	Fe^{3+} is the oxidising agent, because ON decreases from +3 to +2.	• identifies Fe^{3+} as the oxidising agent **[1 mark]** • indicates oxidation number decreases **[1 mark]**

Q	Sample response	The response:
25a)	The reaction occurred in a closed system, therefore matter is not exchanged with the surroundings. This means the system can reach a steady state, where the rate of the forward reaction (conversion of reactants to products) equals the rate of the reverse reaction (products are converted back into reactants) to establish a state of dynamic equilibrium.	• identifies gases reach dynamic equilibrium **[1 mark]** • explains matter is not exchanged with surrounds **[1 mark]** • explains rate of forward reaction is equal to rate of reverse reaction **[1 mark]**
25b)	$K_c = \frac{[XA_3]^2}{[A_2]^3[X_2]}$ $K_c = \frac{[4.2]^2}{[3.4]^3[1.8]}$ $K_c = \frac{17.64}{70.7472} = 0.25$ $K_c<1$ therefore equilibrium lies to the left	• determines $K_c = 0.25$ **[1 mark]** • indicates that since $K_c < 1$, equilibrium lies towards the reactants **[1 mark]**

Q	Sample response	The response:
26a)	pH = 4.0	• determines pH for solution A is 4.0 **[1 mark]**
26b)	$[H^+]$ in Solution B = 0.010 mol L^{-1}	• determines $[H^+]$ for solution B is 0.01 **[1 mark]**
26c)	pH = –log [0.063] = 1.2 pOH = 14 – 1.2 = 12.8	• provides relevant working **[1 mark]** • calculates pOH = 12.8 **[1 mark]**
27	Solutions A, C and D are acids and solutions B and E are bases, because phenol red is yellow when pH < 6.8 and red when pH > 8.4. Solution C is a weak electrolyte (from low conductivity), therefore C is propanoic acid. Solution D has higher conductivity than solution A, therefore D is sulfuric acid and solution A is HCl, because H_2SO_4 is diprotic acid and will give a higher concentration of ions in solution than monoprotic HCl. Solution E is KOH as it has a higher conductivity and therefore is a strong base. Solution B has a lower conductivity and therefore is ammonia, a weak base.	• identifies all five solutions **[1 mark]** • uses indicator data to identify acids and bases **[1 mark]** • uses conductivity data to identify relative strength of bases **[1 mark]** • uses conductivity data to identify relative strength of acids **[1 mark]** • identifies the diprotic acid is more conductive than monoprotic acid **[1 mark]**

Paper 2: Short response

Q	Sample response	The response:
1a)	Compound A is an alcohol.	• identifies the class as alcohol **[1 mark]**
1b) i)	 Compound A is butanol.	• deduces structural formula for butanol **[1 mark]** • provides IUPAC name **[1 mark]**
1b) ii)	 Compound C is 2-butanol.	• deduces structural formula for 2-butanol **[1 mark]** • provides IUPAC name **[1 mark]**
1c)	Butanol and 2-butanol are structural isomers.	• identifies structural isomers **[1 mark]**
1d)	 Compound F is butyl ethanoate.	• provides structural formula for butyl ethanoate **[1 mark]** • provides IUPAC name as butyl ethanoate **[1 mark]**

Q	Sample response	The response:
2a)	Exothermic Increasing temperature decreases K_c, indicating that the equilibrium shifts towards the reactants (endothermic) direction.	• determines forward reaction is exothermic **[1 mark]** • explain that the decrease in K_c as temperature increases indicates endothermic direction is towards the reactants **[1 mark]**
2b)	$8.61\times10^{11}=\frac{[SO_3]^2}{(0.860)^2(0.330)}$ $[SO_3]^2=(0.7396)(0.330)(8.61\times10^{11})=2.10\times10^{11}$ Concentration = 4.58×10^5 M	• provides appropriate working **[1 mark]** • calculates $[SO_3] = 4.58 \times 10^5$ **[1 mark]**
2c)	Halving the volume would double the pressure. To reduce the pressure, the equilibrium would shift toward the product to reduce the number of molecules present. However, due to the reactant decreasing the equilibrium constant remains unchanged.	• indicates that halving the volume doubles the pressure **[1 mark]** • explains that equilibrium will shift to reduce the number of molecules present to reduce pressure **[1 mark]** • explains that equilibrium will shift toward the product **[1 mark]** • explains why the equilibrium constant would not change **[1 mark]**

Q	Sample response	The response:
3a)	$CH_3COOH(aq) + OH^-(aq) \rightleftharpoons CH_3COO^-(aq) + H_2O(l)$ The conjugate base formed is CH_3COO^-.	• provides correct balanced chemical equation **[1 mark]** • identifies CH_3OO^- as conjugate base **[1 mark]**
3b)	$K_b = \frac{1.00 \times 10^{-14}}{10^{-4.76}} = 10^{-9.24} = 5.75 \times 10^{-10}$	• determines K_b is 5.75×10^{-10}
3c)	At equivalence point, moles OH^- = moles H^+ = moles CH_3COO^- moles CH_3COO^- = n × V = 0.10 × 0.015 = 1.50×10^{-3}	• determines moles CH_3COO^- is 1.50×10^{-3} **[1 mark]** • calculates $[CH_3COO^-]$ is 2.31×10^{-2} mol L^{-1} **[1 mark]**
3d)	$[CH_3COOH] = [OH^-] = x$ $K_b = \frac{[OH^-][CH_3COOH]}{[CH_3COO^-]}$ $K_b = 5.75 \times 10^{-10} = \frac{x^2}{[2.31 \times 10^{-2}]}$ $x^2 = 1.33 \times 10^{-11}$ $x = 3.64 \times 10^{-6} = [OH^-]$ $pOH = -\log(3.64 \times 10^{-6}) = 5.44 \sim 5.4$ $pH = 14 - 5.4 = 8.6$	• provides correct substitution **[1 mark]** • calculates $[OH^-]$ is 3.64×10^{-6} M **[1 mark]** • determines pOH is 5.4 **[1 mark]** • calculates pH is 8.6 **[1 mark]**

Q	Sample response	The response:
4a)	The fermentation process requires yeast as a catalyst. Yeast is temperature sensitive.	• identifies fermentation requires yeast as a catalyst **[1 mark]** • identifies that yeast is temperature-sensitive **[1 mark]**
4b)	Cellulose is a linear polymer. The β-glucose monomers in cellulose can pack closely together. This increases hydrogen bonding between adjacent chains, which reduces interactions with water (solvents) and makes hydrolysis of cellulose more difficult than starch.	• identifies cellulose is a linear polymer **[1 mark]** • identifies monomers can pack closely together **[1 mark]** • explains increased H-bonding between adjacent chains makes hydrolysis of cellulose more difficult **[1 mark]**
4c)	$\text{Moles } C_6H_{12}O_6 = \frac{150}{180.18} = 0.833$ $\text{Moles } CH_3CH_2OH = 0.83 \times 2 = 1.67$ $\text{Mass } CH_3CH_2OH = 1.67 \times 46.08 = 76.72\text{ g}$ $\text{Ethanol yield} = \frac{37.5}{\text{theoretical yield}} = \frac{37.5}{76.72} = 48.9\%$	• determines 150 g glucose can produce 1.67 M of ethanol **[1 mark]** • calculates theoretical mass of ethanol as 76.72 g **[1 mark]** • calculates % yield of ethanol is 48.9% **[1 mark]**

Q	Sample response	The response:
5a)	Copper ion is reduced and Cu is plated onto the cathode: Cu^{2+} (aq) + $2e^-$ → Cu(s) Copper anode is oxidised to Cu2+(aq) and is released into solution: Cu(s) → Cu^{2+} (aq) + $2e^-$ Therefore, for every copper ion that is reduced at the cathode, in principle, another one is oxidised at the anode. Therefore, the concentration of the copper(II) sulfate solution should stay the same.	• identifies copper ions are reduced to Cu metal at the cathode and reduction half-equation is Cu^{2+} (aq) + $2e^-$ → Cu(s) **[1 mark]** • identifies copper metal is oxidised to Cu ions at the anode and oxidation half-equation is Cu(s) → Cu^{2+} (aq) + $2e^-$ **[1 mark]** • predicts no change in concentration of copper(II) sulfate solution **[1 mark]** • identifies that copper ions are reduced to copper and copper is oxidised to copper ions at the same rate **[1 mark]**
5b)	Silver is below copper in the reactivity series and therefore doesn't go into solution, as ions are not oxidised and could be found in the sludge. Zinc impurities are above copper in the electrochemical series and will form ions at the anode and go into solution. However, they won't get discharged at the cathode, provided their concentration doesn't get too high.	• identifies Ag is less reactive than Cu and Zn is more reactive than Cu **[1 mark]** • deduces Ag metal is not oxidised (or reduced) and remains as metal **[1 mark]** • deduces Zn metal is oxidised to form ions and found in the solution **[1 mark]** • explains that Zn^{2+} ions remain in solution at low concentration but are reduced to Zn metal at the cathode if concentration becomes too high **[1 mark]**

Q	Sample response	The response:
6a)	Peptide bond Water is formed	• identifies peptide bond **[1 mark]** • identifies water is formed **[1 mark]**
6b)	6 tripeptides can be formed: Gly-His-Lys and Gly-Lys-His	• determines 6 tripeptides can be formed **[1 mark]** • describes one tripeptide **[1 mark]** • describes a second tripeptide **[1 mark]**
6c)	The isoelectric point of His is 7.6. If the pH of the buffer solution is 7.6 histidine will not migrate towards either the anode or cathode because it remains neutral. The isoelectric point Gly is 6, which is less than 7.6. Therefore, in a buffer solution of 7.6 Gly will form a negative ion and migrate towards the anode. Similarly, the isoelectric point for Lys is 9.7, therefore, Lys will form a positive ion and migrate towards the cathode.	• explains when buffer solution is pH 7.6 – histidine is neutral and will not migrate **[1 mark]** – Gly forms a negative ion and migrates towards anode (positive terminal) **[1 mark]** – Lys forms a positive ion and migrates towards the cathode (negative terminal) **[1 mark]**

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