



GuideMyGrades

— YOUR GOALS. OUR EXPERTISE. —

EDEXCEL A LEVEL CHEMISTRY: QUESTIONS BY TOPIC

Redox II (14)

A Level Chemistry Topic 14

6 questions · 64 marks · Mark schemes included

Pearson Edexcel A Level Chemistry (9CH0), June 2017 - June 2025

 [guidemygrades.com](https://www.guidemygrades.com)

 @Guidemygrades

 @Guidemygrades

 @Guidemygrades

 info@guidemygrades.com

 Piccadilly Business Centre, Unit C, Aldow Enterprise Park
Blackett Street, Manchester, M12 6AE

HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any sub-topic heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

QUESTION	SOURCE	MARKS	PAGE
14(a) STANDARD ELECTRODE POTENTIALS AND CELLS		4 questions · 39 marks	3
1. Q5	A Level Paper 1 June 2018	7	4
2. Q2	A Level Paper 3 June 2019	7	6
3. Q5	A Level Paper 3 June 2023	12	8
4. Q8	A Level Paper 1 June 2022	13	11
14(b) REDOX REACTIONS AND TITRATIONS		1 question · 15 marks	15
5. Q8	A Level Paper 3 October 2020	15	16
14(c) FUEL CELLS		1 question · 10 marks	18
6. Q5	A Level Paper 1 June 2024	10	19



QUESTIONS

6 questions · 64 marks · grouped by sub-topic



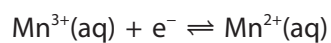
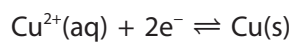
SUB-TOPIC 14(a)

STANDARD ELECTRODE POTENTIALS AND CELLS

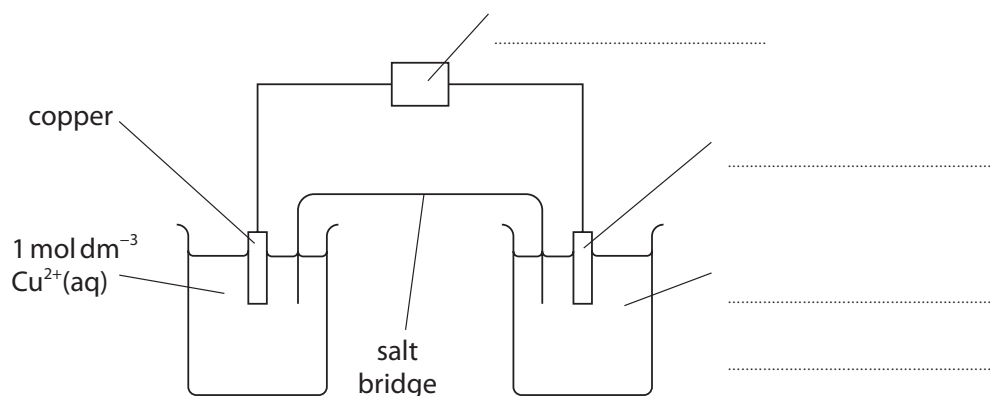
4 questions in this sub-topic · 39 marks · lowest tariff first



- 5 An electrochemical cell is made from the electrode systems represented by these half-equations.



The $E_{\text{cell}}^{\ominus}$ value is measured using the apparatus shown.



- (a) Complete the diagram by adding labels on the dotted lines provided.

(3)

- (b) A salt bridge is used to connect the two half-cells.

- (i) State what chemical is contained in the salt bridge.

(1)

.....

.....

- (ii) Give a possible reason why the salt bridge cannot be replaced by an unreactive metal wire.

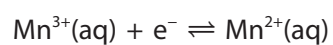
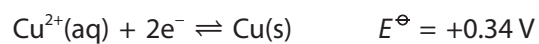
(1)

.....

.....

.....

(c) In this cell, the copper is oxidised and $E_{\text{cell}}^{\ominus} = +1.15\text{V}$.



- (i) Write the overall ionic equation for the reaction taking place.
State symbols are not required.

(1)

- (ii) Calculate the value of the standard electrode potential for the
 $\text{Mn}^{3+}(\text{aq}) \mid \text{Mn}^{2+}(\text{aq})$ half-cell.

(1)

(Total for Question 5 = 7 marks)



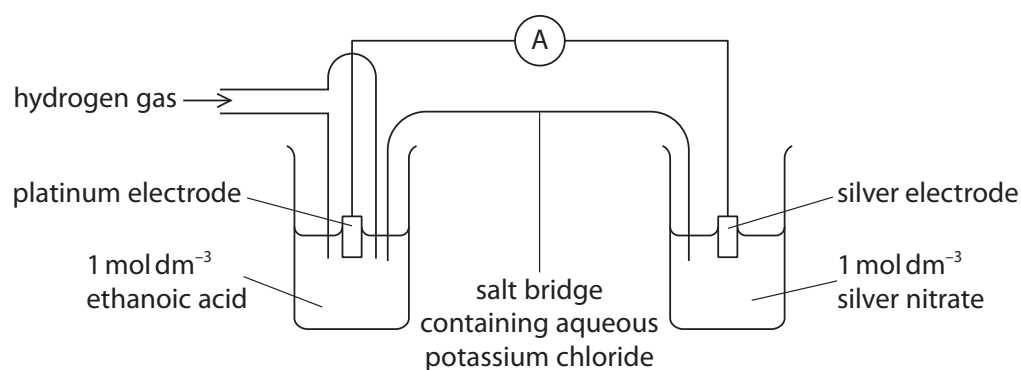
2 This question is about the $\text{Ag}^+(\text{aq})|\text{Ag}(\text{s})$ half-cell.

(a) A student was asked to plan an experiment to measure the standard electrode potential of the $\text{Ag}^+(\text{aq})|\text{Ag}(\text{s})$ half-cell.

(i) State the conditions of temperature and pressure under which standard electrode potentials are measured.

(1)

(ii) The student drew the diagram shown.



Identify **three** mistakes in this diagram and the modifications that should be made to correct them.

(3)

Mistake in diagram	Modification needed to correct mistake

(b) The standard electrode potential, $E^\ominus$, of the $\text{Ag}^+(\text{aq})|\text{Ag}(\text{s})$ half-cell is +0.80V.

The effect of changing the concentration of the ions on the value of the electrode potential, E , in this half-cell is calculated using the equation

$$E = E^\ominus + \frac{RT}{96500} \times \ln[\text{Ag}^+(\text{aq})]$$

where T is the temperature in kelvin and R is the gas constant.

The electrode potential of a $\text{Ag}^+(\text{aq})|\text{Ag}(\text{s})$ half-cell was measured at 20 °C and found to be +0.72V.

Calculate the concentration of silver ions, in mol dm^{-3} , in this half-cell.

(3)

(Total for Question 2 = 7 marks)

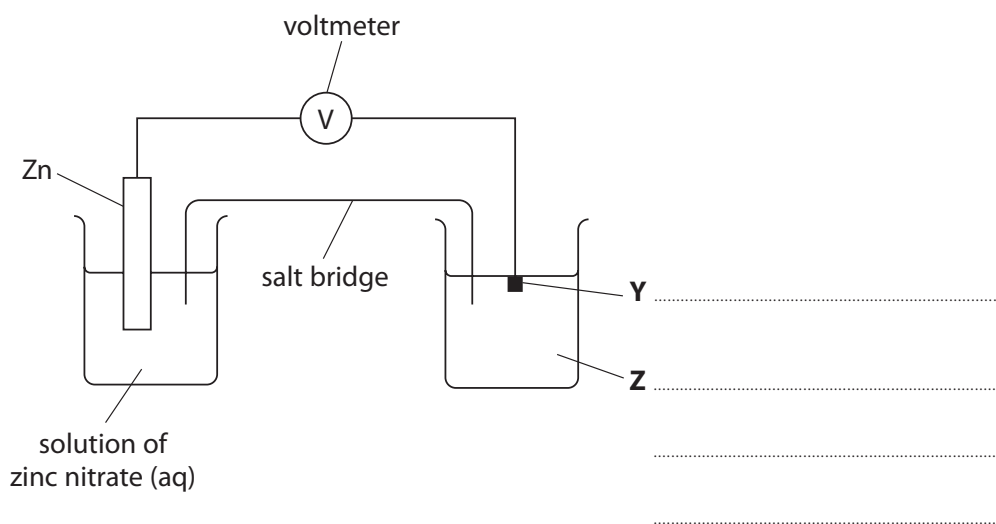


5 This question is about electrochemical cells.

- (a) A diagram is shown of the apparatus that is used to measure the emf of a cell with a zinc/zinc(II) electrode and an acidified manganese(II)/manganate(VII) electrode system.

Complete the labels **Y** and **Z** by naming the substances needed.
Temperature and concentrations are not required.

(3)



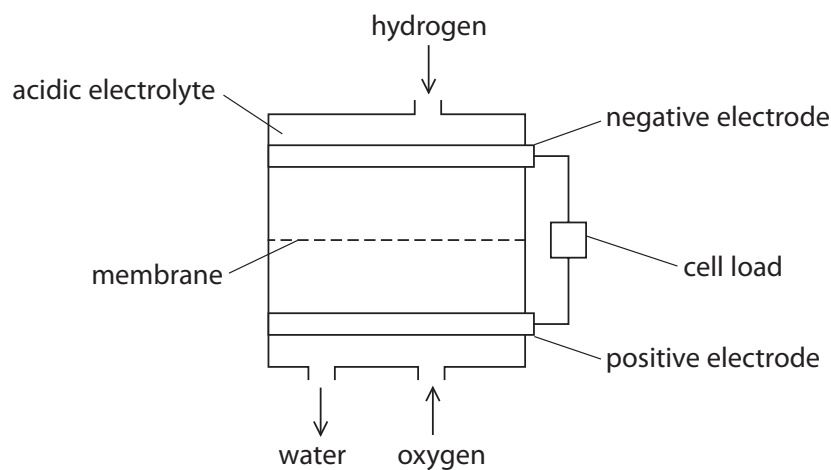
(c) A cell diagram is shown.



Deduce the reduction half-equation.
State symbols are not required.

(1)

(d) State the direction of the electron flow in the hydrogen-oxygen fuel cell shown.
Justify your answer by reference to the redox processes in the cell.



(2)

(e) State one advantage of the hydrogen-oxygen fuel cell over the use of petrol as fuel in a vehicle.

(1)

(Total for Question 5 = 12 marks)



8 This question is about electrode potentials, cells and equilibrium constants.

- (a) Chlorine gas can be prepared by the oxidation of chloride ions with manganate(VII) ions in acid solution.



During this reaction, each manganate(VII) ion accepts five electrons.

Calculate the equilibrium constant, K , for this reaction at 298 K using the expression

$$\ln K = \frac{nE_{\text{cell}}^\ominus F}{RT}$$

where n is the number of electrons transferred in the overall equation,
 F is the Faraday constant ($96\,500 \text{ C mol}^{-1}$) and
 R is the gas constant ($8.31 \text{ J mol}^{-1} \text{ K}^{-1}$).
 Units of K are not required.

(2)



(b) A fuel cell produces a voltage from the reaction between a fuel and oxygen.

The reaction occurring at one electrode in a methanol fuel cell is



Which reaction occurs at the other electrode?

(1)

- ☐ **A** $4\text{H}^+(\text{aq}) + \text{O}_2(\text{g}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$
- ☐ **B** $2\text{H}_2(\text{g}) + 2\text{O}_2(\text{g}) + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq})$
- ☐ **C** $4\text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2(\text{g}) + 2\text{O}_2(\text{g}) + 4\text{e}^-$
- ☐ **D** $2\text{H}_2\text{O}(\text{l}) \rightarrow 4\text{H}^+(\text{aq}) + \text{O}_2(\text{g}) + 4\text{e}^-$

(c) Lead-acid batteries are used as storage cells in some cars.

The electrolyte is sulfuric acid, one electrode is lead and the other is lead(IV) oxide, PbO_2 .

As the cell discharges, the lead and the lead(IV) oxide are both converted to solid lead(II) sulfate, PbSO_4 , and the concentration of the sulfuric acid decreases.

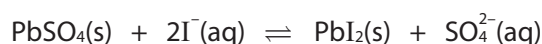
Deduce, using the information given, the two half-equations occurring in the lead-acid battery.

State symbols **are** required.

(3)



- (d) When solid lead(II) sulfate is added to aqueous sodium iodide, an equilibrium is established.



The expression for the equilibrium constant, K_c , for this reaction is

$$K_c = \frac{[\text{SO}_4^{2-}(\text{aq})]}{[\text{I}^-(\text{aq})]^2}$$

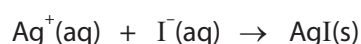
In an experiment, K_c may be determined by adding excess lead(II) sulfate to 25.0 cm^3 of $0.100 \text{ mol dm}^{-3}$ sodium iodide.

The volume remains constant at 25.0 cm^3 .

The mixture is left to reach equilibrium at room temperature.

Ice-cold water is added to freeze the position of equilibrium and the mixture is then titrated with standard silver nitrate solution.

The whole mixture requires 12.20 cm^3 of $0.0500 \text{ mol dm}^{-3}$ silver nitrate solution to react with the aqueous iodide ions at equilibrium.



Calculate the equilibrium concentrations of the sulfate ions and the iodide ions, and hence the value of K_c at room temperature.

Give your answer to an appropriate number of significant figures and include units for K_c , if any.

(7)



(Total for Question 8 = 13 marks)



SUB-TOPIC 14(b)

REDOX REACTIONS AND TITRATIONS

1 question in this sub-topic · 15 marks · lowest tariff first



8 This is a question about chromium(III) and chromium(VI) compounds.

- (a) Describe the observations when aqueous sodium hydroxide is added drop by drop until in excess to a solution of chromium(III) ions.

(2)

- (b) The chromium(III) complex, $[\text{Cr}(\text{OH})_6]^{3-}$, can be oxidised to chromate(VI) ions, CrO_4^{2-} , by hydrogen peroxide solution.

- (i) Deduce the oxidation half-equation for this reaction, which takes place in alkaline conditions. State symbols are not required.

(2)

- (ii) If the solution of chromate(VI) ions is then acidified, the colour of the solution changes to orange as dichromate(VI) ions form.

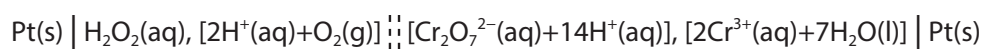
Write the equation for this change. State symbols are not required.

(1)



(iii) In acidic conditions, dichromate(VI) ions can also be reduced to chromium(III) ions using hydrogen peroxide.

The value of $E^{\ominus}_{\text{cell}} = +0.65\text{ V}$ for which the cell diagram is



Deduce from the cell diagram the oxidation and the reduction half-equations, and thus the overall equation for this reaction.

State symbols are not required.

(3)

- (c) Draw a labelled diagram of the apparatus that you would use to measure the standard emf of a cell with a zinc-zinc(II) electrode system and a chromium(III)-dichromate(VI) electrode system.

Include the **formulae** of all the compounds required and the concentrations of the solutions.

(7)

(Total for Question 8 = 15 marks)



SUB-TOPIC 14(c)

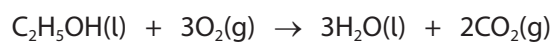
FUEL CELLS

1 question in this sub-topic · 10 marks · lowest tariff first



- 5 This question is about 'Direct Ethanol Fuel Cells' which are being developed to power small electronic devices.

The overall reaction in these fuel cells is shown.



- (a) Calculate the enthalpy change for the reaction using the mean bond enthalpy data.

(3)

Bond	Mean bond enthalpy / kJ mol^{-1}
C—C	347
C—H	413
C—O	358
O—H	464
O=O	498
C=O	805

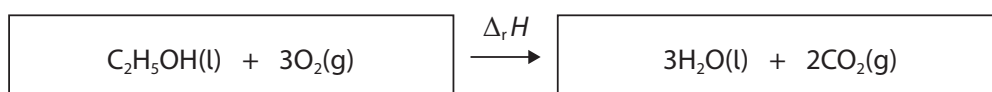
Enthalpy change = ... kJ mol^{-1}



- (b) (i) Complete the enthalpy cycle for the overall reaction in the Direct Ethanol Fuel Cell. Include labels.

(2)

Substance	$\Delta_f H^\ominus / \text{kJ mol}^{-1}$
$\text{C}_2\text{H}_5\text{OH}(\text{l})$	-277
$\text{CO}_2(\text{g})$	-394
$\text{H}_2\text{O}(\text{l})$	-286



- (ii) Calculate a value for the enthalpy change of the Direct Ethanol Fuel Cell reaction, using your cycle.

(1)

Enthalpy change = ... kJ mol^{-1}



(c) Give **two** reasons for the difference between your calculated values in (a) and (b).

(2)

.....

.....

.....

.....

.....

.....

(d) In the Direct Ethanol Fuel Cell under acidic conditions, at one electrode the ethanol is oxidised in the presence of water to produce carbon dioxide, hydrogen ions and electrons.

At the other electrode, the hydrogen ions and electrons combine with oxygen to form water.

Write the two ionic half-equations for this process.
State symbols are not required.

(2)

Oxidation half-equation

Reduction half-equation

(Total for Question 5 = 10 marks)



MARK SCHEMES

official Pearson Edexcel mark schemes



Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)	(high resistance) voltmeter	(1) Allow potentiometer / Wheatstone bridge / just 'V' Ignore high voltage Do not award voltameter	(3)
	platinum /Pt (electrode)	(1) Ignore just 'inert metal' Do not award manganese / Mn	
	manganese(II) and manganese(III) ions / Mn^{2+} and Mn^{3+}	(1) Allow any named manganese(II) salt and manganese(III) salt Ignore concentration and units	

Question Number	Acceptable Answer	Additional Guidance	Mark
5(b)(i)	potassium nitrate / KNO_3	If name and formula are given, both must be correct If more than one substance given, all must be correct Allow potassium chloride / KCl sodium nitrate / NaNO_3 sodium chloride / NaCl ammonium nitrate / NH_4NO_3 ammonium chloride / NH_4Cl Ignore concentration	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
5(b)(ii)	- wire does not allow the flow of ions or - wire (only) allows flow of electrons or - salt bridge allows flow of ions or - salt bridge does not allow the flow of electrons or - a flow of ions is needed to complete the circuit or - ions (need to) flow between the half-cells / between the solutions	Allow any indication of movement for flow in all points Allow the salt bridge donates / removes ions (to balance the charges in the solution and the wire does not do this) Ignore just 'the circuit is not complete' Ignore references to changes in potential difference / $E^\ominus$ / $E^\ominus_{\text{cell}}$	(1)



Question Number	Acceptable Answer	Additional Guidance	Mark
5(c)(i)	correct equation	<u>Example of equation</u> $2\text{Mn}^{3+} + \text{Cu} \rightarrow 2\text{Mn}^{2+} + \text{Cu}^{2+}$ Allow multiples Allow $\rightleftharpoons$ provided equation is written in the direction shown Ignore state symbols, even if incorrect Ignore cancelled electrons e.g. $2\text{Mn}^{3+} + \text{Cu} + 2\text{e} \rightarrow 2\text{Mn}^{2+} + \text{Cu}^{2+} + 2\text{e}$ Do not award equation with uncanceled electrons	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
5(c)(ii)	$E^{\ominus} = 1.15 - (-0.34) = (+)1.49 \text{ (V)}$	Stand alone mark Correct answer with no working scores the mark	(1)

(Total for Question 5 = 7 marks)



Question Number	Acceptable Answers	Additional Guidance	Mark
2(a)(i)	correct temperature and pressure	<u>Examples of values</u> Temperature: 298 K / 25°C Pressure: 1 atm / 1 bar 100 kPa / 1×10^5 Pa / 101 kPa / 1.01×10^5 Pa / $1 \times 10^5 \text{ Nm}^{-2}$ / $1.01 \times 10^5 \text{ Nm}^{-2}$ Values and units are needed Ignore reference to concentration even if incorrect	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
2(a)(ii)	- ammeter / symbol for ammeter and replace with (high resistance) voltmeter / symbol for voltmeter (1) - ethanoic acid and replace with solution that is 1.0 mol dm^{-3} with respect to $\text{H}^+(\text{aq})$ (1) - potassium chloride / chemical in salt bridge and replace with potassium nitrate / KNO_3 / sodium nitrate / NaNO_3 (1)	The mistakes can be in any order Ignore any other errors Ignore reasons for replacements Allow replace with potentiometer / Wheatstone bridge Do not award voltameter Allow replace with (1.0 / 1.16-1.18 mol dm^{-3}) hydrochloric acid / HCl / nitric acid / HNO_3 or Allow 0.5 mol dm^{-3} sulfuric acid / H_2SO_4 Ignore just 'replace with a strong acid' Allow replace chloride with a nitrate anion Ignore replace with a different anion that will not react with Ag^+	(3)



Question Number	Acceptable Answers	Additional Guidance	Mark
2(b)	- substitution of correct values into expression (1) - calculation of $\ln[\text{Ag}^+(\text{aq})]$ (1) - calculation of $[\text{Ag}^+(\text{aq})]$ (1)	<u>Example of calculation</u> $0.72 = 0.80 + \frac{8.31 \times 293}{96500} \times \ln[\text{Ag}^+(\text{aq})]$ $\ln[\text{Ag}^+(\text{aq})] = \frac{(0.72 - 0.80) \times 96500}{8.31 \times 293}$ $= -3.1707$ $[\text{Ag}^+(\text{aq})] = e^{\ln[\text{Ag}^+(\text{aq})]}$ $= 0.041976 / 4.1976 \times 10^{-2} \text{ (mol dm}^{-3}\text{)}$ TE on $\ln[\text{Ag}^+(\text{aq})]$ Ignore SF except 1 SF Correct answer with no working scores full marks Expression can be rearranged before substitution of values	(3)

(Total for Question 2 = 7 marks)

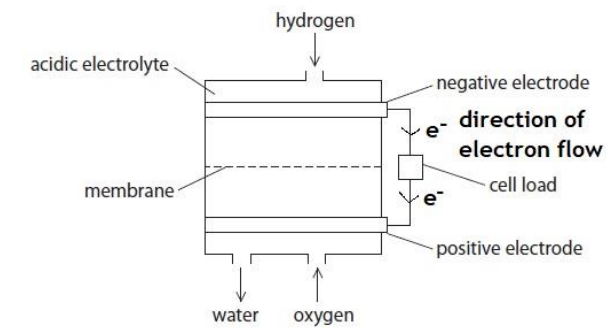


Question Number	Answer	Additional Guidance	Mark
5(a)	An answer which makes reference to the following points: (Y) platinum / Pt (1) (Z) - manganese(II) nitrate / $\text{Mn}(\text{NO}_3)_2$ and potassium manganate(VII) / KMnO_4 (solution) (1) - sulfuric acid (1)	Names or formulae accepted but if both given then both must be correct All three are standalone marks Ignore reference to (platinum) black Allow MnSO_4 Allow sodium manganate(VII)/ NaMnO_4 Allow potassium permanganate for KMnO_4 Oxidation numbers essential if only the names are given Allow nitric acid Do not award use of hydrochloric acid Ignore concentrations throughout Penalise use of hydrochloric acid or manganese halides once only	(3)



Question Number	Answer	Additional Guidance	Mark
5(b)	An explanation that makes reference to the following points: (chromium(VI) reduced to) chromium +2 / (II) (1) - because $E^\ominus_{\text{cell}}$ value for the reduction of chromium(VI) to chromium(III) (1) $E^\ominus_{\text{cell}}$ value for the reduction of chromium(III) to chromium(II) (1) $E^\ominus_{\text{cell}}$ value for the reduction of chromium(II) to chromium (1) - first two reductions occur (because $E^\ominus_{\text{cell}}$ is positive in both cases) and final reaction does not occur (because $E^\ominus_{\text{cell}}$ is negative) (1)	Allow Cr^{2+} Allow TE on candidate $E^\ominus_{\text{cell}}$ values, e.g. all $E^\ominus_{\text{cell}}$ values positive then Cr(0) is the result $E^\ominus_{\text{cell}} = (+1.33 - -0.76 =) (+) 2.09 \text{ (V)}$ $E^\ominus_{\text{cell}} = (-0.41 - -0.76 =) (+) 0.35 \text{ (V)}$ $E^\ominus_{\text{cell}} = (-0.91 - -0.76 =) -0.15 \text{ (V)}$ Accept feasible for occur Ignore equations even if incorrect Penalise reference to Zn^{2+} reacting in the written answer once only for M2 and M3	(5)

Question Number	Answer	Additional Guidance	Mark
5(c)	half-equation	<u>Example of equation</u> $\text{NO}_3^- + 2\text{H}^+ + \text{e}^{(-)} \rightarrow \text{NO}_2 + \text{H}_2\text{O}$ Allow multiples / $\rightleftharpoons$ Ignore state symbols even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
5(d)	An answer that makes reference to the following points: (electrons move) from the negative to the positive electrode (1) (because) the hydrogen is being oxidised / losing electrons and the oxygen is being reduced / gaining electrons (1)	Allow annotation on diagram, see below Allow move from the top electrode to the bottom electrode Ignore just electrons move down/clockwise Do not allow movement through the middle of the fuel cell Allow anode for negative electrode and cathode for positive electrode Allow half-equations such as (Oxidation) $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$ and (Reduction) $\frac{1}{2}\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O}$ Do not award formation of O^{2-} ions M2 is not dependent on M1 	(2)

Question Number	Answer	Additional Guidance	Mark
5(e)	An answer which makes reference to any one of the following points harmless product/water compared to pollutants or less reliant on fossil fuels/non-renewable fuels or more efficient energy production or (can be) smaller and lighter fuel cell	Accept named pollutants e.g. CO/CO₂/SO₂/NO_x Allow hydrogen fuel cell only produces water Allow hydrogen (fuel) is renewable/sustainable Allow no use of fossil fuels Allow less/no green house gases produced Ignore just 'more efficient'	(1)

(Total Question 5 = 12 marks)



Question Number	Answer	Additional Guidance	Mark
8(a)	- substitution of values into the equation (1) - calculation of K_c (1)	Example of calculation $\ln K_c = \frac{5 \times 0.15 \times 96\,500}{8.31 \times 298}$ ($\ln K_c = 29.226$) $K_c = 4.9289 \times 10^{12}$ $= 4.9 \times 10^{12} / 4.93 \times 10^{12}$ TE on their value for $\ln K_c$ Ignore SF except 1SF Correct answer with no working scores (2)	(2)

Question number	Answer	Mark
8(b)	The only correct answer is A $(4\text{H}^+(\text{aq}) + \text{O}_2(\text{g}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l}))$ B is incorrect because methanol does not react with hydrogen C is incorrect because this reaction shows an oxidation D is incorrect because this reaction shows an oxidation	(1)



Question Number	Answer	Additional Guidance	Mark
8(c)	- one half-equation (1) - other half-equation (1) - state symbols (1)	<u>Examples of half-equations</u> $\text{Pb(s)} + \text{SO}_4^{2-}(\text{aq}) \rightleftharpoons \text{PbSO}_4(\text{s}) + 2\text{e}^-$ Allow $\text{Pb(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightleftharpoons \text{PbSO}_4(\text{s}) + 2\text{H}^+(\text{aq}) + 2\text{e}^-$ $\text{PbO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O(l)}$ Allow $\text{PbO}_2(\text{s}) + 2\text{H}^+(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O(l)}$ Allow multiples Allow single headed arrows in the forward direction Ignore missing charge on electrons Conditional on correct species in one equation that has scored either M1 or M2	(3)



Question Number	Answer	Additional Guidance	Mark
8(d)	- calculation of initial mol I⁻ (1) - calculation of eqm mol I⁻ (1) - calculation of mol I⁻ reacted (1) - calculation of eqm mol⁻¹ SO₄²⁻ (1) - calculation of eqm [SO₄²⁻(aq)] and calculation of eqm [I⁻(aq)] (1) - calculation of K_c and answer to 2 / 3 SF (1) - units (1)	<u>Example of calculation</u> initial mol I⁻ = (25.0 × 0.100) ÷ 1000 = 2.5 × 10⁻³ / 0.0025 (mol) eqm mol I⁻ (= mol Ag⁺) = (12.20 × 0.0500) ÷ 1000 = 6.1 × 10⁻⁴ / 0.00061 (mol) mol I⁻ reacted = 2.5 × 10⁻³ – 6.1 × 10⁻⁴ = 1.89 × 10⁻³ / 0.00189 (mol) eqm mol SO₄²⁻ = mol I⁻ reacted / 2 = 1.89 × 10⁻³ ÷ 2 = 9.45 × 10⁻⁴ / 0.000945 eqm [SO₄²⁻] = (9.45 × 10⁻⁴ × 1000) ÷ 25 = 0.0378 (mol dm⁻³) and eqm [I⁻] = (6.1 × 10⁻⁴ × 1000) ÷ 25.0 = 2.44 × 10⁻² / 0.0244 (mol dm⁻³) K_c = 0.0378 ÷ 0.0244² = (63.49) = 63 / 63.5 Do not award unless their numbers are correct or are TE. Allow TE throughout. Correct answer with working gains 7 marks dm³ mol⁻¹ (standalone mark) Allow dm³ mol⁻¹ / mol⁻¹ dm³ / mol⁻¹ dm³	(7)

(Total for Question 8 = 13 mark)



Question Number	Answer	Additional Guidance	Mark
8(a)	A description that makes reference to - green ppt. (1) - ppt dissolves (in excess NaOH) to give a green solution (1)	Accept 'green solid' Allow 'grey-green ppt' Do not award blue-green Ignore shades M2 dependent upon M1 or near-miss	(2)

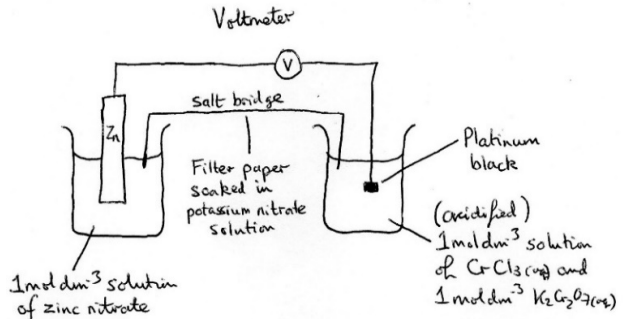
Question Number	Answer	Additional Guidance	Mark
8(b)(i)	- four correct species (1) - balancing and the correct number of electrons (1)	<u>An example of equation</u> $[\text{Cr}(\text{OH})_6]^{3-} + 2\text{OH}^- \rightarrow \text{CrO}_4^{2-} + 4\text{H}_2\text{O} + 3\text{e}^-$ Accept multiples	(2)

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	equation	<u>An example of equation</u> $2\text{CrO}_4^{2-} + 2\text{H}^+ \rightarrow \text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O}$ Accept $\rightleftharpoons$ / multiples	(1)



Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	- oxidation half equation - reduction half equation - overall equation	(1) $\text{H}_2\text{O}_2 \rightarrow 2\text{H}^+ + \text{O}_2 + 2\text{e}^-$ (1) $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$ (1) $\text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ + 3\text{H}_2\text{O}_2 \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{O}_2$ for M3 do not award if H^+ / e^- left on both sides Accept multiples Allow $\rightleftharpoons$ Ignore state symbols even if incorrect Oxidation and reduction half equations scores (2) if not identified but in correct order Award (1) only for M1 and M2 if half equations are not in correct order No TE on incorrect half equations	(3)



Question Number	Answer	Additional Guidance	Mark
8(c)	A diagram that includes (M1) (high resistance) voltmeter/V (1) (M2) salt bridge to complete circuit (1) (M3) filter paper soaked in (saturated) potassium nitrate/KNO_3 solution (1) (M4) zinc electrode of zinc metal and suitable zinc salt (1) (M5) platinum (black) electrode (1) (M6) suitable chromium salts (1) (M7) all solutions to be 1 mol dm^{-3} (wrt ions) (1)	Example of diagram  Salt bridge must dip into the solutions Allow sodium chloride/potassium chloride for potassium nitrate e.g. ZnSO_4 e.g. $\text{CrCl}_3 / \text{K}_2\text{Cr}_2\text{O}_7$ if $\text{Cr}_2(\text{SO}_4)_3$ is used then M7 can only be awarded if its concentration is 0.5 mol dm^{-3} Allow electrodes drawn the other way round Ignore temperature is 298 K Penalise use of just names once only	(7)

(Total Question 8 = 15 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)	- calculation of enthalpy change for bonds breaking - calculation of enthalpy change for bonds forming - total enthalpy change with negative sign	<u>Example of calculation</u> (1) $= (5 \times 413) + 347 + 358 + 464 + (3 \times 498)$ $= (+) 4728 \text{ (kJ mol}^{-1}\text{)}$ (1) $= (6 \times 464) + (4 \times 805)$ $= (-) 6004 \text{ (kJ mol}^{-1}\text{)}$ (1) $= (-6004 + 4728)$ $= -1276 \text{ (kJ mol}^{-1}\text{)}$ Correct answer with no working scores 3. Allow TE for M3 Allow SF apart from 1SF. (+)1276 scores 2	(3)



Question Number	Acceptable Answer	Additional Guidance	Mark
5(b)(i)	An answer that makes reference to the following points: - correct species, balanced, with state symbols in the bottom box (1) - arrows in correct direction and labelled (1)	Allow any suitable labels – e.g just $\Delta_r H^\circ$ / correct numbers left hand -277 and right hand -1646 or 3×-286 and 2×-394 Allow omission of state symbols on the arrows. Allow C(graphite) for C(s)	(2)
5(b)(ii)	calculation of standard enthalpy of combustion of ethanol, $\Delta_c H^\circ$ [C₂H₅OH]	<u>Example of calculation</u> $(\Delta_r H^\circ [\text{C}_2\text{H}_5\text{OH}(\text{l})] = (-286 \times 3) - (2 \times 394) + 277$ $= -1369 \text{ (kJ mol}^{-1}\text{)}$ Allow final answer rounded to -1370 as long as -1369 is seen and the sign on the final answer is correct. Correct answer scores 1 No TE on incorrect cycle	(1)



Question Number	Acceptable Answer	Additional Guidance	Mark
5(c)	An answer that makes reference to the following point: (values are different because) mean bond enthalpies have been used (in the first calculation) (which are different from the actual values) (1) (values are different) because the bond enthalpy values are given for substances in the gas state (and water and ethanol are liquids) (1)	Ignore references to standard conditions	(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
5(d)	An answer that makes reference to the following points: - oxidation half–equation (1) - reduction half–equation (1)	$\text{C}_2\text{H}_5\text{OH} + 3\text{H}_2\text{O} \rightarrow 2\text{CO}_2 + 12\text{e}^{(-)} + 12\text{H}^+$ $4\text{H}^+ + 4\text{e}^{(-)} + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ Allow multiples Allow reversible arrows but equations must be written forwards Comment: Allow 1 mark if both equations correct but oxidation and reduction swapped Ignore state symbols even if incorrect	(2)

(Total for Question 5 = 10 marks)

