



GCE A LEVEL

1410U30-1

TUESDAY, 4 JUNE 2019 – AFTERNOON

CHEMISTRY – A2 unit 3

Physical and Inorganic Chemistry

1 hour 45 minutes plus your additional time allowance

Surname _____

Other Names _____

Centre Number _____

Candidate Number 2 _____

For Examiner's use only			
	Question	Maximum Mark	Mark Awarded
Section A	1. to 8.	10	
Section B	9.	15	
	10.	15	
	11.	12	
	12.	15	
	13.	13	
	Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:

- calculator;
- DATA BOOKLET supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball-point pen or your usual method.

Write your name, centre number and candidate number in the spaces provided on the front cover.

SECTION A

Answer ALL questions in the spaces provided.

SECTION B

Answer ALL questions in the spaces provided.

Candidates are advised to allocate their time appropriately between
**SECTION A (10 MARKS) and
SECTION B (70 MARKS).**

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in Q.11(b).

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

SECTION A

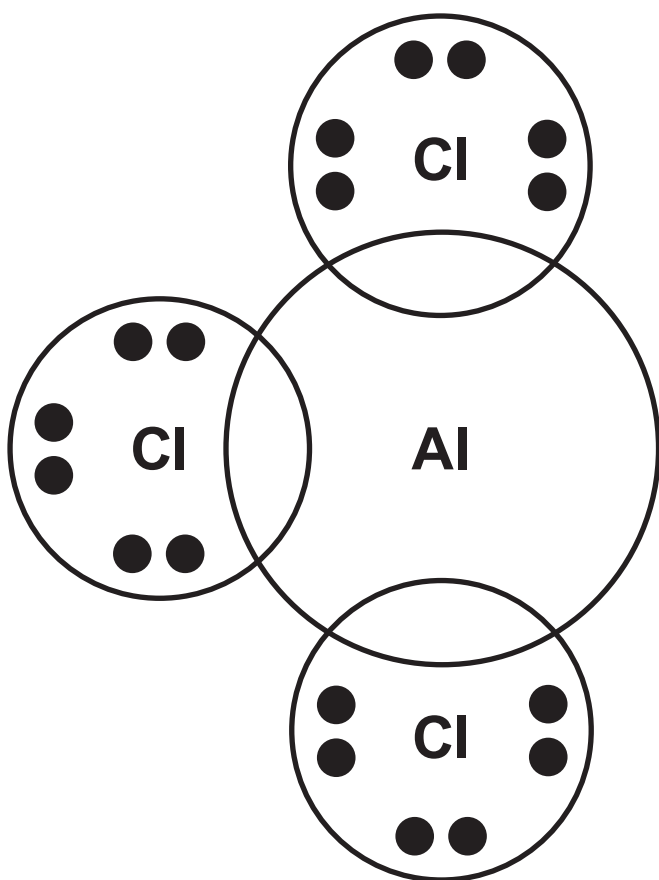
Answer ALL questions in the spaces provided.

1. Complete the electronic structure of the Co^{2+} ion below. [1]

$1s^2 2s^2 2p^6 3s^2 3p^6$ _____

2. The compound $\text{AlCl}_3 \cdot \text{NH}_3$ contains both covalent and coordinate bonds.

Complete the dot and cross diagram for this compound. [2]



3. Write the expression for the ionic product of water, K_w . [1]

4. The standard hydrogen electrode and hydrogen fuel cells both use the same metal as an electrode. Name the metal and explain why this metal is suitable. [1]

5. When CCl_4 is added to water two separate layers are formed and there is no reaction, whilst SiCl_4 reacts violently with water.

Give the reason for this difference. [1]

6. The entropy change of the reaction shown opposite is positive. Give a reason for this. [1]



7. Carbon monoxide can be used to extract iron by the reduction of Fe_3O_4 .

(a) Write an equation for this reaction. [1]

(b) Give a reason why carbon monoxide acts as a reducing agent while the equivalent oxide of lead does not. [1]

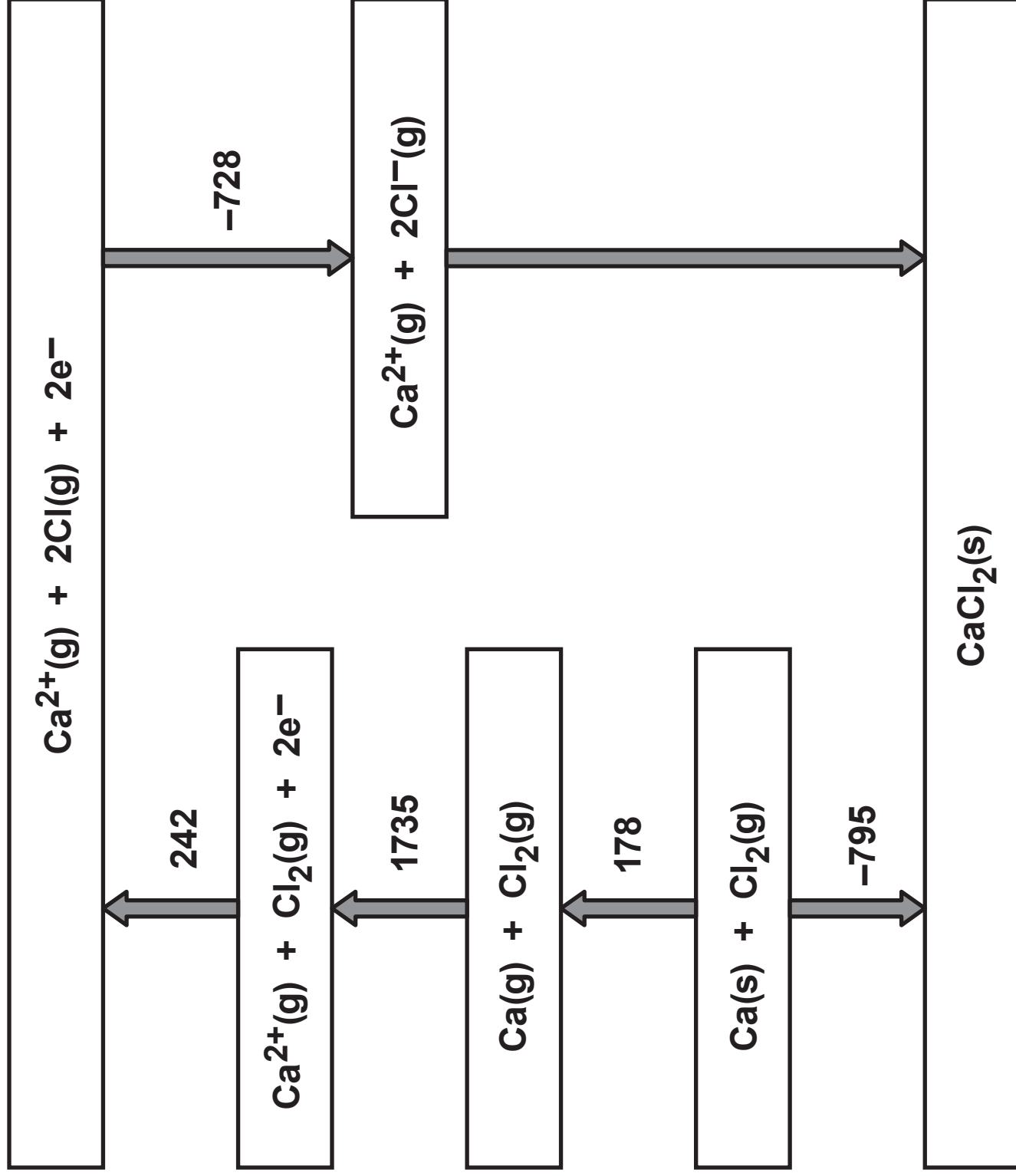
8. Draw the **STRUCTURE** of the copper-containing ion formed when concentrated hydrochloric acid is added to a solution containing $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ions. [1]

SECTION B

Answer ALL questions in the spaces provided.

- 9. Calcium chloride is an ionic solid that is used as a drying agent due to its ability to absorb water and form a range of hydrated crystals.**
- (a) The Born-Haber cycle opposite shows the formation of calcium chloride from its elements.**

All values shown are standard enthalpy changes and are given in kJ mol^{-1} .



- 9(a) (i) Give the value of the standard enthalpy change of atomisation of chlorine. [1]

_____ kJ mol^{-1}

- (ii) Calculate the standard enthalpy of lattice formation of CaCl_2 . [2]

$\Delta_{\text{latt form}} H^\theta =$ _____ kJ mol^{-1}

- 9(a) (iii) A student incorrectly states that the second ionisation energy of calcium is 1735 kJ mol^{-1} as this is the energy needed to form $\text{Ca}^{2+}(\text{g})$ in the Born-Haber cycle.

Suggest a possible value for the second ionisation energy of calcium, giving a reason for your answer. [2]

9(b) The reaction occurring when calcium chloride is used as a drying agent is shown below.



(i) A laboratory manual suggests a **MINIMUM** temperature of 200 °C to remove all the water from the hydrated calcium chloride. At this temperature the reaction occurring is as follows.



A student calculates the enthalpy change when calcium chloride becomes dehydrated as 78.0 kJ mol⁻¹.

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Assuming that this data is correct, calculate a value for the entropy change when calcium chloride becomes dehydrated at this temperature. [3]

$\Delta S =$ _____ $\text{JK}^{-1}\text{mol}^{-1}$

- 9(b) (ii) In the drying process 5.20 g of hydrated calcium chloride forms 3.15 g of anhydrous calcium chloride.

Calculate the value of x in the original $\text{CaCl}_2 \cdot x\text{H}_2\text{O}$. [3]

$x =$ _____

9(b) (iii) State the colour observed in a flame test using calcium chloride. [1]

10. Iodomethane, CH_3I , reacts with a range of nucleophiles. The rate of its reaction with thiosulfate ions, $\text{S}_2\text{O}_3^{2-}$, has been studied at a range of temperatures.
- (a) The reaction is found to be first order with respect to iodomethane and has a rate constant of $3.10 \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$ at a particular temperature.
- (i) Write the rate equation for this reaction. [2]
-
-

- 10(a) (ii) The activation energy for this reaction is 81.1 kJ mol^{-1} with a frequency factor, A , of $5.62 \times 10^{12} \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$. Find the temperature used for this reaction. [3]

$T =$ _____ K

10(b) One method of performing this experiment involves sampling and quenching.

(i) Explain what is meant by the term 'quenching' and why it needs to be carried out. [2]

10(b) (ii) One method of measuring the concentration of thiosulfate ions in solution is by titration using a solution containing iodine. Suggest an indicator for this titration. [1]

(iii) A student suggests using gravimetric analysis to measure the amount of iodide ions produced in the reaction by addition of $\text{Pb}^{2+}(\text{aq})$ ions to form a precipitate. Give the colour of this precipitate. [1]

10(c) Iodomethane is an intermediate in the conversion of methanol to ethanoic acid.

(i) One catalyst used for this reaction is the iridium-containing complex ion $[\text{Ir}(\text{CO})_2\text{I}_2]^-$. It is an example of a homogeneous catalyst.

I. State what is meant by a HOMOGENEOUS catalyst. [1]

II. Explain why transition metal complexes such as $[\text{Ir}(\text{CO})_2\text{I}_2]^-$ can act as homogeneous catalysts. [2]

- 10(c) (ii) Ethanoic acid is a weak acid with $K_a = 1.76 \times 10^{-5} \text{ mol dm}^{-3}$. Calculate the pH of an aqueous solution of ethanoic acid with a concentration of $0.220 \text{ mol dm}^{-3}$. [3]

pH = _____

11. Oxalic acid is the common name for ethanedioic acid. It is found in a wide range of plants and when purified it can form a dihydrate, $(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$. The concentration of a saturated solution of oxalic acid can be found by titration.
- (a) A sample of 25.0 cm^3 of a saturated solution of oxalic acid is diluted to form 250.0 cm^3 of an aqueous solution. Samples of 25.0 cm^3 of this diluted solution were heated and titrated using acidified potassium manganate(VII) to oxidise the oxalic acid.

- 11(a) (i) The half-equation for the oxidation of oxalic acid is shown below.



State the half-equation for the reduction of manganate(VII) ions in acid solution and use it to write the equation for the oxidation of oxalic acid by acidified manganate(VII) ions. [2]

- 11(a) (ii) The titration of 25.0 cm^3 samples of the diluted oxalic acid solution against a potassium manganate(VII) solution of concentration $0.0505 \text{ mol dm}^{-3}$ gave the following results.

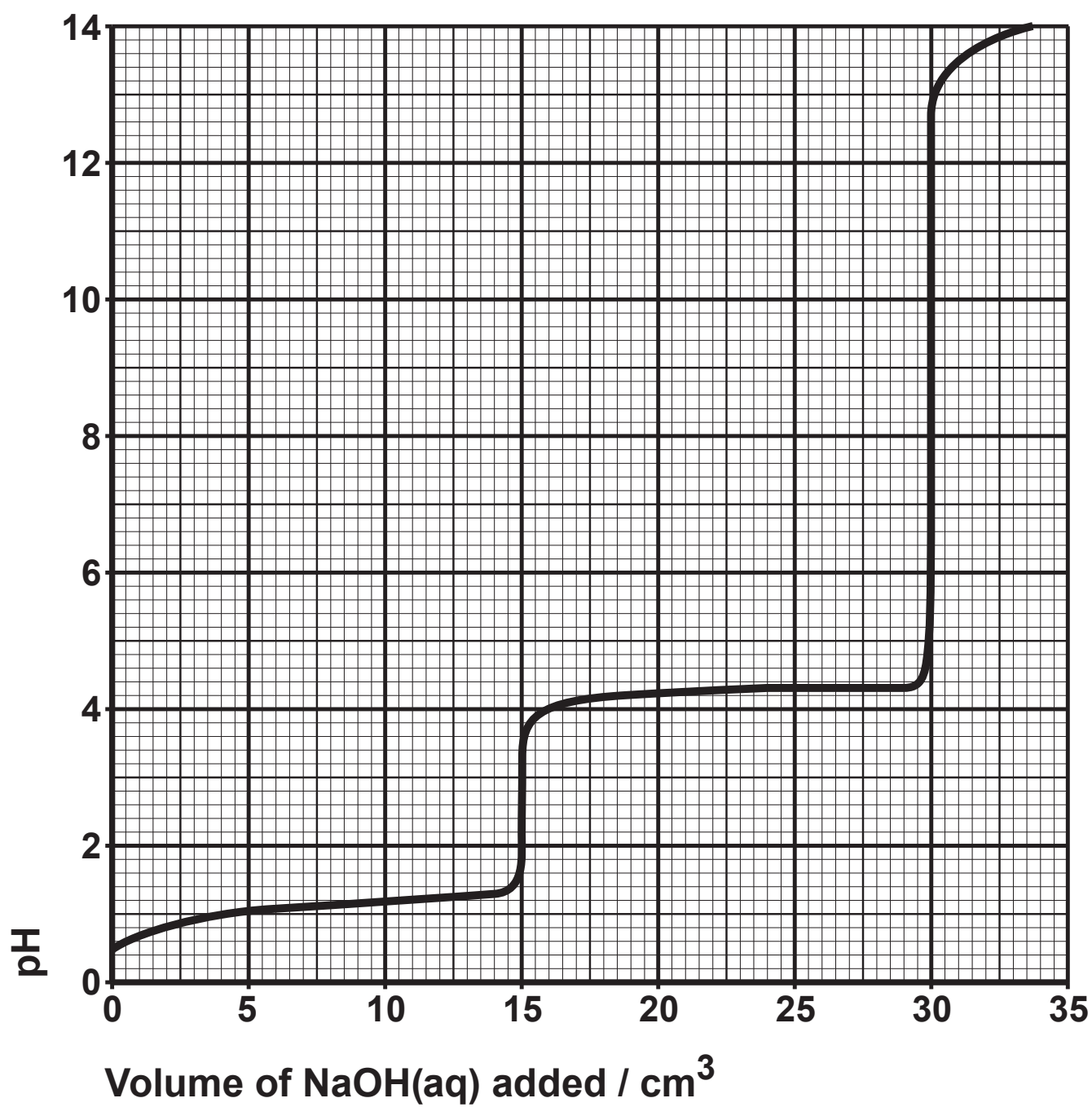
	1	2	3	4
Volume of KMnO_4 solution / cm^3	31.65	31.30	31.60	31.75

- I. Use appropriate data to find the mean volume of KMnO_4 solution used. [1]

Mean volume = _____ cm^3

- 11(a)(ii) II. Calculate the concentration of the original saturated solution of oxalic acid. [3]

Concentration = _____ mol dm⁻³



11(b) Oxalic acid solutions may be analysed using acid-base titrations. The simplified pH curve for the titration of a solution of oxalic acid against sodium hydroxide is given opposite.

Four students undertook the titration in different ways:

- Alice used a pH probe to measure the pH after addition of each portion of sodium hydroxide solution**
- Brychan used the indicator phenolphthalein in his titration; phenolphthalein has a pH range of 8.2 to 10.0**
- Carys used the indicator methyl orange in her titration; methyl orange has a pH range of 3.2 to 4.4**
- David used the indicator cresol red in his titration; cresol red has a pH range of 1.8 to 2.8**

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12(a) A student planned to distinguish between the following eight compounds.

magnesium hydroxide

magnesium carbonate

iron(II) hydroxide

iron(II) carbonate

chromium(III) hydroxide

chromium(III) carbonate

lead(II) hydroxide

lead(II) carbonate

He used the following method.

**Step 1 Add dilute acid until all the solid has disappeared.
Record any effervescence.**

**Step 2 Add 1 cm³ of sodium hydroxide solution to each solution formed in step 1.
Record any precipitate observed.**

12(a) (i) State which compound(s) would give effervescence and why they do so. [2]

12(a) (ii) The student plans to use dilute hydrochloric acid in step 1. His teacher tells him that this is NOT the correct acid to use.

Explain why hydrochloric acid should not be used and suggest an appropriate acid to use in its place. [2]

12(a) (iii) Give the colours of the precipitates formed when sodium hydroxide solution is added to solutions containing the following ions. [2]

Mg²⁺(aq) _____

Fe²⁺(aq) _____

Cr³⁺(aq) _____

Pb²⁺(aq) _____

12(b) Many rocks that contain carbonate anions also contain a mixture of cations. Atomic absorption spectroscopy can be used to find the ratio of the amounts of different cations present.

Analysis of an acid solution formed from the carbonate mineral huntite shows that it contains 91 ng cm^{-3} of magnesium ions and 50 ng cm^{-3} of calcium ions.

These are the only two metal cations present.

(i) Find the formula of the mineral huntite. [3]

Formula _____

- 12(b) (ii) The initial solution was prepared using 220 μg of huntite. Calculate the volume of aqueous acid used to form the solution for analysis. [3]

Volume = _____ dm^3

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	Standard electrode potential, E^θ / V
$\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightleftharpoons \text{Cr}(\text{s})$	-0.78
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Zn}(\text{s})$	-0.76
$\text{Cr}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{Cr}^{2+}(\text{aq})$	-0.42
$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightleftharpoons 4\text{OH}^-(\text{aq})$	+0.40
$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$	+1.33

13(b) Chromium(VI) is present in the anions dichromate(VI), $\text{Cr}_2\text{O}_7^{2-}$, and chromate(VI), CrO_4^{2-} . These ions can be interconverted in solution with the following equilibrium being established.



The equilibrium constant, K_c , for this reaction is $2.42 \times 10^{-15} \text{ mol}^2 \text{ dm}^{-6}$.

In general, dichromate(VI) is the main species in acid solution and chromate(VI) is the main species in alkaline solution.

- 13(b) (i) Write an expression for the equilibrium constant, K_c , for this reaction. [1]

13(b) (ii) The mass of the water in 1.00 cm^3 of a dilute aqueous solution is 1.00 g .

Show that the concentration of water in any dilute aqueous solution is 55.5 mol dm^{-3} .

[2]

- 13(b) (iii) A solution was prepared containing equal concentrations of $\text{Cr}_2\text{O}_7^{2-}$ and CrO_4^{2-} . The concentration of each was $0.057 \text{ mol dm}^{-3}$. A student predicted that a solution containing equal amounts of both must be neutral. Is the student correct? Use calculation(s) to justify your answer. [4]

- 13(b) (iv) The value of the equilibrium constant for this reaction increases when the mixture is warmed. State and explain what information this provides about the enthalpy change of the reaction. [2]**

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END OF PAPER

