Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL

1410U30-1

S18-1410U30-1

CHEMISTRY – A2 unit 3

Physical and Inorganic Chemistry

TUESDAY, 5 JUNE 2018 – AFTERNOON

1 hour 45 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 7.**	**10**	
Section B	**8.**	**14**	
	9.	**18**	
	10.	**12**	
	11.	**18**	
	12.	**8**	
	Total	**80**	

1410U301
01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Booklet** supplied by WJEC.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

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.12***(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.

JUN181410U30101

SECTION A

Answer **all** *questions in the spaces provided.*

1. Give the electronic configuration of a copper atom. [1]

....

2. Excess sodium hydroxide is added to an aqueous solution of chromium(III) chloride, $CrCl_3$. Give the formula of the chromium-containing ion formed. [1]

....

3. *(a)* Write the equation for the reaction of hot concentrated aqueous sodium hydroxide with chlorine. [1]

....

(b) This is an example of a disproportionation reaction. State what is meant by the term *disproportionation*. [1]

....

....

4. Give the observation(s) expected when water is added to $SiCl_4$. [1]

....

....

5. A 25.0 cm^3 sample of a solution containing iodine is titrated against a sodium thiosulfate solution of concentration 0.0200 mol dm^{-3}. This requires 23.25 cm^3 of sodium thiosulfate for complete reaction.

$$I_2(aq) \quad + \quad 2S_2O_3^{2-}(aq) \quad \longrightarrow \quad 2I^-(aq) \quad + \quad S_4O_6^{2-}(aq)$$

Calculate the concentration of the iodine in the solution in g dm^{-3}. [2]

Concentration = ... g dm^{-3}

6. The enthalpy of solution of sodium chloride is +4 kJ mol^{-1}. Explain why this compound is soluble in water despite this value being positive. [1]

....

....

....

7. When a solution containing the weak base ammonia is neutralised using the strong acid sulfuric acid, a solution of ammonium sulfate is formed. Suggest a pH for this solution, giving a reason for your answer. [2]

....

....

....

10

SECTION B

Answer **all** *questions in the spaces provided.*

8. *(a)* Sodium chloride and sodium bromide both react with concentrated sulfuric acid. Describe the observations in both reactions and explain why they are different. [3]

....

....

....

....

....

....

....

(b) Fluorine can form the weak acid hydrofluoric acid, HF. This acid has a K_a value of $7.20 \times 10^{-4}\,\text{mol}\,\text{dm}^{-3}$.

(i) Write an expression for the K_a of hydrofluoric acid. [1]

(ii) Calculate the pH of a solution of hydrofluoric acid of concentration $0.100\,\text{mol}\,\text{dm}^{-3}$. [3]

pH = ...

(iii) The concentration of a solution of hydrofluoric acid can be found by titrating against sodium hydroxide. Not all acid-base indicators would be suitable for this titration. Explain what features would make an indicator suitable for use in a weak acid-strong base titration. [2]

....

....

....

....

....

(iv) Addition of 12.5 cm^3 of 0.100 mol dm^{-3} sodium hydroxide to 25.0 cm^3 of hydrofluoric acid of concentration 0.100 mol dm^{-3} forms a buffer solution.

I. Explain how this buffer solution works. [3]

....

....

....

....

....

....

II. Calculate the pH of this buffer solution. [2]

pH = ...

14

9. Cobalt forms a range of complex ions. Two of these are $[Co(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$.

(a) Draw the structures of the $[Co(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$ ions. [2]

(b) Explain why the $[Co(H_2O)_6]^{2+}$ ion is coloured. [3]

....

....

....

....

....

....

....

(c) A student was given a pink-coloured solution containing $[Co(H_2O)_6]^{2+}$ ions. Upon addition of hydrochloric acid the solution turned blue as $[CoCl_4]^{2-}$ ions formed according to the equilibrium shown below.

$$[Co(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CoCl_4]^{2-} + 6H_2O$$

Aqueous silver nitrate was added to the solution containing $[CoCl_4]^{2-}$.

State and explain the observation(s) expected. [4]

....

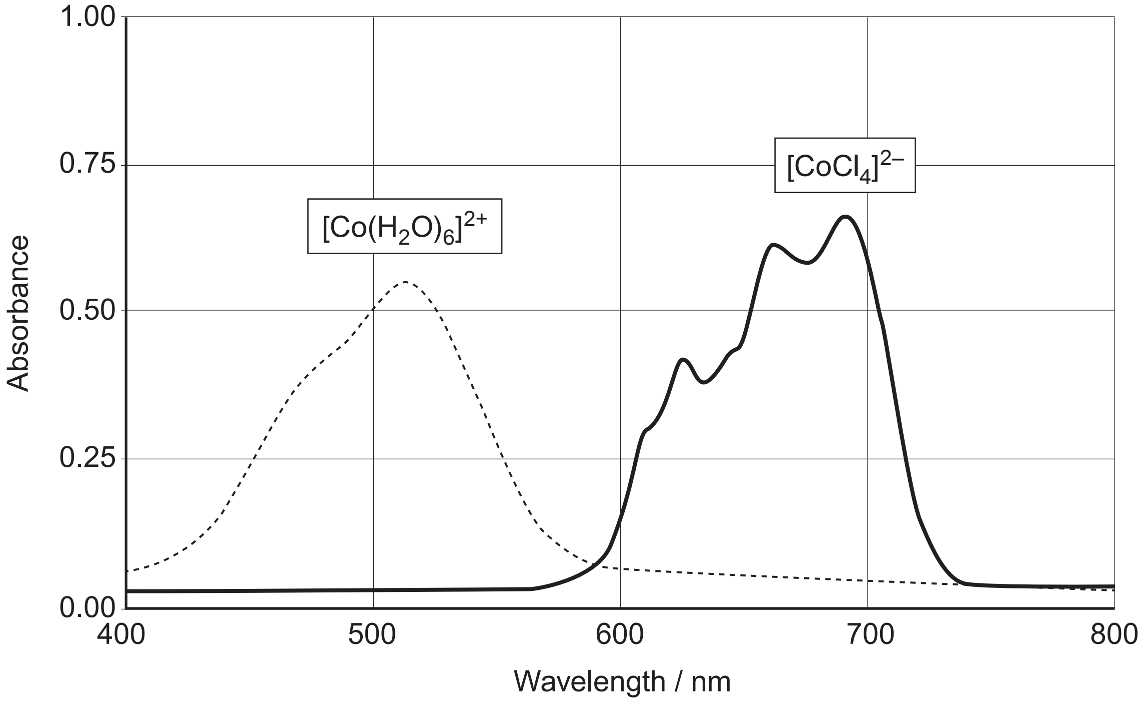
....

....

....

....

(d) These two cobalt-containing ions absorb different frequencies of light. The spectra below show the absorbance at different wavelengths of visible light by the two ions.



(i) The maximum absorbance for the $[Co(H_2O)_6]^{2+}$ ion occurs at a wavelength of 518 nm. Calculate the energy of this absorbance in kJ mol^{-1}. [3]

Energy = ... kJ mol^{-1}

(ii) A colorimeter was used to study the equilibrium between the two ions.

Suggest, giving a reason, an appropriate wavelength to use for the experiment. [1]

....

....

....

Examiner only

(iii) Write the expression for the equilibrium constant, K_c, for this reaction **giving its unit**. [2]

$$[Co(H_2O)_6]^{2+} \quad + \quad 4Cl^- \quad \rightleftharpoons \quad [CoCl_4]^{2-} \quad + \quad 6H_2O$$

K_c =

Unit ....

(iv) A student carries out an experiment starting with separate non-aqueous solutions of $[Co(H_2O)_6]^{2+}$ and Cl^-.

When the two solutions are mixed the initial concentrations of both $[Co(H_2O)_6]^{2+}$ and Cl^- in the mixture are 0.720 mol dm^{-3}. When the mixture reaches equilibrium the concentration of the water is 0.744 mol dm^{-3}.

Calculate the value of the equilibrium constant, K_c. [3]

K_c = ...

1410U301
09

18

Turn over.

10. *(a)* (i) Tin and carbon are both more stable in oxidation state +4 whilst lead is more stable as +2. Explain the difference in the stabilities of these oxidation states. [1]

....

....

(ii) Lead(IV) oxide can act as an oxidising agent when it reacts with concentrated hydrochloric acid. Write an equation for this reaction. [1]

....

(b) Tin(II) ions can be used to reduce iron(III) ions in **acidic** solution.

$$2Fe^{3+}(aq) \;+\; Sn^{2+}(aq) \longrightarrow 2Fe^{2+}(aq) \;+\; Sn^{4+}(aq)$$

$[Fe^{3+}]$ / mol dm^{-3}	$[Sn^{2+}]$ / mol dm^{-3}	pH	Initial rate / mol dm^{-3} s^{-1}
0.200	0.100	0	1.4×10^{-2}
0.300	0.200	0	2.8×10^{-2}
0.400	0.100	1	1.4×10^{-3}
0.400	0.200	1	2.8×10^{-3}

(i) Find the rate equation for this reaction. [3]

(ii) Calculate the value of the rate constant, *k*, for this reaction. [2]

k = ...

(iii) A student suggests that the rate determining step for this reaction is:

$$Fe^{3+} + Sn^{2+} \longrightarrow Fe^{2+} + Sn^{3+}$$

State, giving a reason, whether this is a possible rate determining step for this reaction. [2]

....

....

....

(c) The rate of this reaction can be followed using sampling and quenching.

(i) Explain what is meant by *sampling and quenching*. [1]

....

....

....

(ii) A 5.00 cm^3 sample of the solution was analysed by titration against acidified potassium manganate(VII). The sample required 27.20 cm^3 of manganate(VII) solution of concentration 0.00205 mol dm^{-3} for complete reaction.

Calculate the concentration of Fe^{2+} in the solution. [2]

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$

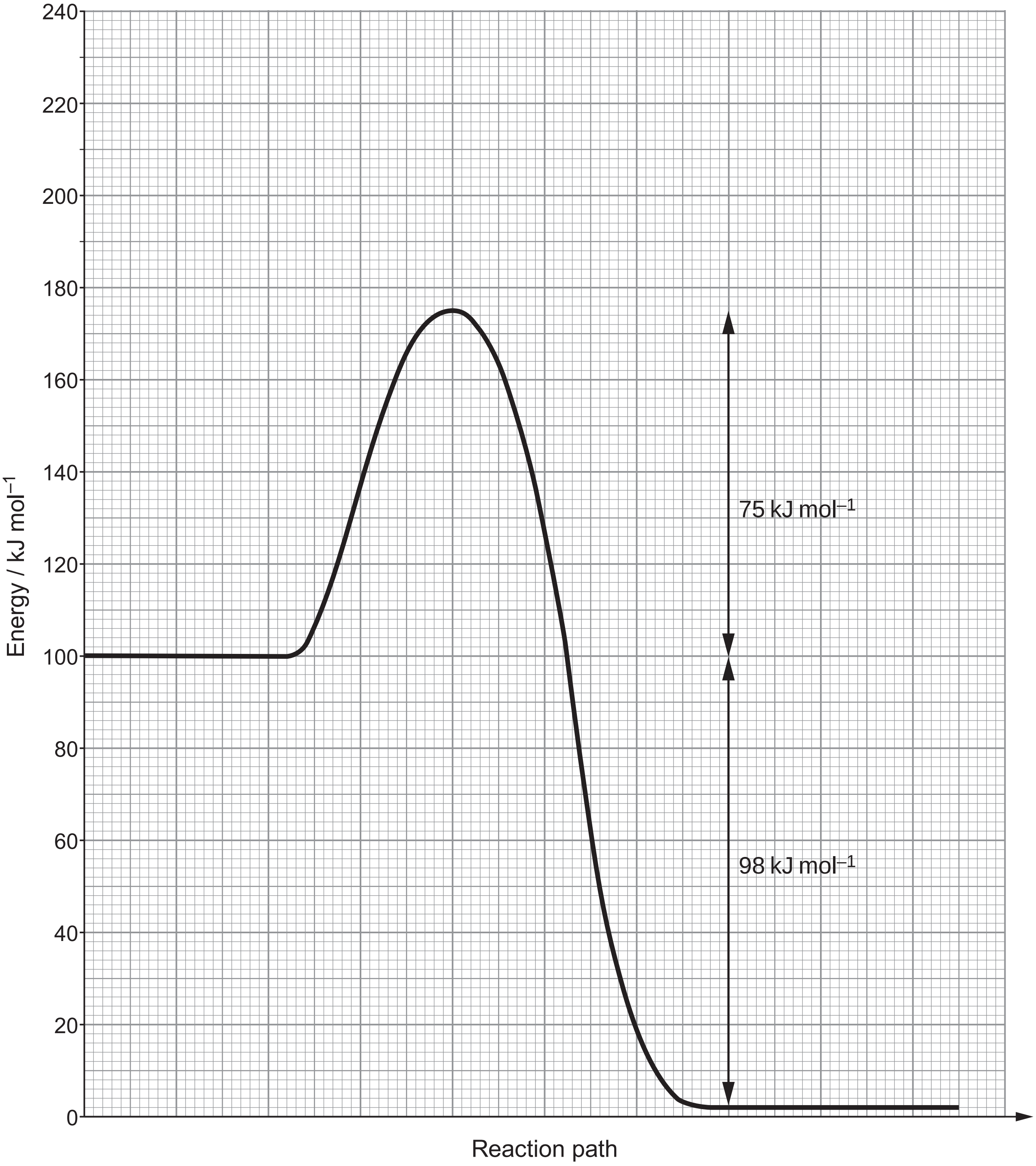
Concentration of Fe^{2+} = ... mol dm^{-3}

12

11. Hydrogen peroxide, H_2O_2, decomposes slowly at 300 K to form water and oxygen gas.

$$2H_2O_2(l) \longrightarrow 2H_2O(l) + O_2(g)$$

The reaction profile for this reaction is shown below.



(a) The rate of decomposition of hydrogen peroxide can be influenced by a range of catalysts. The activation energy when using MnO_2 as a catalyst is 58 kJ mol^{-1}.

Draw the reaction profile for the catalysed reaction **on the grid opposite**. [1]

(b) Another catalyst was used and this gave a value for the rate constant, *k*, of 1.68 mol^{-1} dm^3 s^{-1} and the frequency factor, *A*, of 1.41×10^4 mol^{-1} dm^3 s^{-1} at a temperature of 300 K.

(i) State the Arrhenius equation. [1]

....

(ii) Calculate the activation energy using this catalyst and hence state whether it is a more effective catalyst than MnO_2. [3]

Activation energy = ... kJ mol^{-1}

....

....

....

(c) The standard enthalpy change of formation, $\Delta_f H^\theta$, of water is –286 kJ mol^{-1}.

Use this information and the graph to calculate the standard enthalpy change of formation of hydrogen peroxide. [2]

$\Delta_f H^\theta(H_2O_2)$ = ... kJ mol^{-1}

(d) State whether you would expect the entropy change for the decomposition of hydrogen peroxide to be positive or negative. Give a reason for your answer. [1]

....

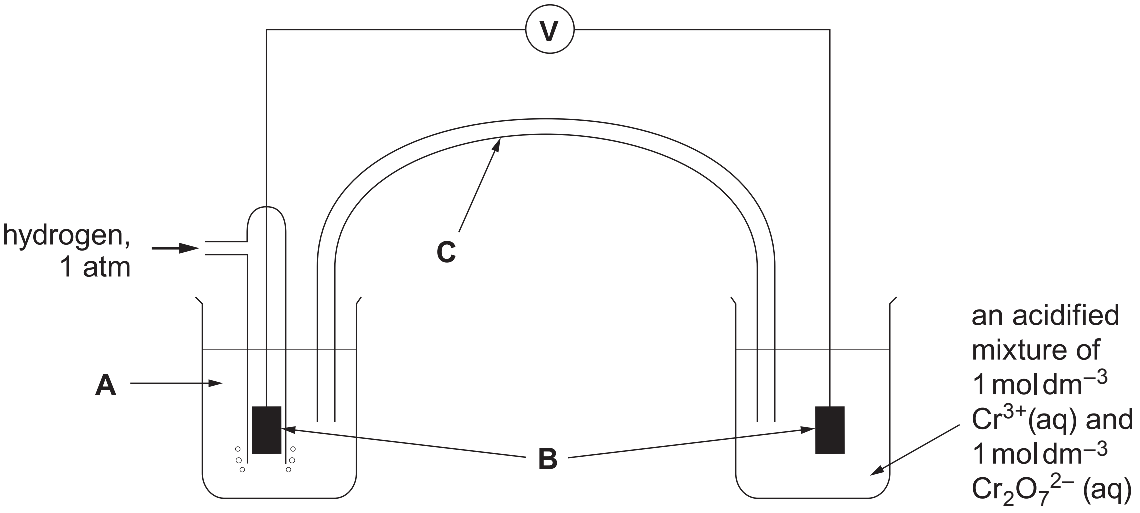
....

Turn over.

(e) One way of assessing whether a reaction is feasible is to use standard electrode potentials.

	Standard electrode potential / V
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1.77
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33

(i) The apparatus below can be used to measure the standard electrode potential for the $Cr_2O_7^{2-}/Cr^{3+}$ half-cell.



I. State what is represented by **A** and **B** on the diagram. [1]

A ....

B ....

II. **On the diagram** show the direction of flow of electrons in the external circuit. [1]

III. State what is represented by **C** on the diagram and state its function. [1]

IV. The concentrations of both $Cr_2O_7^{2-}$ and Cr^{3+} ions are 1 mol dm^{-3}. State and explain how the value shown on the high resistance voltmeter would change if the concentration of the Cr^{3+} ions were increased whilst the concentration of the $Cr_2O_7^{2-}$ was left unchanged. [2]

(ii) It is suggested that hydrogen peroxide could be used to oxidise Cr^{3+} ions in acidic solution to form dichromate ions.

I. Write an equation for this proposed reaction. [1]

II. Use the standard electrode potential values given to predict whether this reaction is feasible. [2]

III. Another method of finding whether a reaction is feasible is to use the Gibbs free energy calculated from standard enthalpy of formation and standard entropy values.

State, giving a reason, whether Gibbs free energies or electrochemical methods are more appropriate for finding whether this reaction is feasible. [2]

18

12. A student was provided with five ionic solids containing familiar cations and anions. Each solid contains a different **cation**. The solids were labelled **A**, **B**, **C**, **D** and **E**.

The student attempted to dissolve all five solids in water. She then attempted to dissolve those that did not dissolve in water in a stoichiometric amount of acid.

The results are given below.

Solid	Addition of water	Addition of dilute sulfuric acid to solid	Addition of dilute nitric acid to solid
A	dissolves giving colourless solution **1**		
B	dissolves giving colourless solution **2**		
C	does not dissolve	pale blue solution **3** forms upon warming with the acid	
D	does not dissolve	effervescence and solution **4** forms	
E	does not dissolve	some effervescence but the solid does not dissolve	effervescence and solution **5** forms

Pairs of the solutions formed were mixed and the observations recorded.

	Solution **5**	Solution **4**	Solution **3**	Solution **2**
Solution **1** (formed by dissolving solid **A**)	no visible change	white precipitate	white precipitate	bright yellow precipitate
Solution **2** (formed by dissolving solid **B**)	no visible change	no visible change	brown solution with a white solid	
Solution **3** (formed by reacting solid **C** with acid)	thick white precipitate	no visible change		
Solution **4** (formed by reacting solid **D** with acid)	thick white precipitate			

Flame tests

Flame tests carried out on solutions **1**, **2**, **3**, **4** and **5** gave no colour with one solution, an apple-green flame with another and a lilac flame with a third. The student noted unfamiliar flame test colours for the other two solutions.

Examiner only

(a) Suggest which anion is present in substances **D** and **E**. Give a reason for your answer. [2]

....

....

....

(b) Use **all** the information provided to suggest identities for compounds **A**-**E**.

Explain clearly how you identified compounds **A** and **C**. [6 QER]

A ....

B ....

C ....

D ....

E ....

Explanation

....

....

....

....

....

....

....

....

....

....

....

....

END OF PAPER

8

BLANK PAGE

PLEASE DO NOT WRITE
ON THIS PAGE

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only