Write-on

Chemistry A
Unit H432

Practice Paper 1B

Name	

Time allowed
2 hours 15 minutes

Information
- The total marks available for this paper is 100. The number of marks available for each question is shown in brackets.
- Answer all questions and show all working

You will need:
An OCR A Chemistry data sheet

You may use:
- A scientific or graphical calculator
- A pencil for graphs and drawings
- A ruler

Question	Mark
MCQs	
16	
17	
18	
19	
20	
21	
Total	

Paper 1B

SECTION A

You should aim to finish this section within 20 minutes.

1 A solution of metal ions formed a precipitate on addition of $NaOH_{(aq)}$ that dissolved on addition of an excess of $NaOH_{(aq)}$. Identify the metal ion.

A Fe^{3+}

B Fe^{2+}

C Cr^{3+}

D Cr^{2+}

Your answer ☐

2 Which of the following combinations of enthalpy changes could be used to determine $\Delta H_r^{\ominus}$ for this reaction?

$$2CO_{(g)} + 2NO_{(g)} \rightarrow 2CO_{2(g)} + N_{2(g)}$$

A $2\Delta H_f^{\ominus}(CO_2) + 2\Delta H_c^{\ominus}(C) + \Delta H_c^{\ominus}(N_2)$

B $2\Delta H_c^{\ominus}(C) - 2\Delta H_f^{\ominus}(NO) - 2\Delta H_f^{\ominus}(CO)$

C $2\Delta H_f^{\ominus}(NO) + \Delta H_f^{\ominus}(CO) - 2\Delta H_f^{\ominus}(CO_2)$

D $\Delta H_c^{\ominus}(N_2) + 2\Delta H_c^{\ominus}(C) - 2\Delta H_f^{\ominus}(CO_2)$

Your answer ☐

3 A lumberjack burns a log for warmth. Which of these is true about this process?

A $\Delta H > 0$ $\Delta S > 0$

B $\Delta H < 0$ $\Delta S < 0$

C $\Delta H > 0$ $\Delta S < 0$

D $\Delta H < 0$ $\Delta S > 0$

Your answer ☐

4 Which of the following represents the electronic structure of cobalt in a CoO_4^{4-} ion?

A $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5$

B $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^9$

C $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^3\,4s^2$

D $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^4\,4s^2$

Your answer ☐

5 Assuming a complete reaction, how many hydroxide ions are produced if 2.00 moles of calcium react with water?

A 3.01×10^{23}

B 6.02×10^{23}

C 1.20×10^{24}

D 2.41×10^{24}

Your answer ☐

6 6.02 g of $SnCl_2.xH_2O$ were dehydrated to leave 5.10 g of $SnCl_2$. What is the value of x?

A 1

B 2

C 3

D 4

Your answer ☐

7 How do nuclear charge and shielding vary down group 7?

A Nuclear charge stays the same, shielding increases

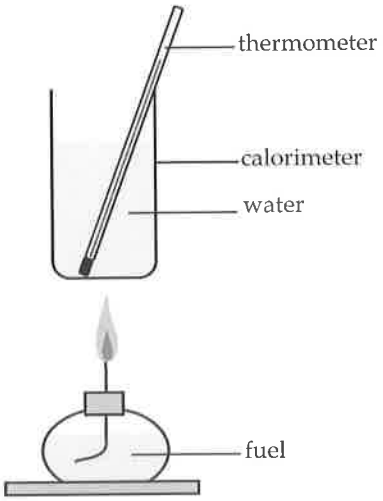
B Nuclear charge stays the same, shielding decreases

C Nuclear charge increases, shielding increases

D Nuclear charge increases, shielding decreases

Your answer ☐

8 A fuel was burned and the enthalpy change calculated using values measured using the following simple set-up:



Which of the following changes would be most important to ensure the value measured is as close as possible to a value recorded in a data book?

A Measuring the temperature using a temperature sensor on a data logger

B Burning all the fuel

C Insulation of the set-up

D Using a larger quantity of water to minimise percentage error

Your answer ☐

9 Use the following values to identify which of the reactions below is most energetically favourable according to electrochemical data.

$Li^{+}_{(aq)} + e^{-} \rightleftharpoons Li_{(s)}$ $E^{\ominus} = -3.04$ V

$Yb^{2+}_{(aq)} + 2e^{-} \rightleftharpoons Yb_{(s)}$ $E^{\ominus} = -2.76$ V

$Be^{2+}_{(aq)} + 2e^{-} \rightleftharpoons Be_{(s)}$ $E^{\ominus} = -1.85$ V

A $Yb_{(s)}$ and $Be^{2+}_{(aq)}$

B $Li^{+}_{(aq)}$ and $Be_{(s)}$

C $Li_{(s)}$ and $Yb^{2+}_{(aq)}$

D $Li_{(s)}$ and $Be_{(s)}$

Your answer ☐

10 A student discovered that a particular endothermic reaction got faster with temperature. Which of these explanations explains why?

A The activation energy gets lower at higher temperatures

B The position of equilibrium shifts to the left

C The position of equilibrium shifts to the right

D The rate constant increases

Your answer ☐

11 Identify the conjugate base of the hydrogen carbonate ion, HCO_3^-.

A H_2CO_3

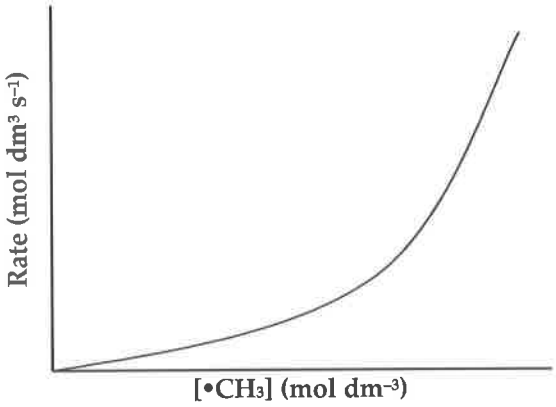
B OH^-

C H^+

D CO_3^{2-}

Your answer ☐

12 The rate of reaction for the formation of C_2H_6 from CH_3 radicals was determined for various concentrations of CH_3 radicals. Identify what conclusion can be made from the following graph.



A The reaction is definitely zeroth order with respect to C_2H_6

B The reaction is definitely not zeroth or first order with respect to $\bullet CH_3$

C The reaction could be either first or second order with respect to $\bullet CH_3$

D The overall order is definitely 2

Your answer ☐

13 An agricultural chemist wants to synthesise 700 g of potassium nitrate from nitric acid. How many moles of nitric acid would be needed if the yield is 73 %?

A 5.06 mol

B 9.48 mol

C 6.91 mol

D 958 mol

Your answer ☐

14 The value of K_p for a reaction decreases when the temperature increases. Which of these statements is true?

1. The reactants and products are all gases.
2. Less energy is needed to break the bonds in the reactants than is released when forming the bonds in the products.
3. The position of equilibrium remains the same.

A Statement 1 only

B Statement 2 only

C Statements 1 and 2 only

D Statements 1, 2 and 3

Your answer ☐

15 A chemist wanted to prepare a 0.100 mol dm^{-3} solution of HCl. The chemist used a measuring cylinder to pour 25.0 cm^3 of 1.00 mol dm^{-3} stock solution of HCl into a volumetric flask, then added distilled water to the volumetric flask up to the 250 cm^3 mark.

Which of the following errors would lead to a lower concentration than 0.100 mol dm^{-3}?

1. Not washing the measuring cylinder that was used to transfer the stock solution afterwards to make sure all the acid was transferred to the volumetric flask
2. Using an unwashed measuring cylinder that had previously been used to transfer alkali
3. Filling the volumetric flask up to the top of the meniscus, instead of the bottom

A 1 only

B 3 only

C 1 and 3 only

D 1 and 2 only

Your answer ☐

SECTION B

16 Sulfur trioxide is an important industrial chemical due to its use in synthesising sulfuric acid. It can be prepared by the following reversible reaction, which is exothermic in the forward direction:

$$O_{2(g)} + 2\ SO_{2(g)} \rightleftharpoons 2\ SO_{3(g)}$$

a) Explain why SO_2 is a polar molecule, but SO_3 is not.

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[2]

b) i) Use the enthalpy of formation data given below to calculate $\Delta H_r^{\ominus}$ for this reaction under standard conditions.

$\Delta H_f^{\ominus}(SO_{2(g)}) = -296.8\ kJ\ mol^{-1}$ $\Delta H_f^{\ominus}(SO_{3(g)}) = -395.7\ kJ\ mol^{-1}$

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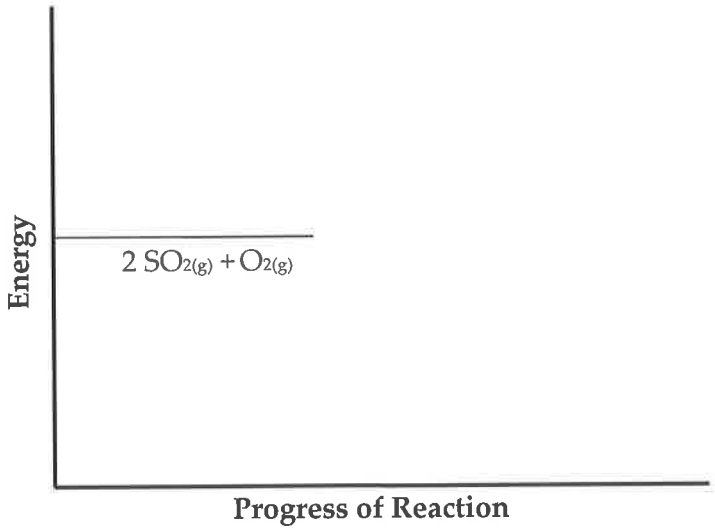
[2]

ii) Complete the enthalpy diagram for this reaction, labelling the enthalpy change and the activation energy.



[2]

c) i) In a container at 298 K, 0.160 moles of $SO_{2(g)}$ and 0.160 moles of $O_{2(g)}$ were allowed to come to equilibrium, at which point the pressure was 500 Pa. From the equilibrium mixture the sulfur trioxide was isolated, giving 3.443 g of gaseous sulfur trioxide product. Calculate K_p for this reaction at this temperature and give its unit.

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ii) Explain how the value of K_p remains constant even if the container is compressed to half the volume.

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d) The industrial conditions for this reaction are 100–200 kPa pressure, 450 °C and the use of a vanadium (V) oxide catalyst.

i) Give the formula of the catalyst.

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[1]

ii) Predict how the value of K_p would differ if no catalyst was present, giving your reasoning.

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iii) Explain the disadvantages of using a temperature higher or lower than 450 °C.

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[3]

QUESTION TOTAL: 21 MARKS

17 Chloric (III) acid is a weak monobasic acid with the formula $HClO_2$ that can be formed from the reaction of Cl_2 and H_2O. Another product is also formed in this reaction. The reaction is one of those that occurs when chlorine is used in water treatment.

a) Predict the identity of the side product, and hence write a balanced equation for the reaction.

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[2]

b) Explain why people may be concerned about chlorine's use in water treatment (assuming that the volume of water treated is large enough that pH is unaffected).

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[1]

c) To check the pH of the water that has been treated, a pH meter may be used. Before it is used, the pH meter is added to buffers with known pHs and repeatedly washed in between. Explain the purpose of this.

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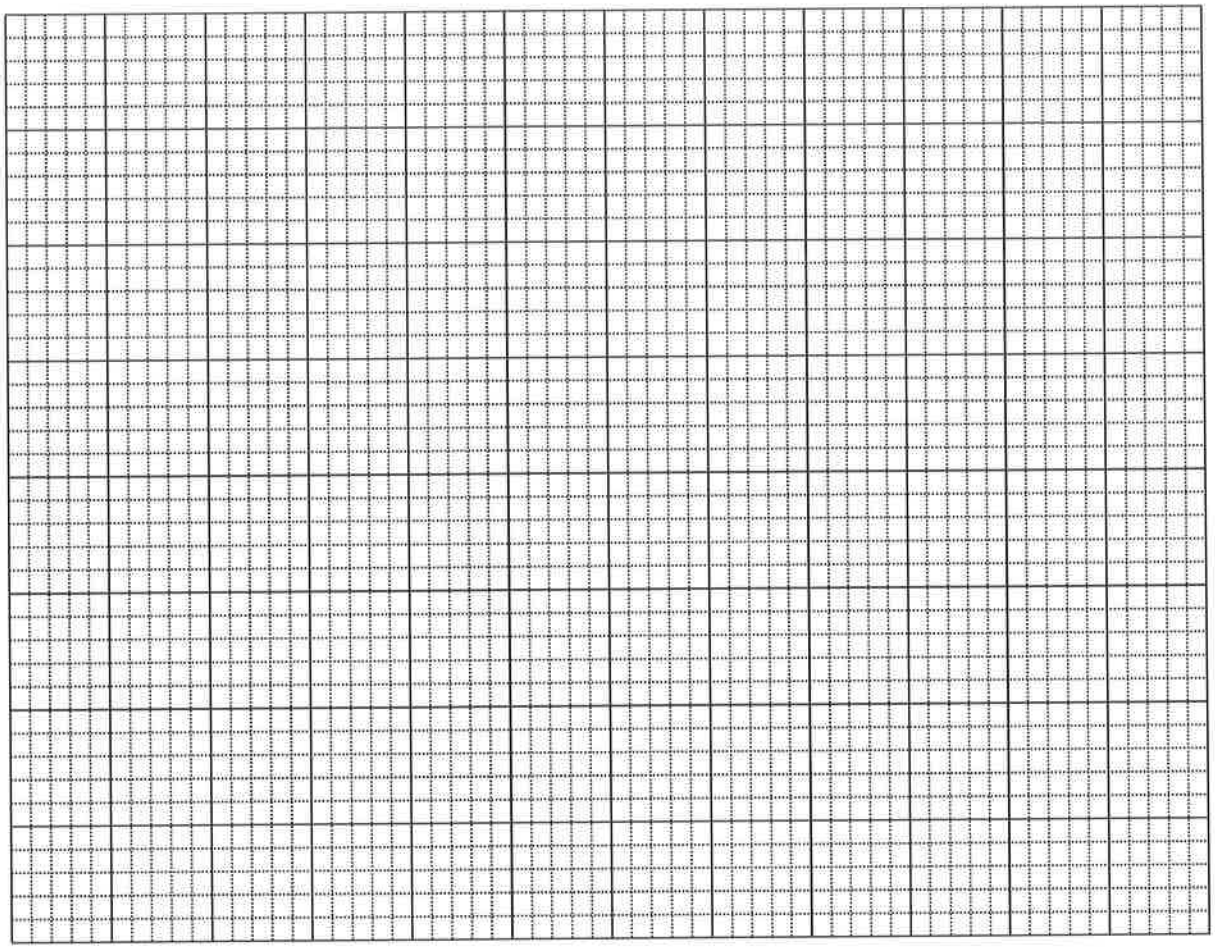
[2]

d) To analyse samples of $HClO_2$ it may be titrated against NaOH and the pH recorded as each portion of NaOH is added. An environmental scientist carried out this analysis and obtained these results:

Volume of $NaOH_{(aq)}$ added (cm^3)	pH
0.0	1.8
2.0	2.1
4.0	2.5
6.0	2.9
8.0	3.5
10.0	10.8
12.0	11.1
14.0	11.3
16.0	11.4

i) Plot a pH curve using these results.

[3]



ii) Explain which of the following indicators would be most appropriate to determine the equivalence point.

Indicator	pH range of colour change
Congo red	3.0–5.0
Bromocresol purple	5.2–6.6
Thymolthalein	8.8–10.5

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[1]

e) The pK_a of $HClO_2$ is 1.94.

i) Calculate the pH of a 0.0100 mol dm^{-3} solution of $HClO_2$.

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[2]

ii) Calculate the concentration of OH^- ions in a 0.0100 mol dm^{-3} solution of $HClO_2$ at 298 K.

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[1]

iii) Given that more than 5 % of $HClO_2$ is dissociated in solution, even though it is a weak acid, explain why the assumptions used to make the calculation in part i) are not valid and the effect this has on the answer.

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[2]

QUESTION TOTAL: 14 MARKS

18 Hydrogen peroxide may be decomposed by a variety of organic and inorganic catalysts according to the equation:

$$2\ H_2O_{2(aq)} \rightarrow 2\ H_2O_{(l)} + O_{2(g)}$$

The use of Fe (III) solutions as catalysts is of particular interest to scientists because it is believed that the reaction forms intermediate species which are highly reactive radicals, which may be used to break down polluting agents. In order to make use of these possibilities, the kinetics of the reaction must be understood.

a) Explain why concentration is expected to have an effect on reaction rate according to simple collision theory.

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[2]

b)* Draw a labelled experimental set-up to show how an initial rates method may be used to compare the rates of decomposition of hydrogen peroxide for different concentrations of Fe (III), and explain how the experiment can be performed.

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c) Use the data below to determine the order of reaction with respect to hydrogen peroxide, and hence the value and unit of the rate constant, k, for reactions at a certain temperature. Ensure you show your working. You can assume that rate is independent of [Fe (III)].

	$[H_2O_2]$ (mol dm^{-3})	Rate (mol dm^{-3} s^{-1})
Reaction 1	5.00×10^{-3}	3.65×10^{-5}
Reaction 2	1.67×10^{-3}	1.21×10^{-5}

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[4]

d) Use your value of k to determine the time it takes for the concentration of H_2O_2 in the first reaction to decrease to 2.50×10^{-3} mol dm^{-3}. If you have not calculated a value for k, you may use a value for k of 1.00×10^{-4}. This is not the correct answer.

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[2]

e) Under different temperature and pH conditions the rate-determining first step was found to be

$$Fe^{3+} + H_2O_2 \rightleftharpoons [FeHO_2]^{2+} + H^+$$

State the overall order of the reaction under these conditions, justifying your answer.

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[2]

QUESTION TOTAL: 16 MARKS

19 A key step in the synthesis of cisplatin is the ligand substitution of two iodide ligands in a solution of $[PtI_4]^{2-}$ with two NH_3 ligands from an ammonia solution to give a cis square planar complex as a precipitate.

a) State the coordination number of platinum in $[PtI_4]^{2-}$.

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[1]

b) Define the term 'complex ion'.

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[1]

c) Draw the structure of the cis isomer produced, and explain how its structure is different to the trans isomer.

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[3]

d) Write a balanced equation for the ligand substitution equation, including state symbols.

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[2]

e) When the cisplatin is ultimately made, it can be used as an anticancer drug. Explain how cisplatin works.

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[2]

f) Suggest why some patients may choose not to use cisplatin.

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[1]

QUESTION TOTAL: 10 MARKS

20 Magnesium and aluminium are two of the most abundant metals in the Earth's crust, and are both found in period 3 of the periodic table.

a)* Describe and explain how melting point varies across period 3.

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[6]

b) The boiling point of aluminium bromide is low and its conductivity is poor as both a liquid and as a solid. Predict the type of structure and bonding seen in liquid aluminium bromide.

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[1]

c) Solid magnesium bromide dissolves in water. The following data can be used to work out the enthalpy of hydration of a magnesium ion.

	Experimental value (kJ mol^{-1})
ΔH_{LE} ($MgBr_{2(s)}$)	-2432
ΔH_{sol} ($MgBr_{2(s)}$)	-192
ΔH_{hyd} ($Br^-_{(g)}$)	-348

i) Define the term 'enthalpy of hydration'.

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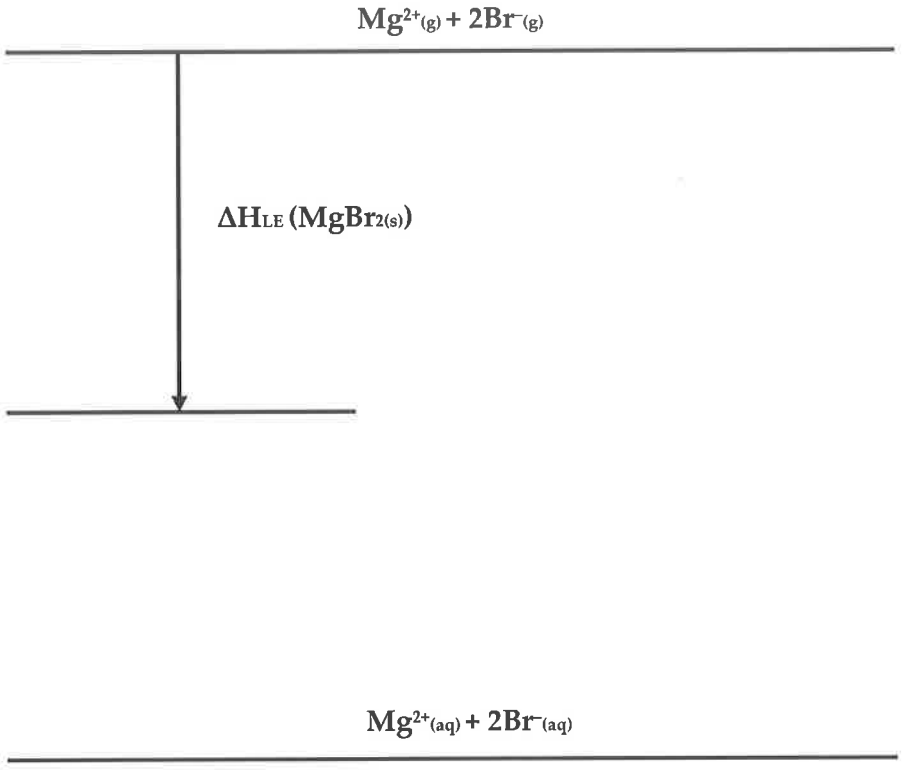
[1]

ii) Use the above data to complete the Born–Haber cycle below and label all the enthalpy changes, including the enthalpy of hydration of an Mg^{2+} ion.

[3]



iii) Use the cycle to calculate the enthalpy of solution.

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[2]

QUESTION TOTAL: 13 MARKS

21 In the presence of acid, zinc can reduce dichromate ions, $Cr_2O_7^{2-}$ to Cr^{3+}, forming Zn^{2+} in the process.

a) Give the oxidation state of chromium in $Cr_2O_7^{2-}$.

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(1)

b) If the experiment is not done carefully, bubbles of hydrogen gas are observed. Explain why.

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(1)

A student wanted to use this reaction to investigate the percentage of zinc in some zinc tablets. The student carried out the following experiment.

- She ground a 25.0 mg zinc tablet and added it to a small quantity of water in a conical flask.
- She placed a magnetic stirring bar in the flask and placed it on a stirrer so the flask contents were continually stirred.
- Above the flask, she set up a burette containing a solution with a 5.00×10^{-3} mol dm^{-3} concentration of $Cr_2O_7^{2-}$ ions.
- She placed an indicator in the flask that would turn violet in the presence of an excess of $Cr_2O_7^{2-}$ ions, i.e. when all the zinc had reacted.
- She added the $Cr_2O_7^{2-}$ solution from the burette until the solution turned violet, and recorded the reading.
- She repeated the experiment to achieve a concordant titre.

Her results are shown below.

	Titration 1	**Titration 2**	**Titration 3**	**Titration 4**
Start reading (cm^3)	0.00	20.90	0.00	21.30
End reading (cm^3)	20.90	41.05	20.30	41.40
Titre (cm^3)				
Mean titre to 1 d.p. (cm^3)				

c) Complete the table above to work out the average titre to 1 decimal place.

(2)

d) Deduce the half equations and, therefore, the overall equation for the reaction, and use it to calculate the percentage by mass of the tablet.

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(7)

e) The student reflected that the method assumed that the only substance in the tablet that reacted with $Cr_2O_7^{2-}$ was the zinc. Explain how this affects the accuracy of the percentage by mass obtained if the assumption is false.

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(1)

f) The student also reflected that she had not shown that her value for the percentage by mass of zinc in the tablet was reproducible. Explain what is needed to show that the value is reproducible.

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(1)

QUESTION TOTAL: 13 MARKS

