

**ADVANCED GCE
CHEMISTRY**

Trends and Patterns

THURSDAY 25 JANUARY 2007

2815/01

Afternoon

Time: 1 hour

Additional materials: Scientific calculator
Data Sheet for Chemistry (Inserted)



Candidate
Name

Centre
Number

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Candidate
Number

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INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- **WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.**

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.

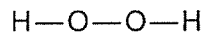
FOR EXAMINER'S USE

Qu.	Max.	Mark
1	7	
2	6	
3	20	
4	12	
TOTAL	45	

This document consists of 12 printed pages and a *Data Sheet for Chemistry*.



(c) Hydrogen peroxide has the following displayed formula.



- (i) Draw a 'dot-and-cross' diagram for a molecule of H_2O_2 showing only the outer shell electrons.

[1]

- (ii) Use the 'dot-and-cross' diagram to predict the H—O—O bond angle in hydrogen peroxide. Explain your answer.

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.....

..... [2]

[Total: 6]



(c) A sample of iron is heated with a stream of dry hydrogen chloride. A different chloride of iron is formed that contains the Fe^{2+} ion. This chloride dissolves in water to form a pale green solution that contains the hexaaquairon(II) complex ion.

(i) Complete the electronic configuration of Fe^{2+} .

$1s^2 2s^2 2p^6$ [1]

(ii) Draw the shape of the hexaaquairon(II) complex ion. Include the bond angles on your diagram.

[2]

(iii) Aqueous sodium hydroxide is added to a solution containing $\text{Fe}^{2+}(\text{aq})$.

State what you would observe.

.....

Write an ionic equation, with state symbols, for the reaction.

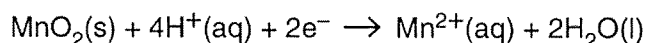
..... [2]



(e) The percentage purity of a sample of manganese(IV) oxide, MnO_2 , can be determined by its reaction with acidified iron(II) ions.

- Stage 1 – A sample of known mass of the impure MnO_2 is added to a conical flask.
- Stage 2 – The sample is reacted with a known excess amount of Fe^{2+} acidified with dilute sulphuric acid.
- Stage 3 – The contents of the flask are heated gently.
- Stage 4 – The cooled contents of the flask are titrated with aqueous potassium manganate(VII) in acidic conditions to find the amount of unreacted Fe^{2+} .

(i) The reduction half-equation for manganese(IV) oxide in the presence of dilute acid is shown below.



Construct the balanced equation for the redox reaction between $\text{Fe}^{2+}(\text{aq})$, $\text{MnO}_2(\text{s})$ and $\text{H}^+(\text{aq})$.

.....

 [1]

(ii) In Stage 1 and Stage 2 a student uses a 0.504 g sample of impure MnO_2 and 100 cm^3 of $0.200 \text{ mol dm}^{-3} \text{ Fe}^{2+}$.

In Stage 4 the student determines that the amount of unreacted Fe^{2+} is 0.0123 mol.

1 mol of MnO_2 reacts with 2 mol of Fe^{2+} .

Calculate the percentage purity of the impure sample of MnO_2 .

percentage purity = % [3]

[Total: 20]



4 In this question, one mark is available for the quality of spelling, punctuation and grammar.

The lattice enthalpy of magnesium chloride, $MgCl_2$, can be determined using a Born-Haber cycle and the following enthalpy changes.

name of process	enthalpy change/ kJ mol^{-1}
enthalpy change of formation of $MgCl_2(s)$	-641
enthalpy change of atomisation of magnesium	+148
first ionisation energy of magnesium	+738
second ionisation energy of magnesium	+1451
enthalpy change of atomisation of chlorine	+123
electron affinity of chlorine	-349

- Define, using an equation with $MgCl_2$ as an example, what is meant by the term *lattice enthalpy*.
- Construct a Born-Haber cycle for $MgCl_2$, including state symbols, and calculate the lattice enthalpy of $MgCl_2$.
- Explain why the lattice enthalpy of $NaBr$ is much less exothermic than that of $MgCl_2$.

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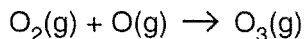
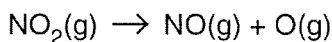
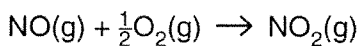


(iii) Calculate the rate constant, k , for this reaction. State the units for k .

$k = \dots\dots\dots$ units $\dots\dots\dots$ [3]

(b) Nitrogen monoxide, NO, is involved in formation of ozone at low levels and the breakdown of ozone at high levels.

(i) In the lower atmosphere, NO is produced by combustion in car engines. Ozone is then formed following the series of reactions shown below.

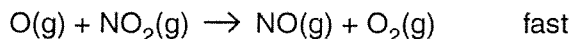
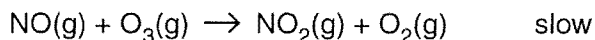


- Write the overall equation for this reaction sequence.
- Identify the catalyst and justify your answer.

.....

 [3]

(ii) In the upper atmosphere, NO removes O_3 by the following reaction mechanism.



Suggest the rate equation for this process. Explain your reasoning.

.....

 [2]

[Total: 14]



- (ii) Explain what happened to the composition of the equilibrium mixture.

.....

 [2]

- (d) The chemist heated the equilibrium mixture and the equilibrium moved to the left.

- (i) Explain what happens to the value of K_c .

.....
 [1]

- (ii) Explain what additional information this observation reveals about the reaction.

.....

 [2]

- (e) Phosphorus pentachloride reacts with magnesium oxide to form phosphorus(V) oxide, P_4O_{10} , and magnesium chloride.

- (i) Write a balanced equation for this reaction.

..... [1]

- (ii) Calculate the mass of PCl_5 needed to form 100 g of P_4O_{10} in this reaction.

mass = [4]

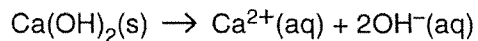
[Total: 14]

[Turn over



- (c) The chemist analysed a sample of water from another part of the sewage works and he found that the calcium hydroxide concentration was $2.7 \times 10^{-3} \text{ mol dm}^{-3}$.

Assume that when solid calcium hydroxide dissolves in water, its ions completely dissociate.



Calculate the pH of this sample.

[3]

- (d) After further treatment, the water could be used for drinking. In the drinking water produced, the OH^{-} concentration was 100 times greater than the H^{+} concentration.

What was the pH of this drinking water?

[1]

[Total: 9]



