THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE
CHEMISTRY
Trends and Patterns

2815/01

Candidates answer on the question paper

OCR Supplied Materials:
- *Data Sheet for Chemistry* (inserted)

Other Materials Required:
- Scientific calculator

Thursday 18 June 2009
Morning

Duration: 1 hour

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **45**.
- 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.
- This document consists of **12** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	10	
2	9	
3	14	
4	12	
TOTAL	45	

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Answer **all** the questions.

1 The lattice enthalpy of an ionic compound can be determined using a Born-Haber cycle.

(a) Complete the following table which shows some of the enthalpy changes needed to calculate the lattice enthalpy of barium oxide.

name of enthalpy change	process
.....	$Ba(s) \rightarrow Ba(g)$
first ionisation energy of barium	.....
.....	$O^-(g) + e^- \rightarrow O^{2-}(g)$
enthalpy change of formation of barium oxide	.....

[4]

(b) Suggest why the lattice enthalpy of an ionic solid cannot be measured directly.

.....

..... **[1]**

(c) The lattice enthalpy of barium oxide is more exothermic than that of barium carbonate.

Explain why.

.....

.....

.....

..... **[2]**

3

(b) Aqueous iron(II) ions, Fe^{2+}, can be oxidised by hydrogen peroxide, H_2O_2, under acidic conditions.

The reduction half-equation is as follows.

$$H_2O_2(aq) + 2H^+(aq) + 2e^- \longrightarrow 2H_2O(l)$$

Construct the equation for the oxidation of $Fe^{2+}(aq)$ to $Fe^{3+}(aq)$ by hydrogen peroxide under acidic conditions.

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..... **[2]**

(c) Describe, with the aid of an ionic equation, how aqueous sodium hydroxide can be used to confirm the presence of $Fe^{3+}(aq)$ ions.

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..... **[2]**

2 The following reactions involve the dichromate(VI) ion, $Cr_2O_7^{2-}$.

equation 2.1 $Cr_2O_7^{2-} + 2OH^- \rightleftharpoons 2CrO_4^{2-} + H_2O$

equation 2.2 $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$

(a) (i) What colour change occurs when the equilibrium position in **equation 2.1** shifts from left to right?

from ..... to ..... **[1]**

(ii) What could be added to the equilibrium mixture in **equation 2.1** to make the position of equilibrium shift from right to left?

..... **[1]**

(iii) Show, using oxidation numbers, that the forward reaction in **equation 2.1** is **not** a redox reaction.

.....

..... **[1]**

(b) The reaction in **equation 2.2** may be used to determine the purity of iron wire.

- 1.20 g of iron wire were reacted with an excess of 2 mol dm^{-3} sulphuric acid.
- The solution was transferred to a volumetric flask and the volume made up to 250 cm^3.
- 25.0 cm^3 of this solution required 23.20 cm^3 of 0.0150 mol dm^{-3} $Cr_2O_7^{2-}$ solution to completely react.

Determine the % purity of the iron wire.

purity of iron wire = ... % **[5]**

[Total: 8]

3 Some standard electrode potentials are shown below.

	$E^{\ominus}$/V
$\frac{1}{2}Br_2 + e^- \rightleftharpoons Br^-$	+1.07
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$\frac{1}{2}Cl_2 + e^- \rightleftharpoons Cl^-$	+1.36
$BrO_3^- + 6H^+ + 5e^- \rightleftharpoons \frac{1}{2}Br_2 + 3H_2O$	+1.52

(a) (i) Define the term *standard electrode potential.*

.....

.....

..... **[2]**

(ii) State the conditions used to measure standard electrode potential.

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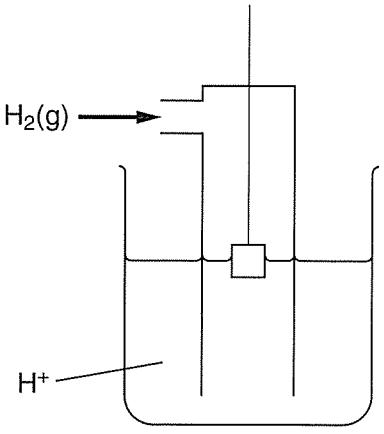
.....

..... **[1]**

(b) Complete the diagram to show how the standard electrode potential for the $\frac{1}{2}Cl_2 + e^- \rightleftharpoons Cl^-$ half-cell, could be measured.



[3]

(c) In acid solution, colourless BrO_3^- ions oxidise Br^- ions to Br_2.

(i) Use the standard electrode potential data opposite to construct an equation for this reaction.

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.....

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..... **[2]**

(ii) Describe what you would see when BrO_3^- reacts with Br^-.

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..... **[1]**

(d) Acidified $Cr_2O_7^{2-}$ ions will oxidise Br^- to Br_2 but will not oxidise Cl^- ions to Cl_2. Explain why.

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..... **[1]**

[Total: 10]

4 **(a)** Titanium(IV) oxide, TiO_2, is used as a pigment in paint.

(i) What is the electron configuration of the Ti^{4+} ion in TiO_2?

$1s^2\ 2s^2$ ..... **[1]**

(ii) What is the colour of TiO_2? Explain your answer using the electron configuration in **(i)**.

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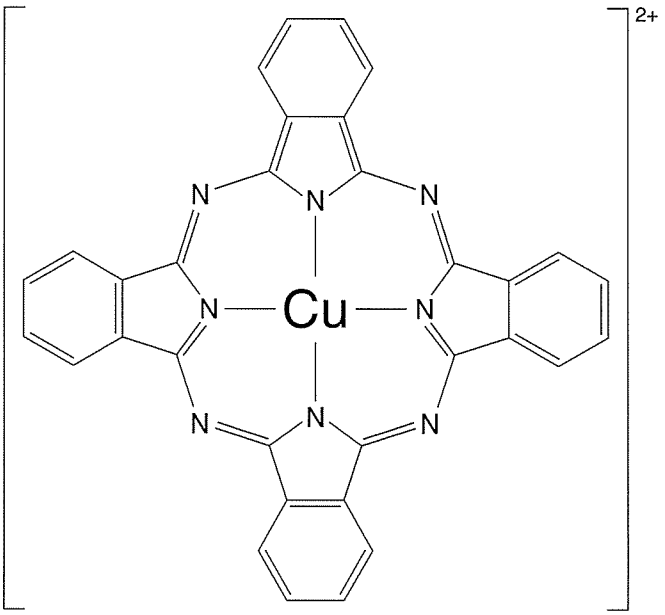
..... **[2]**

(b) Monastral Blue is an example of a copper complex, in which the phthalocyanine ligand is complexed with a Cu^{2+} ion.



(i) What type of bonding exists between the Cu^{2+} ion and the phthalocyanine ligand?

..... **[1]**

(ii) The Cu^{2+} ion has the electron configuration $[Ar]3d^9$. Explain why this configuration leads to the copper complex being coloured.

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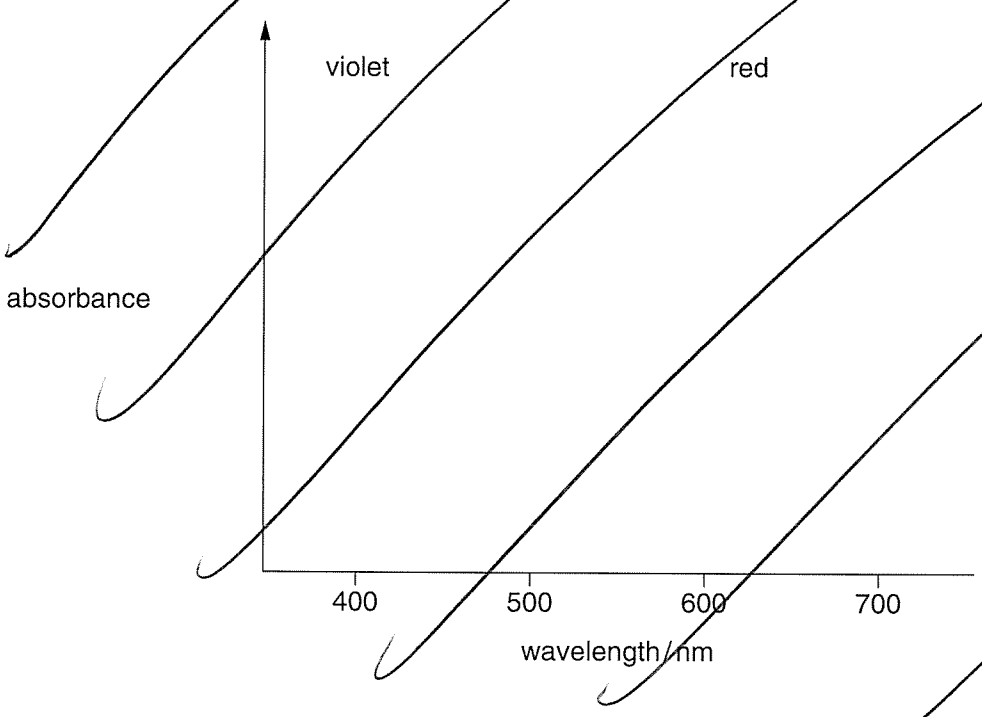
..... **[3]**

(c) It is possible to produce a visible spectrum for Monastral Blue. Sketch a diagram of the visible spectrum for Monastral Blue on the axes below.



[1]

[Total: 8]

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

Transition metals and their ions form complexes which may show stereoisomerism.

- What is meant by *stereoisomerism*?
- Using suitable examples, describe with the aid of diagrams the different types of stereoisomerism shown by complex ions.
- Some transition metal complexes are used in medicine. Describe and explain one such use.

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.... [11]

Quality of Written Communication [1]

[Total: 12]

END OF QUESTION PAPER

2 Chlorine dioxide, ClO_2, is a liquid at room temperature and pressure.
In an aqueous solution it is used as a bleach.

(a) In aqueous solution, chlorine dioxide, ClO_2, reacts with hydroxide ions, OH^-.

This reaction is carried out three times using different concentrations of the two reactants. The initial rate of each reaction is determined and the results are shown below.

experiment	$[ClO_2(aq)]$ /mol dm^{-3}	$[OH^-(aq)]$ /mol dm^{-3}	initial rate /mol dm^{-3} s^{-1}
1	0.010	0.030	6.00×10^{-4}
2	0.010	0.075	1.50×10^{-3}
3	0.030	0.030	5.40×10^{-3}

(i) For each reactant, deduce the order of reaction. Show your reasoning.

$OH^-(aq)$ .....

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$ClO_2(aq)$ .....

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..... **[4]**

(ii) Deduce the rate equation for the reaction.

..... **[1]**

(iii) Calculate the rate constant, *k*, for this reaction. State the units, if any.
Give your answer to an appropriate number of significant figures.

rate constant, *k*: ..... units: ..... **[3]**

(b) The mechanism for this reaction takes place in several steps.

In the overall equation, 2 mol ClO_2 reacts with 2 mol OH^- to form an aqueous solution containing chlorate(III) ions and chlorate(V) ions.

Chlorate(III) ions have the formula ClO_2^-.

(i) How does the rate equation provide evidence that the reaction takes place by more than one step?

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..... **[1]**

(ii) Suggest the overall equation.

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..... **[2]**

[Total: 11]

3 Benzoic acid, C_6H_5COOH, is a weak acid, used for preserving fruit juices.

The acid dissociation constant, K_a, of benzoic acid is 6.30×10^{-5} mol dm^{-3} at 25 °C.

(a) Write the equation for the dissociation of benzoic acid when dissolved in water.

..... **[1]**

(b) Write the expression for the acid dissociation constant, K_a, of benzoic acid.

[1]

(c) The solubility of benzoic acid in water is 3.40 g dm^{-3} at 25 °C.

Calculate the pH of a saturated solution of benzoic acid in water at 25 °C.

[5]

(d) In this question, one mark is available for the quality of use and organisation of scientific terms.

A buffer solution is needed for preserving fruit juice.

A chemist at the fruit juice company prepared a benzoic acid/sodium benzoate buffer with concentrations of 0.105 mol dm^{-3} C_6H_5COOH and 0.125 mol dm^{-3} C_6H_5COONa.

- State what a buffer solution is and explain how this solution acts as a buffer solution. Include equations in your answer.
- Calculate the pH of this benzoic acid/sodium benzoate buffer at 25 °C. Show all your working.

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..... **[8]**

Quality of Written Communication **[1]**

[Total: 16]

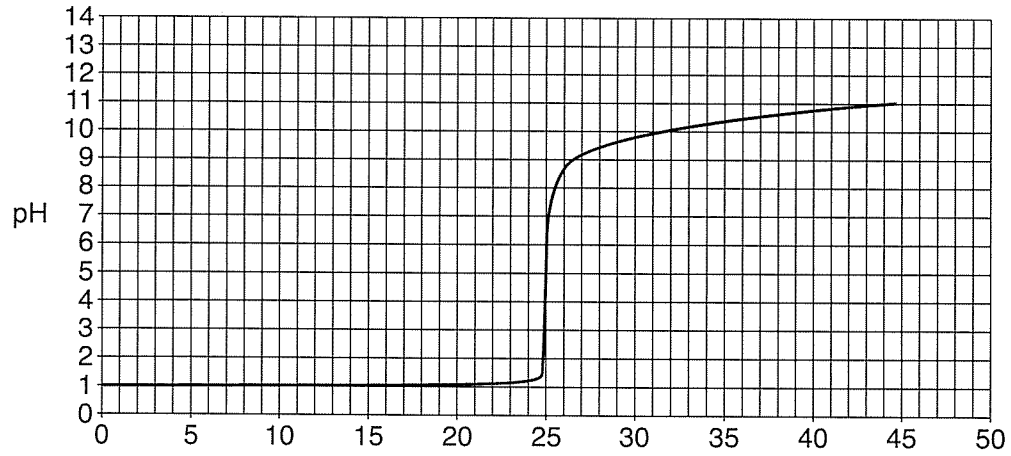
4 Nitric acid, HNO_3, is a strong acid which can also behave as an oxidising agent.

(a) Nitric acid reacts with bases, such as aqueous ammonia, $NH_3(aq)$, to form salts.

A 25.0 cm^3 sample of $HNO_3(aq)$ was placed in a conical flask.

$NH_3(aq)$ was added from a burette until the pH showed little further change.
The NH_3 concentration was the same as the HNO_3 concentration.

The pH curve for this titration is shown below.



(i) Deduce the concentration of the nitric acid.

[1]

(ii) How can you tell from this pH curve that aqueous ammonia is a weak base?

.....

..... **[1]**

(iii) What is the formula for the salt formed in this reaction?

..... **[1]**

(iv) The pH ranges for four indicators are shown below.

indicator	pH range
malachite green	0.2–1.8
resazurin	3.8–6.4
metacresol purple	7.4–9.0
alizarin yellow R	10.1–12.0

Which of these four indicators is most suitable for this titration?

..... **[1]**

(v) The titration was repeated but using $NH_3(aq)$ with **twice** the concentration of the original ammonia solution.

What **two** differences would there be between this titration curve and the one shown in part **(a)**?

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..... **[2]**

(b) When nitric acid reacts with magnesium metal, different gases are formed, depending on the concentration of the nitric acid. Each reaction producing a gas is a redox reaction.

- With very dilute nitric acid, H_2 gas is evolved.
- With concentrated nitric acid, NO_2 gas is evolved.

(i) Write a full equation and an ionic equation for the reaction of magnesium with very dilute nitric acid.

full equation .....

ionic equation ..... **[2]**

(ii) Use oxidation numbers to show the reduction that takes place when magnesium reacts with dilute and with concentrated nitric acid.

dilute HNO_3 .....

concentrated HNO_3 ..... **[2]**

[Total: 10]