Candidate Name	Centre Number	Candidate Number
		2

GCE A level

336/01

CHEMISTRY CH6a

A.M. THURSDAY, 19 June 2008

1 hour 10 minutes

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1	
B	2	
C	3	
	4	
TOTAL MARK		

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Sheet** which contains a **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

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

Section A Answer the question in the spaces provided.
Section B Answer the question in the spaces provided.
Section C Answer **both** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)**, **Section B (15 marks)** and **Section C (25 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 50.

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

You are reminded that marking will take into account the Quality of Written Communication used in all written answers.

Page 13 may be used for rough work.

SECTION A

Answer the questions in the spaces provided.

1. *(a)* Polonium, in Group VI of the Periodic Table, is an extremely poisonous element; ingestion of just 7×10^{-12}g is likely to be fatal.
In 2006 a man was poisoned by the radioactive isotope ^{210}Po.

(i) This isotope is an alpha emitter. Give the mass number and the symbol of the isotope formed by the emission of one α particle from one atom of this polonium isotope. [1]

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(ii) The half life of ^{210}Po is 138 days.
Calculate how long it would take for a sample containing 800 μg of ^{210}Po to decay so that the sample contained 50 μg of the isotope. [1]

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(b) Oxygen, another member of Group VI, exists as O_2 and ozone, O_3.

(i) Oxygen is produced by heating both sodium nitrate and hydrated calcium nitrate.
State what is **seen** when both compounds are heated separately, naming the products other than oxygen. Equations are not needed. [4]

Sodium nitrate .....

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Calcium nitrate .....

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(ii) I. **Briefly** describe how the atmospheric ozone layer is being destroyed by CFCs such as 1-chloro-1, 1-difluoroethane, $CClF_2CH_3$. [1]

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II. In terms of bond energies, comment on why 1-chloro-1, 1-difluoroethane has this effect on ozone but 1, 1-difluoroethane does not. [1]

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(iii) Ozone can be used to break a carbon to carbon double bond, C=C, present in organic compounds.
Each double bond that is broken needs one molecule of ozone.
A sample of an organic compound **Z** containing 4×10^{-4} mole of **Z** reacted with $28{\cdot}8\,cm^3$ of ozone at room temperature and pressure.
Find the number of carbon to carbon double bonds present in each molecule of compound **Z**. [2]
(1 mole of ozone has a volume of $24\,dm^3$ at room temperature and pressure).

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Section A Total [10]

SECTION B

2. *Read the passage below and then answer the questions (a) to (h) in the spaces provided.*

Titanium - an element for the 21st century

The first titanium mineral was discovered in 1791 in Cornwall and the first sample of titanium(IV) oxide was produced in 1795.
Early attempts to extract the metal from its oxide by heating it with carbon failed because titanium carbide is formed. It was not until 1910 that pure titanium was made, by heating titanium(IV) chloride with sodium.

$$TiCl_4 + 4Na \longrightarrow Ti + 4NaCl$$

Titanium metal is as strong as steel but is 45% lighter and is therefore used extensively in the aircraft industry. The metal resists corrosion as it has an impervious coating of titanium(IV) oxide. The metal bonds well to bone, is not rejected by the body and is much in demand for replacement joints.

Titanium has two common oxidation states, +3 and +4.

Titanium(III) chloride forms a violet aqueous solution which is readily oxidised by the oxygen in air to a colourless titanium(IV) compound. An aqueous solution of titanium(III) chloride is a very powerful reducing agent.

Titanium(IV) chloride is a colourless liquid that has a boiling temperature of 136 °C. This compound is used in Ziegler catalyst systems, together with organic compounds of aluminium. In the process of propene polymerisation, the catalyst is used at 100 °C in hexane solution. The product is high density poly(propene).

This chloride is vigorously hydrolysed by water to give titanium(IV) oxide and hydrochloric acid.

In previous years, paint was based on white lead mixed with linseed oil. White lead is a basic carbonate of lead, $2PbCO_3.Pb(OH)_2$. Lead compounds are poisonous and the white lead pigment has been largely replaced by the non-toxic titanium(IV) oxide (titanium dioxide).
This titanium compound has become increasingly important and more than 50% of the production of the compound goes to the paint industry.

One method to find the concentration of titanium in an aqueous solution is by using colorimetry. An acid solution containing titanium(IV) is treated with hydrogen peroxide, when a yellow solution is produced. The concentration of titanium present in the unknown sample is found by measuring the intensity of the yellow colour produced. This is then compared with the intensity of a series of standard solutions containing titanium, often by a graphical method.

The future for titanium and its compounds looks promising, as further uses are found for this strong, but light metal and its compounds, which show little toxicity to humans.

– End of passage –

(a) Titanium is produced by heating titanium(IV) chloride with sodium.

$$TiCl_4 + 4Na \longrightarrow Ti + 4NaCl$$

Using the oxidation states (numbers) involved, explain why this process is described as a redox reaction. [2]

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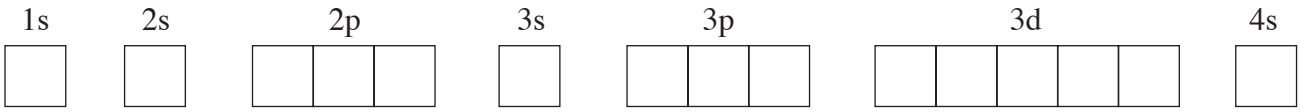
(b) (i) Using the convention of arrows to represent electrons, show the electronic configuration of the titanium(III) ion, Ti^{3+}. [1]



(ii) In aqueous solution, titanium(III) ions are present as the complex ion, $[Ti(H_2O)_6]^{3+}$.
Explain in terms of d-orbital splitting why this ion is violet in white light. [3]

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(c) When a solution containing aqueous Ti^{3+} ions is added to aqueous manganate(VII) ions, MnO_4^-, reduction of the manganate(VII) occurs giving $Mn^{2+}(aq)$ ions.

State the colour change that occurs for the manganese-containing ions in this reaction.

[1]

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(d) Use the valence shell electron pair repulsion principle (VSEPR) to deduce the shape of the titanium(IV) chloride molecule, explaining your answer.
The titanium atom does not have any outer orbital lone pairs in this compound. [2]

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(e) Titanium(IV) chloride is used as part of a homogeneous Ziegler catalyst system to polymerise alkenes.
State **another** example of a reaction that uses a homogeneous catalyst, stating the catalyst. [1]

Reaction .....

Catalyst .....

(f) Titanium(IV) chloride is vigorously hydrolysed by water in a similar way to silicon(IV) chloride. Give the equation for the hydrolysis of titanium(IV) chloride by water. [1]

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(g) Titanium alloys are used for making parts for jet engines.
A sample of an alloy of mass 1·42 g was dissolved in acid and the solution made up exactly to a volume of 1 dm^3.
50 cm^3 of this solution was then diluted to 1 dm^3 by adding water.
The diluted sample was analysed for titanium by colorimetry and gave an absorption reading of 0·96.
Use the graph on **page 7** to find the concentration of titanium in the diluted solution and hence the concentration of titanium in the original solution.
Use your values to find the percentage of titanium in the alloy. [3]

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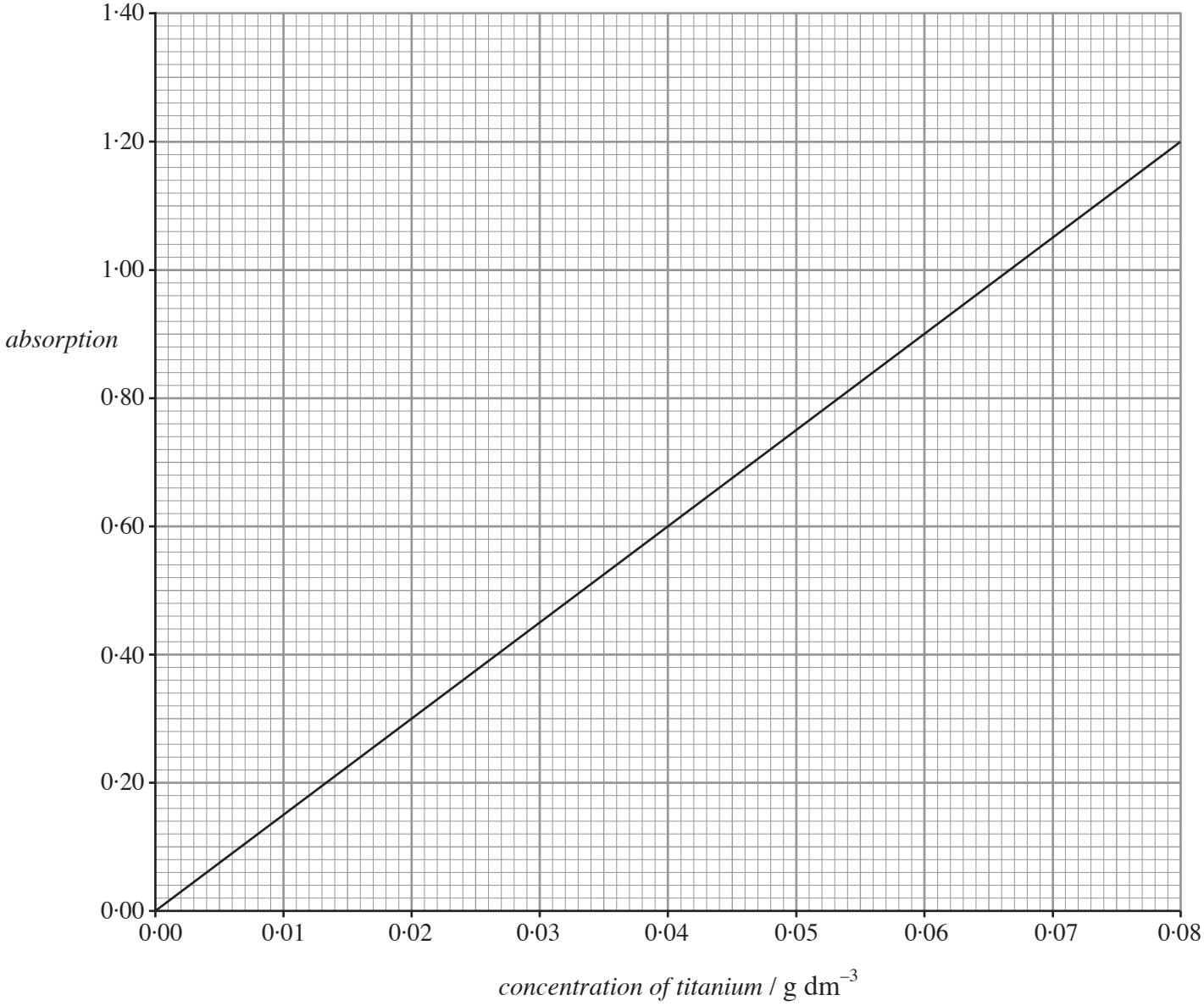
% Ti = ...



(h) Basic lead carbonate (white lead) was formerly used as the pigment base in paint.
A sample of white lead is dissolved in a suitable acid.
State what is seen when aqueous iodide ions are added to this solution containing lead(II) ions. [1]

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Section B Total [15]

SECTION C

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

3. Modern lipsticks contain a variety of ingredients that are necessary to satisfy the demands of the customer.

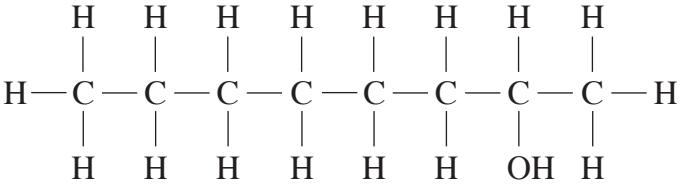
(a) The main body of lipstick is made of castor oil and wax.

(i) Castor oil is an ester of an unsaturated acid, ricinoleic acid.
State, giving reagent(s) and observation(s), how you would show that castor oil is an unsaturated compound.

Reagent(s) ..... [1]

Observation(s) ..... [1]

(ii) When castor oil is strongly heated with aqueous sodium hydroxide, one of the products is octan-2-ol.



octan-2-ol

I. Identify the chiral centre in the formula of octan-2-ol by using an asterisk (*). [1]

II. Octan-2-ol, prepared in the reaction described above, consists of a racemic mixture. Explain what is meant by the term ***racemic mixture*** and state how this would affect the plane of polarised light. [2]

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(b) The dyes used in lipstick are combined with aluminium oxide or titanium(IV) oxide. Both these oxides are described as ***amphoteric*** oxides.
Describe what is meant by the term ***amphoteric***, illustrating your answer with suitable equations using an ***amphoteric*** element or its oxide/hydroxide of your choice. [3]

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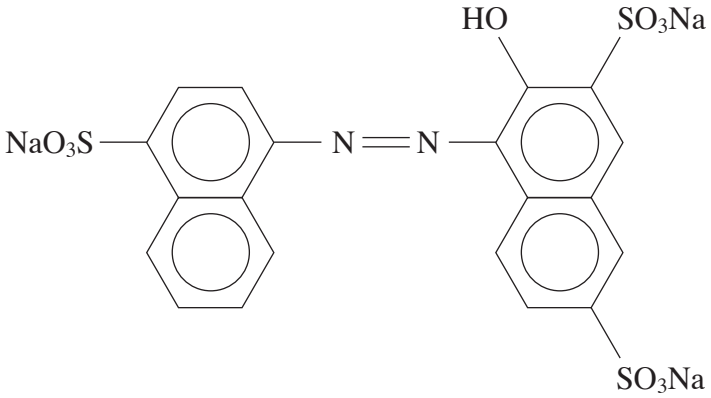
(c) One of the dyes used in lipstick is the red azo dye amaranth.



amaranth

(i) Azo dyes can be made from an aromatic amine by reacting it with nitric(III) acid (nitrous acid).
Describe how a typical azo dye can be made from phenylamine, stating the reagents and conditions necessary. No equations are required. [2]

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(ii) Amaranth contains a phenolic functional group.
State how you would test for a phenol, giving the result of the test. [2]

Reagent(s) .....

Observation(s) .....

(d) The dye amaranth strongly absorbs visible light at 521 nm.
Another dye used in lipstick, rhodamine, absorbs strongly at 543 nm.
State which of these two dyes has the higher absorption frequency, giving a reason for your choice. [1]

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Total [13]

4. Hydrogen iodide, HI, is a colourless gas that can be made by a variety of methods.

(a) A poor method is to heat sodium iodide with concentrated sulphuric acid.
Unfortunately, little hydrogen iodide is produced and the products include sulphur dioxide and hydrogen sulphide.
Explain why these sulphur-containing products are formed. [1]

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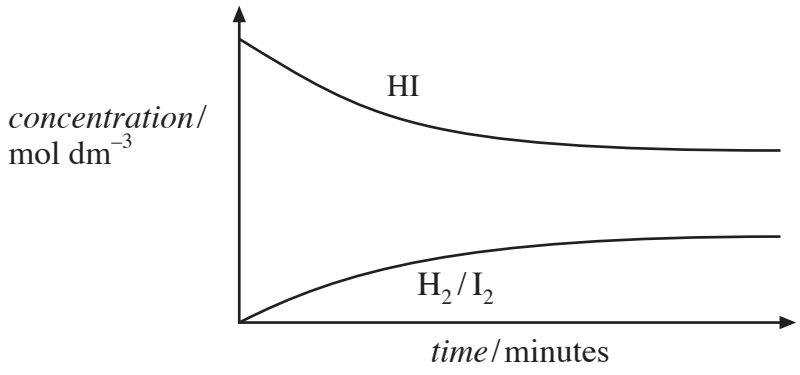
(b) Gaseous hydrogen iodide decomposes when heated, giving hydrogen gas and iodine vapour, eventually reaching a position of dynamic equilibrium.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

(i) Write the expression for the equilibrium constant in terms of concentration, K_c, for this reaction and state its units (if any). [2]

Units .....

(ii) At a certain temperature, K_c, has the numerical value of 0·25 and the rate of decomposition into hydrogen and iodine vapour is slow.
The graph below shows how the concentration of hydrogen iodide and hydrogen (or iodine) would change from the start of the reaction until a position of equilibrium is reached.
Describe and explain the shapes of the curves in terms of concentrations and rates. In your answer you should also consider how the value of the equilibrium constant has affected the relative position of the lines on the graph. [6]



(c) The enthalpy changes for the formation of hydrogen iodide from hydrogen and gaseous/solid iodine are given below.

$$H_2(g) + I_2(s) \longrightarrow 2HI(g) \qquad \Delta H = +50{\cdot}2 \text{ kJ mol}^{-1}$$

$$H_2(g) + I_2(g) \longrightarrow 2HI(g) \qquad \Delta H = -12{\cdot}1 \text{ kJ mol}^{-1}$$

Use these equations to calculate, by use of an energy cycle or otherwise, the enthalpy change, ΔH, for the reaction [2]

$$I_2(s) \longrightarrow I_2(g)$$

ΔH = ... kJ mol^{-1}

(d) Iodoethane reacts with aqueous hydrogen iodide (hydriodic acid) under suitable conditions to produce ethane.

$$C_2H_5I + HI \longrightarrow C_2H_6 + I_2$$

The proton nmr spectrum of iodoethane is seen as a quartet and a triplet.
State how the nmr spectrum of ethane would differ from that of iodoethane, giving a reason for your answer. [1]

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Total [12]

Section C Total [25]

Examiner only

Rough Work