TAYLOR'S COLLEGE

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Class	Student Number	Name

CAMBRIDGE A LEVEL PROGRAMME

A2 TRIAL EXAMINATION MARCH / APRIL 2011

(January & March 2010 Intakes)

Monday **4 April 2011** **1.30 pm – 3.30 pm**

CHEMISTRY 9701/42

PAPER 4 Structured Questions **2 hours**

Candidates answer on the Question Paper
Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, class and student number in the spaces at the top of this page.
Write in dark blue or black pen.
Do not use staples, paper clips, highlighters, glue or correction fluid

Section A
Answer **all** questions

Section B
Answer **all** questions.

You may lose marks if you do not show your workings or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question

For Examiner's Use	
1	
2	
3	
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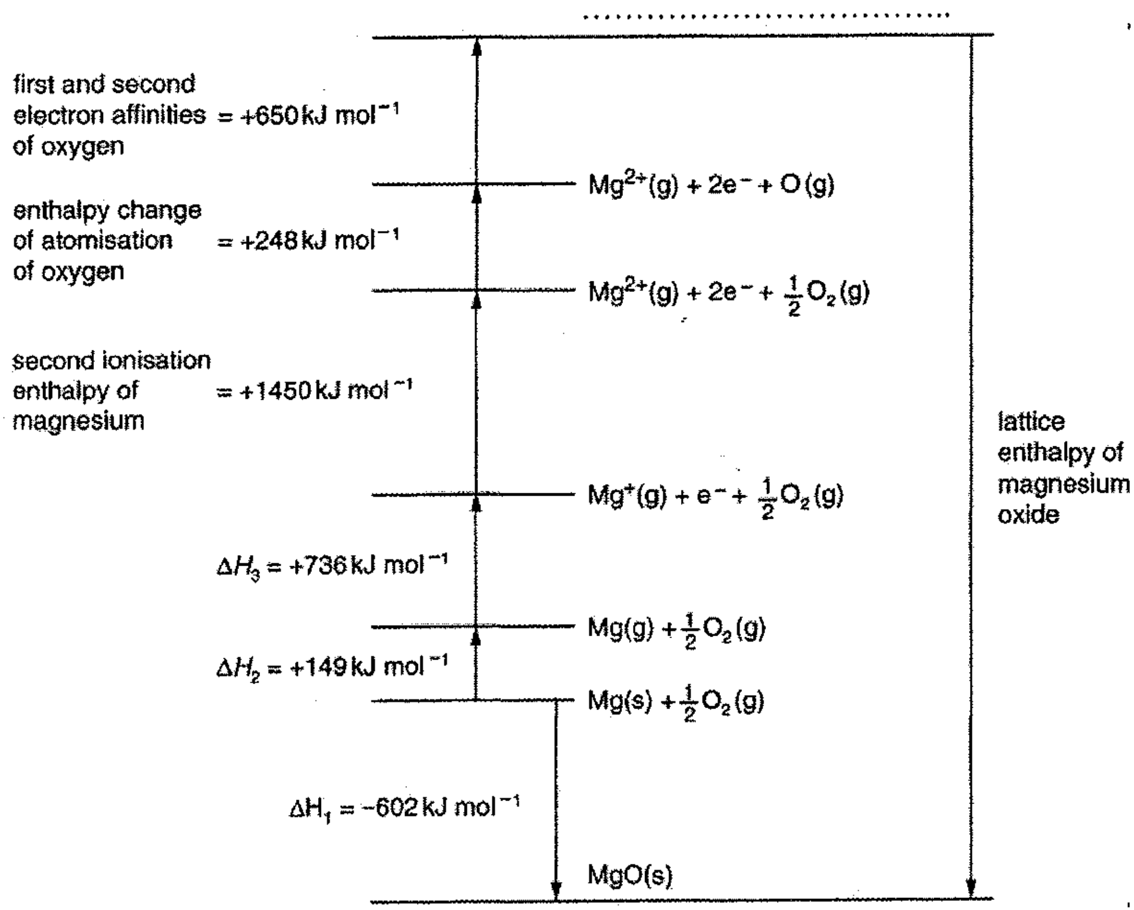
7	
8	
9	
10	
11	
Total	

This document consists of **22** printed pages

 [Turn over

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

1. The Born-Haber cycle below can be used to calculate the lattice energy for magnesium oxide.



(a) (i) Write down the name for each of the following enthalpy changes.

ΔH_1 ....

ΔH_2 ....

ΔH_3 ....

(ii) Write down the missing formula on the dotted line on top of the Born-Haber cycle. Include state symbols.

(iii) The equations representing the first and second electron affinities for oxygen are shown below.

$$O(g) + e^- \rightarrow O^-(g) \qquad \Delta H = -141 \text{ kJ mol}^{-1}$$
$$O^-(g) + e^- \rightarrow O^{2-}(g) \qquad \Delta H = +791 \text{ kJ mol}^{-1}$$

Suggest why the enthalpy change for the second of these processes is positive.

....

....

[5]

(b) (i) Use the Born-Haber cycle to calculate the lattice energy of magnesium oxide.

Answer ....

(ii) Describe how, and explain why, the lattice energy of magnesium oxide differs from that of barium oxide.

....

....

....

[4]

(c) Give **one** reason why magnesium oxide is good material to make the lining of a furnace.

....[1]

[Total : 10]

[Turn over

2. (a) Nicotine, $C_{10}H_{14}N$, is a drug of addiction present in tobacco. Nicotine and its conjugate acid are in equilibrium in aqueous solution.

$C_{10}H_{14}NH^+ \leftrightarrow C_{10}H_{14}N + H^+$ $\qquad K_a = 1.6 \times 10^{-8}\ mol\ dm^{-3}$

(i) Give the expression of the acid dissociation constant for the equilibrium given above.

(ii) Calculate the ratio of $[C_{10}H_{14}N]$ / $[C_{10}H_{14}NH^+]$ in an aqueous solution at pH 7.

[3]

(b) Nicotine and its conjugate acid are present in the fatty tissue of the bladder walls and in the urine inside the bladder. If the pH of the urine decreases, explain what happens to the concentration of the conjugate acid of nicotine in the urine of a smoker's body.

....

....

....

....

[2]

(c) A saturated solution of calcium hydroxide is found to have a pH of 12.3 at 25°C using a pH meter.

(i) Write the K_{sp} expression of calcium hydroxide and give its unit.

(ii) Calculate the concentration of the hydroxide ion, OH^- and the calcium ion, Ca^{2+}, of the solution at 25°C.

$[OH^-]$ = ...

$[Ca^{2+}]$ = ...

(iii) Calculate the solubility product, K_{sp} value for the calcium hydroxide at 25°C.

[6]

[Total : 11]

[Turn over

3. Hydrogen peroxide, H_2O_2, is a strong oxidising agent that has bleaching properties.

Hydrogen peroxide oxidises iodide ions, I^-(aq), in the presence of acid, H^+(aq). The initial rate of formation of I_2 (aq) was measured for each experiment.

Some of the experimental results are shown in the table below.

Experiment	$[H_2O_2]$ /mol dm^{-3}	$[I^-]$ / mol dm^{-3}	$[H^+]$ / mol dm^{-3}	Initial rate / mol dm^{-3}s^{-1}
1	0.020	0.010	0.0050	2.30×10^{-6}
2	0.040	0.010	0.0050	4.60×10^{-6}
3	0.020	0.010	0.010	4.60×10^{-6}
4	0.020	0.005	0.0050	1.15 10^{-6}

(a) Use the data in the table to deduce the order of reaction with respect to

$[H_2O_2]$:

$[I^-]$:

$[H^+]$:

[3]

(b) Write the rate equation for the reaction.

....[1]

(c) Use the data from Experiment 1 to calculate a value of the rate constant, k, stating its units.

[2]
[Total : 6]

4. (a) Describe and explain the trend in the thermal stability of group II carbonates.

....

....

....

....[3]

(b) The tetrachlorides of elements of group IV of the periodic table are readily hydrolysed but tetrachloromethane is exceptional in that it does not react with water.

(i) Write a balanced equation for the reaction between silicon tetrachloride with water.

....

(ii) Explain the unreactivity of tetrachloromethane towards water.

....

....
[2]

[Turn over

(c) (i) Describe the acid/base properties of the oxides of silicon, Si and lead, Pb in the group IV of the periodic table.

Si : ....

Pb : ....

(ii) Write two equations corresponding to the nature of Pb described in c (i).

....

....

[4]

[Total : 9]

5. The use of Standard Redox Potentials in the *Data Booklet* is required for this question.

(a) Draw a labeled diagram of a standard hydrogen electrode.

[3]

(b) Write the ionic equation and calculate the electrode potential when the cell in (a) is connected to a standard Br_2/Br^- electrode half cell.

....

....

....[1]

(c) (i) Which oxidation state of iron will reduce $V^{3+}(aq)$ to $V^{2+}(aq)$?

....

(ii) Justify your answer in c (i).

………………………………………………………………………………………

………………………………………………………………………………………

[3]

(d) (i) Metallic copper will reduce $VO^{2+}(aq)$ to $V^{3+}(aq)$ under certain conditions. Write a balanced equation for this reaction.

………………………………………………………………………………………

(ii) What is the overall standard cell potential for the above reaction.

………………………………………………………………………………………

[2]
[Total : 9]

6. Copper is a typical transition element. It forms coloured compounds and complex ions.

(a) Explain what is meant by the term *transition element.*

....

.... [1]

(b) Aqueous ammonia reacts with water in the following way.

$$NH_3(aq) + H_2O(l) \leftrightarrow NH_4^+(aq) + OH^-(aq)$$

When aqueous ammonia is added drop wise to aqueous copper (II) ions, a very pale blue precipitate is observed which disappears in excess ammonia to give deep blue solution.
Write balanced equations to show the formation from aqueous copper (II) ions of

(i) The pale blue precipitate,

....

(ii) The deep blue solution.

.... [2]

(c) A ligand substitution involving $[Cu(H_2O)_6]^{2+}$ is shown below.

$$[Cu(H_2O)_6]^{2+} \xrightarrow[\text{reagent } \mathbf{X}]{} [CuCl_4]^{2-}$$

(i) Draw **and** name the shape for the $[Cu(H_2O)_6]^{2+}$ ion.

Shape : ....

(ii) State the name of reagent **X**.

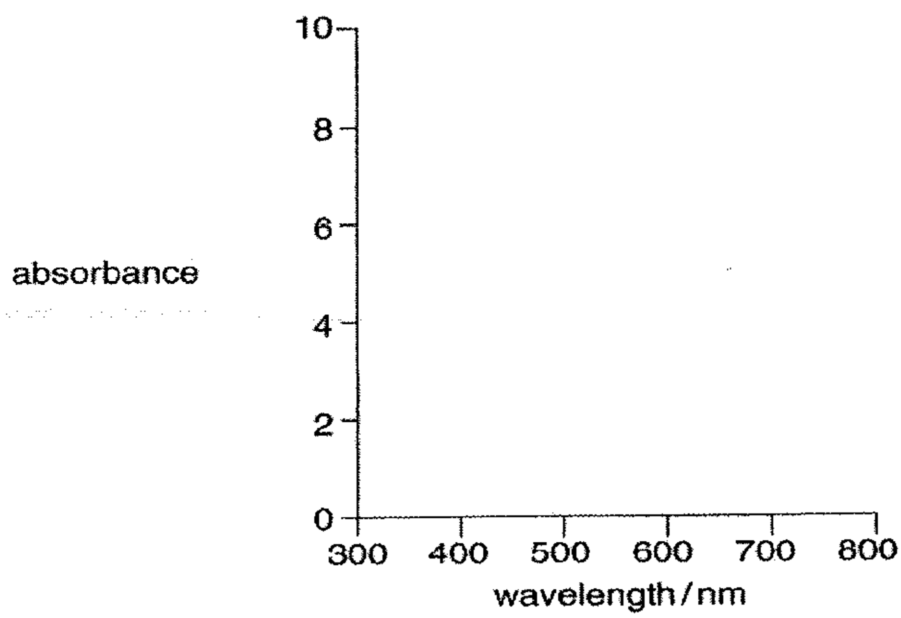
....

[3]

(d) The following table lists the colours and energies of photons of light of certain wavelengths.

wavelength / nm	energy of photon	colour of photon
400	high	violet
450	↓	blue
500	lower	green
600	↓	yellow
650	low	red

(i) Sketch on the axes below the absorption spectrum you would predict for $[CuCl_4]^{2-}$ ion.



[Turn over

(ii) In which complex, $[CuCl_4]^{2-}$ or $[Cu(H_2O)_6]^{2+}$, will the energy gap between the two groups of d-orbitals be the larger? Explain your answer.

....

....

[2]

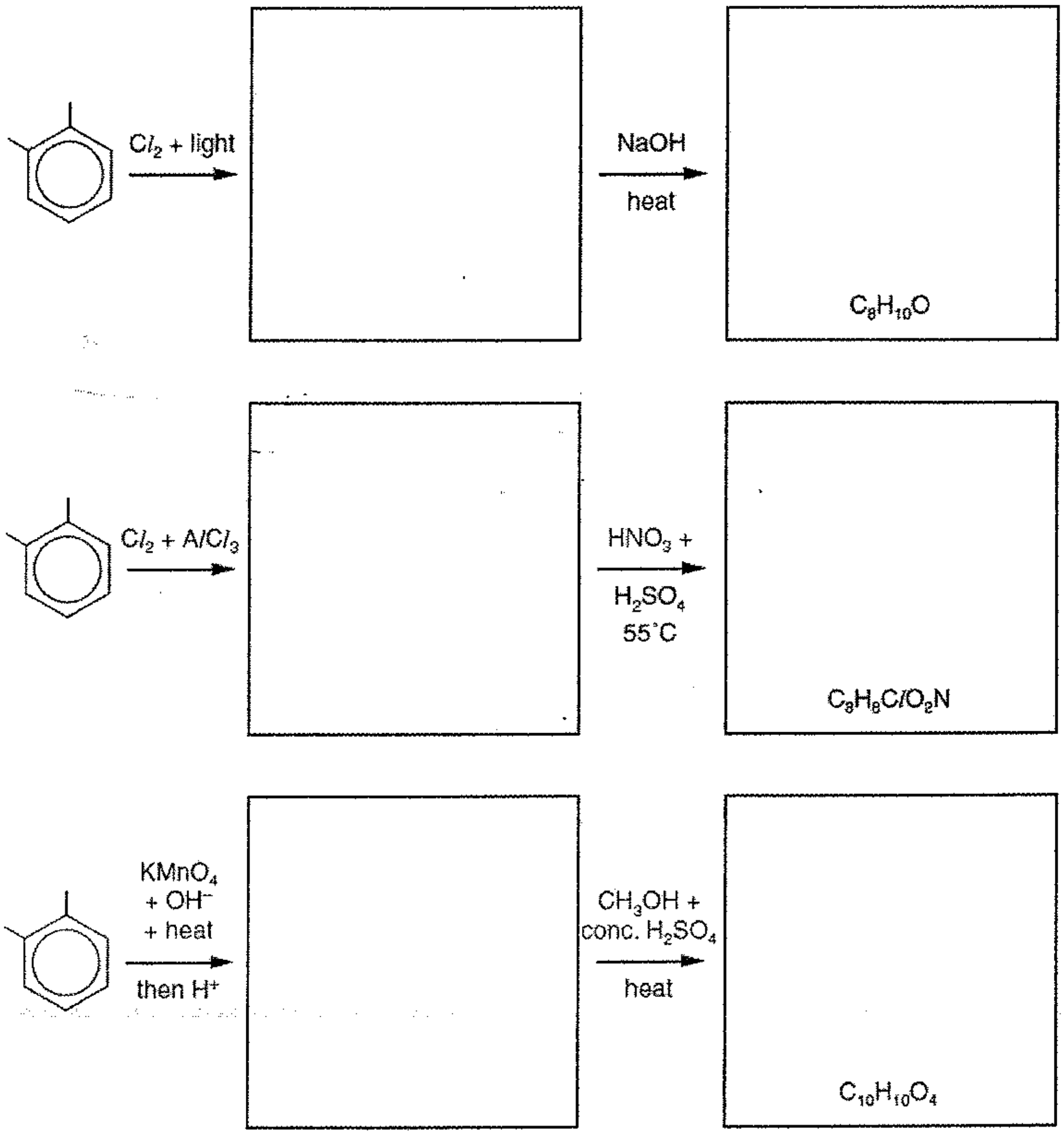
[Total : 8]

7. Benzene can be nitrated to form nitrobenzene, $C_6H_5NO_2$.

(a) Use curly arrows to show the mechanism for the nitration of benzene.

[3]

(b) Predict the products of the following reactions and draw their structures in the boxes provided. Note that the molecular formula of the final product is given in each case



[6]
[Total:9]

[Turn over

8. Amides can be made by reacting amines with acyl chlorides, as in the example below.

$$\mathbf{CH_3COCl + H_2NCH_2CH_3 \rightarrow CH_3CONHCH_2CH_3 + HCl}$$

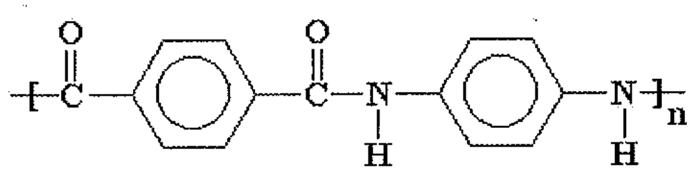
(a) What type of reaction is this?

....[1]

(b) What compound could CH_3COCl be made from, and what reagent would you use?

....[2]

(c) *Kevlar* is a low weight, high strength polyamide used as reinforcement in car tyres, aircraft wings and in bullet-proof vests. A portion of its chain is shown below.



(i) What type of polymerisation produces *Kevlar*?

....

(ii) Draw the structural formulae of the monomers from which *Kevlar* is made.

(iii) Suggest a reason why *Kevlar* is much stronger than most other polyamides.

....

....

(iv) What reaction conditions are needed to break the amide bonds in *Kevlar*?

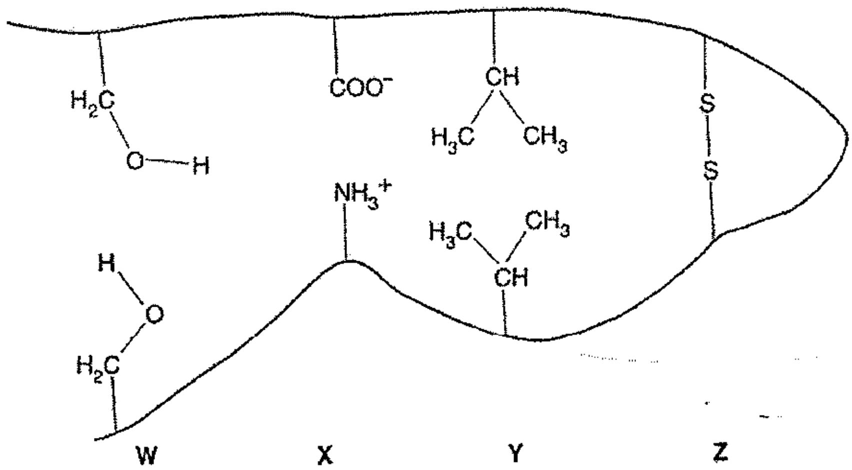
....

[5]

[Total : 8]

Section B – Applications of Chemistry
Answer **all** questions in the spaces provided.

9. The diagram shows a section of polypeptide chain with some side chains of amino acids which can be involved in maintaining the tertiary protein structure.



(a) State the type of bonding or attraction involved at each of the sites W to Z shown.

W ....

X ....

Y ....

Z ....

[4]

(b) At which site in the diagram will the bonding be weakest?

....[1]

(c) Identify and explain which of W to Z is most likely to be affected by

(i) a change of pH from 7.0 to 10.0?

....

....

....

(ii) increase in temperature?

....

....

....

[4]

(d) Use two molecules of glycine, H_2NCH_2COOH, to show how amino acids are linked in a dipeptide. Show every bond in a displayed structure.

[2]
[Total : 11]

[Turn over

10. Mass spectrometry is an important technique used to determine the structure of organic compounds, such as drug testing and the identification of pollutants.

(a) The mass spectrum of an organic compound shows a significant (M + 1) peak.

(i) What causes this peak?

....

(ii) Explain how this peak can give more information about the compound.

....

....

....

[3]

(b) Halogenoalkanes containing a single chlorine or bromine atom will also show a peak at (M + 2). For each halogen, state which isotope causes the (M + 2) peak.

chlorine.......................... bromine.................................

[1]

(c) Bromochloromethane, CH_2BrCl, can be used for fumigating grain to prevent insect attack. The mass spectrum of bromochloroethane has an M peak at m/e 128, together with (M + 2) and (M + 4) peaks.

(i) Which molecular ions give rise to the

M peak ....

(M + 2) peak ....

(M + 4) peak ....

(ii) Suggest the ratio of the heights of the M : (M + 2) : (M + 4) peaks.

[3]

(d) Two isomeric alcohols A and B have the formula $C_4H_{10}O$.
The mass spectrum of A shows a major peak at m/e (M – 45) but no peak at m/e (M – 43). The mass spectrum of B shows major peaks at both m/e (M – 45) and m/e (M – 43).

Suggest a reason for these different fragmentation patterns, and hence the structural formulae for A and B.

....

....

....

....

....

A	B

[3]
[Total : 10]

11. Read the following article about the use of bacteria in mining, and then answer the questions that follow it.

The discovery that bacteria could 'mine' metals for us was made in Spain. The Rio Tinto mine, in the southwest corner of Spain, was originally mined for copper by the Romans some 2,000 years ago. In 1752, some mining engineers looked over the mine to see if it could possibly be re-opened. They noticed streams of a blue-green liquid running from spoil heaps of the processed rock that lay around the mine. When this blue-green liquid ran over iron, it coated the iron with a brown film. The brown film was metallic copper.

There was still some copper left in the spoil heaps. At the time, everybody thought that the copper was being dissolved in the liquid through a simple chemical reaction. But in 1947, US scientists discovered that the copper was being 'mined' by a bacterium called *Thiobacillus ferrooxidans*. The bacterium *Thiobacillus ferrooxidans* lives off the chemical energy trapped in metal sulphides. In the ore, the copper exists as copper sulphide. The bacteria gain energy by converting the copper sulphide to copper sulphate, which is then excreted. At the same time, they absorb the difference in energy in the chemical bonds. These bacteria can also obtain energy in similar reactions with ores of zinc, lead and uranium.

(a) Use the *Data Booklet* to explain why the blue-green liquid coated the iron with copper.

Write an equation for the reaction.

....

....[2]

(b) Suggest **two** reasons why this method of extracting copper might be useful for ore containing only a small percentage of copper.

(i) ....

....

(ii) ....

....

[2]

(c) Suggest **one** disadvantage of using bacteria rather than traditional mining and smelting methods.

....

....[1]

(d) In conventional copper mining, the ore will typically contain 0.5 – 2.0% copper, which gives an idea of what a valuable resource copper is.

(i) The ore from a particular mine contains 0.75% copper, and 150 000 tonnes of ore are mined each year. From this ore about 60% of the copper is extracted, and the remainder is left in the 'spoil heaps' of processed ore.

What mass of copper is extracted each year?

(ii) If the use of bacteria can recover a further 17% of copper from the spoil heaps, what is the extra mass of copper produced?

[2]

(e) Suggest why bacteria are unlikely to be used in the extraction of aluminium.

....

....[1]

[Turn over

(f) Metals like copper and zinc from abandoned mines can contaminate ground-water. Suggest one way of removing these contaminants.

....

....[1]

[Total: 9]