TAYLOR'S COLLEGE

Wisdom • Integrity • Excellence

Class	Student Number	Name

CAMBRIDGE A LEVEL PROGRAMME

A2 TRIAL EXAMINATION MARCH / APRIL 2010

(January and March 2009 Intakes)

Friday **2 April 2010** **8.30 am – 10.15 am**

CHEMISTRY 9701/42

PAPER 4 Structured Questions **1 hour 45 minutes**

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	
4	
5	
6	
7	
8	
9	
Total	

This document consists of **16** printed pages

[Turn over

Section A

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

1. a) Using magnesium fluoride, MgF_2 as an example, define lattice energy.

.....

.....

[2]

b) Using the data given below as well as relevant data from the *Data Booklet*, construct a Born-Haber energy level diagram and calculate the lattice energy of magnesium fluoride.

Enthalpy change of atomisation of Mg: +148 kJ mol^{-1}
Electron affinity of fluorine: -328 kJ mol^{-1}
Enthalpy change of formation of MgF_2 (s): -1121 kJ mol^{-1}

[3]

c) The actual lattice energy of magnesium fluoride is –2952 kJ mol^{-1}. Explain the difference between your calculated value and actual value given.

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[1]

d) How would you expect the magnitude of lattice energy of magnesium chloride to compare with that of magnesium fluoride? Explain your reasoning.

.....

.....

[2]
[Total: 8]

2. a) A possible method for producing power for a heart pacemaker is to implant a zinc and a platinum electrode into the body tissues. These electrodes in the oxygen-containing body fluid will form a "biogalvanic" cell in which zinc is oxidized and oxygen is reduced to water.

i) Write balanced half-equations for the reaction that occurs at the anode and cathode.

Anode: .....

Cathode: .....

ii) Hence write a balanced equation for the overall reaction of the "biogalvanic" cell.

.....

[3]

b) Using related data from the *Data Booklet*, calculate the E°_{cell} for the "biogalvanic" cell.

.....

[1]

c) A current of 40 μA is produced by the cell. How long will it take for a 6.5 g of zinc electrode to be depleted? ($1\mu A = 10^{-6}A$)

time = ...seconds

[3]

d) The lead-acid accumulator is a storage battery because it can be recharged. It consists of a series of cells containing lead plate anodes, lead dioxide plates cathodes and an electrolyte of 6 mol dm^{-3} sulphuric acid.

When it is operating, the reaction that occurs at the electrode are;

$PbSO_4(s) + 2e^- \rightleftharpoons Pb(s) + SO_4^{2-}(aq)$ $\quad E^\theta = -0.36\ V$

$PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^- \rightleftharpoons PbSO_4(s) + 2H_2O(l)$ $\quad E^\theta = +1.69\ V$

i) Write the overall equation for the reaction upon discharge and calculate the voltage delivered by the battery if it contains a series of 6 cells.

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.....

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ii) Why is the battery rechargeable?

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iii) Explain why the measurement of the electrolyte density can be used to indicate the extent of discharge of the cell.

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.....

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[6]

[Total: 13]

3. 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.

$C_{10}H_{14}NH^+ \rightleftharpoons C_{10}H_{14}N + H^+ \quad K_a = 1.6 \times 10^{-8}$ 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.

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[2]

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

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.

$[OH^-]$ = ...

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

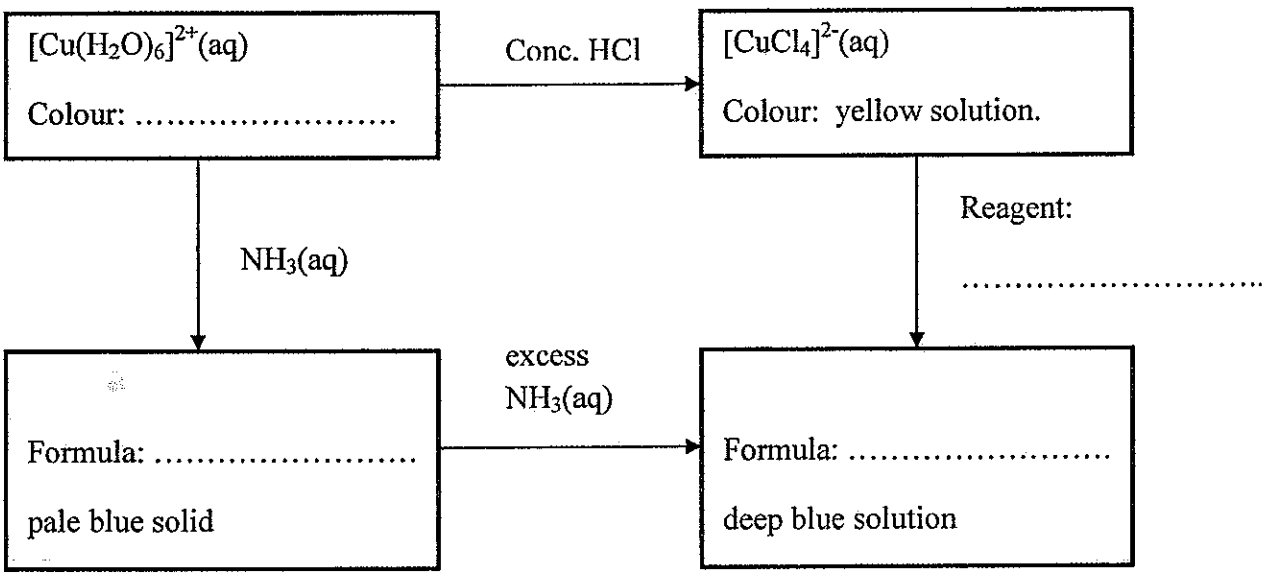
iii) Calculate the solubility product, K_{sp} value for calcium hydroxide at 25°C.

[6]

[Total: 11]

4. A student investigates ligand substitution in complexes experimentally. He divided a solution of aqueous copper(II) sulphate into two portions. He then added concentrated hydrochloric acid to one portion and excess aqueous ammonia to the other.

a) Fill in the blanks in the figure below.



[4]

b) What do you understand by the term '*ligand*'?

.....

.....

[1]

c) State the type of bonding formed between a ligand and copper(II) ion, Cu^{2+}.

.....

[1]

d) Aqueous ammonia is added slowly in to a solution of $Cu^{2+}(aq)$. Describe the reactions with the aid of equations.

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[2]

e) Draw the structure of the complex ion formed when excess aqueous ammonia is added to the copper solution.

[2]

f) When concentrated hydrochloric acid is added to a solution of $Cu^{2+}(aq)$, the colour changes to yellow. On adding water, the colour returns to pale blue.

Write an equation and suggest an explanation for these changes.

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[3]

[Total: 13]

5. a) i) State and explain the relative basicities of ammonia, ethylamine and phenylamine.

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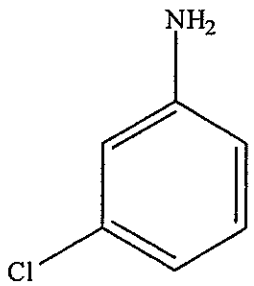
ii) Suggest with reasons, how the basicity of 3-chlorophenylamine, might be compared with that of phenylamine:



3-chlorophenylamine

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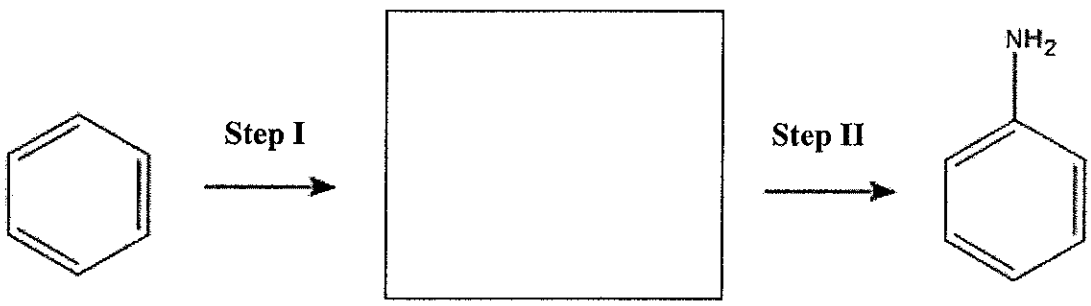
[5]

b) The following is the scheme for the production of phenylamine from benzene.



i) Draw the structure in the box provided above

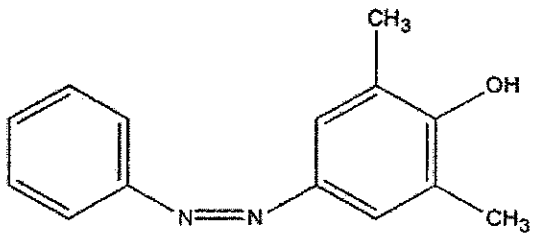
ii) State the reagents and conditions for the following steps:

Step I: .....

Step II: .....

[5]

c) The dye **A** can be obtained from an amine and a phenol under suitable conditions



Dye **A**

i) Draw the structural formula of the amine and the phenol used to synthesize **A**.

ii) State the reagents and conditions to convert the above two compounds to **A**.

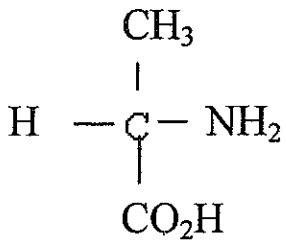
Reagent(s): .....

Condition: .....

[4]

[Total: 14]

6. a) 2-aminopropanoic acid has the following formula.



i) In aqueous solution, 2-aminopropanoic acid exists in different forms at different pH values. The zwitterions predominates between pH values of 2.3 and 9.7, Draw the structure of the predominant form of 2-aminopropanoic acid at pH values of 2.0, 6.0 and 10.0

pH 2.0	pH 6.0	pH 10.0

ii) State and explain how you would expect the melting point of an unionized covalent form of 2-aminopropanoic acid to compare with the actual property of the zwitterionic form.

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.....

iii) Amino acids are components of protein. Draw a diagram to show how a linkage may be formed between 2-aminopropanoic acid and the amino acid glycine, $H_2NCH_2CO_2H$.

iv) Name a synthetic polymer in which you would find the type of linkage in **(iii)**.

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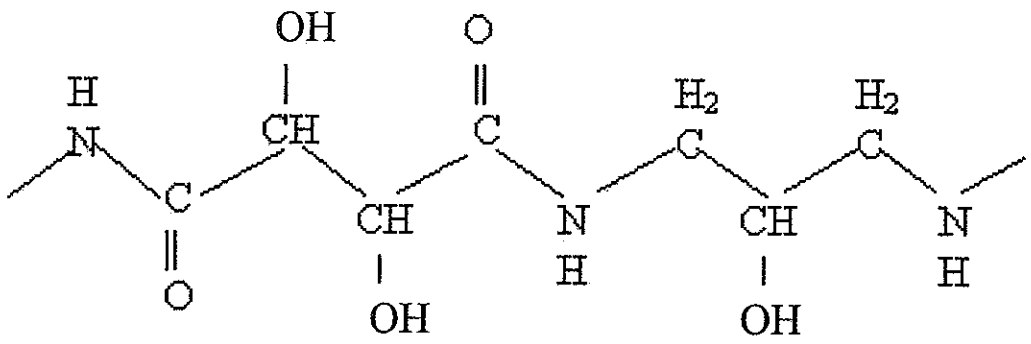
[8]

b) The following diagram shows a section of a polymer.



i) What type of polymerization has occurred to form this polymer?

.....

ii) Draw the structure of each of the monomers that make up the polymer.

[3]

[Total: 11]

Section B – Applications of Chemistry

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

7. Thiomersal is a mercury-containing substance that has been added to vaccines to prevent bacterial and fungal contamination. The vaccine that protects against the smallpox virus contains thiomersal. Viruses consist of DNA or RNA wrapped in a protein coat.

a) i) By using a simple block diagram draw two repeat units of a strand of DNA.

ii) Explain briefly the role of m-RNA.

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iii) Give **three** differences between DNA and RNA.

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[7]

b) i) Describe the bonding by which a tertiary structure is stabilised.

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ii) Suggest how the heavy metal mercury in thiomersal may disrupt the tertiary structure of a protein.

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[4]

[Total 11]

8. a) A dibasic acid, **B**, was shaken with water and ether for some time. 10.0 cm^3 of the aqueous layer was found to contain 0.854 g of the acid, whereas 10.0 cm^3 of the ether layer was found to contain 0.159 g of the acid.

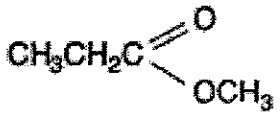
i) Find the partition coefficient of the acid **B** between water and ether.

ii) In another experiment, 1.0 g of the dibasic acid was added to 10.0 cm^3 of water and 20.0 cm^3 of ether. This was shaken until all the acid has dissolved and equilibrium was established. Calculate the volume of 0.20 mol dm^{-3} sodium hydroxide solution required to neutralize the acid **B** in both the aqueous and organic layers.

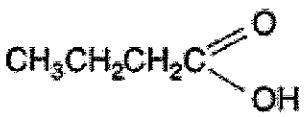
(The M_r of dibasic acid = 118)

[5]

b) A compound **C** is known to have either structure **I** or structure **II** as shown below.



I



II

C was investigated by using nuclear magnetic resonance spectroscopy.

i) The nuclear magnetic resonance spectrum of **C** includes a triplet of peaks and a quartet of peaks. Indicate which groups of protons in the molecule are responsible for each of these multiple peaks, and outline how the splitting patterns arise.

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ii) The nuclear magnetic resonance spectrum of **C** shows one other peak. Suggest the chemical shift and the splitting pattern of this peak.

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iii) Describe and explain how the addition of deuterium oxide to a sample of **C** could be used to distinguish between the two structures shown.

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iv) The mass spectra of compounds **I** and **II** are different. Give **two** differences in these spectra.

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[8]
[Total: 13]

9. During the early 1970s nearly one million tonnes of CFCs were being manufactured annually. Uses included blowing agents for making foam, cleaning agents, propellants and as a component of air conditioning units.

a) Give **three** physical or chemical properties relevant to their use in these applications.

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[2]

b) Using appropriate equations, describe how $CFCl_3$ (CFC-11) can be involved in the destruction of ozone layer. Explain why a single molecule of CFC may destroy many molecules of ozone.

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[4]

[Total: 6]