TAYLOR'S UNIVERSITY COLLEGE
Wisdom · Integrity · Excellence

Class	Student Number	Name

CAMBRIDGE A LEVEL PROGRAMME

A2 TRIAL EXAMINATION SEPTEMBER 2009

(June 2008 Intake)

Thursday **3 September 2009** **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	
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7	
8	
9	
10	
11	
Total	

This document consists of **18** printed pages

Section A

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

1. (a) Define the term *lattice energy*.

.....

.....

.....

[2]

(b) Write an equation to represent the lattice energy of barium chloride. Include state symbols for all species involved.

.....

[1]

(c) (i) Draw a fully-labelled Born-Haber cycle for the formation of solid barium chloride from its elements. Include state symbols for all species involved.

(ii) Use your Born-Haber cycle, the following data, and further data from the *Data Booklet* to calculate a value for the electron affinity of chlorine.

Standard enthalpy change of formation of barium chloride	-859 kJ mol^{-1}
Standard enthalpy change of atomisation of barium	+180 kJ mol^{-1}
Lattice energy of barium chloride	-2056 kJ mol^{-1}

[5]

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

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.....

.....

[2]
[Total: 10]

2. (a) (i) Draw a fully labelled diagram to show how you could use a standard hydrogen electrode to measure the standard electrode potential, $E^{\ominus}$, of $Cr^{3+}(aq)/Cr^{2+}(aq)$.

(ii) Predict how the $E^{\ominus}$ of $Cr^{3+}(aq)/Cr^{2+}(aq)$ would vary when the $[Cr^{3+}]$ is decreased.

.....

.....

[6]

(b) Use the standard electrode potential data in the table below to answer the questions which follow.

	$E^{\ominus}$/V
$Ce^{4+} + e^- \leftrightarrow Ce^{3+}$	+1.70
$MnO_4^- + 8H^+ + 5e^- \leftrightarrow Mn^{2+} + 4H_2O$	+1.51
$Cl_2 + 2e^- \leftrightarrow 2Cl^-$	+1.36
$VO_2^+ + 2H^+ + e^- \leftrightarrow VO^{2+} + H_2O$	+1.00
$Fe^{3+} + e^- \leftrightarrow Fe^{2+}$	+0.77
$SO_4^{2-} + 4H^+ + 2e^- \leftrightarrow H_2SO_3 + H_2O$	+0.17

(i) Which one of the species given in the table is the strongest oxidising agent?

.....

(ii) Which of the species in the table could convert Fe^{2+} into Fe^{3+} but could not convert Mn^{2+} into MnO_4^-?

.....

[3]

[Total: 9]

3. (a) A saturated calcium hydroxide solution is prepared. 25 cm^3 of this solution is titrated with 0.05 mol dm^{-3} hydrochloric acid and 23.75 cm^3 of hydrochloric acid are required for complete neutralisation.

(i) Calculate the concentration (in mol dm^{-3}) of calcium hydroxide, $Ca(OH)_2$ in the saturated solution.

(ii) Write an expression for the solubility product, K_{sp}, for $Ca(OH)_2$, including its units.

(iii) Use the value obtained in (a)(i) to calculate the solubility product of $Ca(OH)_2$.

[6]

(b) (i) Calculate the pH of a 0.01 mol dm^{-3} solution of ethanoic acid. K_a for ethanoic acid is 1.75×10^{-5} mol dm^{-3}.

(ii) A buffer solution is prepared by adding 3.20 g of sodium ethanoate to 1.00 dm^3 ethanoic acid of concentration 0.01 mol dm^{-3}. Calculate the pH of this buffer solution. K_a for ethanoic acid is 1.75×10^{-5} mol dm^{-3}.

[4]
[Total: 10]

4. Two substances X and Y react in an inert solvent according to the equation

$$X + 2Y \rightarrow XY_2$$

In a study to determine the order of reaction between X and Y, the following results are obtained.

Experiment	Initial concentration of X (mol dm^{-3})	Initial concentration of Y (mol dm^{-3})	Initial rate of formation of XY_2 (mol dm^{-3} min^{-1})
1	0.10	0.10	0.0010
2	0.10	0.20	0.0040
3	0.15	0.10	0.0010
4	0.20	0.20	

(a) Predict the initial rate for the formation of XY_2 in Experiment 4.

.....

[1]

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

X :

Y :

[2]

(c) Write the rate equation for the reaction.

.....

[1]

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

[2]

[Total: 6]

5. (a) Describe and explain the trend in the solubilities of the sulphates of the Group II elements.

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[3]

(b) Most of the elements in Group IV form two types of oxides with general formulae MO and MO_2. The melting points of some oxides of Group IV elements with general formulae of XO_2 are given below.

Oxide	CO_2	SiO_2
m.p. /°C	-78	1610

Explain, in term of structure and bonding, the different in melting point.

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.....

[3]

(c) The elements of Group IV all form tetrachlorides with the general formula MCl_4.

(i) Draw a diagram of a molecule of $SiCl_4$ and stating its bond angle.

Bond angle

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(ii) Describe the reaction of $SiCl_4$ when shaken with water and give an equation.

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[4]

[Total : 10]

6. (a) Explain why transition element complexes are often coloured. You may use the example of water being progressively added to anhydrous copper sulphate in your explanation.

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[4]

(b) Articles made from copper and its alloys can be cleaned of their oxide tarnish by the use of metal polishes containing aqueous ammonia and an abrasive.

(i) Suggest **two** common oxidation states of copper.

.....

(ii) Name a common copper containing alloy.

.....

(iii) Assuming the tarnish contains copper (II) ions suggest with an equation how the aqueous ammonia might react with the tarnish and suggest the colour of the resulting solution.

.....

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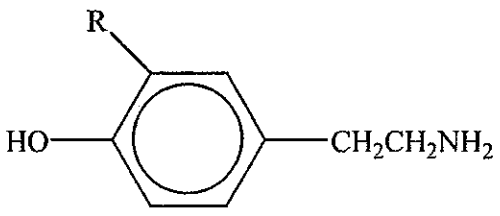
.....

[6]

[Total : 10]

7. Dopamine, which has the structure shown below, is an important neurotransmitter both in the central nervous system and in peripheral tissues.



Dopamine

Where R = alkyl group

(a) Name the two functional groups in the Dopamine molecule.

.....

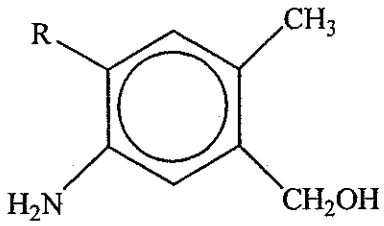
[1]

(b) (i) Draw a structure of the product formed when dopamine reacts with warm dilute nitric acid.

(ii) Describe the mechanism for the product formed in **b(i)**.

[4]

(c) Compound **A** as showed below is an isomer of Dopamine.



Compound **A**

Where R = alkyl group

(i) Suggest the structural formula of the compound formed by reacting Compound **A** with nitrous acid at 5°C.

(ii) Describe a test (reagents and observations) that would distinguish compound **A** from Dopamine.

reagents;

.....

observation with **A**;

.....

observation with Dopamine.

.....

[3]

[Total : 8]

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

$$CH_3COCl + H_2NCH_2CH_3 \rightarrow CH_3CONHCH_2CH_3 + HCl$$

(a) What type of reaction is this?

.....

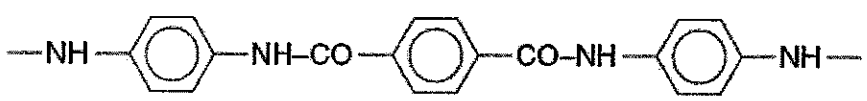
[1]

(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*?

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(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*?

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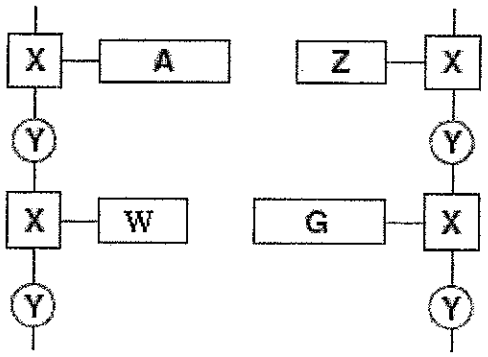
[4]

[Total : 7]

[Turn over

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

9. (a) The diagram represents a section of the DNA.



Where A and G are bases.

(i) Identify the blocks labelled **W**, **X**, **Y** and **Z**.

W : .....

X : .....

Y : .....

Z : .....

(ii) Using dot notation, show the hydrogen bonds formed between the bases on the diagram above.

[6]

(b) Sodium and potassium ion are involved in the transmission of the signal that stimulates nerve cells. Explain.

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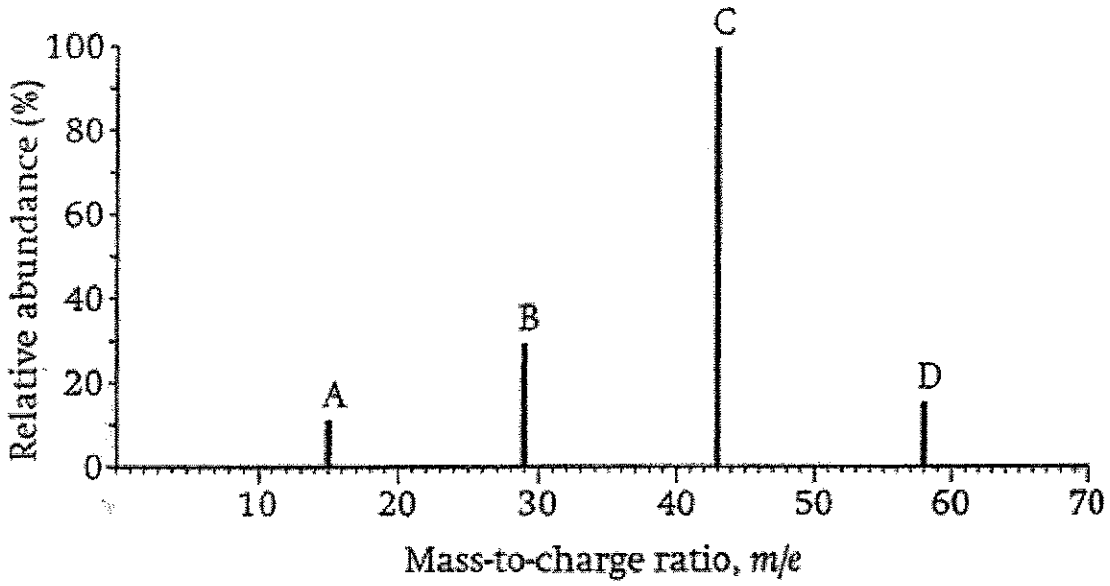
[4]
[Total : 10]

10. (a) The mass spectrum below represents part of the mass spectrum of a straight-chain alkane.



(i) Give the m/e value of the molecular ion peak. Identify the structural formula of the molecular ion peak.

.....

.....

(ii) The other three peaks are fragmentation peaks. Give the m/e value of these three fragmentation peaks and identify the structural formula of these peaks.

m/e value	structural formula

[5]

[Turn over

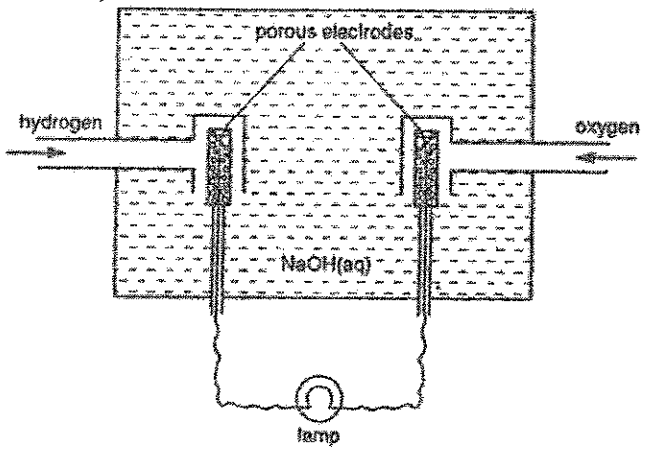
(b) Compound Q has the molecular formula $C_4H_8O_2$.
Compound Q contains ketone and –OH functional groups.
The NMR spectrum of compound Q shows 4 peaks. The table below gives δ values for each of these peaks.

δ / ppm	2.20	2.69	3.40	3.84
Number of protons responsible for the peak	3H	2H	1H	2H
Splitting pattern	singlet	triplet	singlet	triplet

Deduce the structure of compound Q, explaining how you arrive at your answer.

[5]
[Total: 10]

11. (a) A fuel cell which is environmental friendly is an alternative of the conventional battery. It is obtained from hydrogen and oxygen gases. A fuel cell is illustrated in the diagram below. There is a common electrolyte of aqueous sodium hydroxide. One electrode in the fuel cell becomes the anode (negative terminal) and the other the cathode (positive terminal).



(i) Write the half equation for the reaction occurring at the left hand (hydrogen) and right hand (oxygen) electrode when the cell operates.

Left: .....

Right: .....

(ii) Write the overall equation for the reaction.

.....

(iii) State **one** advantage, and **one** disadvantage of using fuel cells to power road vehicles compared to hydrocarbon fuels such as petrol.

Advantage:

.....

.....

Disadvantage:

.....

.....

[5]

[Turn over

(b) CFCs were introduced as a refrigerator compressor liquid by the engineer Thomas Midgley in the 1920s. Unfortunately CFCs were found to cause a huge environmental problem. CFCs are particularly stable and do not break down until they get to the stratosphere.

(i) State **two** properties of CFCs which causes them to be useful?

.....

(ii) Explain, giving appropriate equations, why usage of CFC presents an environmental concern?

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[5]

[Total: 10]