| Name: | | Index Number: | | Class: | |
|---|---|---|---|---|---|

# DUNMAN HIGH SCHOOL
# Preliminary Examination
# Year 6

## H2 CHEMISTRY

9647/02

Paper 2 Structured

**21 September 2011**

**2 hours**

Additional Materials: Data Booklet

**INSTRUCTIONS TO CANDIDATES**

1 Write your **name**, **index number** and **class** on this cover page.

2 Answer ***all*** questions.

3 Write your answers in the spaces provided on the question paper.

4 A *Data Booklet* is provided.

5 The number of marks is given in brackets [ ] at the end of each question or part question.

6 You may use a calculator.

| FOR EXAMINER'S USE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Question No.** | **1** | **2** | **3** | **4** | **5** | **6** | **Total** | **%** |
| **Marks** | /12 | /14 | /15 | /11 | /11 | /9 | /[72] | |

This question paper consists of 18 printed pages and 0 blank page.

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

## 1 Planning

When aqueous sodium chloride, NaC*l*, is added to aqueous lead(II) nitrate, $Pb(NO_3)_2$, a white precipitate of lead chloride, $PbCl_2$, is produced. A suggested stoichiometric equation is

$$Pb(NO_3)_2(aq) + 2NaCl(aq) \rightarrow PbCl_2(s) + 2NaNO_3(aq)$$

In separate experiments, different volumes of 0.20 mol $dm^{-3}$ aqueous sodium chloride are added to a fixed volume of 0.10 mol $dm^{-3}$ aqueous lead(II) nitrate. In each case, the precipitate, $PbCl_2$ will be formed. This precipitate is then filtered, washed with distilled water and thoroughly dried. The mass of the precipitate is recorded.

You are to plan an experiment to investigate this reaction in order to confirm or reject the stoichiometry of the equation.

**(a) (i)** By considering the suggested stoichiometric equation, predict how the number of moles of the precipitate, $PbCl_2$, will change as the number of moles of NaC*l* added increases.

Prediction: .....

.....

**(ii)** Sketch the graph which would result if NaC*l* is the *limiting reagent*. Start your graph with no NaC*l* added.


[2]

**(b)** You are provided with 250 $cm^3$ of 0.20 mol $dm^{-3}$ aqueous sodium chloride and some solid lead(II) nitrate.

**(i)** Outline how you would prepare 250 $cm^3$ of 0.10 mol $dm^{-3}$ aqueous lead(II) nitrate.

[$A_r$: N, 14.0; O, 16.0; Pb, 207.0]

**(ii)** You will be carrying out five sets of experiments to obtain different masses of precipitate. Give a step by step description of how you would carry out **one** such experiment.

You need to state only the following:

- the volumes of each solution to be used,
- how the volumes will be measured, and
- how you would dry the precipitate.

[6]

**(c)** In the table below

- enter appropriate headings to show recorded and calculated data. The headings should include appropriate units,
- enter the volumes from your plan in **(b)**,
- enter suitable volumes for four further experiments.

| experiment | | | | | |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |

[3]

**(d)** How would you ensure that at the end of each experiment the precipitate is thoroughly dried?

.....

..... [1]

[Total: 12]

**2** Iodine forms an intense blue complex with starch and many chemical reactions make use of this property.

**(a)** In the iodine clock reaction, the following set of reactions take place and a colour change involving the iodine–starch complex happens after a fixed time delay, allowing the kinetics of the reaction to be determined.

Step I: $2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$

Step II: $I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$

During an experiment to determine the rate equation for these reactions, different concentrations of KI, $Na_2S_2O_8$ and $Na_2S_2O_3$ are mixed according to the following table. The rates for the colour change in each solution are shown below.

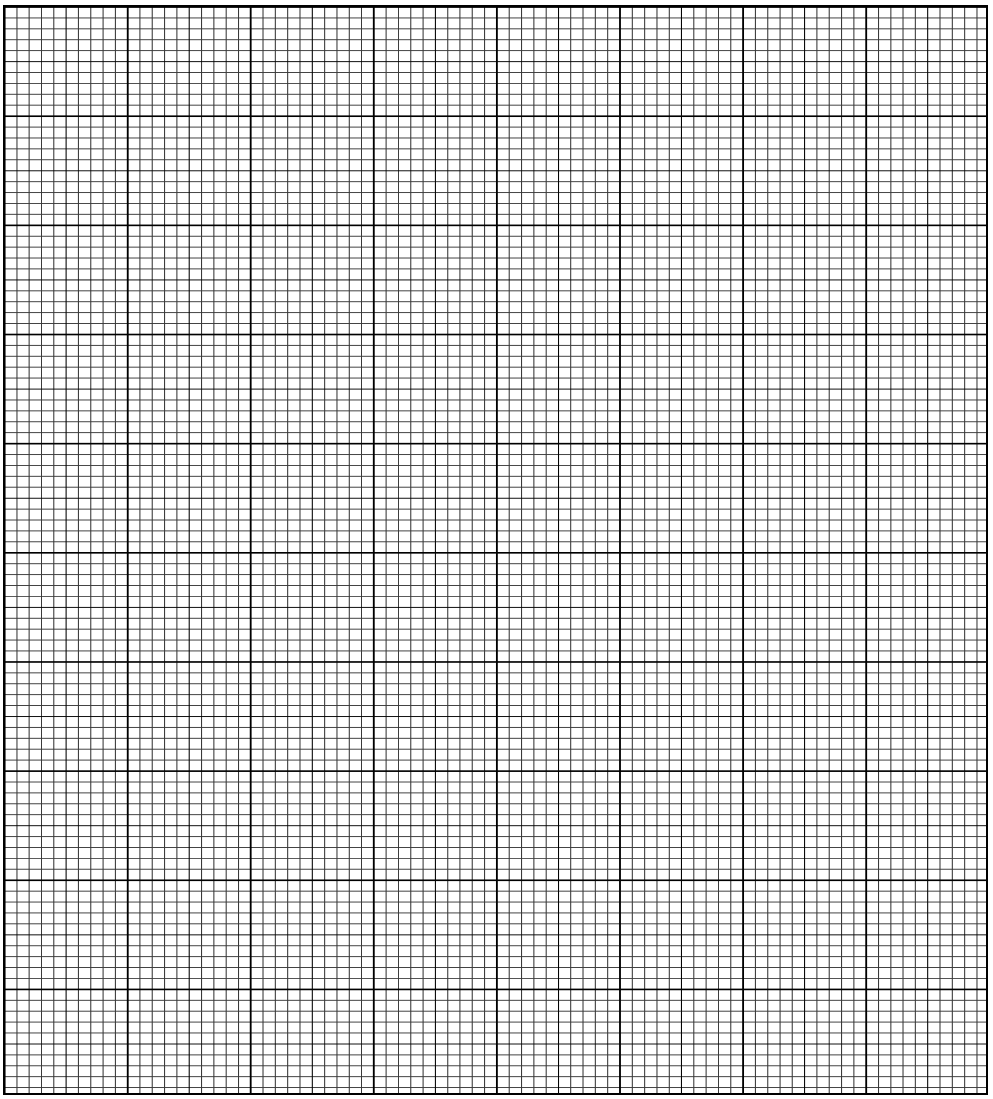
| flask | $[I^-]$/ mol dm$^{-3}$ | $[S_2O_8^{2-}]$ / mol dm$^{-3}$ | $[S_2O_3^{2-}]$ / mol dm$^{-3}$ | rate /s$^{-1}$ |
|---|---|---|---|---|
| 1 | 0.10 | 0.10 | 0.06 | 0.0222 |
| 2 | 0.10 | 0.20 | 0.06 | 0.0434 |
| 3 | 0.10 | 0.30 | 0.06 | 0.0665 |
| 4 | 0.20 | 0.15 | 0.05 | 0.0685 |
| 5 | 0.20 | 0.15 | 0.12 | 0.0675 |
| 6 | 0.20 | 0.15 | 0.18 | 0.0672 |

**(i)** Deduce two sets of variables whose values can be plotted to obtain the order of reaction with respect to either $S_2O_8^{2-}$ or $S_2O_3^{2-}$.

plot : .....

against : .....

**(ii)** On the grids provided, plot a graph using the variables in **(i)** and determine the order of reaction with respect to $S_2O_8^{2-}$. Label the axes and the graph.



Order of reaction with respect to $S_2O_8^{2-}$: .....

**(iii)** Plot another line on the axes above to determine the order of reaction with respect to $S_2O_3^{2-}$.

Order of reaction with respect to $S_2O_3^{2-}$: .....

**(iv)** Using a non–graphical method, deduce the order of reaction with respect to $I^-$.

**(v)** Hence or otherwise, write the rate equation and decide if step I could be the rate determining step for the iodine clock reaction.

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[10]

**(b)** In the determination of the mass percentage of ascorbic acid ($C_6H_8O_6$) present in vitamin C tablets, the following reaction involving iodine takes place.

$$C_6H_8O_6 + I_2 \rightarrow C_6H_6O_6 + 2I^- + 2H^+$$

Due to the low solubility of iodine in water, it is generated *in situ* using potassium iodate(V), potassium iodide and sulfuric acid. In this reaction, iodine is the only product.

**(i)** Write a balanced equation for the reaction between $IO_3^-$ and $I^-$ to obtain $I_2$.

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A 3.0 g sample of the tablet is crushed and dissolved in 100.0 $cm^3$ of dilute sulfuric acid. To this solution, 1.08 g of potassium iodate(V) and 4.32 g of potassium iodide is added. A 25.0 $cm^3$ aliquot is withdrawn and 21.60 $cm^3$ of 0.1 mol $dm^{-3}$ thiosulfate is required to titrate with the excess iodine, using starch as an indicator.

**(ii)** Calculate the total amount of iodine produced from reacting potassium iodate(V) with potassium iodide.

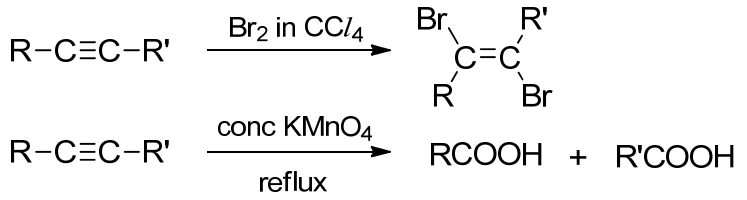
**(iii)** Determine the total amount of *excess* iodine in the 100 $cm^3$ solution.

**(iv)** Hence or otherwise, obtain the mass percentage of ascorbic acid in the sample.

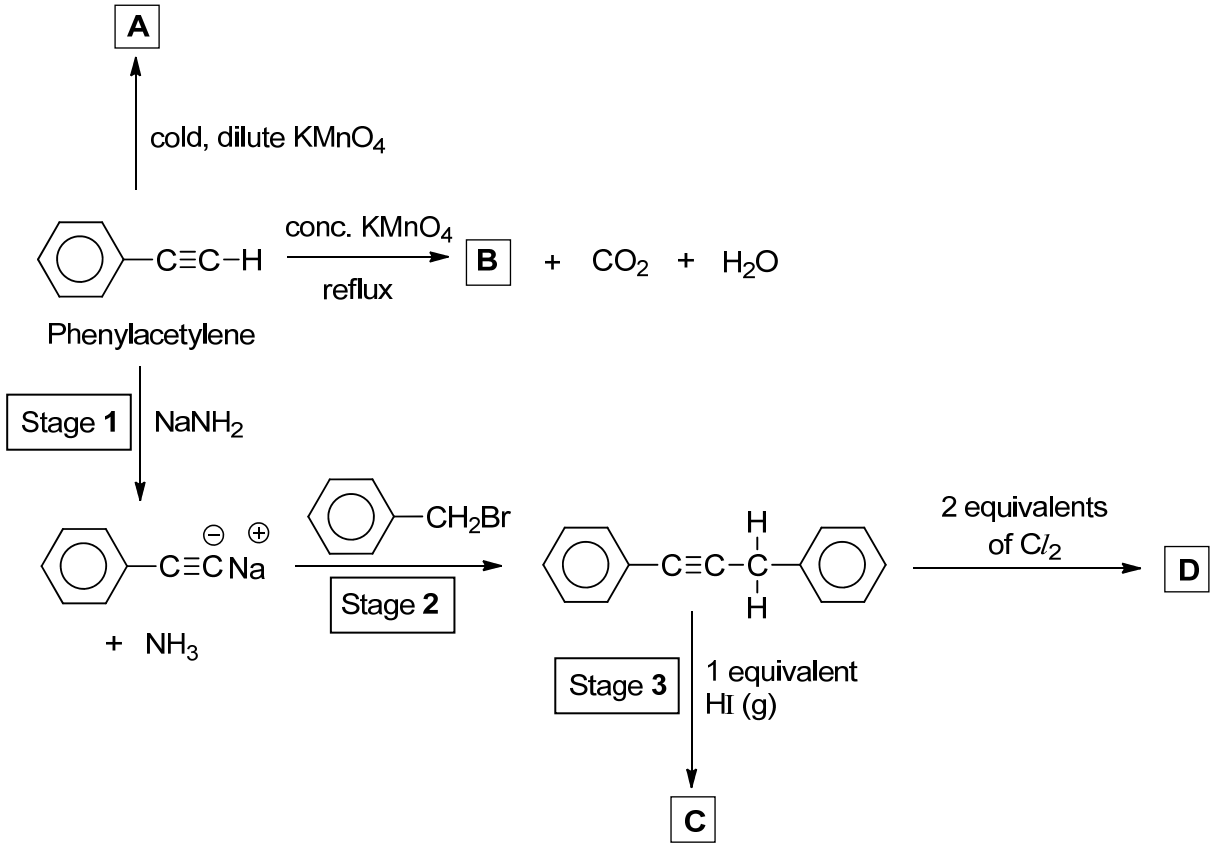
[4]

[Total: 14]

**3** Alkynes are hydrocarbons containing a C≡C triple bond. Reactions involving alkynes resemble that of corresponding alkenes. For example, alkynes react with bromine in tetrachloromethane to give dibromoalkenes. In the mild oxidation of alkynes, the $\pi$ bonds are broken and a dicarbonyl compound is formed, while oxidation with powerful oxidising agents such as potassium manganate(VII) cleaves the C≡C triple bond.




**(a)** The following reaction scheme shows some reactions involving phenylacetylene ($C_6H_5CCH$), an alkyne that is useful in organic synthesis.




**(i)** State the types of reaction for stages **1** and **2**.

stage **1** : .....

stage **2** : .....

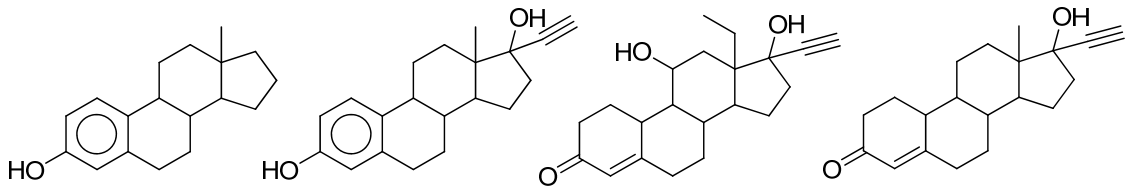
**(ii)** Draw the structures for the organic products **A** to **D** from the reaction scheme.

| | |
|---|---|
| **A** | **B** |
| **C** | **D** |

**(iii)** Name and outline the mechanism for stage **3**, using only equations. Clearly indicate the arrows and the intermediate.

[9]

**(b)** Alkynes are also found in many naturally occurring organic molecules, such as the hormone molecules shown below.




**E** **F** **G** **H**

Complete the following sequence of chemical tests by stating suitable reagents, conditions and observations at each step, to identify the stated hormone molecules.

| step | reagents, conditions and observations | molecule |
|---|---|---|
| 1 | reagent and conditions:<br><br>observation: | **G** |
| 2 | reagent and conditions:<br><br>observation: | **H** |
| 3 | reagent and conditions:<br><br>observation: | **F** |
| 4 | reagent and conditions:<br><br>observation: | **E** |

[6]

[Total: 15]

**4** Group IV elements progress towards metallic behaviour down the group. The table below shows selected data for the dioxides from carbon to germanium.

| compound | formula | melting point/ $^{o}$C | acid–base nature |
|---|---|---|---|
| carbon dioxide | $CO_2$ | –78 | acidic |
| silicon dioxide | $SiO_2$ | 1600 | weakly acidic |
| germanium dioxide | $GeO_2$ | 1200 | |

**(a)** State the valence shell electronic configuration of these elements, and their oxidation state in the above dioxides.

[2]

**(b)** Explain the difference in melting points between carbon dioxide and silicon dioxide, with respect to chemical bonding and structure.

[3]

**(c)** Using the concept of diagonal relationship as well as information from the trend above, suggest the acid–base nature of germanium dioxide by completing the table above.

[1]

**(d)** Tin(II) chloride can react with water according to the following equilibrium.

$$SnCl_2\,(aq) + H_2O\,(l) \rightleftharpoons Sn(OH)Cl\,(s) + HCl\,(aq)$$

Qualitatively explain the effect when sodium carbonate is added into the mixture at equilibrium.

[2]

**(e)** Different lead compounds can be reduced to the elemental form. One example is the reaction between lead(II) oxide and lead(II) sulfide.

$$2PbO\ (s) + PbS\ (s) \rightarrow 3Pb\ (s) + SO_2\ (g) \qquad (\Delta H = +180\ kJ\ mol^{-1})$$

**(i)** State how the entropy of the reaction will most likely change.

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**(ii)** Hence or otherwise, explain why heating is required for the reaction to occur.

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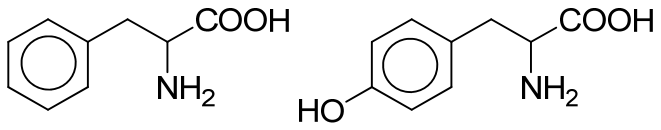
[3]

[Total: 11]

**5** The natural occurring amino acids phenylalanine and tyrosine are important building blocks for many molecules in plants and animals.

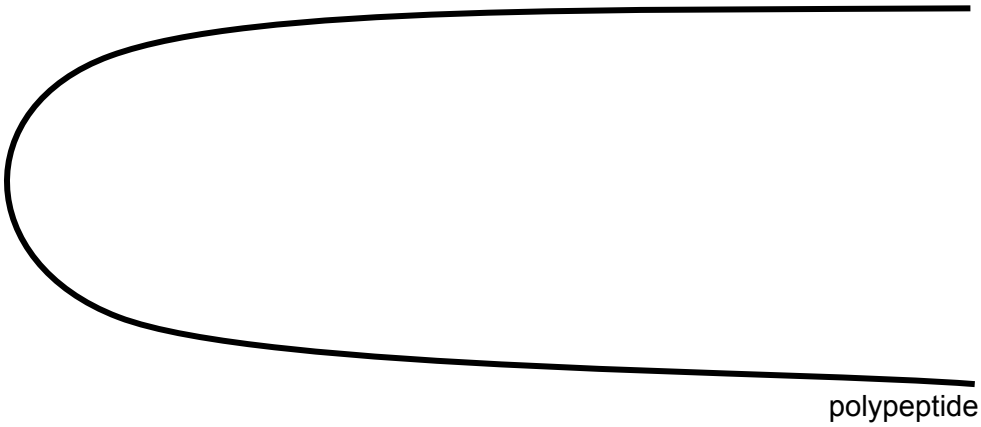



phenylalanine tyrosine

**(a)** Draw and label on the polypeptide below, different side chain interactions for each pair of amino acid residues.

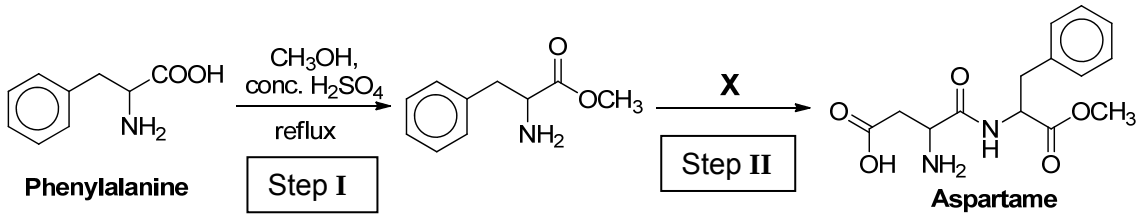
**(i)** two tyrosine residues

**(ii)** a phenylalanine and a tyrosine residue




[3]

**(b)** Phenylalanine, together with aspartic acid and methanol, is also used to make aspartame, an artificial sweetener. The main synthetic steps are shown below.




**Phenylalanine** **Aspartame**

**(i)** Draw a possible structure for **X** used in Step **II**.

**(ii)** Suggest a reason for **not** mixing **X**, phenylalanine and methanol together in a one–step synthesis of aspartame.

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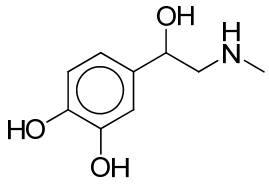
[2]

**(c)** In mammals, tyrosine forms adrenaline, a 'fight or flight' hormone.




adrenaline

**(i)** Draw a pair of enantiomers for adrenaline in the space below.

**(ii)** Tyrosine and adrenaline are separately reacted with aqueous bromine in a cold, dark room. State and explain which molecule would decolourise bromine at a faster rate.

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**(iii)** Tyrosine is soluble in water, while adrenaline is not. Explain this difference in their solubilities.

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[6]

[Total: 11]

**6** Rhodium is a second row transition element with a melting point of 1964 °C.

**(a)** Explain why rhodium has a much higher melting point than strontium, which is also found in the same period.

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[2]

**(b)** Although the rhodium atom has more electrons than the strontium atom, the atomic radius of rhodium is smaller than that of strontium.

Provide an explanation for this.

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[2]

**(c)** Rhodium is often plated onto white gold jewellery to make it look brighter. Jewellers use a "bath solution" containing aqueous rhodium(III) sulfate in the process. Draw a labeled diagram for the electroplating of rhodium, including appropriate labels, polarity and the direction of electron flow.

[3]

**(d)** Some rare metals are extracted from their chlorides using magnesium as the reducing agent. Using the standard electrode potential of rhodium(III) and any other relevant data from the *Data Booklet*, suggest and explain if the same method can be applied to rhodium(III) chloride.

$$Rh^{3+} + 3e \rightleftharpoons Rh \qquad E^{\theta} = +0.76\ V$$

[2]

[Total: 9]