Name:		Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination 2015
Year 6

H1 CHEMISTRY 8872/02

Paper 2 Section A (Structured Questions) **16 September 2015**

Paper 2 Section B (Free–Response Questions) **2 hours**

Additional Materials: Data Booklet, Writing Paper

INSTRUCTIONS TO CANDIDATES

1 Answer **all** questions in Section A, and any **two** questions in Section B.

2 Write your **name** and **class** on this cover page.

Section A

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

4 You are advised to spend a maximum of 1 hour on Section A.

Section B

5 Write your **name** and **class** on the Cover Sheet provided.

6 Write your answers on the separate writing papers provided.

7 Answer any two questions.

8 Start each question on a fresh sheet of paper. ***Marks will be deducted if you fail to do so.***

9 At the end of the examination, fasten all your work securely together with the Cover Sheet on top.

10 You are advised to spend a maximum of 1 hour on Section B.

For Examiner's Use	
Question No.	**Section A Marks**
1	**9**
2	**8**
3	**8**
4	**7**
5	**8**
Total	**40**

INFORMATION FOR CANDIDATES

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

You are advised to show all workings in calculations.

You are reminded of the need for good English and clear presentation in your answers.

Section A

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

1 **(a)** Calcium ethanedioate, CaC_2O_4, is a white needle–like crystalline solid. When a pure sample of anhydrous CaC_2O_4 was heated strongly at 400 °C until no further change in mass is observed, a white solid **B** and 0.028 g of carbon monoxide gas were obtained as the **only** products.

(i) Given that 1 mole of CaC_2O_4 decomposes to give 1 mole of CO(g), write a balanced equation for the thermal decomposition of CaC_2O_4 and identify solid **B**.

equation : ....

solid **B** : ....

(ii) Hence, determine the mass of **B** obtained in the reaction.

[3]

(b) The formula of potassium hydrogen ethanedioate can be written as $K_xH_y(C_2O_4)_z$. In an experiment to determine the values of ***x***, ***y*** and ***z***, 4.50 g of this compound was dissolved in water and the solution made up to 1 dm^3.

20.0 cm^3 of the solution was pipetted into a conical flask and then titrated with 0.0200 mol dm^{-3} $KMnO_4$ in an acidic medium. It was found that 16.50 cm^3 of $KMnO_4$(aq) was needed for the complete reaction with ethanedioate ions, $C_2O_4^{2-}$, present. During the titration, effervescence of carbon dioxide is produced.

Given the reaction of manganate(VII) in acidic medium as:

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

(i) Write a balanced half–equation for the reaction of $C_2O_4^{2-}$ during titration.

half–equation : ....

(ii) Calculate the mass of $C_2O_4^{2-}$ present in 1 dm^3 of the solution.

(iii) Given that 4.50 g of potassium hydrogen ethanedioate contains 0.060 g of hydrogen, calculate the mass of potassium present in the sample.

(iv) Hence, determine the values ***x***, ***y*** and ***z***.

[6]

[Total: 9]

2 The following table lists the standard enthalpy changes of combustion, $\Delta H_c^\ominus$, of some monohydric alcohols.

alcohol	$\Delta H_c^\ominus$ / kJ mol^{-1}
methanol	–715
ethanol	–1367
propan–1–ol	?
butan–1–ol	–2671

(a) Write an equation to represent the standard enthalpy change of combustion of propan–1–ol.

.... [1]

(b) **(i)** The difference in the standard enthalpy change of combustion of methanol and ethanol is –652 kJ mol^{-1}. By considering the structures of the two alcohols, suggest the significance of this difference.

....

....

....

....

(ii) Hence suggest a value of $\Delta H_c^\ominus$ for propan–1–ol.

Suggest a value of $\Delta H_c^\ominus$ for propan–1–ol : ....

(iii) Given that $\Delta H_f^\ominus[H_2O(l)]$ = –286 kJ mol^{-1} and $\Delta H_f^\ominus[CO_2(g)]$ = –394 kJ mol^{-1}, and using your answer to **(b)(ii)**, calculate the standard enthalpy change of formation of propan–1–ol, $\Delta H_f^\ominus[CH_3CH_2CH_2OH(l)]$.

[4]

(c) Ethanol is metabolised in the body by an *enzyme* called alcohol dehydrogenase. Define *enzyme* and describe how alcohol dehydrogenase affects the rate of ethanol metabolism in the body.

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....

....

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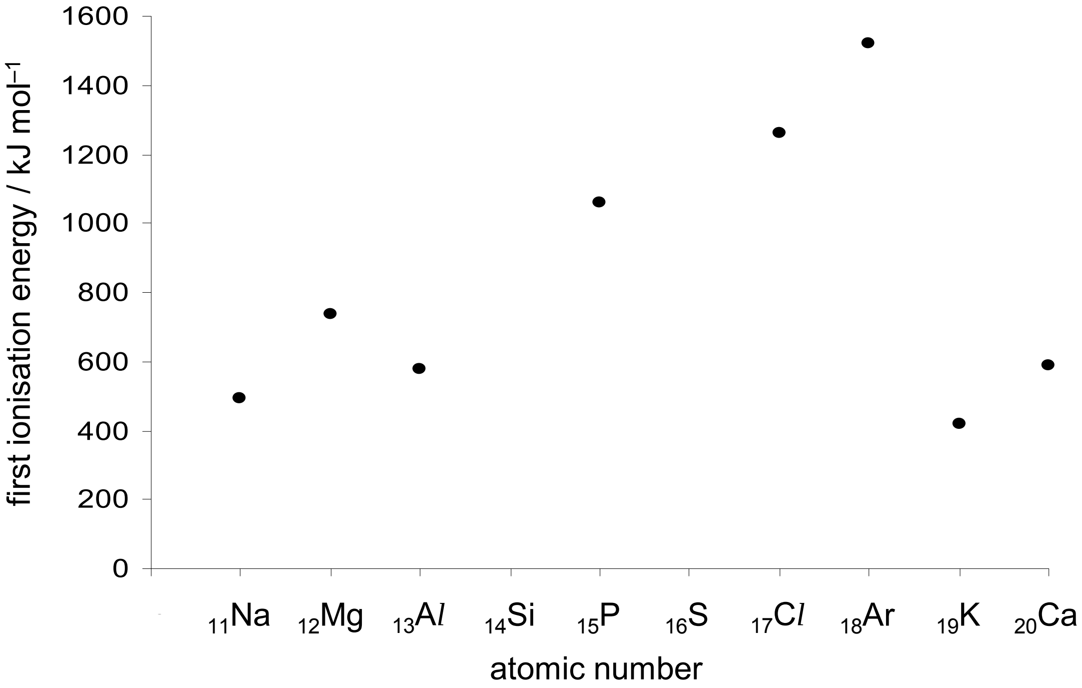
....

....

[3]

[Total: 8]

3 **(a)** Below is the incomplete sketch of the plot of first ionisation energies against atomic (proton) numbers for ten elements.



(i) On the diagram above, use crosses (×) to mark the first ionisation energies of **Si** and **S**.

(ii) Explain why the first ionisation energy of potassium is lower than that of sodium.

....

....

....

....

....

....

(iii) State which of the ten elements is likely to have the lowest second ionisation energy and write an equation to represent the second ionisation energy of this element.

element : ....

equation : ....

[4]

(b) **X**, **Y** and **Z** are elements in Period 3 of the Periodic Table. The oxide of **X** dissolves sparingly in water to give a weakly alkaline solution. The oxide of **Y** does not react with water, but reacts with both acids and bases. **Z** reacts with oxygen to form a covalent oxide with a very high melting point.

(i) Fill in the table below by identifying the elements **X**, **Y** and **Z** and suggest the pH of their chlorides in water.

	identity of element	pH of the chloride in water
X		
Y		
Z		

(ii) Write balanced chemical equations to show how oxide of **Y** reacts with both hydrochloric acid and calcium hydroxide.

....

....

[4]

[Total: 8]

4 Data concerning methanol and two of its analogues are given in the table below.

compound	M_r	atomic radius of **Z** in CH_3**Z**H / nm	dipole moment / D	boiling point / °C	pK_a (pK_a = $-\log_{10}K_a$)
CH_3OH	32.0	0.073	1.7	65	15.5
CH_3SH	48.1	0.102	1.5	6	10.4
CH_3SeH	95.0	0.116	1.3	25	≈ 5

No calculation is required.

(a) Explain the differences in boiling points of the three compounds.

....

....

....

....

....

....

[3]

(b) Arrange the three compounds in order of **decreasing** acidity and suggest a reason for this trend.

....

....

....

[2]

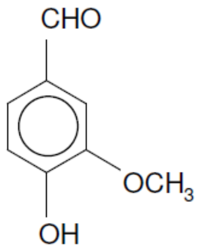
(c) When each of the three compounds has dissolved, each molecule is surrounded by water molecules. Draw simple diagrams to show how a water molecule interacts with a CH_3SH molecule and with a CH_3OH molecule. Label each diagram to show the type of interaction involved.

CH_3SH	CH_3OH

[2]

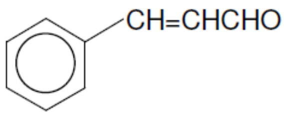
[Total: 7]

5 Three important natural–occurring compounds used as flavourings in the food industry are shown below:



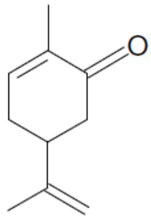
vanillin
(from vanilla bean)

A



cinnamaldehyde
(oil of cinnamon)

B



carvone
(oil of spearmint)

C

(a) Describe two chemical tests which can be used to distinguish the three compounds.

....

....

....

....

....

.... [3]

(b) Give two reasons to explain whether compound **C** can exhibit geometric isomerism.

....

....

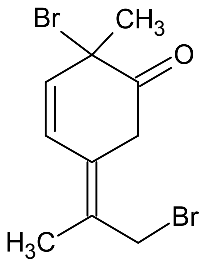
....

....

....

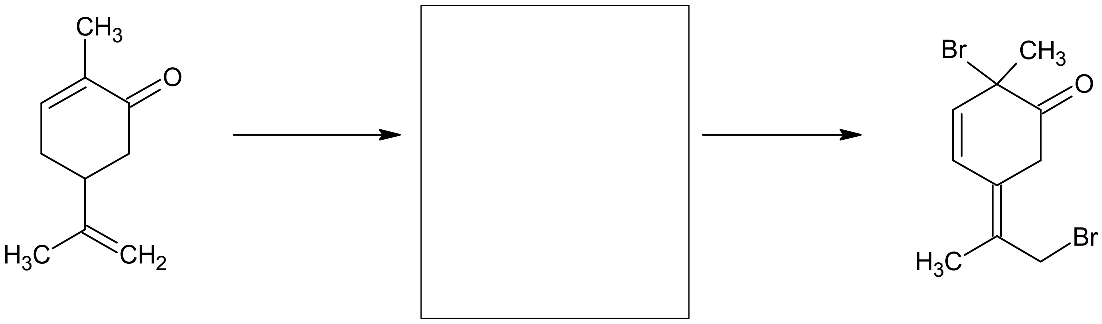
.... [2]

(c) Carvone can be converted to a common precursor **D** in a two–step synthesis for the making of synthetic flavourings.



Compound **D**

State the reagents and conditions for each step and give the structure of the intermediate in the synthesis of **D**.



[3]

[Total: 8]

Section B

Answer any **two** questions from this section on separate answer paper.

1(a) Simple esters are flammable liquids. Flammability is affected by volatility. Methyl ethanoate is an example of one such flammable liquid with a characteristically pleasant smell.

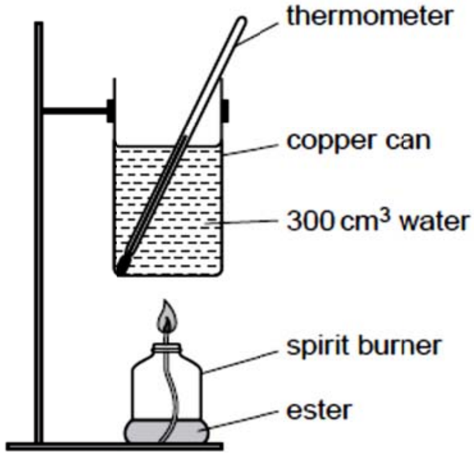
(i) Define the term standard enthalpy change of formation of methyl ethanoate.

(ii) Use the standard enthalpy changes of combustion, $\Delta H_c^\ominus$ of some substances in the table shown below to calculate the standard enthalpy change of formation of methyl ethanoate.

Substance	**$\Delta H_c^\ominus$ (298 K) / kJ mol^{-1}**
carbon	–394
hydrogen	–286
methyl ethanoate	–1592

[3]

(b) A student used the apparatus shown below in an attempt to determine the standard enthalpy change of combustion for ethyl ethanoate.



A preliminary experiment was carried out using methyl ethanoate. The ester was burned in a spirit burner underneath a copper can so that the flame from the burner heated 300 cm^3 of water in the can. It was found that 0.980 g of methyl ethanoate was required to raise the temperature of the water in the can by 10.0 °C.

(i) Using the $\Delta H_c^\ominus$ value in **(a)(ii),** calculate the maximum heat released by mass of methyl ethanoate burned in the preliminary experiment. Hence, calculate the percentage of heat transferred to heat up the water in the can.

In your calculation, ignore the heat capacity of the copper can, and use the figure of 4.18 J g^{-1} K^{-1} for the specific heat capacity of water.

(ii) When the experiment was repeated with ethyl ethanoate, the following results were obtained.

Mass of ethyl ethanoate burned = 0.948 g
Increase in temperature of 300 cm^3 water = 11.5 °C

Using your answer in **(b)(i)** calculate the apparent (theorectical) $\Delta H_c^{\ominus}$ of ethyl ethanoate.

[5]

(c) Methyl ethanoate can be prepared using methanol, CH_3OH and ethanoic acid in the laboratory.

(i) Write an equation for the formation of methyl ethanoate using methanol and ethanoic acid. State the conditions required.

Methanol can be converted into ethanoic acid in a three–step synthesis as shown.

$$CH_3OH \xrightarrow{\text{Step 1}} \mathbf{P} \xrightarrow{\text{Step 2}} \mathbf{Q} \xrightarrow{\text{Step 3}} \text{ethanoic acid}$$

(ii) Suggest reagents and conditions for Steps 1, 2 and 3. State the intermediate compounds **P** and **Q** formed during the synthesis.

(iii) State the oxidation number of carbon in methanol, CH_3OH.

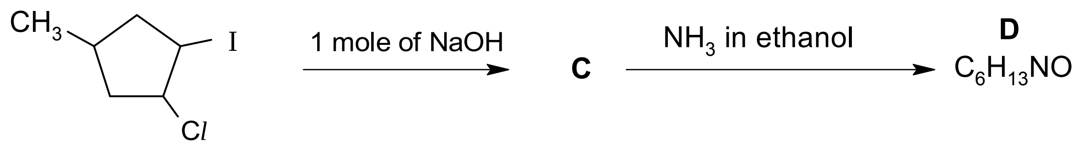
(iv) Using **only** the elements C, H and O, draw the structural formulae of two compounds, **A** and **B**, each containing a single carbon atom with an oxidation number of 0 and +2 respectively.

(v) Suggest reagents and conditions for converting methanol into each of the three compounds **A** and **B.**

[10]

(d) Successive reactions of dihalgeno compounds are shown below. The following transformations show the different reactivities of the organic dihalogeno compound.

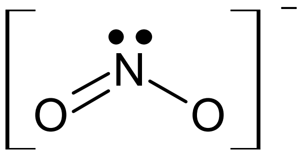
Suggest the structures of compounds **C** and **D**.



[2]
[Total: 20]

2(a) **(i)** Draw a dot–and–cross diagram to show the bonding in the molecule of NO_2.

(ii) The following diagram shows the shape of the NO_2^- ion.



Suggest a value for the O–N–O bond angle in the NO_2^- ion and explain your answer.

Hence, suggest a value for the O–N–O bond angle in the NO_2 molecule, giving reasons for your choice.

[5]

(b) At room temperature, gaseous nitrogen dioxide and dinitrogen tetraoxide are in dynamic equilibrium according to the following equation:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = +58 \text{ kJ mol}^{-1}$$

(i) State *Le Chatelier's Principle*.

(ii) Use the Le Chatelier's Principle to deduce qualitatively the effect of increasing

I pressure **II** temperature

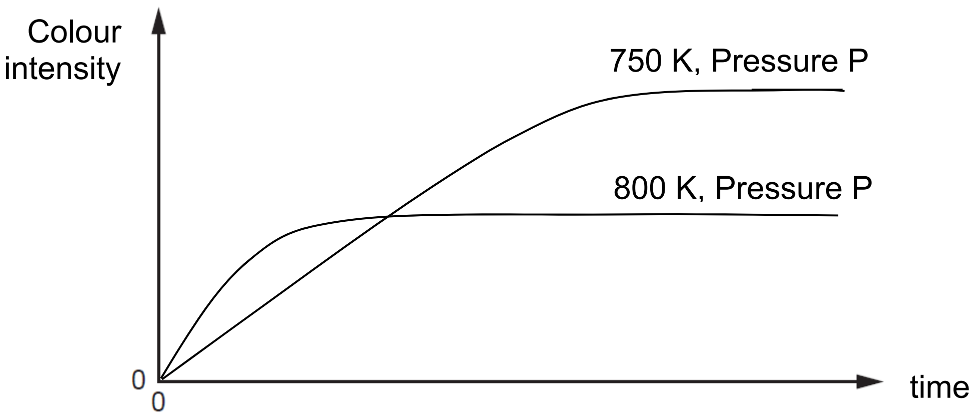
on the average molecular mass of a mixture of N_2O_4 and NO_2.

[5]

(c) Equimolar mixtures of NO and O_2 are allowed to react at two different temperatures. The equation for the reaction is

$$2NO\ (g) + O_2\ (g) \rightleftharpoons 2\ NO_2\ (g)$$

The colour intensity of the reaction mixture is monitored over a period of time. The graphs below show the variation of the colour intensity with time and at different temperatures.



(i) State the significance of the colour intensity in this reaction.

(ii) Using collision theory, explain the difference in the initial slopes of the two graphs.

(iii) What conclusion can be made about each mixture when the colour intensity reaches a constant value?

(iv) Based on the information given, state whether the formation of NO_2 is endothermic or exothermic.

(v) The kinetics of the reaction between NO and O_2 is investigated and the following results obtained.

Experiment No.	*Partial pressure,* P_{NO} / N m^{-2}	*Partial pressure,* P_{O2} / N m^{-2}	initial rate/ N m^{-2} s^{-1}
1	0.40	0.60	2.00
2	0.40	0.50	1.67
3	0.50	0.80	4.17

Deduce the order of reaction with respect to NO and O_2. Hence, write a rate equation for the forward reaction.

(vi) Hence, calculate the rate constant and state its units.

(vii) Considering your answers in **(v)**, sketch a graph expected for the reaction at a higher pressure, P_1, and at 750 K. Label your graph.

[10]
[Total: 20]

3(a) Under controlled conditions, alkanes can undergo 'cracking' and reforming to produce alkenes which are more useful.
In the following reactions, alkenes **A** and **B** were obtained as shown:

I $CH_3CH_2CH(CH_2CH_3)C(CH_3)_3 \rightarrow \underset{\mathbf{A}}{C_5H_{10}} + (CH_3)_3CH$

II $CH_3(CH_2)_3CH(CH_2CH_3)CH_3 \rightarrow \underset{\mathbf{B}}{C_6H_{10}} + H_2 + CH_3CH_3$

(i) Based on Reaction **I** and **II**, what do you understand by the term 'cracking'?

(ii) State an industrial use for forming alkenes **A** and **B**.

(iii) When one mole of alkene **B** reacts with hot acidified $KMnO_4$, two moles of carbon dioxide and one mole of 2–methylpropanedioic acid were formed. Explain this reaction and hence draw the structure of **B**.

(v) State and explain the type of stereoisomerism that exists in **A**.
Draw and label the stereoisomers of **A**.

[7]

(b) **(i)** A student wanted to identify an unknown Group I metal, **R**, using a sample of the Group I carbonate, $\mathbf{R}_2CO_3$. She heated a 3.00 g sample of $\mathbf{R}_2CO_3$ in a boiling tube and the decomposition reaction was as shown:

$$\mathbf{R}_2CO_3(s) \rightarrow \mathbf{R}_2O(s) + CO_2(g)$$

The gas evolved was bubbled into a solution of calcium hydroxide. A white precipitate formed was found to have a mass of 2.17 g. Calculate the relative molecular mass of $\mathbf{R}_2CO_3$ and hence identify **R**.

(ii) $\mathbf{R}_2O$ formed in **(b)(i)** can be dissolved in water to form a strong alkali, **R**OH. A buffer solution was formed when **R**OH was added to excess propanoic acid. Explain, with the aid of equations, explain how this buffer solution resists pH change when a small amount of acid or base was added.

(iii) The pH of propanoic acid solution is 2.5. 27.0 cm^3 of 0.2 mol dm^{-3} potassium hydroxide was required to fully neutralise 25.0 cm^3 of propanoic acid solution.
Write an expression for the acid dissociation constant, K_a, of propanoic acid and hence calculate a value for K_a of propanoic acid.

[8]

(c) **(i)** Explain fully which compound, propanoic acid or 2–hydroxypropanoic acid, has a lower pK_a value.

(ii) Suggest a simple chemical test to distinguish between propanoic acid and 2–hydroxypropanoic acid. Your answers should include the reagents and conditions, observations and balanced equation(s).

[5]
[Total: 20]

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