H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

CANDIDATE NAME

CLASS

TUTOR'S NAME

CHEMISTRY

8873/02

Paper 2

11 September 2018

2 hours

Candidates answer on the Question Paper

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section **A**
Answer **all** the questions.

Section **B**
Answer **one** question.

The use of an approved scientific calculator is expected, where appropriate.
A Data Booklet is provided.

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	
A1	/ 8
A2	/ 12
A3	/ 8
A4	/ 10
A5	/ 22
B	/ 20
Total	**/ 80**

This document consists of **25** printed pages and **1** blank page.

Section A

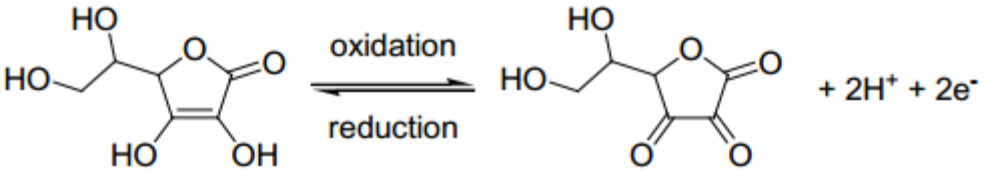
Answer **all** questions in this section in the spaces provided.

For examiner's use only

1 A sample of supplement, Appelin B12 syrup, is analysed for the concentrations of benzoic acid and Vitamin C (also known as ascorbic acid). 100 cm^3 of the Appelin B12 syrup is dissolved in water and made up to 250 cm^3.

Reaction 1: A 25.0 cm^3 aliquot requires 35.65 cm^3 of 0.018 mol dm^{-3} of sodium hydroxide for complete neutralisation.

Vitamin C (ascorbic acid) is also a mild reducing agent with the following oxidation equation.



ascorbic acid dehydroascorbic acid

Reaction 2: Another 25.0 cm^3 aliquot requires 33.40 cm^3 of 0.017 mol dm^{-3} iodine solution for complete redox reaction.

(a) Calculate the total amount of acid present in 100 cm^3 of the Appelin B12 syrup. Assume that ascorbic acid is a monoprotic acid.

[2]

(b) State the reacting mole ratio of ascorbic acid and iodine.

.....[1]

(c) Calculate the amount of ascorbic acid present in 100 cm^3 of Appelin B12 syrup.

[1]

For examiner's use only

(d) Suggest suitable indicators for both **reactions 1** and **2**.

Reaction 1: .....

Reaction 2: .....[1]

(e) Calculate the respective masses of benzoic acid and ascorbic acid in 100 cm^3 of Appelin B12 syrup.
(M_r of benzoic acid = 122.0; M_r of ascorbic acid = 176.0)

[2]

(f) Given that daily required amount of ascorbic acid for children is 50 mg, calculate the dosage (in cm^3) of Appelin B12 syrup a child should consume.

[1]

[Total: 8]

For examiner's use only

2(a) Nitrogen trichloride is a liquid found in tear gas and is a lachrymator agent which can be used as a chemical weapon that causes severe eye and respiratory pain. Nitrogen trichloride reacts with steam to form ammonia and hypochlorous acid according to the following equation.

$$NCl_3 + 3H_2O \rightarrow NH_3 + 3HOCl$$

(i) Draw 3-dimensional sketches of NCl_3 and HOCl and state the shape and bond angle of each molecule.

Compound	3-D sketch	Shape	Bond Angle
NCl_3			
HOCl			

[5]

(ii) With the aid of a diagram, explain the solubility of ammonia in water.

.....

.....

.....[2]

For examiner's use only

(b) Write an equation representing the second ionisation energy of chlorine. Hence, explain the difference in the second ionisation energies between chlorine and sulfur.

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.....

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.....[2]

(c) Sodium, aluminium and phosphorus burn in oxygen to form sodium oxide, Na_2O, aluminium oxide, Al_2O_3, and phosphorus pentoxide, P_4O_{10}, respectively.
Write equations for any reactions that these oxides would have with hydrochloric acid and with sodium hydroxide. Identify any of these oxides that show no reaction by indicating *no reaction*.

Oxide	Reaction with hydrochloric acid	Reaction with sodium hydroxide
Na_2O		
Al_2O_3		
P_4O_{10}		

[3]

[Total: 12]

For examiner's use only

3 Water, H_2O, covers about two-third of the Earth's surface and is vital to life.

(a) About 0.005% of water molecules consist of an oxygen atom bonded to two atoms of the hydrogen *isotope*, deuterium, $^{2}_{1}D$. The compound formed is deuterium oxide, D_2O and is also known as 'heavy water'.

(i) What do you understand by the term *isotope?*

.....

.....[1]

(ii) State the number of subatomic particles present in one molecule of D_2O.

Number of protons	
Number of neutrons	
Number of electrons	

[1]

(b) When pure H_2O and pure D_2O are mixed, an exchange of H and D atoms takes place and the following equilibrium is established.

$$D_2O(l) + H_2O(l) \rightleftharpoons 2HDO(l) \qquad K_c = 3.56 \text{ at } 298 \text{ K}$$

When 30 g of D_2O and 27 g of H_2O are mixed, how many moles of HDO will be present at equilibrium at 298 K?

[3]

For examiner's use only

(c) In pure water, a very small fraction of water molecules donate protons to other water molecules to form hydronium ions and hydroxide ions.

$$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

This type of reaction is known as the auto-ionisation of water and the equilibrium constant for the reaction is K_w. The extent of auto-ionisation and hence, the value of K_w is dependent on temperature.

(i) Given pH of water at 30 ^oC is 6.92, calculate the value of K_w at 30 ^oC.

[1]

(ii) By comparing your answer in **(i)** with the value of K_w at 25 ^oC, suggest how the enthalpy changes during the auto-ionisation of water. Explain your reasoning clearly.

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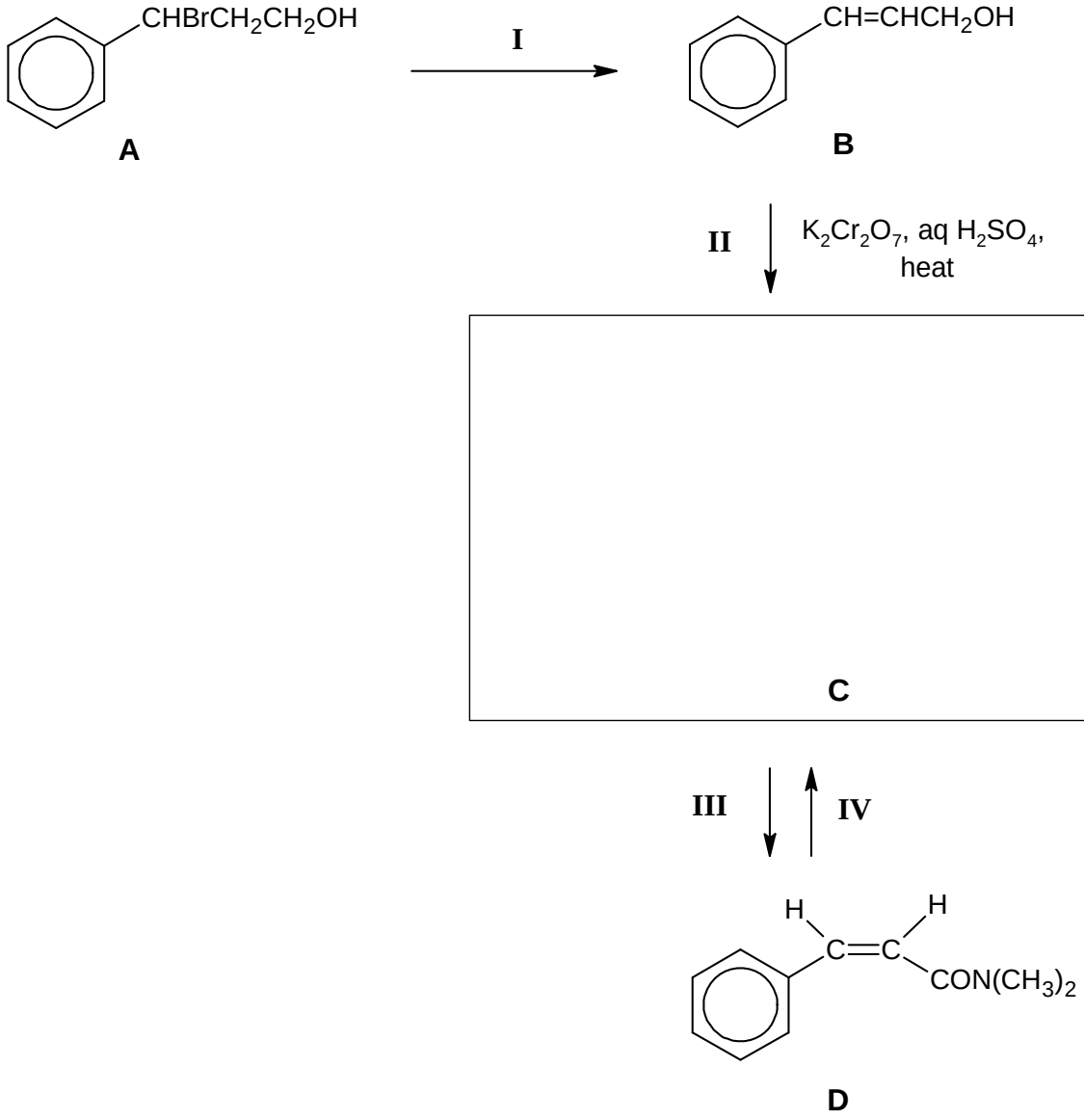
.....

.....[2]

[Total: 8]

For examiner's use only

4 Study the following reaction scheme involving compound **A** and answer the questions below.



(a) State the type of reaction for steps **I** to **IV**.

I: .....

II: .....

III: .....

IV: .....

[2]

(b) Draw the structure of **C** in the box provided above. [1]

For examiner's use only

(c) Suggest suitable reagents and conditions for steps **I**, **III** and **IV**.

I: .....

III: .....

IV: .....

[3]

(d) Write a balanced equation for step **IV**.

[1]

Compound **D** exhibits *cis-trans isomerism*.

(e) Define the term *cis-trans isomerism*.

.....

.....[2]

(f) Draw the displayed formula of the other isomer of **D**.

[1]

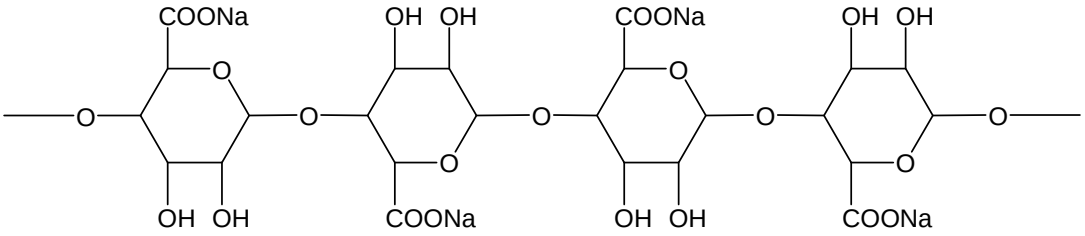
[Total: 10]

For examiner's use only

5 Molecular gastronomy is the modernist style of cuisine that combines science and cooking. Its techniques are currently being applied in the kitchens of many well-known restaurants worldwide.

One such technique is called *spherification* which involves a simple gelling reaction between sodium alginate and calcium ions to create flavoured caviar which are small spheres of flavour that burst in the mouth when they are consumed.

Sodium alginate is the sodium salt of alginic acid, a polysaccharide used by brown algae to support its cell walls. It is extracted from seaweed and used widely in industries like food and medicine.



structure of sodium alginate polymer

(a)(i) What types of bonding exist in sodium alginate?

.....[1]

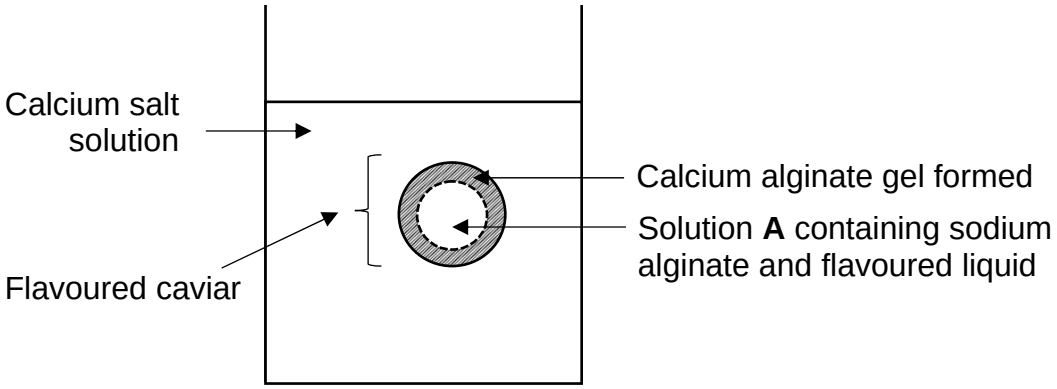
(ii) The structure of sodium alginate is rigid whereby all single C-O-C bonds are unable to rotate. Draw the structure of a repeat unit of sodium alginate.

[1]

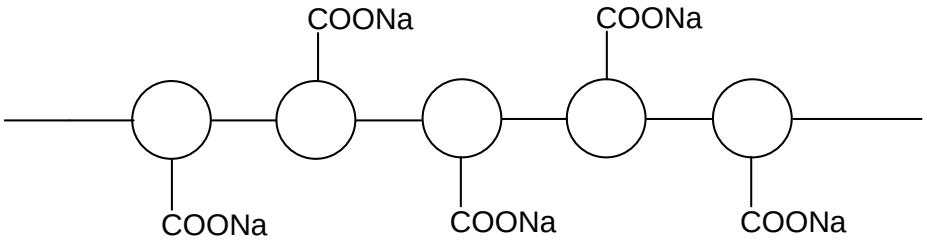
For examiner's use only

(b) The steps for spherification involving sodium alginate and calcium ions are as follows:

1. Flavoured water and sodium alginate powder are mixed and stirred to form solution **A** which is a homogeneous solution.
2. A syringe is used to add solution **A** dropwise to a calcium salt solution.
3. The calcium ions diffuse into solution **A** and the long-chain alginate polymers become cross-linked with Ca^{2+} ions, forming a gel-like substance.
4. The flavoured caviar can then be separated from the solution.



(i) A simplified diagram representing sodium alginate polymer is shown below.



Explain, in terms of bonding, how the cross-linked calcium alginate polymer is formed with the aid of a labelled diagram.

.....

.....[3]

For examiner's use only

(ii) Explain why calcium alginate is insoluble in water.

.....

.....

.....

.....[2]

Not all flavoured drinks or liquids can be used for flavoured caviar. The pH of the flavoured liquid needs to be greater than 3.6 as the sodium alginate will react and the resultant solution will thicken and coagulate. The flavoured drink should also be of a lower calcium content for spherification to be successful.

Many chefs have used the spherification technique to encapsulate certain flavourful liquids in their dishes. Some examples of liquids and their nutritional information are given below.

Flavoured liquid	Calcium content in 100 g of liquid / mg	pH
Lime juice	33	1.8
Grape juice	11	2.7
Apple juice	8	3.5
Carrot puree	20	4.8
Mango puree	4	5.0
Milkfish extract	55	5.4
Cow's Milk	125	6.8
Red cabbage juice	45	7.0
Sardine extract	382	7.3

(c) Based on the above information, suggest and explain why some of the following liquids will not be suitable for this method of spherification.

(i) Lime juice

.....

.....

.....[1]

(ii) Sardine extract

.....

.....

.....[1]

For examiner's use only

(d) Suggest and explain which of the liquids in the table on page **12** will most likely result in successful spherification of its flavoured caviar.

.....

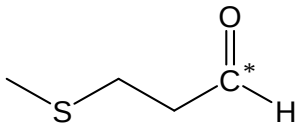
.....

.....[2]

(e) A chef wanted to serve a sphere of milkfish with lime. She mixed 50 g of milkfish extract and 10 g of lime juice. Calculate the pH of the resultant solution and deduce if the acidity of the solution is suitable for spherification.
[Assume densities of all solutions are 1 g cm^{-3}.]

[3]

(f) Only about one fifth of flavour perception comes from the tongue's taste buds; most of the flavours come from smell. When humans chew food, volatile molecules are sent to the nose where they are met by hundreds of different odour receptors.
One example of such a compound is methional. It is a volatile colourless liquid with a strong smell of cooked potatoes with bacon notes.



Methional

(i) Using VSEPR theory, explain why the shape about the sulfur and the carbon atom marked with an asterisk (*) is different.

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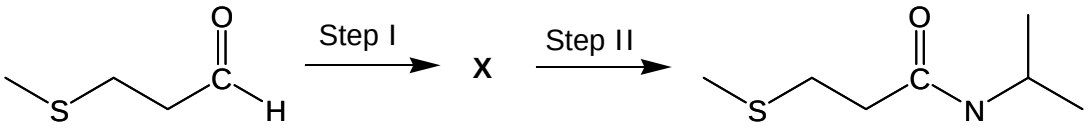
.....

.....

.....[3]

For examiner's use only

(ii) Methional can undergo a two-step reaction to form **Y**.



Methional **Y**

Suggest the type of reaction and the reagents and conditions for each step. Hence, draw the structure of **X**.

	Step I	Step II
Type of reaction		
Reagents and conditions		

Structure of **X**:

[5]

[Total: 22]

Section B

Answer **one** question from this section, in the spaces provided.

For examiner's use only

6(a) Oxides of nitrogen such as NO_2 are air pollutants that are present in the exhaust gases of internal combustion engines. Modern cars are equipped with a catalytic converter that reduces emissions of these harmful compounds. The catalytic converter uses nanoparticles of platinum, palladium and rhodium which act as heterogeneous catalyst.

(i) Write an equation for the reaction involving NO_2 which occurs in the catalytic converter.

.....[1]

(ii) Explain why platinum can be described as a *heterogeneous* catalyst.

.....

.....[1]

(iii) Outline the mode of action of the catalyst used.

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.....[3]

For examiner's use only

(iv) Explain the term *nanoparticles*.

.....

.....[1]

(v) Explain the significance of using nanoparticles in the catalytic process.

.....

.....

.....

.....

.....[2]

(vi) Predict how nanoparticles of platinum could present a risk to the environment.

.....

.....

.....[1]

For examiner's use only

(b) Nitrogen dioxide, NO_2, is a brown gas while nitrogen tetroxide, N_2O_4, is a colourless gas. The following equilibrium between these two gases was set up.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H < 0$$

Describe, and explain, what you would see after the following changes have been made and the system is allowed to reach equilibrium again.

(i) The temperature is decreased.

.....

.....

.....

.....

.....[2]

(ii) The pressure is decreased.

.....

.....

.....

.....

.....[2]

For examiner's use only

(c) Nitrogen tetroxide is a strong oxidising agent. It is liquefied and used as a propellant in combination with a hydrazine-based rocket fuel.

$$2N_2H_4(l) + N_2O_4(l) \rightarrow 3N_2(g) + 4H_2O(l)$$

(i) Suggest a way to liquefy nitrogen tetroxide gas and explain your answer.

.....

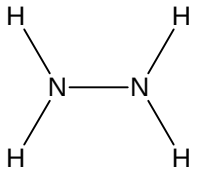
.....

.....

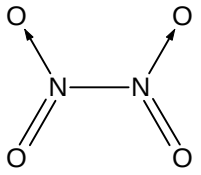
.....[2]

Some average bond enthalpies are given below.

bond	bond enthalpy / kJ mol^{-1}
N–O	201
N=O	607



hydrazine



dinitrogen tetroxide

(ii) Use the data in the table above, and relevant data from the *Data Booklet* to calculate the enthalpy change of the reaction of hydrazine with dinitrogen tetroxide.

[2]

(iii) The theoretical standard enthalpy change of reaction is found to be –1258 kJ mol^{-1}. Suggest another reason other than the bond energies used are average values for the difference between your calculated value in **(ii)** and the theoretical value.

.....

.....

.....[1]

For examiner's use only

(d) Hydrazine is also a strong reducing agent. Warming hydrazine with nitric acid results in the production of gaseous nitrogen, N_2, and nitrogen monoxide, NO.

(i) Write a half-equation for the reduction of the nitrate ion, NO_3^- to nitrogen monoxide in acidic solution.

.....[1]

(ii) Draw a 'dot-and-cross' diagram of nitrate ion, NO_3^-.

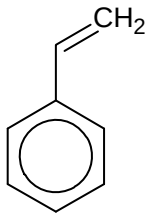
[1]

[Total: 20]

For examiner's use only

7 Polystyrene (PS) plastic is a naturally transparent thermoplastic that is available as both a typical solid plastic as well in the form of a rigid foam material. Polystyrene plastic is commonly used in a variety of consumer product applications and is also particularly useful for commercial packaging. Dow Chemical Company invented a proprietary process to make their trademarked and well-known polystyrene foam product "styrofoam" in 1941.

(a) The monomer of polystyrene is phenylethene or styrene, as shown below:



(i) Draw the structure of polystyrene. Identify the type of reaction to synthesise polystyrene.

.....[2]

(ii) State one difference in physical property between polystyrene and poly(diallyl phthalate), which has cross-links between the polymer chains.

.....

.....

.....[1]

(iii) Suggest one advantage in the use of polystyrene as compared to poly(diallyl phthalate).

.....

.....

.....[1]

For examiner's use only

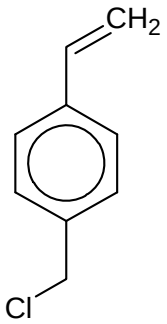
(iv) State one negative impact from the use of non-recyclable plastics.

.....

.....

.....[1]

(b) To produce plastics of different hardness and textures, the styrene monomer can be converted to other types of monomers such as the one shown below.



This compound (C_9H_9Cl) reacts with excess alcoholic ammonia, heated in a sealed tube according to the following general equation:

$$C_9H_9Cl + 2NH_3 \rightarrow C_9H_9NH_2 + NH_4Cl$$

Three sets of experiments were performed separately to determine the rate of reaction. Initial concentrations of the two reagents were varied for each experiment and the results are shown below.

Experiment	$[C_9H_9Cl]$/ mol dm^{-3}	$[NH_3]$/ mol dm^{-3}	Initial Rate $\times 10^{-3}$/ mol dm^{-3} s^{-1}
1	0.03	0.1	4.9
2	0.02	0.1	3.2
3	0.01	0.4	6.3

(i) Using the data above, determine the order of reaction with respect to C_9H_9Cl and NH_3.

[2]

For examiner's use only

(ii) Hence, state the rate equation.

.....[1]

(iii) Using the values from experiment 3, determine the rate constant and state its units.

rate constant, k = …… units …….. [2]

For examiner's use only

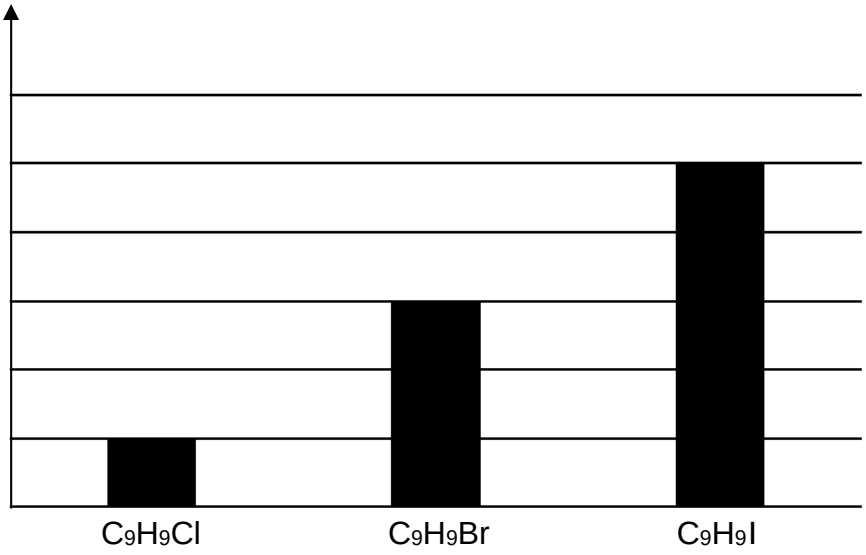
(c) Under suitable conditions, halogenoalkanes can be hydrolysed.

Equimolar samples of C_9H_9Cl, C_9H_9Br and C_9H_9I are added to separate test-tubes of ethanolic silver nitrate and warmed in a water bath at 60 ^oC for 10 minutes.

The relative amount of the respective precipitates formed are calculated.

The results are as follows:

Amount of precipitate obtained



(i) State the colour of the precipitate obtained from the reaction with C_9H_9Br.

.....[1]

(ii) With the aid of the *Data Booklet*, suggest an explanation for the trend of the amount of precipitates obtained.

.....

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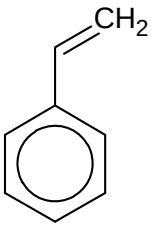
.....[2]

For examiner's use only

(d) Styrene, is a good starting material for synthesis reactions.



Styrene

When styrene is added to excess cold concentrated H_2SO_4, followed by water and heat, isomeric alcohols **A** and **B** are formed. One of the isomers is a primary alcohol. When isomers **A** and **B** undergo oxidation separately, **C,** a ketone, and **D**, phenylethanoic acid are produced respectively.

Styrene can also react with hydrogen in the presence of platinum catalyst at room temperature to form **E**.

(i) Explain which isomer, **A** or **B,** is the primary alcohol.

.....

.....

.....[2]

(ii) Hence, draw the structure of the primary alcohol isomer.

[1]

(iii) Draw the structure of **E**.

[1]

(iv) **B** and **D** react to form **F.** State the type of functional group present in **F**.

.....[1]

For examiner's use only

(v) Suggest a simple chemical test to differentiate styrene from **C**, with the corresponding observations.

.....

.....

.....[2]

[Total: 20]

For examiner's use only

2018 H1 Chemistry Prelim Paper 2 Answers

1 **(a)** Amount of NaOH = 35.65/1000 x 0.018 = $\underline{6.42 \times 10^{-4} \text{ mol}}$ [1]

Amount of acid in 250 cm^3 = 0.00700 x 250/25 = $\underline{6.42 \times 10^{-3} \text{ mol}}$ [1]

(b) 1 mol of ascorbic acid reacts with 1 mol of iodine [1]

(c) Amount of ascorbic acid in 100 ml syrup
= [(33.40/1000) x 0.017] x (250/25)
= 0.005678
= $\underline{5.68 \times 10^{-3} \text{ mol}}$ [1] ecf if b(i) wrong

(d) Reaction 1 (Neutralisation) – Screened methyl orange/ methyl orange/ thymol blue
(Reaction 2) Redox reaction – Starch [1]

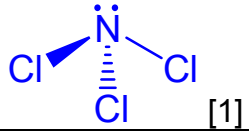
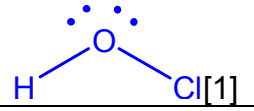
(e) Amount of benzoic acid = 0.006417 – 0.005678 = 7.39×10^{-4} mol

Mass of benzoic acid = 7.39×10^{-4} x 122.0 = $\underline{0.0902 \text{ g}}$ [1]
Mass of ascorbic acid = 0.00568 x 176.0 = $\underline{1.00 \text{ g}}$ [1] ecf in **(b)(ii)** wrong

(f) Since 1g (= 1000 mg) of ascorbic acid is found in 100 cm^3 of Appelin Syrup,

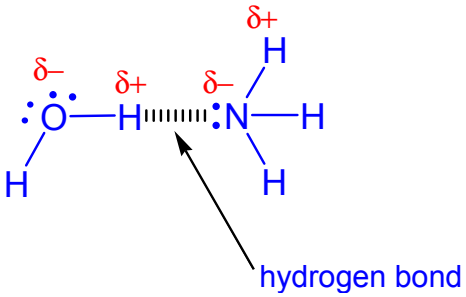
Dosage of Appelin B12 Syrup = (50/1000) x 100
= 5 cm^3 [1]

2 **(a)** **(i)**

Compound	3D sketch	Shape	Bond Angle
NCl_3	 [1]	Trigonal pyramidal [1]	107°
HOCl	 [1]	Bent [1]	105°

[1] for correct bond angles for both molecules

(ii) The energy released in forming strong hydrogen bonds between ammonia and water molecules is sufficient to overcome the hydrogen bonds between water molecules and the hydrogen bonds between ammonia molecules. [1]



[1] – lone pairs, hydrogen bond, partial charges, label

(b) $Cl^+(g) \rightarrow Cl^{2+}(g) + e$ [1]

Cl^+: $[Ne]3s^2\ 3p_x^2\ 3p_y^1\ 3p_z^1$
S^+: $[Ne]3s^2\ 3p_x^1\ 3p_y^1\ 3p_z^1$
Less energy is required to remove the paired $3p_x$ electron in Cl^+ as it experiences inter-electron repulsion. [1]

(c)

Oxide	Reaction with hydrochloric acid	Reaction with sodium hydroxide
Na_2O	$Na_2O(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l)$	No reaction
Al_2O_3	$Al_2O_3(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2O(l)$	$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \rightarrow 2NaAl(OH)_4(aq)$
P_4O_{10}	No reaction	$P_4O_{10}(s) + 12NaOH(aq) \rightarrow 4Na_3PO_4(aq) + 6H_2O(l)$

[1] for each row

3 **(a)** **(i)** Isotopes are atoms of the same element which have the same atomic number/number of protons but different nucleon number/number of neutrons. [1]

(ii) Number of protons : 10
Number of neutrons: 10
Number of electrons: 10 [1]

(b)

	D_2O	H_2O	HDO
Initial amt/ mol	30 / 20.0 = 1.5	27 / 18.0 = 1.5	0
Change/ mol	-x	-x	+2x
Eqm amt/ mol	1.5 – x	1.5 – x	2x

[1] for initial amounts

Let volume of mixture be V dm^3.

$$\frac{(\frac{2x}{V})^2}{(\frac{1.5-x}{V})^2} = 3.56$$

$\frac{2x}{1.5-x} = 1.886$ [1] for correct substitution. Mark for V?

$x = 0.7279$

n(HDO) = $2x = 1.46$ mol [1]

*Note if students got M_r of D_2O wrong. They will not be able to solve the wrong quadratic equation (only max 1 out of 3 marks).

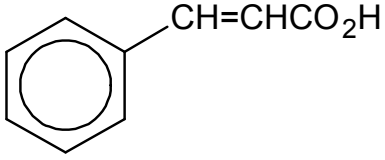
(c) **(i)** $[H^+] = 10^{-6.92} = 1.202 \times 10^{-7}$ mol dm^{-3}
Since water is neutral, $[OH^-] = [H^+] = 1.202 \times 10^{-7}$ mol dm^{-3}
$K_w = [H^+][OH^-] = (1.202 \times 10^{-7})^2 = 1.45 \times 10^{-14}$ mol^2 dm^{-6} [1] for value

(ii) Value of K_w at 25 ^oC is 1.0×10^{-14}

At higher temperature of 30 ^oC, K_w increases. Positon of equilbrium has shifted to the right and the forward endothermic reaction is favoured. [1]

Hence the forward reaction (auto-ionisation of water) is endothermic. **Enthalpy increases** (more positive/ more endothermic) during reaction. [1]

4 **(a)** **I**: Elimination
II: Oxidation
III: Condensation
IV: Acidic hydrolysis

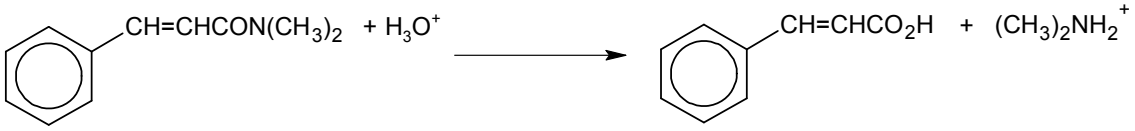
(b) 

(c) **I**: Ethanolic NaOH, heat under reflux – ***heat under reflux is a must to be written for this R&C.***

III: $(CH_3)_2NH$ or dimethylamine
N,N' Dicyclohexylcarbodiimide with 5% DMAP catalyst
Many have missed out the amine reagent or included heat under reflux (which was unnecessary).

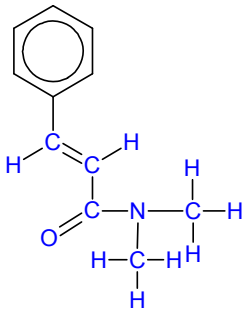
IV: Dilute H_2SO_4, heat (under reflux) – ***aq or dilute acid should be mentioned but students often missed out.***

(d) Equation for step **IV**:



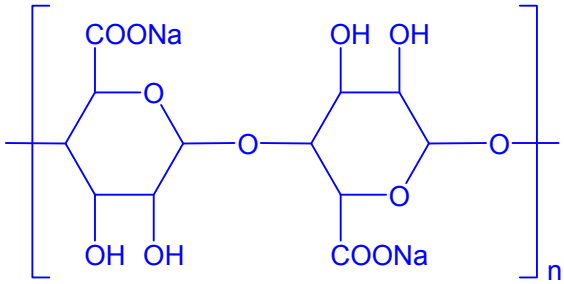
(e) Cis-trans isomerism occurs when there is restricted rotation about a C=C π bond in an aliphatic alkene [1] and when there are two different groups on each carbon of the double bond. [1]

(f)



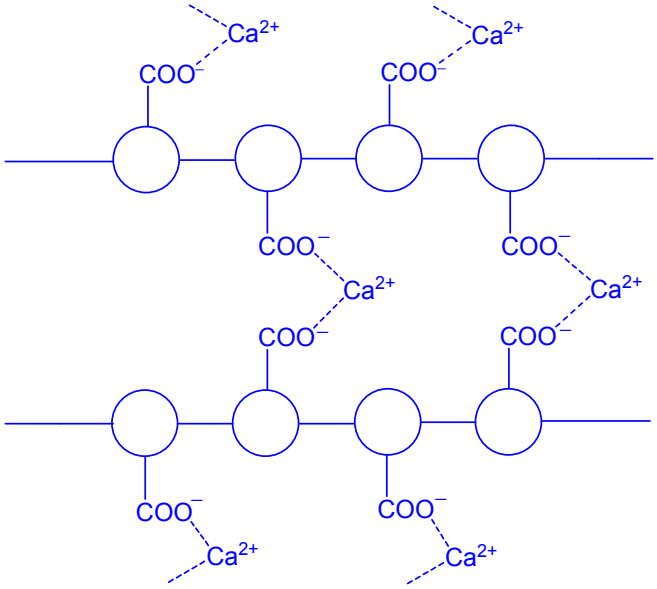
5 **(a)** **(i)** Ionic bonds (between oppositely charged ions) and covalent bonds (between atoms) [1]

(ii)



[1]

(b) **(i)**



[1] – show at least two chains crosslinking
[1] – Ca^{2+} near to two opposite chain $-COO^-$ groups

It is held by ionic bonds between one Ca^{2+} and two alginate monomers. [1]

(ii) The energy released when calcium alginate forms ion-dipole interactions (and hydrogen bonds) with the water molecules is insufficient to overcome the strong ionic bonds between calcium ions and alginate ions. [2]

(c) (i) Lime juice has a pH lower than 3.6. The high concentration of H^+ in lime juice will acidify sodium alginate to form alginic acid (acid-base reaction) which prevents spherification from occurring. [1]

(ii) Sardine extract has a very high calcium content and will solidify in the sodium alginate solution immediately to form calcium alginate. [1]

(d) Mango puree. [1]
Its pH is greater than 3.6 and it has the lowest calcium content. [1]

(e) $[H^+]$ from milkfish extract = $10^{-5.4} = 3.981\times10^{-6}$ mol dm^{-3}
$[H^+]$ from lime juice = $10^{-1.8} = 0.01585$ mol dm^{-3} [1]

$$[H^+] \text{ of solution} = \frac{3.981\times10^{-6}(\frac{50}{1000})+0.01585(\frac{10}{1000})}{\frac{50+10}{1000}} \quad [1]$$

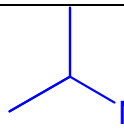
$$= 0.002644 \text{ mol dm}^{-3}$$

pH = –log (0.002644) = 2.57 (pH < 3.6)
The solution is too acidic. It is unsuitable for spherification. [1]

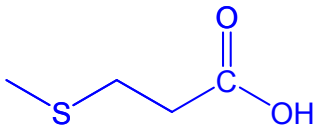
(f) (i)
- There are 3 bond pair and 0 lone pair of electrons about C* atom.
- There are 2 bond pairs and 2 bond pairs of electrons about S atom.
- According to the VSEPR theory, the electron pairs will arrange themselves as far apart as possible to minimise repulsions.
- Hence the shape about C* atom is trigonal planar and
- the shape about S atom is bent.

5 points – [3], 4points – [2], 3-2 points – [1]

(ii)

	Step I	Step II
Type of reaction	Oxidation [1]	Condensation [1]
Reagents and conditions	$K_2Cr_2O_7$(aq), H_2SO_4(aq), heat under reflux **or** $KMnO_4$(aq), H_2SO_4(aq), heat under reflux [1]	 DCC (N,N'-Dicyclohexylcarbodiimide) with 5% DMAP catalyst [1]

Structure of Compound X:



[1]

6 (a) (i) $NO_2 \rightarrow ½N_2 + O_2$ [1]

Accept $2CO + NO_2 \rightarrow ½ N_2 + 2CO_2$

(ii) The reactants and catalyst are in different phases. [1]

(iii) Reactant molecules diffuse towards the platinum catalyst surface.

Reactant molecules become chemically adsorbed on neighbouring active sites by forming bonds with the catalyst surface.

This caused the covalent bonds within the molecules to weaken, hence lowering the activation energy of the reaction.

The adsorbed molecules are also held in the right orientation for reaction to occur, hence increasing the frequency of effective "collisions".

Eventually, the molecules dissociate, forming highly reactive intermediates which then react to form the products.

After reaction, the product molecules desorbed and diffuse away from the surface.

[3] for 4 points, [2] for 3 points, [1] for 2 points

(iv) Nanoparticles are discrete particles with all three dimensions in the size range between 1 to 100 nm. [1]

(v) When the particles used are in the nanoscale, they provide a larger surface area to volume ratio compared to particles in larger dimensions.

Hence, there will be greater number of active sites for reactions to occur.

This increases the ratio of platinum ions on the surface of a platinum nanoparticle to platinum ions that are buried inside the same platinum nanoparticle.

[2] for 3 points, [1] for 2 points

(vi) Nanoparticles which are released into the environment might be taken in by bacteria and protozoa through their cell membranes, thus allowing the nanomaterials to enter the biological food chain. [1]

(b) (i) By Le Chatelier's Principle, a decrease in temperature will favour the exothermic reaction to compensate the lowered heat which is the forward reaction. Hence the position of equilibrium will shift to the right.

The mixture is decolourised.

[2] for 3 points and [1] for 2 points

(ii) By Le Chatelier's Principle, a decrease in pressure will favour the reaction that produced a greater amount of gas which is the backward reaction. Hence the position of equilibrium shifts to the left.

The brown colour of the mixture is intensified.

[2] for 3 points and [1] for 2 points

(c) (i) By exerting high pressure [1]
At high pressure, the molecules are pushed closer together, resulting in the forming of intermolecular forces of attraction between the molecules. [1]

or

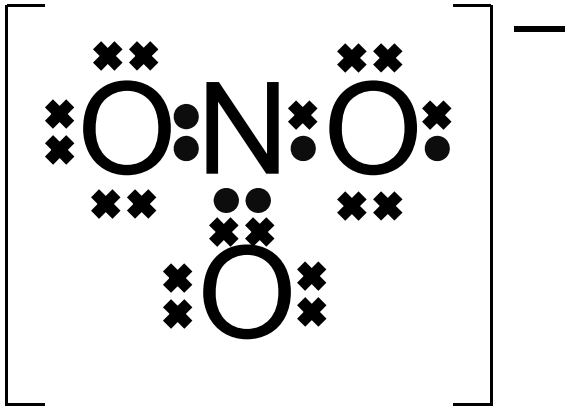
By lowering the temperature [1]
At low temperature, the molecules will move at a slower speed. This helps to bring the molecules closer together, resulting in the forming of intermolecular forces of attraction between the molecules. [1]

(ii) $\Delta H_{rxn} = \sum$ BE(bonds broken) – $\sum$ BE(bonds formed)
=160(3) + 390(8) + 201(2) + 607(2) – 944(3) – 460(8) [1]
= –1296
= –1300 kJ mol^{-1} [1]

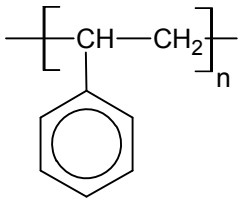
(iii) Nitrogen tetroxide, hydrazine and water exists as liquids and the enthalpy change of vapourisation of these compounds have to be taken into account.[1]

(d) (i) $NO_3^- + 4H^+ + 3e \rightarrow NO + 2H_2O$ [1]

(ii)



7 (a) (i)



[1]

Addition polymerisation [1]

(ii) Polystyrene is a thermoplastic which has low melting point (or flexible; low tensile strength) while poly (diallyl phthalate) is a thermoset polymer which has high melting point (or rigid; high tensile strength) [1]

(iii) Polystyrene is highly recyclable or has very good reshaping capability [1]

(iv) Plastics are finite resources (economic factor)
Harm to environment, human health (environment factor)
[1] for any logical answer

(b) (i) (By reasoning method)
Comparing experiment 1 and 2
When $[C_9H_9Cl]$ is increased by 1.5 times, the initial rate of reaction increases by approximately 4.9/3.2 ≈ 1.5.
Hence, the order of reaction wrt C_9H_9Cl is 1. [1]

Comparing experiment 2 and 3
When $[C_9H_9Cl]$ is halved and $[NH_3]$ is increased by 4 times, the initial rate of reaction is almost doubled (6.3/3.2)
Hence, the order of reaction wrt NH_3 is 1. [1]

Can accept calculation method.

(ii) Rate = $k[C_9H_9Cl]^1 [NH_3]^1$ [1]

(iii) Rate = $k[C_9H_9Cl]^1 [NH_3]^1$
$6.3 \times 10^{-3} = k\ (0.01)(0.4)$
$k = 1.58$ [1] $mol^{-1}\ dm^3\ s^{-1}$ [1] including units

(c) (i) Rate of hydrolysis depends on the strength of the C–X bond.

- Down the group, bond length increases: C–Cl < C–Br < C–I
- Orbital overlap becomes less effective down the group.
- Strength of C-X bond: C–Cl (340) > C–Br (280) > C–I (240)

Or atomic radius: Cl (0.099) < Br (0.114) < I (0.133)

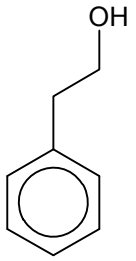
- Rate of hydrolysis: $C_9H_9Cl < C_9H_9Br < C_9H_9I$

Amount of ppt from R-X: $C_9H_9\ Cl < C_9H_9Br < C_9H_9I$

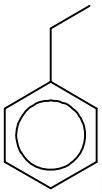
[2] for 4 points

(ii) Pale cream precipitate [1]

(d) **(i)** Compound **B** [1]
Primary alcohol can be oxidized to form carboxylic acid. Since **D** is a carboxylic acid, **B** has to be a primary alcohol. [1]

(ii) Primary alcohol: 

[1]

(iii)  [1]

(iv) Compound **F** is an ester. [1]

(v) Add Br_2 in CCl_4 to separate test tubes of styrene and C. [1]

Observation
Styrene: Orange-red Br_2 decolourises
C: Orange-red Br_2 remains [1]

OR

Add $KMnO_4$, dilute H_2SO_4 to separate test tubes of styrene and C

Observation
Styrene: Purple colour decolourises
C: Purple colour remains