IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

M02/420/H(3)

CHEMISTRY
HIGHER LEVEL
PAPER 3

Tuesday 21 May 2002 (morning)

1 hour 15 minutes

Name

Number

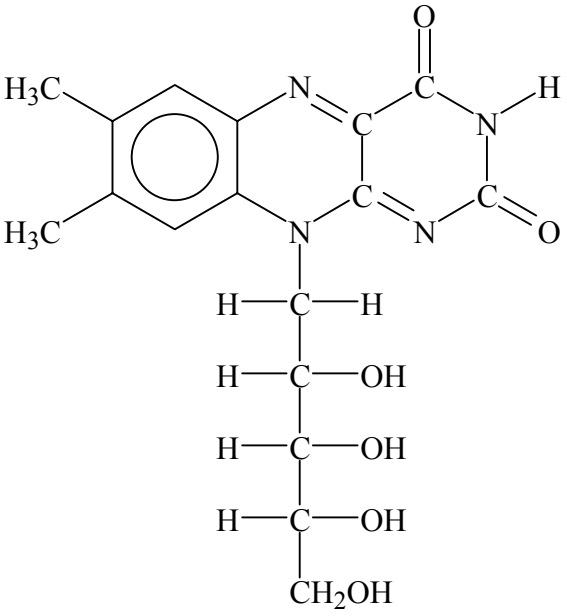
INSTRUCTIONS TO CANDIDATES

- Write your candidate name and number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers in a continuation answer booklet, and indicate the number of booklets used in the box below. Write your name and candidate number on the front cover of the continuation answer booklets, and attach them to this question paper using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the boxes below.

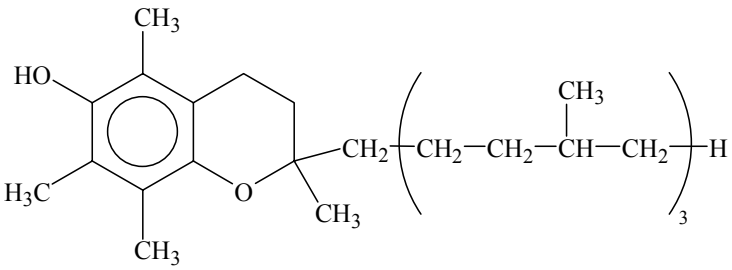
OPTIONS ANSWERED		EXAMINER	TEAM LEADER	IBCA
		/25	/25	/25
		/25	/25	/25
NUMBER OF CONTINUATION BOOKLETS USED	. . . . .	TOTAL /50	TOTAL /50	TOTAL /50

Option C – Human biochemistry

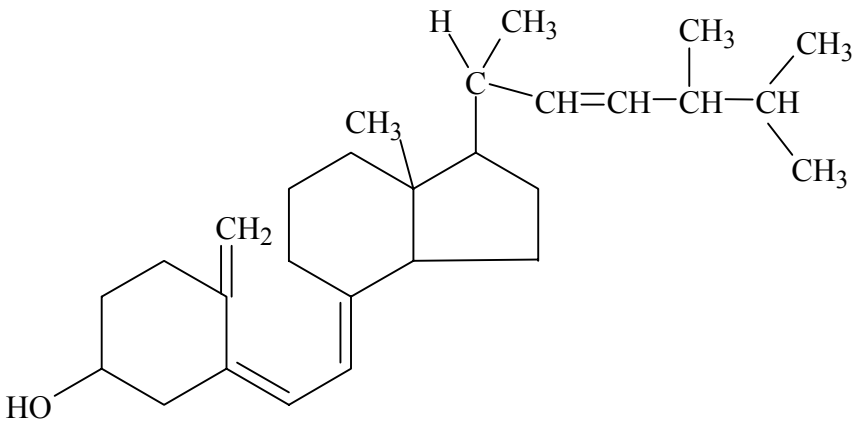
C1. Vitamins may be classified as either *water soluble* or *fat soluble*. The structures of four vitamins, labelled **W**, **X**, **Y** and **Z**, are shown below.



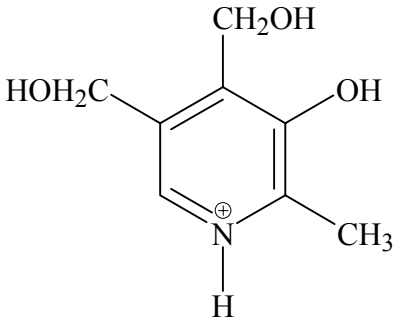
W



X



Y



Z

(This question continues on the following page)

(Question C1 continued)

Identify which **two** structures from **W**, **X**, **Y** and **Z** are **water soluble** vitamins. For **one** of the structures you have chosen, explain what feature(s) lead to its solubility in water. *[4]*

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C2. (a) State **two** reasons why the vitamin C content of vegetables decreases when they are boiled in water. *[2]*

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(b) State **one** important function of vitamin C in the body and state the disease which results from deficiency of this vitamin. *[2]*

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C3. The structure of the *disaccharide* sucrose is shown in the Data Booklet. One of the *monosaccharides* from which sucrose is formed is α-glucose.

(a) Outline what is meant by the term *monosaccharide*. *[2]*

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(b) (i) Give the structural formulas of the two monosaccharides that react to form sucrose. *[2]*

(ii) State the other product of the reaction and name the type of reaction. *[2]*

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(c) Name the other monosaccharide (apart from α-glucose) from which sucrose is formed. *[1]*

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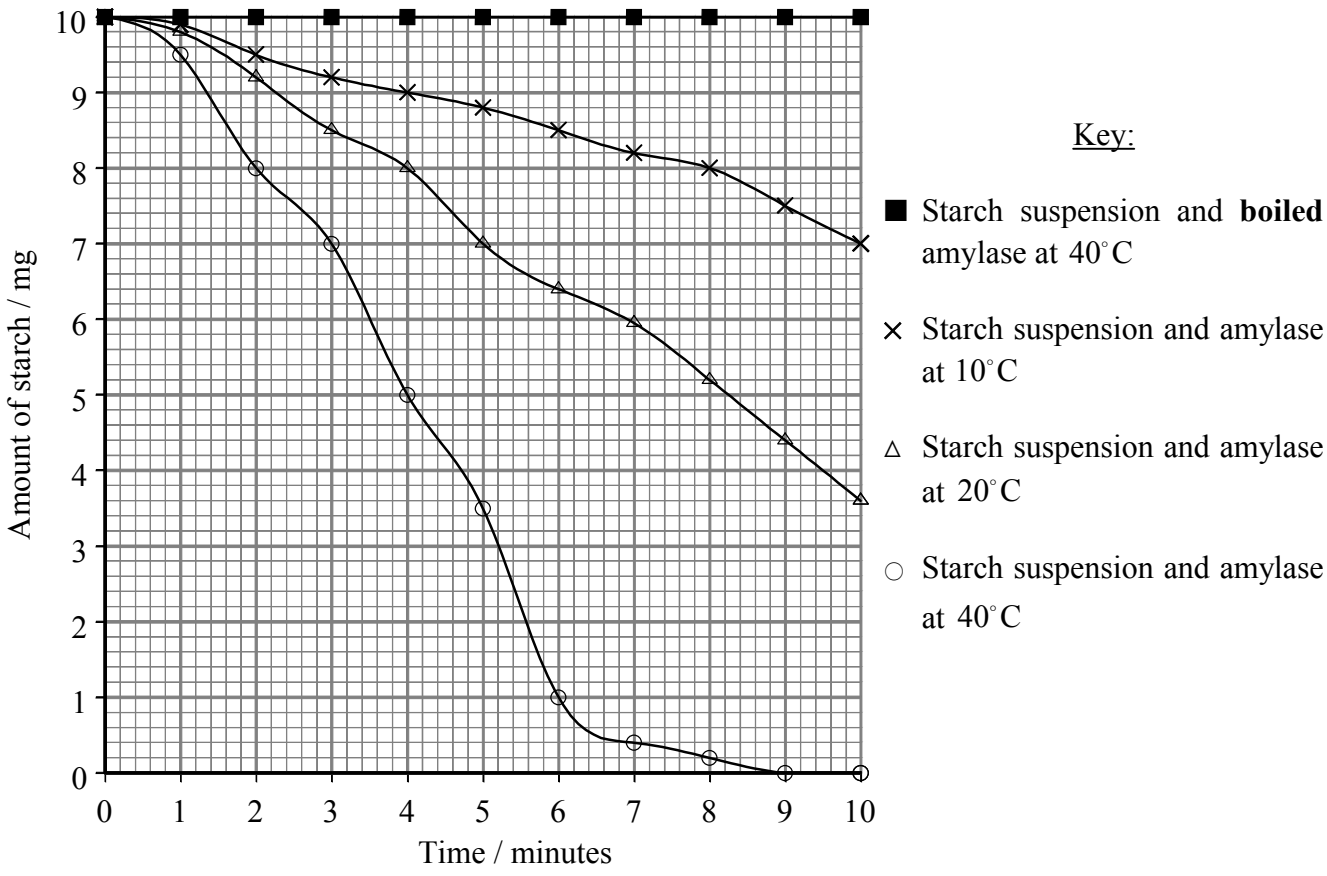
C4. The enzyme amylase breaks down starch to maltose. The effect of temperature on this action of amylase was investigated. The results are shown in the graph below.



With reference to the graph, state and explain the effect of temperature on the activity of amylase. *[5]*

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C5. Describe briefly or sketch the structure of a dinucleotide containing adenine and cytosine. Show and explain how this dinucleotide would associate with a second dinucleotide to form part of a DNA molecule. *[5]*

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Option D – Environmental chemistry

D1. (a) Explain why rain water is naturally slightly acidic. Give an equation to support your answer. *[2]*

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(b) (i) Identify the two major pollutants that cause acid rain. For each, state the man-made source. *[4]*

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(ii) For **each** of the pollutants mentioned in (b) (i), outline **two** different methods by which their contribution to acid rain could be reduced. *[4]*

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D2. (a) State **two** gases that contribute to the greenhouse effect. *[2]*

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(b) Explain how these gases contribute to this effect. *[3]*

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D3. Ozone depletion in the upper atmosphere poses a threat to living organisms.

(a) Describe, with the help of balanced equations, the ozone–oxygen system that existed in the upper atmosphere before its disturbance by human activities. In your answer describe the role of light in this process and discuss the importance of wavelength in the reactions involved. *[5]*

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(b) Discuss the role of chlorofluorocarbons (CFCs) in the process of ozone depletion. Your answer should include a description of the mechanism and an explanation as to why a small amount of CFCs has such a large effect on the ozone layer. *[5]*

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Option E – Chemical industries

E1. The production of aluminium involves purification and electrolysis.

(a) Name the ore from which aluminium is extracted. *[1]*

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(b) Name **one** impurity which is removed at the purification stage. *[1]*

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(c) State why aluminium is not obtained from its oxide by carbon reduction. *[1]*

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(d) Write ionic equations for the reactions that take place during electrolysis at each electrode. *[2]*

Anode: . . . . . .

Cathode: . . . . . .

(e) For **each** of the cases below, state **two** properties of aluminium that make it suitable for use as

(i) cooking pans; *[1]*

. . . . . .

(ii) overhead electric cables. *[1]*

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(f) Aluminium is higher in the reactivity series than iron, yet reacts more slowly with dilute hydrochloric acid at room temperature. Explain this. *[1]*

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E2. The Contact process involves the reversible combination of sulfur dioxide and oxygen, in the presence of a catalyst, according to the equation below:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -192 \text{ kJ mol}^{-1}$$

(a) Sulfur dioxide is produced by burning sulfur in air. Write an equation for this reaction. *[1]*

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(b) State and explain the effect on the yield of sulfur trioxide of

(i) increasing the temperature; *[1]*

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(ii) increasing the pressure. *[1]*

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(c) The Contact process is carried out at $450^{\circ}C$ and at a pressure just above atmospheric. Explain the choice of these conditions. *[2]*

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(d) Sulfur trioxide is used to make sulfuric acid. Give **four** major uses of sulfuric acid. *[2]*

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E3. Give an account of the main features of the chlor-alkali industry, including reference to:

- the names of **two** cells used;
- advantages and disadvantages of **each** cell;
- equations for the electrode reactions;
- the names and **two** uses of **each** of the three products formed. *[10]*

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Option F – Fuels and energy

F1. (a) (i) α, β and γ are three forms of radiation found in nature. In the table below, name these forms of radiation and state their relative charges. *[3]*

Radiation	Name	Relative Charge
α	. . . . .	. . . . .
β	. . . . .	. . . . .
γ	. . . . .	. . . . .

(ii) List the three forms of radiation in order of **increasing** penetrating power (the least penetrating first). *[1]*

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(b) (i) The half-life of ^{90}Sr is 27 years. Calculate the time for the activity of a sample of ^{90}Sr to decay to 12.5 % of its original level. Show your working. *[2]*

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(ii) State why it is meaningless to refer to the half-life of a single atom of ^{90}Sr. *[1]*

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(This question continues on the following page)

(Question F1 continued)

(c) Calculate the neutron to proton ratio of ^{90}Sr. Explain how this value allows the type of decay that ^{90}Sr undergoes to be predicted and write an equation for the decay. State how the combined masses of the particles produced differ from the mass of ^{90}Sr and explain the significance of this. *[5]*

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F2. (a) In *active solar heating*, heat is captured and then distributed by pumps and/or fans using a fluid such as air or water.

(i) State **one** advantage of using air. *[1]*

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(ii) State **one** advantage of using water. *[1]*

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(b) State the main difference between *active* and *passive* solar heating. *[1]*

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(c) State **one** advantage of solar heating. *[1]*

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(d) One way of converting solar energy into other forms is by photosynthesis.

(i) Write a balanced equation for the photosynthesis of glucose. *[2]*

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(ii) Identify the substance present in plants needed for photosynthesis. *[1]*

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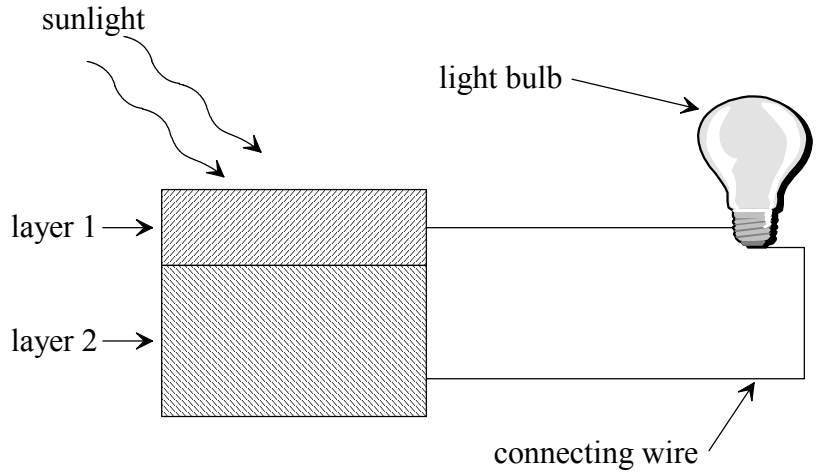
F3. One way of utilising solar energy is by photovoltaic technology.



State, with an example, what *intrinsic semiconductors* are and outline how their properties can be altered to make the layers of a photovoltaic cell. In your answer, state clearly how the composition of layer 1 differs from layer 2. *[6]*

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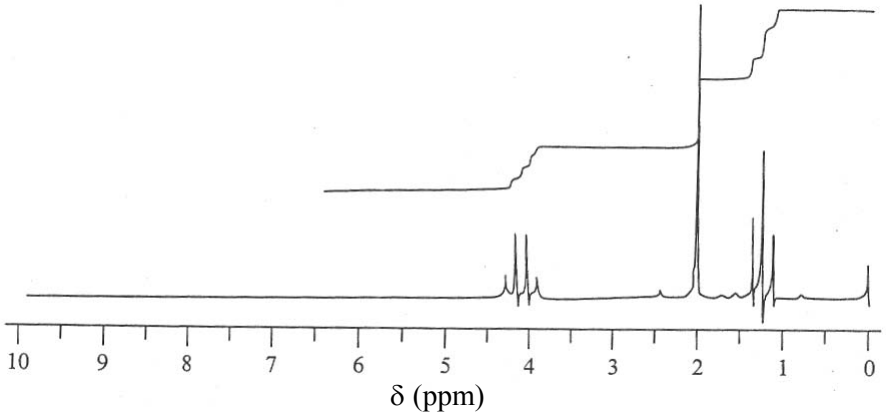
Option G – Modern analytical chemistry

G1. The ^1H NMR spectrum of an unknown compound of molecular formula $C_4H_8O_2$ is given below:



(a) Identify the substance responsible for the peak at 0 ppm and state its purpose. *[2]*

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(b) Explain what information about the compound can be obtained from: *[3]*

(i) the number of peaks;

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(ii) the area under each peak;

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(iii) the multiplicity of each peak.

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(c) By reference to Table 19 of The Data Booklet, identify the groups responsible for the peaks at: *[3]*

1.3 ppm: . . . . . .

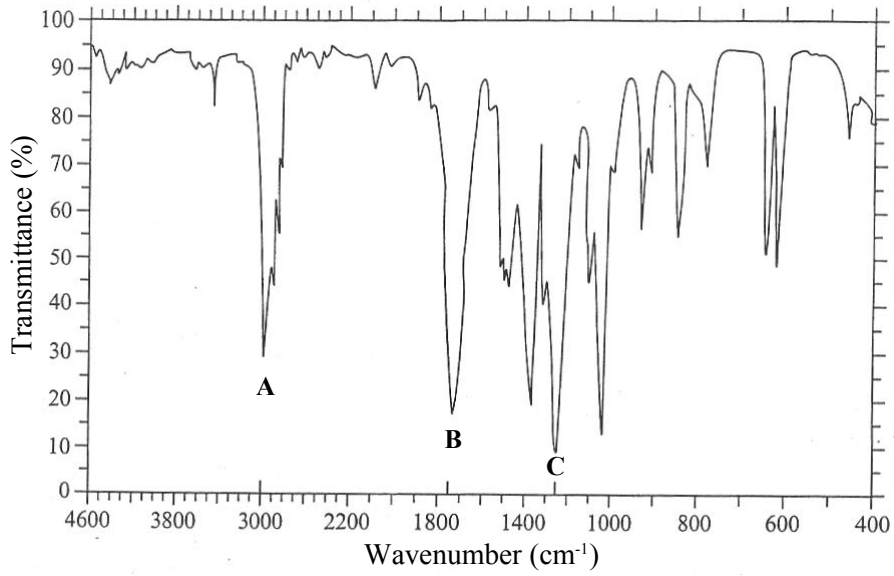
2.0 ppm: . . . . . .

4.1 ppm: . . . . . .

(This question continues on the following page)

(Question G1 continued)

Below is the infrared spectrum of the same compound:



(d) Identify which bonds are responsible for the absorptions labelled **A**, **B** and **C**. *[3]*

A: . . . . . .

B: . . . . . .

C: . . . . . .

(e) Give the name and structural formula of the compound. *[2]*

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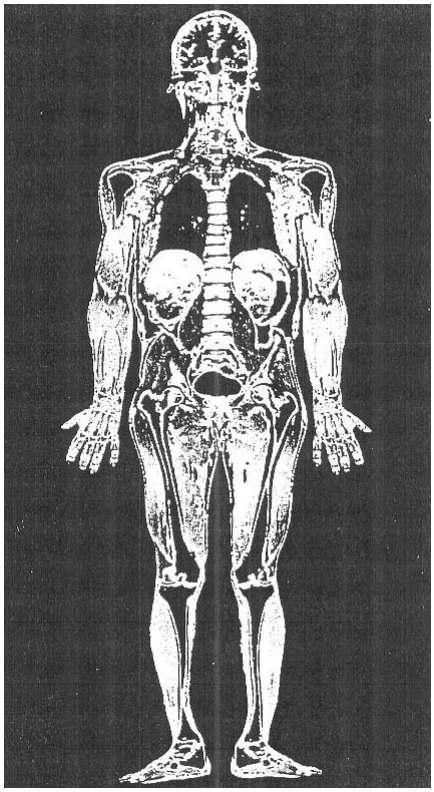
(This question continues on the following page)

(Question G1 continued)

The following is an image of the human body. Such images are useful medically in detecting abnormalities and diseased tissue.



(f) State the technique that was used to produce this image. *[1]*

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(g) State **one** advantage of this technique. *[1]*

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G2. (a) Outline the basic principle of **all** chromatographic techniques. *[2]*

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(b) Suggest, with a reason, which chromatographic technique could be used to separate a mixture of liquid hydrocarbons. Describe how the components would be separated using this technique. *[6]*

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(c) The chromatographic technique used to separate the hydrocarbons can be coupled with mass spectrometry. State what information mass spectrometry could provide about each of the hydrocarbon components. *[2]*

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Option H – Further organic chemistry

H1. An organic compound **A** of molecular formula C_3H_6 reacts with hydrogen chloride to form two organic products **B** and **C**. **B** and **C** have the molecular formula C_3H_7Cl. The yield of **B** in the reaction is much greater than that of **C**.

(a) Give the structural formulas of **A**, **B** and **C**. *[3]*

(b) State the type of reaction for the conversion of **A** into **B** and write the full mechanism for this reaction. Use the mechanism to explain why **B** rather than **C** is the major product of the reaction. *[6]*

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(This question continues on the following page)

(Question H1 continued)

(c) Both **B** and **C** can be converted back into **A**.

(i) Identify this type of reaction, and state the reagent and conditions which would give the best yield of **A**. *[3]*

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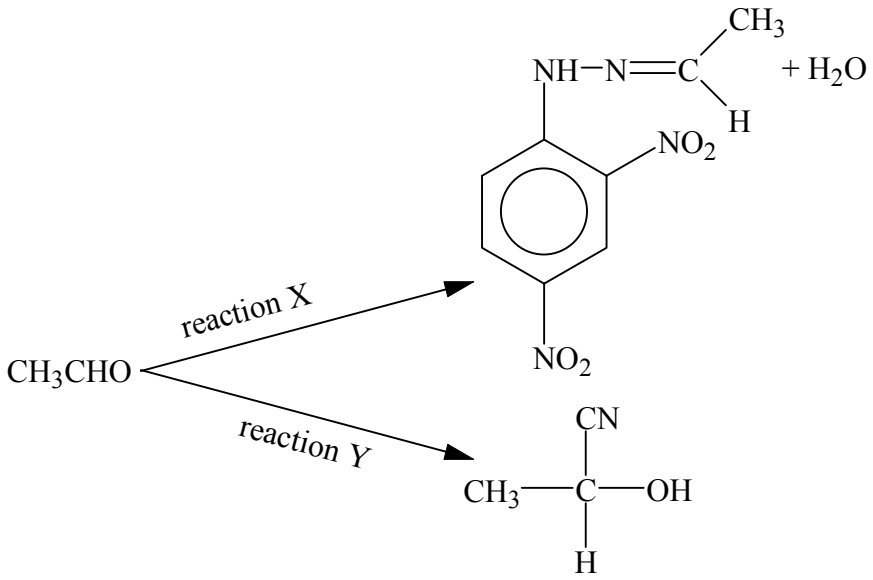
(ii) Outline the mechanism for the conversion of **B** into **A**. *[3]*

H2. Two reactions of ethanal are shown below.



(a) (i) State the type of reaction for: *[2]*

X: . . . . . .

Y: . . . . . .

(ii) Give the structure of the compound formed when reaction X is carried out using the alkanal of formula C_6H_5CHO instead of ethanal. *[1]*

(b) State the reagent used for reaction X and explain how this reaction can be used for the identification of individual alkanals and alkanones. *[4]*

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(This question continues on the following page)

(Question H2 continued)

(c) Explain why reaction Y is useful in organic synthesis and give the structure of the compound formed when the product of reaction Y is hydrolysed. Explain why the product of this reaction exists in different isomeric forms. *[3]*

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