



88126106

**CHEMISTRY  
STANDARD LEVEL  
PAPER 3**

Monday 12 November 2012 (morning)

1 hour

Candidate session number

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Examination code

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**INSTRUCTIONS TO CANDIDATES**

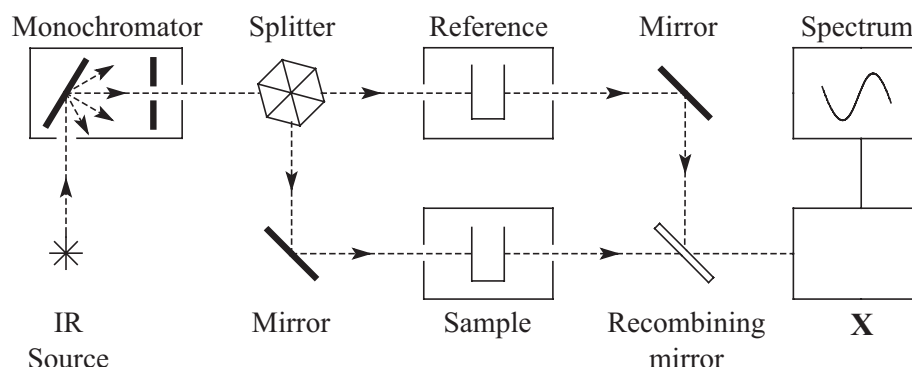
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- A clean copy of the **Chemistry Data Booklet** is required for this paper.
- The maximum mark for this examination paper is [40 marks].



0132

**Option A — Modern analytical chemistry**

**A1.** The diagram below represents a simple double-beam infrared (IR) spectrometer.



(a) Describe briefly the function of the following components of the spectrometer. [3]

Monochromator:

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Splitter:

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Reference:

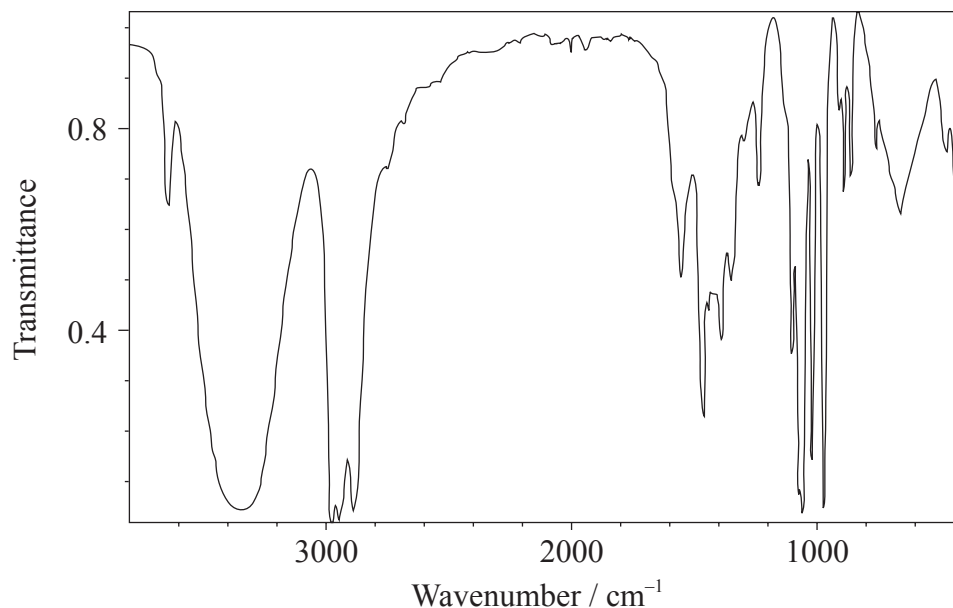
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(b) Identify the component of the spectrometer marked X. [1]

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- A2. The IR spectrum below represents one of the three organic compounds: propan-1-ol ( $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ ), propanal ( $\text{CH}_3\text{CH}_2\text{CHO}$ ) or propanoic acid ( $\text{CH}_3\text{CH}_2\text{COOH}$ ).



- (a) Analyse the spectrum and identify **two** bonds other than C–H that are present and **one** that is absent in this compound. Refer to Table 17 of the Data booklet to complete the table. [3]

Bonds present:

Wavenumber / $\text{cm}^{-1}$	Bond
2850–3000	C–H

Bond absent:

Wavenumber / $\text{cm}^{-1}$	Bond

(This question continues on the following page)



(Question A2 continued)

- (b) The mass spectrum of the same compound contains strong peaks of  $(M_r-15)^+$  and  $(M_r-17)^+$  ions. The first signal corresponds to the loss of a methyl group,  $\text{CH}_3$ , from the molecule. Deduce which fragment is lost to produce the second peak. [1]

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- (c) Using the information above, deduce the identity of the organic compound. [1]

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- (d) Predict the number of peaks in the  $^1\text{H}$ NMR spectrum of this compound. [1]

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**A3.** Magnetic resonance imaging (MRI) is a medical application of NMR spectroscopy.

- (a) State **one** advantage of MRI over X-ray medical imaging with reference to the electromagnetic spectrum. [1]

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- (b) Outline how MRI is used to scan the human body. [3]

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A4. Chromatography is one of the most universal analytical techniques.

(a) State **one** qualitative and **one** quantitative use of chromatography.

[2]

Qualitative:

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Quantitative:

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(b) Using column chromatography as an example, explain how components of a mixture interact with the stationary and mobile phases, and explain how the separation of the components is achieved.

[4]

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**Option B — Human biochemistry**

**B1.** Carbohydrates are essential components of all living organisms.

- (a) State **two** functions of carbohydrates in the human body and state an example of a carbohydrate that performs each function. [2]

<p>Function 1:</p> <p>.....</p> <p>.....</p> <p>Example 1:</p> <p>.....</p> <p>.....</p> <p>Function 2:</p> <p>.....</p> <p>.....</p> <p>Example 2:</p> <p>.....</p> <p>.....</p>
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- (b) State what is meant by the term *dietary fibre*. [1]

<p>.....</p> <p>.....</p>
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**Turn over**

*(Question B1 continued)*

- (c) Describe the importance of dietary fibre for a balanced diet and the prevention of various health conditions.

[3]

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**B2.** There are several types of lipids in the human body. One of these types, triglycerides, might be made of fatty acids with different degrees of saturation.

(a) State **one** example of each of the following types of fatty acids (refer to Table 22 of the Data Booklet if necessary). [3]

<p>Saturated:</p> <p>.....</p> <p>Mono-unsaturated:</p> <p>.....</p> <p>Poly-unsaturated:</p> <p>.....</p>
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(b) Describe, by completing the equation below, the condensation of glycerol and the three fatty acids named in (a) to make a triglyceride. [2]

$\begin{array}{c} \text{CH}_2\text{—O—H} \\   \\ \text{CH—O—H} \\   \\ \text{CH}_2\text{—O—H} \end{array} +$
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(Question B2 continued)

- (c) (i) State the names of **two** other types of lipids present in the human body. [1]

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- (ii) Compare their composition with that of triglycerides. [2]

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**B3.** Proteins are products of polycondensation of 2-amino acids. In addition to their biochemical functions, proteins and individual 2-amino acids may act as acid–base buffers.

- (a) At pH 7, a solution of alanine contains both the zwitterion and negatively charged (anionic) forms of alanine. Deduce the structural formula of each of these forms. Refer to Table 19 of the Data Booklet. [2]

Zwitterion:

Anionic:

(This question continues on the following page)



*(Question B3 continued)*

- (b) State equations which show the buffer action of the solution from (a) when a small amount of strong acid is added and a small amount of strong base is added. [2]

Reaction with a strong acid:

Reaction with a strong base:

- (c) Explain the differences between the primary and secondary structures of proteins and state the bond types responsible for maintaining these structures. [2]

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**Option C — Chemistry in industry and technology**

**C1.** Worldwide a large quantity of iron is made every year. It is usually made in a continuous process in a blast furnace.

(a) State the purpose of **three** principal raw materials that are put into a blast furnace. [3]

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(b) State **two** balanced chemical equations which show the formation of liquid iron in a blast furnace. [2]

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2. ....  
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(c) Suggest **one** equation for a reaction occurring in a blast furnace which can be considered to be a neutralization reaction. [1]

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*(Question C1 continued)*

- (d) Describe **two** ways in which the brittleness of “pig iron” is reduced to produce steel which is more homogeneous, ductile and workable without it fracturing. [2]

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**C2.** In the oil industry surplus long-chain hydrocarbons are converted into shorter, more useful hydrocarbons by various kinds of cracking.

State whether each of the following are examples of homogeneous or heterogeneous catalysis. [3]

Steam cracking:

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Catalytic cracking:

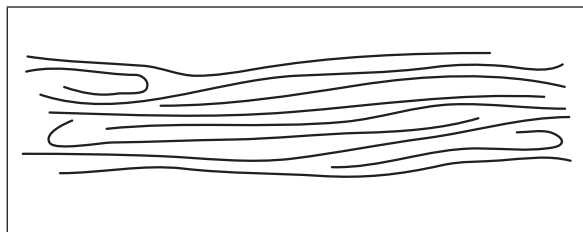
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Hydrocracking:

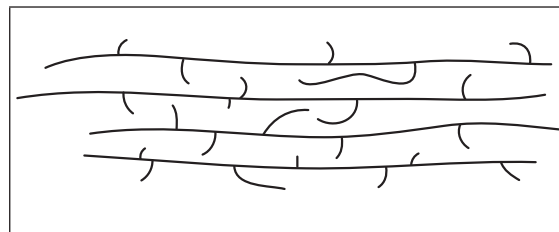
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**C3.** The two diagrams below show the arrangement of molecules in two different types of polyethene, labelled **A** and **B**.



**A**



**B**

(a) Predict which type of polyethene (**A** or **B**) has the strongest intermolecular forces, highest density and greatest flexibility.

(i) Strongest intermolecular forces:

[1]

.....

(ii) Highest density:

[1]

.....

(iii) Greatest flexibility:

[1]

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*(This question continues on the following page)*



*(Question C3 continued)*

- (b) The polymer polyvinyl chloride (PVC), also known as poly(chloroethene), is hard and brittle when pure. Explain, in terms of intermolecular forces, how adding a plasticizer to PVC modifies the properties of the polymer. [3]

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- C4.** State **three** factors which need to be considered when an industrial catalyst is chosen. In **each** case explain why they are important. [3]

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**Option D — Medicines and drugs**

**D1.** (a) Creating a new pharmaceutical product is a long and complex process. Outline the main stages of this process in the correct order. [3]

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(b) There are various ways to administer drugs to a patient. One of the common methods, parenteral, is also known as injection. State and describe **two** other methods of administering drugs. [2]

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(c) The efficiency of certain drugs is strongly dependent on the frequency and regularity of their administration. Explain the importance of patient compliance when the patient is treated with antibacterials. [2]

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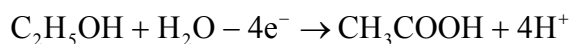
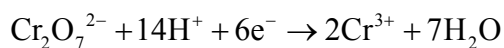
**D2.** Physiological effects of drugs can be significantly reduced, enhanced or altered by other drugs or foods. The problem of drug interactions is particularly important for patients who consume excessive amounts of ethanol.

- (a) State **one** possible adverse effect of consuming ethanol together with each of the following drugs. [2]

Aspirin: ..... .....
Diazepam (Valium®): ..... .....

(b) Detection of ethanol and accurate measurement of its levels in the human body is important for the effective treatment of patients and is required by law in certain cases (such as road accidents).

- (i) With reference to the half-equations below, explain in terms of electron transfer, whether dichromate(VI) ions and ethanol are reduced or oxidized in the breathalyser. [2]



Dichromate(VI) ions: ..... .....
Ethanol: ..... .....

*(This question continues on the following page)*



*(Question D2 continued)*

- (ii) Explain how the concentration of ethanol is determined by the use of a fuel cell in the intoximeter. [2]

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- (iii) Explain how infrared (IR) radiation can be used to determine the level of ethanol in the breath, blood or urine. [2]

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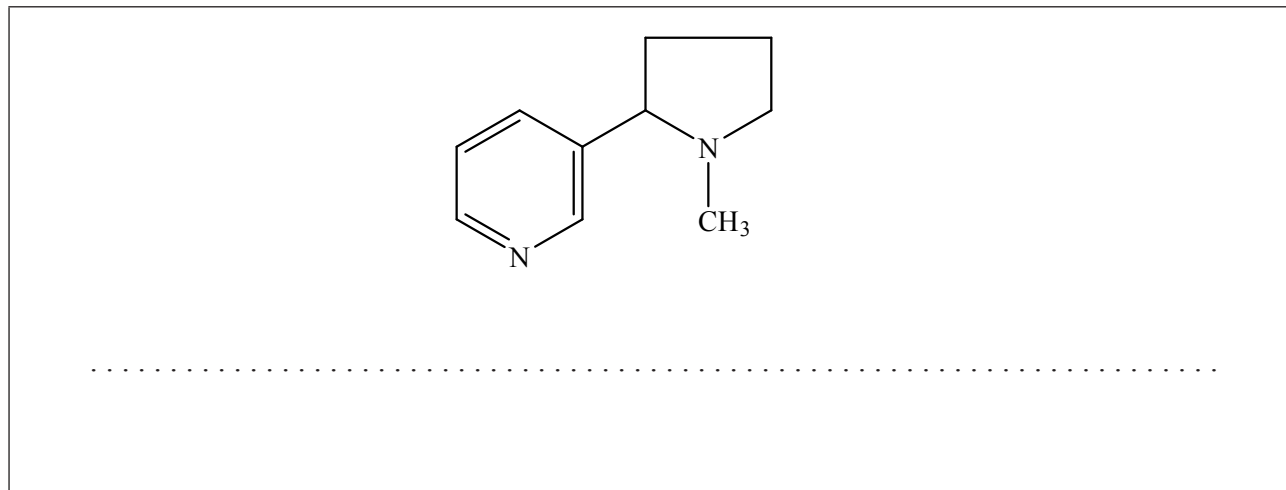
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**D3.** Nicotine is a stimulant that enhances the activity of the nervous system and produces other physiological effects.

- (a) The structure of nicotine is given below. State whether the amino group in the five-membered ring is primary, secondary or tertiary. [1]



- (b) One short-term and one long-term effect of nicotine consumption is given in the table below. State **two** other short-term and **two** other long-term effects of nicotine consumption in the spaces provided. [4]

Short-term effects	Long-term effects
faster heart rate	addiction



**Option E — Environmental chemistry**

**E1.** Acid deposition is a major environmental concern. Although it is usually associated with human activities, natural sources can also contribute to this phenomenon.

(a) State **one** natural origin of acid deposition. [1]

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(b) State equations which represent chemical transformations of elemental sulfur into sulfurous acid,  $H_2SO_3$ . [2]

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(c) Discuss the possible ways of decreasing acid deposition and its adverse effects on the environment. [4]

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**E2.** Human activity leads to contamination of water with various pollutants. Before this water can be released to the environment or re-used, the pollutants have to be removed or their levels lowered.

- (a) Heavy metals are released to the environment by mining. This is an example of a primary pollutant. State **two** other primary pollutants commonly found in waste water, and identify **one** source of each pollutant. [2]

Primary pollutant	Source
heavy metals	waste from mining

- (b) Outline the processes involved in each of the following stages of water treatment **and** identify one type of substance removed in each case. [3]

Primary stage:

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Secondary stage:

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Tertiary stage:

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E3. The concentration of dissolved oxygen greatly affects the decomposition of organic material in water and the development of aquatic ecosystems.

- (a) The following redox reactions represent bacterial decomposition of organic waste under different conditions. Identify the most likely environment (aerobic or anaerobic) for each reaction. [2]

Reaction	Environment
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$	
$CH_3COO^- + H_2O \rightarrow CH_4 + HCO_3^-$	
$2CH_2O + SO_4^{2-} \rightarrow 2CO_2 + H_2S + 2OH^-$	
$2CH_2O + O_2 + 2OH^- \rightarrow 2HCOO^- + 2H_2O$	

- (b) Describe how eutrophication and thermal pollution decrease the concentration of dissolved oxygen in water. State **one** change in an aquatic ecosystem caused by these processes. [3]

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**E4.** Although more and more materials become available for recycling, some waste still needs to be disposed of. Two common methods of waste disposal are landfills and incineration. Compare the advantages and disadvantages of these methods. [3]

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**Option F — Food chemistry**

**F1.** Fats are complex molecules derived from fatty acids and glycerol. They are an important part of our diet and have many functions in the body including energy storage.

(a) Identify the main functional group present in

(i) all fats.

[1]

.....

(ii) all fatty acids.

[1]

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(b) Chocolate is a luxury food made from cocoa, sugars, unsaturated vegetable fats, milk whey and emulsifiers. Bars of chocolate sold in hot climates are made with a different blend of vegetable fats from bars sold in cold climates.

Explain why fats with different physical properties are used for making chocolate sold in different climates, and suggest how the structure of fat molecules used in a hot climate might differ from those used in a cold climate.

[3]

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**F2.** Table 22 of the Data Booklet gives the structures of some fatty acids. Linolenic and linoleic acids are examples of essential fatty acids, known as omega-3 and omega-6 fatty acids.

- (a) State the type of rancidity that fats containing essential fatty acids are most prone to, and identify the functional group in the fat molecules that is involved. [2]

Type of rancidity:

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Functional group:

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- (b) Describe **two** different ways, used in the food industry, to minimize the rate at which fats become rancid, and state **one** example of each. [4]

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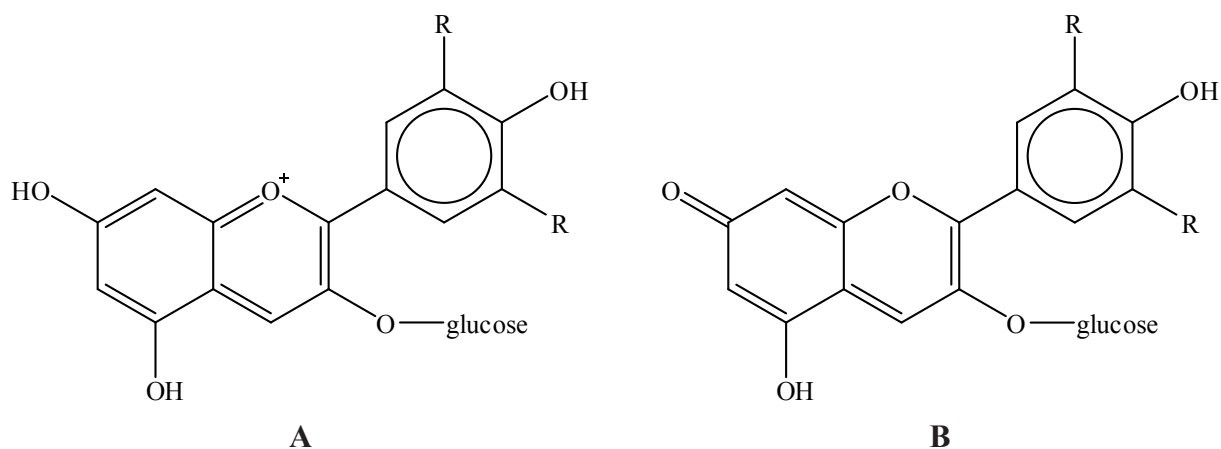
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**F3.** Anthocyanins, the pigments which occur naturally in many flowers and fruits, have antioxidant properties and often change colour as the temperature or pH changes. The diagrams show two structures of the same anthocyanin under different conditions.



(a) Using diagrams **A** and **B**, deduce whether structure **A** or structure **B** is more likely to exist in acid solution, and explain your answer. [2]

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(b) List **two** other types of natural antioxidants that occur in some traditional food substances such as green tea, turmeric, oregano, blueberries, cranberries and dark chocolate. [2]

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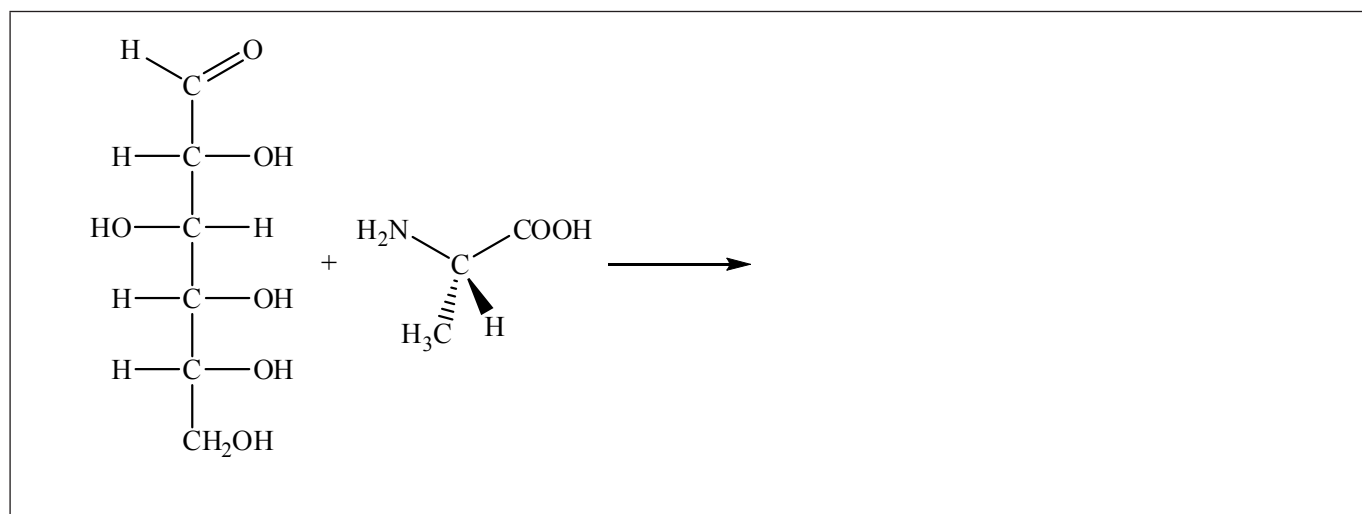
(Question F3 continued)

- (c) With reference to the electromagnetic spectrum, explain why ripe strawberries appear red in daylight. [2]

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**F4.** The Maillard reaction is responsible for the non-enzymatic browning of food when it is cooked. The browning is caused by condensation reactions between the aldehyde groups of sugars and the amino groups of amino acids.

- (a) Deduce the products formed in the Maillard reaction, which takes place between the aldehyde group of glucose and the amine group of alanine during cooking. [1]



- (b) Suggest why foods containing milk readily undergo the Maillard reaction. [1]

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**Option G — Further organic chemistry**

**G1.** One of the challenges of synthetic organic chemistry is the preparation of substances with an increased number of carbon atoms. Hydrogen cyanide and organometallic reagents are commonly used for this purpose.

- (a) State the equation for the reaction of hydrogen cyanide, HCN, with propanal,  $\text{CH}_3\text{CH}_2\text{CHO}$ . [1]

- (b) State the reaction type in (a). [1]

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- (c) State the general name for the product of the reaction in (a). [1]

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*(This question continues on the following page)*



*(Question G1 continued)*

- (d) State the formula of the organic product of the reaction of propanal with ethylmagnesium bromide,  $\text{CH}_3\text{CH}_2\text{MgBr}$ . [1]

- (e) Deduce a two-step reaction pathway for the conversion of 1-bromopropane,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$ , into butanoic acid,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ , using an organometallic reagent as the intermediate. State the appropriate equations and the reaction conditions for each step. [3]

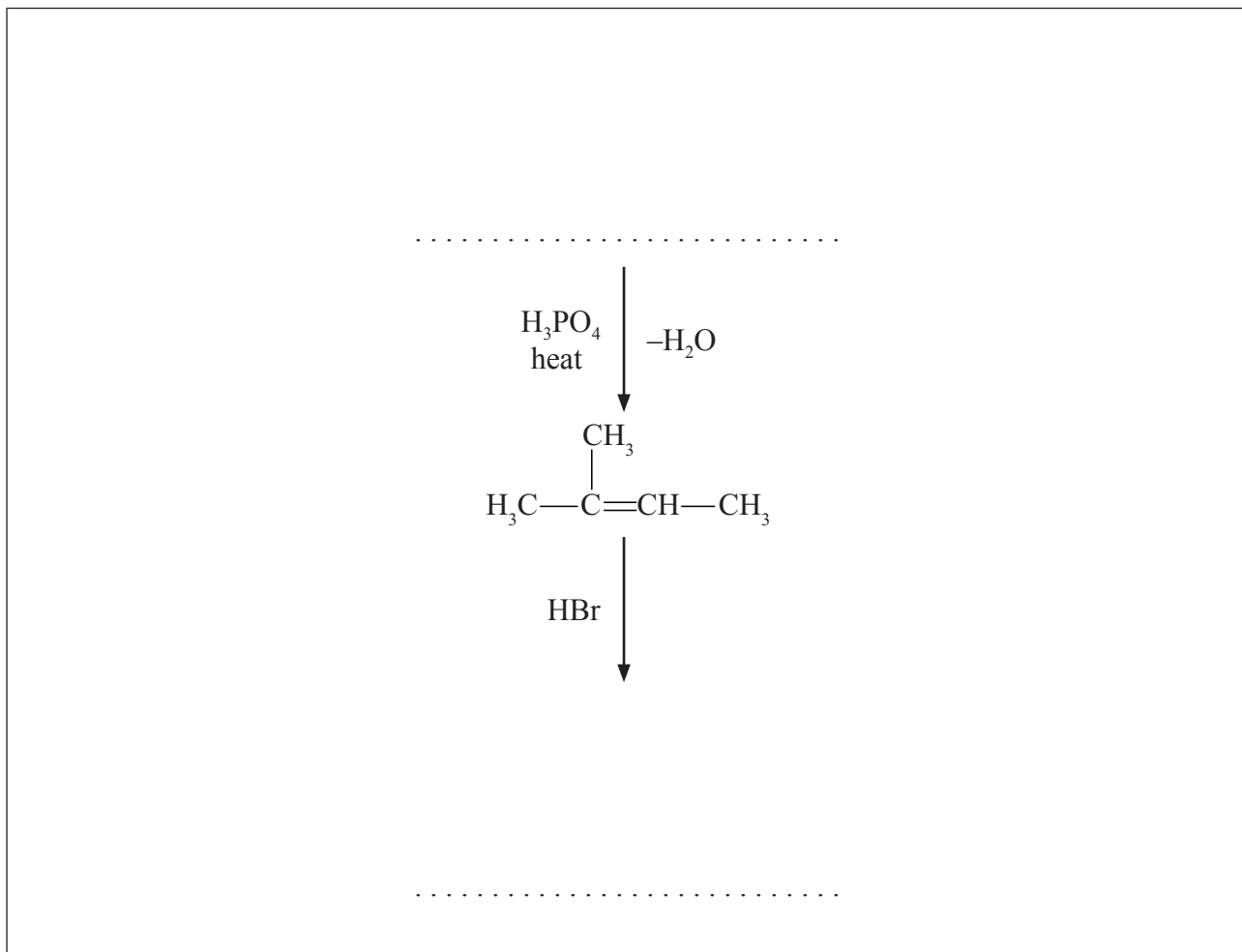
Step 1:

Step 2:



**G2.** Dehydration of alcohols leads to alkenes, which can be used as intermediates for further chemical transformations.

- (a) State the structural formula of the organic reactant and the structural formula of the final organic product needed to complete the following two-step reaction pathway. [2]



- (b) State the reaction type for each step of the transformation in (a). [2]

Step 1:

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Step 2:

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*(This question continues on the following page)*



*(Question G2 continued)*

- (c) Explain, using equations and curly arrows to represent the movement of electron pairs, the mechanism of the dehydration of 3-methylbutan-2-ol,  $\text{CH}_3\text{CH}(\text{OH})\text{CH}(\text{CH}_3)_2$ . [4]



**G3.** The acidity of phenols varies with the nature of substituents in their molecules. Table 15 of the Data Booklet provides some examples.

- (a) State and explain how the presence of a nitro group attached to the benzene ring affects the acidity of phenols. [3]

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- (b) State how the acidity of 3,5-dinitrophenol compares to that of phenol and 2,4,6-trinitrophenol. [1]

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- (c) Suggest the  $pK_a$  value for 3,5-dinitrophenol. [1]

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