



22136112

**CHEMISTRY
STANDARD LEVEL
PAPER 3**

Friday 17 May 2013 (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 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].



0136

Option A — Modern analytical chemistry

A1. Compound **P** contains a carbonyl group (C=O) and has the molecular formula C₃H₆O.

(a) Draw the **two** possible structures of compound **P**. [1]

(b) Explain why the infrared spectra of the structures in (a) are very similar. [1]

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(c) Explain how the mass spectra of the structures in (a) can be used to distinguish between them. [2]

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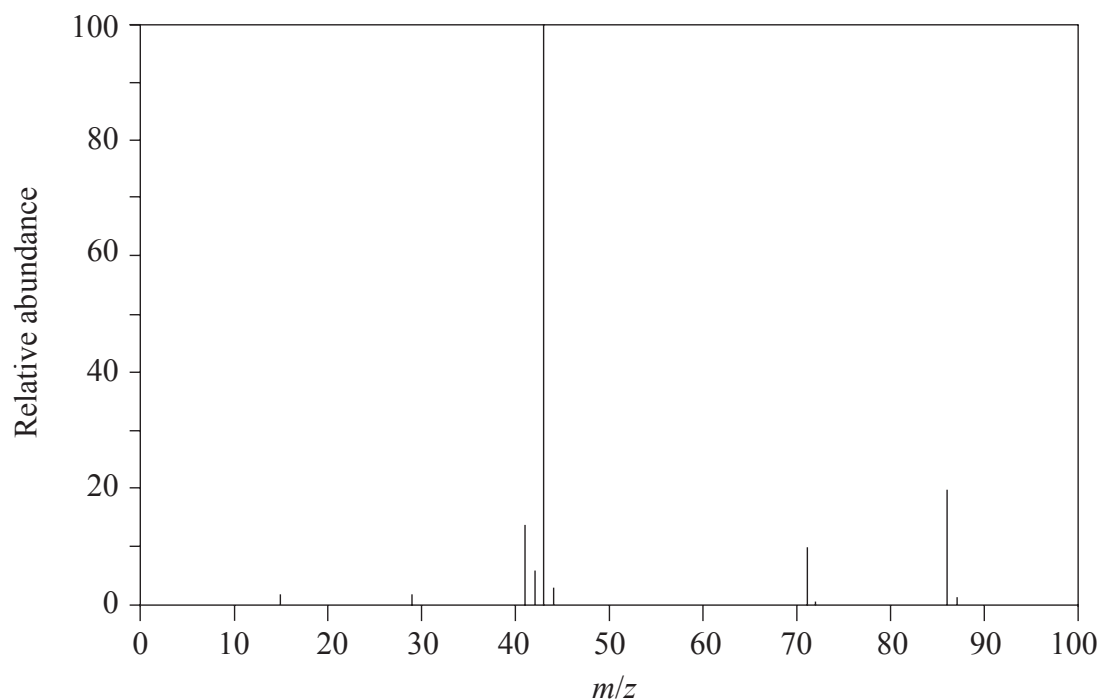
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(Question A1 continued)

(d) Pentan-2-one has the following mass spectrum.



(i) Deduce the formulas of the species with the m/z values at 86, 71 and 43. [3]

$m/z = 86$:

$m/z = 71$:

$m/z = 43$:

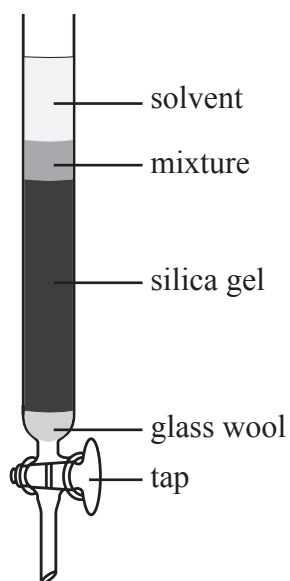
(ii) Suggest a reason for the peak at $m/z = 43$ having an exceptionally high relative abundance. [1]

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A2. The diagram shows the apparatus used in column chromatography.



(a) A mixture is run through a chromatography column. Explain how the components of the mixture are separated. [3]

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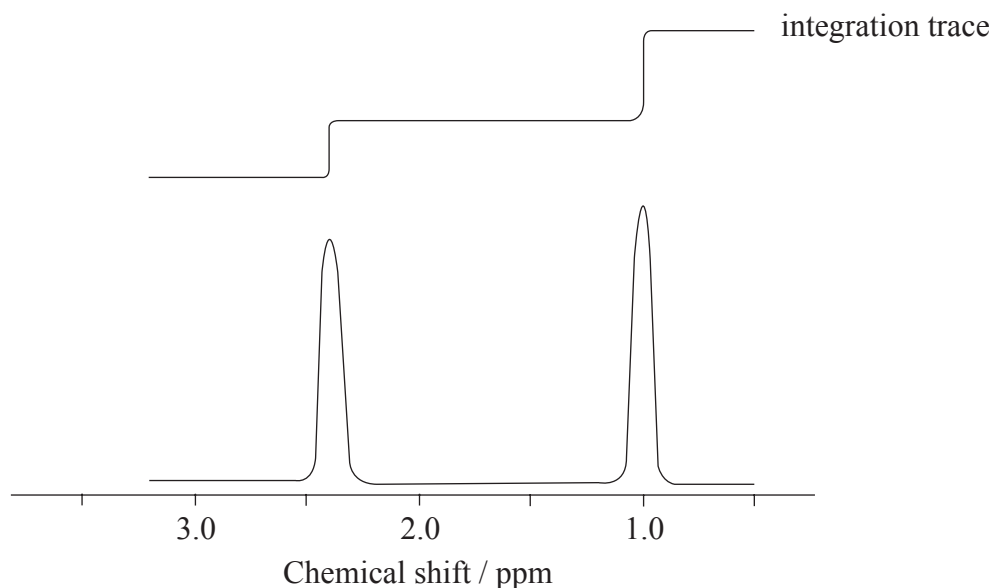
(b) Identify **one** advantage of using column chromatography rather than thin-layer chromatography. [1]

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A3. The low resolution ^1H NMR spectrum of compound **Q** is shown.



(a) Identify what information from the spectrum allows the determination of the relative numbers of hydrogen atoms producing each peak. [1]

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(b) Deduce which of the following compounds is **Q**. [1]

$\text{CH}_3\text{CH}_2\text{CH}_3$ $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$ $\text{CH}_3\text{CH}_2\text{OH}$

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(c) Identify the wavenumbers of **two** peaks in the infrared spectrum of compound **Q**, using Table 17 of the Data Booklet. [1]

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A4. The electromagnetic spectrum is given in Table 3 of the Data Booklet.

Different types of electromagnetic radiation are used to excite atoms and molecules.

(a) Identify the type of radiation

(i) whose photons have the lowest frequency. [1]

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(ii) that causes molecules to rotate faster. [1]

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(iii) that causes a change in bond polarity. [1]

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(b) Visible radiation causes electronic transitions in atoms. These transitions are responsible for absorption and emission spectra. Identify **one** similarity and **one** difference in the appearance of absorption and emission spectra. [2]

Similarity:

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Difference:

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Option B — Human biochemistry

B1. Proteins are formed during condensation reactions of 2-amino acids.

- (a) (i) Using Table 19 of the Data Booklet, deduce the structural formulas of the **two** dipeptides formed by the reaction of leucine (Leu) with valine (Val). [2]

Dipeptide 1:

Dipeptide 2:

(This question continues on the following page)



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Turn over

(Question B1 continued)

(ii) State the other substance formed during this reaction. [1]

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(b) Explain how amino acids can be analysed using electrophoresis. [4]

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(c) List **two** functions of proteins in the body. [1]

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B2. Monosaccharides and disaccharides are classes of carbohydrates.

(a) Describe the structural features of monosaccharides. [2]

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(b) (i) Draw the structures of α -glucose and β -glucose. [2]

α -glucose	β -glucose
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(ii) Two α -glucose molecules condense to form the disaccharide maltose. Draw the structure of maltose. [1]

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(Question B2 continued)

- (c) (i) State what is meant by the term *dietary fibre*. [1]

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- (ii) Describe why a diet high in dietary fibre is important. [3]

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- B3.** (a) The structures of retinol (vitamin A) and vitamin D are given in Table 21 of the Data Booklet. Deduce whether each vitamin is water-soluble or fat-soluble and explain your answer by referring to their structures. [2]

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- (b) State the name of a condition or disease that may be prevented by eating cereals that have vitamin D added to them. [1]

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Option C — Chemistry in industry and technology

C1. Aluminium is the most abundant metal on Earth and its alloys are widely used.

(a) Discuss **two** environmental concerns associated with the production of aluminium. [2]

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(b) Describe what is meant by the term *alloy*. [1]

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(c) State the main improvement made to the properties of aluminium when it is alloyed. [1]

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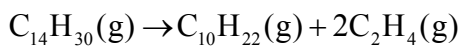
(d) State **two** properties that make aluminium suitable for use as foil for **food packaging**. [1]

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C2. Cracking is the process by which long-chain alkanes found in oil are broken down into smaller molecules.

(a) The following reaction occurs during the cracking of tetradecane, $C_{14}H_{30}$.



Suggest a use for each of the products formed in the reaction. [2]

<p>$C_{10}H_{22}$:</p> <p>.....</p> <p>.....</p> <p>C_2H_4:</p> <p>.....</p> <p>.....</p>

(b) State the main type of product obtained from steam cracking. [1]

<p>.....</p>

(c) Catalytic cracking uses silica as a heterogeneous catalyst. Explain the mode of action of a heterogeneous catalyst. [2]

<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>

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(Question C2 continued)

(d) State **one** advantage of using a heterogeneous catalyst rather than a homogeneous catalyst. [1]

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(e) Discuss **two** factors that need to be considered when choosing a catalyst for a process. [2]

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C3. Liquid crystals are sometimes used in the construction of “smart windows”.

Smart windows are milky white as their randomly arranged liquid crystals scatter light. When a voltage is applied, the liquid crystals align in the same direction. The light then passes through them without scattering, making the windows transparent.

(a) State the property of the liquid-crystal molecules that allows them to align when a voltage is applied. [1]

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(b) List **two** substances that can behave as liquid crystals. [1]

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(c) Distinguish between *thermotropic* and *lyotropic* liquid crystals. [2]

Thermotropic liquid crystals:
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Lyotropic liquid crystals:
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C4. Poly(propene) has different forms. Isotactic poly(propene) is tough, while atactic poly(propene) is flexible.

(a) State the difference in the structure of the two polymers. [1]

Isotactic:

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Atactic:

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(b) Explain how the difference in structure results in the different properties of isotactic and atactic poly(propene). [2]

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Option D — Medicines and drugs

D1. Analgesics can be either mild or strong.

(a) Explain how mild and strong analgesics prevent pain. [2]

Mild analgesics:

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Strong analgesics:

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(b) Aspirin and paracetamol (acetaminophen) are examples of mild analgesics. State **one** advantage and **one** disadvantage of using paracetamol instead of aspirin as a mild analgesic. [2]

Advantage:

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Disadvantage:

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(This question continues on the following page)



(Question D1 continued)

- (c) State a reason why it is dangerous to use aspirin while consuming alcohol. [1]

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- (d) Morphine, codeine and diamorphine (heroin) are all examples of strong analgesics. Their structures are found in Table 20 of the Data Booklet.

- (i) Deduce from the structures the names of **two** functional groups present in all three analgesics. [1]

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- (ii) Deduce the name of **one** functional group present in diamorphine (heroin) but not in morphine or codeine. [1]

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D2. Depressants can have different effects depending on their doses.

- (a) State **one** effect of a depressant at moderate dosage and **one** effect of a depressant at high dosage. [1]

<p>Moderate dosage:</p> <p>.....</p> <p>.....</p> <p>High dosage:</p> <p>.....</p> <p>.....</p>

- (b) A breathalyser containing crystals of potassium dichromate(VI) can be used by the police to detect whether a driver has consumed alcohol.

- (i) State the chemical formula for potassium dichromate(VI). [1]

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- (ii) Describe the colour change observed during its reaction with ethanol. [1]

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- (iii) State the oxidation number of chromium in the product. [1]

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(This question continues on the following page)



(Question D2 continued)

- (iv) Deduce the **full** balanced chemical equation for the redox reaction of ethanol with acidified potassium dichromate(VI). [2]

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- (v) State the name of the organic product formed. [1]

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- (c) An intoximeter is used to determine an accurate value for the concentration of ethanol in the breath. Explain **one** technique used for the detection of ethanol in an intoximeter. [3]

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D3. Stimulants are often classified as psychoactive drugs.

(a) List **two** physiological effects of stimulants. [1]

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(b) Amphetamine and epinephrine (adrenaline) are chemically similar in that both compounds are derived from the phenylethylamine structure. The structures of both compounds can be found in Table 20 of the Data Booklet.

(i) Draw the structure of the phenyl group. [1]

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(ii) Suggest which compound contains a primary amine. [1]

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Option E — Environmental chemistry

E1. Increasing concentrations of greenhouse gases are considered to cause global warming. Ozone depletion is another environmental concern.

(a) Identify a gas that is both a greenhouse gas and a cause of ozone depletion. [1]

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(b) Outline **one** impact of each environmental concern and suggest a way to reduce it. [4]

Environmental concern	Impact	Way to reduce impact
Global warming
Ozone depletion



E2. Waste water may contain a number of different pollutants that have a negative effect on health and the environment.

(a) Identify **one** source of each of the following pollutants found in waste water.

(i) Nitrate ions.

[1]

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(ii) Polychlorinated biphenyls (PCBs).

[1]

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(iii) Dioxins.

[1]

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(This question continues on the following page)



(Question E2 continued)

(b) Nitrates are removed from waste water using chemical or biological processes during the tertiary stage of water treatment.

(i) Outline a biological process used for removing nitrates. [2]

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(ii) State **one** advantage of biological processes over chemical processes. [1]

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E3. Nitrogen monoxide gas, NO, is emitted by cars and leads to acid deposition.

(a) Discuss the damage to the environment caused by acid deposition. [3]

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(b) A catalytic converter can reduce emissions of nitrogen monoxide. Identify the type of reaction that occurs in the catalytic converter and state a chemical equation to illustrate your answer. [2]

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E4. Societies have the option of different methods for waste disposal.

Compare landfills with incineration as methods for waste disposal. [4]

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Option F — Food chemistry

F1. Many factors affect the shelf life of food products.

(a) Explain the meaning of the term *shelf life*. [2]

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(b) State **two** factors that affect shelf life. [2]

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(c) Describe the rancidity of fats. [1]

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(This question continues on the following page)



Turn over

(Question F1 continued)

(d) Antioxidants occur naturally (such as vitamin C) or can be synthetic.

(i) Define the term *antioxidant*. [1]

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(ii) Identify an element that is a common naturally occurring antioxidant. [1]

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(iii) State **one** food in which this antioxidant can occur. [1]

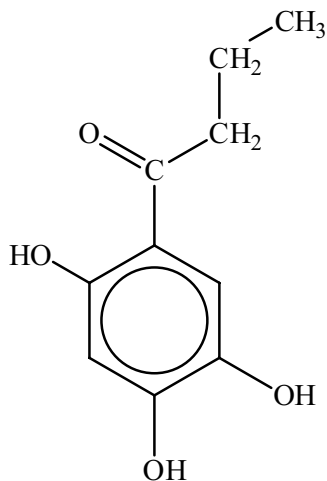
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(Question F1 continued)

- (e) The structures of three synthetic antioxidants, 2-BHA, 3-BHA and BHT are given in Table 22 of the Data Booklet. Another synthetic antioxidant is THBP whose structure is shown below.



THBP

- (i) Deduce which of these four antioxidants contain the phenol group. [2]

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- (ii) Deduce whether THBP contains the tertiary butyl group. [1]

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- (iii) Suggest the function of the tertiary butyl group in antioxidants. [1]

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F2. The food industry uses food-grade dyes and pigments to increase the appeal of food products.

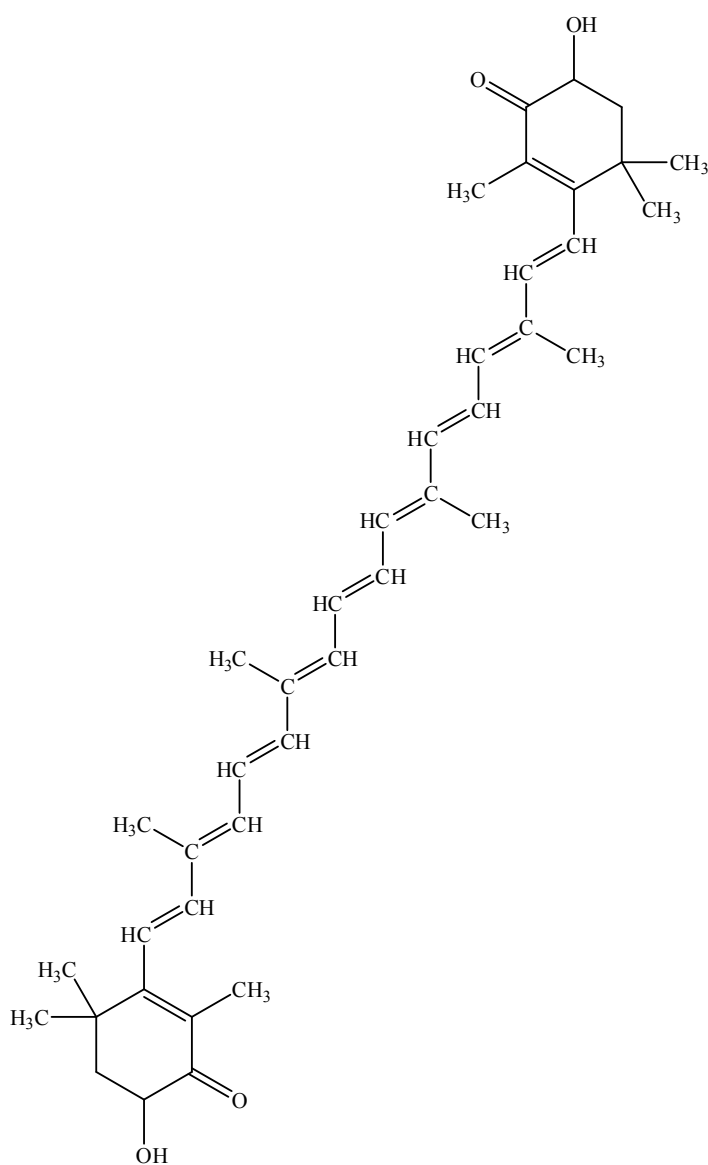
(a) State the difference in terms of solubility between a dye and a pigment.

[1]

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(b) The pigment associated with the olive-green colour of the outer shell of the American lobster is astaxanthin, shown below. When cooked the lobster changes to a red colour.



Astaxanthin

(This question continues on the following page)



(Question F2 continued)

- (i) Identify the class of pigment to which astaxanthin belongs. [1]

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- (ii) Explain why the properties of pigments in the shell of a live lobster can lead to colour variation (for example, from olive-green to orange). [1]

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- (iii) Explain how the colour of astaxanthin changes to red when cooked. [2]

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F3. The Maillard reaction is the basis of non-enzymatic browning and involves the reaction between carbohydrates and proteins.

(a) The first step of this reaction involves a condensation reaction between a reducing sugar, such as glucose, and an amino acid.

(i) Using RCHO to represent glucose and H_2NR' to represent an amino acid, deduce the structural formula of the product. [1]

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(ii) Identify the other product of this reaction. [1]

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(b) Other than condensation, state the name of **one** type of reaction involved in the other two steps of the Maillard reaction. [1]

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Option G — Further organic chemistry

G1. Benzene, C_6H_6 , is found naturally in crude oil.

(a) Describe the chemical structure of benzene. [3]

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(b) State **one** piece of **chemical** evidence that supports this description. [1]

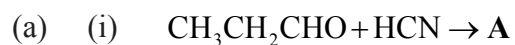
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(c) State and explain the relative rates of hydrolysis of (bromomethyl)benzene, $C_6H_5CH_2Br$, and bromobenzene, C_6H_5Br . [3]

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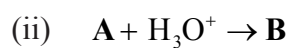


G2. Deduce the structural formulas of the major products, **A–F**, formed in the following reactions.



[1]

A:



[1]

B:

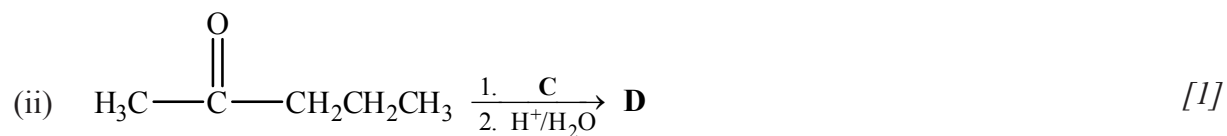
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(Question G2 continued)



C:

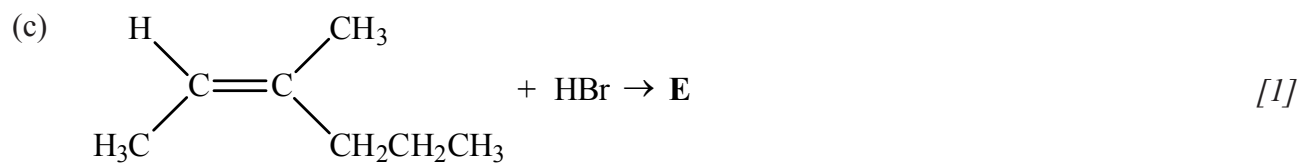
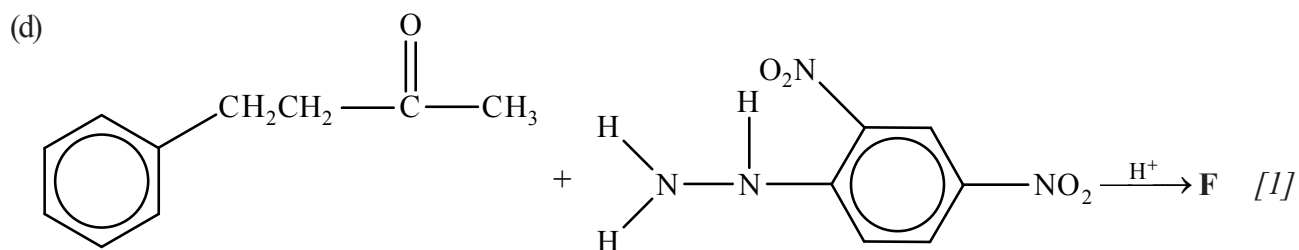


D:

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(Question G2 continued)

**E:****F:**

G3. Elimination reactions are an important type of reaction in organic chemistry.

- (a) Describe, using curly arrows to represent the movement of electron pairs, the mechanism of the reaction of butan-1-ol, $\text{CH}_3(\text{CH}_2)_3\text{OH}$, with concentrated phosphoric acid, H_3PO_4 . [4]

- (b) Suggest why it is better to use phosphoric acid, H_3PO_4 , instead of sulfuric acid, H_2SO_4 , in this reaction. [1]

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G4. Explain whether ethanoic acid, CH_3COOH , or chloroethanoic acid, CH_2ClCOOH , is the most acidic. [2]

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