



22136118

**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

Please **do not** write on this page.

Answers written on this page
will not be marked.



0236

Option A — Modern analytical chemistry

A1. Paper chromatography is a simple method used to separate and identify the components in a mixture. To aid identification, the retention factor, R_f , of an unknown component can be compared with the R_f values of pure samples of the possible components.

(a) State the meaning of the term *retention factor*. [1]

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(b) Explain why the value of the retention factor for the same component can be very different if different solvents (eluent) are used for the mobile phase. [2]

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(c) If the components of the mixture are coloured then they can be seen with the naked eye. Describe **two** different ways in which a chromatogram can be developed if the components are colourless. [2]

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A2. (a) Describe the function of the following components during the operation of a double-beam infrared spectrometer.

(i) Monochromator.

[1]

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(ii) Rotating mirrors.

[1]

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(iii) Photomultiplier (photodiode).

[1]

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(Question A2 continued)

(b) Organic compounds containing a carbon-carbon double bond, (C=C), absorb infrared radiation in the region 1610–1680 cm^{-1} .

(i) Outline the reasons why compounds containing C=C bonds absorb infrared radiation. [2]

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(ii) Explain why different compounds containing C=C bonds absorb infrared radiation at slightly different wavenumbers. [1]

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(c) Describe how the wavelength, the frequency, and the energy, change in moving from the infrared region of the electromagnetic spectrum to the radio region of the electromagnetic spectrum. [3]

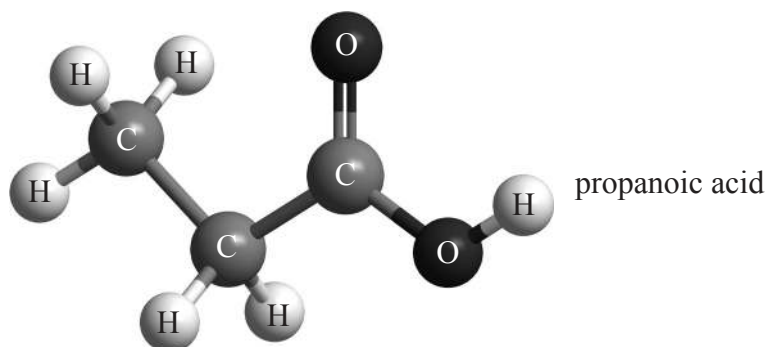
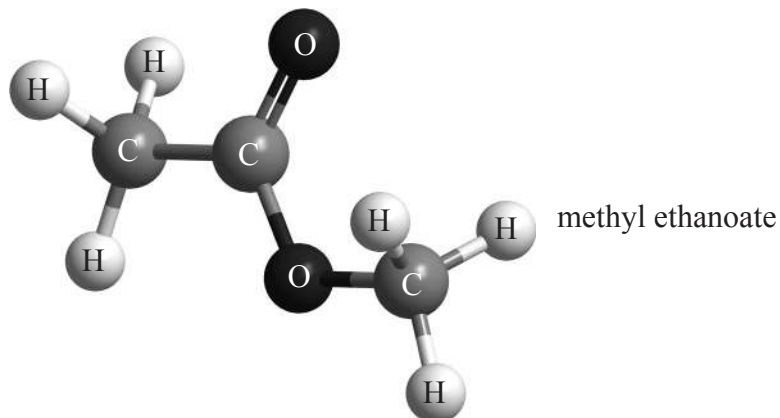
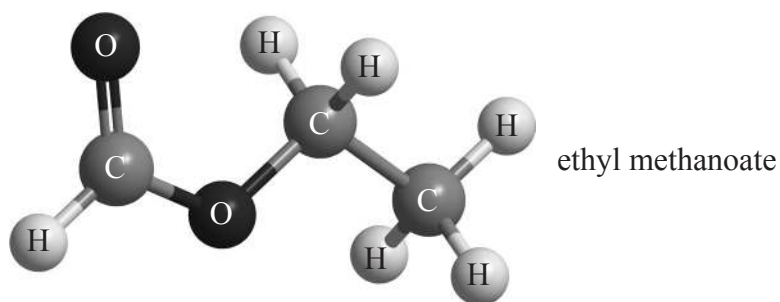
Wavelength:
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Frequency:
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Energy:
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A3. Three isomers of $C_3H_6O_2$ are ethyl methanoate, methyl ethanoate and propanoic acid.



- (a) Explain which of the three compounds has a mass spectrum which contains peaks at $m/z = 59$ and 44. [2]

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(Question A3 continued)

- (b) Explain which of the three compounds has an infrared spectrum with a broad absorption between $2500\text{--}3300\text{ cm}^{-1}$ and an absorption at 1730 cm^{-1} . [2]

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- (c) Explain which of the three compounds has a ^1H NMR spectrum showing two peaks with equal areas under each peak. [2]

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Option B — Human biochemistry

B1. Lipids play a significant role in human nutrition and have many important biological functions. The triglycerides are one type of lipid.

Table 22 of the Data Booklet shows the formulas of some fatty acids.

- (a) (i) Olive oil contains a triglyceride (glyceryl trioleate) which, on hydrolysis, yields propane-1,2,3-triol (glycerol) and oleic acid.

Deduce the equation for this reaction. You may use the letter R to represent the hydrocarbon chains. [3]

- (ii) Calculate the iodine number for oleic acid (M_r of oleic acid = 282.52). [2]

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(Question B1 continued)

- (b) (i) Linoleic acid and stearic acid have similar molecular masses. Explain why linoleic acid has a much lower melting point than stearic acid. [2]

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- (ii) Linoleic acid and linolenic acid are classed as essential fatty acids. State the importance of these fatty acids in the human diet. [1]

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B2. Papain is a globular protein which is present in papaya fruit. Part of the sequence of its polypeptide chain is Gly–Cys–Val–Gly.

(a) Proteins such as papain are formed by the condensation reactions of 2-amino acids.

By referring to Table 19 of the Data Booklet, draw the structural formulas of the **two** dipeptides formed by the reaction of glycine with cysteine. [2]

(b) In the analysis of proteins, mixtures of amino acids with different isoelectric points can be separated using electrophoresis.

(i) Describe the essential features of electrophoresis. [3]

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(Question B2 continued)

- (ii) Arginine, cysteine and glycine undergo electrophoresis at pH 6.0. Deduce which amino acid moves towards the positive electrode (anode). [1]

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- (c) (i) Describe what is meant by the tertiary structure of proteins. [1]

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- (ii) Identify **two** interactions which are responsible for this type of structure. [1]

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B3. Micronutrients are essential components of a healthy diet. Complete the table by deducing the solubility **and/or** the medical condition caused by a deficiency of each micronutrient. [4]

Micronutrient	Fat-soluble / water-soluble	Medical condition
Vitamin A (retinol)		
Vitamin C (ascorbic acid)	water-soluble	
Vitamin D (calciferol)		rickets



Option C — Chemistry in industry and technology

C1. (a) The main ore used to produce aluminium by electrolysis is bauxite. Bauxite is mainly aluminium hydroxide, and contains iron(III) oxide and titanium(IV) oxide as impurities.

(i) Explain how pure aluminium oxide is obtained from bauxite. [3]

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(ii) Explain why sodium hexafluoroaluminate, Na_3AlF_6 , (cryolite) is added to the aluminium oxide before electrolysis takes place to produce aluminium. [1]

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(iii) State the half-equations for the reactions taking place at the positive and negative electrodes during the production of aluminium by electrolysis. [2]

Positive electrode (anode):
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Negative electrode (cathode):
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(Question C1 continued)

- (b) Before the introduction of the electrolytic method by Hall and Héroult in the 1880s it was very difficult to obtain aluminium metal from its ores. Suggest **one** way in which it was achieved. [1]

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- (c) The worldwide production of aluminium by electrolysis makes a significant impact on global warming. Suggest **two** different ways in which the process increases the amount of carbon dioxide in the atmosphere. [2]

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C2. (a) Distinguish between a *homogeneous* and a *heterogeneous* catalyst. [1]

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(b) Other than cost, state **one** advantage and **one** disadvantage of using a homogeneous catalyst rather than a heterogeneous catalyst. [2]

Advantage:
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Disadvantage:
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(c) Other than selectivity and cost, list **three** factors which should be considered when choosing a catalyst for a particular industrial process. [3]

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C3. (a) Poly(ethene) can be produced in a low density (LDPE) or a high density (HDPE) form.

(i) Describe how the two forms differ in their chemical structure. [1]

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(ii) Explain in terms of their structures how the flexibility of the two forms of poly(ethene) differ. [2]

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(b) (i) Describe why pentane is sometimes added during the formation of poly(phenylethene), also known as polystyrene. [1]

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(ii) State **one** use for the product formed from this process. [1]

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Option D — Medicines and drugs

D1. The structures of aspirin and diamorphine (heroin) are given in Table 20 of the Data Booklet.

- (a) Other than the benzene (aromatic) ring, state the name of the functional group that is common to both aspirin and diamorphine. [1]

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- (b) Describe the different ways in which aspirin and diamorphine function when they relieve or prevent pain. [2]

Aspirin:
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Diamorphine:
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(Question D1 continued)

- (c) Other than the prevention of pain and/or the reduction of fever, state **one** reason why aspirin is often prescribed or recommended to some people for daily use. [1]

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- (d) Discuss **one** advantage and **one** disadvantage of taking diamorphine rather than morphine to relieve pain. [2]

Advantage:
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Disadvantage:
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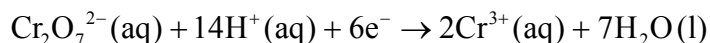
D2. Ethanol is a depressant.

- (a) Describe the effects of depressants when taken in moderate doses and in higher doses. [2]

Moderate doses:
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Higher doses:
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- (b) The presence of ethanol in the breath can be detected by blowing into a “bag” through a tube containing acidified potassium dichromate(VI). The half-equation for the dichromate reaction is:



- (i) Describe the colour change observed when the dichromate ion reacts with the ethanol. [1]

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- (ii) State the name of the organic product formed during the reaction. [1]

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(Question D2 continued)

- (c) In order to quantify exactly how much ethanol is present in the blood, a person may be required to give a blood sample or may be asked to blow into an intoximeter. Explain the chemistry behind the techniques for determining the ethanol content in a blood sample and by using an intoximeter. [4]

Blood sample:

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Intoximeter:

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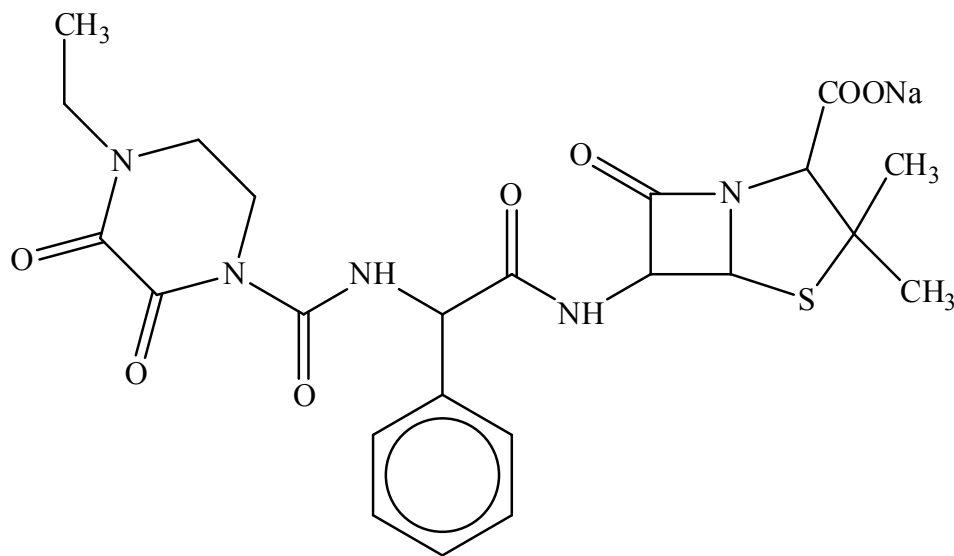
- (d) Ethanol may exert a synergistic effect when taken with other medicines. State the meaning of the term *synergistic effect*. [1]

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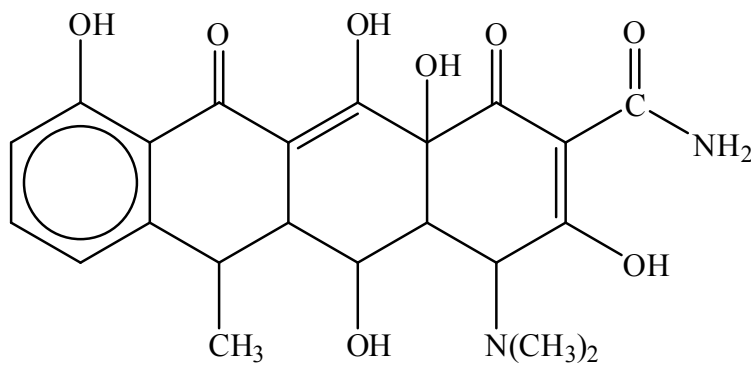
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D3. Two different antibacterials are sodium piperacillin and doxycycline. Sodium piperacillin is a type of penicillin and doxycycline belongs to a class of drugs known as the tetracyclines.



Sodium piperacillin



Doxycycline

(a) Explain how penicillins are able to cure certain diseases caused by bacteria.

[2]

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(Question D3 continued)

- (b) Sodium piperacillin has a different side chain to the original penicillin developed by Florey and Chain. State **one** advantage of changing the side chain. [1]

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- (c) Explain why it may be necessary to give a mixture of several different types of antibacterials (such as penicillins and tetracyclines) to patients suffering from diseases such as tuberculosis (TB) or MRSA (a disease caused by the presence of the *staphylococcus aureus* bacterium). [2]

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Option E — Environmental chemistry

E1. Acid deposition can have a significant impact on aquatic environments such as lakes or wetlands.

(a) (i) State what is meant by the term *acid deposition*. [1]

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(ii) Identify **one** oxide which causes acid deposition **and** state the balanced chemical equation to show how it reacts with water. [2]

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(iii) One effect of acid deposition is to decrease the pH of lake water. Suggest how this effect could be reversed. [1]

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(b) State **two** ways in which the emissions of the oxide identified in (a) (ii) can be decreased. [2]

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E2. Emissions of ozone-depleting substances such as CFCs have decreased extensively as a result of the Montreal Protocol. In the most recent assessment of ozone depletion by the United Nations Environmental Programme, scientists predict a substantial recovery of the ozone layer by 2050.

- (a) Using equations, explain the natural formation and depletion of ozone in the upper atmosphere. [2]

Formation: Depletion:
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- (b) (i) Although the use of harmful CFCs is being phased out, suggest why these compounds are expected to remain in the atmosphere for the next 80–100 years. [1]

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Turn over

(Question E2 continued)

- (ii) Discuss **one** advantage and **two** disadvantages of using hydrocarbons as alternatives to CFCs. [3]

<p>Advantage:</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>Disadvantages:</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>



E3. There is growing concern that the current rate of soil degradation could affect food production in many parts of the world.

Two factors which cause soil degradation are nutrient depletion and soil pollution. Discuss these **two** factors as causes of soil degradation.

[4]

Nutrient depletion:

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Soil pollution:

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E4. In order to make waste water acceptable for drinking, it is treated in a series of steps to remove hazardous substances.

Tertiary treatment removes phosphates, nitrates and heavy metal ions from water.

(a) State an ionic equation, including the state symbols, to show how hydrogen sulfide gas, $\text{H}_2\text{S}(\text{g})$, is able to remove mercury(II) ions, $\text{Hg}^{2+}(\text{aq})$, when it is bubbled through a water sample. [2]

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(b) Lakes and rivers with significant levels of nitrates and phosphates are under threat of eutrophication. Describe the process of eutrophication. [2]

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Option F — Food chemistry

F1. Antioxidants are often used to extend the shelf life of food.

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

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(b) State a natural source for each of the following naturally occurring antioxidants. [2]

β -carotene:

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Selenium:

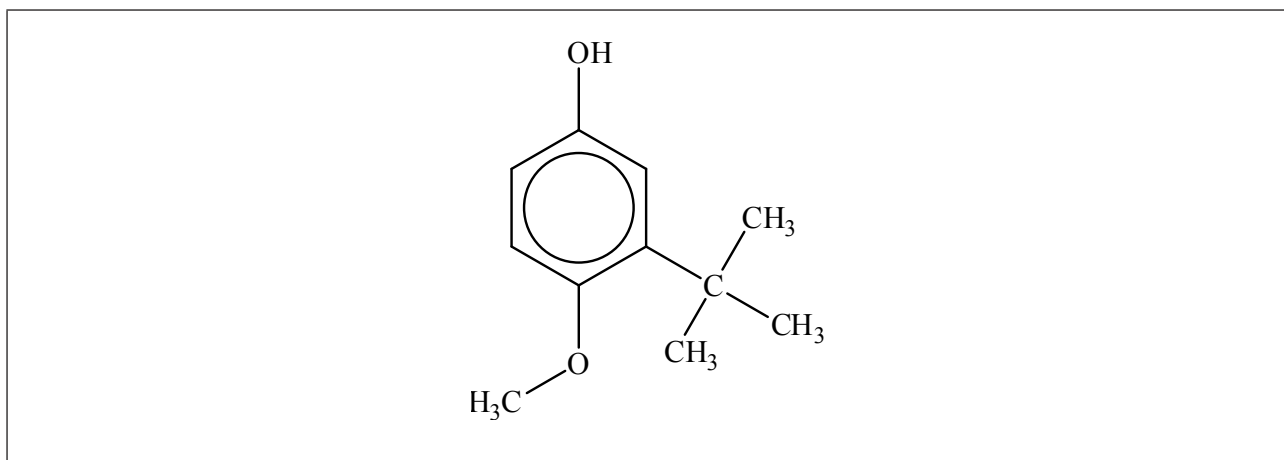
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(Question F1 continued)

- (c) The structure of a synthetic antioxidant, 2-BHA (2-*tert*-butyl-4-hydroxyanisole) is shown below.



Draw a circle around the part of the 2-BHA molecule which corresponds to:

- (i) the phenolic group, and label it A. [1]
- (ii) the tertiary butyl group, and label it B. [1]
- (d) Discuss **two** advantages and **one** disadvantage of natural and/or synthetic antioxidants. [3]

Advantages:

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Disadvantage:

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F2. Naturally occurring pigments give many foods their distinctive colours.

(a) List **two** factors which may affect the colour stability of a pigment. [2]

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(b) Chlorophyll is a pigment found in green vegetables.

A student decided to investigate the effect of sodium hydrogencarbonate, NaHCO_3 , and vinegar on the colour of cooked green peas. Her results are shown below:

Experiment	Colour of peas before cooking	Colour of peas after cooking
Peas heated in water containing NaHCO_3	Green	Green
Peas heated in water containing vinegar	Green	Olive-brown

(i) State how the sodium hydrogencarbonate maintains the green colour of the peas. [1]

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(Question F2 continued)

- (ii) The structure of chlorophyll is shown in Table 22 of the Data Booklet. Describe what happens to the structure of chlorophyll when the peas are heated in water containing vinegar. [1]

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- (iii) State the substance responsible for the olive-brown colour. [1]

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- (c) The brown colour of roast meat is mainly due to the products of the Maillard reactions. Explain the chemistry of these non-enzymatic browning reactions. [3]

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F3. In recent years, the use of soybean oil by the food industry has increased. A significant proportion of this oil is produced from genetically modified soybeans.

Discuss **two** benefits and **two** concerns of using genetically modified foods.

[4]

Benefits:

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Concerns:

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Option G — Further organic chemistry

G1. (a) When 2-methylbut-1-ene, $\text{H}_2\text{C}=\text{C}(\text{CH}_3)\text{CH}_2\text{CH}_3$, reacts with hydrogen bromide the major organic product is 2-bromo-2-methylbutane, $(\text{CH}_3)_2\text{C}(\text{Br})\text{CH}_2\text{CH}_3$.

(i) State the name of the mechanism which describes this type of reaction. [1]

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(ii) Describe the mechanism of this reaction using structural formulas and curly arrows to represent the movement of electron pairs. [3]

(iii) Explain why the major organic product is 2-bromo-2-methylbutane and not 1-bromo-2-methylbutane. [2]

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(Question G1 continued)

- (b) Outline **one** way in which 2-bromo-2-methylbutane could be converted into 2-methylbutan-2-ol. [1]

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- (c) 2-methylbutan-2-ol can also be synthesized starting with bromoethane and propanone via an organometallic intermediate. State the reagents and conditions necessary to prepare the organometallic reagent from the bromoethane. [2]

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- G2. (a) Discuss **three** separate pieces of evidence (physical or chemical) to show that the bonding between the carbon atoms in benzene is not simply alternate double and single carbon-carbon covalent bonds.

[3]

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- (b) Describe and explain the reactivities of iodobenzene and (iodomethyl)benzene with a warm aqueous solution of sodium hydroxide.

[4]

Iodobenzene:

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(Iodomethyl)benzene:

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G3. (a) Explain why methanoic acid is a stronger acid than ethanoic acid. [2]

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(b) Explain why 3-chloropropanoic acid is a stronger acid than propanoic acid. [2]

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