



22116118

**CHEMISTRY
STANDARD LEVEL
PAPER 3**

Tuesday 10 May 2011 (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.



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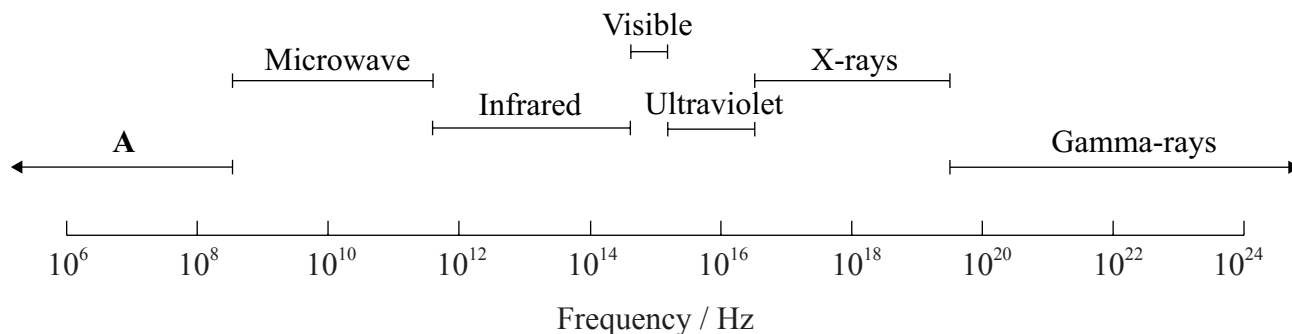
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Option A — Modern analytical chemistry

A1. Selected regions of the electromagnetic spectrum are represented in order of increasing frequency below.



(a) Identify region A. [1]

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(b) Identify the atomic or molecular processes associated with microwave and ultraviolet radiation. [2]

Microwave:
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Ultraviolet:
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(c) State which region of the electromagnetic spectrum can be used to identify the functional groups present in a molecule. [1]

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Turn over

(Question A1 continued)

- (d) Explain why the absorptions in infrared (IR) spectroscopy occur at much higher frequency than those in ^1H NMR spectroscopy. [2]

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A2. Infrared spectroscopy is commonly used as an analytical technique by inorganic, physical and organic chemists.

(a) Explain why hydrogen bromide is IR active whereas bromine is IR inactive. [1]

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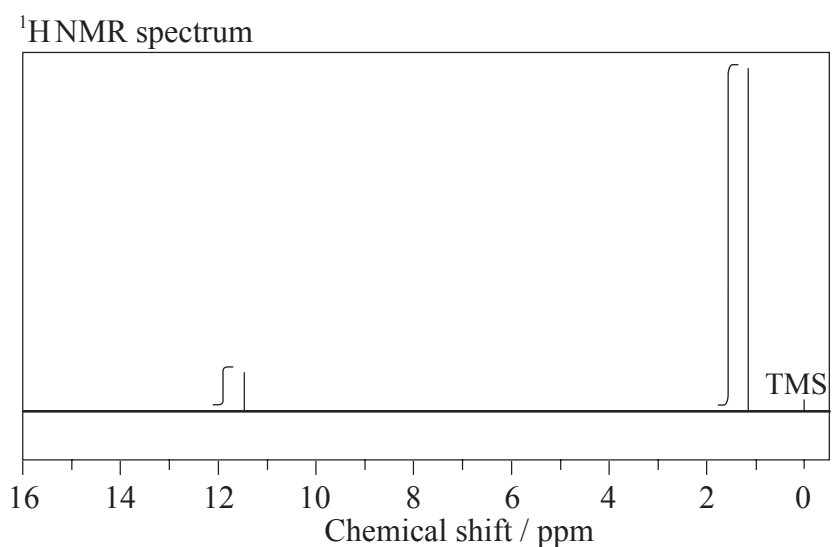
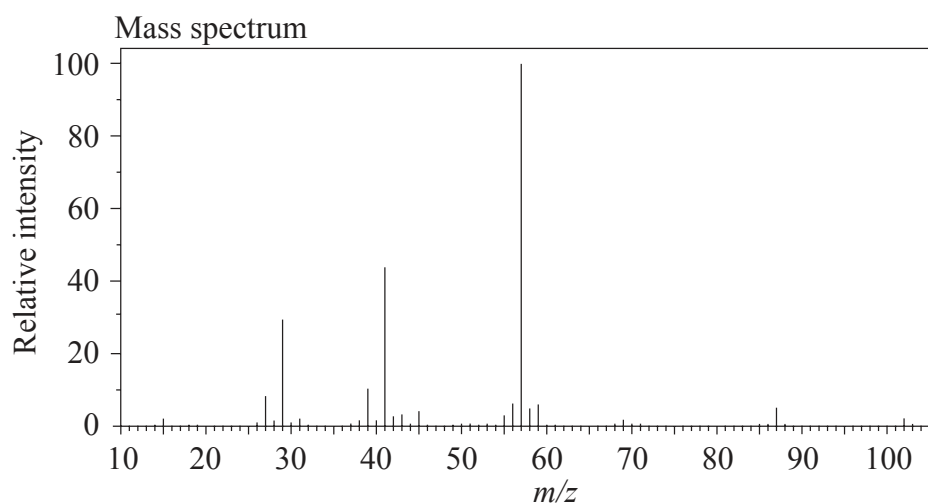
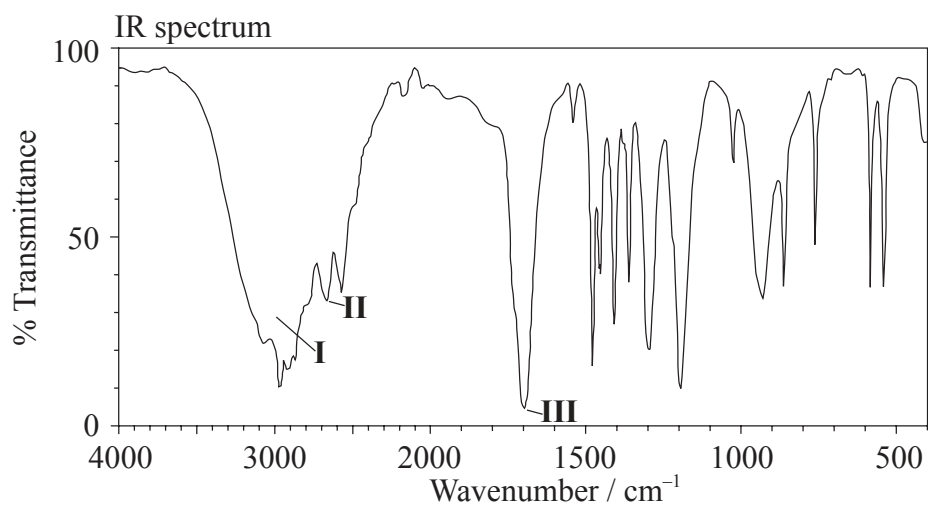


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(Question A2 continued)

- (b) The IR spectrum, mass spectrum and ^1H NMR spectrum of an unknown compound, **X**, of molecular formula $\text{C}_5\text{H}_{10}\text{O}_2$, are as follows.



[Source: SDBSWeb: <http://riod01.ibase.aist.go.jp/sdbs/> (National Institute of Advanced Industrial Science and Technology)]

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(Question A2 continued)

- (i) In the IR spectrum, identify the bond responsible for each of the absorptions labelled **I**, **II** and **III**. [3]

I:

II:

III:

- (ii) In the mass spectrum, deduce which fragments the m/z values at 102, 57 and 45 correspond to. [3]

$m/z = 102:$

$m/z = 57:$

$m/z = 45:$

- (iii) Identify the peak at 11.5 ppm in the ^1H NMR spectrum. [1]

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- (iv) State what information can be obtained from the integration traces in the ^1H NMR spectrum about the hydrogen atoms responsible for the peak at 1.2 ppm. [1]

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(Question A2 continued)

(v) Deduce the structure of **X**.

[1]

(vi) $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_3$ is an isomer of **X**. Deduce **two** differences between the ^1H NMR spectrum of this isomer and that of **X**.

[2]

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A3. Nuclear magnetic resonance (NMR) spectroscopy is the basis of a diagnostic medical technique called magnetic resonance imaging (MRI). The instrument used in this technique in a hospital is shown below.



[Source: http://en.wikipedia.org/wiki/File:Modern_3T_MRI.JPG]

Explain the role of NMR in this technique which can be used to obtain a three-dimensional view of organs in the human body.

[2]

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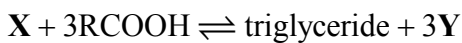


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Option B — Human biochemistry

B1. Triglycerides are one of three types of lipid found in the human body. The following equation represents the formation of a triglyceride.



- (a) Identify the compounds **X** and **Y**. [2]

<p>X:</p> <p>Y:</p>

- (b) Draw the structural formula of a triglyceride formed from one molecule each of octanoic acid, lauric acid and stearic acid. The formulas of the acids are shown in Table 22 of the Data Booklet. [1]

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- (c) Explain whether the triglyceride in part (b) is a solid or a liquid at room temperature. [3]

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(Question B1 continued)

(d) Identify the type of reaction that occurs during the formation of a triglyceride. [1]

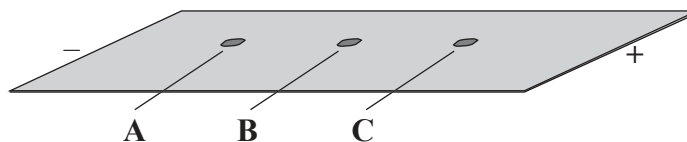
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(e) Explain why fats have a higher energy value per mole than carbohydrates. [1]

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B2. (a) A mixture of the amino acids serine (Ser), glutamic acid (Glu) and lysine (Lys) was separated using electrophoresis and a buffer of pH 5.7. A drop containing the mixture was placed in the centre of the paper and a potential difference was applied. The amino acids were developed and the following results were obtained.



(i) Describe how the amino acid spots may have been developed. [1]

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(ii) Predict which amino acid is present at spot **C**. Explain your answer. [3]

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(iii) The amino acid at spot **B** is at its isoelectric point. Describe **one** characteristic of an amino acid at its isoelectric point. [1]

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(Question B2 continued)

(b) Explain, using equations, how the amino acid glycine (Gly) can act as a buffer. [2]

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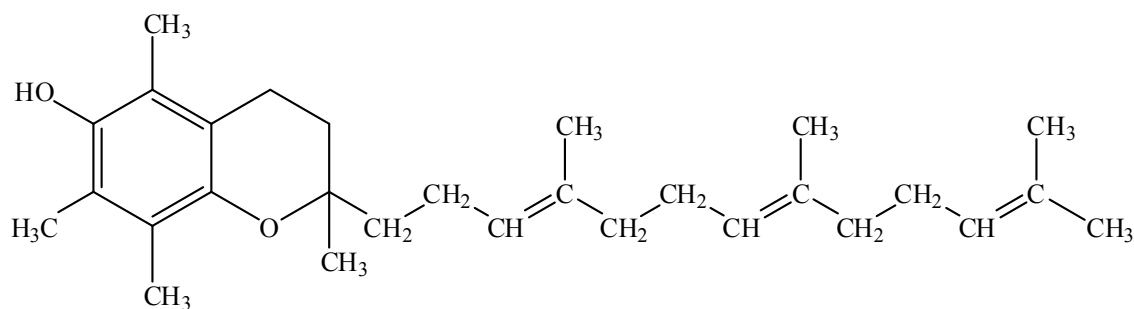
B3. (a) Define the term *micronutrient* and state **one** example of a mineral which is a micronutrient. [2]

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(b) Suggest the name of a condition or disease that may be improved by eating margarine that has vitamin A added to it. [1]

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(c) The structure of one form of vitamin E is shown below.



State and explain whether vitamin E is fat soluble or water soluble. [2]

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Option C — Chemistry in industry and technology

C1. Aluminium and its alloys are widely used in industry.

(a) Aluminium metal is obtained by the electrolysis of alumina dissolved in molten cryolite.

(i) Explain the function of the molten cryolite. [1]

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(ii) State the half-equations for the reactions that take place at each electrode. [2]

Positive electrode (anode):
.....
Negative electrode (cathode):
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(b) Outline **two** different ways that carbon dioxide may be produced during the production of aluminium. [2]

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C2. Catalysts may be homogeneous or heterogeneous.

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

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(b) (i) Explain how a heterogeneous catalyst may increase the rate of the reaction between carbon monoxide, CO(g), and nitrogen monoxide, NO(g). [2]

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(ii) Outline **one** disadvantage of using a heterogeneous catalyst rather than a homogeneous catalyst. [1]

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(Question C2 continued)

- (c) Discuss **two** factors which need to be considered when selecting a catalyst for a particular chemical process. [2]

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- (d) (i) Identify the catalyst used in the catalytic cracking of long chain hydrocarbons and state **one** other condition needed. [2]

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- (ii) State an equation for the catalytic cracking of the straight chain hydrocarbon pentadecane, $C_{15}H_{32}$, to produce **two** products with similar masses. [1]

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C3. Liquid-crystal displays are used in digital watches, calculators and laptops.

- (a) Describe the liquid-crystal state, in terms of molecular arrangement, and explain what happens as temperature increases. [3]

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- (b) Discuss **three** properties a substance should have if it is to be used in liquid-crystal displays. [3]

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Option D — Medicines and drugs

D1. (a) Aspirin and paracetamol (acetaminophen) are mild analgesics.

(i) State **one** advantage of aspirin and **one** disadvantage of paracetamol (acetaminophen). [2]

Advantage of aspirin: Disadvantage of paracetamol:

(ii) Explain why it is dangerous to take aspirin when ethanol has also been consumed. [1]

.....

(This question continues on the following page)



Turn over

(Question D1 continued)

(b) Morphine is a strong analgesic which is administered parenterally.

(i) State the meaning of the term *parenteral*. [1]

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(ii) Explain how a strong analgesic such as morphine prevents pain. [2]

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(iii) The structures of morphine and diamorphine (heroin) are shown in Table 20 of the Data Booklet. State the name of a functional group present in diamorphine (heroin) but not in morphine. [1]

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D2. Caffeine and nicotine are two common stimulants.

(a) Describe **two** effects of large amounts of caffeine on the human body. [2]

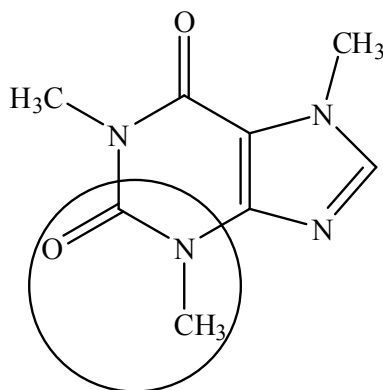
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(b) (i) State the name of the functional group circled on the structure of caffeine. [1]



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(ii) Deduce which functional group is common to both nicotine and caffeine. [1]

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(iii) Identify **one** short-term effect of nicotine consumption. [1]

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D3. During drug development, trials are conducted to determine the therapeutic window.

(a) Explain the meaning of the term *therapeutic window* and discuss its importance in drug administration. [4]

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(b) Explain the use of placebos in clinical trials on humans. [3]

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(c) Identify **one** other effect of a drug which must be determined during clinical trials. [1]

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Option E — Environmental chemistry

E1. Carbon dioxide, methane and chlorofluorocarbons (CFCs) are well known greenhouse gases. Nitrogen trifluoride, NF_3 , is thousands of times more effective at warming the atmosphere than an equal mass of carbon dioxide. NF_3 can be used in the manufacture of computer chips and thin-film solar photovoltaic cells.

- (a) Identify **two** greenhouse gases not mentioned above. One of the gases that you identify should contain a nitrogen atom. For each gas, state its source. [4]

<p>Greenhouse gas 1:</p> <p>.....</p> <p>Source:</p> <p>.....</p> <p>Greenhouse gas 2:</p> <p>.....</p> <p>Source:</p> <p>.....</p>

- (b) The methane produced by sheep and cows can contribute to global warming. In Australia, it is considered that sheep and cows produce approximately 14 % of the country's total greenhouse emissions. Explain how this methane is formed. [1]

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

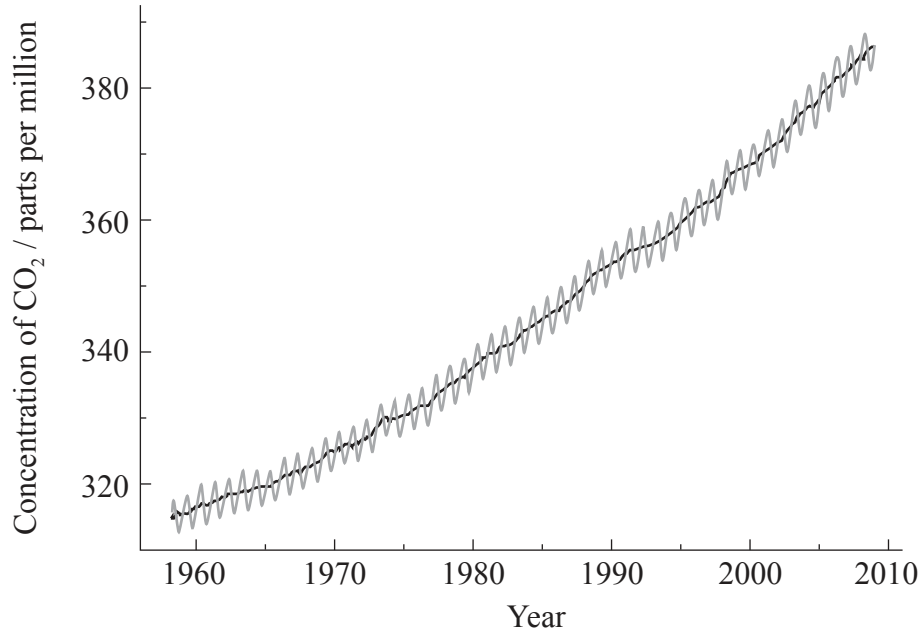
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(Question E1 continued)

- (c) The following graph shows the annual increase in the concentration of atmospheric carbon dioxide recorded at Mauna Loa, Hawaii.



[Source: http://scrippsco2.ucsd.edu/graphics_gallery/mauna_loa_record/mauna_loa_record.html]

Explain why the graph is not smooth but involves annual fluctuations (shown in grey). [1]

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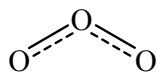
(d) State **one** effect of global warming. [1]

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E2. In the stratosphere, ozone helps to protect the Earth from harmful frequencies of light. The structure of ozone is shown below.



(a) Describe, using equations, the formation of ozone in the stratosphere by natural processes. [2]

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(b) Chlorofluorocarbons (CFCs) deplete the ozone layer.

(i) List **two** sources of CFCs. [2]

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(ii) Discuss **one** advantage and **one** disadvantage of using hydrocarbons as alternatives to CFCs. [2]

Advantage:
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Disadvantage:
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E3. Fresh supplies of water are of major importance to society today.

- (a) Both mercury and polychlorinated biphenyls (PCBs) can potentially cause serious health effects when present in water. State **one** source for each of these two pollutants. [2]

Mercury: PCBs:

- (b) Fresh water can be obtained from sea water by using multi-stage distillation and reverse osmosis. Evaluate these **two** processes. Your answer should include a description of **each** process. [5]

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Option F — Food chemistry

F1. (a) Rancidity is the perception of flavours in lipids that our senses perceive as off because of a disagreeable smell, taste, texture or appearance. The processes that create the off-flavours may be hydrolytic rancidity or oxidative rancidity in lipids.

(i) Predict the products of hydrolytic rancidity of fats. [2]

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(ii) The hydrolysis of milk products is used in the making of cheese. State **two** conditions which increase the rate of hydrolysis of fats in milk. [3]

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(iii) Potato chips (crisps) are cooked in oils made from unsaturated fatty acids. Explain in terms of chemical processes why potato chips are purchased in sealed, opaque, nitrogen-filled foil packs and taste best when freshly opened. [3]

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(Question F1 continued)

- (b) Emulsifiers are used in the production of salad dressing to form an oil-in-water emulsion. This increases the shelf life of the dressing. Describe the action of the emulsifiers. [3]

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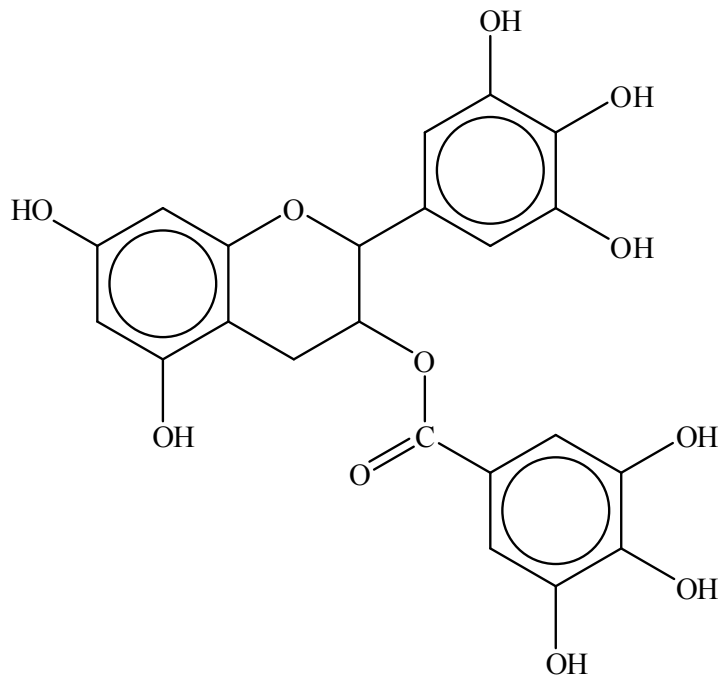
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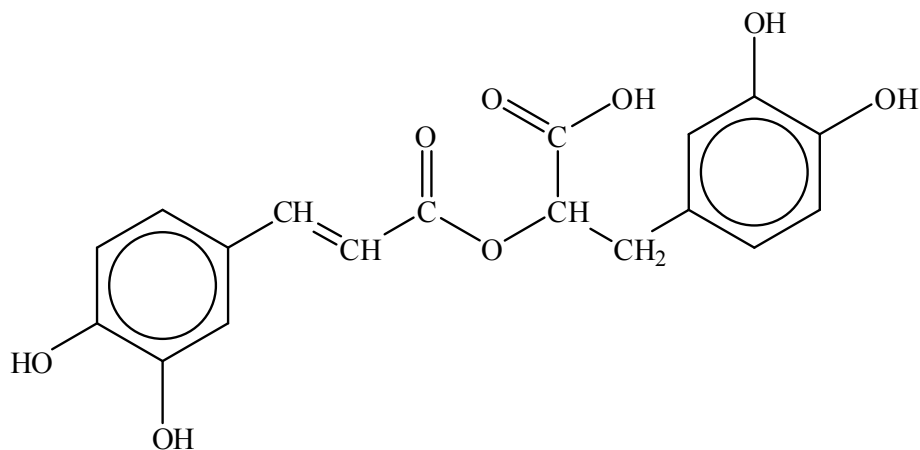
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- F2. (a) Antioxidants are substances that slow the rate of oxidation of foods and may also be consumed to provide health benefits. Two traditional foods with antioxidant properties are green tea and oregano. Green tea contains epigallocatechin-3-gallate (EGCG) and oregano contains rosmarinic acid. The structures of these two compounds are shown below.



Epigallocatechin-3-gallate (EGCG)



Rosmarinic acid

- (i) Compare the structural features of EGCG and rosmarinic acid. [2]

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(Question F2 continued)

- (ii) List **two** health benefits of consuming foods such as green tea and oregano. [2]

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(b) Anthocyanins are naturally occurring pigments responsible for the colour of blueberries and cranberries. The structures of two forms of anthocyanins are shown in Table 22 of the Data Booklet.

- (i) Using the abbreviations QB for quinoidal base and FC⁺ for flavylum cation, state an equation to describe how pH affects the colour of anthocyanins. [1]

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- (ii) Suggest why blueberries should not be stored in aluminium cans. [2]

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F3. Genetic engineering is an important technique used to alter the properties of foods.

(a) Define the term *genetically modified (GM) food*. [1]

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(b) Discuss **one** benefit and **one** concern of using genetically modified (GM) crops in food. [2]

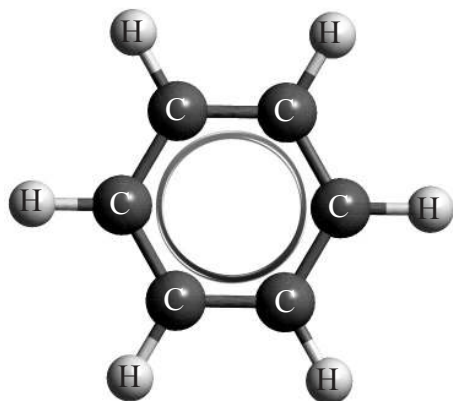
Benefit:
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Concern:
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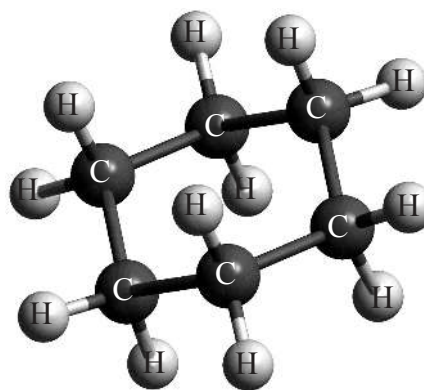


Option G — Further organic chemistry

G1. Benzene, C_6H_6 , is a planar compound which differs from the non-planar structure of cyclohexane, C_6H_{12} . The structures of benzene and the most stable form of cyclohexane are represented below.



Benzene



Cyclohexane

- (a) With reference to the compounds benzene, cyclohexane and 1,3-cyclohexadiene, state which compound would contain the shortest carbon-carbon bond length. [1]

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- (b) Explain why it is more common for benzene to undergo substitution reactions than addition reactions. [1]

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(Question G1 continued)

- (c) Suggest why chloromethylbenzene, $C_6H_5CH_2Cl$, reacts with warm aqueous sodium hydroxide, NaOH, easily whereas for chlorobenzene, C_6H_5Cl , stronger conditions such as high temperature (*e.g.* 350 °C) are needed. [2]

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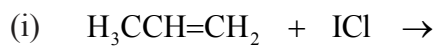
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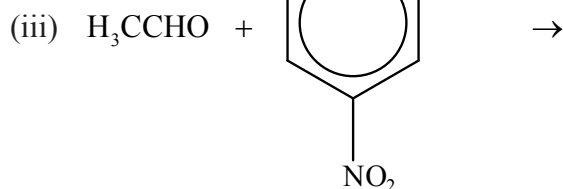
- G2. (a) Draw the structural formulas of the **major** organic products formed in the following reactions.



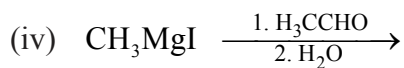
[1]



[1]



[1]



[1]

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(Question G2 continued)

- (b) Draw the structural formula of the other product of the reaction in part (a) (i). [1]

- (c) Identify each of the types of reaction in (a) as elimination, nucleophilic addition, electrophilic addition, acid-base, addition-elimination or Grignard. [4]

Reaction	Type
(a) (i)	
(a) (ii)	
(a) (iii)	
(a) (iv)	



G3. Identify a suitable catalyst for the dehydration reaction of ethanol, $\text{CH}_3\text{CH}_2\text{OH}$, and describe and explain the mechanism of the reaction using curly arrows to represent the movement of electron pairs. State the name of the organic product formed.

[4]

Catalyst:

.....

Mechanism:

Name of organic product:

.....



G4. Deduce a two-step reaction pathway which can be used to convert butan-1-ol, $\text{CH}_3(\text{CH}_2)_3\text{OH}$, into 1,2-dibromobutane, $\text{CH}_3\text{CH}_2\text{CHBrCH}_2\text{Br}$. State the reagents used in each step and identify the product formed in step 1. [3]

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