



88146106

**CHEMISTRY
STANDARD LEVEL
PAPER 3**

Candidate session number

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Wednesday 19 November 2014 (morning)

Examination code

1 hour

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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].

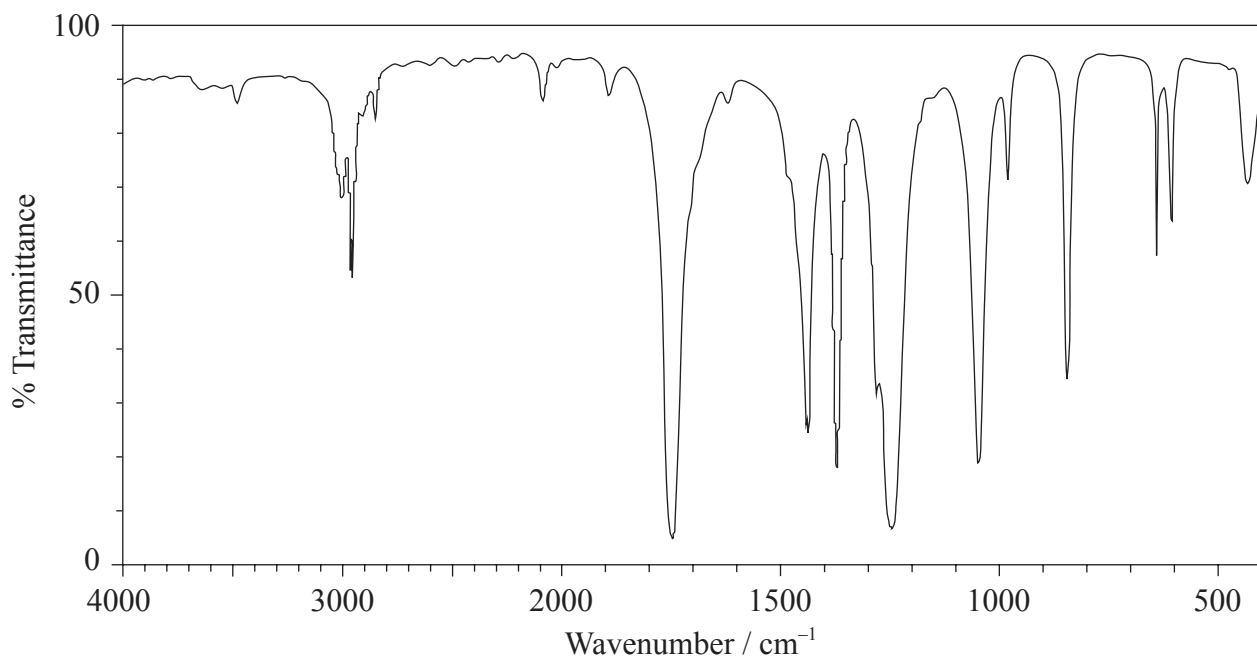
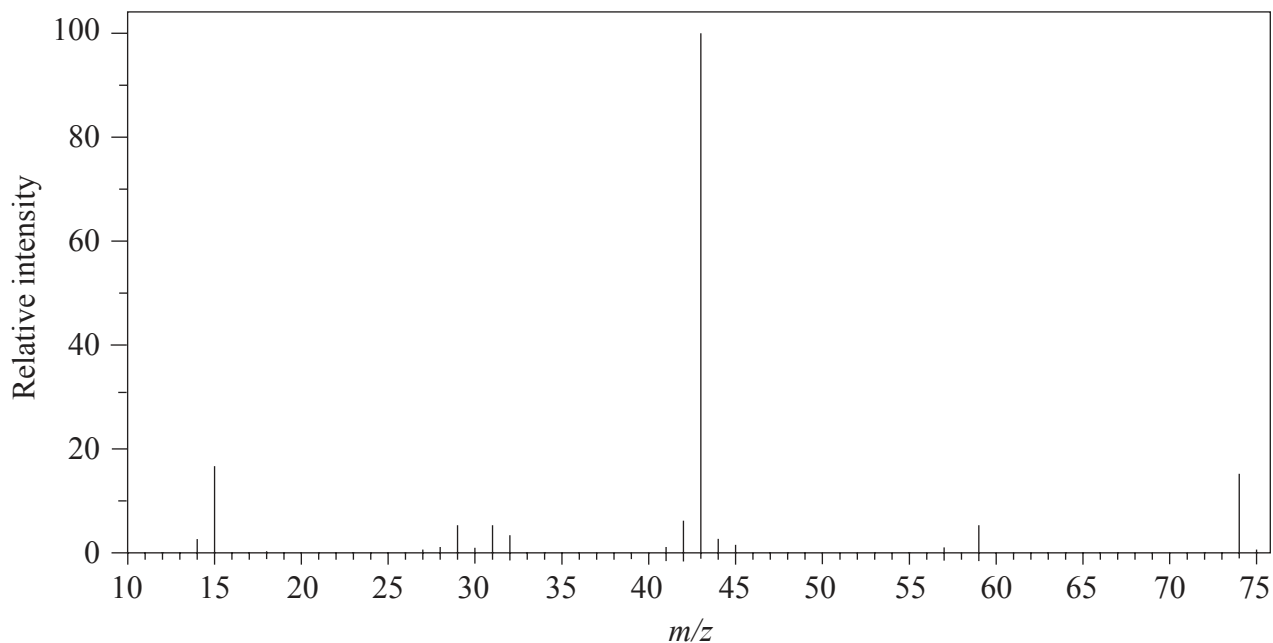
Option	Questions
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36EP01

Option A — Modern analytical chemistry

1. The mass spectrum and infrared (IR) spectrum of a compound are shown below.



[Source: SDBS web: www.sdbb.riodb.aist.go.jp (National Institute of Advanced Industrial Science and Technology, 2013)]

(Option A continues on the following page)



36EP02

(Option A, question 1 continued)

- (a) (i) State the information about this particular compound that can be derived from the mass spectrum and outline how it is found. [2]

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- (ii) Suggest how the fragment with $m/z = 43$ is formed from the original molecule. [1]

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- (b) (i) Use the IR spectrum in the region $1600 - 1800 \text{ cm}^{-1}$ to deduce **one** functional group that is present in the compound and **one** group that is absent. [2]

Present:
.....
.....
Absent:
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.....

(Option A continues on the following page)



(Option A, question 1 continued)

- (ii) The molecular formula of the compound is $C_3H_6O_2$. Explain, with reference to another region of the IR spectrum, why the compound could **not** be propanoic acid, CH_3CH_2COOH . [2]

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- (iii) Deduce the structures of two possible isomers of propanoic acid consistent with the IR spectrum. [2]

- (c) 1H NMR spectroscopy is often very useful in distinguishing between closely related compounds such as those above.

- (i) State the region of the electromagnetic spectrum that is used in this technique. [1]

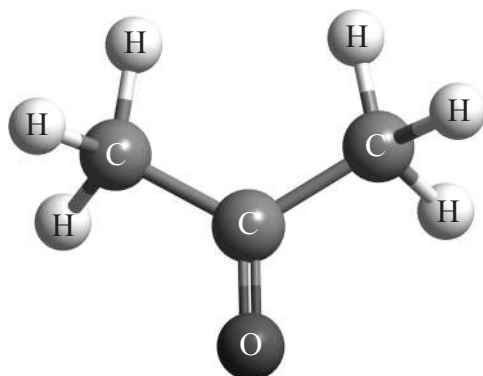
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(Option A continues on the following page)

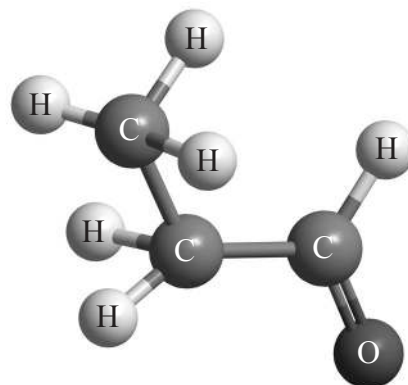


(Option A, question 1 continued)

(ii) The structures of two other closely related compounds are shown below.



Compound I



Compound II

Discuss how you would expect the ^1H NMR spectra of these two compounds to differ, using Table 18 of the Data Booklet.

[2]

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(Option A continues on the following page)



36EP05

Turn over

(Option A continued)

2. Waste water from an abandoned copper mine is suspected of polluting a community's drinking water supply, causing concern that the concentration of dissolved copper compounds might exceed the legal limit of 1.3 ppm.

(a) State the most appropriate analytical technique to investigate the concentration of copper in the water supply. [1]

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(b) Outline how this technique could be used to determine the concentration of copper ions present in a particular sample of water. [2]

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(Option A continues on the following page)



(Option A continued)

3. The principles of chromatography can be demonstrated using paper chromatography to analyse the ink of a pen, using propanone as the mobile phase.

(a) State how you could tell whether the ink was a single substance or a mixture of components. [1]

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(b) Explain how paper chromatography separates the components. [2]

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(c) The R_f value of the components of the ink could be measured. Define the term R_f . [1]

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(d) State **one** factor that would alter the R_f value of a particular component. [1]

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End of Option A



36EP07

Turn over

Option B — Human biochemistry

4. (a) Define the term *iodine number*. [1]

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- (b) Diets that are high in omega-3 fatty acids are recommended as healthy for the heart. Eicosapentaenoic acid ($M_r=302$) is a common omega-3 fatty acid found in fish oils. Calculate the number of carbon-carbon double bonds in one molecule of this acid if 3.02 g of this acid reacts with 12.7 g of I_2 ($M_r=254$). [3]

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5. List **two** health problems associated with a diet that is low in dietary fibre. [2]

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(Option B continues on the following page)



(Option B continued)

6. (a) Draw the structure of a 2-amino acid.

[1]

(b) (i) Using Table 19 of the Data Booklet, draw the structure of the **two** dipeptides formed by the reaction of glycine with valine.

[2]

(ii) State the other product of the reaction in (i).

[1]

.....

(Option B continues on the following page)



36EP09

Turn over

(Option B, question 6 continued)

- (c) Explain how a given protein can be broken down into its constituent amino acids and how these can be identified by electrophoresis. [5]

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7. (a) The structures of some fatty acids are given in Table 22 of the Data Booklet. State why it is important to have a diet that contains essential fatty acids. [1]

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- (b) Compare the structures and chemical formulas of the two essential fatty acids linoleic acid and linolenic acid. [4]

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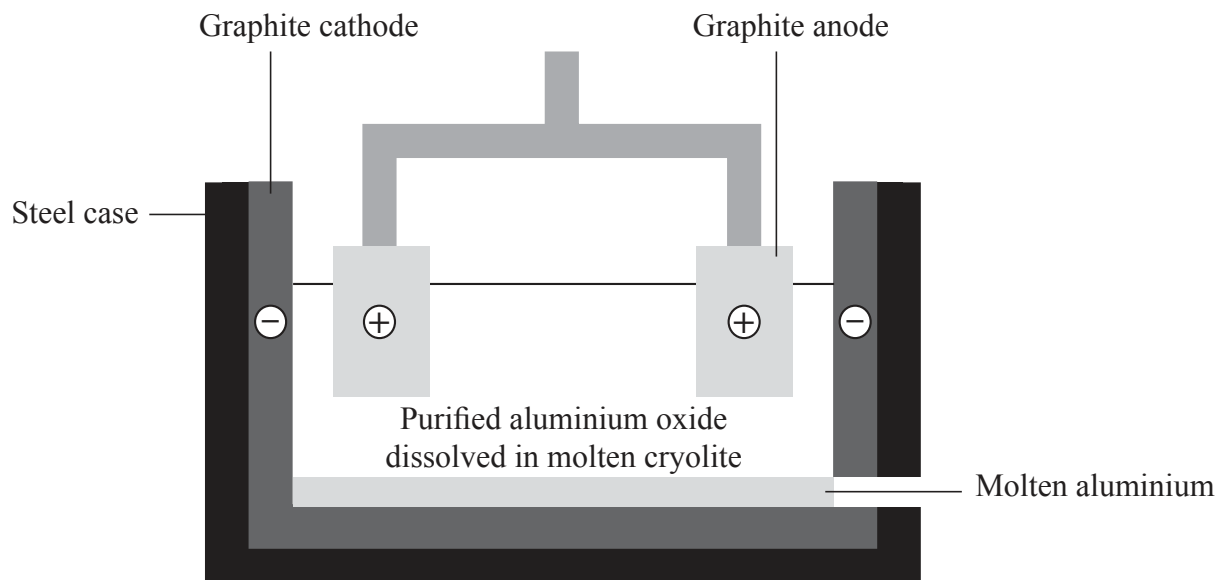
End of Option B



36EP10

Option C — Chemistry in industry and technology

8. Aluminium is chemically reactive so it has to be extracted by the electrolysis of aluminium oxide dissolved in molten cryolite.



- (a) Deduce an equation for the discharge of the ions at each electrode. [2]

Positive electrode (anode):

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.....

Negative electrode (cathode):

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(Option C continues on the following page)



36EP11

Turn over

(Option C, question 8 continued)

- (b) (i) Outline why aluminium is alloyed with copper and magnesium when used to construct aircraft bodies. [1]

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- (ii) State **two** properties of aluminium that make it suitable for use in overhead power cables. [1]

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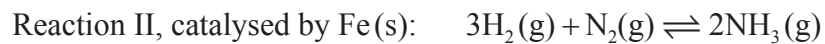
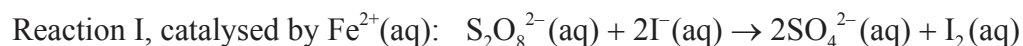
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(Option C continues on the following page)



(Option C continued)

9. Iron acts as a catalyst in the chemical reactions below.



(a) State the type of catalysis occurring in reaction I. [1]

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(b) Outline the mechanism by which each catalyst lowers the activation energy in the reactions above, and state a particular disadvantage of each type of catalysis. [4]

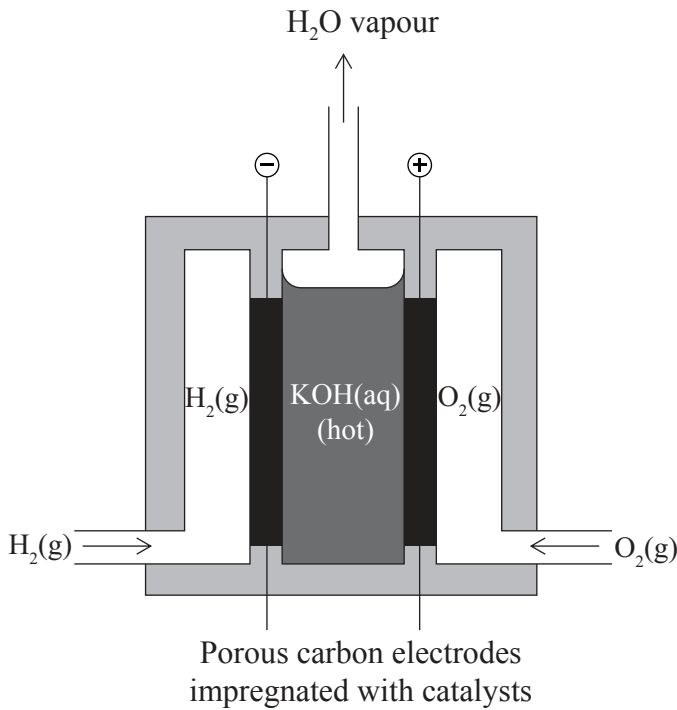
Catalyst	Mechanism	Disadvantage
$\text{Fe}^{2+}(\text{aq})$
$\text{Fe}(\text{s})$

(Option C continues on the following page)

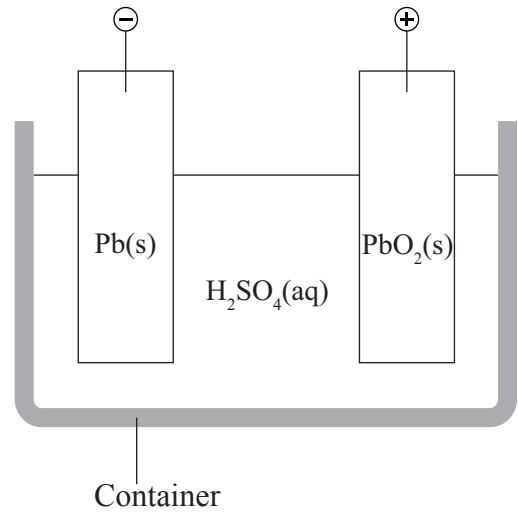


(Option C continued)

10. The diagrams below show a hydrogen-oxygen fuel cell with an alkaline electrolyte and a lead-acid battery (accumulator).



Hydrogen-oxygen fuel cell



One cell of a lead-acid battery

[Source: adapted from <http://chempaths.chemeddl.org>]

Discuss **one** advantage and **one** disadvantage for both fuel cells and lead-acid batteries.

[4]

	Advantage	Disadvantage
Fuel cells
Lead-acid batteries

(Option C continues on the following page)



36EP14

(Option C continued)

11. Liquid crystals are widely used in displays.

(a) Describe the meaning of the term liquid crystals. [1]

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(b) When a liquid-crystal display is warmed with a hairdryer, the display loses its clarity and may no longer be visible. Explain why this happens on a molecular level. [2]

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(Option C continues on the following page)



36EP15

Turn over

(Option C continued)

12. There is much debate about the need for laws to regulate research and development into nanotechnology.

(a) Define the term *nanotechnology*. [2]

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(b) Discuss **two** concerns about its development and use. [2]

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End of Option C



36EP16

Option D — Medicines and drugs

13. The development of new and improved medications for the reduction and management of pain is an important part of 21st-century medicine.

(a) Explain the way that mild and strong analgesics prevent pain. [4]

<p>Mild analgesics:</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>Strong analgesics:</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>

(b) The structure of morphine and diamorphine (heroin) are shown in Table 20 of the Data Booklet. State the name of the functional group present in diamorphine that is not present in morphine. [1]

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

(Option D continues on the following page)



36EP17

Turn over

(Option D, question 13 continued)

- (c) Discuss **two** advantages and **two** disadvantages of the medical use of morphine and its derivatives.

[2]

Advantages:

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Disadvantages:

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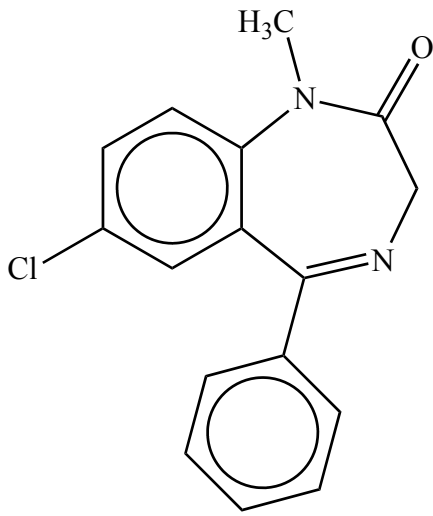
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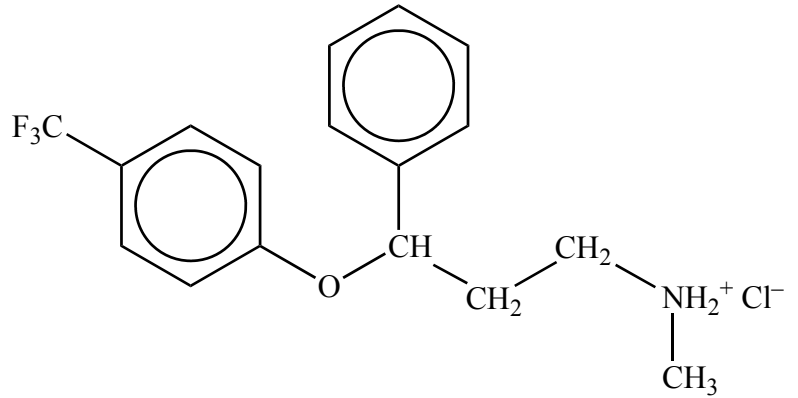
36EP18

(Option D continued)

14. Compare the structures of diazepam (Valium®) and fluoxetine hydrochloride (Prozac®). [2]



Diazepam (Valium®)



Fluoxetine hydrochloride (Prozac®)

One similarity:

.....
.....

One difference:

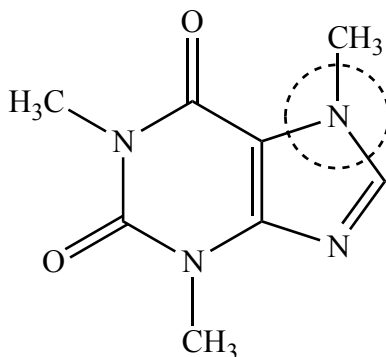
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(Option D continues on the following page)



(Option D continued)

15. (a) Caffeine is commonly used as a stimulant. State the name of the functional group circled in the structure below. [1]



Caffeine

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- (b) State **two** side-effects of caffeine consumption on the body. [1]

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(Option D continues on the following page)



(Option D continued)

16. The first commercially available antibiotic came from a class of compounds known as the penicillins.

(a) Outline the role played by Florey and Chain in the development of penicillin. [2]

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(b) Explain how penicillins work and why it is necessary to continually modify the side-chain. [3]

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(Option D continues on the following page)



36EP21

Turn over

(Option D continued)

17. (a) State **two** ways in which viruses are different from bacteria. [2]

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(b) Describe **two** ways in which antiviral drugs work. [2]

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End of Option D



36EP22

Option E — Environmental chemistry

18. (a) Nitrogen oxides, NO_x , are known air pollutants. State **one** natural and **one** anthropogenic source of NO_x . [2]

Natural source:

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Anthropogenic source:

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- (b) State **one** form of pollution produced as a result of excess NO_x in the atmosphere. [1]

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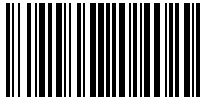
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- (c) State **one** method to decrease the presence of NO_x in the atmosphere. [1]

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(Option E continues on the following page)



36EP23

Turn over

(Option E continued)

19. (a) Describe how the greenhouse effect causes the atmosphere of the Earth to increase in temperature. [3]

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- (b) Identify **one** greenhouse gas other than CO₂ and H₂O and suggest a significant source. [2]

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(Option E continues on the following page)



(Option E continued)

20. The ozone layer protects us by absorbing ultraviolet (UV) radiation from the Sun during its natural formation and depletion.

(a) Describe, using equations, the formation and depletion of ozone in the stratosphere by natural processes. [3]

<p>Formation:</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>Depletion:</p> <p>.....</p> <p>.....</p> <p>.....</p>

(b) Chlorofluorocarbons (CFCs) are known to cause the catalytic depletion of ozone. Alternatives to CFCs include hydrocarbons and hydrofluorocarbons. Suggest **two** properties that give these alternatives advantages over CFCs. [2]

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(Option E continues on the following page)



36EP25

Turn over

(Option E continued)

21. (a) Landfill sites are used to dispose of about 90% of the world's household waste, but incineration is being increasingly used in some countries. Compare the two disposal methods. [4]

One advantage of landfill:

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One disadvantage of landfill:

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One advantage of incineration:

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One disadvantage of incineration:

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- (b) Suggest **two** problems associated with storing high-level radioactive waste underground. [2]

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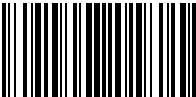
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End of Option E



36EP26

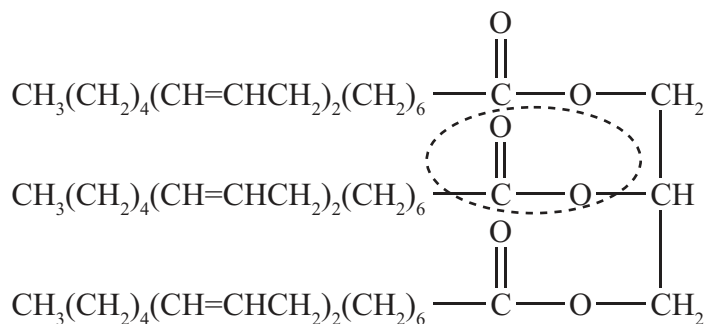
Option F — Food chemistry

22. Most foods contain nutrients.

- (a) Lipids, minerals and water are examples of nutrients. State **two** other examples and a food source for each. [2]

Nutrient	Food source
.....
.....

- (b) Triglycerides are formed by the reaction of propane-1,2,3-triol (glycerol) with fatty acids.



- (i) State the name of the functional group circled in the triglyceride. [1]

.....

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

.....

(Option F continues on the following page)



(Option F, question 22 continued)

- (c) (i) State the difference in structure between the fatty acids found in an oil and those in a fat. [1]

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- (ii) Comment on the relative stability of oils and fats and state the names of **two** possible types of degradation reaction. [2]

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(Option F continues on the following page)



(Option F continued)

23. Most packaged foods have an expiry (best before) date printed on the packet giving an indication of the product's shelf life.

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

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(ii) Identify **one** factor that changes the shelf life and how it affects the quality of foods. [2]

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(b) State **two** traditional methods that can be used to extend the shelf life of foods. [1]

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(Option F continues on the following page)



36EP29

Turn over

(Option F continued)

24. Foods contain pigments.

(a) Red meat contains the colourant heme, the oxidation of which causes the meat to become discoloured.

(i) Outline the oxidation processes that occur. [3]

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(ii) Other than by using additives, state **one** way in which oxidation can be minimized. [1]

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(b) Comment on the importance of international agreement on permitted artificial colourants in food. [2]

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(Option F continues on the following page)



36EP30

(Option F continued)

25. Suggest **two** concerns of growing and eating genetically modified (GM) foods. *[2]*

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End of Option F

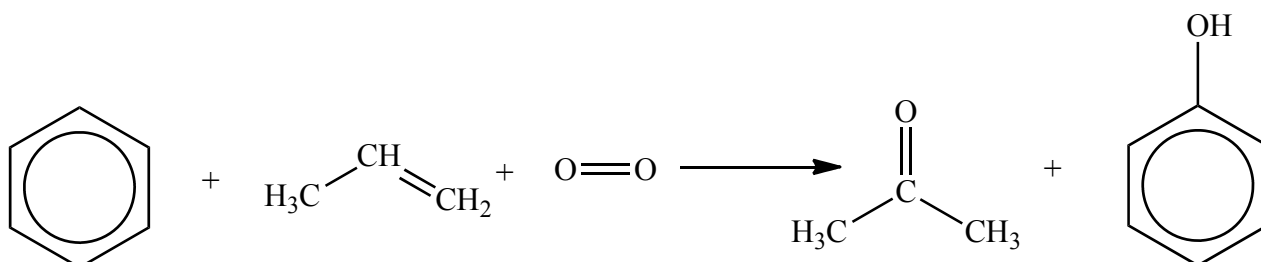


36EP31

Turn over

Option G — Further organic chemistry

26. The cumene process is used for the production of both propanone and phenol. The overall reaction is shown in the equation below.



This process is important in the polymer industry. Propanone can be converted into methyl methacrylate, the monomer used to make Perspex[®], and phenol is used in phenol-methanal resins, which are important thermosetting plastics.

- (a) (i) Like alcohols and carboxylic acids, phenols contain a hydroxyl (O–H) group. List these three classes of compounds in order of **increasing** acidity of the hydroxyl group. [1]

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- (ii) State and explain how the presence of a halogen substituent might affect the acidity of carboxylic acids. [3]

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(Option G continues on the following page)



(Option G, question 26 continued)

- (iii) Phenol could also be produced by the hydrolysis of chlorobenzene. Explain why the hydrolysis of chlorobenzene is a very slow reaction. [2]

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- (iv) Some reactions of chlorobenzene, such as its reaction with magnesium, are similar to those of other halogenoalkanes. State an equation for this reaction and one essential condition for this to occur. [2]

Equation:

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Condition:

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(Option G continues on the following page)

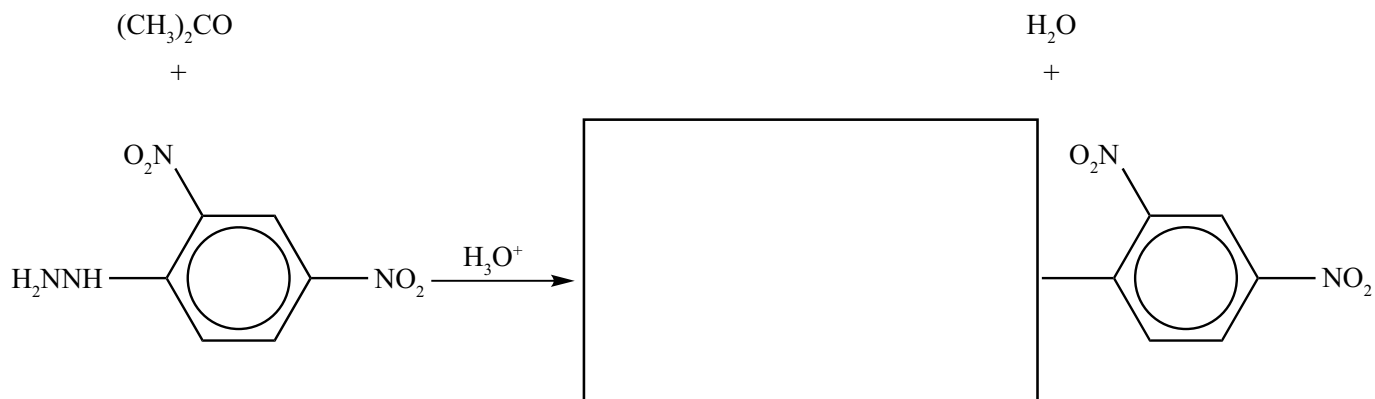


36EP33

Turn over

(Option G, question 26 continued)

- (b) (i) Propanone and other carbonyl compounds react with 2,4-dinitrophenylhydrazine.



Complete the equation above by drawing the rest of the structure of the organic product.

[1]

- (ii) State what would be observed when the reaction occurs.

[1]

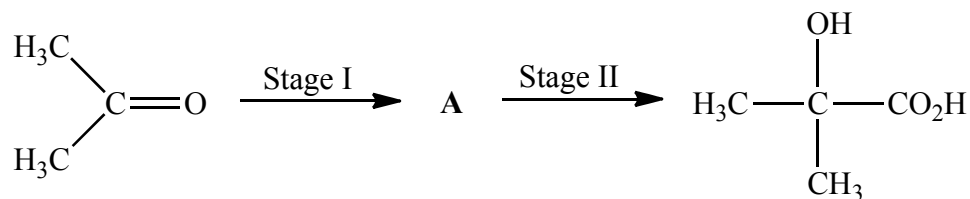
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(Option G continues on the following page)



(Option G, question 26 continued)

- (c) To produce methyl methacrylate, propanone must first be converted into 2-hydroxy-2-methylpropanoic acid, as shown in the scheme below.



- (i) State the structure of the intermediate **A** and the reagents for both its formation from propanone and its conversion to the final product. [3]

Structure of **A**:

Reagent to form **A**:

.....

Reagent for converting **A** to the final product:

.....

(Option G continues on the following page)



(Option G, question 26 continued)

- (ii) 2-hydroxy-2-methylpropanoic acid is dehydrated, by heating with phosphoric acid, to produce methacrylic acid ($\text{CH}_2=\text{C}(\text{CH}_3)\text{COOH}$), which is esterified with methanol to give the methyl methacrylate monomer. Explain the mechanism of the dehydration reaction. [4]

- (d) Propanone could also be formed from propene by reaction with steam over an acidic catalyst, followed by oxidation of the product.

The reaction of propene with water can yield two possible products. Explain, in terms of the stability of the intermediate carbocations, why one is formed in much greater quantities than the other. [3]

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End of Option G



36EP36