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CHEMISTRY
STANDARD LEVEL
PAPER 3

Candidate session number

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Wednesday 9 May 2012 (morning)

1 hour

Examination code

2	2	1	2	–	6	1	1	2

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. Analytical techniques are very useful in determining molecular structures. A compound, **X**, has the empirical formula C_2H_4O.

(a) Identify the analytical technique that would most readily provide the additional data required to calculate the molecular formula of **X**. *[1]*

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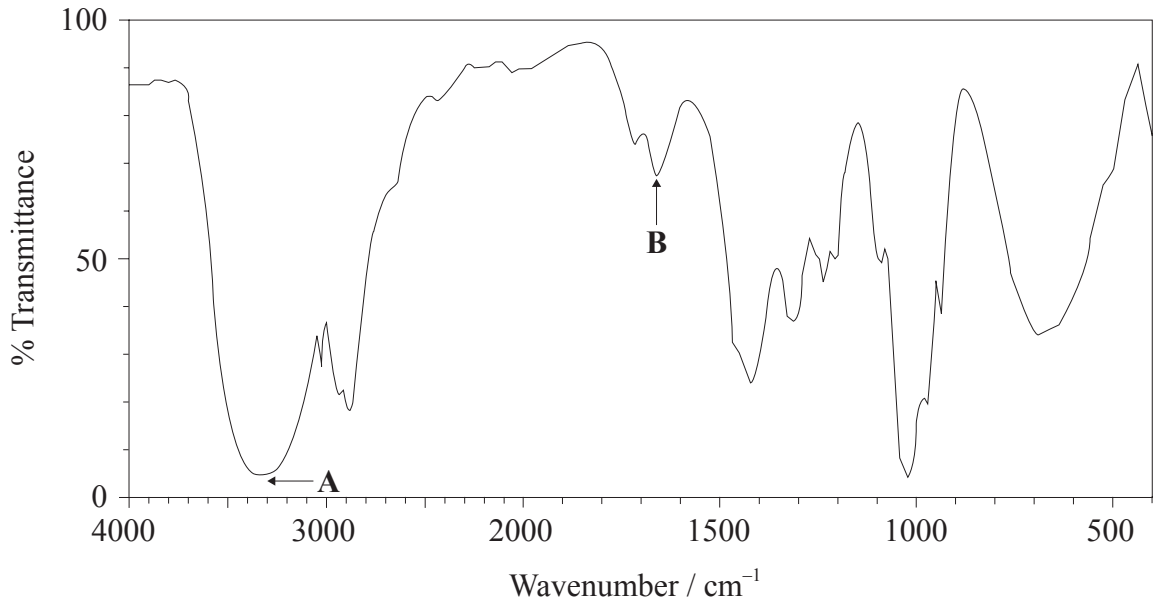
(b) The molecular formula of **X** is $C_4H_8O_2$. The information in the IR spectrum below can be used to help determine the structure of **X**.



(i) State what information about a molecule can be obtained from its IR spectrum. *[1]*

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(Question A1 continued)

(ii) Deduce the information obtained from absorptions **A** and **B**. *[2]*

A: . . . . . .

B: . . . . . .

(iii) Comment on the absence of any major absorption in the region 1700–1750 cm^{-1}. *[1]*

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(c) The ^{1}H NMR spectrum of **X** shows three peaks with relative areas of 2:1:1.

(i) Deduce what information can be obtained from these data. *[2]*

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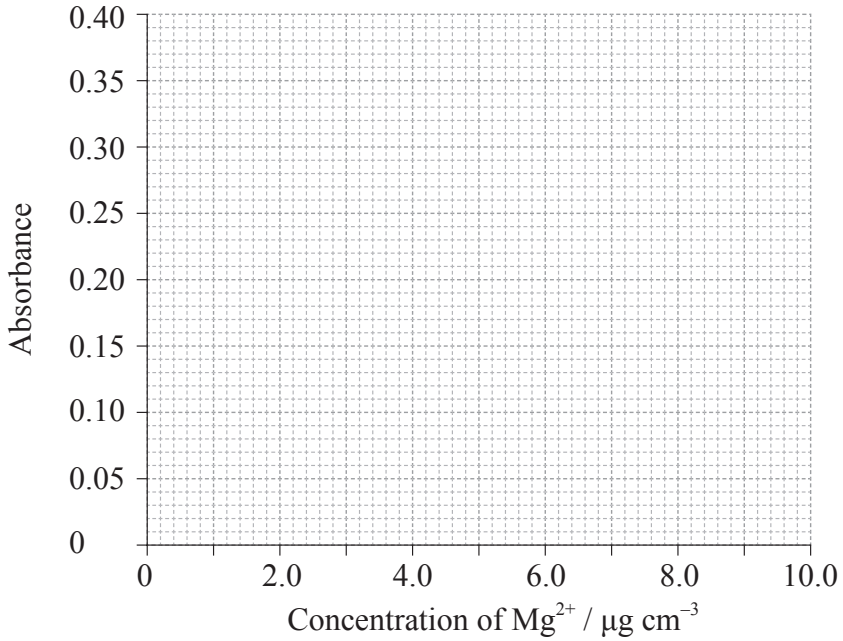
(ii) Deduce the structure of **X**. *[2]*

A2. Atomic absorption spectroscopy is frequently used to determine the concentration of metal ions in aqueous solution.

(a) Atomic absorption spectroscopy was used to determine the concentration of magnesium in cast iron. Solutions of known concentration were used for calibration.

Concentration of Mg^{2+} / μg cm^{-3}	2.00	4.00	6.00	8.00	10.00
Absorbance	0.085	0.169	0.242	0.316	0.393

Construct a calibration graph using the axes below. *[2]*



(b) When a 0.200 g sample of cast iron was dissolved in acid to produce 100 cm^3 of solution, the absorbance of the resulting solution was 0.131. Calculate the percentage by mass of magnesium in the sample. *[3]*

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(Question A2 continued)

(c) The same sample is also analysed for calcium. Identify the change to the instrument that is required. *[1]*

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A3. Chromatography is a technique frequently used to separate mixtures of substances.

(a) Describe how you would show that a sugar solution was a mixture of two substances using the technique of thin-layer chromatography (TLC). *[3]*

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(b) Given solutions of glucose and fructose, explain how you would show that these were the two sugars present in the mixture. *[2]*

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Option B — Human biochemistry

B1. A potato chip (crisp) was ignited and the flame was used to heat a test tube containing water.

Mass of potato chip / g	0.421
Mass of water / g	20.0
Initial temperature of water / °C	17.8
Final temperature of water / °C	51.3

(a) (i) Calculate the heat required, in kJ, to raise the temperature of the water, using data in the table above and from Table 2 of the Data Booklet. *[2]*

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(ii) Determine the enthalpy of combustion of the potato chip, in kJ g^{-1}. *[1]*

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(This question continues on the following page)

(Question B1 continued)

(b) This energy comes mainly from the combustion of triglycerides. State the name of **one** other type of lipid found in the body and **one** role, other than energy storage, of this type of lipid. *[2]*

Name:

. . . . . .

. . . . . .

Role:

. . . . . .

. . . . . .

(c) Explain why lipids have a higher energy content than carbohydrates. *[1]*

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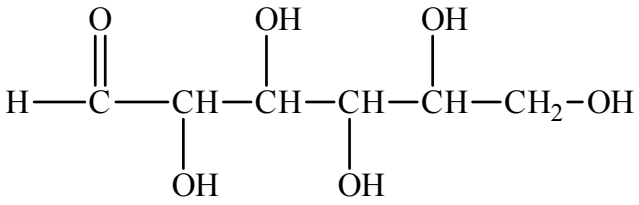
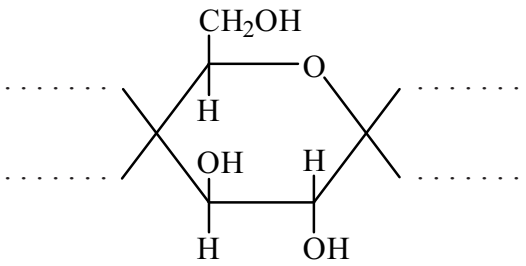
B2. The straight chain form of glucose is represented below.

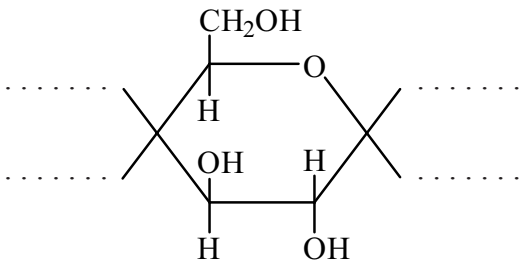


(a) Glucose is mainly present in one of two cyclic forms: α-glucose and β-glucose. Distinguish between the two cyclic forms by completing the diagrams below. *[2]*

α-glucose



β-glucose



(b) Fructose is an isomer of glucose, but they differ with regard to one functional group and hence in their redox properties.

(i) Identify the functional group present in glucose, but not fructose. *[1]*

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(ii) Identify the functional group present in fructose, but not glucose. *[1]*

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(This question continues on the following page)

(Question B2 continued)

(iii) Identify the sugar that acts as a reducing agent. *[1]*

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(c) Outline how the structure of cellulose is related to that of glucose. *[2]*

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(d) Cellulose cannot be digested by humans.

(i) Explain why this is the case. *[1]*

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. . . . . .

(ii) This property makes cellulose a major part of an essential dietary component. State the name of this component and one condition that can result from its deficiency. *[2]*

Name:

. . . . . .

Condition:

. . . . . .

B3. Macronutrients and micronutrients are essential components of a balanced diet.

(a) State the difference between macronutrients and micronutrients. *[1]*

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(b) State **one** consequence of a deficiency of thiamin (vitamin B_1). *[1]*

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(c) Suggest **two** ways in which vitamin deficiencies can be avoided. *[2]*

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Option C — Chemistry in industry and technology

C1. Aluminium and iron are both widely used in modern society.

(a) State **two** major uses of aluminium. *[1]*

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. . . . . .

(b) Iron is much cheaper and stronger than aluminium, but in spite of this, aluminium is preferred to iron-based alloys for uses where it is exposed to the atmosphere. State the major disadvantage of using iron compared to aluminium. *[1]*

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. . . . . .

(c) Almost all iron is used in the form of an alloy. State the name of the most common type of iron alloy and the other element that is an essential component of these alloys. *[1]*

Name:

. . . . . .

Other element:

. . . . . .

(This question continues on the following page)

(Question C1 continued)

(d) An early alloy of aluminium was Duralumin which contained small quantities of copper and magnesium. This is stronger and more rigid than pure aluminium. Explain on an atomic level why the addition of other elements has this effect. *[2]*

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C2. Fuel cells and rechargeable batteries are both convenient ways of providing portable electric power.

(a) Compare fuel cells and rechargeable batteries giving **one** similarity and **one** difference. *[2]*

Similarity:

. . . . . .

. . . . . .

Difference:

. . . . . .

. . . . . .

(b) One common type of rechargeable cell is the nickel–cadmium (NiCad) battery. For each terminal of this battery state the initial and final oxidation number of the element when the cell is delivering a current. Hence deduce which electrode is acting as the anode and which the cathode. *[3]*

	Positive terminal (when delivering a current)	**Negative terminal (when delivering a current)**
Initial oxidation number		
Final oxidation number		
Anode / cathode		

(c) A common type of fuel cell uses hydrogen and oxygen with an acidic electrolyte. State the half-equations for the reactions at the two electrodes. *[2]*

Positive electrode:

. . . . . .

Negative electrode:

. . . . . .

(This question continues on the following page)

(Question C2 continued)

(d) The electrodes of fuel cells and rechargeable batteries have a feature in common with heterogeneous catalysts. Identify this feature and state why it is important for them to work efficiently. *[2]*

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C3. Petroleum (mineral oil) can be used either as a fuel or a chemical feedstock.

(a) Name **two** fuels that are obtained from petroleum. *[1]*

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. . . . . .

(b) Describe **one** environmental problem that can result from the combustion of these fuels in the internal combustion engine and identify the specific combustion product responsible. *[2]*

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(c) Plastic litter is an environmental problem that results from the use of petroleum as a chemical feedstock. Identify the property of plastics that is responsible for this. *[1]*

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(d) One product that is made from crude oil is the chemical feedstock that can be used to synthesize commercial liquid-crystal displays. Discuss the properties that a substance must have to make it suitable for use as a liquid-crystal display. *[2]*

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Option D — Medicines and drugs

D1. Drugs are most commonly taken orally.

(a) State **one** advantage and **one** disadvantage of this. *[2]*

Advantage:

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Disadvantage:

. . . . . .
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(b) List **three** methods, other than orally, that can be used for the administration of a drug. *[2]*

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D2. Ethanol is a depressant that can be consumed in the form of alcoholic drinks. The danger is that there is little control over the amount used.

(a) Discuss the long-term consequences of ethanol abuse, both for the individual and for society. *[3]*

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(b) A number of other depressants that are frequently prescribed for stress relief are shown in Table 20 of the Data Booklet. State the names of **two** drugs of this type that have very similar structures. *[1]*

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. . . . . .

(c) There is a third type of depressant, also shown in Table 20 of the Data Booklet, which is much more water-soluble than the two depressants in (b). Explain, in terms of its structure, why this is. *[2]*

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D3. Many diseases are the result of infection of the body by either bacteria or viruses.

(a) (i) State the name of **one** disease caused by each. *[2]*

Bacteria:

. . . . . .

Viruses:

. . . . . .

(ii) Discuss the differences between bacteria and viruses. *[3]*

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(b) Penicillin G was one of the first antibiotics to be discovered. State the main contribution of Chain and Florey to its development. *[1]*

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(Question D3 continued)

(c) Describe **two** misuses of antibiotics that have led to some bacteria becoming resistant. *[2]*

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(d) It is much more difficult to produce effective antiviral drugs than drugs that kill bacteria. Describe **two** ways in which antiviral drugs work. *[2]*

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Option E — Environmental chemistry

E1. The temperature of the Earth's surface is currently increasing. Many scientists attribute this to an increase in the levels of greenhouse gases in the atmosphere as a result of human activity.

(a) Explain how the interaction of greenhouse gases in the atmosphere with radiation could lead to an increase in the temperature of the Earth's surface. *[3]*

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(b) Suggest why carbon dioxide is the greenhouse gas most frequently connected with the effect of human activity. *[1]*

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(c) Other than carbon dioxide and water, identify **one** other greenhouse gas and state its source. *[2]*

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E2. One major environmental problem that affects many countries is acid rain.

(a) Explain, writing an appropriate equation, why, even in an unpolluted environment, rainwater is still slightly acidic. *[2]*

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(b) Nitrogen monoxide pollution is a major contributor of acid rain.

(i) Outline the major source of this gas, including an equation. *[2]*

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(ii) Describe, including an equation, a chemical method used to control the emission of this pollutant. *[2]*

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(iii) Identify a compound, to which nitrogen monoxide is eventually converted, that is responsible for acidity in lakes and rivers. *[1]*

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E3. Many current environmental problems result from the intensive production of cereal crops.

(a) Intensive methods deplete soil organic matter (SOM). State **two** important components of SOM and describe **one** function of this material. *[3]*

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(b) Explain what natural nutrient cycles are, why intensive crop production interferes with these and how farmers compensate for this. *[3]*

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(c) State the name of a class of compounds, other than that referred to in (b), that is frequently used in intensive agriculture. *[1]*

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Option F — Food chemistry

F1. Most foods are complex mixtures and many components of them are nutrients.

(a) State an example of a *food* that is not a *nutrient* and use this to explain the difference between these two terms. *[3]*

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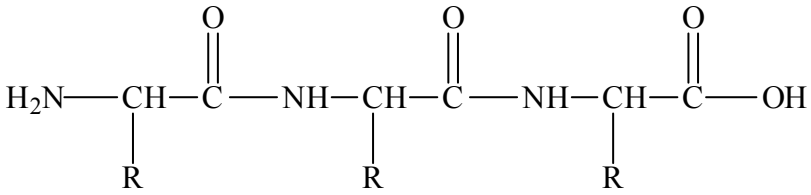
(Question F1 continued)

(b) Identify the types of nutrients **A**, **B** and **C**. *[3]*

A



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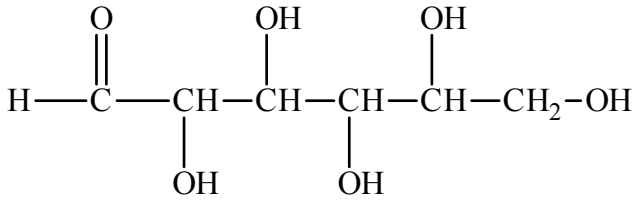
B



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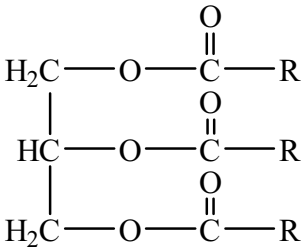
C



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(c) State the names of **two** types of nutrient other than those shown in part (b). *[2]*

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F2. Rancidity limits the shelf life of foods containing oils and fats.

(a) Rancidity can occur as a result of two separate processes. State these processes and explain the difference between them. *[3]*

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(b) Substances such as THBP (2,4,5-trihydroxybutyrophenone) and TBHQ (*tert*-butylhydroquinone) are often added to slow down rancidity.

(i) State the name given to additives of this nature. *[1]*

. . . . . .

(ii) State the name of **one** naturally occurring substance which has a similar effect in slowing down rancidity. Identify a food that is rich in this and state an additional health benefit thought to arise from its regular consumption. *[3]*

Compound:

. . . . . .

Food:

. . . . . .

Benefit:

. . . . . .
. . . . . .

F3. Texture is an important feature of food. Various dispersed systems have distinctive textures.

(a) Describe what is meant by the term *dispersed system*. *[1]*

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. . . . . .

(b) Identify the phases of the two components of an emulsion. *[1]*

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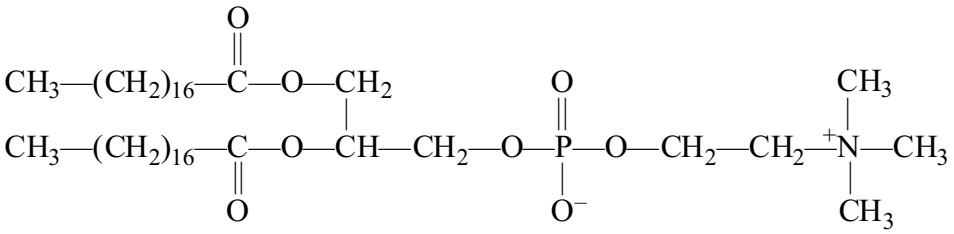
(c) Emulsifiers such as lecithin are frequently used to prevent the separation of emulsions. One component of lecithin has the structure shown below.



Explain how emulsifiers, such as this, stabilize emulsions. *[3]*

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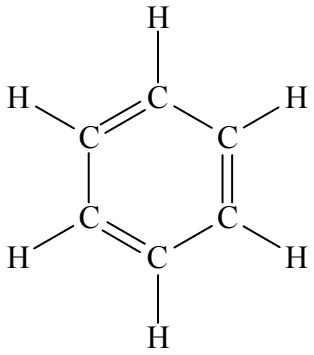
Option G — Further organic chemistry

G1. The structure of benzene originally described by August Kekulé is shown below.



Explain, giving **two** different pieces of evidence, why this is not a valid structure for the bonding in benzene. *[2]*

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G2. Consider the two-stage reaction pathways below.

$$CH_3CH_2I \xrightarrow{\mathbf{I}} \mathbf{Y} \xrightarrow{\mathbf{II}} CH_3CH_2COOH$$

$$CH_3CHO \xrightarrow{\mathbf{III}} CH_3CH(OH)CN \xrightarrow{\mathbf{IV}} CH_3CH(OH)COOH$$

(a) Other than altering the functional groups, identify the fundamental structural change that these two pathways achieve. *[1]*

. . . . . .
. . . . . .

(b) Given that **Y** does not contain nitrogen, deduce its structural formula. *[1]*

(c) State the reagent(s) required for reaction **I** and for reaction **II**. *[3]*

Reaction **I**:

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. . . . . .

Reaction **II**:

. . . . . .
. . . . . .

(This question continues on the following page)

(Question G2 continued)

(d) Explain the mechanism of reaction **III**, using curly arrows to represent the movement of electron pairs. *[4]*

(e) State what would be observed if 2,4-dinitrophenylhydrazine was reacted with the starting material for reaction **III**. *[1]*

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(f) The products of both reaction pathways are carboxylic acids. Suggest which is the stronger acid and explain your answer. *[3]*

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G3. The base strength of amines depends on their structure.

(a) Draw the structure of a primary amine, a secondary amine and a tertiary amine of molecular formula C_3H_9N. *[3]*

Primary	Secondary	Tertiary

(b) Explain why the secondary amine is a stronger base than the primary amine. *[2]*

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