



22116112

**CHEMISTRY
STANDARD LEVEL
PAPER 3**

Tuesday 10 May 2011 (morning)

1 hour

Candidate session number

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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.



0136

Option A — Modern analytical chemistry

A1. (a) One commonly used analytical technique is atomic absorption spectroscopy. State **one** use of this technique. [1]

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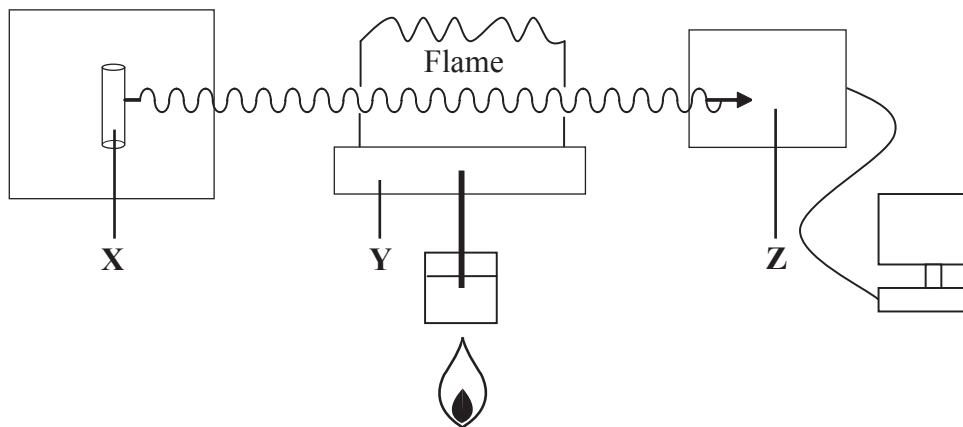
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(Question A1 continued)

- (b) The diagram below represents the components of an atomic absorption spectrophotometer. Identify the components marked **X**, **Y** and **Z** and explain their function in the analysis of a sample by this technique. [6]



X – Name:

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X – Function:

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Y – Name:

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Y – Function:

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Z – Name:

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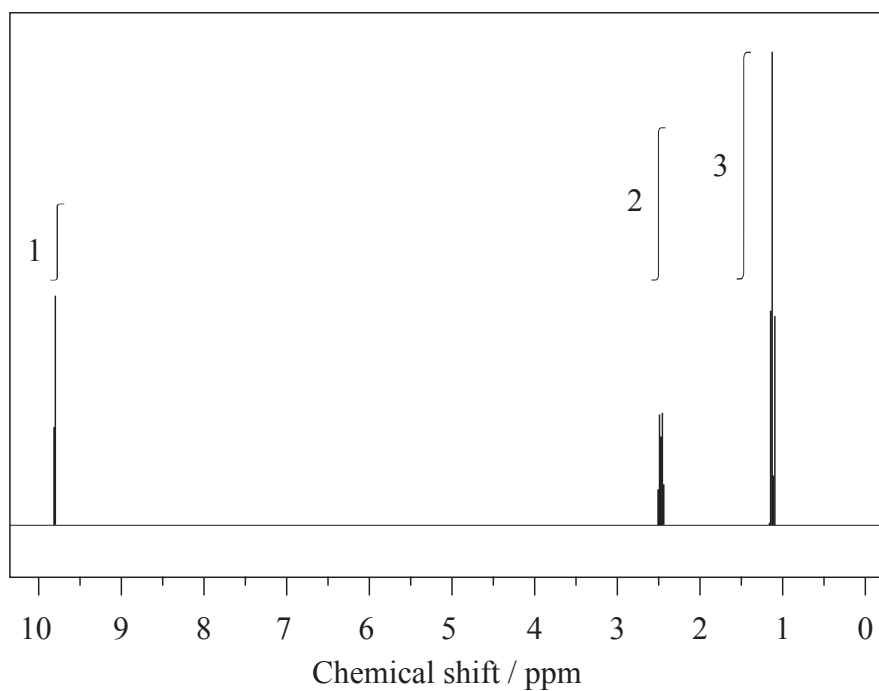
Z – Function:

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A2. The ^1H NMR spectrum of **X** with molecular formula $\text{C}_3\text{H}_6\text{O}$ is shown below.



(a) Deduce which of the following compounds is **X** and explain your answer. [2]



Compound:

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Explanation:

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(Question A2 continued)

- (b) Deduce which one of the peaks in the ^1H NMR spectrum of **X** would also occur in the spectrum of one of the other isomers, giving your reasoning. [2]

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- (c) The infrared and mass spectra for **X** were also recorded.

- (i) Apart from absorptions due to C–C and C–H bonds, suggest **one** absorption, in wavenumbers, that would be present in the infrared spectrum. [1]

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- (ii) Apart from absorptions due to C–C and C–H bonds, suggest **one** absorption, in wavenumbers, absent in this infrared spectrum but present in one of the other compounds shown in part (a). [1]

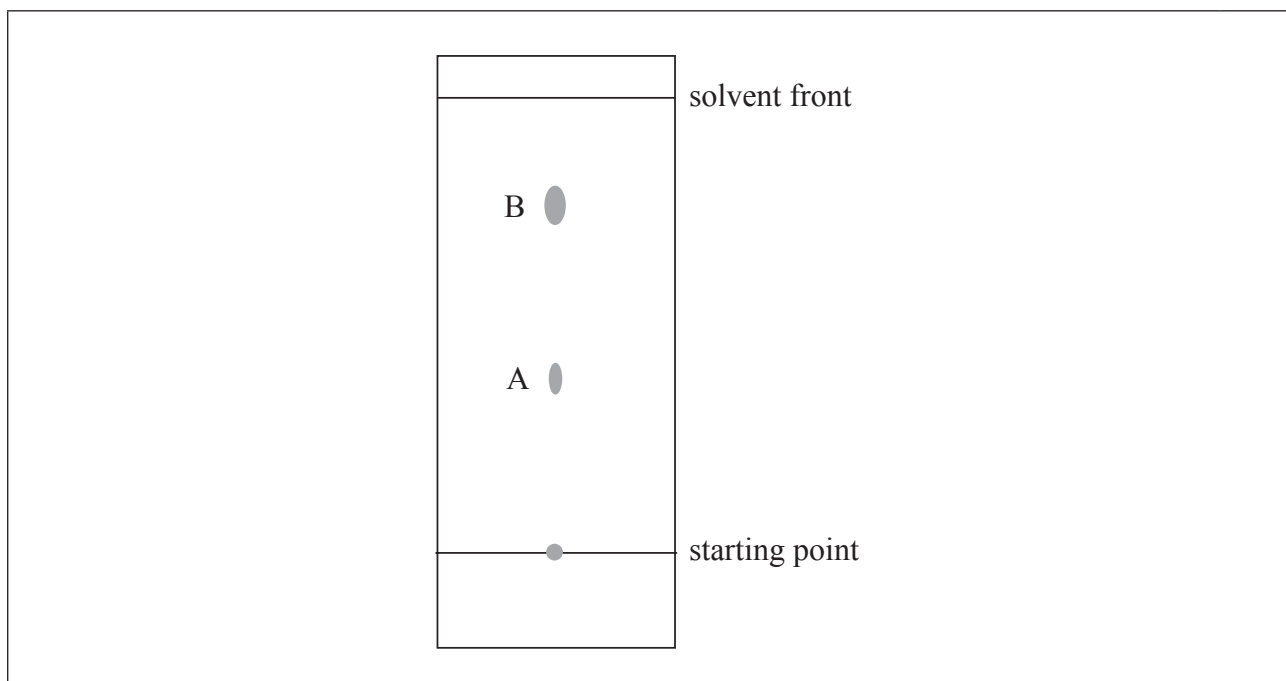
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- (d) Suggest the formulas and m/z values of **two** species that would be detected in the mass spectrum. [2]

Species:
m/z:
Species:
m/z:



A3. A sample of food colouring was analysed using thin-layer chromatography to check whether it contained a banned substance. The R_f value of the banned substance is 0.25 under the same conditions.



(a) State the number of components used to produce the food colouring. [1]

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(b) Identify a stationary phase commonly used in thin-layer chromatography. [1]

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(c) Identify the component in this chromatogram that has the greatest attraction for the stationary phase. [1]

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(Question A3 continued)

- (d) Explain what is meant by the term R_f value. [1]

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- (e) Predict where you would expect the banned dye to appear on the chromatogram and mark this spot with a circle on the diagram on the previous page. [1]



Option B — Human biochemistry

B1. Starch and cellulose are polysaccharides found in plants.

(a) State the names of **two** polysaccharides found in starch and distinguish between their structures. [3]

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(b) Compare the structural features of starch and cellulose. [3]

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(c) Humans can digest starch but cannot digest cellulose. Explain why humans cannot digest cellulose. [1]

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- B2.** (a) Determine the number of double bonds in linoleic acid, $C_{18}H_{32}O_2$, and linolenic acid, $C_{18}H_{30}O_2$, and suggest which fatty acid will have a higher iodine number. [2]

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- (b) Explain why it is important to include the fatty acids linoleic and linolenic acid in a balanced diet. [2]

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- B3.** (a) Some synthetic hormones are similar in structure to progesterone and estrogen and may be used to prevent pregnancy. Outline the mode of action of these hormones as oral contraceptives. [3]

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- (b) Some other synthetic hormones are similar in structure to testosterone and are used as anabolic steroids. Outline **one** medical and **one** non-medical use of anabolic steroids. [2]

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Option C — Chemistry in industry and technology

C1. Many recent developments in chemistry have involved making use of devices that operate on a nanoscale.

- (a) (i) State the scale at which nanotechnology takes place and outline the importance of working at this scale. [2]

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- (ii) State **one** public concern regarding the development of nanotechnology. [1]

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- (b) One development has been the production of nanotubes. Describe the way in which the arrangement of carbon atoms in the wall and sealed end of a nanotube differ. [2]

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C2. (a) The initial products of the fractional distillation of oil often undergo cracking. This can be carried out in a number of ways. State the **major** reason for choosing each of the following techniques. [3]

Catalytic cracking:

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Thermal cracking:

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Steam cracking:

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(b) Catalytic cracking uses heterogeneous catalysts.

(i) Explain how these differ from homogeneous catalysts. [1]

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(ii) Identify **one** disadvantage of using heterogeneous catalysts. [1]

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(Question C2 continued)

- (c) Many of the compounds produced by cracking are used in the manufacture of addition polymers. State the essential structural feature of these compounds and explain its importance. [2]

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- (d) The polymers often have other substances added to modify their properties. One group of additives are plasticizers. State how plasticizers modify the physical properties of polyvinyl chloride and explain at the molecular level how this is achieved. [2]

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C3. Steel is a vital structural material in modern society. Some of it is obtained from recycled iron and steel, but much of it is produced from iron ore using a blast furnace.

(a) Outline the process by which iron, produced in a blast furnace, is converted to steel. [3]

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(b) Describe **one** heat treatment of steel and the way in which it alters the physical properties of steel. [2]

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(c) State **one** negative impact that the production of iron and steel has on the environment. [1]

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Option D — Medicines and drugs

D1. Nicotine and caffeine are commonly classified as stimulants, and ethanol is a common depressant.

(a) State the name of **one** functional group which is present in caffeine but absent in nicotine. [1]

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(b) Other than methyl groups, state the name of **one** functional group present in both caffeine and nicotine. [1]

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(c) State **two** symptoms associated with caffeine being consumed in large amounts. [1]

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(Question D1 continued)

(d) State **two** short-term and **two** long-term effects of nicotine consumption. [2]

Short-term:

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Long-term:

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(e) (i) Outline the meaning of the term *sympathomimetic drug*. [1]

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(ii) State **one** example of a sympathomimetic drug other than nicotine. [1]

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(f) Outline what is meant by the term *synergistic effect* of ethanol using a suitable example. [2]

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D2. Two substances commonly used in antacid tablets are magnesium hydroxide and aluminium hydroxide.

(a) State an equation to represent a neutralization reaction with one of the above antacids. [1]

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(b) State and explain whether 0.1 mol of magnesium hydroxide is more effective or less effective than 0.1 mol of aluminium hydroxide. [1]

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(c) Suggest why compounds such as sodium hydroxide or potassium hydroxide cannot be used as an antacid. [1]

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(Question D2 continued)

(d) Explain why alginates and dimethicone are often included in antacid tablets. [2]

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| <p>Alginates:</p> <p>.....</p> <p>.....</p> <p>Dimethicone:</p> <p>.....</p> <p>.....</p> |
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D3. (a) State **two** differences in structure between viruses and bacteria. [2]

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

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(c) Discuss **two** difficulties associated with the development of drugs for the effective treatment of AIDS. [2]

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Option E — Environmental chemistry

E1. (a) State an equation that shows why rain water is naturally acidic. [1]

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(b) The two major acids that cause acid rain originate from different sources.

(i) Outline the process responsible for the production of each acid and state an equation to show its formation. [4]

Acid 1:

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Acid 2:

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(ii) Acid rain has caused damage to limestone buildings and marble statues. State an equation to represent the reaction of acid rain with limestone or marble. [1]

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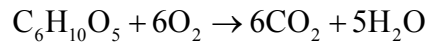
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E2. Organic matter present in water can be decomposed under aerobic and anaerobic conditions by bacteria.

- (a) Identify the product, different in each case, when compounds containing the following elements are subjected to aerobic and anaerobic conditions. [4]

| Element | Aerobic decomposition | Anaerobic decomposition |
|------------|-----------------------|-------------------------|
| Carbon | | |
| Nitrogen | | |
| Sulfur | | |
| Phosphorus | | |

- (b) In a certain lake, anaerobic conditions exist due to the presence of 10 ppm by mass (0.010 g dm^{-3}) of organic matter. Determine the mass of oxygen required to oxidize the organic matter in 1 dm^3 of water. Assume that the aerobic decomposition process can be represented by the following equation. [2]



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E3. In certain parts of the world fresh water is obtained from sea water using multi-stage distillation and reverse osmosis.

Discuss the essential steps involved in **one** of these processes.

[3]

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- E4. (a) Outline a condition that leads to the production of carbon monoxide, CO, in an internal combustion engine. [1]

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- (b) State an equation for the reaction that takes place between CO and a primary pollutant in a catalytic converter of an internal combustion engine. [2]

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- (c) Identify the environmental problem associated with one of the products formed in part (b). [1]

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- (d) Other than the use of a catalytic converter, state **two** methods of controlling CO emission from an internal combustion engine. [1]

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Option F — Food chemistry

F1. Fats and vegetable oils are triesters of glycerol with fatty acids. Many of these acids contain 18 carbon atoms. The table shows the relative percentages of various C₁₈ fatty acid chains in four common fats and oils.

| Fat/Oil | C ₁₇ H ₃₅ COO- / % | C ₁₇ H ₃₃ COO- / % | C ₁₇ H ₃₁ COO- / % | C ₁₇ H ₂₉ COO- / % |
|-------------|---|---|---|---|
| Tallow | 52 | 44 | 3 | 1 |
| Linseed Oil | 5 | 32 | 18 | 45 |
| Olive Oil | 2 | 83 | 15 | 0 |
| Peanut Oil | 7 | 47 | 46 | 0 |

(a) Deduce which fat or oil from the table could best be described as: [2]

| |
|--|
| <p>saturated</p> <p>.....</p> <p>mono-unsaturated</p> <p>.....</p> <p>poly-unsaturated.</p> <p>.....</p> |
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(Question F1 continued)

- (b) (i) Explain the meaning of the term *shelf life* and suggest which fat or oil from the table would have the shortest shelf life. [2]

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- (ii) Describe **two** ways in which shelf life could be increased. [2]

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- (c) State the conditions required for the hydrogenation of unsaturated oils. [2]

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(Question F1 continued)

- (d) Hydrogenation can result in the formation of trans fatty acids. Outline the meaning of the term *trans fatty acids* and explain why their formation is undesirable. [2]

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F2. One property of foods that affects their desirability is their colour.

(a) (i) State the difference between a dye and a pigment. [1]

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(ii) Explain, in terms of their effect on light, why these compounds are coloured. [1]

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(b) State a common food, apart from carrots, in which the following classes of pigment are found. [2]

An anthocyanin:
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A carotene:
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(c) Identify **one** other coloured compound commonly found in uncooked foods. [1]

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(This question continues on the following page)



(Question F2 continued)

- (d) Countries have different laws about the use of synthetic colourants in food. Explain why this can be dangerous for the consumer. [1]

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F3. Many food items contain genetically modified ingredients.

- (a) Explain what is meant by the term *genetically modified food*. [1]

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- (b) Describe **two** advantages and **one** concern about the use of genetically modified food. [3]

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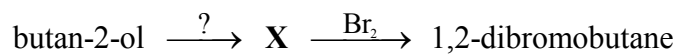
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Option G — Further organic chemistry

G1. Butan-2-ol cannot be directly converted to 1,2-dibromobutane. The conversion can be carried out in two stages by first converting butan-2-ol into **X**, which is then reacted with bromine.



(a) State the name and draw the structural formula of **X**.

[2]

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|-------------|
| Name: |
| Structure: |

(b) State an equation and the conditions needed for the conversion of butan-2-ol into **X**.

[2]

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(Question G1 continued)

- (c) Describe the mechanism of the second stage of the conversion, which occurs when bromine is added to **X**, using curly arrows to show the movement of electron pairs. [3]

- (d) Butan-1-ol could be used instead of butan-2-ol. Compare the yield of 1,2-dibromobutane expected for butan-1-ol with that obtained for butan-2-ol. Explain your answer. [2]

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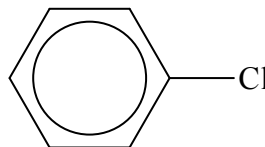
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G2. (a) Compare the rates of hydrolysis of the compounds below and suggest **two** reasons for the difference in reactivity. [3]



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(b) State the formula of the product formed when 2-chloropropane reacts with magnesium to form a Grignard reagent and state the conditions required for this reaction to occur. [2]

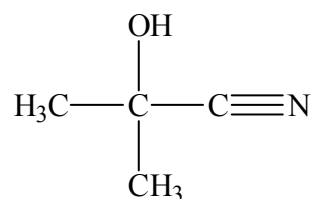
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(Question G2 continued)

- (c) Grignard reagents are often used to increase the length of the hydrocarbon chain in molecules. An alternative way of doing this is to use cyanohydrins such as:



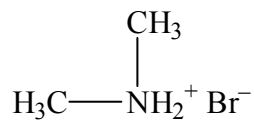
- (i) State the reagents that react to produce this compound. [1]

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- (ii) Draw the structural formula of the organic compound that is produced by the hydrolysis of this cyanohydrin. [1]



- G3.** (a) State the class of compounds to which the substance below belongs and deduce a balanced equation for its reaction with aqueous sodium hydroxide. [2]



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- (b) Explain how the pH of an aqueous solution of the organic product from part (a) would compare with the pH of aqueous ammonia of the same concentration. [2]

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