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**CHEMISTRY**  
**STANDARD LEVEL**  
**PAPER 3**

Wednesday 4 November 2009 (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 in the spaces provided. You may continue your answers on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.



0127

**Option A — Modern analytical chemistry**

**A1.** <sup>1</sup>H NMR and IR spectroscopy both involve the absorption of electromagnetic radiation.

(a) (i) Identify the region of the electromagnetic spectrum used in <sup>1</sup>H NMR spectroscopy. [1]

.....

(ii) Identify which of these two techniques involves higher energy radiation. [1]

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.....

(b) Identify which of the following molecules absorbs IR radiation and explain your choice. [2]

H<sub>2</sub>            O<sub>2</sub>            HCl

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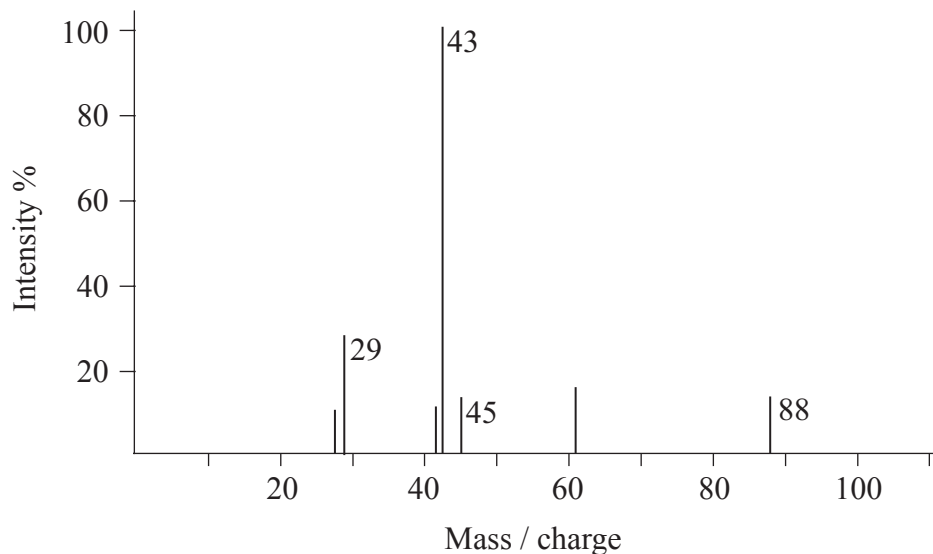
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A2. (a) The mass spectrum of an unknown compound, X, of empirical formula C<sub>2</sub>H<sub>4</sub>O is shown below.



[Source: Cleapss Guides: L202 Spectra (Cleapss School Science Service), Sept 2000.]

(i) Determine the relative molecular mass of X from the mass spectrum and deduce the formula of the molecular ion. [2]

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(ii) Identify a fragment which gives rise to the peak at  $m/z = 29$ . [1]

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(iii) Comment on the absence of a peak at  $m/z = 59$ . [1]

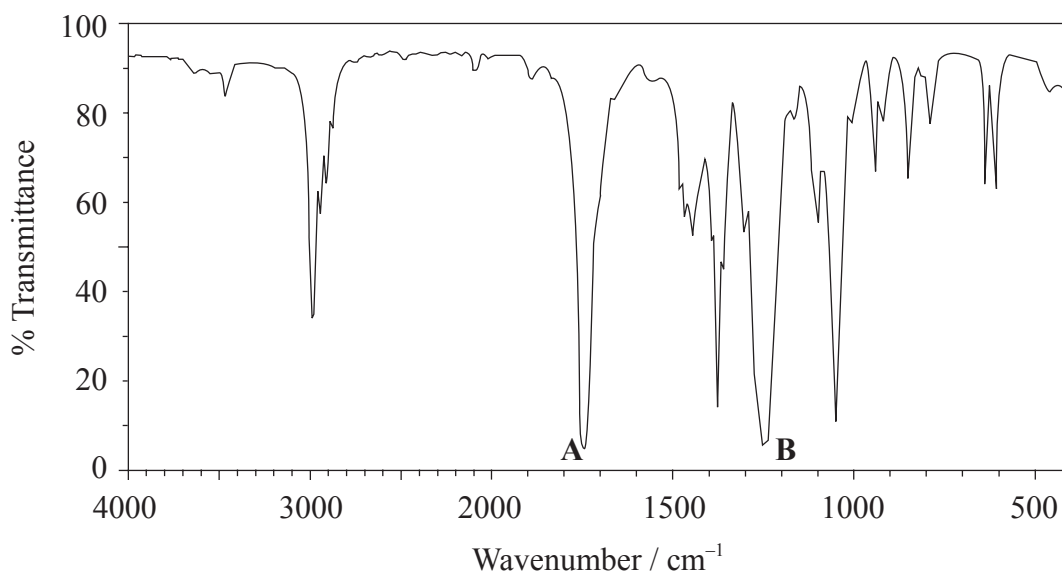
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(Question A2 continued)

(b) The IR spectrum of **X** is shown below.



[Source: [http://modbo1.ibase.go.jp/sdbs/cgi-bin/cre\\_index.cgi?lang=eng](http://modbo1.ibase.go.jp/sdbs/cgi-bin/cre_index.cgi?lang=eng)]

(i) Use Table 17 of the Data Booklet to identify the bonds which correspond to the absorptions **A** and **B**. [1]

**A:** .....

**B:** .....

(ii) Deduce the name of the functional group present in **X**. [1]

.....

(This question continues on the following page)



(Question A2 continued)

- (c) (i) The  $^1\text{H}$ NMR spectrum of **X** shows three peaks. State the information that can be obtained from the number of peaks. [1]

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- (ii) The  $^1\text{H}$ NMR spectrum of **X** includes peaks at 2.0 and 4.1 ppm. Use Table 18 of the Data Booklet to suggest the chemical shift of the third peak and state its relative peak area. Show your answers in the table below. [2]

Peak	Chemical shift / ppm	Relative peak area
First	2.0	3
Second	4.1	2
Third		

- (iii) Deduce a possible structure for **X** that is consistent with the mass, IR and  $^1\text{H}$ NMR spectra. [1]



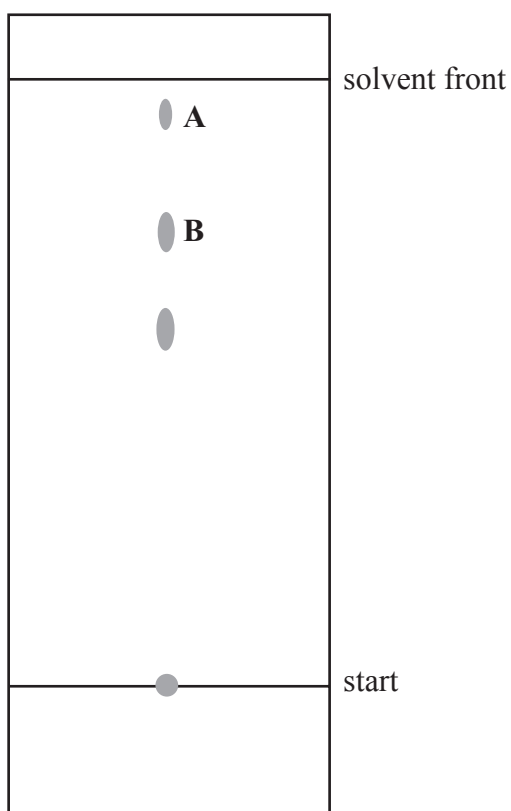
**A3.** Chromatography is used to test for the presence of illegal drugs in sport.

(a) A chromatogram of a concentrated urine sample from an athlete shows the presence of a banned substance known to have an  $R_f$  value of 0.75.

(i) Define the term  $R_f$  value. [1]

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.....

(ii) Calculate the  $R_f$  values for **A** and **B**, and so deduce which of the spots corresponds to the banned substance. [2]



$R_f$  of **A**:

.....

$R_f$  of **B**:

.....

Banned substance:

.....

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*(Question A3 continued)*

- (iii) Suggest how the results could change if the experiment was repeated with a different solvent. [1]

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- (b) Paper and column chromatography both have stationary and mobile phases. Identify the stationary phases in the different techniques. [2]

Paper chromatography:

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Column chromatography:

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**Option B — Human biochemistry**

**B1.** Proteins are vital components of living systems.

(a) State the general formula of 2-amino acids. [1]

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(b) State **two** characteristic properties of 2-amino acids. [2]

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(c) Using Table 19 of the Data Booklet, deduce the structural formula of **two** dipeptides that could be formed by the reaction of alanine with serine and state the other product of the reaction. [3]

Other product of the reaction:

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(d) (i) Explain the difference between the primary and secondary structure of proteins. [2]

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(ii) State the predominant interaction responsible for the secondary structure. [1]

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*(Question B1 continued)*

(e) Explain how a sample of a protein can be analysed by electrophoresis. [5]

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**B2.** A balanced diet is needed for good health.

(a) Distinguish between micronutrients and macronutrients and state **one** example of each. [3]

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Example of a micronutrient:

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Example of a macronutrient:

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(b) By comparing the structures of vitamins A, C and D given in Table 21 of the Data Booklet, state and explain which of the three vitamins is most soluble in water. [2]

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(c) State **one** effect of vitamin C deficiency. [1]

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**Option C — Chemistry in industry and technology**

**C1.** (a) Aluminium is extracted by the electrolysis of a molten mixture containing alumina,  $\text{Al}_2\text{O}_3$ , using graphite electrodes.

(i) Explain why the molten electrolyte also contains cryolite. [1]

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(ii) State a half-equation for the reaction at the negative electrode (cathode). [1]

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(iii) Oxygen is produced at the positive electrode (anode). State the name of another gas produced at this electrode. [1]

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(b) (i) State **two** properties of aluminium that make it suitable for use as an overhead electric cable. [1]

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(ii) Alloys of aluminium with nickel are used to make engine parts. Explain, by referring to the structure of these alloys, why they are less malleable than pure aluminium. [2]

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**C2.** Polyvinyl chloride (PVC) and polyethene are both polymers made from crude oil.

(a) Explain why PVC is less flexible than polyethene. [2]

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(b) State how PVC can be made more flexible during its manufacture and explain the increase in flexibility on a molecular level. [2]

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(c) PVC can exist in isotactic and atactic forms. Draw the structure of the isotactic form showing a chain of at least six carbon atoms. [1]



**C3.** Nano-sized ‘*test-tubes*’ with one open end, can be formed from carbon structures.

(a) Describe these ‘*test-tubes*’ with reference to the structures of carbon allotropes. [2]

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(b) These tubes are believed to be stronger than steel. Explain the strength of these ‘*test-tubes*’ on a molecular level. [1]

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(c) Carbon nanotubes can be used as catalysts.

(i) Suggest **two** reasons why they are effective heterogeneous catalysts. [2]

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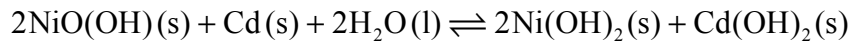
(ii) State **one** potential concern associated with the use of carbon nanotubes. [1]

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C4. Rechargeable nickel-cadmium batteries are used in portable electrical equipment and emergency lighting.

The **discharge** process can be summarized by the equation below.



(a) State the change in oxidation number of the cadmium and deduce if it is acting as the positive or negative electrode during the discharge process. [2]

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(b) Identify a physical property of Cd(OH)<sub>2</sub> which allows this process to be reversed and the battery recharged. [1]

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**Option D — Medicines and drugs**

**D1.** (a) Alexander Fleming, Howard Florey and Ernst Chain shared the Nobel Prize for “the discovery of penicillin and its curative effect in various infectious diseases”.

- (i) Outline the contributions of Fleming, Florey and Chain to the development of penicillins. [2]

Fleming:

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Florey and Chain:

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- (ii) Describe the mode of action of penicillins in treating infectious diseases. [2]

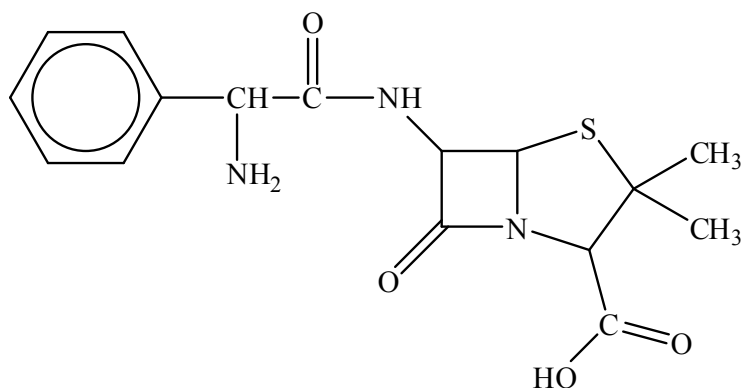
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(Question D1 continued)

- (b) Ampicillin is a semi-synthetic penicillin used to treat lung infections. The structure of the antibiotic is shown below.



- (i) Identify **two** functional groups present in the side chain (R) of ampicillin by comparing its structure to that of penicillin in Table 20 in the Data Booklet. [2]

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- (ii) Explain why it is important to continue to develop semi-synthetic penicillins. [2]

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D2. (a) Explain the meaning of the terms:

(i) *side-effect* [1]

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(ii) *therapeutic window* [1]

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(iii) *placebo effect.* [1]

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(b) The effectiveness of a drug depends on the method of administration.

(i) One method of injecting drugs into the body results in the drug having a very rapid effect. State the method and explain its rapid action. [2]

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(ii) List the **two** other methods which can be used to inject drugs into the body. [1]

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(iii) Identify the method of administration used to treat respiratory diseases such as asthma. [1]

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**D3.** Amphetamine and methamphetamine are widely abused drugs.

(a) State **one** short-term effect of amphetamine on the human body. [1]

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(b) Explain why amphetamine is classified as a *sympathomimetic drug* and relate this to its structure. [2]

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(c) Regular use of amphetamine and methamphetamine can lead to *tolerance*. Explain why this is potentially dangerous. [2]

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**Option E — Environmental chemistry**

**E1.** It is now widely accepted that the increased production of carbon dioxide is leading to global warming.

(a) Describe how carbon dioxide acts as a greenhouse gas. [2]

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(b) Discuss the influence of increasing amounts of greenhouse gases on the environment. [3]

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**E2.** The biochemical oxygen demand (BOD) is a measure of water pollution.

(a) State what is meant by the term *biochemical oxygen demand* (BOD). [2]

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(b) Identify the stage of sewage treatment which removes the substances responsible for high BOD values and explain how this is done. [2]

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(c) Describe how the addition of nitrates or phosphates to water can increase the BOD value of a water sample. [2]

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**E3.** Identify **two** pollutants, other than carbon dioxide and carbon monoxide, emitted by car exhausts and describe how each is produced. [3]

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**E4.** Landfill sites are used to dispose of about 90% of the world’s domestic waste, but incineration is being increasingly used in some countries. [2]

(a) State **one** advantage of each method. [2]

Landfill:

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Incineration:

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(b) Suggest why some biodegradable plastics do not decompose in landfill sites. [1]

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(c) High-level and low-level wastes are two types of radioactive waste. Compare the half-lives and the methods of disposal of the two types of waste. [3]

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**Option F — Food chemistry**

**F1.** Malnutrition can be caused by starvation, dieting or a person eating an excess of highly processed food.

(a) State **one** function of a nutrient. [1]

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(b) Describe the structural composition of the following nutrients:

(i) fats and oils [2]

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(ii) monosaccharides. [2]

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(c) Liver is a source of arachidonic acid,  $\text{CH}_3(\text{CH}_2)_4(\text{CH}=\text{CHCH}_2)_4(\text{CH}_2)_2\text{COOH}$ , and fish oils are a source of linolenic acid. With reference to the structure of linolenic acid in Table 22 of the Data Booklet, explain why arachidonic acid has a much lower melting point compared to linolenic acid, even though it contains two more carbon atoms. [3]

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**F2.** An example of a genetically modified (GM) food is the Flavr Savr tomato.

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

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(b) Suggest **two** benefits and **one** potential concern of using GM crops, such as Flavr Savr tomatoes, rather than tomatoes grown using traditional methods. [3]

Benefits:

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Potential concern:

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F3. Antioxidants can be used to prolong the shelf life of food.

(a) Define the terms:

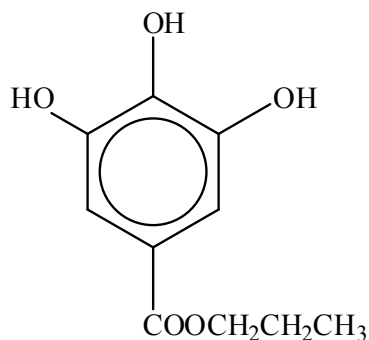
(i) *shelf life* [1]

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(ii) *antioxidant*. [1]

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(b) Using Table 22 of the Data Booklet, and the structure of propyl gallate (PG) below, compare the structural features of the three common antioxidants 3-BHA, BHT and PG. [4]



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*(Question F3 continued)*

- (c) State **one** example of a common naturally occurring antioxidant and state **one** possible long-term health benefit of consuming food in which it is present. [2]

Antioxidant:

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Long-term health benefit:

.....

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**Option G — Further organic chemistry**

**G1.** Consider the two amines methylamine,  $\text{CH}_3\text{NH}_2$ , and dimethylamine,  $(\text{CH}_3)_2\text{NH}$ .

(a) Using Table 15 of the Data Booklet, state which of the amines is the more basic. [1]

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(b) Explain the relative basicities of the two amines. [2]

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**G2.** Ethanoic acid and chloroethanoic acid both contain the carboxyl group.

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

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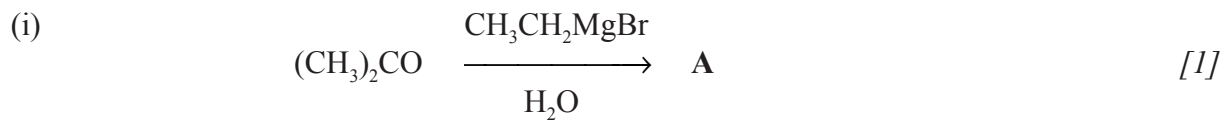
(b) Starting with chloromethane, outline **one** possible reaction pathway to synthesize ethanoic acid. Your answer should include:  
• the reagents used  
• a relevant chemical equation for each step. [2]

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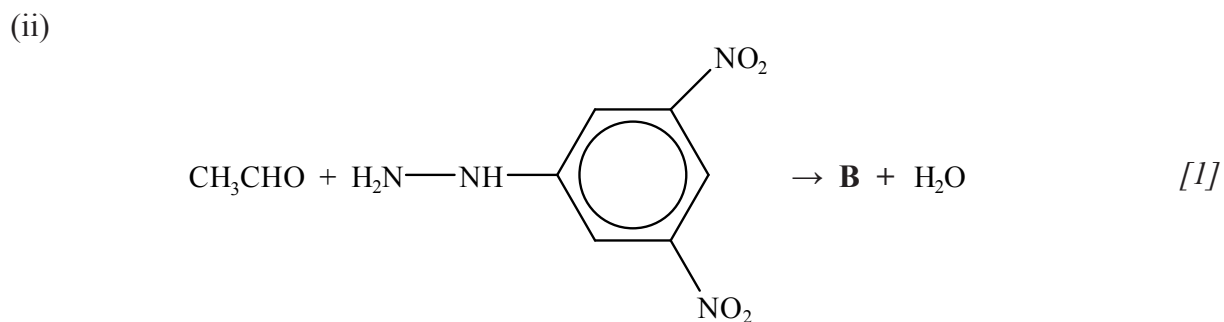


**G3.** The carbonyl chemistry of both aldehydes and ketones involves a number of different types of reactions.

(a) State the formulas of the products **A** and **B**, formed in the following reactions.



**A:** .....



**B:** .....

(b) State the type of reaction involved in the formation of **B** and  $\text{H}_2\text{O}$  in (a) (ii). [1]

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- G4.** (a) Alkenes commonly react by electrophilic addition reactions. Describe the mechanism of the following reaction, using curly arrows to show the movement of electron pairs, and suggest the reason for the formation of the major organic product, **C**. [5]



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- (b) Alcohols can undergo elimination reactions. Describe the mechanism of the following reaction, using curly arrows to show the movement of electron pairs, and identify the organic product, **D**. [5]

