

**SECTION A****Specific instructions for Section A**

Section A consists of 20 multiple-choice questions. Section A is worth 24 per cent of the marks available. You should spend approximately 22 minutes on Section A. Choose the response that is **correct** or **best** answers the question and mark your choice on the multiple-choice answer sheet according to the instructions on that sheet. A correct answer is worth 1 mark; an incorrect answer is worth no marks. No mark will be given if more than one answer is shown for any question. Marks will **not** be deducted for incorrect answers. You should attempt every question.

**Question 1**

Which of the following is **not** considered a typical use for mass spectrometry?

- A. determining the percentage elemental composition of a metallic alloy
- B. calculating the isotopic abundance in elements
- C. confirming the presence of -OH and -COOH in organic compounds
- D. calculating the molecular mass of organic compounds

**Question 2**

Correct procedures for a titration include which of the following?

- I. Draining a pipette by touching the tip to the side of the conical flask used for the titration
  - II. Rinsing the burette with distilled water just before filling it with the liquid to be used in the titration
  - III. Swirling the solution in the conical flask frequently during the titration
- A. I only
  - B. I and III only
  - C. II and III only
  - D. I, II, and III

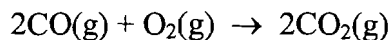
**Question 3**

Propan-1-ol ( $M = 60 \text{ g mol}^{-1}$ ) undergoes complete fragmentation in a mass spectrometer. What is the  $m/e$  value of the base peak in its mass spectrum?

- A. 29
- B. 31
- C. 59
- D. 60

**Question 4**

One of the functions of the catalytic converter in your car is to oxidise carbon monoxide to carbon dioxide according to the equation



If 15.0 g of carbon monoxide reacts with 9.0 g of oxygen gas, approximately how many grams of which compound remains unreacted?

- A. 0.8 g of carbon monoxide
- B. 7 g of carbon monoxide
- C. 8 g of oxygen
- D. 0.4 g of oxygen

**Question 5**

Concentrations of coloured substances are commonly measured by means of a UV-visible spectrophotometer.

Which of the following would ensure that correct values are obtained for the measured absorbance?

- I. There must be enough of the sample solution in the tube to ensure all of the light passes through the solution.
  - II. The instrument must be periodically recalibrated using a standard solution.
  - III. The standard solutions used for calibrating the instrument must include a saturated solution.
- A. I only
  - B. I and II only
  - C. II and III only
  - D. I, II, and III

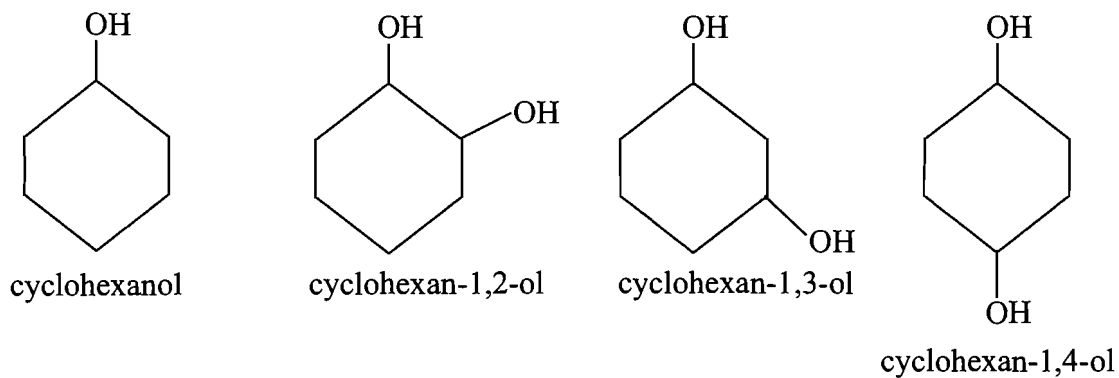
**Question 6**

The most suitable method to identify the alcohols in a mixture of alcohols of relatively low molar mass would be

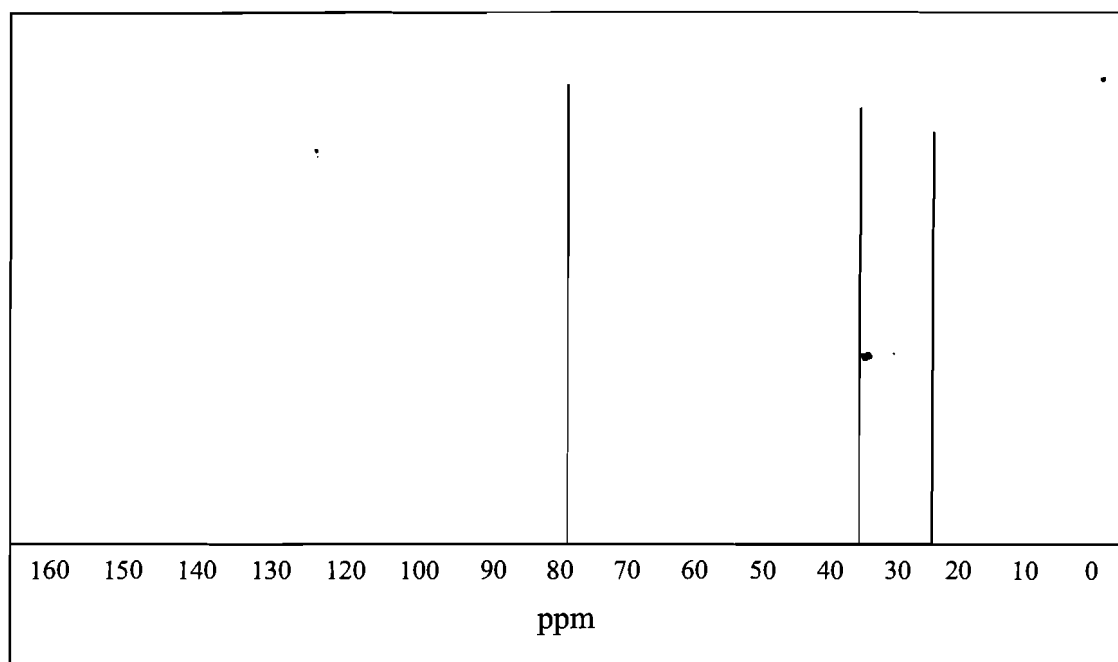
- A. atomic absorption spectroscopy
- B. mass spectrometry
- C. UV-visible spectrometry
- D. gas-liquid chromatography

**Question 7**

Four cyclic alcohols, cyclohexanol, cyclohexan-1,2-diol, cyclohexan-1,3-diol and cyclohexan-1,4-diol were compared using  $^{13}\text{C}$  NMR spectroscopy.



The  $^{13}\text{C}$  NMR spectrum of one of these compounds is shown below.

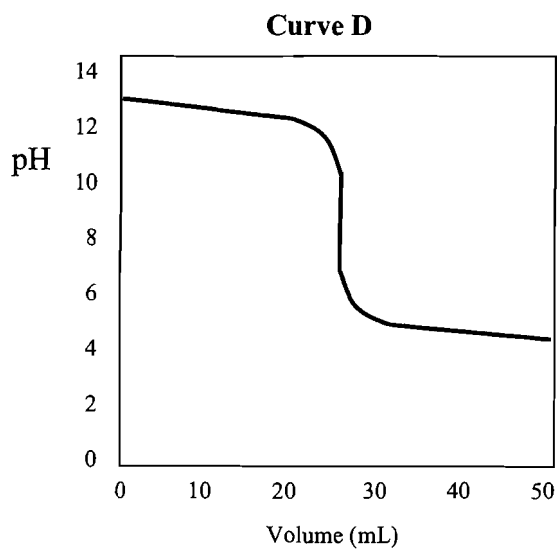
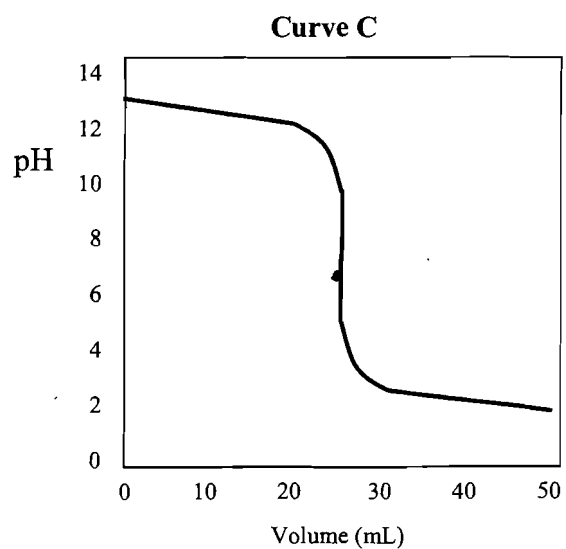
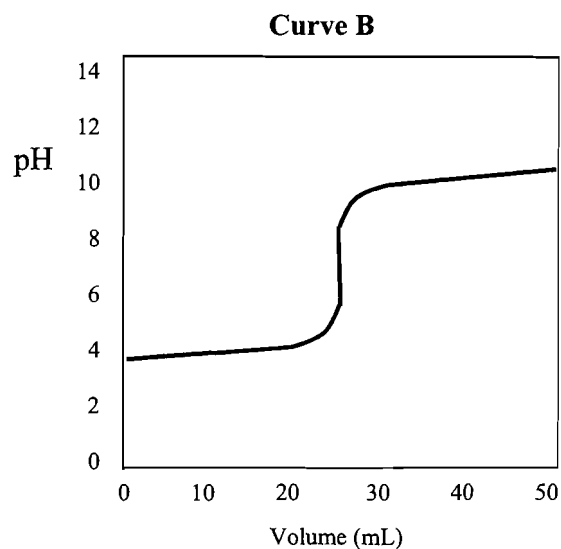
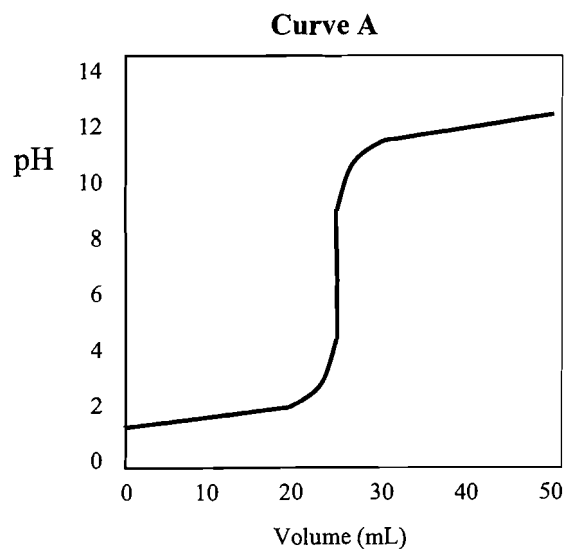


The  $^{13}\text{C}$  spectrum is of the compound

- A. cyclohexanol
- B. cyclohexan-1,2-diol
- C. cyclohexan-1,3-diol
- D. cyclohexan-1,4-diol

**Question 8**

The pH curves labelled A, B, C and D represent combinations of different acids and bases. All solutions have a concentration of  $0.1 \text{ mol L}^{-1}$ .

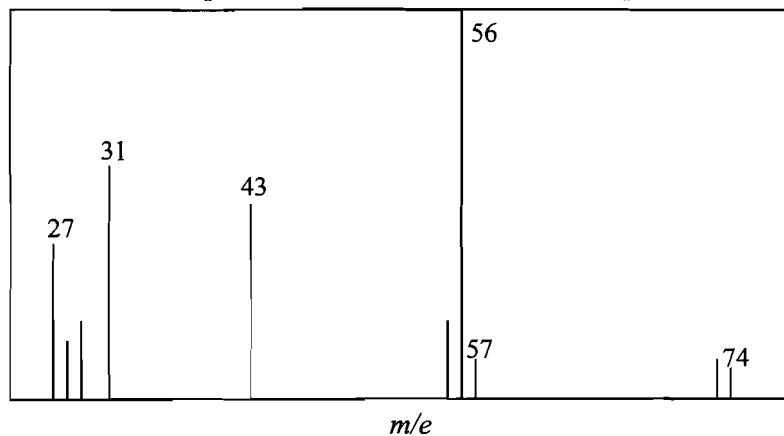


The titration curve produced by the addition of ethanoic acid to 25 mL of sodium hydroxide is:

- A. Curve A
- B. Curve B
- C. Curve C
- D. Curve D

**Question 9**

The diagram represents the mass spectrum of a pure sample.



Which of the listed pure samples is most likely to produce the mass spectrum?

- A. ethanol
- B. propan-1-ol
- C. butan-1-ol
- D. pentan-1-ol

**Question 10**

1 M solutions of several salts are prepared.

Which of the following salts produces the solution with the **highest** pH?

- A.  $\text{Na}_2\text{CO}_3$
- B.  $\text{NaNO}_3$
- C.  $\text{NH}_4\text{Cl}$
- D.  $\text{Na}_2\text{SO}_4$

**Question 11**

The molecule  $\text{HOCH}_2\text{CH}_2\text{OH}$  will have a  $^1\text{H}$  NMR spectrum consisting of

- A. two singlets
- B. a triplet and a doublet
- C. a singlet and a triplet
- D. a singlet and a doublet

**Question 12**

For the partial redox reaction:  $\text{MnO}_2(\text{s}) + x \text{H}_2\text{O}(\text{l}) \rightarrow \text{MnO}_4^-(\text{aq}) + y \text{H}^+(\text{aq}) + z \text{e}^-$ , which of the following sets of numerical values of  $x$ ,  $y$  and  $z$  would balance the equation?

	<b>x</b>	<b>y</b>	<b>z</b>
<b>A.</b>	1	2	1
<b>B.</b>	2	4	3
<b>C.</b>	3	6	5
<b>D.</b>	4	2	1

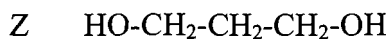
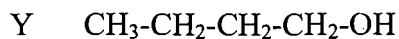
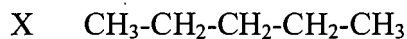
**Question 13**

Which of the following molecules does not absorb infrared radiation?

- A.**  $\text{SO}_2$
- B.**  $\text{HCl}$
- C.**  $\text{H}_2\text{O}$
- D.**  $\text{N}_2$

**Question 14**

The letters X, Y, Z represent three organic compounds as shown below



Based on the concepts of polarity and hydrogen bonding, which of the following sequences correctly lists the compounds above in order of increasing solubility in water?

- A.**  $Z < Y < X$
- B.**  $Y < Z < X$
- C.**  $X < Z < Y$
- D.**  $X < Y < Z$

**Question 15**

Aminoethane is best prepared from the reaction of ammonia and

- A. chloroethane, followed by addition of a strong base
- B. ethane, in the presence of ultraviolet light
- C. ethane, in the presence of a catalyst
- D. ethanol, followed by addition of a strong acid

**Question 16**

The reaction between chlorine and ethane in ultraviolet light is an example of

- A. an elimination reaction
- B. a substitution reaction
- C. an addition reaction
- D. a condensation reaction

**Question 17**

Linoleic acid is a fatty acid with formula  $C_{18}H_{32}O_2$ . From this information, linoleic acid is likely to be

- A. a polyunsaturated fatty acid
- B. a monounsaturated fatty acid
- C. a saturated fatty acid
- D. a solid at room temperature

**Question 18**

What is the chemical formula of the organic product of the reaction between ethanol and methanoic acid?

- A.  $CH_3CH_2CHO$
- B.  $CH_3COOCH_3$
- C.  $HCOOCH_2CH_3$
- D.  $CH_3COOCH_2CH_3$

**Question 19**

Which of the following is a major component of biomass?

- A. Natural gas
- B. Ethanol
- C. Cellulose
- D. Crude oil

**Question 20**

Which compound is a member of the same homologous series as 1-fluoropropane?

- A. 1-chloropropene
- B. 1-chloropropane
- C. 1-fluorobutane
- D. 2-bromobutane

**END OF SECTION A**



**SECTION B****Specific instructions for Section B**

Section B consists of eight short answer questions numbered 1 to 8; you must answer all of these questions. This section is worth 62 marks, which is approximately 76 per cent of the total.

You should spend approximately 68 minutes on this section.

The marks allotted to each question and suggested times are shown at the end of each question.

Questions must be answered in the spaces provided in this book.

To obtain full marks for your response you should

- give simplified answers with an appropriate number of significant figures for all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure all chemical equations are balanced and that the formulas for individual substances include an indication of state (for example,  $\text{H}_2(\text{g})$ ;  $\text{NaCl}(\text{s})$ ).

**Question 1**

Several groups of chemistry students set out to measure the exact concentration of laboratory bench bottles of sulfuric acid which are labelled as 2 M.

They prepared a solution of the primary standard, anhydrous sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) by accurately weighing out 2.65 g and dissolving this in a 250.0 mL volumetric flask.

- a) Calculate the concentration, in  $\text{mol L}^{-1}$ , of the prepared sodium carbonate solution.

---

---

---

---

- b) Write a balanced equation for the complete reaction of sodium carbonate and sulfuric acid.

---

**Question 1 (continued)**

- c) Each group took a 10.00 mL aliquot of the 2 M acid and diluted it to 250.0 mL in a volumetric flask. The diluted acid solution was placed in a 50 mL burette. The students then took a 20.00 mL aliquot of the sodium carbonate by pipette and placed this into a conical flask. The sodium carbonate solution was titrated with the diluted acid solution. The average titre of sulfuric acid solution was found to be 26.10 mL.

Determine the **exact** concentration, in mol L<sup>-1</sup>, of the original 2 M acid.  
Show all working.

---

---

---

---

---

---

---

---

- d) One group (A) did not carefully read the label of the acid and used a bottle labelled as 2 M hydrochloric acid instead of 2 M sulfuric acid.  
Explain how this would affect the average titre.

---

---

- e) Another group (B) inadvertently used a 20.00 mL pipette to take the original aliquot of 2 M acid.  
Explain how this would affect the average titre.

---

---

- f) One of the groups (A or B) was unable to easily complete the titration.  
Which one and why?

---

---

---

---

2 + 1 + 3 + 1 + 1 + 1 = 9 marks  
*Suggested time: 10 minutes*

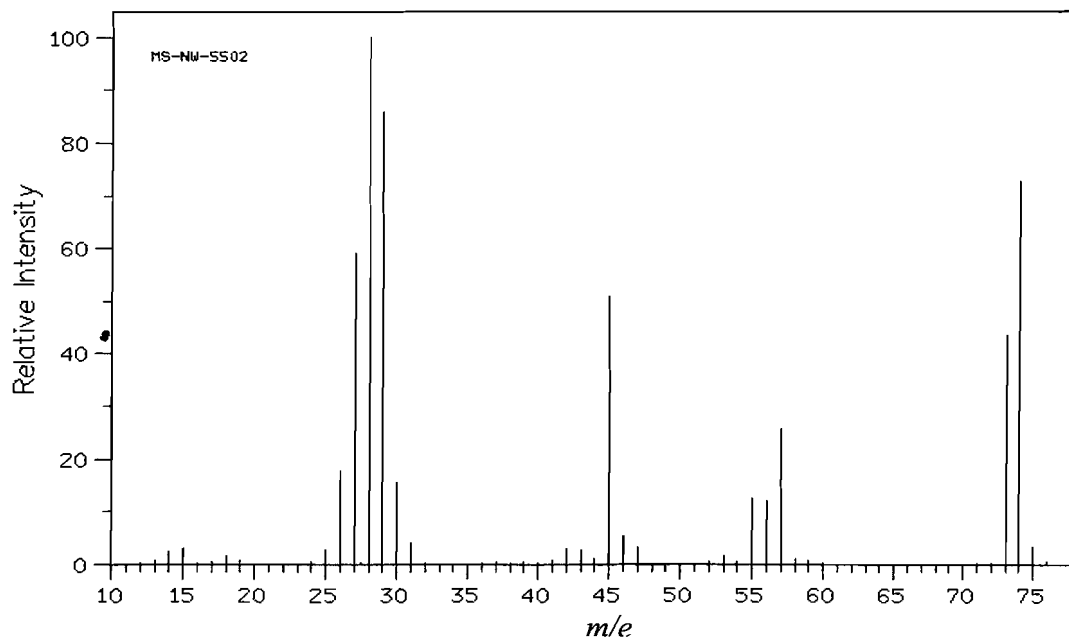


**Question 4**

All data given in this question refers to the one compound.

- a) The microanalysis of a compound gives the following results: C: 48.6 %; H: 8.1 % and O: 43.2 %. Determine the empirical formula of the compound.

- b) The mass spectrum of the compound referred to in part (a) is given below.



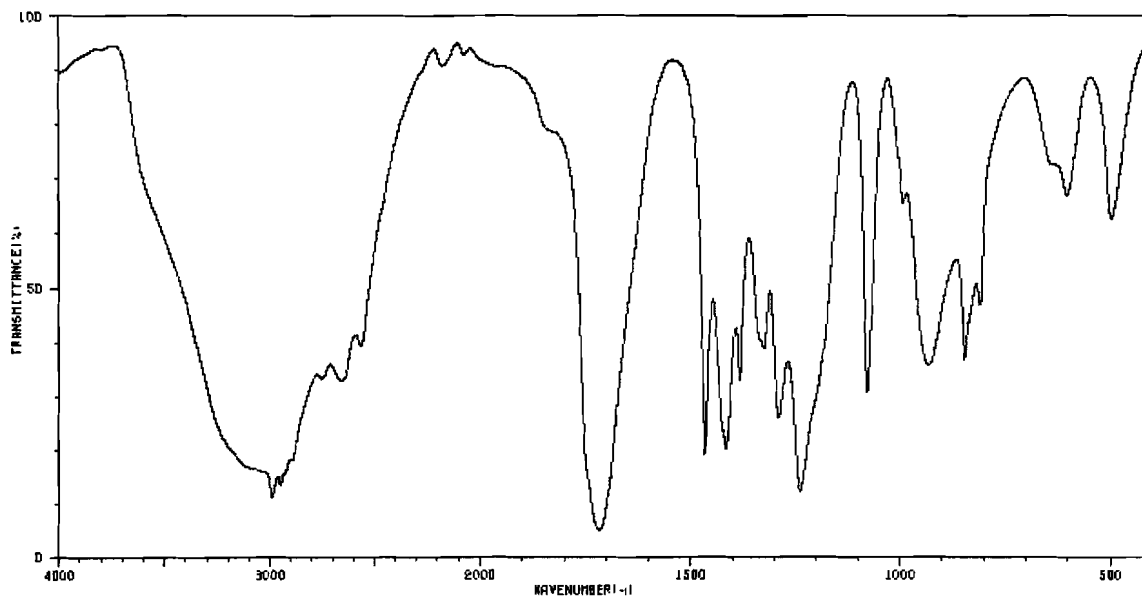
Suggest the chemical formulae of the species responsible for the given  $m/e$  values

<b><math>m/e</math> value</b>	<b>29</b>	<b>45</b>	<b>73</b>	<b>74</b>
<b>Species</b>				

- c) State the molecular formula of the compound.
-

**Question 4 (continued)**

d) The infrared spectrum of this compound is shown below.



This IR spectrum shows a number of significant absorptions.

Assign a chemical bond to each of the following absorptions.

The broad peak at  $3050\text{ cm}^{-1}$

---

The sharp peak at  $2920\text{ cm}^{-1}$

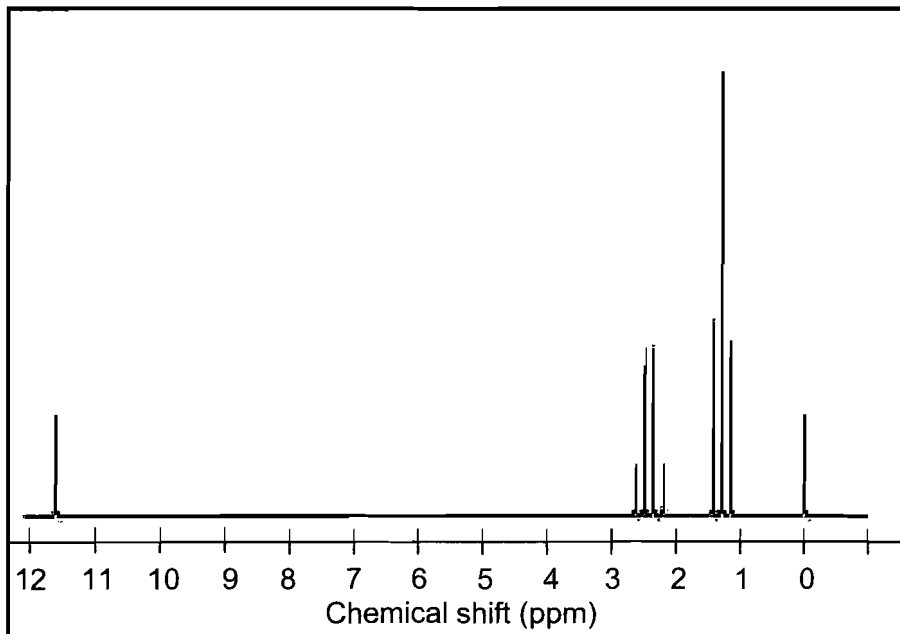
---

The peak at  $1720\text{ cm}^{-1}$

---

**Question 4 (continued)**

e) The  $^1\text{H}$  NMR spectrum for the compound is shown below.



Ratio of the areas under the peaks

Chemical shift	1.3	2.4	11.7
Relative Area	3	2	1

(i) Explain the cause of the peak at  $\delta = 0$  ppm and explain its significance.

---



---



---

(ii) Using the information from parts a), b), c) and d) and the NMR spectrum deduce the structural formula **and** name the compound.

**Question 5**

a) A nucleotide of DNA contains deoxyribose, a phosphate group and an organic base. With the aid of a simplified labelled diagram indicate how the components of the nucleotides are linked together to form polynucleotides.

(b) (i) Describe how a DNA profile can be obtained from a sample of blood taken from a crime scene.

---



---



---



---



---



---

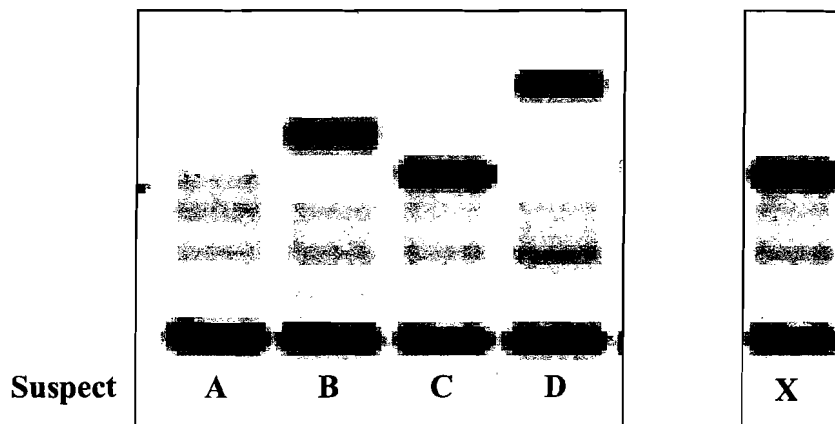


---



---

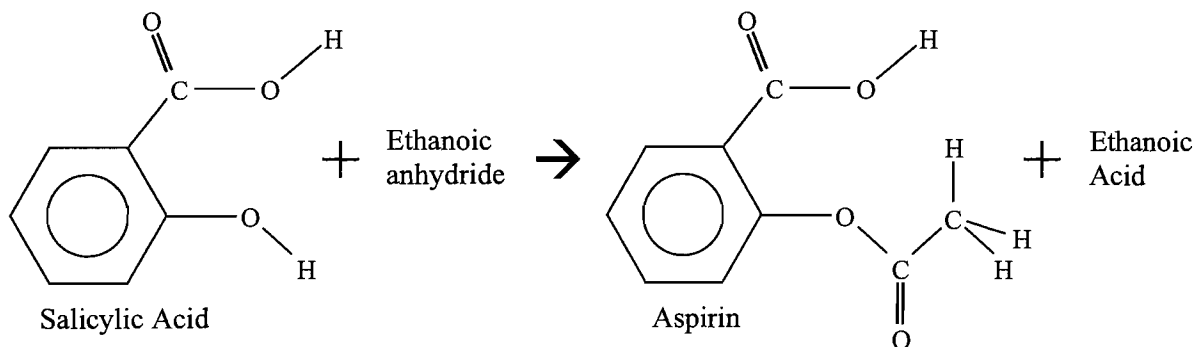
(ii) The following DNA profiles were produced. Profile X was produced using a blood sample located at the crime scene.  
Which suspect(s) is(are) likely to be associated with the crime? \_\_\_\_\_



2 + [4 + 1] = 7 marks  
Suggested time: 8 minutes

**Question 6**

Aspirin is a substance produced from salicylic acid and used as a mild analgesic. The synthetic pathway is completed by the following reaction.



- a) Deduce the molecular formula of aspirin.

---

- b) Circle **and** clearly indicate the name of each of the functional groups in salicylic acid.

---



---

- c) (i) Name the functional group formed in the synthesis of aspirin.

---

- (ii) What is the name of the type of reaction that produces this functional group?

---

1 + 2 + [1 + 1] = 5 marks  
Suggested time: 5 minutes



**Question 7**

Serine is an amino acid found in living organisms.

- a) What part of the serine molecule acts as a base?

---

- b) Electrophoresis of an aqueous solution of serine under acidic conditions causes the amino acid to move towards the negative terminal, while electrophoresis under alkaline conditions causes it to move towards the positive terminal.

Explain these observations. Include chemical formulas showing serine in acidic and alkaline solutions.

---

---

---

---

---

---

---

---

---

---

- c) Two serine molecules may join together to form a dipeptide.

(i) What is the name of this type of reaction? \_\_\_\_\_

(ii) Another product is formed in this reaction.  
What is the chemical formula of this product? \_\_\_\_\_

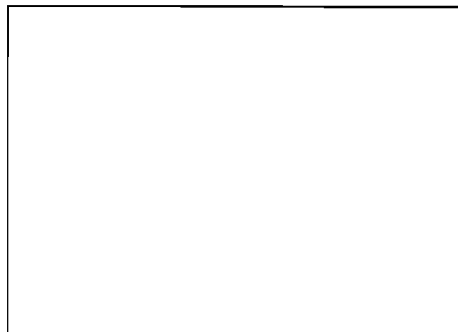
(iii) Draw the structural formula (showing all chemical bonds) of the dipeptide formed from two serine molecules in neutral conditions.

**Question 8**

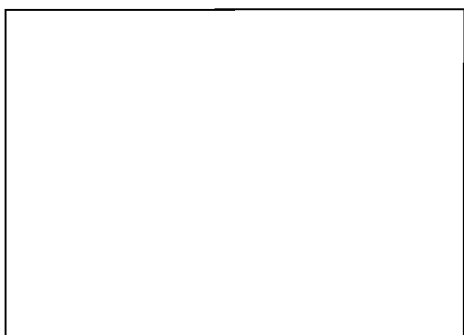
- a) Draw the structural formula of the following organic compounds.



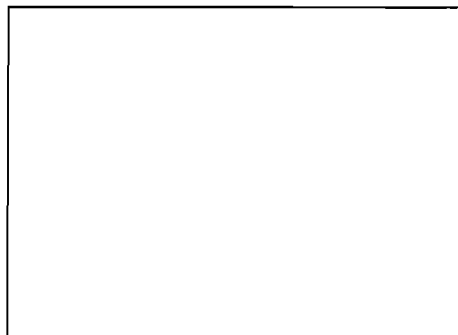
Butan-1-ol



Methylpropan-2-ol



But-1-ene



Butanoic acid

- b) Give one chemical test that can be used to distinguish between each of the following pairs of compounds.

Describe the results that would be expected in each test.

Where appropriate give chemical equations for the reactions that are involved.

- (i) Butan-1-ol and Butanoic acid

---

---

---

---

---

---

---

**Question 8 (continued)**

(ii) Butan-1-ol and But-1-ene

---

---

---

---

---

---

(iii) Butan-1-ol and Methylpropan-2-ol

---

---

---

---

---

---

[4 x 1] + [3 x 2] = 10 marks  
*Suggested time: 11 minutes*

**END OF EXAMINATION**