# *INSIGHT*

***Trial Exam Paper***

# 2009

# CHEMISTRY

# Written examination 1

**STUDENT NAME:**

## QUESTION AND ANSWER BOOK

*Reading time: 15 minutes*
*Writing time: 1 hour 30 minutes*

**Structure of book**

| *Section* | *Number of questions* | *Number of questions to be answered* | *Number of marks* |
|---|---|---|---|
| A | 20 | 20 | 20 |
| B | 8 | 8 | 58 |
| | | | Total 78 |

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring sheets of paper or white out liquid/tape into the examination.

**Materials provided**

- The question and answer book of 21 pages, with a removable data sheet.
- An answer sheet for multiple-choice questions.

**Instructions**

- Remove the data sheet from this book during reading time.
- Write your **name** in the box provided.
- You must answer the questions in English.

**At the end of the examination**

- Place the multiple-choice answer sheet inside the front cover of this question and answer book.

**Students are NOT permitted to bring mobile phones or any other electronic devices into the examination.**

# SECTION A – Multiple-choice questions

## Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for the multiple-choice questions.
Choose the response that is **correct** or that **best answers** the questions.
1 mark will be awarded for a correct answer; no marks will be awarded for an incorrect answer.
Marks are **not** deducted for incorrect answers
No marks will be awarded if more than one answer is complete for any question.

**Question 1**

A 100 mL solution of glucose, $C_6H_{12}O_6$, has a concentration of 75.0 g $L^{-1}$. The number of glucose molecules in the solution is

**A.** 0.0417
**B.** 0.417
**C.** $2.51 \times 10^{22}$
**D.** $2.51 \times 10^{23}$

*Questions 2 and 3 refer to the following information.*

A sample of brick cleaner is diluted in a volumetric flask. Aliquots of the diluted solution are transferred to conical flasks, and a few drops of indicator are added to each. Then, each aliquot is titrated for hydrochloric acid content using a standard solution of sodium hydroxide.

**Question 2**

The term 'standard solution' refers to the fact that the sodium hydroxide solution

**A.** was prepared directly from a good primary standard.
**B.** has a concentration of 1.0 M.
**C.** was prepared using a volumetric flask.
**D.** has an accurately known concentration.

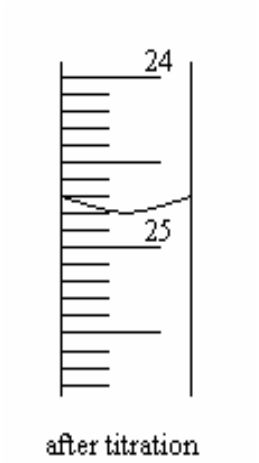
**Question 3**

The best indicator for the analysis and the colour change observed is

| | **Indicator** | **Colour change observed** |
|---|---|---|
| **A.** | bromothymol blue | yellow to blue |
| **B.** | bromothymol blue | blue to yellow |
| **C.** | thymol blue | red to yellow |
| **D.** | thymol blue | yellow to red |

**Question 4**

An aliquot of 20.00 mL of 0.100 M $CH_3COOH$ is placed in a conical flask. A solution of sodium hydroxide is aded to a burette. The initial volume of the burette was 8.40 mL. The diagram below shows the relevant section of the burette after the titration is complete.




after titration

The concentration, in mol $L^{-1}$, of the sodium hydroxide is

**A.** 0.0806
**B.** 0.119
**C.** 0.122
**D.** unable to be determined from the information provided.

**Question 5**

The Hazelwood power station in the Latrobe Valley uses about 36 000 tonnes of coal each day. Coal contains 25.0% carbon by mass (1 tonne = $10^6$ g). The volume of carbon dioxide, in L, released each day by the power station at 18°C and 1.03 atm is

**A.** $1.08 \times 10^9$
**B.** $1.74 \times 10^{10}$
**C.** $6.98 \times 10^{10}$
**D.** $1.09 \times 10^{11}$

**Question 6**

Which of the following gases will occupy the biggest volume at STP?

**A.** 10.0 g of $CO_2$
**B.** 10.0 g of $NO_2$
**C.** 10.0 g of $SO_2$
**D.** 10.0 g of $O_2$

**Question 7**

A polymer is known to contain only carbon, hydrogen and chlorine. It contains 38.4% carbon and 4.84% hydrogen. The number of carbon atoms in the empirical formula is

**A.** 1
**B.** 2
**C**. 3
**D.** 4

**Question 8**

A volume of 30.0 mL of 0.10 M sulfuric acid ($H_2SO_4$) reacts with 30.0 mL of 0.10 M sodium hydroxide solution. The concentration of sulfate ions in the resultant solution, in M, is

**A.** 0.0
**B.** 0.0030
**C.** 0.050
**D.** 0.10

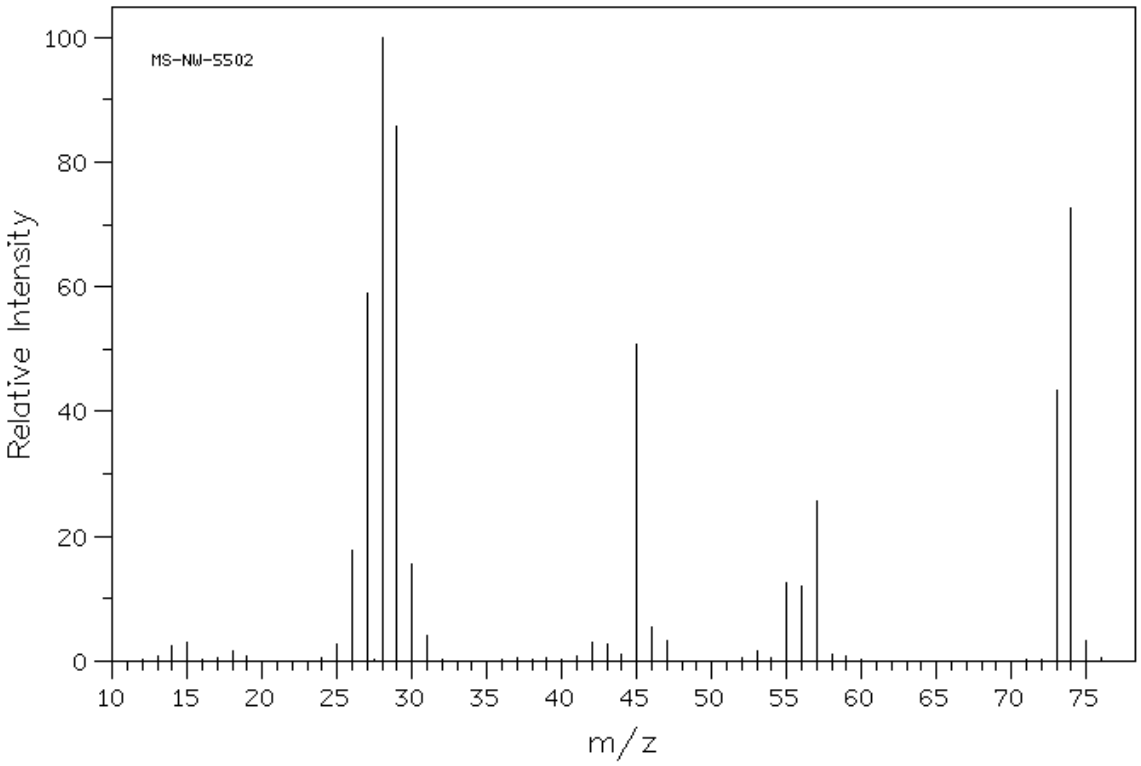
**Question 9**

A mixture of amino acids is analysed using thin layer chromatography. The amino acid serine moves 4.0 cm up the plate from the origin and has an $R_f$ value of 0.76. The amino acid valine travels 3.0 cm up the plate from the origin. The $R_f$ value of valine is

**A.** 0.25
**B.** 0.57
**C.** 0.75
**D.** 2.28

**Question 10**

The mass spectrum of propanoic acid is given below.




*Source:* http://riodb01.ibase.aist.go.jp/sdbs/cgi-bin/direct_frame_top.cgi

What fragment must have been lost from the molecular ion to account for the high peak at m/z 73?

**A.** H

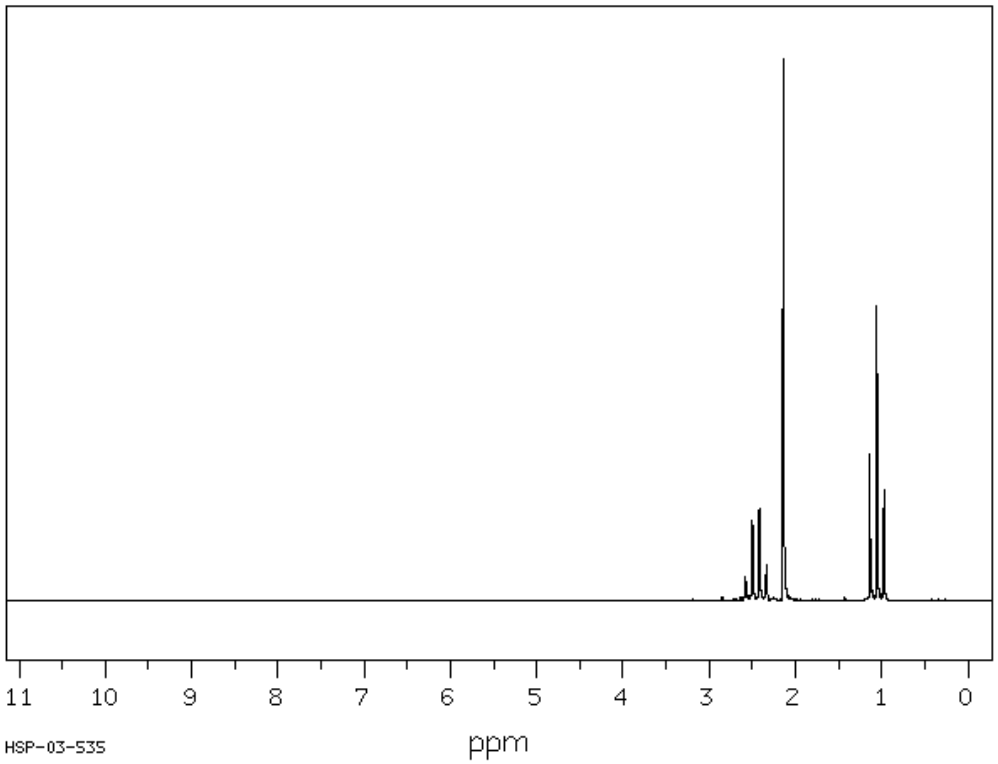
**B.** $H^+$

**C.** $H_2$

**D.** $H_2^+$

**Question 11**

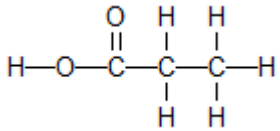
The $^{1}H$ nuclear magnetic resonance (NMR) spectrum of an unknown compound is shown below.



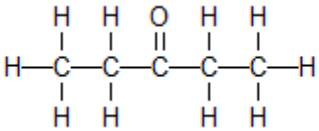

*Source:* http://riodb01.ibase.aist.go.jp/sdbs/cgi-bin/direct_frame_top.cgi

The structure of the compound could be

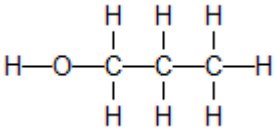
**A.**



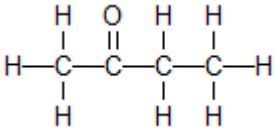
**B.**



**C.**



**D.**



**Question 12**

Aspirin is widely used for pain relief and to reduce fever. Which of the following statements regarding the synthesis of aspirin is **not** correct?

**A.** Aspirin can be formed by a reaction between the carboxyl group on one molecule and the hydroxyl group on another.

**B.** Aspirin contains carboxyl and ester functional groups.

**C.** Aspirin can be synthesised by a reaction between salicylic acid and ethanoic anhydride.

**D.** The carboxyl functional group on salicylic acid is involved in the reaction with another molecule to form aspirin.

**Question 13**

Which of the following statements about DNA is **not** correct?

**A.** DNA contains only the elements carbon, hydrogen, oxygen, nitrogen and phosphorous.

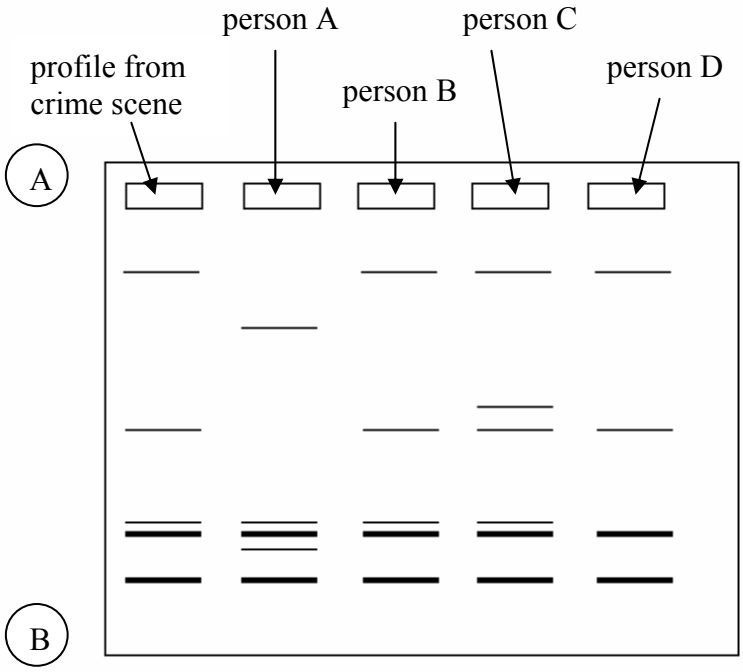
**B.** A piece of double-stranded DNA, which is 50 base pairs in length and contains 20 thymine bases, will also contain 20 guanine bases.

**C.** The bonding responsible for the primary structure of DNA is the same type of bonding as that responsible for the primary structure of proteins.

**D.** All DNA fragments are negatively charged.

**Question 14**

Gel electrophoresis can be used to separate DNA fragments in forensic chemistry. It can be used to obtain a DNA profile from hair left at a crime scene, which then can be compared to a number of suspects. One such analysis, using gel electrophoresis, is shown below.




Which of the following statements about the analysis is **not** correct?

**A.** The samples from persons B, C and D all contain at least one fragment with a higher molecular mass than any of the fragments in the sample from person A.

**B.** Person B is most likely to be the guilty individual.

**C.** The positive terminal of the power supply is connected to end B of the gel.

**D.** The rate at which the DNA fragments in each sample move through the gel depends on their molecular mass and the number of positive charges present on each fragment.

**Question 15**

A triglyceride is formed by a reaction between glycerol and three myristic acid molecules. The molar mass of the triglyceride, in g $mol^{-1}$, will be

**A.** 504

**B.** 722

**C.** 758

**D.** 776

**Question 16**

A sample of an alkanol is placed in a cell and has infrared radiation passed through it. The difference in the radiation transmitted through the sample cell compared with a reference cell is due to energy being absorbed to

**A.** move the molecule to a higher vibrational energy level.

**B.** ionise and fragment the molecules.

**C.** promote an electron from a lower energy level to a higher energy level.

**D.** promote the nucleons to a higher spin level.

**Question 17**

An unknown organic molecule that is able to dissolve in water is thought to be an alkanol or a carboxylic acid. The analytical technique most suitable for identifying whether the organic molecule belongs to either of these homologous series is

**A.** nuclear magnetic resonance (NMR) spectroscopy.

**B.** UV-visible spectroscopy.

**C.** infrared (IR) spectroscopy.

**D.** mass spectroscopy.

**Question 18**

Which of the following is the most unsaturated fatty acid?

**A.** linoleic acid

**B.** linolenic acid

**C.** arachidic acid

**D.** arachidonic acid

**Question 19**

Fractional distillation can be used in the laboratory to separate a mixture of alkenes into components. Which of the following statements about fractional distillation is **not** correct?

**A.** The separation of components in fractional distillation is a physical process.

**B.** The first component collected in the laboratory will have the highest molar mass.

**C.** The last component collected in the laboratory will have the highest boiling temperature.

**D.** The order in which the components in this mixture are collected will depend on the strength of their dispersion forces.

**Question 20**

Correct functioning of an enzyme is dependent on its three-dimensional structure. If this structure is disrupted the protein will denature.

Which of the following changes could result in denaturation?

I The addition of a strong base.
II An increase in temperature.
III A decrease in temperature.

**A.** I only
**B.** II and III only
**C.** I and II only
**D.** I, II and III

**END OF SECTION A**

## SECTION B – Short-answer questions

### Instructions for Section B

Answer **all** questions in the spaces provided
To obtain **full marks** for your responses you should

- give simplified answers with an appropriate number of significant figures to 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 working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$; NaCl(s)

**Question 1**

The concentration of iron(II) ions, $Fe^{2+}(aq)$, in a solution can be determined by volumetric analysis. Shown below is the method used in one such analysis to determine the iron(II) content of lawn fertiliser.

**Method**

- 16.80 g of lawn fertiliser is dissolved in water and the solution made up to 500.0 mL in a volumetric flask.
- Approximately 20 mL of 1 M sulfuric acid is added to three separate 20.00 mL samples of this solution.
- A 0.01000 M standard solution of potassium permanganate, $KMnO_4$, is used to titrate each of the samples. In this reaction, the iron(II) ions are oxidised to iron(III) ions and the purple permanganate ions are reduced to colourless manganese(II) ions.

The results of this analysis are shown below.

**Results**

Mass of lawn fertiliser = 16.80 g

Volume of volumetric flask = 500.0 mL

Volume of fertiliser solution in each sample = 20.00 mL

| Sample | 1 | 2 | 3 |
|---|---|---|---|
| Titre volume (mL) | 10.21 | 10.25 | 10.25 |

**a.** **i.** Determine the oxidation number of manganese in the permanganate ion.

_____

1 mark

**ii.** Write a balanced half-equation for the reduction reaction that takes place in this analysis.

_____

_____

1 mark

**iii.** Write a balanced equation for the overall reaction that takes place in this analysis.

_____

_____

_____

2 marks

**b.** Why is an indicator **not** required for this titration?

_____

_____

_____

1 mark

**c.** Calculate

**i.** the amount, in mol, of $Fe^{2+}(aq)$ in the 500.0 mL volumetric flask.

_____

_____

_____

_____

_____

2 marks

**ii.** the percentage, by mass, of iron(II) in the lawn fertiliser.

_____

_____

_____

_____

_____

2 marks

**d.** Several actions that could occur during this analytical procedure are listed below (**A–D**).

**i.** For each action, indicate the likely effect on the calculated percentage of iron(II) ions in the fertiliser by placing a tick in the appropriate box.

| Action | Calculated result would be too low | No effect on calculated result | Calculated result would be too high |
|---|---|---|---|
| **A.** The volumetric flask had been washed previously with distilled water, but not dried. | | | |
| **B.** A 25.00 mL pipette was unknowingly used instead of a 20.00 mL pipette. | | | |
| **C.** The mass of the fertiliser was recorded incorrectly. The recorded mass was 0.15 g less than the actual mass. | | | |
| **D.** The burette had been washed previously with distilled water only. | | | |

4 marks

**ii.** Explain your reasoning for the answer that you have given in the case of action **B**.

_____

_____

_____

1 mark

Total 4 + 1 + 4 + 5 = 14 marks

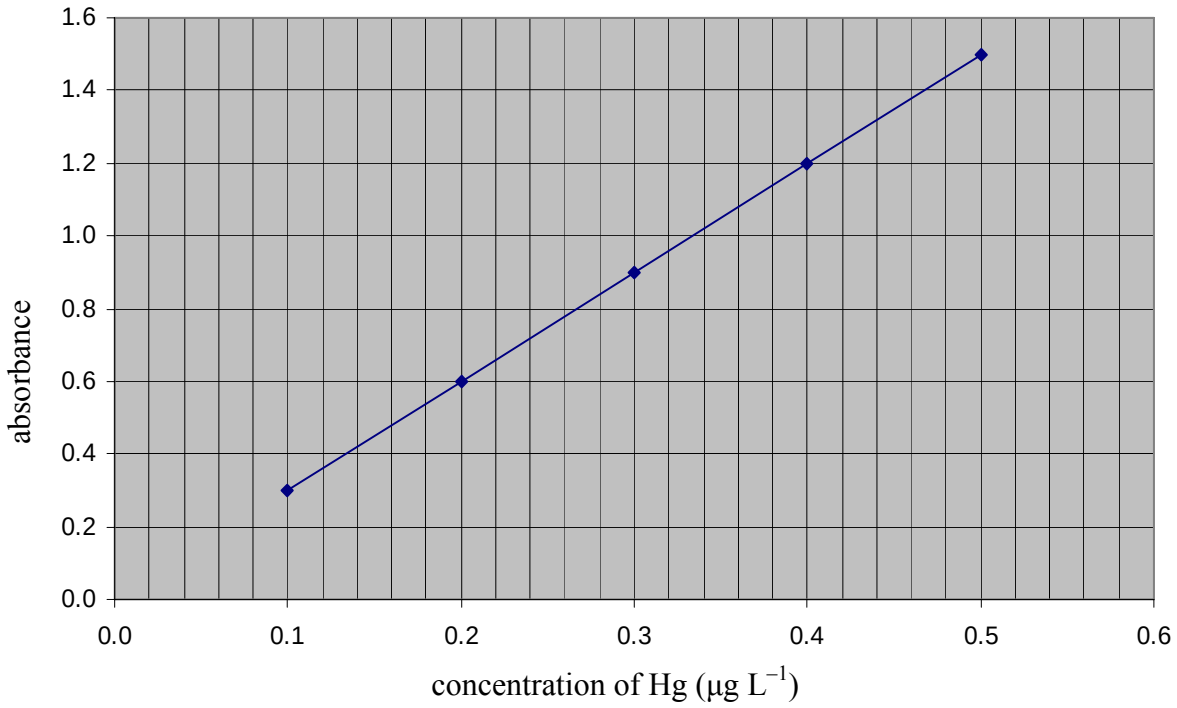
**Question 2**

Mercury poisoning is a disease in humans caused by excessively high exposure to mercury (Hg). Due to safety concerns, the mercury content of commercially traded shellfish that is intended for consumption by humans should not exceed 0.5 mg $kg^{-1}$. One way to determine the mercury content in shellfish is to analyse samples using atomic absorption spectroscopy (AAS).

A mass of 0.1373 g of freeze-dried sample of shellfish tissue is dissolved in 2.00 mL of nitric acid, heated for 3 hours at 125°C and transferred to a 500.0 mL volumetric flask, where it is made up to the mark with deionised water. A volume of 1.00 mL of this solution is then further diluted to 250.0 mL in a second volumetric flask. AAS is used to measure the absorbance of this solution, which is found to be 1.03.

Next, the absorbance of a series of Hg solutions of known concentration was measured using AAS and a calibration graph drawn.

**Calibration graph**



**a.** What is the concentration, in μg $L^{-1}$, of mercury in the 250.0 mL volumetric flask?

_____

1 mark

**b.** Calculate the mass, in mg, of mercury in the shellfish sample.

_____

_____

_____

_____

_____

2 marks

**c.** Should this shellfish be traded commercially? Justify your answer.

_____

_____

_____

_____

_____

3 marks

**d.** **i.** What type of lamp would be used in the AAS for this analysis?

_____

1 mark

**ii.** Explain why this type of lamp is used.

_____

_____

_____

1 mark
Total 1 + 2 + 3 + 2 = 8 marks

**Question 3**

A mixture of ethanol, 1-propanol and 1-butanol is analysed using gas chromatography (GC).

**a.** Predict which molecule will travel through the chromatography column at the fastest rate. Give a reason for your choice.

_____

_____

2 marks

**b.** Explain how gas chromatography can be used for qualitative analysis.

_____

_____

1 mark

**c.** Explain how gas chromatography can be used for quantitative analysis.

_____

_____

1 mark

**d.** Predict which of the molecules in the mixture will show the greatest number of peaks in a $^{13}C$ NMR spectrum. Give a reason for your answer.

_____

_____

_____

2 marks
Total 2 + 1 + 1 + 2 = 6 marks

**Question 4**

A compound, X, is known to be a carboxylic acid of molecular formula $C_5H_{10}O_2$. The structure, which may or may not be branched, is unknown.

**a.** In the boxes below, draw the structures, showing **all** bonds, of the four possible carboxylic acids with the molecular formula $C_5H_{10}O_2$.

| | |
|---|---|
| Carboxylic acid I | Carboxylic acid II |
| Carboxylic acid III | Carboxylic acid IV |

4 marks

Compound X shows four peaks in the $^1H$ NMR spectrum and four peaks in the $^{13}C$ NMR spectrum.

**b.** What conclusions about the structure of X can be determined from this information?

_____

_____

2 marks

**c.** Identify compound X by

- circling the correct structure in part **i** that corresponds to compound X.
- writing the systematic name of compound X below.

_____

2 marks
Total 4 + 2 + 2 = 8 marks

**SECTION B** – continued
**TURN OVER**

**Question 5**

**a.** Draw the structure of the amino acid, aspartic acid, as it would exist in solution at pH 13. Show **all** bonds.

1 mark

**b.** What is the molecular formula of the amino acid, tyrosine?

_____

1 mark

**c.** A tripeptide forms between two aspartic acids and one tyrosine.

**i.** How many different tripeptides could be possibly formed?

_____

1 mark

**ii.** Name **all** of the functional groups that would be present on any of the tripeptides formed.

_____

2 marks

Proteins have different levels of structure.

**d.** **i.** Name the type of bonding responsible for the primary structure of a protein.

_____

1 mark

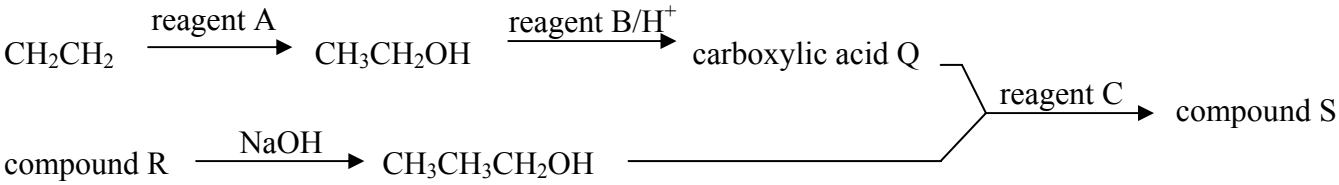
**ii.** Name the type of bonding responsible for the secondary structure of a protein.

_____

1 mark
Total 1 + 1 + 3 + 2 = 7 marks

**Question 6**

An ester can be produced using the partly completed reaction pathway shown below.




**a.** In the space provided below, give the formulas of reagents A, B and C.

reagent A _____

reagent B _____

reagent C _____

3 marks

**b.** In the space provided below, give the systematic names of compounds Q and R.

compound Q _____

compound R _____

2 marks

**c.** **i.** In the space below, draw the structure, showing **all** bonds, of compound S.

1 mark

**ii.** Give a systematic name for compound S.

_____

1 mark
Total 3 + 2 + 2 = 7 marks

**Question 7**

Ethanol, biodiesel and biogas are all biochemical fuels.

**a.** What is the basis for classifying these fuels as 'biochemical' fuels?

_____

1 mark

**b.** Write a balanced chemical reaction for the production of ethanol by the fermentation of glucose.

_____

_____

1 mark

**c.** **i.** Give the name of the functional group present in ethanol.

_____

1 mark

**ii.** In which wavelength range, in $cm^{-1}$, would you expect this functional group to show a peak on an infrared absorption spectrum for ethanol?

_____

1 mark
Total 1 + 1 + 2 = 4 marks

**Question 8**

A volume of 20.0 mL of 0.103 M NaCl(aq) was added to 15.0 mL of 0.855 M $AgNO_3$(aq). A reaction occurs according to the equation

$$NaCl(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgCl(s)$$

**a.** Calculate the mass of silver chloride you would expect to be precipitated from this reaction mixture.

_____

_____

_____

_____

_____

2 marks

**b.** Give **two** sources of experimental error that would cause the mass of the precipitate to be higher than it should be.

_____

_____

_____

_____

2 marks
Total 2 + 2 = 4 marks

**END OF QUESTION AND ANSWER BOOK**