INSIGHT

Trial Exam Paper

2010

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	10	10	53
			Total 73

- 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 19 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

The technique best used to identify the presence of more than one isotope of copper in a copper sample is

A. infrared spectroscopy.
B. UV-visible spectroscopy.
C. atomic absorption spectroscopy.
D. mass spectrometry.

Question 2

A mixture containing the compounds 1-chloro-2-methylhexane, 1-chloro-2-methylbutane and 1-chloro-2-methyloctane was analysed using gas chromatography. The molecule expected to have the longest retention time in the chromatography column is

A. 1-chloro-2-methylhexane.
B. 1-chloro-2-methylbutane.
C. 1-chloro-2-methyloctane.
D. unable to be predicted from the information provided.

Question 3

A mixture of glucose and sucrose was analysed using high-performance liquid chromatography. The chromatogram of the mixture produced the following peak areas.

Compound	Peak area
0.145 mol of glucose	674 units
0.305 mol of sucrose	1205 units

An analysis of a separate sample of glucose under the same conditions gave a peak area of 1205 units. The expected amount of glucose in the second sample is

A. 0.0811
B. 0.145
C. 0.259
D. 0.305

Question 4

Which one of the following compounds is expected to show three peaks in a ^{1}H NMR spectrum and two peaks in a ^{13}C NMR spectrum?

A. chloroethane
B. ethanol
C. ethanoic acid
D. ethyl ethanoate

Question 5

Spectroscopic techniques involve the analysis of substances based on their absorptions of a range of energies.

Consider the following statements about different spectroscopic techniques.

I Infra-red spectroscopy involves the absorption of infra-red radiation to promote electrons to higher energy levels.

II UV-visible spectroscopy and atomic absorption (AAS) spectroscopy both involve the absorption of light to promote electrons to higher energy levels.

III ^{13}C NMR spectroscopy involves the absorption of radio waves by **all** of the ^{12}C atoms present in a sample of a molecule under analysis.

Which of the statements above are true?

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

Question 6

A compound is formed by adding together samples of $C_2H_5OH(l)$ and $HCOOH(l)$ in the presence of concentrated sulfuric acid. This compound is then analysed using high resolution ^{1}H NMR. The number of sets of peaks and the splitting pattern expected for the compound are

A. two sets of peaks; both consisting of a single peak.
B. two sets of peaks; both split into four fine peaks.
C. three sets of peaks; one single, one split into three and one split into four fine peaks.
D. three sets of peaks; one single, one split into two and one split into three fine peaks.

Question 7

Which of the following correctly represents the coefficents in the following equation when it is correctly balanced?

$$\_\_Cr_2O_7^{2-}(aq) + \_\_H^{+}(aq) + \_\_C_2H_5OH(aq) \rightarrow \_\_Cr^{3+}(aq) + \_\_H_2O(l) + \_\_CH_3COOH(aq)$$

A. 1, 14, 1, 2, 7, 1
B. 2, 16, 1, 4, 14, 1
C. 2, 16, 3, 4, 11, 3
D. 1, 14, 3, 2, 7, 3

Question 8

A sample of a hydrocarbon is burnt in pure oxygen. The only products are 13.2 g of $CO_2(g)$ and 5.40 g of $H_2O(g)$. The name of the hydrocarbon is

A. methane.
B. ethene.
C. ethane.
D. propane.

Questions 9 and 10 refer to the following information.

0.245 g of pure C_3H_7COOH was dissolved in water to a total volume of 25.00 mL and titrated with 0.105 M NaOH solution.

Question 9

The volume of NaOH solution, in mL, required to reach the end point of the titration was closest to

A. less than 26.5
B. 26.5
C. 53.0
D. 1110

Question 10

Which of the following gives a suitable indicator and the expected colour change for this titration?

	Suitable indicator	**Expected colour change**
A.	methyl red	red to yellow
B.	methyl red	yellow to red
C.	phenolphthalein	colourless to red
D.	phenolphthalein	red to colourless

Question 11

A sample of propane gas combusts completely in oxygen. A volume of 5.48 L of carbon dioxide is produced when measured at 22.0°C and 1.00 atm. The mass, in g, of propane that combusted was

A. 3.32
B. 9.41
C. 29.9
D. 401

Question 12

Consider the following statements about alkanes.

I Alkanes react with oxygen to produce carbon dioxide and water.

II Alkanes react with hydrogen chloride to produce chloroalkanes.

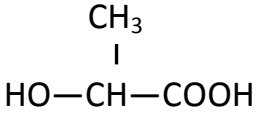
III Alkanes react with sodium hydroxide to produce alkanols.

Which of the statements above are true?

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

Question 13

Lactic acid is an organic substance produced in the body during high levels of activity when the oxygen requirements of the muscles are greater than can be supplied by the blood circulation system. A representation of lactic acid is given below.



Which of the following reagents would you expect lactic acid **not** to react with under the conditions indicated?

A. CH_3OH and H_2SO_4 catalyst
B. $H_2O(l)$ at room temperature
C. $Br_2(aq)$ at room temperature
D. $MnO_4^-(aq)$ and $H^+(aq)$

Question 14

Consider the following statements about isomers.

I Isomers share the same molecular formula.

II Isomers share the same physical and chemical properties.

III Isomers share identical infra-red spectrums.

Which of the statements above are true?

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

Question 15

The melting temperature of a piece of double-stranded DNA is the temperature at which 50% of the strand separates into single strands. Two fragments of DNA of equal length have different melting temperatures. The melting temperature of fragment A is higher than that of fragment B. This is best explained by

A. Fragment A has a greater percentage of adenine bases than fragment B.

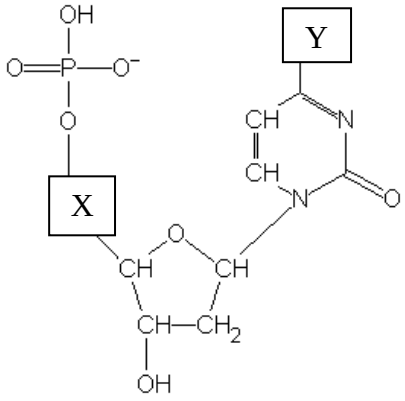
B. Fragment B has a greater percentage of cytosine bases than fragment A.

C. Fragment A has a higher number of disulfide cross-links than fragment B.

D. Fragment A has a greater percentage of guanine bases than fragment B.

Question 16

Part of the structure of a nucleotide is represented in the diagram below.



The formulas of the atom or groups of atoms represented by X and Y are

	X	**Y**
A.	NH	NH_2
B.	CH_2	NH_2
C.	NH	CH_3
D.	CH_2	CH_3

Question 17

The amino acid sequence of a small polypeptide molecule is shown below.

Ala – Gly – Asn – Pro – Ala – Val

The number of amide (peptide) functional groups in this polypeptide, and the expected pH of the polypeptide when dissolved in water is

	–CONH	**pH**
A.	5	basic
B.	5	neutral
C.	6	neutral
D.	6	acidic

Question 18

Biochemical fuels are best defined as

A. fuels derived from plant materials.
B. fuels produced by the anaerobic decay of wastes.
C. fuels that do not produce carbon dioxide when combusted.
D. fuels used by living things to provide energy.

Question 19

Consider the following reactions.

I Production of a nucleotide from deoxyribose, phosphate and adenine

II Production of polyethene from ethene

III Production of a disaccharide from monosaccharides

Which of these reactions could **not** be classified as a condensation reaction?

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

Question 20

The ester ethyl ethanoate is prepared by reacting ethanol with ethanoic acid in the presence of concentrated sulfuric acid. The boiling points of these three compounds and water are shown below.

$CH_3COOCH_2CH_3$	57°C
CH_3CH_2OH	78°C
H_2O	100°C
CH_3COOH	118°C

Fractional distillation can be used to extract pure ethyl ethanoate from the reaction mixture. The best way to achieve this is to

A. heat the reaction mixture in a distillation flask until the temperature at the top of the fractionating column is 118°C, and collect the fraction that condenses at this temperature.
B. heat the reaction mixture in a distillation flask until the temperature at the top of the fractionating column is 57°C, and collect the fraction that condenses at this temperature.
C. heat the reaction mixture in a distillation flask until the temperature at the top of the fractionating column is 57°C, and collect the fraction that remains in the flask at this temperature.
D. heat the reaction mixture in a distillation flask until the temperature at the top of the fractionating column is 118°C, and collect the fraction that remains in the flask at this temperature.

END OF SECTION A
TURN OVER

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

3,5,5-trimethylhexan-1-ol is a compound used in perfumes.

a. Draw the structural formula of 3,5,5-trimethylhexan-1-ol, clearly showing all bonds.

1 mark

b. Name the part of the structure of 3,5,5-trimethylhexan-1-ol that enables it to dissolve in water.

_____

_____

1 mark

c. Give the name of an analytical technique that could be used to quantitatively analyse a solution containing 3,5,5-trimethylhexan-1-ol.

_____

1 mark

Total 1 + 1 + 1 = 3 marks

Question 2

A student wishes to accurately determine the concentration of a solution of sodium hydroxide in a titration against a standard solution of nitric acid, HNO_3.

A solution of 0.100 M HNO_3 is required for the analysis. However, the only stock solution of HNO_3 available to the student is 1.00 M.

a. Describe, in detail, the steps the student must follow to accurately obtain a 500 mL solution of 0.100 M HNO_3.

_____

_____

_____

_____

_____

_____

_____

3 marks

The student then adds the diluted nitric acid to the burette for the analysis of sodium hydroxide. However, instead of previously cleaning the burette by rinsing it with the diluted nitric acid solution, the student rinses it with the 1.00 M stock solution. The concentration of sodium hydroxide is then determined.

b. Will the calculated concentration of sodium hydroxide be higher or lower than the true value? Explain your answer.

_____

_____

_____

2 marks

The student repeats the titration another three times. One of these titre amounts was determined to be discrepant. The three volumes are shown below.

Titre	Volume (mL)
1	24.55
2	24.90
3	24.60

c. Give two errors the student may have made that would have caused the discrepant titre.

_____

_____

_____

_____

2 marks

Total 3 + 2 + 2 = 7 marks

Question 3

Acetylsalicylic acid, or aspirin, is a drug commonly used as an analgesic (painkiller), to reduce fever and also as an anti-inflammatory. Aspirin can be produced in the laboratory by a number of different synthetic pathways. In one pathway, one molecule of salicylic acid reacts with one molecule of ethanoic acid to produce one molecule of aspirin and a water molecule.

A sample of aspirin (molar mass 180 g mol^{-1}) was prepared by reacting 3.65 g of salicylic acid (molar mass 138 g mol^{-1}) with 8.40 mL of ethanoic acid, in a conical flask. After the reaction was complete, the precipitated white crystals were collected, dried to constant mass and weighed.

The results below were obtained.

mass of salicylic acid	3.65 g
volume of ethanoic acid	8.40 mL
mass of product	4.50 g
density of ethanoic acid	1.05 g mL^{-1}

a. **i.** Calculate the initial amount, in moles, of ethanoic acid used.

_____

_____

_____

2 marks

ii. Calculate the initial amount, in moles, of salicylic acid used.

_____

_____

_____

1 mark

iii. Calculate the maximum mass of aspirin that can be theoretically produced from these starting amounts.

_____

_____

_____

_____

_____

_____

2 marks

iv. Calculate the percentage yield of aspirin in this preparation.

_____

_____

1 mark

b. A second pathway for preparing aspirin is one in which salicylic acid reacts with ethanoic anhydride. Give two reasons why this pathway is preferred over the one used in part **a**.

_____

_____

2 marks

Total 6 + 2 = 8 marks

Question 4

In a 1.00 L vessel, 600 mL of chlorine gas, Cl_2, is added to 400 mL of a saturated hydrocarbon that contains two carbon atoms. The vessel is then subjected to UV light for a period of time.

a. Write a chemical equation for the first reaction between chlorine gas and the hydrocarbon.

_____

_____

1 mark

b. Assuming constant temperature and pressure, what volume is produced of the largest product?

_____

_____

_____

_____

_____

2 marks

c. What will be the total volume, in L, of gases present once the reaction has finished.

_____

_____

_____

1 mark

d. Write a chemical equation for a possible subsequent reaction in the vessel in which the largest product formed in part **a.** is a reactant.

_____

_____

1 mark

Total 1 + 2 + 1 + 1 = 5 marks

Question 5

The IR and ^{13}C NMR spectra of a particular organic compound revealed the data below.

IR spectrum

Significant peak	Wavelength (cm^{-1})
1	1300
2	1700
3	3400 (broad)

^{13}C NMR spectrum

Peak	Chemical shift (ppm)
1	8.9
2	27.6
3	181.6

a. What type of information does the IR spectrum give you about the structure of a molecule?

_____

1 mark

b. In the list given below, circle the part of the molecule that absorbs energy in order to produce the IR spectrum as shown.

electrons nucleons covalent bonds dispersion forces

1 mark

c. What type of information does the ^{13}C NMR spectrum give you about the structure of a molecule?

_____

1 mark

d. In the list given below, circle the part of the molecule that absorbs energy in order to produce the ^{13}C NMR spectrum as shown.

electrons nucleons covalent bonds dispersion forces

1 mark

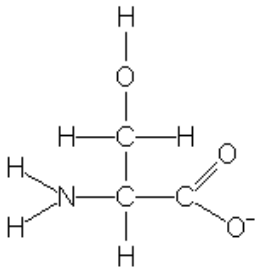
e. Draw the structural formula and give the name of the organic compound that causes this spectral data to be produced.

2 marks

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

Question 6

Consider the amino acid as represented by the structure below.



a. From the list below, circle the pH of the solution this amino acid would be dissolved in for it to exist as the structure given above.

pH 3 pH 5 pH 7 pH 9

1 mark

b. On the structure above, circle the part(s) of the molecule that would contribute to the secondary structure of a polypeptide using this amino acid.

1 mark

c. Give the name of the main type of bonding this amino acid might use to contribute to the tertiary structure of a polypeptide of which this amino acid was a part.

_____

1 mark

d. **i.** This amino acid links with glycine and threonine to form a tripeptide. How many possible different tripeptides could be produced?

_____

1 mark

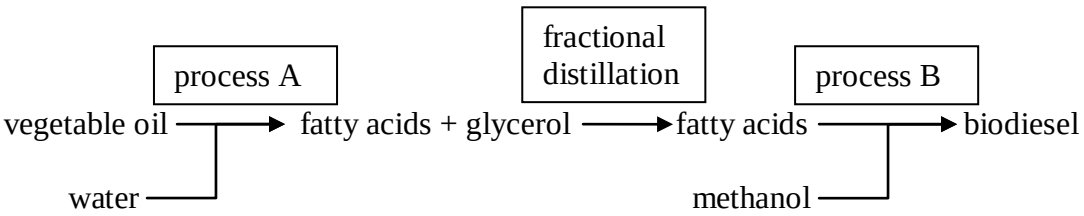
ii. Draw the structure of one of the possible tripeptides that could result.

1 mark

Total 1 + 1 + 1 + 2 = 5 marks

Question 7

Consider the flow chart below, showing the production of biodiesel, a biochemical fuel.



a. What type of reaction is process A?

_____

1 mark

b. What type of reaction is process B?

_____

1 mark

c. Write a balanced chemical equation for a reaction that could occur at process B.

_____

_____

2 marks

d. Give two advantages of biodiesel over diesel as a fuel for vehicles.

_____

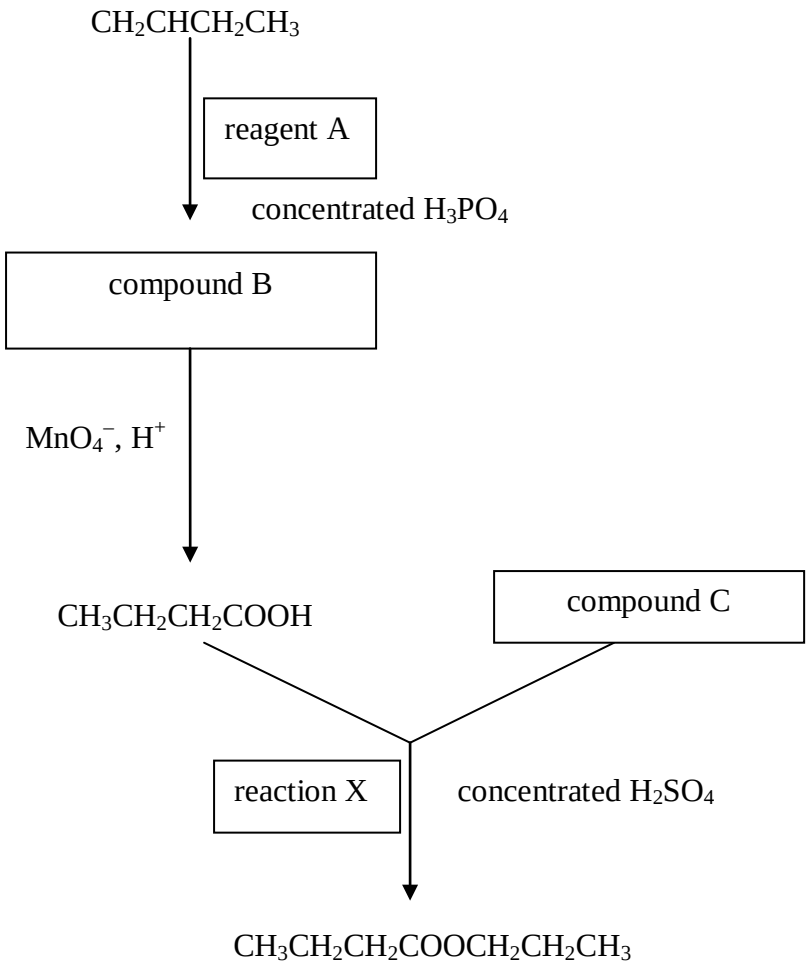
_____

2 marks

Total 1 + 1 + 2 + 2 = 6 marks

Question 8

Consider the partly completed reaction pathway shown below.



a. What is the formula of reagent A?

_____

1 mark

b. Draw a structure of compound B.

1 mark

c. What is the name of compound C?

_____

1 mark

d. Write a balanced chemical equation for reaction X.

_____

_____

1 mark

Total 1 + 1 + 1 + 1 = 4 marks

Question 9

a. Describe the difference between the primary and secondary structures of DNA.

_____

_____

_____

2 marks

b. DNA sequences are used to code for amino acid sequences in proteins, such as enzymes. Explain how a change in the primary structure of an enzyme can affect the ability of the enzyme to catalyse a reaction.

_____

_____

_____

2 marks

c. Name one method/change, other than altering the primary structure, which can alter an enzyme's catalytic ability.

_____

1 mark

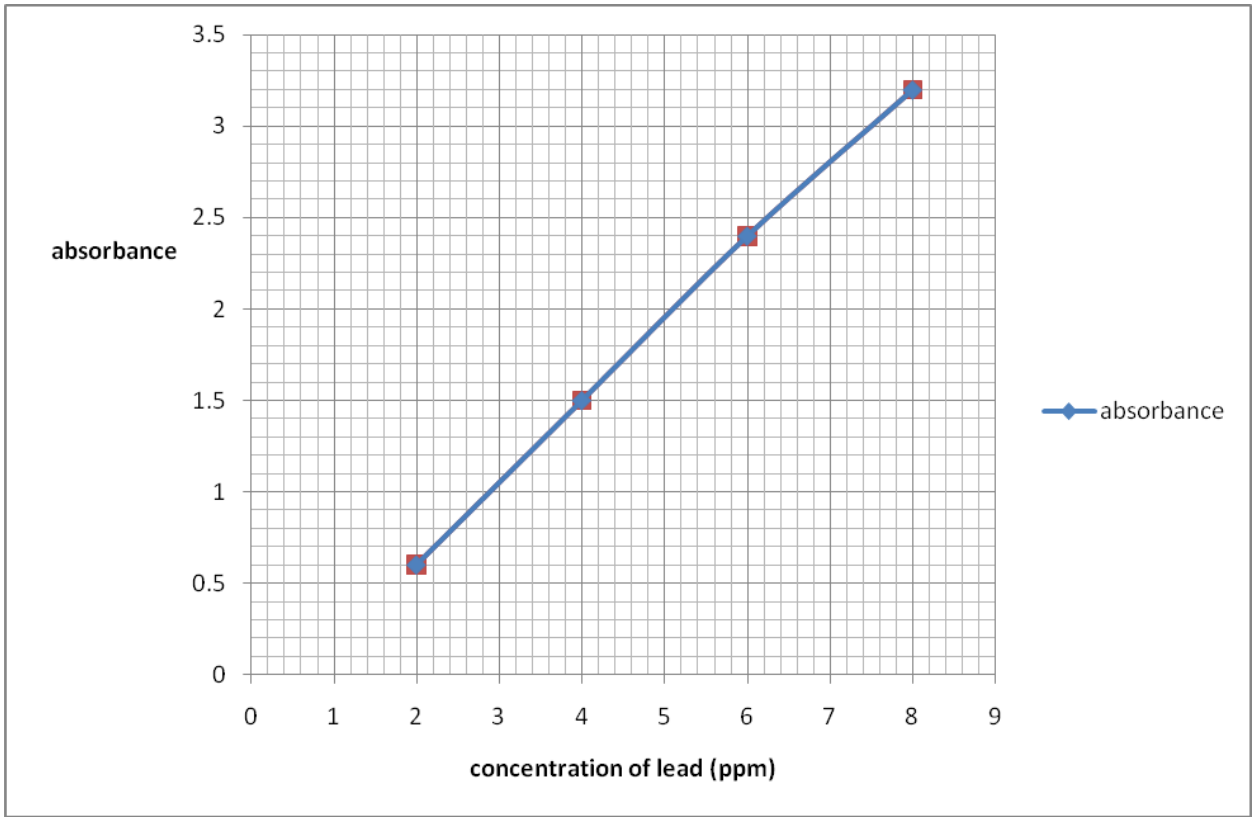
Total 2 + 2 + 1 = 5 marks

Question 10

An experiment was carried out to determine the percentage of lead in a particular batch of shellfish. One of the shellfish was removed from its shell and chopped finely. A 2.30 g sample was heated with 10 mL of nitric acid. The mixture was then filtered and made up to a volume of 1.00 L. A 25.00 mL aliquot of this solution was then further diluted to 100.0 mL in a flask. This solution was then analysed using atomic absorption spectroscopy and found to have an absorbance of 1.20.

The absorbances of a series of standard solutions of lead (II) ions were also measured and a calibration graph drawn.

Calibration graph



a. What is the concentration, in ppm, of lead (II) ions in the 100 mL volumetric flask?

_____

1 mark

b. Calculate the mass, in mg, of lead in the 1.00 L shellfish sample.

_____

_____

_____

_____

_____

2 marks

c. Calculate the percentage, by mass, of lead in the shellfish sample.

_____

_____

_____

1 mark

Total 1 + 2 + 1 = 4 marks

END OF QUESTION AND ANSWER BOOK