THE SCHOOL FOR EXCELLENCE (TSFX)

UNIT 3 CHEMISTRY 2009

WRITTEN EXAMINATION 1

Reading Time: 15 minutes
Writing Time: 1 hour 30 minutes

QUESTION AND ANSWER BOOK

Structure of Booklet

Section		*Number of Questions*	*Number of Questions to be Answered*	*Number of Marks*	*Suggested Times (min)*
A	Multiple choice questions	20	20	20	20
B	Short answer questions	9	9	63	63
				Total 83	Total 83

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SECTION A - MULTIPLE CHOICE QUESTIONS

Instructions For Section A

Section A consists of 20 multiple-choice questions. Answer all 20 questions.
Choose the response that is **correct** or **best answers the question.**
A correct answer scores 1, an incorrect answer scores 0.
No marks will be given if more than one answer is shown for any question.

QUESTION 1
The number of ions in 3 mole of H_3PO_4 is closest to

A 1.81×10^{24}
B 7.22×10^{24}
C 3.61×10^{24}
D 1.44×10^{25}

QUESTION 2
A $15.00\ g$ sample of an unstable hydrated salt, $Na_2SO_4.xH_2O$ was found to contain $7.05\ g$ of water. The value of x in this formula is

A 1
B 3
C 5
D 7

QUESTION 3
Which of the following statements is **incorrect**?

A The oxidation n umber of Cl in $Ba(ClO_3)_2$ is $+5$.
B The oxidation number of N in NH_3 is $-\frac{1}{3}$.
C The oxidation number of O in OF_2 is -2.
D The oxidation number of H in $LiAlH_4$ is $+1$.

QUESTION 4
In which of the following concentration determinations would a back titration definitely be preferable to a direct titration?

A Hydrochloric acid solution
B Sodium hydrogen sulfate solution
C Ammonium chloride solution
D Sodium hydroxide solution

QUESTION 5
The sulfur in a sample of steel was burned in a stream of oxygen to produce sulfur dioxide.

$$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$$

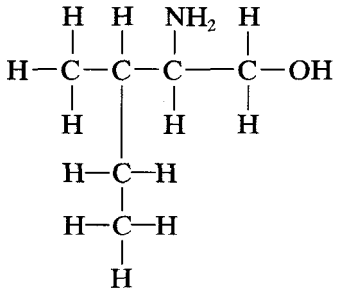
The sulfur dioxide was then oxidised to sulfate using a hydrogen peroxide solution that contained 3 mole of sodium hydroxide, $NaOH$. The following reaction occurred:

$$SO_{2(g)} + H_2O_{2(g)} + 2OH^-_{(aq)} \rightarrow SO^{2-}_{4(aq)} + 2H_2O_{(l)}$$

The excess base was then titrated with HCl . If the number of mole of HCl required for this titration was 1 mole, the amount, in mole, of sulfur in the steel sample is

A 1
B 2
C 3
D 4

QUESTION 6
The systematic name for the compound below is



A 2-amino-3-methylpentan-1-ol
B 4-amino-3-methylpentan-1-ol
C 3-amino-2-ethylbutan-2-ol
D 2-ethyl-3-aminobutan-4-ol

QUESTION 7
The organic compound with the lowest solubility in octane is

A Butanol
B Decanol
C Hexanol
D Octanol

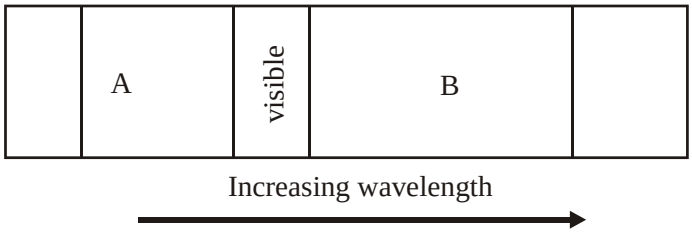
QUESTION 8
When chlorine is mixed with propane and irradiated with UV light, the number of different compounds formed would be

A 1
B 2
C 3
D More than 3

QUESTION 9
When chlorine is mixed with propene, the number of different compounds obtained would be

A 1
B 2
C 3
D More than 3

QUESTION 10
The figure below depicts the visible region of the electromagnetic spectrum and the two regions nearest to it.



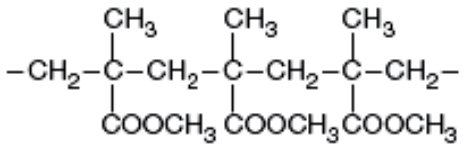
Section A in the diagram above could be used in an instrument to give information about

A the concentration of a metallic species.
B the environment of atoms in molecules.
C the functional groups present in a molecule.
D the concentration of organic compounds in solution.

QUESTION 11
In atomic absorption spectroscopy (AAS) the analysis is based on the

A absorption by the analyte of visible light only.
B absorption by the analyte of visible and UV light.
C absorption of the emissions by the analyte in the instrument.
D absorption of the atoms of the analyte by the standard solution.

QUESTION 12
Part of the addition polymer perspex is illustrated below.



The monomer used to produce this polymer is

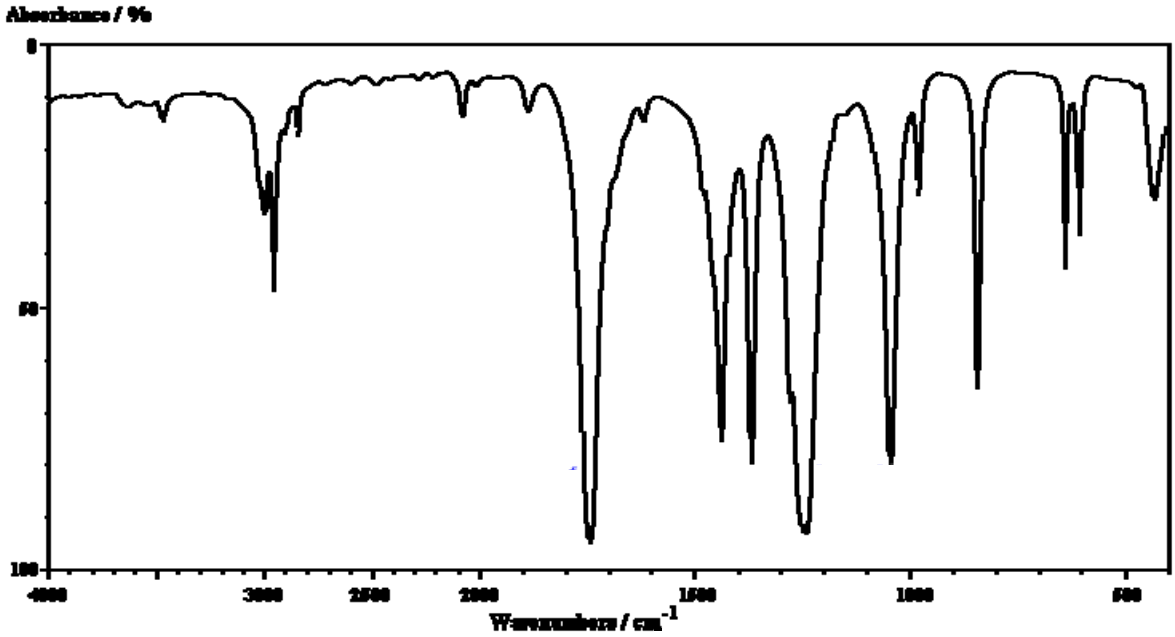
A $CH_3 - C(CH_3) - CO - O - CH_3$

B $CH_2 = C(CH_3) - CO - O = CH_2$

C $CH_2 = C(CH_3) - CO - O - CH_3$

D $CH_2 - C(CH_3) - CO - O - CH_3$

QUESTION 13
The Infrared spectrum of an organic compound is given below.



The molecule that produced this spectrum is most likely to be

A CH_3COOCH_3
B CH_3CH_2COOH
C CH_3CH_2OH
D $CH_3CH_2NH_2$

QUESTION 14
A certain amino acid contained 40.4% carbon, 7.9% hydrogen and 15.7& nitrogen.
If the balance of the molecule is oxygen, the amino acid is most likely to be

A Alanine
B Cysteine
C Glycine
D Valine

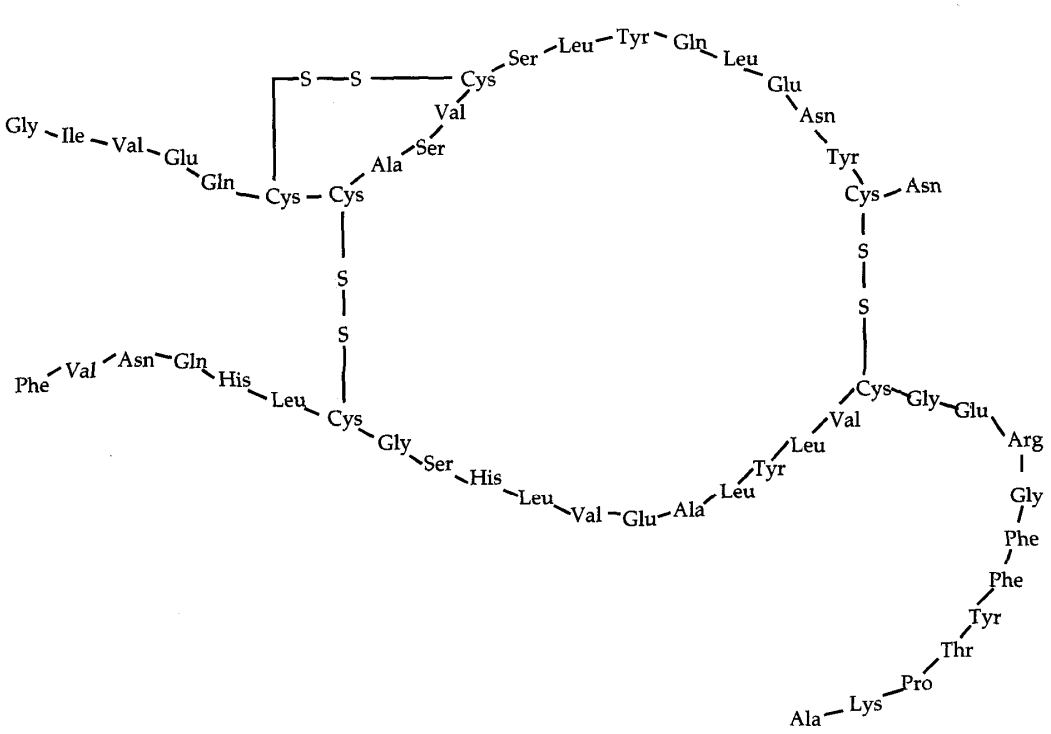
QUESTION 15
The formula of the amino acid serine at pH 9.0 is

A $^{+}H_3NCH(CH_2OH)COO^{-}$
B $^{+}H_3NCH(CH_2OH)COOH$
C $H_2NCH(CH_2OH)COO^{-}$
D $H_2NCH(CH_2O^{-})COO^{-}$

QUESTION 16
An analytical technique that **could not** be used to obtain information that could assist in the determination of the structure of an amino acid is

A Atomic Absorption Spectroscopy
B Nuclear Magnetic Resonance Spectroscopy
C Infrared spectroscopy
D Thin Layer Chromatography

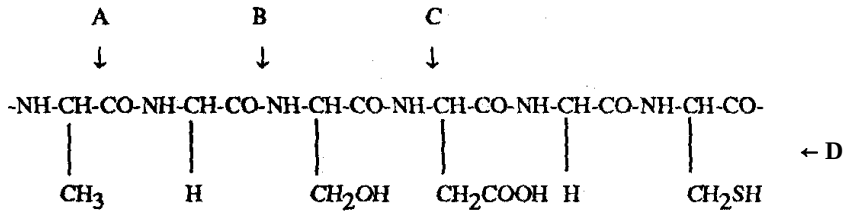
QUESTION 17
The diagram below shows the primary structure of ox insulin.



The bond between cysteine molecules (Cys) is used to maintain

A the primary structure of a protein.
B the secondary structure of a protein.
C the tertiary structure of a protein.
D the primary, secondary and tertiary structures of a protein.

QUESTION 18
The following diagram shows part of a protein molecule.



At which point would the protein chain be broken during digestion?

A At point A
B At point B
C At point C
D At point D

QUESTION 19
One strand from a double stranded DNA has the following sequence of bases:

3'-CTGACGCCT-5'

The complementary nucleotide strand is

A 3'-CTGACGCCT-5'
B 5'-CTGACGCCT-3'
C 3'-GACTGCGGA-5'
D 5'-GACTGCGGA-3'

QUESTION 20
Which molecule is classified as a carbohydrate?

A $C_2H_4O_2$
B $C_{18}H_{32}O_{16}$
C $C_{18}H_{34}O_2$
D $C_3H_7O_2N$

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 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 that all 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
John has always been interested in cooking and so decides to mix his hobby with his studies to determine the accuracy of a claim on the packet of bicarbonate soda that he had been using.

The label on this packet states: "**Ingredients: Bicarbonate soda**"

implying that the product is 100% bicarbonate soda. He knew that bicarbonate soda was the old common name still in use for the compound known by chemists as sodium hydrogen carbonate, $NaHCO_3$.

John collected a bottle containing $0.100\,M\ HCl$ from the school laboratory, as well as a $250\,mL$ volumetric flask, $20\,ml$ pipette, a $20\,ml$ burette and a $50\,ml$ burette. He carefully weighed out $2.06\,g$ of baking soda, transferred it to the $250\,mL$ volumetric flask and added water to the mark. After careful mixing, $20.00\,ml$ was transferred to a conical flask.

a. (i) Write an equation to represent the reaction that would occur during the titration.

_____

_____

1 mark

(ii) Explain why a $20\,ml$ burette will not be adequate for this titration. Provide relevant calculations to support your answer.

_____

_____

_____

_____

_____

2 marks

John fills a $50.00\,mL$ burette with the $0.100\,M\ HCl$ solution and adds a few drops of phenolphthalein indicator into the flask containing $NaHCO_3$.

b. Is phenolphthalein an appropriate indicator for this reaction? Give a reason to support your answer.

_____

_____

_____

1 mark

John performs 4 titrations and the following titres were obtained:

24.36 mL 22.64 mL 22.58 mL 22.56 mL

He calculates a mean titre of 24.04 mL and uses this value for his calculations.

c. (i) Comment on John's calculation of the mean.

_____

_____

1 mark

(ii) Using John's calculated mean, find the % purity of the bicarbonate soda.

_____

_____

_____

_____

_____

2 marks

(iii) Give two reasons why John's calculated percentage purity markedly overestimates the true value. In your answer, provide a clear explanation as to how these reasons results in a higher calculated percentage.

_____

_____

_____

_____

_____

_____

_____

_____

_____

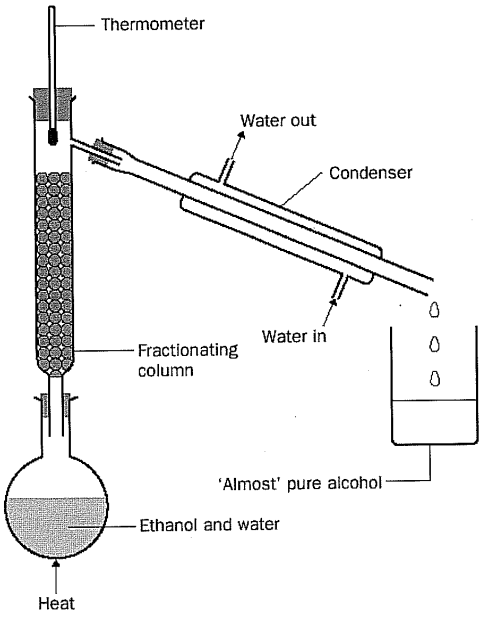
3 marks

Total 10 marks

QUESTION 2

Liquid nitrogen is used for many cooling and cryogenic applications, and is commonly used in doctor's surgeries for the removal of warts. To produce liquid nitrogen, air is liquefied and then purified using fractional distillation, in a process similar to that used for the refining of crude oil.

A fractionating column used to separate ethanol from water is illustrated below.



The fractionating column is packed with glass beads or some other unreactive material that has a high surface area.

a. (i) What is the purpose of the glass beads?

_____

_____

1 mark

(ii) What is used in place of glass beads in fractionating towers designed to separate the components of crude oil?

_____

_____

1 mark

The main components of dry air consists of argon, carbon dioxide, helium, neon and nitrogen oxygen.

b. (i) State the order in which the components of air would be collected.

_____

_____

1 mark

(ii) Provide clear reasons for the order in (i) above. In your answer, give the name of the bond that directly determines the boiling point of each component to be separated.

_____

_____

_____

_____

_____

_____

_____

_____

_____

3 marks

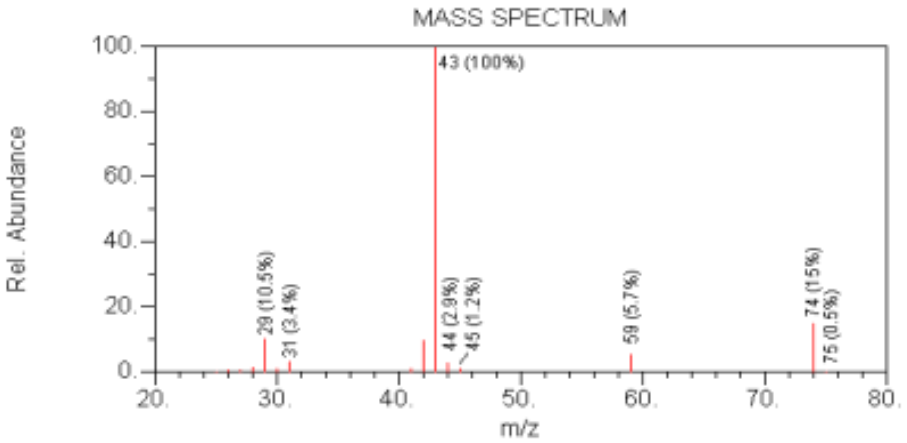
Total 6 marks

QUESTION 3
By burning a sample of a compound and measuring the amount of carbon dioxide and water produced, the empirical formula of the compound is found to be $C_3H_6O_2$.

a. In the space below, draw the structural formulas of the 3 possible isomers of the compound stating their systematic names.

3 marks

b. The mass spectrum of the compound is shown below.



(i) Identify the species that produced the peaks at mass/charge ratio 74 and 75 clearly identifying the difference between the two species.

2 marks

(ii) Identify the molecular mass of the most stable fragment.

1 mark

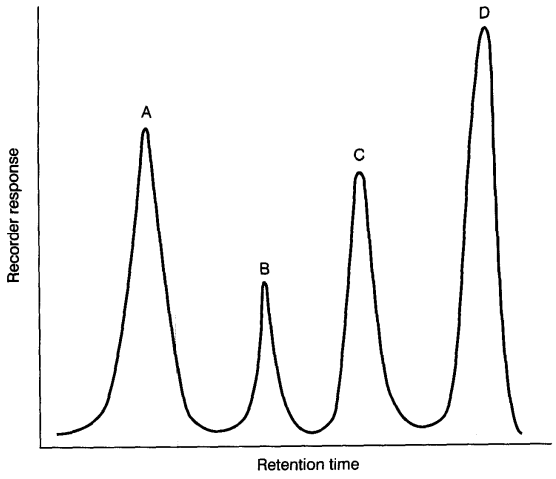
(iii) State the systematic name of the isomer of $C_3H_6O_2$ that produced the mass spectrum. Give a reason for your answer.

2 marks

Total 8 marks

QUESTION 4

A mixture of alcohols with molecular formula C_4H_9OH were introduced into the gas-liquid chromatograph, and the following chromatogram was obtained:



a. Two isomers of the alcohol with molecular formula C_4H_9OH are given below.

$CH_3C(CH_3)_2OH$
$CH_3CH_2CH_2CH_2OH$

Which peak, A or D, most likely represents the isomer with formula $CH_3C(CH_3)_2OH$? Give a reason for your answer.

_____

_____

_____

2 marks

b. (i) The carbon-13 NMR spectrum of alcohol B gives rise to 3 peaks.
Give the semi-structural formula of the alcohol B.

_____

_____

1 mark

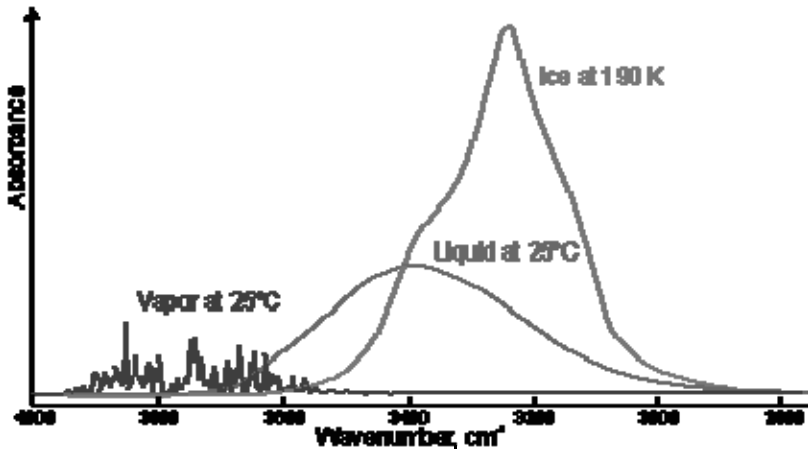
(ii) Predict the ratio of the areas under the peaks in the corresponding ^1H NMR spectrum for alcohol B.

_____

_____

1 mark

c. The UV-Visible spectrograph of water at different temperatures is given below.



Give a reason why water produces peaks at different wavenumbers when in different states.

_____

_____

_____

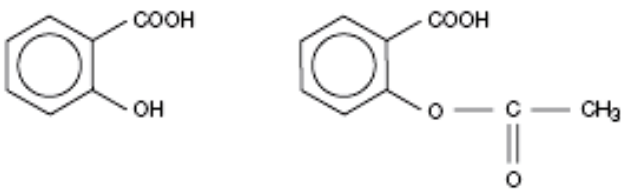
_____

1 mark

Total 5 marks

QUESTION 5

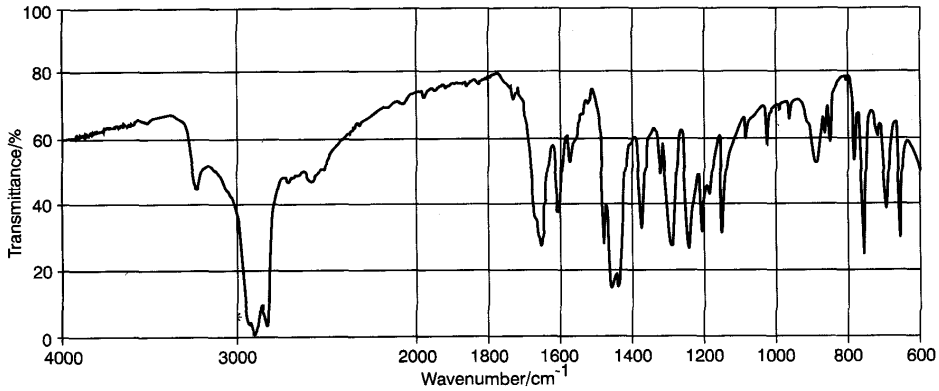
The molecular structures of salicyclic acid and acetylsalicyclic acid are given below.



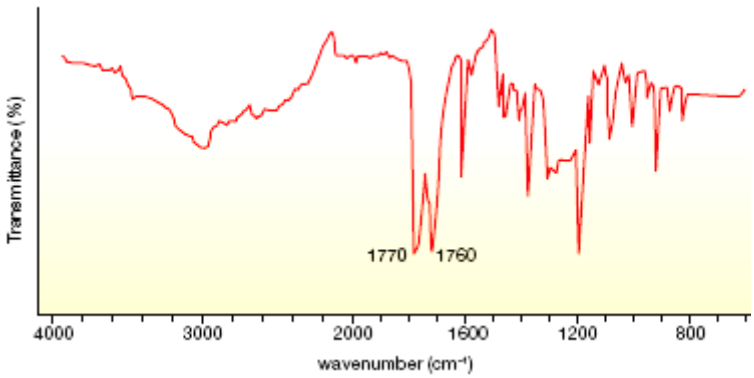
Salicylic acid Acetylsalicylic acid

These molecules were analysed using infra-red spectroscopy and the following spectra were obtained.

Infra-Red Spectrum of Salicyclic Acid



Infra-Red Spectrum of Acetylsalicyclic Acid



a. Account for the existence of two separate peaks at 1770 cm^{-1} and 1760 cm^{-1} in the spectrum for acetylsalicyclic acid indicating which group(s) of atoms are responsible for these peaks.

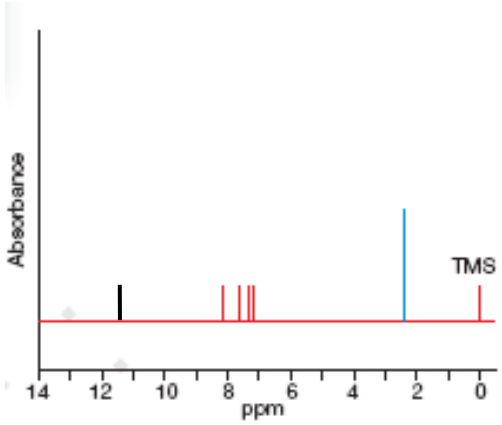
_____

_____

_____

2 marks

b. The proton NMR spectrum of acetylsalicyclic acid is given below.



(i) Would the proton NMR spectrum of salicyclic acid display the same number of peaks as that present in the spectrum of acetylsalicyclic acid? Give a reason for your answer.

_____

_____

_____

(ii) Where would the peak located at approximately 11.7 ppm in the given spectrum appear when salicyclic acid is analysed? Circle the correct answer from the options below and provide a reason for your chosen answer.

Peak will appear at a shift value smaller than 11.7 ppm	Peak will appear at a shift value larger than 11.7 ppm

_____

_____

_____

_____

_____

_____

(iii) Account for the similarities in the shift values of the 4 middle peaks in the spectrum above.

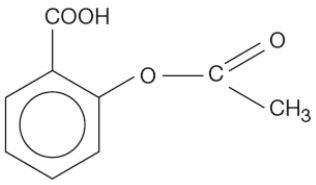
_____

_____

_____

1+2+1 = 4 marks

c. Write a structural equation to represent the hydrolysis of acetylsalicyclic acid under alkaline conditions.

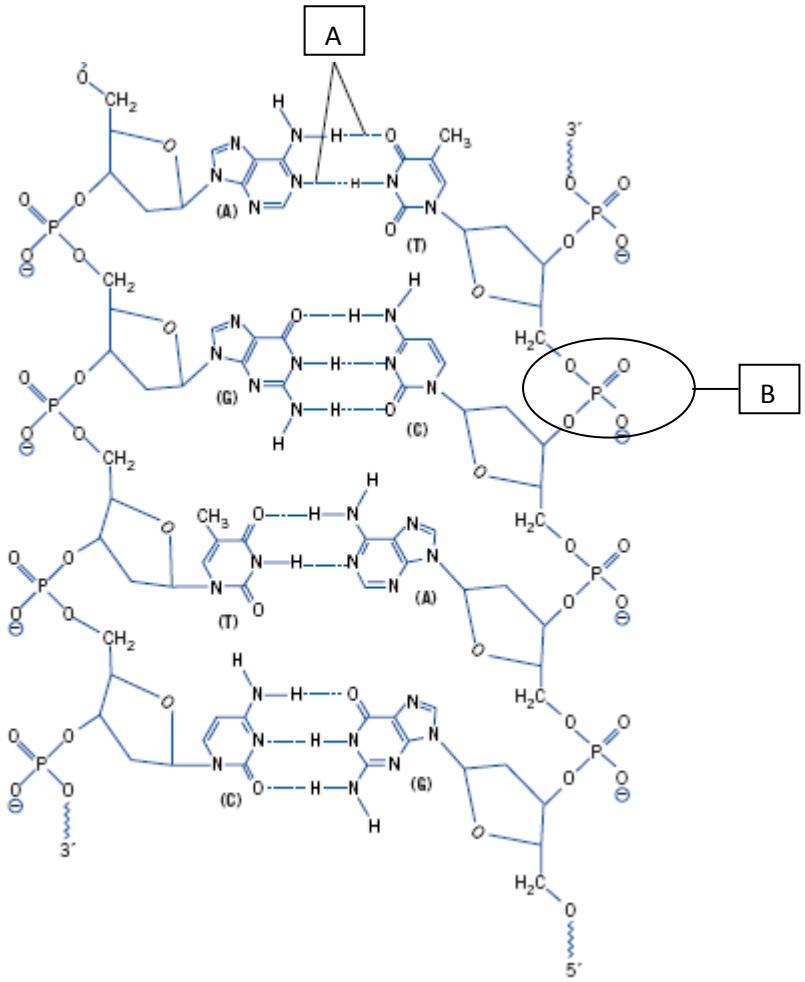


2 marks

Total 8 marks

QUESTION 6

A component of DNA is illustrated below.



a. (i) Name the bond at A and B.

Bond at A: _____

Bond at B: _____

(ii) A particular gene consists of thirty nucleotides. How many molecules of water would be required to completely hydrolyse this gene?

_____

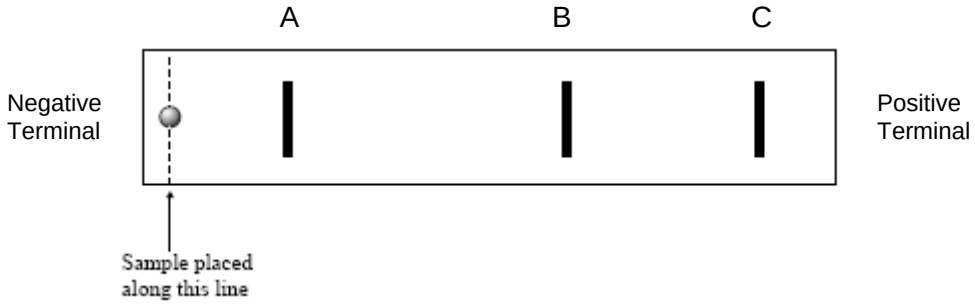
_____

_____

_____

1+1 = 2 marks

b. In order to obtain a DNA fingerprint, DNA is first extracted from a sample, copied in large numbers using a technique known as polymerase chain reaction (PCR) and then broken into fragments using enzymes. The DNA fragments are then applied to a gel and separated by passing an electric current through the system.



(i) Give a reason why the DNA fragments are applied at the negative terminal.

_____

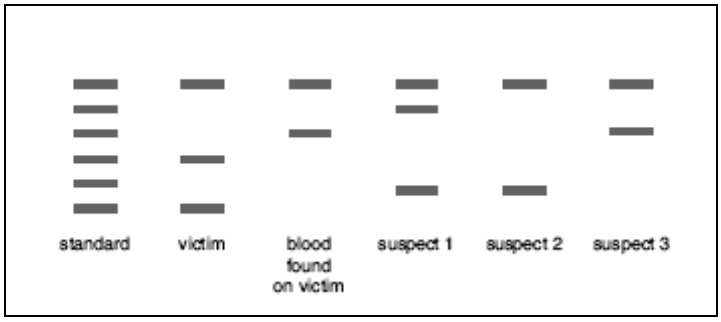
_____

(ii) Assume that each of the fragments A, B and C consist of a chain containing 10 nucleotide bases. If one fragment consists solely of guanine bases, one fragment consists solely of thymine bases, and the third fragment consists of a mixture of both bases, which fragment best represents the fragment consisting solely of guanine bases?

_____

1+1 = 2 marks

c. The diagram below shows the results of an investigation to determine whether any of 3 suspects found at a crime scene were involved in the homicide that eventuated.



(i) Which suspect should be investigated further?

_____

(ii) Give a reason as to why this fingerprint would not be enough to convict the suspect.

_____

_____

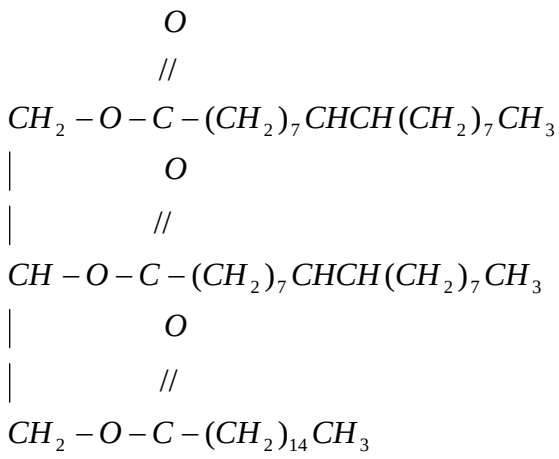
_____

1+1 = 2 marks

Total 6 marks

QUESTION 7

Fats and oils in foods are made up of complex mixtures of saturated and unsaturated fatty acids. One such example is olive oil and is illustrated below.



a. (i) In the space above, write an equation to show the hydrolysis of this oil clearly indicating the products of the reaction.

2 marks

b. Some of the products of the hydrolysis of fats and oils can be used to form biodiesel.

i. Write an equation to represent the production of a biodiesel fuel from olive oil.

_____

_____

ii. Write an equation to show the incomplete combustion of your biodiesel fuel.

_____

_____

1 + 1 = 2 marks

c. A sample of olive oil was reacted as described below:

$$\text{oil} + \text{A} \xrightarrow{\text{B}} \text{fat}$$

(i) Identify:

Reagent A: _____

Substance B: _____

(ii) Which statement below **incorrectly** describes a change in the physical property of the oil when it is converted into fat? Circle the incorrect response.

A Product becomes more solid.
B The melting point of the product decreases.
C Product becomes harder to spread.
D The density of the product increases.

1+1+1 = 3 marks

Total 7 marks

QUESTION 8

A substance V with molecular formula C_3H_8O is dehydrated by treating it with concentrated sulfuric acid to form substance W, C_3H_6. Substance V is also oxidised to X, $C_3H_6O_2$, using acidified potassium dichromate.

Oxidation of compound W with acidified potassium dichromate solution produces compound Y, $C_2H_4O_2$.

Substances V and Y react in the presence of a concentrated sulfuric acid to produce a sweet smelling compound, Z.

Use this information to identify the substances V, W, X, Y and Z.

V = _____

W = _____

X = _____

Y = _____

Z = _____

5 marks

QUESTION 9

Solid $K_2Cr_2O_7$ is added to excess oxalic acid, $H_2C_2O_4$ to produce $5.00\,L$ of CO_2 at 75.0^oC and $1.07\,atm$ pressure.

a. If the reduction product of $Cr_2O_7^{2-}$ is Cr^{3+}, write an equation to describe the reaction that occurs when $K_2Cr_2O_7$ reacts with $H_2C_2O_4$.

2 marks

b. Calculate the mass of $K_2Cr_2O_7$ that reacted.

2 marks

c. If the mass of $K_2Cr_2O_7$ calculated in (b) was dissolved in $25.00\,L$ of water, determine the concentration of potassium ions in the resultant solution in ppm.

2 marks

Total 6 marks

End of Paper