MELBOURNE HIGH SCHOOL

UNIT 3 CHEMISTRY

TRIAL EXAMINATION

2008

QUESTION AND ANSWER BOOKLET

Wednesday 28 May 2008
Reading time : 15 minutes
Writing time : 90 minutes

Section	*Number of questions*	*Number of questions to be answered*	Number of marks	Suggested time (minutes)
A	20	20	20	23
B	9	9	60	67
		Total	80	90

Materials : * Question and answer booklet consisting of a cover page and 13 pages of questions - pages are numbered 2 to 14
* Answer sheet for multiple-choice questions.

Instructions : * Multiple choice items are to be answered by filling in the appropriate box which corresponds to the answer of your choice in the question booklet.
* Short answer questions are to be answered in the spaces provided.
* All written responses must be in English.
* Chemical equations and half equations must include symbols of state.
* Numerical answers are to be given to appropriate numbers of significant figures.
* A unit must be given in numerical answers that require a unit for complete specification.
***Students must bring in to the examination a clean, stapled copy of the data book.**
* Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, and a scientific calculator.
*** Students are NOT permitted to bring graphics calculators, mobile phones and/or any other electronic communication devices into the examination room, blank sheets of paper, white out liquid/tape**.

Submission : * At the conclusion of the exam, place the Multiple Choice answer sheet inside this booklet.

Section A / 20

Section B / 60

Total / 80

2008 UNIT 3 SECTION A

Specific instructions for Section A

- This section consists of 20 multiple-choice items, which are to be answered by shading the box on the answer sheet that corresponds to your answer in **lead pencil**.
- If you wish to change an answer, erase the original answer completely.
- A correct answer scores 1 mark and an incorrect answer scores 0 marks.
- 1 × 20 = 20 marks, 23 minutes

1 Determine the pH of a solution when 20 mL of 0.050 M HCl is added to 20 mL of 0.050 M $Ca(OH)_2$.

A. 12.7
B. 12.4
C. 7
D. 1.6

2 Which of the reactions below is an acid / base reaction?

A. $2H_2SO_{4(aq)} + 3S_{(s)} \rightarrow 3SO_{2(g)} + 2H_2O_{(l)}$
B. $H_2SO_{4(aq)} + BaCl_{2(aq)} \rightarrow BaSO_{4(s)} + 2HCl_{(aq)}$
C. $H_2SO_{4(aq)} + Zn_{(s)} \rightarrow ZnSO_{4(aq)} + 2H_2O_{(l)} + SO_{2\,(g)}$
D. $H_2SO_{4(aq)} + H_2O_{(l)} \rightarrow HSO_4^-{}_{(aq)} + H_3O^+_{(aq)}$

3 In a titration, an acid of known concentration is placed in a burette and reacted with a base that has been pipetted into a conical flask. What should each piece of glassware be rinsed with immediately before titration?

	Conical Flask	Pipette	Burette
A.	Base	Water	Water
B.	Base	Base	Acid
C.	Water	Water	Water
D.	Water	Base	Acid

4 Which one of the following substances is best analysed by Gas Chromatography (GC)?

A. pentene
B. calcium
C. deoxyribonucleic acid
D. nitric acid

5 10.00g of blue hydrated copper sulfate ($CuSO_4.5H_2O$) is dried in an oven at 110ºC until it is colourless, and reaches constant mass. The mass of the anhydrous copper sulfate is

A. 3.60 g
B. 5.52 g
C. 6.40 g
D. 8.99 g

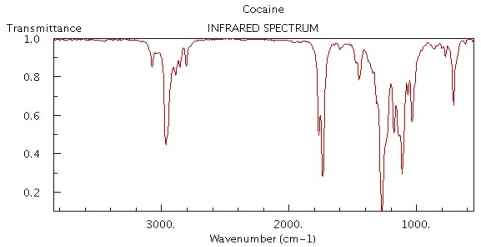
6 The amount of sodium chloride in a brand of potato chips is confirmed by gravimetric analysis. 100 g of the chips are crushed, and macerated in water. The solution is filtered, and the filter paper carefully rinsed. The resultant solution is treated with excess silver nitrate solution, and the solid formed was collected by Buchner filtration. When dried the solid weighed 3.724 g. The % mass of sodium chloride in the chips is

A. 1.22%
B. 1.26%
C. 1.52%
D. 2.56%

7 An aerosol can of fly spray has a volume of 150 mL. The contents of the can exert a pressure of 9.0×10^5 Pa at 22ºC. If the contents of the can are heated to 105ºC what pressure is exerted now on the can? (Assume that the can has not exploded!)

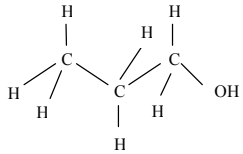
A. 7.0×10^5 Pa
B. 4.3×10^6 Pa
C. 1.9×10^5 Pa
D. 1.2×10^6 Pa

8 The infrared spectrum of cocaine is shown below. From this it may be concluded that

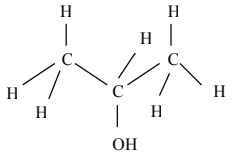


A. cocaine does not contain any C=O bonds.
B. cocaine contains C-H bonds.
C. cocaine is an alcohol.
D. cocaine does not contain any C-C bonds.

9 Which statement about compounds I and II is not true?



Compound I



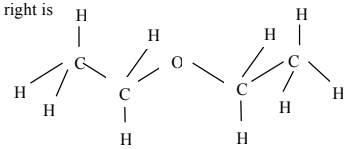
Compound II

A. The mass spectrum of both compounds will show a peak at a mass-to-charge ratio of 60.
B. The low resolution ^{1}H NMR spectrum of Compound I has four peaks, and that of Compound II has three peaks.
C. The ^{13}C NMR spectrum of Compound I has three peaks and that of Compound II has two peaks.
D. The fingerprint region of the IR spectra will be identical for both compounds.

10 Propan-1-ol will exhibit a high resolution NMR spectrum showing a broad peak (1 H) at 2.3 ppm and

A. a triplet (6 H) and a quartet (2 H).
B. a triplet (6 H) and a septet (2 H).
C. 2 triplets (2 H, 3 H) and a sextet (2 H).
D. 2 triplets (2 H, 3 H) and a quartet (2 H).

11 The correct systematic name of the compound at the right is



A. diethyl ether
B. ethyl ethanoate
C. methyl ethanoate
D. diethanol

12 If an alkanol is oxidised it forms

A. a diol
B. an amine
C. a carboxylic acid
D. an isomer

13 Esters are formed via the pathway of

A. addition polymerisation between an alkanol and a carboxylic acid.
B. condensation polymerisation between an alkanol and carboxylic acid.
C. addition polymerisation between an alkanol and an amine.
D. condensation polymerisation between an alkanol and an amine.

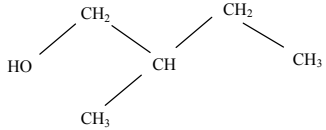
14 The amino acid valine dissolves in water. In an aqueous solution with a pH of 7, valine is acting as

A. an acid only.
B. a base only.
C. neither an acid nor a base.
D. a zwitterion.

15 An enzyme is heated from 25ºC to 100ºC. The part that is least affected by the increase in temperature is the

A. primary structure.
B. secondary structure.
C. tertiary structures.
D. active site.

16 Name the following molecule



A. 3-methyl butan-1-ol
B. 1-pentanol
C. 2-ethyl-1-hydroxypropane
D. 1-hydroxy-2-methylbutane

17 The molecule $C_3H_6Cl_2$ has a number of possible isomers. How many straight chain isomers are there of this molecule?

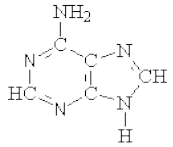
A. 3
B. 4
C. 5
D. 6

18 A polyunsaturated fat is hydrolysed. Glycerol and a polyunsaturated acid are formed. Which one of the following is a possible formula of the acid?

A. $C_{18}H_{37}COOH$
B. $C_{16}H_{29}COOH$
C. $C_{20}H_{41}COOH$
D. $C_{14}H_{27}COOH$

19 The nucleotide shown will bond in the DNA molecule with

A. Adenine
B. Cytosine
C. Guanine
D. Thymine



20 The reagents required to convert ethene to ethanol are
A. chlorine gas followed by sodium hydroxide
B. hydrochloric acid followed by sulfuric acid
C. chlorine gas followed by phosphoric acid
D. hydrochloric acid followed by sodium hydroxide

End of Section A

2008 UNIT 3 SECTION B

Specific instructions for Section B
- This section consists of 9 short answer questions which are to be answered in the spaces provided.
- Numerical answers must be given to the appropriate number of significant figures.
- Symbols of state must be included in all equations and half equations.
- No credit will be given for an incorrect numerical answer unless it is supported by working.
- 60 marks, 67 minutes

1. [4 marks, 4 minutes]
A solution of sodium ethanoate (sodium acetate) is found to have a pH of 11.1.

a What is the $[OH^-]$ in this solution?

b With the aid of an equation, explain why this solution is alkaline (basic).

(2 + 2 = 4 marks)

2. [8 marks, 10 minutes]
Propanoic acid (propionic acid), CH_3CH_2COOH, is a weak acid. It is used as a food preservative, and as a precursor for chemical synthesis.

a Write the equation for the hydrolysis of propanoic acid.

b Explain why it would be better to use a back titration to analyse for the concentration of propanoic acid in solution, rather than a direct titration.

c 20.00mL of a solution of propanoic acid was mixed with 50.00 mL of 0.196 M sodium hydroxide solution.

i write the balanced chemical equation for this reaction.

_____

The resulting solution was titrated against 0.298 M hydrochloric acid to determine the amount of unreacted sodium hydroxide. A titre of 18.64 mL was obtained. Calculate:

ii the amount, in mol, of sodium hydroxide initially added to the propanoic acid solution;

iii the amount of hydrochloric acid used;

iv the amount of sodium hydroxide in excess after reaction with the propanoic acid;

v the amount of sodium hydroxide that reacted with the propanoic acid;

vi the concentration of the propanoic acid.

(1 + 1 + 6 = 8 marks)

3. [10 marks, 12 minutes]

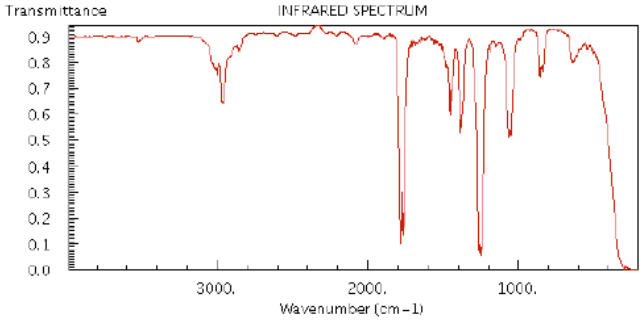
Compound X contains carbon, hydrogen and oxygen only.

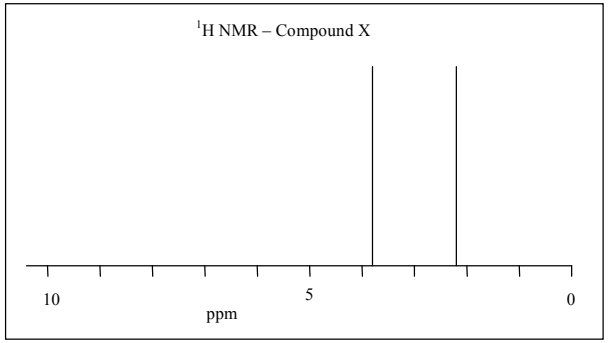
a 1.00g of compound X was burnt in excess oxygen. The products of the reaction were 1.78 g of carbon dioxide, and 0.730 g of water. Find the empirical formula of compound X.

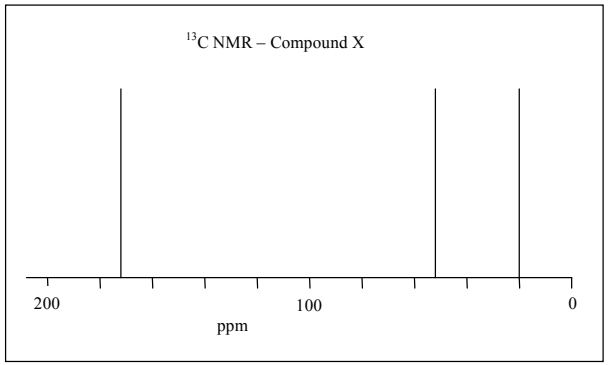
b A mass spectrum analysis of compound X contains 2 significant peaks. They have a mass to charge ratio of 43 and 74. What is the molecular formula of compound X?

_____

Below are the IR, high resolution ^{1}H NMR, and ^{13}C spectra of Compound X.







c Explain why it is possible to have splitting (ie doublet, triplets etc) in high resolution ^{1}H NMR, but splitting is not seen in ^{13}C NMR.

_____

_____

_____

_____

_____

d Draw the chemical structure and name Compound X.

Name of Compound X _____

e Use red pen to circle the carbon atom, on the molecule you have drawn above, which has led to the peak on the ^{13}C NMR spectrum at about 170 ppm.

f Suggest the formula of the fragment ion which led to the peak in the mass spectrum at 43.

(3 + 1 + 2 + 2 + 1 + 1 = 10 marks)

4. [4 marks, 5 minutes]

One of the most common methods for determining the concentration of metal ions in water samples involves titration with a reagent called EDTA. In alkaline solution EDTA is present as an anion with a 4- charge. In this form it reacts with metal ions such as calcium and magnesium in a 1 : 1 ratio:

$$Ca^{2+} + EDTA^{4-} \rightarrow Ca(EDTA)^{2-}$$

When the reaction between the metal ions and $EDTA^{4-}$ is complete, an indicator also present in the solution changes colour.

A student used the following procedure to determine the concentration of calcium in a sample of water:
- 50.0 mL of water sample was pipetted into a conical flask
- 5.00 mL of ammonia/ammonium ion buffer and two drops of indicator were added
- Sample was titrated with 0.0200 M $EDTA^{4-}$ until indicator changed colour
- The above procedure was repeated a further three times
- The average volume of $EDTA^{4-}$ used in the four titrations was 24.00 mL

a What is the average number of moles of $EDTA^{4-}$ added to reach the end point?

_____

b The student used the answer to part (a) to calculate the concentration of Ca^{2+} in the water sample in mg L^{-1}. What concentration was obtained?

c The concentration of Ca^{2+} in the water sample was also determined by atomic absorption spectroscopy, and found to be 16% lower than the value obtained by titration with $EDTA^{4-}$. Suggest a reason why the concentration of Ca^{2+} determined by EDTA titration was higher.

_____

_____

_____

_____

_____

(1 + 2 + 1 = 4 marks)

5 [6 marks, 7 minutes]

The amino acids present in a sample of fruit juice can be detected by thin-layer chromatography. R_f values of some amino acids using two separate solvents are given in the table below.

Amino Acid	Solvent 1 R_f	Solvent 2 R_f
Alanine	0.50	0.86
Arginine	0.13	0.60
Glutamic acid	0.25	0.33
Glycine	0.20	0.40
Isoleucine	0.57	0.81
Leucine	0.58	0.82
Proline	0.39	0.88
Threonine	0.21	0.49
Tyrosine	0.38	0.62
Valine	0.40	0.74

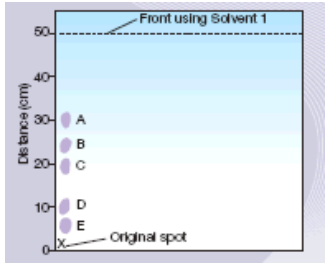


Figure 1 – picture from "Chemistry 2"

To achieve better separation of the complex mixture of substances present in the juice, a 'two-way' chromatogram was prepared. The first step in this procedure was to run a chromatogram using Solvent 1. The results of this chromatogram are shown in Figure 1.

a Calculate the R_f value of spot A, and identify the amino acid/s possibly responsible for the spot.

_____

_____

The paper was then turned around so that it lay at a right angle to the original and a second chromatogram was run using Solvent 2. Figure 2 shows the appearance of the paper after some time.

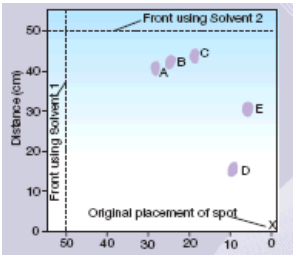


Figure 2 – picture from "Chemistry 2"

b Use the table of R_f values to identify component E.

_____

c What is the advantage of a two-way chromatogram?

_____

_____

_____

_____

_____

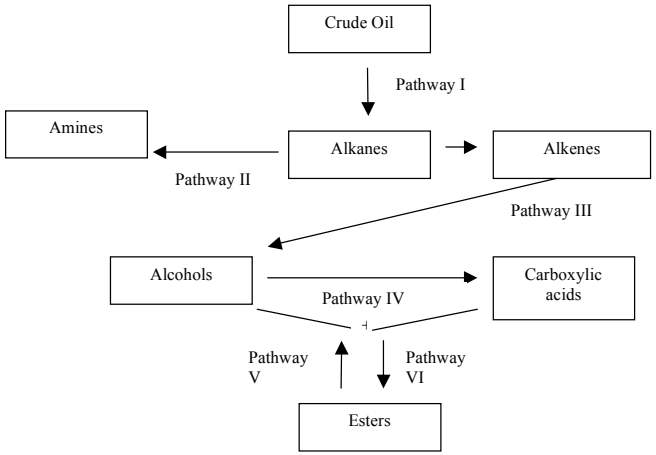
_____

d If this mixture was run through an HPLC using Solvent 2, which compound would have the lowest retention time?

_____

(2 + 1 + 2 + 1 = 6 marks)

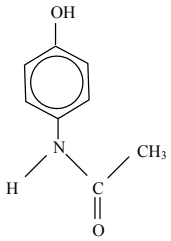
6 [14 marks, 14 minutes]
This diagram shows a number of reaction pathways that organic molecules can undergo.



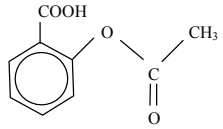
a Complete the table by inserting the numbers I to VI in the pathway column.

Reaction class	Pathway
Substitution reaction	
Addition reaction	
Fractional distillation	
Condensation	
Oxidation	
Hydrolysis	

b. Two common pain killers found in supermarkets are aspirin and paracetamol. The structures of these molecules are shown below.



Paracetamol



Aspirin

Indicate which of the above molecules contain the following functional groups, by placing a tick in the appropriate place in the table.

Functional Group	Neither molecule	Paracetamol	Aspirin	Both molecules
hydroxyl				
amide				
ester				
ether				

c. Draw the structure of the benzyl ring containing precursor molecules for paracetamol and aspirin, and name the type of chemical link formed by the condensation reaction used to produce the pain killers.

Paracetamol Aspirin

Chemical link:_____ Chemical link:_____

(6 + 4 + 4 = 14 marks)

7. [4 marks, 5 minutes]

a Show the chemical structure of the product of the condensation reaction between arachidonic acid and glycerol.

b Name the small molecule also formed. _____

c Name the type of chemical link formed. _____

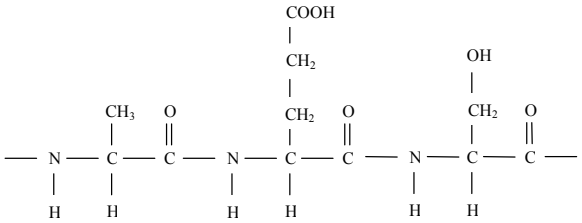
d Write a balanced chemical equation for the complete combustion in excess oxygen of the fatty acid above.

_____

(1 + 1 + 1 + 1 = 4 marks)

8. [6 marks, 6 minutes]

A section of protein is shown below.



a Circle the peptide links in the protein fragment above.

b Name the amino acids produced by hydrolysis of this protein fragment.

_____

c Draw the structure of the amino acid with the largest molecular mass formed after hydrolysis of this protein fragment.

d Name an amino acid not shown already in this question which

i contains a hydroxyl group. _____

ii will form a negatively charged ion in a solution of pH 13. _____

iii will form a positively charged ion in a solution of pH 1. _____

(1 + 1 + 1 + 3 = 6 marks)

9. [4 marks, 4 minutes]

Industrial ethanol is produced by reacting steam with ethene (ethylene) in the presence of solid orthophosphoric acid.

a Ethanol can be used to produce bromoethane. Write the equation for this reaction.

_____

b What type of reaction is this conversion?

_____

c Ethanol can be oxidised by the reaction with acidified potassium permanganate. Write the oxidation half equation for this reaction.

_____

d The product of the oxidation in part c above can be reacted with propanol. What is the name of the organic product of this reaction.

_____

(1 + 1 + 1 + 1 = 4 marks)

END of EXAM

Answers

1	B	6	C	11	A	16	D
2	D	7	D	12	C	17	B
3	D	8	B	13	B	18	B
4	A	9	D	14	D	19	D
5	C	10	C	15	A	20	A

Question 1.