
NATIONAL UNIVERSITY OF LESOTHO
FACULTY OF SCIENCE & TECHNOLOGY
DEPARTMENT OF CHEMISTRY & CHEMICAL TECHNOLOGY
BSc & BSc Ed FINAL EXAMINATION
C4730 ORGANIC YEAR III CHEMISTRY

January 2024

Marks: 100

Time: 3 Hours

Instructions

This question paper is divided into two Sections (A and B)

Section A consists of 25 multiple choice questions, each carrying 1 mark.

Answer all questions in Section A

Section B consists of four (4) questions, each carrying a total of 25 marks

Answer any Three questions

Begin each question on a fresh page, and write neatly

SECTION A (compulsory)**25 marks**

- 1.** _____ is the first alkaloid that was isolated and fully characterised around the 1800s.
A Cocaine
B Morphine
C Tropine
D Mescaline
- 2.** Which of the following statements is true about alkaloids?
A Alkaloids are made up of isoprene units
B Alkaloids are acidic
C Alkaloids form precipitates when reacted with heavy metal iodides
D Alkaloids are precursors of aromatic amino acids
- 3.** The protozoan that causes malaria is known as _____.
A Anopheles
B Mosquito
C *Staphylococcus*
D *Plasmodium*
- 4.** Dragendorff's reagent is used to test for the presence of _____.
A Steroids
B Carbohydrates
C Terpenoids
D Alkaloids
- 5.** What are some functions of secondary metabolites?
A They are used to attract insects to pollinate the plant and to disperse the seed.
B Protecting the plant from herbivores such as insects
C They are used to derive medicine
D All of the above
- 6.** Any compound produced by a plant is known as
A Primary metabolite
B Secondary metabolite
C Green metabolite
D Plant metabolite
- 7.** A 50/50 mixture of the *D* and *L* isomers of a given chiral compound has optical rotation of zero. Such a mixture is said to be ...
A Racemic
B Enantiomeric
C Pure
D Achiral
- 8.** What is the parent compound from which steroids are derived?
A Vitamin D
B Cholesterol
C Glycerol
D Triglyceride

9. This major class of secondary metabolites is among the most pharmacologically active compounds (many have dramatic physiological effects on humans) examples include morphine, cocaine, and caffeine.

- A Flavonoids
- B Terpenoids
- C Phenolics
- D Alkaloids

10. Isoprene rule states that...

- A Structures of terpenoids are made from cholesterol
- B Terpenoids structures are made up of isoprene units that have been joined in a regular head-to-tail manner
- C All terpenoids are structurally constructed from squalene
- D Structures of terpenoids are biosynthesised through the acetate pathway

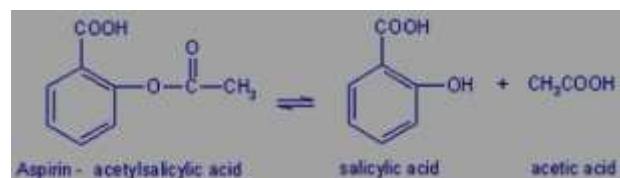
11. Which structure is that of the isoprene?

- A $\text{H}_2\text{C}=\text{C}(\text{CH}_3)\text{CH}=\text{CH}_2$
- B $\text{H}_2\text{C}=\text{CHCH}_2\text{CH}=\text{CH}_2$
- C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}=\text{CH}_2$
- D $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}=\text{CH}_2$

12. How many isoprene units are present in a sesquiterpene?

- A 15
- B 3
- C 10
- D 4

13. Aspirin (below) is converted into salicylic acid in your body by which of the following reactions?



- A Oxidation
- B Substitution
- C Deamination
- D Hydrolysis

14. A pure sample of the (+) enantiomer of compound D shows $[\alpha] = 42^\circ$. What would be the observed rotation if a solution of the sample was made by dissolving 0.250g in 2.0mL of acetonitrile and was placed in a 0.5dm cell?

- A 2.600°
- B 5.250°
- C 2.625°
- D 26.25°

15. What do all steroids have in common?

- A they contain four rings of carbon
- B they are water-soluble
- C they are manufactured by the liver
- D they contain at least one fatty acid

16. An optically pure organic compound has a specific rotation of $+40^\circ$. The percentage optical purity of a sample that exhibits specific rotation of $+32^\circ$ is

- A 8 %
- B 12 %
- C 20 %
- D 80 %

17. The phospholipids cephalin and lecithin differ in

- A the number of phosphate groups present
- B the amino alcohol present
- C the number of carbon atoms present
- D none of the above

18. Created through the mevalonate pathway, they are composed of isoprene units.

- A Alkaloids
- B Fatty acids
- C Flavonoids
- D Terpenoids

19. Which of the following statements is false about prostaglandins?

- A They are characterised by a 5 C cyclic structure
- B They act like hormones
- C They are hydrolysable
- D They are compounds containing 20 C atoms derived from arachidonic acid

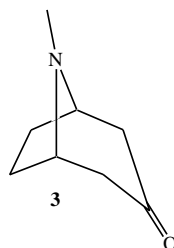
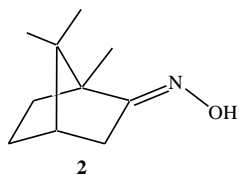
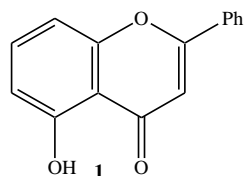
20. Structural isomers are also known as

- A Stereoisomers
- B Geometrical isomers
- C Spatial isomers
- D Constitutional isomers

21. What separation method is involved in the production of essential oils?

- A Distillation
- B Fractional distillation
- C Decantation
- D Filtration

22. Among the following, the compound/s that can be classified as a terpene derivative is (are):



- A 1 only
- B 2 only
- C 1 and 2
- D 2 and 3

23. Which statement/s is (are) true about ω -3 fatty acids?

- i. the human body cannot manufacture them
- ii. they are obtained from the diet
- iii. they are important in metabolism
- iv. they are obtained from plants

A i only

B ii only

C i, ii and iii

D All of the above

24. Which statement/s is (are) true about the fatty acids, Arachidonic acid (ARA), Dihomo- γ -linolenic acid (DGLA) and Eicosapentaenoic acid (EPA).

- i) They are examples of saturated fatty acids
- ii) They are C20 fatty acids
- iii) They are unsaturated fatty acids
- iv) They are the precursors of prostaglandins

A i only

B ii only

C iv only

D ii, iii and iv

25. Glucose and mannose are _____

A Enantiomers

B Mesomers

C Epimers

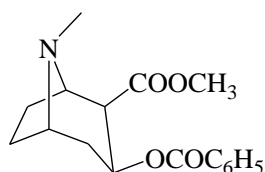
D Polymers

SECTION B (answer any three questions)

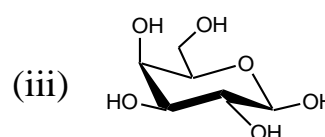
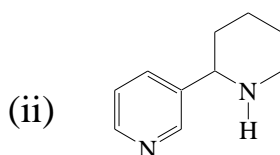
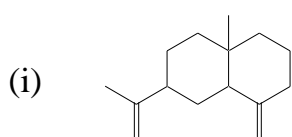
75 marks

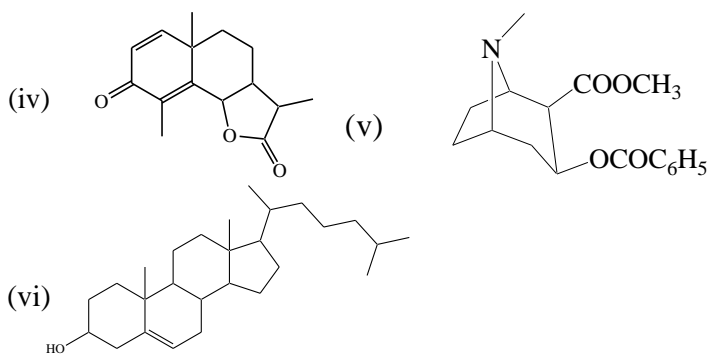
Question One

a) Cocaine is a chiral tropane alkaloid obtained from the leaves of *Erythroxylum coca*. Its structure is given below;



- i) Identify and name all the functional groups present on cocaine. [2 marks]
 - ii) Mark all chirality centres present on the structure. [2 marks]
 - iii) What are the hydrolysis products of cocaine? Give their structures. [3 marks]
- b) Classify each of the following molecules as alkaloid, terpenoid, steroid or carbohydrate. [6 marks]





c) Draw the most stable chair conformations of the following molecules:

i) Cyclohexanol

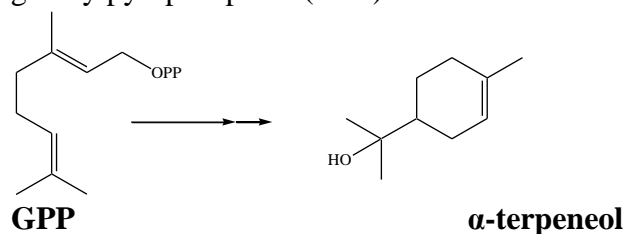
[2 marks]

ii) *trans*-4-methylcyclohexanol

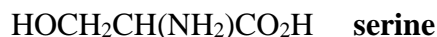
[2 marks]

d) Propose a plausible mechanism for the biosynthesis of α -terpeneol from geranylpyrophosphate (GPP).

[4 marks]



d) Serine is an example of a non-essential amino acid. Its structure is given below.



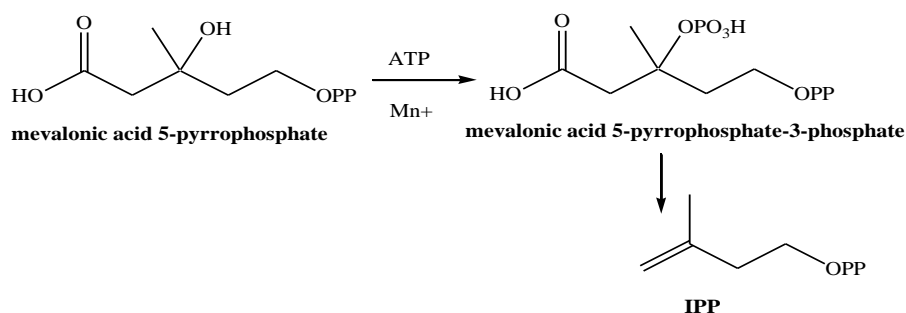
Use Fischer projection formulae to draw two enantiomers of serine.

[4 marks]

Question two

a) Isopentenylpyrophosphate (IPP) is formed enzymatically from the pyrophosphate of mevalonic acid by the action of adenosine triphosphate (ATP) and Mn^+ ions.

In the first step of this conversion, it is believed that the function of ATP is to phosphorylate mevalonic acid 5-pyrophosphate at the 3-position.



i) Explain what happens in the last step of this conversion.

[2 marks]

ii) Explain why the 3-phosphate derivative undergoes the reaction more readily than the 3-hydroxy derivative.

[2 marks]

iii) Give one example of a common reducing agent in biological systems.

[1 mark]

b) Outline a reaction sequence for the preparation of hexanoic acid from acetyl Co-enzyme A and malonyl Co-enzyme A.

[8 marks]

c) Alkaloids are a class of naturally occurring large group of pharmacologically active nitrogen containing secondary metabolites of plant, microbial or animal origin.

(i) State any two properties of alkaloids. [2 marks]

(ii) Name a functional group that distinguishes alkaloids from other secondary metabolites. [2 marks]

(iii) Describe one chemical test that can be used to detect the presence of alkaloids in a plant sample. [4 marks]

(iv) Draw/ state any two heterocycles upon which structures of alkaloids are based. [2 marks]

d) Draw the structure of a fatty acid, C₂₀:4, *n*-6 [2 marks]

Question three

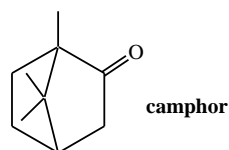
a) Giving examples in each case, define each of the following terms as used in natural products chemistry. [6 marks]

i) Essential fatty acids

ii) Enantiomers

iii) Secondary metabolites

b) Camphor, a monoterpene that is used topically to help relieve pain and also as a topical antiseptic, has the following structure;



i) Is camphor chiral or achiral? [1 mark]

ii) How many chirality centres does it have? [1 mark]

iii) Redraw the structure of camphor and clearly mark all the isoprene units present. [2 marks]

iv) Draw the structure of a terpenol that is obtained when camphor is reduced with LiAlH₄. [2 marks]

c) Give the **biological sources** as well as **pharmaceutical importance** of each of the following drugs: [8 marks]

(i) Cocaine

(ii) Quinine

(iii) Morphine

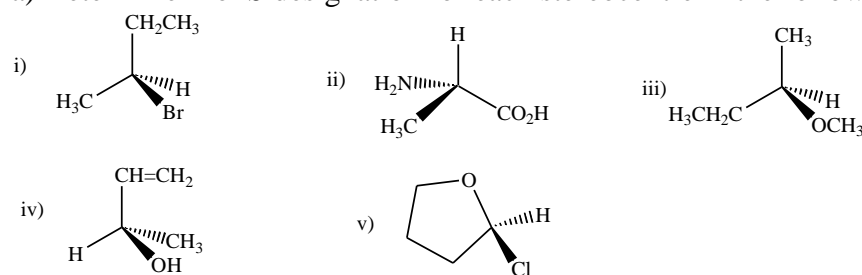
(iv) Caffeine

d) Name any two sex hormones and state their biological importance. [4 marks]

e) Mention one health hazard that is caused by tobacco smoking. [1 mark]

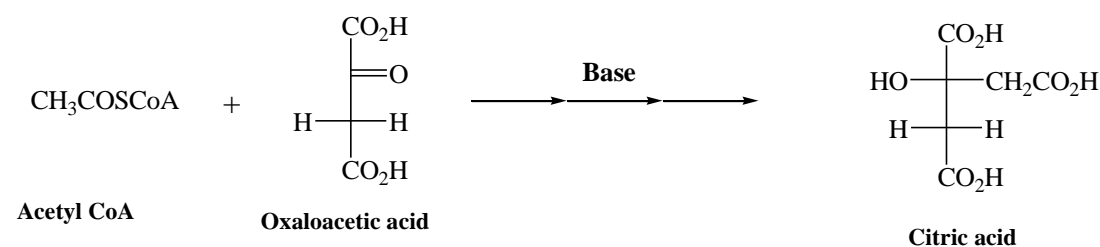
Question four

a) Determine *R* or *S* designation for each stereocentre in the following molecules.



[5 marks]

b) Nature uses the two-carbon acetate fragment of acetyl co-enzyme A (Acetyl CoA) as the major building block for synthesis of various biological molecules. The following reaction illustrates the biosynthesis of citric acid from the condensation of acetyl CoA with oxaloacetic acid.



- (i) Show a detailed mechanism for the reaction. [4 marks]
 (ii) Would you expect citric acid to be chiral or achiral? Explain. [1+1 marks]

c) Fats and oils are both triacylglycerides. They are easily distinguishable from each other in that fats are solids while oils are liquids at room temperature. Fats can either be optically active or inactive depending on their structures.

i) Draw the structure of an optically active fat that yields 2 equivalents of stearic acid and 1 equivalent of oleic acid on hydrolysis. [2 marks]

ii) Draw the structure of an optically inactive fat that yields the same products on hydrolysis. [2 marks]

d) Given that (*S*)-2-bromobutane has a specific rotation of +23.1°, and that of (*R*)-2-bromobutane is -23.1°.

i) What is the percentage optical purity of a sample whose observed rotation is +18.4°? [3 marks]

ii) Which enantiomer is present in excess? [1 mark]

iii) Calculate the percentage composition of the mixture. [4 marks]

e) Mention any two importances of terpenoids. [2 marks]

~END OF PAPER~

STRUCTURES OF SOME FATTY ACIDS

Acid Chain	C:N	Type	Structure
Caprylic	C8 : 0	S	$\text{CH}_3 (\text{CH}_2)_6 \text{COOH}$
Capric	C10 : 0	S	$\text{CH}_3 (\text{CH}_2)_8 \text{COOH}$
Lauric	C12 : 0	S	$\text{CH}_3(\text{CH}_2)_{10} \text{COOH}$
Myristic	C14 : 0	S	$\text{CH}_3(\text{CH}_2)_{12} \text{COOH}$
Palmitic	C16 : 0	S	$\text{CH}_3(\text{CH}_2)_{14} \text{COOH}$
Palmitoleic	C16 : 1	US	$\text{CH}_3(\text{CH}_2)_5 \text{CH}=\text{CH}(\text{CH}_2)_7 \text{COOH}$
Stearic	C18 : 0	S	$\text{CH}_3(\text{CH}_2)_{16} \text{COOH}$
Oleic	C18 : 1	US	$\text{CH}_3(\text{CH}_2)_7 \text{CH}=\text{CH}(\text{CH}_2)_7 \text{COOH}$