TECHNICAL UNIVERSITY OF MOMBASA

School of Applied and Health Sciences

DEPARTMENT OF PURE AND APPLIED SCIENCES

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN APPLIED CHEMISTRY

ACH 4316: NATURAL PRODUCTS CHEMISTRY

SPECIAL/SUPPLEMENTARY EXAMINATION

SERIES: JULY 2025 SERIES

TIME: 2 HOURS

DATE: JULY 2025

Instructions to Candidates

You should have the following for this examination

Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Attemptquestion ONE (Compulsory) and any other TWO questions.

Do not write on the question paper.

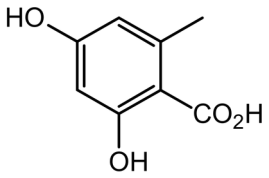
Question One (30 Marks)

(a) A state any four common biological reactions other than alkylation involved in biosynthesis of natural products. [**4 marks**]

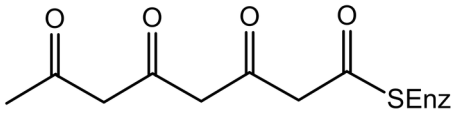
(b) Name and provide the structures of three alkylating agent commonly encountered in biosynthesis of alkylated natural molecules. [**6 marks**]

(c) Name and describe two methods by which phytochemicals may be extracted from a plant material by making use of solvent extraction. [**4 marks**]

(d) Orsellinic acid (**1**) is biosynthesized from a poly-β-keto thioester (**2**).



(**1**)



(**2**)

Suggest the folding pattern of (**2**) that would lead to biosynthesis of Orsellinic acid (**1**), and provide the biosynthetic intermediates and the reaction mechanism leading to formation of Orsellinic acid (**2**) from the suggested folding pattern. **[6 marks]**

(e) Describe the following terms as applied in the chemistry of natural products:

[5 marks]

i. Phytochemicals
ii. Bioassay
iii. Phytochemical screening
iv. Biosynthetic building blocks
v. Bioassay-guided isolation

(f) Describe the structure, occurrence, and biological significance of steroids.

[5 Marks]

Question Two (20 Marks)

(a) Outline the main biosynthetic pathways through which fatty acids are synthesized, highlighting their key intermediates and enzymes involved. **[5 Marks]**

(b) Name five classes of fatty acids. **[5 marks]**

(c) Briefly describe biosynthetic pathways of prostaglandins and leukotrienes from fatty acids.

[5 Marks]

(d) Outline the role of prostaglandins and leukotrienes in the human body. **[5 marks]**

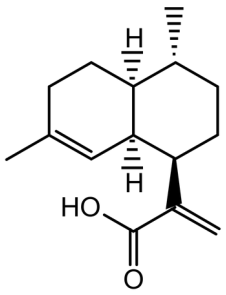
Question Three (20 Marks)

(a) What are essential oils? **[2 marks]**

(b) Explain how gas chromatography (GC) is used for the characterization and quantification of terpenes/ terpenoids in essential oils. **[4 marks]**

(c) Artemisinic acid (**3**) is a terpenoid isolated from *Artemisia annua* L., and has a variety of pharmacological activity, such as antimalarial activity, anti-

tumor activity, antipyretic effect, antibacterial activity, allelopathy effect and anti-adipogenesis effect.



(**3**)

i. Name two functional groups in artemisinic acid (**3**). [**2 marks**]

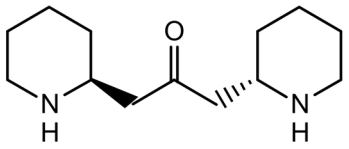
ii. Account for the name of the molecule; artemisinic acid. [**2 marks**]

iii. Outline the biosynthesis of artemisinic acid (**9**) starting from DMAPP and IPP clearly indicating the folding pattern of the isoprenyl unit leading to the molecule (Only reaction mechanism leading to the formation of the bicyclic ring system is required). [**8 marks**]

Question Four (20 Marks)

(a) Explain how the presences of nitrogen atom(s) in alkaloids facilitate their isolation and purification from plant materials. [**2 marks**]

(b) Anaferine (**4**) is a piperidine alkaloid which is biosynthetically obtained from L-Lysine (**5**) and acetoacetyl-CoA (**6**). Outline the biosynthesis of anaferine (**13**) indicating all the biosynthetic intermediates and reaction mechanism leading to the formation of the heterocylic ring and the attachment of the acetate unit. [**10 marks**]



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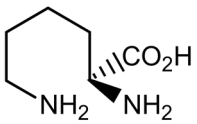
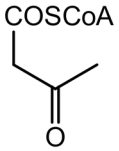
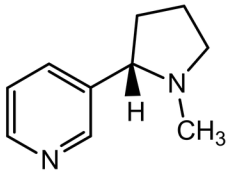


(**5**)

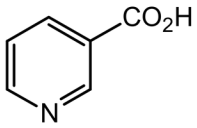


(**6**)

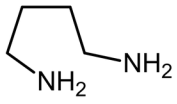
(c) Nicotine (**7**) is a pyridine alkaloid which is biosynthesized from nicotinic acid (**8**) and putrescine (**9**). Provide the biosynthetic pathway leading to formation of nicotine (16) clearly indicating the intermediates involve. [**8 marks**]



(**7**)



(**8**)

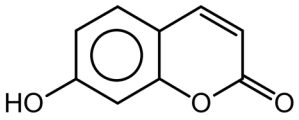


(**9**)

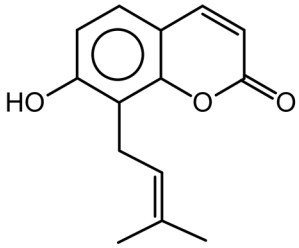
Question Five (20 Marks)

(a) Name five challenges and limitations associated with biomimetic synthesis of natural products. [**5 marks**]

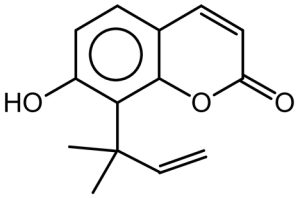
(b) The aluminium trichloride catalysed reaction between umbelliferone (Structure **10**) and a chlorinated alkyl gives compounds **11** and **12** as the two main products.



(**10**)



(**11**)



(**12**)

i. Provide the structure of the chlorinated alkyl that is required in the conversion of umbelliferone (Structure **10**) to compounds **11** and **12**. [**2 marks**]

ii. Provide the reaction mechanism leading to the formation of compounds 32 and 33 from umbeliferone (31) and the chlorinated alkyl identified in i. above [**8 marks**]

iii. Acid treatment of compounds **12** leads to set of two products. Suggest the structures of the two products and identify the major. Account for the major product. [**5 marks**]