Technical University of Mombasa

Faculty of Applied and Health Sciences

DEPARTMENT OF PURE AND APPLIED SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF TECHNOLOGY IN APPLIED CHEMISTRY (ANALYTICAL OPTION)

BTAC 12J$_2$ & 12M$_2$ & 11M

ACH 4316 : NATURAL PRODUCT CHEMISTRY

SEMESTER EXAMINATION

DECEMBER 2013 SERIES 2 HOURS

Instructions to candidates:

This paper consist of FIVE questions
Answer question ONE (compulsory) and any other TWO questions

QUESTION ONE

a) (i) What is biosynthesis as applied in the chemistry of natural products? **(1mark)**

(ii) Other than oxidative coupling, name four common types of reactions involved in biosynthesis of natural products. **(2marks)**

b) (i) Name four classes of terpenoids and state the number of isoprene units in each case. **(4marks)**

(ii) Taxol(1), a highly derivalized terpenoid isolated from taxus brerifolia has shown promise as an anti-tumor agent in breast and ovarian cancers.

I. State the origin of the name of the compound. **(1mark)**

II. Name FOUR functional groups in the molecule **(2marks)**

III. Trace the structure of the compound and identify the isoprene units in the molecule **(4marks)**

c) (i) Name TWO biosynthetic units involved in the biosynthesis of straight chain fatty acids. **(1mark)**

(ii) Identify all the primary building blocks of 2,4,6,8-tetramethyldecanoic acid. (2) **(2marks)**

(iii) Explain why olefinic fatty acids are usually liquid in nature. **(1mark)**

d) Endocrocin (3) found in species of penicillium and Aspergillus fungi is formed by folding a polyketide containing eight C_2 units to form the periphery of the carbon skeleton

(i) Provide the folding pattern of the poly-β-keto ester synthetic unit that would lead to formation of endocrocin and account for the extra oxygen atom in endocrocin. (3marks)

(ii) Emodin can be formed by decaroxylation reaction of endocrocin Draw the structure of emodin and make use of curly arrows to provide the reaction mechanism leading to the formation of emodin from endocrocin **(3marks)**

e. Anthraniloyl-CoA(4) can act as a starter unit for malonate chain extension with the aromatization of the acetate – derived portion leading to formation of quinoline (5) or acridine (6) alkanoids based on the number of acetate units incorporated. Describe the biosynthesis of the quinoline and acridine nucleus from the building blocks indicating the intermediates involved in each case. **(6marks)**

QUESTION TWO

a) Stereospecific allylic isomensation of IPP (7) yeld DMAPP. Provide the structure of DMAPP **(1.5marks)**

b) IPP and DMAPP can undergo head to tail condensation to form geranyl pyrophosphate (8). Make use of curly arrows to provide the mechanism for the condensation reaction. **(2.5marks)**

c) The monoterpenes α-terpeneol (9) and β-phellandrene (10) are biosynthesized from geranyl pyrophosphate (8)

(i) Provide the folding pattern of geranyl pyrophosphate (8) that will lead to formation of α-terpeneol (9) and β-phellanrene(10) **(2marks)**

(ii) Suggest a reaction mechanism for the formation of α-terpineol (9) and β-pheuandrene (10) from geranyl pyrophosphate (8) indicating all the intermediates involved in the biosynthetic process. **(6marks)**

d) α-santonin (11) has been identified as the principal anthelmintic component of various Artemisia species such as *A.Cilia*, and has found considerable use for removal of roundworms, although potential toxicity limits its application.

(i) α-santonin (11) is sesquiterpene biosynthesized from farnesyl pyrophosphate (12) which leads to α-santonin(11).

(ii) Describe the biosynthesis of α-santonin(11) from farnesyl pyrophosphate (12) indicating all the intermediates and the reaction mechanism leading to their formation. **(6marks)**

QUESTION THREE

a) What are alkaloids. Name SIX classes of alkaloids based on the main skeleton nucleus that constitute the individual classes. **(4marks)**

b) Anhalonidine (13) which is a representative of simple *tetra hydroisoquinoline* derivative is biosynthe sized from 3,4-dydroryphenylalanine (L-DOPA) (14) and pyruvic acid (15).

(i) Provide the biosynthetic pathway of anhalonidine (13) from the burlding blocks. **(7marks)**

(ii) Show the mechanistic details of the formation of the 6-membered heterocyclic ring form the intermediates leading to its formation. **(4marks)**

c) The alkaloid berberine (16) which is found in many member of the Berberidaceae and Ranunculaceae families has antiamoebic, antibacterial, and anti-inflammatory properties. The alkaloid is biosynthesized as per the following scheme

(i) Provide the reaction mechanism leading to the formation of the heterocyclic ring system from the iminium ion intermediate by making use of curly arrows. **(2marks)**

(ii) Provide the structures of the intermediates A and B **(2marks)**

(iii) Name Biomolecule X. **(1mark)**

QUESTION FOUR

a) A biominatic synthesis for a flavones (17) can be achieved by using compound (18) and appropriate acyl chloride.

(i) Provide the structure of the acyl chloride that may be used in the synthetic conversion **(1mark)**

(ii) Give a detailed reaction mechanism and the required reagents for the synthetic scheme leading to the formation of flavone 17. **(6marks)**

b) Umbeliferone (19) can be synthesized from 2,4-dihydroxybenzaldehyde and ethanoic anhydride. Provide other reagents and reaction mechanism leading to the formation of umbelliferone(19). **(5marks)**

c) The aluminium trichloride catalysed reaction between umbelliferone (19) and dimethyl allyl-chloride gives other coumarins (20) and (21) as the two main products.

(i) Provide the reaction mechanism leading to the formation of the coumarins (20) and (21). **(5marks)**

(ii) Acid treatment of (21) leads to a set of 1000 products and identify the major product. **(3marks)**

QUESTION FIVE

a) Why is it easier to use UV spectroscopy to characterize acetylenic fatty acids as opposed to olefinic fatty acids? **(2marks)**

b) Describe the basic skeleton of prostaglandins . **(3marks)**

c) The PGH_2(22) is biosynthesized from arachidonic acid (23) through radical oxidation which allows addition of O_2 and formation of peroxide radical.

(i) Provide the biosynthetic pathway leading to formation of PGH_2 (22) indicating the intermediates and reaction mechanism leading to their formation. **(5marks)**

(ii) Draw the structures of three prostaglandins that may be formed from the radical cleavage of the cyclic peroxide PGH_2(22) **(3marks)**

d) Phloracetophenone(24) is aromatic polyketide

(i) Provide the structure of the poly-β-keto ester that leads to the formation of phloracetophenone. **(2marks)**

(ii) Provide the synthetic pathway phloroacetophenone form poly-β-keto ester and give the reaction mechanism leading to formation of the aromatic ring system. **(5marks)**