



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF APPLIED SCIENCES
DEPARTMENT OF APPLIED CHEMISTRY

ORGANIC SYNTHESIS 11 – SCH 2202

March 2025

Second Semester Examination Paper 2025

This examination paper consists of 7 printed pages

Time Allowed: 3 hours
Total Marks: 100
Special Requirements: Scientific Calculator
Internal Examiner: Dr C. Changunda
External Examiner:

INSTRUCTIONS & INFORMATION

1. Answer **all** questions in Section A and **any 3** questions Section B. Section A carries 40 marks and each question in Section B carries 20 marks.
2. Start new question on a new page. (Not each part of a question).
3. Show mechanisms or synthesis by means of push and pull arrows.

MARK ALLOCATION

QUESTION	MARKS
1.	40
2.	20
3.	20
4.	20
5.	20
TOTAL POSSIBLE MARKS	100

SECTION A

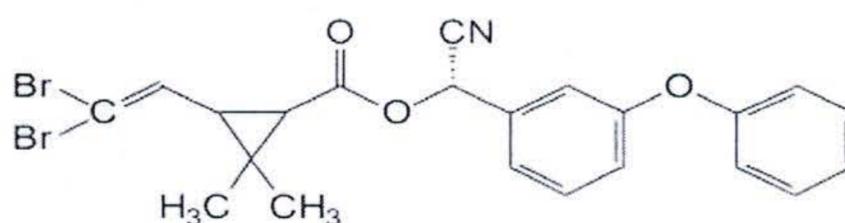
Question 1

a. Define the following terms as they relate to organic synthesis:

- i. Functional group [2 marks]
- ii. Protecting group [2 marks]
- iii. Retrosynthesis [2 marks]
- iv. Aldol condensation [2 marks]
- v. Reimer-Tiemann formylation [2 marks]

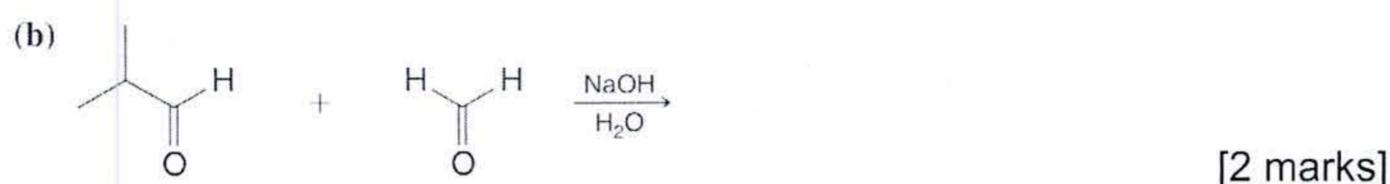
b. What are the five key properties of a good protecting group? [5 marks]

c. The structure shown below belongs to a widely used pyrethroid compound, deltamethrin.

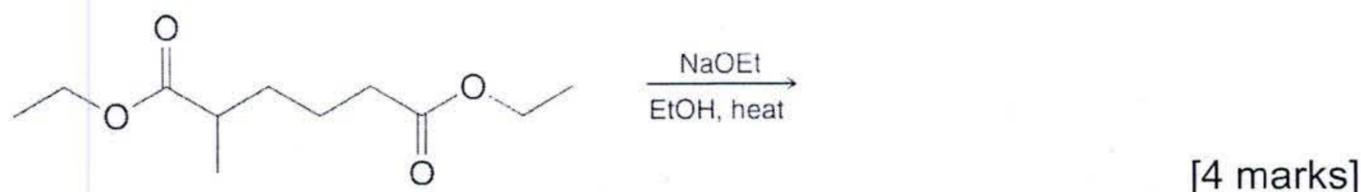


Identify and name all the functional groups in the compound represented above. [5 marks]

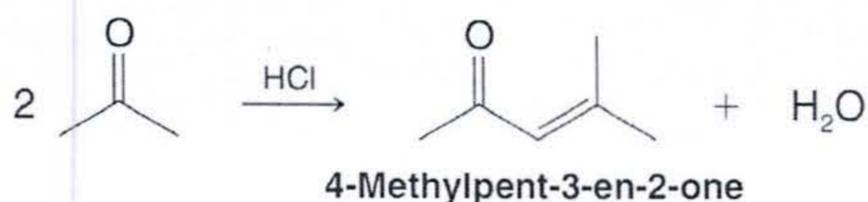
d. Predict the products from each of the following crossed aldol reactions.



e. Write structural formulas for both of the possible products from the following Dieckmann condensation, and predict which one would likely predominate,



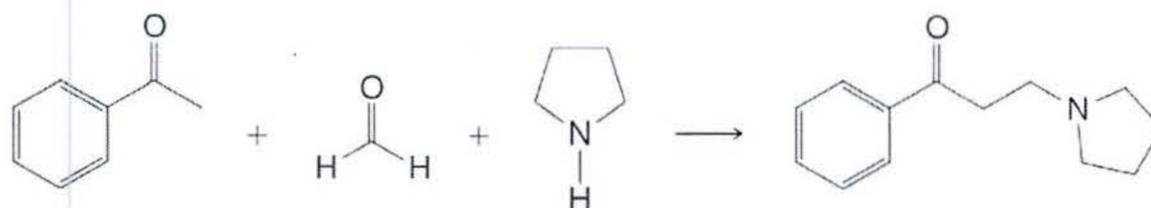
f. Show a mechanistic explanation of the following reaction.



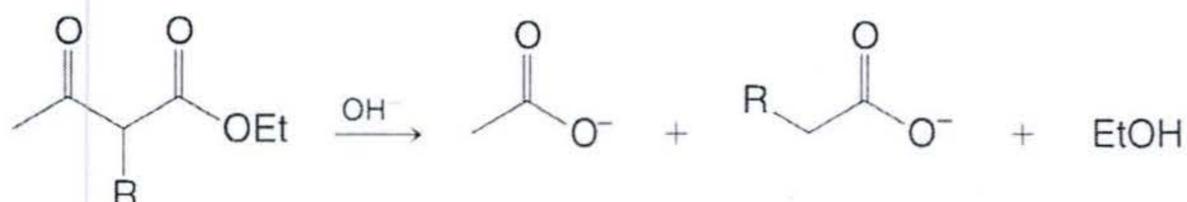
[4 marks]

g. To which type of reaction does the following transformation belong? Demonstrate mechanistically how the product in the reaction shown below is formed.

[5 marks]



h. In contrast to the reaction with dilute alkali, when concentrated solutions of NaOH are used, acetoacetic esters undergo cleavage as shown below.

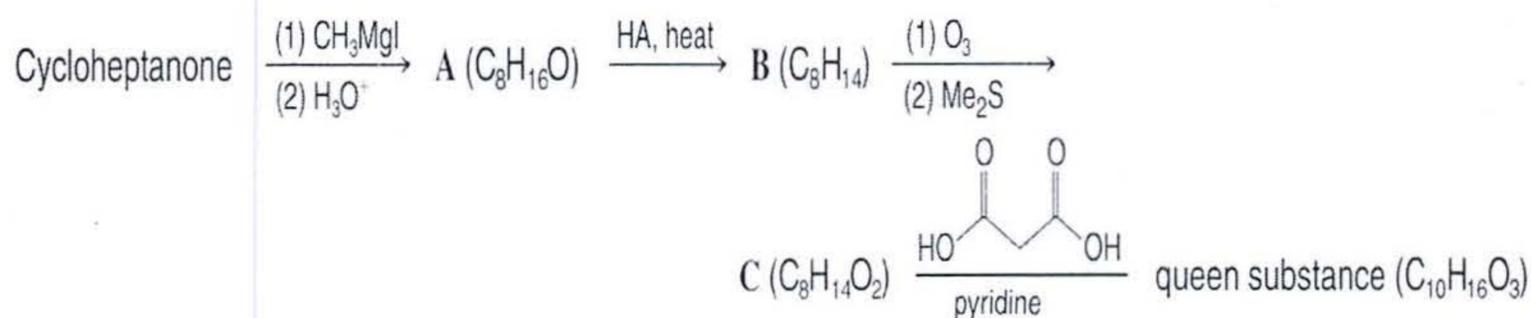


Give a mechanistic explanation of the reaction shown above. [3 marks]

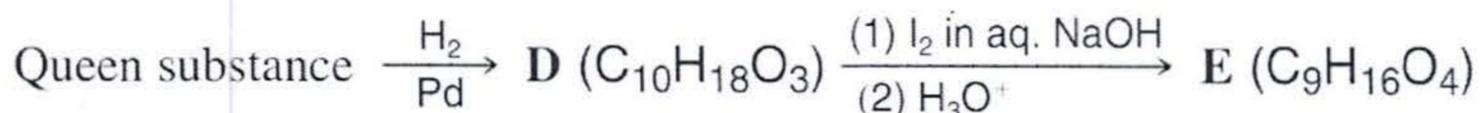
SECTION B

Question 2

The mandibular glands of queen bees secrete a fluid that contains a remarkable compound known as "queen substance." When even an exceedingly small amount of the queen substance is transferred to worker bees, it inhibits the development of their ovaries and prevents the workers from bearing new queens. Queen substance, a monocarboxylic acid with the molecular formula $\text{C}_{10}\text{H}_{16}\text{O}_3$, has been synthesized by the following route:



On catalytic hydrogenation, queen substance yields compound D, which, on treatment with iodine in sodium hydroxide and subsequent acidification, yields a dicarboxylic acid E; that is,



Provide structures for the queen substance and compounds A–E.

Question 3

The Perkin condensation is an aldol-type condensation in which an aromatic aldehyde (ArCHO) reacts with a carboxylic acid anhydride, (RCH₂CO)₂O, to give an α,β -unsaturated acid (ArCH=CRCO₂H). The catalyst that is usually employed is the potassium salt of the carboxylic acid (RCH₂CO₂K).

(a) Outline the Perkin condensation that takes place when benzaldehyde reacts with propanoic anhydride in the presence of potassium propanoate. [12 marks]

(b) How would you use a Perkin condensation to prepare *p*-chlorocinnamic acid, *p*-ClC₆H₄CH=CHCO₂H? [8 marks]

Question 4

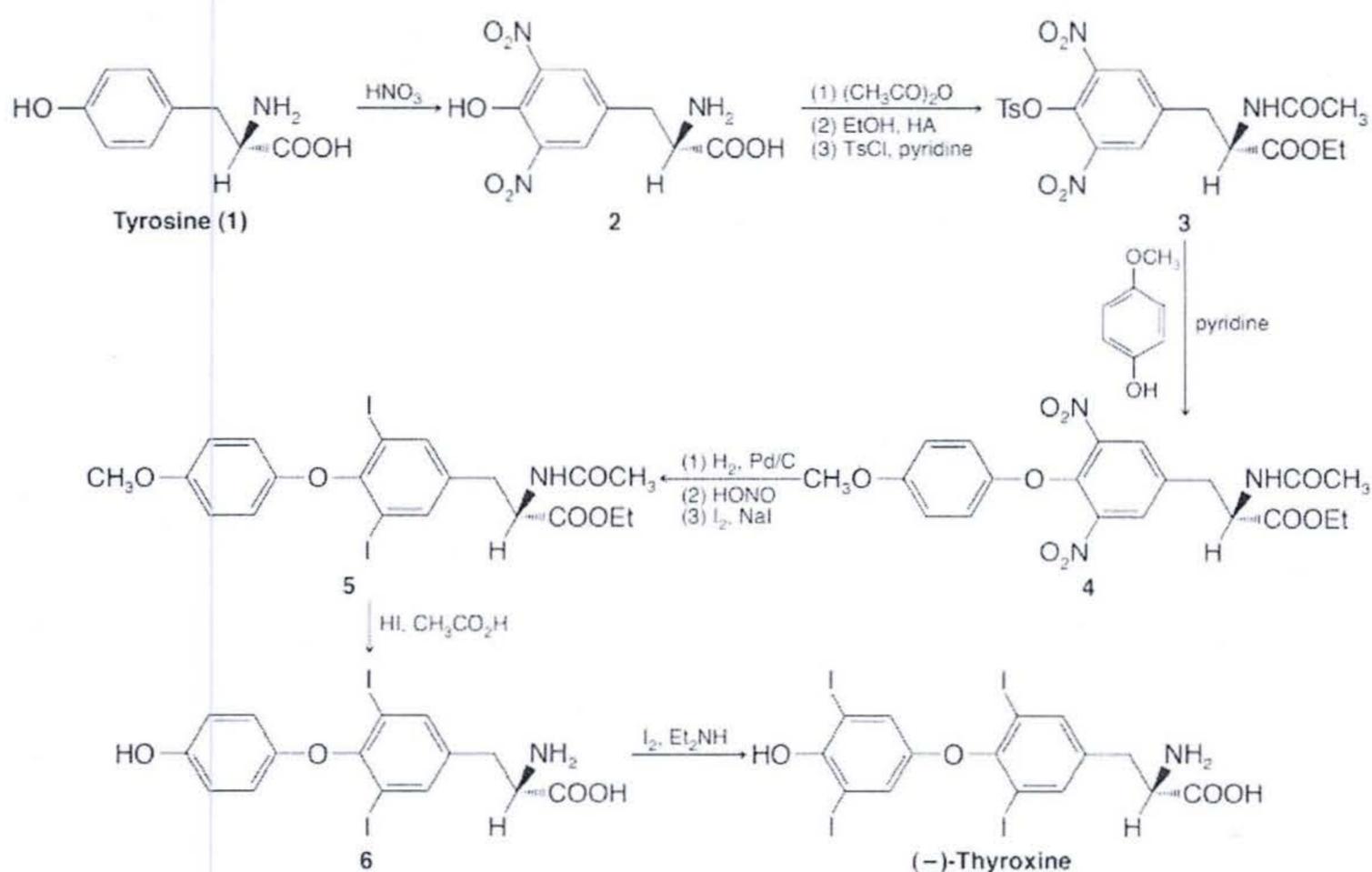
Thyroxine is a hormone produced by the thyroid gland that is involved in regulating metabolic activity. The following is a synthesis of optically pure thyroxine from the amino acid tyrosine. This synthesis proved to be useful on an industrial scale.

(a) **1 to 2.** What type of reaction is involved in the conversion of **1** to **2**? Write a detailed mechanism for this transformation. Explain why the nitro groups appear where they do in **2**. [5 marks]

(b) **2 to 3.** (i) Write a detailed mechanism for step (1) in the conversion of **2** to **3**.
 (ii) Write a detailed mechanism for step (2) in the conversion of **2** to **3**.
 (iii) Write a detailed mechanism for step (3) in the conversion of **2** to **3**. [5 marks]

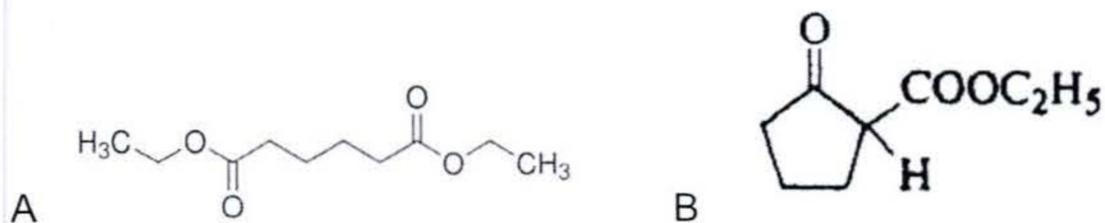
(c) **3 to 4.** (i) What type of reaction mechanism is involved in the conversion of **3** to **4**? (ii) Write a detailed mechanism for the reaction from **3** to **4**. What key intermediate is involved? [5 marks]

d) **5 to 6.** Write a detailed mechanism for conversion of the methoxyl group of **5** to the phenolic hydroxyl of **6**.

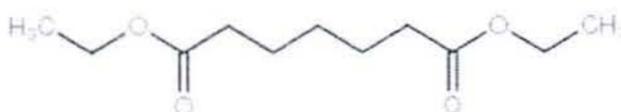


Question 5

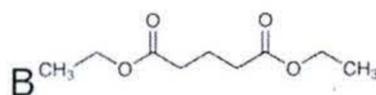
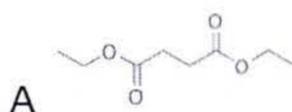
- a. Sodium ethoxide converts ethyl adipate A into 2-carbethoxycyclopentanone B (shown below).



- What is the name of this reaction? [1 mark]
- How do you account for the formation of the cyclic compound shown above? [5 marks]
- What product would you expect from the action of sodium ethoxide on ethyl pimelate (ethyl heptanedioate, shown below)? [5 marks]



- Would you expect similar behavior from ethyl succinate A or ethyl glutarate, B?



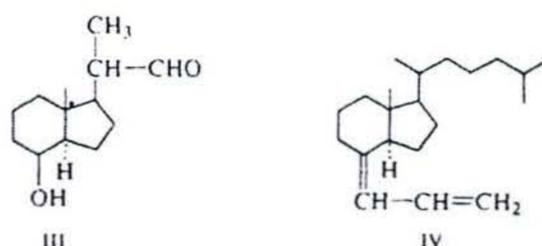
[4 marks]

- v. Actually, ethylsuccinate reacts with sodium ethoxide to form a compound with formula $C_{12}H_{16}O_6$ with a six-membered ring. What is the likely structure of this compound? [5 marks]

Question 6

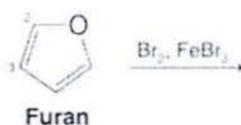
As part of the total synthesis of vitamin D3, compound III was converted to IV by a number of stages, two of which involved the use of a Wittig reaction.

- a. State 3 limitations of the Wittig reaction. [6 marks]
 b. Show how the conversion from III to IV might have been carried out. [14 marks]



Question 7

- a. Briefly explain the three major challenges associated with use of protecting groups in organic synthesis. [6 marks]
 b. Treating cyclohexene with acetyl chloride and $AlCl_3$ leads to the formation of a product with the molecular formula $C_8H_{13}ClO$. Treating this product with a base leads to the formation of 1-acetylcyclohexene. Propose mechanisms for both steps of this sequence of reactions. [10 marks]
 c. Furan undergoes electrophilic aromatic substitution. Use resonance structures for possible arenium ion intermediates to predict whether furan is likely to undergo bromination more rapidly at C2 or at C3.



[4 marks]

End of Question Paper.