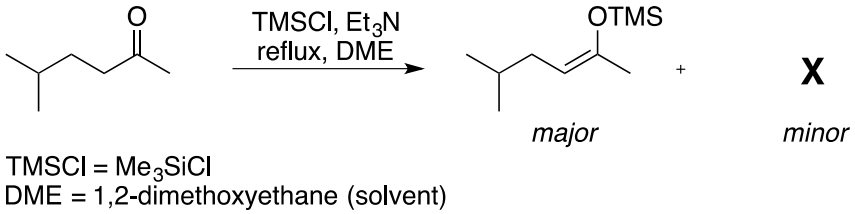
2.O1 – Organic Synthesis Part 1

Q1. Answer **ALL** parts, a), b) and c)

a) For the reaction shown below:

i) State the type of selectivity being displayed.

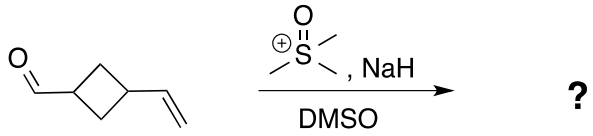
ii) Draw the alternative product **X** which may be formed as a minor component.



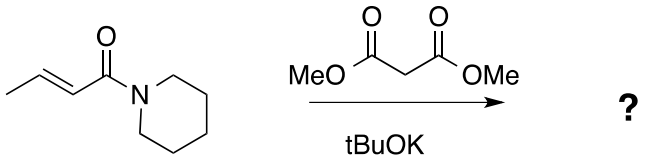
(3 marks)

b) Predict the product of **TWO** of the following reactions. For each of the reactions you choose, provide a mechanism and explain the key features that lead to any observed selectivity.
Note: you can assume a standard aqueous quench/work-up procedure is undertaken to isolate the organic product.

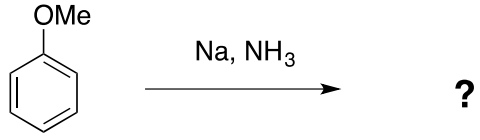
i)



ii)



iii)



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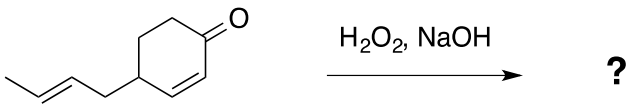


(5 marks each)

c) Answer part i) **AND** part ii) with consideration of the synthetic scheme shown below.

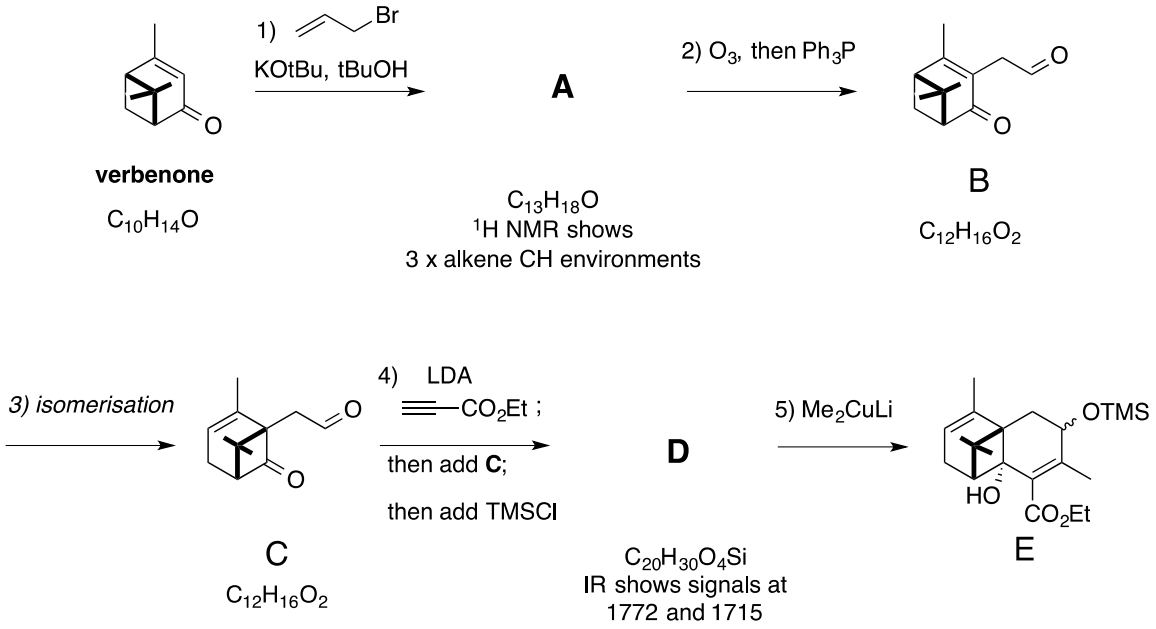
The sequence shows the early stages of a synthesis of anticancer agent Taxol by Wender (*J. Am. Chem. Soc.* 1997).

i) Identify compound **A**, and provide a mechanism for its formation from verbenone.

(6 marks)

ii) Identify compound **D**, and suggest a mechanism for the formation of **E** from **D.**

(6 marks)



2.O2 – Heteroaromatics

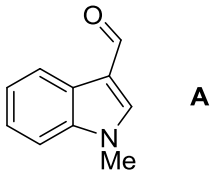
Answer **ALL** parts of this question.

a) Explain **TWO** of the following, using curly arrow mechanisms to illustrate your answers.

i) Treatment of 3-methylhexane-2,5-dione with a Brønsted acid catalyst gives 2,3,5-trimethylfuran as the organic product.

ii) Pyridine undergoes electrophilic aromatic substitution (S_EAr) preferentially at the 3-position.

iii) Treatment of 1-methylindole with phosphorus oxychloride ($POCl_3$) and *N*,*N*-dimethylformamide ($(CH_3)_2NCHO$) followed by aqueous work-up gives 1-methylindole-3-carbaldehyde **A** as the major product.

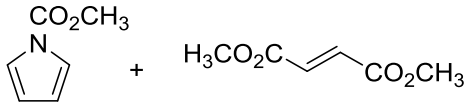


A

(5 marks each)

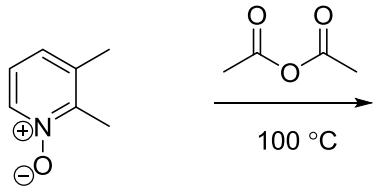
b) Identify the product of **ONE** of the following reactions, and write a mechanism for its formation.

i)



B **B** has the formula $C_{12}H_{15}NO_6$

ii)



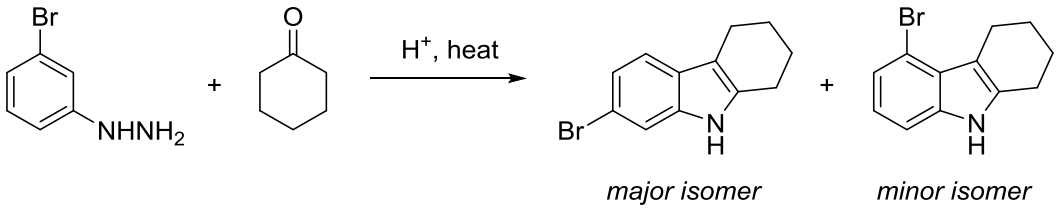
C **C** has the formula $C_9H_{11}NO_2$

(5 marks each)

QUESTION CONTINUED OVERLEAF

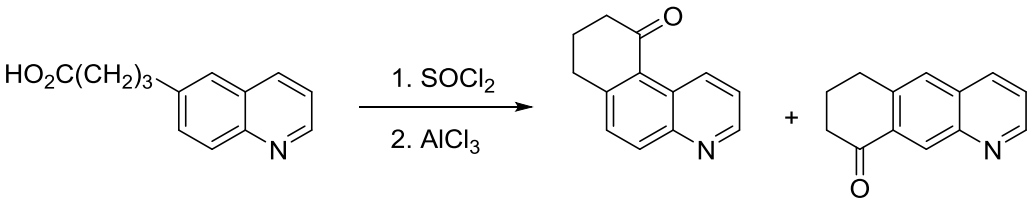
c) For **EITHER** i) **OR** ii) below, give a detailed mechanism for the formation of the major product shown, and explain the observed selectivity for the major isomer.

i)



major isomer *minor isomer*

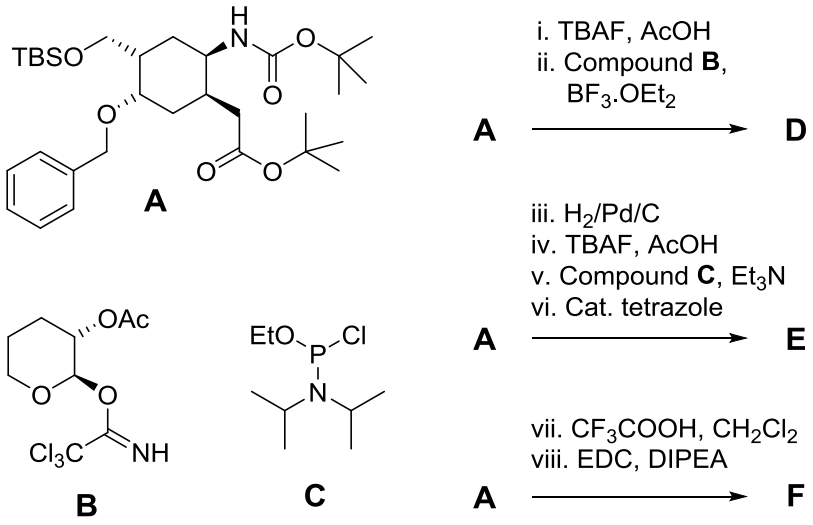
ii)



major isomer *minor isomer*

(10 marks each)

2.O3 – Bioorganic Chemistry



Notes:
TBAF = tetra-*n*-butylammonium fluoride
EDC = 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide
DIPEA= *N*,*N*-diisopropylethylamine
TBS = *tert*-butyldimethylsilyl

Answer part a) and **TWO** of the parts b)-d) of this question.

a) Identify the orthogonal sets of protecting groups present in molecule **A**, above, and identify the functional groups they are protecting.

(7 marks)

b) Identify the product formed in each step leading to formation of **D**, and provide a mechanism for steps (i) and (ii).

(9 marks)

c) Identify the product formed in each step leading to formation of **E**, and provide mechanisms for steps (v) and (vi).

(9 marks)

d) Identify the product formed in each step leading to formation of **F**, and provide mechanisms for steps (vii) and (viii).

(9 marks)

2.O4 – Pericyclic Reactions

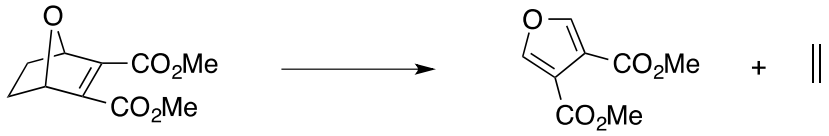
Answer **ALL** parts of this question.

a) Define the term sigmatropic rearrangement.

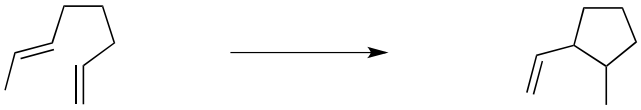
(5 marks)

b) For **TWO** of the following **THREE** thermal reactions, draw a curly arrow mechanism and write down the class of pericyclic reaction to which it belongs.

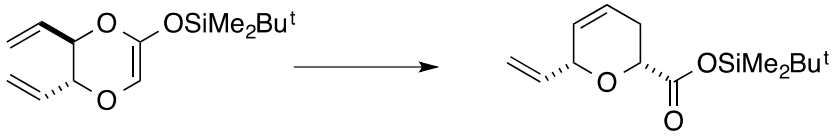
i)



ii)

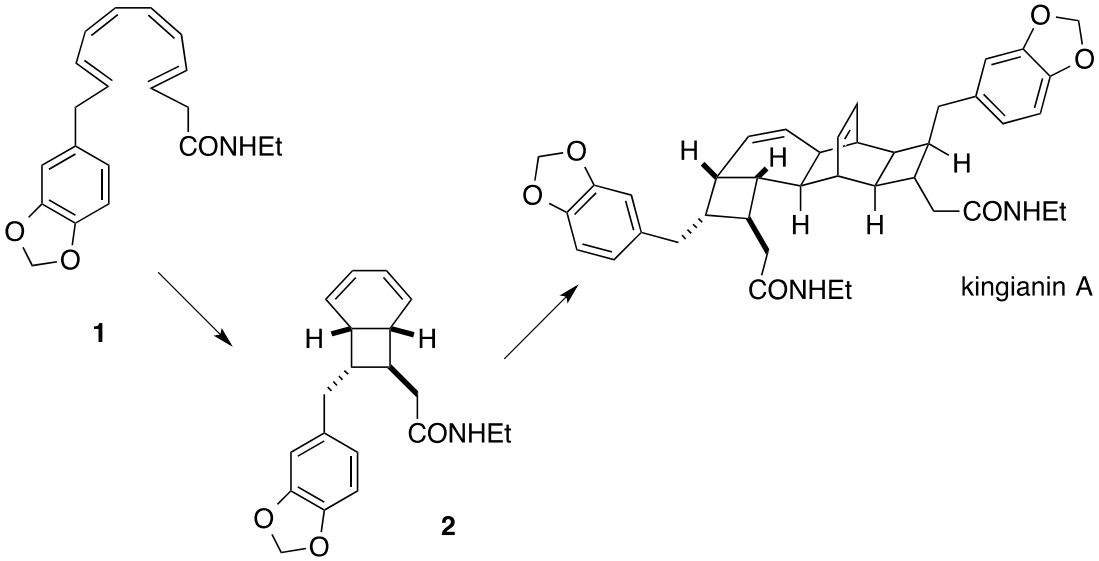


iii)



(10 marks)

c) The following scheme is a proposal for the biosynthesis of kingianin A. Explain how substrate **1** might be converted to compound **2** under thermal conditions, paying particular attention to the stereochemistry. Write down the structure of an unwanted diastereoisomer of **2** that might form. By what class of pericyclic reaction is compound **2** converted into kingianin A?



(10 marks)

2.O6 – Fundamentals of Polymer Chemistry

Answer part a) and **EITHER** part b) **OR** part c) of this question.

a) Answer **ALL** parts of this question.

i) Consider the following distributions of polybutadiene chains:

5 (wt)% chains of degree of polymerisation 40
25 (wt)% chains of degree of polymerisation 50
40 (wt)% chains of degree of polymerisation 70
30 (wt)% chains of degree of polymerisation 100

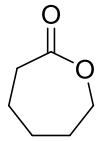
Calculate the number and weight average molecular weight of this collection of polymer chains.

(4 marks)

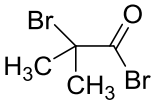
Draw two isomers of this polymer.

(2 marks)

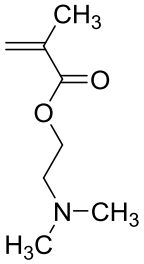
ii) Treatment of caprolactone (**1**) with ethylenediamine initiator, yields a polymer **A**, which can be converted to a macroinitiator **B** when reacted with two equivalents of (**2**). Macroinitiator **B** was then used in the controlled polymerisation of acrylamide (**3**) in the presence of CuBr and bipyridine, to form a block co-polymer **C**.



(1)



(**2**)



(**3**)

Draw the structures of **A, B** and **C**.

(6 marks)

Describe both polymerisation mechanisms

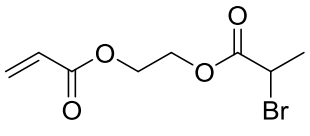
(4 marks)

What is the role of bipyridine in the second polymerisation

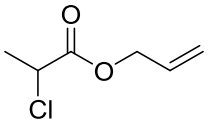
(1 mark)

QUESTION CONTINUED OVERLEAF

iii) The polymerisation of monomer **4** in the presence of cupric chloride catalyst, yields polymer with a different polymer architecture than the polymer formed from monomer **5** under identical polymerisation conditions. Explain the reasons for these differences.



(**4**)



(**5**)

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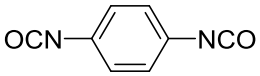
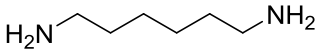
(4 marks)

b) Answer **ALL** parts of this question.

i) Draw the polymer formed from the polymerisation of monomers **(6)** and **(7)**. What is the name of this type of polymer molecular structure?



(6)



(7)

(2 marks)

ii) Explain two molecular features of this polymer that strongly influence its physical properties.

(2 marks)

c) In the polymerisation of monomers (**6**) and (**7**), shown in part b), one of the two monomers is in excess to the ratio 1:1.05 and the extent of reaction is 0.98. What is the number average molecular weight of the resulting polymer?

(4 marks)