

UNIVERSITY OF RUHUNA

FACULTY OF FISHERIES AND MARINE SCIENCES & TECHNOLOGY



Academic Year 2023/2024

Bachelor of Science Honors in Marine and Freshwater Sciences Degree

Bachelor of Science Honors in Fisheries and Marine Sciences Degree

Level IV Semester I Examinations – April/May 2025

CHM 4121: Green Chemistry- Theory

Part II –(55 marks)

Answer one question only.

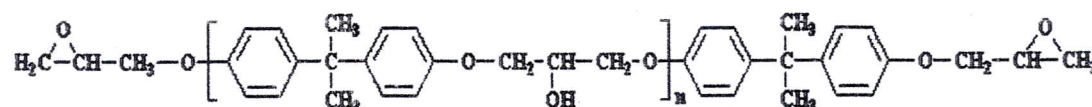
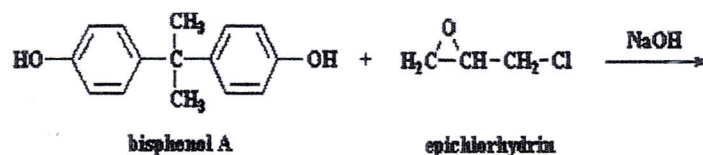
Answer all parts.

a) "Catalytic reagents (as selective as possible) are superior to stoichiometric reagents"

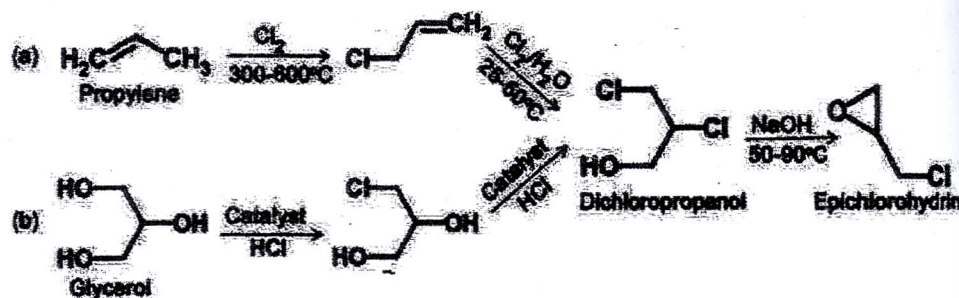
- I) Define the term "Catalyst". (05 marks)
- II) "Use Catalysts, Not Stoichiometric Reagents" is the ninth principle of Green Chemistry. Briefly define this principle and elaborate on two advantages of using catalysts (10 marks)
- III) State the difference between catalytic and stoichiometric reagents (05 marks)
- IV) In the margarine industry, hydrogenation is used to convert vegetable oils into semi-solid fats. Pd/Ni/Pt are the commonly used heterogeneous catalysts in this process. List **three key characteristics** of heterogeneous catalysts. (15 marks)

b) Epoxy resins are widely used in the paint and coatings industry due to their excellent adhesion, chemical resistance, and mechanical properties. One common method for producing epoxy resins is through the reaction of bisphenol A (BPA) with epichlorohydrin (ECH).

Note: Both bisphenol A and epichlorohydrin are derived from petrochemical sources.



Synthesis of epichlorohydrin is possible via following two pathways.



- I) By carefully analyzing the overall synthesis pathways, identify any **two** potential environmental and/or human health risks associated with the synthesis. (05 marks)
- II) Identify which Green Chemistry principle(s) are violated or least considered in this conventional synthesis. (10 marks)
- III) Considering the provided synthesis pathways for epichlorohydrin, determine which route (**Route a or Route b**) is the more environmentally favorable choice. Justify your answer (15 marks)
- IV) Epoxy resins are often cured with ionic liquids such as imidazolium- and phosphonium-based compounds to enhance their mechanical and chemical properties. State **three** advantages of using ionic liquids in this curing process. (15 marks)
- V) Which Green Chemistry principle(s) are demonstrated through the use of ionic liquids in the curing process of epoxy resins? (05 marks)
- VI) BPA-free epoxy coatings are now a globally trending application. With the knowledge you have from Green Chemistry, suggest any three modifications that can be done to the conventional synthesis pathway to make it greener. Consider aspects such as the starting materials, waste generation, energy efficiency, etc. (15 marks)

2) Answer all parts.

a) Persistent, bioaccumulative, and toxic (PBT) substances are a major health concern.

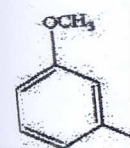
I) Explain the term PBT.

II) State what is meant by bioaccumulative.

III) Pyrocool is a traditional method of waste management.

Chemistry

b) Bromination product is a by-product. The products. The



3-methoxy



3-methoxy

The following

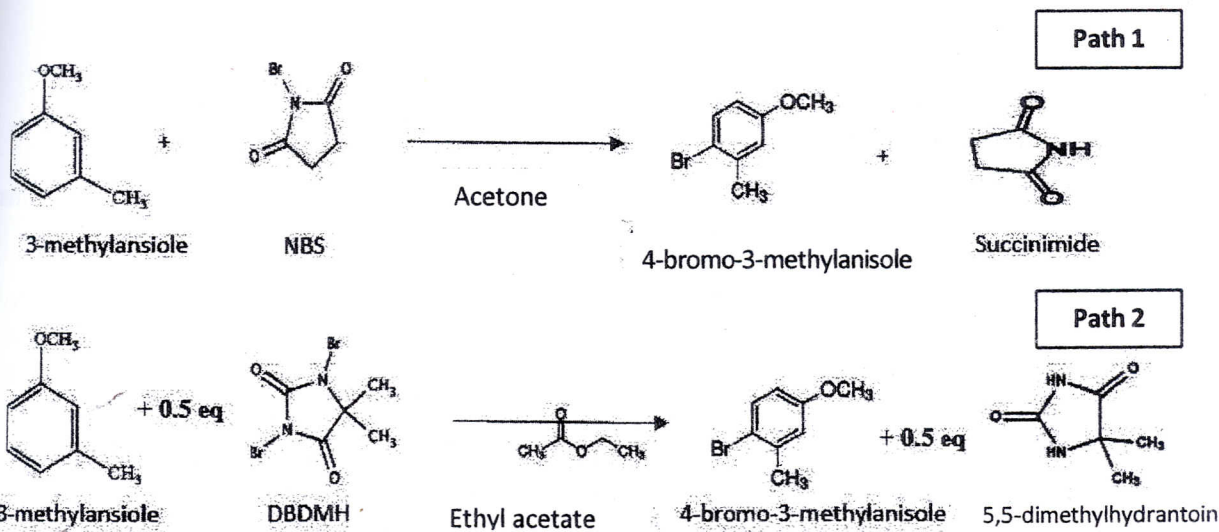
answer all parts.

a) Persistent, bio accumulative, and toxic (PBT) substances pose significant environmental and health concerns due to their long-term presence in ecosystems.

- I) Explain the term "Bio accumulation" (05 marks)
- II) State what is meant by the green chemistry principle, "Design for degradation" (10 marks)
- III) Pyrocool fire extinguishers have been recognized for their environmental advantages over traditional fire suppressants. Discuss its impact and explain how the tenth principle of Green Chemistry has been applied in the development of Pyrocool to address these issues.

(20 marks)

b) Bromination of 3-methylanisole can be done via any of the reactions given below. The desired product is 4-bromo-3-methylanisole and succinimide and 5, 5-dimethylhydrantoin are waste products. The solvent of each reaction is on the arrow.



The following data are provided.

Compound	Molecular weight (g mol ⁻¹)
3-methylanisole	122.17
NBS	177.99
Acetone	58.08
Ethyl acetate	88.11
Succinimide	99.09
4-bromo-3-methylanisole	201.06
DBDMH	285.92
5,5-dimethylhydrantoin	128.13

D) Calculate the atom economy for both reaction pathways.

(15 marks)

II) Which synthetic pathway (**Path 1 or 2**) is more efficient in utilizing reactants to form the desired product? (10 marks)

III) Suggest **two** possible modifications to the existing synthetic pathways to improve atom economy. (10 marks)

IV) Considering a large scale perspective, determine the E factor and PMI for the most effective method you identified **in part II**.

Assume the following estimated masses that are used in the process:

	Path 1 /kg	Path 2 /kg
Raw materials	1630	1570
Acetone	xxxxxxxxxxxxxxxxxxxx	100
Ethyl acetate	200	xxxxxxxxxxxxxxxxxxxx
Desired Product	303	290

(15 marks)

V) In the bromination process, hazardous waste generation and worker exposure to brominating agents are two major concerns. If funding is available, should the priority be given to developing a greener bromination method that minimizes waste or to enhancing safety measures or workers handling hazardous chemicals? Justify your answer.

(15 marks)

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