UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
JANUARY 2025 SEMESTER

COURSE	**:**	**CEB4233 - SUSTAINABLE ENGINEERING PRACTICES**
DATE	**:**	**16 APRIL 2025 (WEDNESDAY)**
TIME	**:**	**9.00 AM - 12.00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **FIVE (5)** pages in this Question Booklet including the cover page .

ii. **DOUBLE-SIDED** Question Booklet.

1. Eutrophication, a process where nitrogen and phosphorus build up in a water body, is one of the main pollution issues endangering freshwater lakes. Accessible freshwater on Earth is only limited to 0.01% access with more than half of which is located at lakes. The growth of potentially harmful algae blooms (HAB), which can be extremely toxic, results from eutrophication. Globally, over 100,000 lakes experience HABs to potentially leave millions of people without access to clean water each year.

   a. Explain the relationship between urbanization and human activities towards eutrophication. Provide **TWO (2)** causes and correlating effects to justify your explanation.

   [9 marks]

   b. As an environmental engineer, recommend **THREE (3)** potential measures to reduce eutrophication impacts and improve clean water access conditions with supported justifications.

   [6 marks]

   c. Apart from eutrophication, ocean acidification is no longer an exclusive environmental problem due to the burning of fossil fuels. Develop **THREE (3)** cradle-to-grave mitigation strategies from an environmental stewardship perspective to address this issue while considering sustainable economic development.

   [9 marks]

2. A river located in Sabah is a water catchment area of about 16,800 square kilometres. The river plays multiple roles to the local communities including water supply, transportation and fisheries in the region. However, water quality of the river and its tributaries has declined since the intensified conversion of floodplain forests to oil palm plantations in the 1980s. Presently, the river faces severe pollution and decline in water quality with palm oil mills and oil palm plantations located in the area are said to be the main culprits. In this context, palm oil biomass is heavily sourced out for the production of biodiesel to strengthen Malaysia's standing in renewable energy capacity.

a. Choose **TWO (2)** relevant Life's Principles that are associated to the scenario above. Elaborate your discussions accordingly with appropriate solutions for each Life's Principles outlined to ensure sustainable production of biodiesel.

[10 marks]

b. As an effort to implement sustainable engineering solutions, an innovative design approach, particularly design for environment (DfE), should be heavily emphasised. Discuss the **FOUR (4)** limitations associated to the aforementioned approach and propose **ONE (1)** appropriate solution to overcome each limitation.

[12 marks]

c. Based on the principles of industrial ecology, dematerialization of industrial output is imperative in the circular economy approach. Justify the statement with respect to the improvement of biodiesel production in Malaysia.

[4 marks]

3. Butadiene acetoxylation process is an alternative production route of tetrahydrofuran (THF) which utilises acetic acid and butadiene as its starting material. Acetic acid is predominantly produced from carbonylation of methanol with carbon monoxide industrially. Methanol is reacted catalytically with carbon monoxide at liquid phases with the use of rhodium-based catalyst at high temperature and pressure. Unreacted feedstock materials will be sent to wastewater treatment plant for further treatment. The Department of Environment (DOE) has received a proposal to build an industrial plant for the production of THF.

a. As the appointed environmental officer, identify **THREE (3)** suitable ecological and social scoping based on potential key environmental issues arising from this project and predict its impact magnitudes accordingly. Justify your answers.

[12 marks]

b. Propose **TWO (2)** approaches that can be used to mitigate the impact of the proposed project based on your answers in **part (a)**.

[4 marks]

c. Process intensification refers to the substantial improvement of manufacturing and processing designs in terms of cost-effectiveness and efficiency. Based on **part (b)**, discuss **FOUR (4)** key drivers in the implementation of process intensification to produce THF.

[8 marks]

4. It has been reported that the plastic industry is gradually shifting towards bio-based alternatives to mitigate the environmental impacts of conventional petroleum-based plastics. Among bio-based plastics, polylactic acid (PLA) has gained significant attention due to its biodegradability, low carbon footprint, and wide applications in food packaging. However, the production of PLA still poses environmental concerns due to high energy consumption, the use of chemical catalysts, and the competition for agricultural resources. A life cycle assessment (LCA) should be conducted to understand the carbon footprint and resource depletion impacts of bio-based plastics production.

For the production of PLA, the process begins with the fermentation of biomass-derived sugars, such as glucose from corn starch or sugarcane, using lactic acid bacteria. The resulting lactic acid undergoes a condensation reaction followed by polymerization, typically using a metal-based catalyst, to form PLA resin. The final product is then processed into various forms, including films, fibers, or molded products, through extrusion or injection molding.

a. Identify a suitable goal, scope and functional unit to define the LCA of PLA production in accordance with ISO14040 framework.

[6 marks]

b. Compare **TWO (2)** distinct differences between LCA and Environmental Impact Assessment (EIA) in terms of "impact analysis" approach in the production of PLA.

[8 marks]

c. Construct a generalised flow chart of the life cycle system for PLA production within the scope of "cradle-to-grave", complete with all the possible inputs and outputs of the cycle. State **TWO (2)** parameters required for good quality data collection.

[12 marks]

- END OF PAPER -