Course: CHEM F337   Part A: **Closed Book**   Time: 90 min.
Course Title: Green Chemistry and Catalysis   Max. Marks: 60
Instruction to students**:** Answer all questions and answer all parts of a question together

Q. 1 a) Explain why the use of product yield as a way of measuring the efficiency of a chemical reaction is considered to be inadequate in the context of green chemistry.   **2**

b) Define the terms atom economy (AE), E-factor and effective mass yield (EMY). Comment critically on their appropriateness as a green chemistry metrics. Give examples of chemical reactions with 100% atom economy and with <50% atom economy.   **6**

c) A preparation of 4-bromoanisole ($BrC_6H_4OCH_3$) is shown below.

$C_6H_5OCH_3$ (108 g) + Br_2 (200 g) $\rightarrow$ $BrC_6H_3OCH_3$ (120 g) + HBr
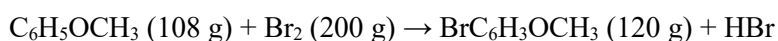
Calculate percentage yield, atom economy and E-factor, stating any assumptions.   **6**

Q. 2 a) Write at least two characteristic of the following solvents because of which they are considered as alternative solvents to traditional solvents. Which of these is/are renewable solvent?

i) Ionic liquids   ii) $scCO_2$ iii) Ethyl lactate   **4**

b) Why ionic liquids are termed as 'designer solvents'? Provide an example to support your answer.   **3**

c) 'Design for Energy Efficiency' is one of the twelve principles of green chemistry. Explain this principle in relation to synthetic chemistry.   **3**

Q. 3 a) Compare the insertion process and migration process in catalysis with example.   **4**

b) Define turn over number (TON) in homogeneous catalysis. Benzophenone is prepared in 91% yield by the carbonylative Suzuki-Miyaura coupling of phenyl iodide (0.5 mmol) and phenyl boronic acid (0.75 mmol) in the presence of K_2CO_3 (1.5 mmol), Pd(0) catalyst (10^{-4} mol %), CO (2 bar) in anisole (10 mL) at 120 °C after 5 h. Calculate TON and TOF for this reaction.   **6**

c) Write mechanism for the reduction of propene using Wilkinson's catalyst.   **4**

Q. 4 a) Define ROMP. Write structural unit of polymer obtained from the following reaction.   **3**
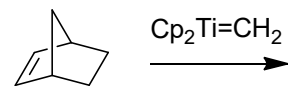
b) Differentiate between isotactic, syndiotactic and atactic polymers.   **3**

c) Reduction of aliphatic nitro compounds with hypophosphites under ultrasonic irradiation can be classified as a type II reaction, termed "false sonochemistry". Explain, why?   **3**

Q. 5 a) Write conventional and clean synthesis of adipic acid. Highlight the green chemistry principle involved in clean synthesis of adipic acid.   **4**

b) Differentiate between the characteristics of heterogeneous and homogeneous catalysis.   **3**

c) Write basic composition of zeolite catalyst. Comment on polarity of zeolite with Si/Al ratio greater than one.   **3**

d) The traditional synthesis of ethylbenzene is a Friedel-Crafts alkylation. The modern industrial synthesis involves mixing ethylene and benzene in the presence of a zeolite (ZSM-5). In what ways would you consider this method to be greener than the Friedel-Crafts reaction?   **3**

-End of the examination-