



# TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED AND HEALTH SCIENCES

DEPARTMENT OF PURE & APPLIED SCIENCES

UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN ANALYTICAL CHEMISTRY

ACH 4410: GREEN CHEMISTRY

END OF SEMESTER EXAMINATION

**SERIES:** APRIL 2016

**TIME:** 2 HOURS

**DATE:** Pick Date May 2016

## PAPER II

### Instructions to Candidates

You should have the following for this examination

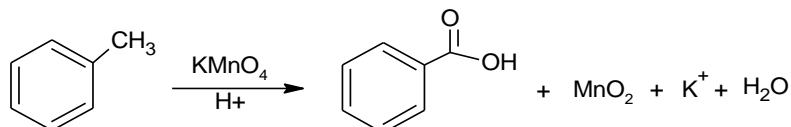
-Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Attempt question ONE (Compulsory) and any other TWO questions.

**Do not write on the question paper.**

### Question ONE

- (a) Highlight the merits of the following green principles, indicating the issues addressed by the principles.
- (i) Applying less hazardous synthesis methods. (4 marks)
- (ii) Designing products that degrade easily. (4 marks)
- (b) The use of stoichiometric reagents in organic synthesis results in the generation of large amounts of waste. Provide TWO options for addressing the above problem. (4 marks)
- (c) Toluene can be oxidised to benzoic acid using potassium permanganate in acid medium according to the following reaction;



- (i) Identify the problems associated with the reaction, with reference to green principles. (4 marks)
- (ii) Provide an alternative oxidation method to alleviate the identified problems. (4 marks)
- (d) State any FOUR advantages of using polymer supported substrates and reagents in organic synthesis. (4 marks)
- (e) Highlight the environmental impacts of halogenated hydrocarbons, such as CCl<sub>4</sub> and CHCl<sub>3</sub>, which are often applied as solvents in organic reactions. (6 marks)

### Question TWO

- (a) Briefly describe the characteristics that make the following solvents favourable for use in organic reactions.
- (i) Water (5 marks)
- (ii) Ethylene glycol. (5 marks)
- (b) An S<sub>N</sub>2 reaction between CH<sub>3</sub>Br and NH<sub>3</sub> with a catalytic amount of water at first proceeds rapidly and subsequently slows down considerably.
- (i) Write an equation for the reaction, showing the intermediate state. (2 marks)
- (ii) Explain the above observation. (6 marks)
- (c) Give any ONE disadvantage of using methanol in a fuel cell. (2 marks)

### Question THREE

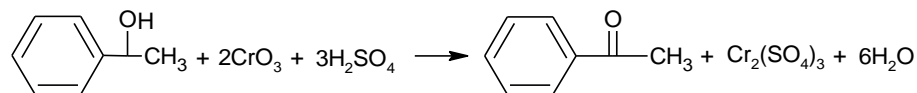
- (a) Describe the nature and application of the following energy sources, indicating their suitability in green synthesis.
- (i) Microwaves (5 marks)
- (ii) Electromagnetic radiation. (5 marks)
- (b) Describe the nature of phase transfer catalysts and their use in organic synthesis. Give an appropriate example of a phase transfer catalyst, explaining how it functions, and TWO applicable organic reactions. (10 marks)

#### Question FOUR

(a) (i) Outline the preparation of ethanol and acetic acid using enzymes. (6 marks)

(ii) Give any FOUR reasons why the use of enzymes in organic synthesis is favourable for manufacturers. (4 marks)

(b) Calculate the atom efficiency for the following oxidation reaction;



(4 marks)

(b) (i) Write reaction equations showing the two common methods of industrial preparation of maleic anhydride. (4 marks)

(ii) Provide any TWO uses of maleic anhydride in chemical manufacturing. (2 marks)

#### Question FIVE

(a) (i) Describe the characteristics of supercritical water. (8 marks)

(ii) Give any TWO applications of supercritical water in industry. (4 marks)

(b) (i) Describe the advantages of solid phase transformations in organic synthesis. (5 marks)

(ii) Provide an appropriate example of an organic transformation reaction in solid phase. (3 marks)