



MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR SCIENCE (ANALYTICAL CHEMISTRY)

SAN 206: GREEN CHEMISTRY

DATE: 7/12/2021

TIME: 8.30-10.30 AM

INSTRUCTIONS

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks)).
- Answer any **two** questions from section **B** (each 20 marks)).

SECTION A: (COMPULSORY)

QUESTION ONE COMPULSORY (30 MARKS)

- a) Green Chemistry is relatively a new field branch of Chemistry which has come about due to environmental pollution which has led to climate change manifested in global warming among other global challenges. Explain briefly how the following branches of chemistry, Physical chemistry, Analytical chemistry, Inorganic chemistry, Organic chemistry, Synthetic chemistry and Environmental Chemistry have clearly brought out environmental pollution issues which Green Chemistry intends to resolve. (2 marks)
- b) Environmental chemistry is intimately interconnected with Green Chemistry. Clearly with the help of examples, show how Green Chemistry complements Environmental Chemistry. (6 marks)

- c) With the help of examples of some of the principles which Green Chemistry embraces, show clearly how Green Chemistry can address the current environmental problems which are currently being addressed through the command-and-control regulation system, which has not completely succeeded to curb global environmental pollution. (7 marks)
- d) Environmental chemistry only looks at the hydrosphere, atmosphere, biosphere and the lithosphere as segments of the environment. However, Green chemistry has added the 5th component, the **anthrosphere**.
Explain why is this component necessary as part of the components of the environment. (5 marks)

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

- a) Chemicals manufacturing which embraces Synthetic Chemistry mostly focuses on costs of economic factors such as costs of feedstock, energy requirements and marketability of products.
- State other four additional costs the chemical manufacturing should accommodate which the Green Chemistry advocates for. (8 marks)
 - However, the four additional costs stated in 2a (i) above can be reduced by embracing two approaches espoused by Green chemistry. State clearly these two approaches. (4 marks)
- b) The risk which is associated with any manufacturing process is considered to be a product of hazard and exposure to the workers or any other party. Explain fully how the current practice of Command and Control approach handles risks associated with manufacturing. (4 marks)
- c) Explain how the approach as contained in the 12 principles of Green Chemistry is considered more effective in the reduction of risks associated with manufacturing. (4 marks)

QUESTION THREE (20 MARKS)

- a) Traditionally a chemical reaction or synthesis process is considered to go to completion by measuring its yield. However, Green Chemistry advocates for atom economy. Show clearly how the two approaches measure the completion of a reaction by use of appropriate equations. (4 marks)

- b) Consider the following reaction, which goes to completion in which the desired product is $\text{HCl}_{(\text{g})}$.

$2\text{NaCl}_{(\text{s})} + \text{H}_2\text{SO}_{4(\text{aq})} \longrightarrow 2\text{HCl}_{(\text{g})} + \text{Na}_2\text{SO}_{4(\text{s})}$. Yield calculation for the above reaction gives 100%. (4 marks)

- Explain why the percent atom economy approach gives a lower figure of less than 100%. (4 marks)
- Work out by calculations the percent atom economy for the above reaction. (4 marks)
Useful information: Atomic masses Na= 23, Cl = 35.5, H = 1 S =32, O = 16.
- The value obtained in 3(a)ii is NOT 100%. Suggest an alternative synthesis process which can yield a percent atom economy of 100%. (4 marks)

QUESTION FOUR (20 MARKS)

- a) A chemical reaction occurs when chemical bonds are broken and formed, and atoms are exchanged to produce chemically different species. The statement above is qualified by the following reaction,



The final product is ozone, which forms part of the stratosphere.

- What is the role of $h\nu$ in this reaction? (2 marks)
 - In which compound are bonds broken and in which are they formed above? (2 marks)
 - What role does this compound (O_3) play in our lives? (3 marks)
- b) Through Environmental Chemistry, it has been shown the chemical O_3 is being depleted by substances used in refrigerators.
- What is the name of this chemical used in refrigerators which is depleting O_3 in the stratosphere? (1 mark)
 - As a result, this chemical is now replaced in the refrigerators we currently use in our homes. What does this show us is the relationship between Environmental chemistry and Green chemistry? (2 marks)
- c) Hydrogen is the simplest element in the periodic table. H_2 has many applications as a gas and is regarded as a green element

- i. Qualify the above statement in the process where H_2 gas is manufactured from electrolysis of water to produce H_2 to be used as a fuel for industry and automobiles as a green source of energy. (2 marks)
- ii. Discuss the reactions which take place, with the help of a suitable diagram, where electrical energy is produced with the production of H_2O , which is itself a green product. (3 marks)
- d) In Green chemistry, we advocate for a process that should be safer and has a high percentage of atom economy as opposed to the traditional way of calculating the product yield. Consider two routes by which $FeSO_4$ can be prepared from either Fe metal or FeO by reacting either material with sulphuric acid. Look at the two routes in the preparation of $FeSO_4$ in terms of maximum safety, production of minimum byproduct, and utilizes readily available materials. Decide which of the two routes will be preferred over the other. (5 marks)

QUESTION FIVE (20 MARKS)

Describe how Green Chemistry controls Environmental pollution by use of the following green alternatives to conventional methods.

- a) Ionic liquids (5 marks)
- b) Supercritical CO_2 and supercritical H_2O (5 marks)
- c) Solvent free reactions (5 marks)
- d) Microwave assisted solvent free organic synthesis (5 marks)