



# MACHAKOS UNIVERSITY

University Examinations 2022/2023

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR  
BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

SAN 414: GREEN CHEMISTRY

DATE:

TIME:

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**INSTRUCTIONS:**

- The paper consists of **two** sections.
- Section **A** is **compulsory**.
- Answer any **two** questions from section **B**.
- Periodic Table is provided

## Section A – Compulsory (30 marks)

### QUESTION ONE (30 MARKS)

- a) List six classes of green solvents and indicate which considerations should be put in place in the use of solvents and auxiliaries. (5 marks)
- b) Explain the difference between sustainable chemistry and green chemistry. (4 marks)
- c) Using three relevant occurrences in the past, explain the importance of green chemistry. (6 marks)
- d) Use of protecting groups/derivatization should be avoided whenever possible. Explain. (2 marks)
- e) Using a relevant example, explain Cannizzaro reaction and its relevance in teaching of the principles of green chemistry. Which principle is most applicable in this case? (6 marks)
- f) Using your knowledge of organic chemistry, determine the atom economy and percentage yield for the production of phenytoin from benzil and urea in the presence of alcoholic potassium hydroxide. (5 marks)
- g) Name the conventional solvent that was used for dry cleaning purposes which later confirmed to be a suspected carcinogen. Propose one greener solvent that can be used to achieve its original intended purpose. (2 marks)

### SECTION B - Answer any two questions from section B (20 marks each)

#### QUESTION TWO (20 MARKS)

- a) Using relevant equations where necessary, discuss a greener route for synthesis of:
- i) Ethanal commercially. (2 marks)
  - ii) Propane. (2 marks)
  - iii) Cyclohexane. (2 marks)
  - iv) Polycarbonates. (2 marks)
- b) Explain why the reactions described in Q2(a) above are considered to be green methods of synthesis. (2 marks)
- c) The pharmaceutical industry is continually seeking ways to develop medicines with less harmful side effects using processes that produce less toxic waste.
- i) Discuss in details both the green and non-green synthesis of ibuprofen. (5 marks)

- ii) Explain the economic advantages of Bausch Health Companies (BHC) synthesis of Ibuprofen. (5 marks)

**QUESTION THREE (20 MARKS)**

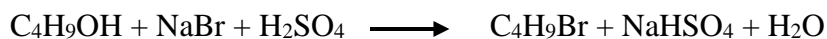
- a) Green Chemistry is not a solution to all environmental problems but the most fundamental approach to preventing pollution. Discuss. (6 marks)
- b) Briefly explain:
- i) Ways in which Triple Bottom Line companies use to promote sustainability. (3 marks)
  - ii) The natural cycle of chemicals in the environment and how man has altered the cycle. (3 marks)
- c) Using relevant examples, explain ultrasound assisted green synthesis as used in the following two listed synthetic processes.
- i) Esterification. (4 marks)
  - ii) Saponification. (4 marks)

**QUESTION FOUR (20 MARKS)**

- a) List and explain two ways in which an analytical chemist can measure the efficiency of a reaction. (5 marks)
- b) Discuss:
- i) The concept of risk. (2 marks)
  - ii) How it has been determined. (2 marks)
  - iii) How risk has traditionally been reduced in industry. (2 marks)
  - iv) How green chemistry approach the problem of risk. (2 marks)
- c) Discuss the advantages and disadvantages of using supercritical CO<sub>2</sub> as a solvent in place of organic solvents. (7 marks)

**QUESTION FIVE (20 MARKS)**

- a) Consider the following acid promoted nucleophilic substitution reaction.



The reaction was carried out by dissolving 1.33 g of sodium bromide in 1.5 mL of water.

Then 0.80 mL of 1-butanol and 1.1 mL (2.0 g) of concentrated sulfuric acid was added.

Calculate;

- i) Theoretical yield. (2 marks)
- ii) Percentage yield. (2 marks)
- iii) Comment on your answer in terms of application of green chemistry. (2 marks)
- b) Discuss the following based on the principles of Green Chemistry.
- i) The choice of reaction conditions in chemical reactions. (5 marks)
- ii) The selection of a solvent for a product synthesis. (5 marks)
- iii) Describe the importance of Q5bi) and Q5bii) in our society. (2 marks)
- c) Describe the attribute of the two major group of catalysts in green chemistry. (2 marks)

Hydrogen 1 H 1.008																	Helium 2 He 4.0026
Lithium 3 Li 6.94	Beryllium 4 Be 9.0122											Boron 5 B 10.81	Carbon 6 C 12.011	Nitrogen 7 N 14.007	Oxygen 8 O 15.999	Fluorine 9 F 18.998	Neon 10 Ne 20.180
Sodium 11 Na 22.990	Magnesium 12 Mg 24.305											Aluminum 13 Al 26.982	Silicon 14 Si 28.085	Phosphorus 15 P 30.974	Sulfur 16 S 32.06	Chlorine 17 Cl 35.45	Argon 18 Ar 39.95
Potassium 19 K 39.098	Calcium 20 Ca 40.078	Scandium 21 Sc 44.956	Titanium 22 Ti 47.867	Vanadium 23 V 50.942	Chromium 24 Cr 51.996	Manganese 25 Mn 54.938	Iron 26 Fe 55.845	Cobalt 27 Co 58.933	Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.38	Gallium 31 Ga 69.723	Germanium 32 Ge 72.630	Arsenic 33 As 74.922	Selenium 34 Se 78.971	Bromine 35 Br 79.904	Krypton 36 Kr 83.798
Rubidium 37 Rb 85.468	Strontium 38 Sr 87.62	Yttrium 39 Y 88.906	Zirconium 40 Zr 91.224	Niobium 41 Nb 92.906	Molybdenum 42 Mo 95.95	Technetium 43 Tc [97]	Ruthenium 44 Ru 101.07	Rhodium 45 Rh 102.91	Palladium 46 Pd 106.42	Silver 47 Ag 107.87	Cadmium 48 Cd 112.41	Indium 49 In 114.82	Tin 50 Sn 118.71	Antimony 51 Sb 121.76	Tellurium 52 Te 127.60	Iodine 53 I 126.90	Xenon 54 Xe 131.29
Cesium 55 Cs 132.91	Barium 56 Ba 137.33	Lanthanum 57 La 138.91	Hafnium 72 Hf 178.49	Tantalum 73 Ta 180.95	Tungsten 74 W 183.84	Rhenium 75 Re 186.21	Osmium 76 Os 190.23	Iridium 77 Ir 192.22	Platinum 78 Pt 195.08	Gold 79 Au 196.97	Mercury 80 Hg 200.59	Thallium 81 Tl 204.38	Lead 82 Pb 207.2	Bismuth 83 Bi 208.98	Polonium 84 Po [209]	Astatine 85 At [210]	Radon 86 Rn [222]
Francium 87 Fr [223]	Radium 88 Ra [226]	Actinium 89 Ac [227]	Rutherfordium 104 Rf [267]	Dubnium 105 Db [268]	Seaborgium 106 Sg [269]	Bohrium 107 Bh [270]	Hassium 108 Hs [269]	Meitnerium 109 Mt [278]	Darmstadtium 110 Ds [281]	Roentgenium 111 Rg [282]	Copernicium 112 Cn [285]	Nihonium 113 Nh [286]	Flerovium 114 Fl [289]	Moscovium 115 Mc [290]	Livermorium 116 Lv [293]	Tennessee 117 Ts [294]	Oganesson 118 Og [294]