



MACHAKOS UNIVERSITY

University Examinations 2022/2023 Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

SAN 206: GREEN CHEMISTRY

DATE: 12/4/2023

TIME: 8:30 – 10:30 AM

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

- a) Explain the difference between sustainable chemistry and green chemistry. (4 marks)
- b) Discuss:
- i) The concept of risk. (2 marks)
 - ii) How risk has traditionally been reduced in industry. (2 marks)
 - iii) How green chemistry approaches the problem of risk. (2 marks)
- c) Elaborate the following statements:
- i) 'Use of protecting groups/derivatization should be avoided whenever possible'. (2 marks)
 - ii) 'Microwave heating is greener technology'. (2 marks)
- d) Write down the twelve principles of Green Chemistry and explain any two principles of Green Chemistry with help of examples. (8 marks)
- e) 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. (4 marks)
- f) Describe the attribute of the two major groups of catalysts in green chemistry. (4 marks)

SECTION B - ANSWER ANY TWO QUESTIONS (20 MARKS EACH)

QUESTION TWO (20 MARKS)

- a) Using relevant equations where necessary, discuss
- i) A greener route for synthesis of adipic acid. (5 marks)
 - ii) Some of the problems associated with conventional synthesis of catechol and adipic acid. (6 marks)
- b) 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. (6 marks)
 - ii) Explain the economic advantages of Bausch Health Companies (BHC) synthesis of Ibuprofen. (3 marks)

QUESTION THREE (20 MARKS)

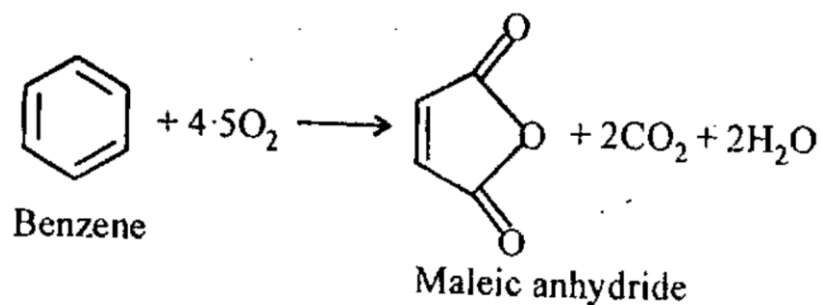
- a) Define the following terms
- i) Ionic liquids (ILs). (1 mark)
 - ii) Supercritical CO₂. (1 mark)
- b) Briefly explain the type of reaction vessels that are used in microwave reactions. (2 marks)
- c) Discuss the advantages of water as solvent in comparison to ionic liquids. (4 marks)
- d) Compare and contrast microwave and conventional methods of synthesis. (8 marks)
- e) Plastic waste imposes a great problem in today's world. Discuss the approach of an environmentalist and a green chemist in combating this problem. (4 marks)

QUESTION FOUR (20 MARKS)

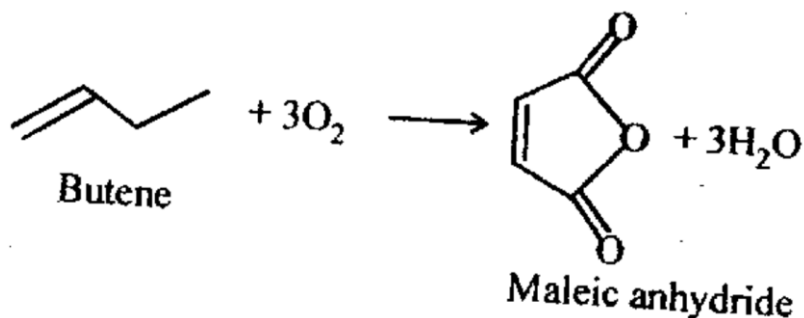
- a) Green Chemistry is not a solution to all environmental problems but the most fundamental approach to preventing pollution. Discuss. (6 marks)
- b) Briefly explain:
- i) Ways in which Triple Bottom Line companies use to promote sustainability. (3 marks)
 - ii) The natural cycle of chemicals in the 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 methods.
- i) Esterification. (4 marks)
 - ii) Saponification. (4 marks)

QUESTION FIVE (20 MARKS)

- a) List and explain two ways in which an analytical chemist can measure the efficiency of a reaction. (5 marks)
- b) Maleic anhydride may be synthesized by the following two routes:
- Route 1, by benzene oxidation.



Route 2, Butene oxidation.



- i) Calculate the % atom economy of both reactions. (3 marks)
 - ii) Briefly discuss the advantages that would be there if Route II were offered as green chemistry alternative for the production of maleic anhydride. (2 marks)
- c) Using a relevant example,
- i) explain Cannizzaro reaction and its relevance in teaching of the principles of green chemistry. Which principle is most applicable in this case? (5 marks)
 - ii) in terms of relevant occurrences in the past, explain the importance of green chemistry. (5 marks)

Periodic Table of the Elements 2006																	
1 H 1.01																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 15.99	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95										
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (270)	109 Mt (268)	110 Ds (281)	111 Rg (272)							

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
140.12	140.91	144.24	(145)	150.36	151.97	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
232.04	231.04	238.03	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(262)