

**CONFIDENTIAL**



**UNIVERSITI TUN HUSSEIN ONN MALAYSIA**

**FINAL EXAMINATION  
SEMESTER I  
SESSION 2014/2015**

COURSE NAME : FUNDAMENTALS OF GREEN  
CHEMISTRY  
COURSE CODE : DAU 32103  
PROGRAMME : 3 DAU  
EXAMINATION DATE : DECEMBER 2014/ JANUARY 2015  
DURATION : 2 HOURS AND 30 MINUTES  
INSTRUCTION : SECTION A) ANSWER ALL  
QUESTIONS  
SECTION B) ANSWER **THREE**  
**(3)** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

**CONFIDENTIAL**

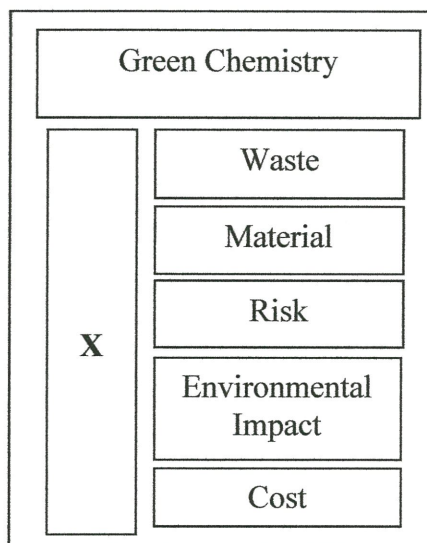
**SECTION A**

- Green chemistry aims to?
  - Design chemical products and process that maximize profits
  - Design safer chemical products and processes that reduce or eliminate the use and generation of hazardous substances
  - Design chemical products and processes that work most efficiently
  - Utilize non-renewable energy
- Which of the following are among the 12 Principles of Green Chemistry?
  - Design commercially viable products
  - Use only new solvents
  - Use catalysts, not stoichiometric reagents
  - Re-use waste
- The first listed of the 12 Principles of Green Chemistry is?
  - Prevent waste
  - Catalysis
  - Atom economy
  - Benign solvents
- The use of solar power is covered within Green Chemistry Principle # 6, which is?
  - Design for energy efficiency
  - Atom economy
  - Design benign chemicals
  - Less hazardous synthesis
- Biodiesel is an example of which of the 12 Principles of Green Chemistry?
  - #1 – Waste prevention
  - #5 – Safer solvents
  - #7 – Use of renewable feedstocks
  - #9 – Use of catalysis
- Which is the main focus emerged from the 12 principles of green chemistry?
  - Less and safe
  - Sustainable and waste reducing
  - Process-oriented
  - All of the above
- This word is synonymous with green chemistry and also means harmless, or gentle and not life threatening.
  - Sustainable
  - Benign
  - User friendly
  - Greenness

8. The Principle #5 of Green Chemistry, Safer Solvent and Auxilliaries is to use
- (I) non-toxic solvent
  - (II) alternative solvent
  - (III) solvent free condition reactions
  - (IV) stable and inexpensive solvent
- (A) I and II  
(B) I and III  
(C) I, II and III  
(D) All of the above
9. Which of the following is the greenest solvent?
- (A) Formaldehyde
  - (B) Benzene
  - (C) Ethanol
  - (D) Water
10. \_\_\_\_\_ refers to the breakup within a compound due to microbial activity is.
- (A) Microbial degradation
  - (B) Agro-degradation
  - (C) Photo-degradation
  - (D) Decomposition
11. Environmental benefits of green chemistry include?
- (A) Fewer raw materials and natural resources used
  - (B) Cleaner production technologies & reduced emissions
  - (C) Smaller quantities of hazardous waste to be treated and disposed of
  - (D) All of the above
12. Shortly after mid-night in December 1984, a reaction caused 40 tons poisonous methyl isocyanate gas escaped from a pesticide plant into densely populated area of this city, \_\_\_\_\_ causing 5000 deaths and 200 000 injuries.
- (A) Hinkley
  - (B) Bhopal
  - (C) Calcutta
  - (D) Siberia
13. Benzene, a \_\_\_\_\_ substance, is an important industrial solvent used in the production of pharmaceuticals, plastics, and dyes?
- (A) Odorless
  - (B) Non-flammable
  - (C) Carcinogenic
  - (D) Biodegradable

14. Soybean is used to replace traditional inks in printer cartridges, highlighting which of the Green chemistry principles?
- (A) Atom economy
  - (B) Use of Renewable Feedstock's
  - (C) Reduce derivatives
  - (D) Prevent waste
15. An example of green chemistry is?
- (A) Recycled carpet
  - (B) A product made on Earth Day
  - (C) A sublimation reaction
  - (D) Bio-plastics
16. Green chemistry synthesis could also involve which of the following?
- (A) High temperature
  - (B) Dichloromethane
  - (C) Fossil fuels
  - (D) Microwave
17. Green chemistry can reduce all but which of the following?
- (A) Cost
  - (B) Awareness
  - (C) Risk & Hazard
  - (D) Waste
18. In most chemical reactions, the reaction vessels provide the main component below EXCEPT
- (A) Solvent
  - (B) By-product
  - (C) Reagent/catalyst
  - (D) Energy input
19. The advantages of using catalyst are
- (I) The reactions go faster
  - (II) Use more energy
  - (III) Catalysts are consumed
  - (IV) Catalysts are recycled
- (A) I and II
  - (B) I and III
  - (C) I and IV
  - (D) All of the above

20. The word missing on the left side of the figure labeled as X below is?



- (A) Facilitating  
(B) Enhancing  
(C) Reducing  
(D) Awareness
21. \_\_\_\_\_, or VOCs, have been replaced and were banned in some paints?  
(A) Versatile Organic Chemicals  
(B) Volatile Organic Compounds  
(C) Volatile Organic Components  
(D) Versatile Odorless Components
22. Which of the followings is non-renewable energy?  
(A) Solar energy  
(B) Natural gas  
(C) Biodiesel  
(D) Hydropower energy
23. Below are the gases that exhibit the greenhouse properties found in nature EXCEPT  
(A) Nitrous oxide  
(B) Chlorofluorocarbon  
(C) Methane  
(D) Carbon dioxide

24. Which of the followings are greenhouse gases that have been identified as potentials towards global warming?
- (I) Methane
  - (II) Carbon dioxide
  - (III) Water vapor
  - (IV) Nitrogen
- 
- (A) I and II
  - (B) I, and IV
  - (C) I, II and III
  - (D) All of the above
25. The traditional acid catalyst which is an extremely corrosive, hazardous and toxic chemical used in the lab is
- (A) HCl (hydrochloric acid)
  - (B) H<sub>2</sub>SO<sub>4</sub> (sulfuric acid)
  - (C) HF (hydrogen fluoride)
  - (D) HNO<sub>3</sub> (nitric acid)

**(25 marks)**

## SECTION B

Q1 (a) Define the following terms.

- (i) Atom economy
- (ii) E-factor
- (iii) Green chemistry
- (iv) Environmental chemistry

(4 marks)

(b) An ideal user encourages green initiatives. List out **four (4)** criterias of ideal user.

(4 marks)

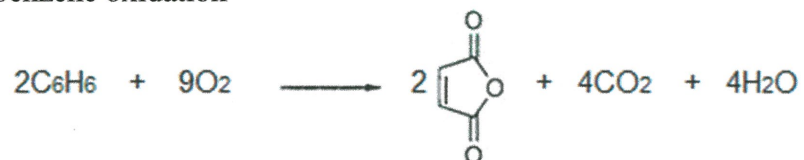
(c) State **two (2)** basic principles of green chemistry and explain each of the principles.

(4 marks)

(d) Maleic anhydride,  $C_4H_2O_3$  can be synthesized by the following two routes:

Route 1:

By benzene oxidation



Route II:

By butene oxidation



Answer the following questions.

(i) Determine the % atom economy of both the reactions.

(10 marks)

- (ii) Explain the advantages would there be if Route II was offered as a green chemistry alternative for the production of maleic anhydride.

Given Molar mass : maleic anhydride (98.06g/mol), carbon dioxide (44g/mol), water (18 g/mol), oxygen, O<sub>2</sub> ( 32g/mol), benzene (78g/mol) and butene (56g/mol)

(3 marks)

- Q2** (a) Ultrasound-assisted organic synthesis and microwave irradiation methods are another “green” methodology which are applied in many organic synthetic routes. Answer the following questions.

- (i) Explain the definition of ultrasound sonication method. (2 marks)

- (ii) Explain the mechanism of ultrasound sonication method. Your explanation may include cavitation process and graphical presentation. (6 marks)

- (iii) State the advantages of using ultrasound sonication method. (4 marks)

- (b) Explain the mechanism of microwave irradiation method. (7 marks)

- (c) List **three (3)** differences between ultrasound sonication method and microwave irradiation method. (6 marks)

- Q3** (a) (i) Define the terms catalysis, biocatalysis and enzyme. (3 marks)

- (ii) Differentiate between homogeneous catalyst and heterogeneous catalyst and give example for each type. (4 marks)

- (iii) List out the advantages of using biocatalyst in the chemical reactions in the context of green chemistry. (3 marks)



- (b) “Organic solvents are a major part of chemical processes and research activities in chemical laboratories. The Green Chemistry is aiming to promote the use of “greener” solvents, solvent-free reactions or alternatives that can be benign to environment and human health”. From this statement, answer the following questions.
- (i) State the green chemistry principle that associated with the use of solvent and explain. (4 marks)
  - (ii) State **four (4)** criterias of solvent selection to be considered in Green Chemistry. (4 marks)
  - (iii) Define green solvents. (1 marks)
  - (iv) Give **three (3)** characteristics of green solvent. (3 marks)
  - (v) Water is one of the green solvents. The use of water as solvent is the best solution in Green Chemistry. Explain. (3 marks)
- Q4**
- (a) Explain the terms of greenhouse gases. Give examples of greenhouse gases. (4 marks)
  - (b) Explain the phenomenon of greenhouse effect. (4 marks)
  - (c) A material balance for the accumulation of  $CO_2$  in the environment consists of  $CO_2$  generation due to natural causes and human activities.
    - (i) State the formula for the depletion of  $CO_2$  due to its absorption in the natural sinks. (4 marks)
    - (ii) Interpret the formula in the perspective of Green Chemistry. (6 marks)
    - (iii) The various sinks for  $CO_2$  absorption have been depleting because of deforestation. Explain your answer. (2 marks)

- (d) Chemists, engineers, and biochemists strive for green and sustainable development and face several challenges in the next decade. List **five (5)** focus of the chemists, technologists, and engineers that they should go toward in the next decade.

(5 marks)

**- END OF QUESTIONS -**