UNIVERSITY OF FORT HARE

CHEMICAL TECHNOLOGY 2 (PAC 315)

ASSESSMENT JUNE 2023

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Time: 4 HOURS

Subject: PAC 315

Marks: 100

Internal Examiners

MR. V. MAGAYA

External Examiners

PROF D. ONWUDIWE

INSTRUCTIONS

ANSWER ALL THE QUESTIONS

PAC 315 SECOND ASSESSMENT FOR MODERATION JUNE 2023

1(a). What are the products of the transesterification of vegetable oil by methanol in the presence of sodium hydroxide as a catalyst? [4]

(b) Why should the water content in vegetable oil be kept low in the process in 1a above? [3]

(c) Give three disadvantages of using alkaline catalysts in the transesterification in 1a above. [6]

2. If you had to choose between using cellophane (a cellulose product) or polypropylene (a plastic) as packaging material, which one would you choose? Give two reasons for your choice. [4]

3(a). State two reasons why carbon formation during the conversion of natural gas to syngas is undesirable. [4]

(b) Give two reactions that form carbon as one of the products in the generation of syngas from natural gas. [6]

(c) Give three reactions that reduce carbon formation in refineries. [9]

4(a). The Majuba power station in Mpumalanga was designed to use underground coal gasification. What are the benefits of gasification over simple pulverized coal combustion? [6]

(b) What are the disadvantages of using carbon capture and storage in power plants? [6]

5(a). Give three reactions that lead to the formation of organic compounds in the Fischer-Tropsch process. [9]

(b) Explain why iron catalysts (instead of cobalt catalysts) are better suited for the Fischer-Tropsch process when coal-derived syngas is used. [4]

6. MTBE has been used as an oxygenate in several countries. Some of these countries have banned its use.

(a) Give the full name of MTBE [1]

(b) Give the molecular formula of MTBE [1]

(c) Why was the use of MTBE discontinued in some countries? [2]

7(a). Biomass is highly functionalized with higher oxygen content than crude oil. Why is it not necessary to remove the oxygen from biomass so that it resembles crude oil? [6]

(b) What are the advantages of using biobutanol as a biofuel instead of bioethanol? [6]

8(a). Explain how polymerization occurs through the step growth mechanism. [3]

(b) Explain how long chains of polyethene form through radical polymerization. [3]

(c) What is backbiting? [3]

(d) How can the formation of extremely long chains of polyethene be prevented? [4]

9(a). The pH in the production of Baker's yeast is adjusted at three different stages of the process. What are the reasons for the adjustments? [6]

(b) The production of high fructose corn syrup requires the addition of metal ions such as magnesium salts. What are the reasons for this addition? [4]

MEMORANDUM FOR THE JUNE 2023 PAC 315 SECOND ASSESSMENT

1(a). Fatty acid methyl esters and glycerol

(b) Water hydrolyses the triglycerides leading to the formation of fatty acids that react with the sodium hydroxide to form soap.

(c) The process is energy intensive,

recovery of the glycerol by-product is difficult,

neutralization of the catalyst produces a large amount of waste salts.

2. If the choice is cellophane, the reasons must be because it is a renewable product and it is biodegradable.

If the choice is polypropylene, the reasons must be because it is cheaper, it does not turn yellow with use, it is inert, and is recyclable.

3(a). Carbon poisons catalysts and its accumulation on refinery tubes leads to blockages

(b) $CH_4 \rightleftharpoons C + 2\ H_2$

$2\ CO \rightleftharpoons C + CO_2$

(c) $C + H_2O \rightleftharpoons CO + H_2$ with excess steam

$2\ C + O_2 \rightleftharpoons 2\ CO$ OR $C + O_2 \rightleftharpoons CO_2$ depending on O_2 supply

$C + 2\ H_2 \rightleftharpoons CH_4$

4(a). Gasification gives high energy efficiency for the coal burnt,

Has low environmental impact,

Has the ability to produce electricity as well as synthetic fuels, chemicals and marketable by-products such as sulphur.

(b) CCS leads to increased capital costs

Energy efficiency is lower with CCS,

Electricity costs are higher due to the two reasons above

5(a). $n\ CO + (2n + 1)\ H_2 \rightarrow Cn\ H_{2n+2} + n\ H_2O$

$n\ CO + 2n\ H_2 \rightarrow C_nH_{2n} + n\ H_2O$

$n\ CO + 2n\ H_2 \rightarrow H(CH_2)_nOH + (n - 1)\ H_2O$

(b) Coal-derived syngas has a low H_2/CO ratio. Iron catalysts promote the water-gas shift reaction, $CO + H_2O \rightleftharpoons CO_2 + H_2$, thus increasing the proportion of H_2 and improving the H_2/CO ratio. Cobalt catalysts are unable to affect the H_2/CO ratio and are suitable for natural-gas derived syngas whose H_2/CO ratio is already high.

6(a). Methyl tert-butyl ether

(b) $(CH_3)_3COCH_3$

(c) It was found to have environmental problems

7(a). Leaving the biomass unchanged saves process steps and hydrogen that would be used for removing oxygen.

The product quality might be better with oxygen atoms present since oxygen-containing molecules often result in smokeless combustion for fuels like diesel, resulting in less pollution.

When less oxygen is removed, less mass is lost.

(b) Butanol better tolerates water contamination,

It is less corrosive than ethanol,

It has a higher energy content,

It is more suitable for distribution through existing pipelines for gasoline.

ANY 3 OF THE ABOVE.

8(a). Functional groups on monomers react leading to the elimination of a small molecule like water. The chain grows as a result of repeated reactions of such functional groups.

(b) A radical initiator breaks apart to yield radicals that attack the ethane monomers resulting in the radical electron relocating to a carbon atom of the monomer. This new radical attacks another monomer to yield a new radical and the chain grows on the radical end as a result of such attacks.

(c) Backbiting is folding back of a growing polymer chain so that the radical end attacks a carbon along the length of the chain resulting in a transfer of a hydrogen to the end of the chain and a new radical point to appear at the point of attack. Further chain growth occurs at this new radical point.

(d) By adding a modifier or by using a solvent that will react with the radical end of the growing chain and deactivate the radical

9(a). the medium is initially made acidic to precipitate inorganic sustances

Ammonia is then added to adjust the pH and provide the nitrogen necessary for the growth of the yeast cells.

The pH is then increased to 5 to prevent strong colouring of the yeast.

(b) Metal ions facilitate the catalytic activity of glucose isomerase that is used to convert glucose to fructose.

The salts are also used to adjust the pH.