P525/1
CHEMISTRY
PAPER 1
(Theory)
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2 Hours

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S.6 S026 PRE-MOCK TEST II
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Answer all questions in all sections

ITEM 1

In flavour and fragrance industries in Uganda, processors extract volatile compounds from plants e.g., vanilla and mint that may involve mixtures showing non-ideal behaviour. When separating miscible components, deviations from Raoult's law create distillation challenges (minimum or maximum boiling azeotropes). For heat-sensitive immiscible essential oils, steam distillation is preferred. A company analyses a mixture and plans to scale up production sustainably.

Task

a) Compare ideal and non-ideal solutions in terms of obedience to Raoult's law and draw a boiling point vs composition diagram for a maximum boiling azeotrope.

b) Explain how steam distillation overcomes limitations of fractional distillation for immiscible systems.

c) For an ethanol-water mixture (positive deviation leading to minimum boiling azeotrope), explain why pure ethanol cannot be obtained by simple distillation and how this relates to vapour pressure curves.

d) In steam distillation of a plant oil, if $\mathbf{P°_{Water} = 740\ mmHg}$ and $P°_{Oil} = \boldsymbol{20\ mmHg}$ at the distillation temperature, calculate the mass percentage of oil in the distillate assuming:
$\mathbf{Mr\text{-}_{oil} = 150}$ and $\mathbf{Mr_{water} = 18.}$

e) Propose how knowledge of ideal/non-ideal behaviour and steam distillation can improve efficiency in Uganda's essential oils and agro-processing sector.

ITEM 2

MedCare Formulations Ltd, a pharmaceutical company in Kampala, has expanded its women's health division to produce **Aci-Jel Balance®,** a pH stabilising vaginal medicine used in the management of *vaginitis*. The product relies on a controlled release system containing ethyl ethanoate, which hydrolyses in the body to generate small amounts of ethanoic acid essential for preventing harmful microbial growth. During checkup, the chemists must verify the efficiency of the ester production step, because the yield of ethyl

ethanoate determines how well the final medicine will perform. The key step is the esterification reaction:

$$CHCOOH(l) + CHCHOH(l) \rightleftharpoons CHCOOCH(l) + HO(l), \qquad \Delta H = negative$$

To check product consistency, a batch test was conducted with 2.00 mole of ethanoic acid mixed with 10.00 moles of ethanol and sealed in a glass tube. The tube was kept in a water bath at 60°C for several hours. After cooling, the tube was broken into cold water and the resulting mixture required 290 cm^3 of 0.200 M sodium hydroxide during titration to neutralize the unreacted ethanoic acid at equilibrium. Chemists also prepared a 0.010 M ethanoic acid solution with known acid dissociation constant $\mathbf{K}a = \mathbf{1.8 \times 10}$. Because the final product must safely maintain pH inside the human body, the company designs a buffer system made from ethanoic acid and sodium ethanoate and must know has it works those the company manager and community is concerned about possible environmental impacts that may emerge from the industry.

You have been contacted for help.

Task

As a learner of chemistry guide the company on how to;

(a) Calculate the equilibrium constant for the esterification reaction and predict the extent of the reaction.

(b) Explain how both the amount of ethyl ethanoate produced, the position and rate of attainment of equilibrium would change if:

i) More ethanol is added to the reacting mixture.

Ii) Water is removed during the reaction.

ITEM 3

A small chemical plant near a rural community recently discharged an unknown hydrocarbon into a drainage channel used by households and livestock. Environmental officers collected the sample, **labelled G,** and performed preliminary tests. The molecular formula of G is $\mathbf{C_4H_6}$**,** and when treated with silver nitrate solution in ammonia, a **white precipitate** was formed. Further tests with bromine water and acidified potassium manganate(VII) indicate that G contains unsaturation. The environmental chemistry team is tasked with ***identifying G*** and ***investigating its chemical properties***. They also need to predict its likely reactions in both laboratory and environmental conditions, explore possible synthetic routes from simple alkenes such as but-1-ene, ethanol and a metal residue calcium carbide, and assess potential environmental and health impacts. The team is particularly interested in the mechanism of **how G reacts with water** in the presence of sulphuric acid and mercury(II) sulfate, with hydrogen bromide to yield 1-bromo compound, bromine liquid and potassium manganate(VII) using equations. Safe handling and mitigation strategies are also to be considered.

The team also is interested in the pathway of conversion of G into certain aromatic compounds such as Toluene(methylbenzene), benzaldehyde, and Phenylalanine(Aniline) which can be converted to certain salicylates such as ***aspirin*** (4-hydroxybenzoic**)**

Before any decision is made the team must know: **structure, functional group and possible isomerism** of compound. Apply correct IUPAC names to G and all related products formed in laboratory reactions. Predict major products at each reaction stage based on organic reactivity and mechanism for key reactions. Explain stepwise reaction pathways leading formation of G, classifying type of reaction at each stage, and evaluate the environmental and health impacts associated with G and its derivatives while proposing mitigation strategies.

Task:

As a learner of chemistry, make a write up to help the team inform their decision making.

END