UNIVERSITY OF JOHANNESBURG

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| **PROGRAM** | : NATIONAL DIPLOMA<br>*CHEMICAL ENGINEERING* | |
| **SUBJECT** | : **CHEMICAL ENGINEERING TECHNOLOGY 2** | |
| **CODE** | : **WAR2111** | |
| **DATE** | : SUMMER EXAMINATION 2015<br>10 NOVEMBER 2015 | |
| **DURATION** | : (SESSION 1) 08:30 - 11:30 | |
| **WEIGHT** | : 40 : 60 | |
| **TOTAL MARKS** | : 78 | |

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| **EXAMINERS** | : DR R. HUBERTS / MR T. FALAYI | 080207003 |
| **MODERATOR** | : PROF F. NTULI | 2242 |
| **NUMBER OF PAGES** | : 4 | |

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**INSTRUCTIONS** : ANSWER ALL QUESTIONS. WORK ACCURATELY AND ENTER ANSWERS ON BLACKBOARD (Bb) AS REQUIRED. NON-PROGRAMMABLE CALCULATORS PERMITTED (ONLY ONE PER CANDIDATE).

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## QUESTION 1

1.1 The velocity of a car is given by:

$v = 5 + 3t$

Where:
$v$ = velocity in m/s
$t$ = time in s
1.1.1 What are the units for 5? (1)
1.1.2 What are the units for 3? (3)

1.2 A syrup contains $x$ g of sucrose/100g of water at 25°C. The solution has a specific gravity of $y$. ($x$ and $y$ are given on Bb). Calculate the following:

1.2.1 The mass fraction of sucrose in the syrup (4)
1.2.2 Given that the density of water is 1000 kg/m$^3$, what is the density of the syrup? (3)

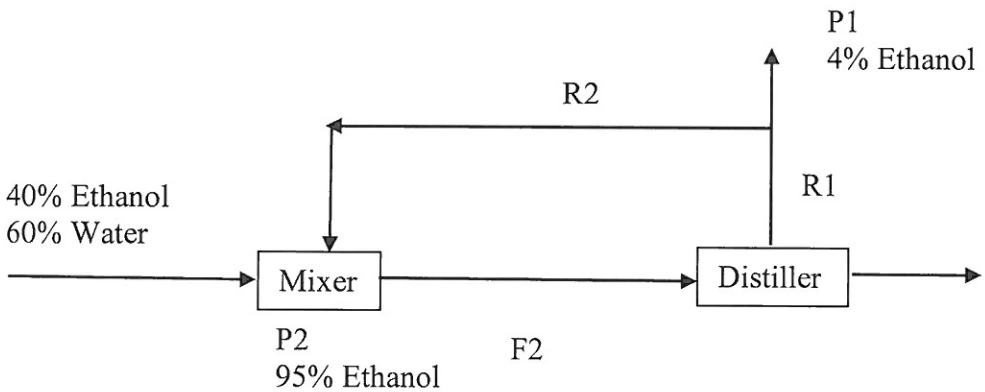
**[11]**

## QUESTION 2

In the process of producing concentrated ethanol a feed containing 40% ethanol and 60% water is mixed with a recycle stream. The product of the mixer is fed to a distiller whose product is 95% ethanol and the overheads is 4% Ethanol. The process is shown in the diagram.

2.1. What are the degrees of freedom for the entire process as shown in the diagram? (5)

2.2. Perform a total material balance and an ethanol balance over the whole plant and determine the flow rate of the product (P2) in kg/h. (7)




**[12]**

## QUESTION 3

3.1 300 g of sulphuric acid ($H_2SO_4$) reacts with sodium hydroxide (NaOH, mass given on Bb) according to the equation below:
$H_2SO_4$= 98.079g/mol, NaOH=40 g/mol, $Na_2SO_4$=142.04 g/mol

$$H_2SO_4(l) + 2NaOH(s) \rightarrow Na_2SO_4(s) + 2H_2O(l)$$

The product is found to have 155g of sodium sulphate ($Na_2SO_4$)

3.1.1 Determine the limiting reagent. (7)

3.1.2 What is the yield %? (5)

3.1.3 What is the % excess of the reactant in excess? (4)

3.1.4 Using $Na_2SO_4$, calculate the extent of reaction, $\xi$. (5)

3.1.5 Given that the heats of formation of $H_2SO_4$, NaOH, $Na_2SO_4$, and $H_2O$ are -811.32, -426.6, -1384.45 and -285.84 in $kJmol^{-1}$ respectively, calculate the standard heat of the reaction in $kJmol^{-1}$. (3)

3.2. A gas mixture containing 60% by volume ethene ($C_2H_6$) and 40% inerts (non-reactive gases) is completely combusted with excess air (% excess is given on Bb). Assume air is made up of 21% $O_2$ and 79% $N_2$. The reaction is shown below

$$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$$

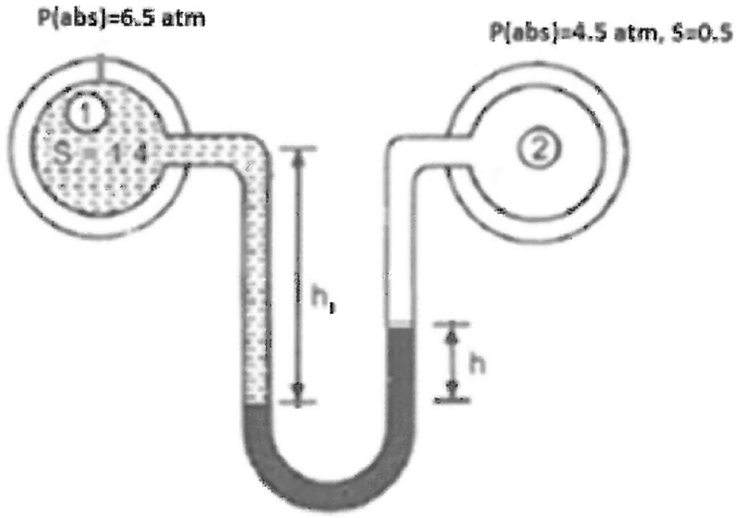
3.2.1 Balance the above equation without using fractions. (5)

3.2.2 How many $m^3$ of air is supplied for $1m^3$ of mixture combusted at 1atm? (11)

Choose a basis of 100 mol for the gas mixture and assume ideal gas behaviour.

**[40]**

## QUESTION 4




The diagram shows a u-tube differential manometer connecting two pipes 1 and 2. The liquid in pipe 1 has a specific gravity of 1.4 at an absolute pressure of 6.5 atm. The liquid in pipe 2 has a specific gravity of 0.5 and is at an absolute pressure of 4.5 atm. Calculate the height $h$ in SI units (the difference between the mercury levels in the two limbs). The density of mercury is 13600 kg/$m^3$ and the density of water is 1000 kg/$m^3$. Take g = 9.81 m/$s^2$.

**[15]**

**TOTAL MARKS = 78**

**FULL MARKS=78**

## FACTORS FOR UNIT CONVERSIONS

| Quantity | Equivalent Values |
|---|---|
| **Mass** | 1 kg = 1000 g = 0.001 metric ton = 2.20462 $lb_m$ = 35.27392 oz<br>1 $lb_m$ = 16 oz = $5 \times 10^{-4}$ ton = 453.593 g = 0.453593 kg |
| **Length** | 1 m = 100 cm = 1000 mm = $10^6$ microns (μm) = $10^{10}$ angstroms (Å)<br>= 39.37 in. = 3.2808 ft = 1.0936 yd = 0.0006214 mile<br>1 ft = 12 in. = 1/3 yd = 0.3048 m = 30.48 cm |
| **Volume** | 1 $m^3$ = 1000 L = $10^6$ $cm^3$ = $10^6$ mL<br>= 35.3145 $ft^3$ = 220.83 imperial gallons = 264.17 gal<br>= 1056.68 qt<br>1 $ft^3$ = 1728 $in.^3$ = 7.4805 gal = 0.028317 $m^3$ = 28.317 L<br>= 28.317 $cm^3$ |
| **Force** | 1 N = 1 kg·m/$s^2$ = $10^5$ dynes = $10^5$ g·cm/$s^2$ = 0.22481 $lb_f$<br>1 $lb_f$ = 32.174 $lb_m$·ft/$s^2$ = 4.4482 N = $4.4482 \times 10^5$ dynes |
| **Pressure** | 1 atm = $1.01325 \times 10^5$ N/$m^2$ (Pa) = 101.325 kPa = 1.01325 bar<br>= $1.01325 \times 10^6$ dynes/$cm^2$<br>= 760 mm Hg at 0°C (torr) = 10.333 m $H_2O$ at 4°C<br>= 14.696 $lb_f$/$in.^2$ (psi) = 33.9 ft $H_2O$ at 4°C<br>= 29.921 in. Hg at 0°C |
| **Energy** | 1 J = 1 N·m = $10^7$ ergs = $10^7$ dyne·cm<br>= $2.778 \times 10^{-7}$ kW·h = 0.23901 cal<br>= 0.7376 ft-$lb_f$ = $9.486 \times 10^{-4}$ Btu |
| **Power** | 1 W = 1 J/s = 0.23901 cal/s = 0.7376 ft·$lb_f$/s = $9.486 \times 10^{-4}$ Btu/s<br>= $1.341 \times 10^{-3}$ hp |

$T(\text{K}) = T(°\text{C}) + 273.15$

$T(°\text{R}) = T(°\text{F}) + 459.67$

$T(°\text{R}) = 1.8T(\text{K})$

$T(°\text{F}) = 1.8T(°\text{C}) + 32$