UNIVERSITY
JOHANNESBURG

PROGRAM : NATIONAL DIPLOMA
CHEMICAL ENGINEERING

SUBJECT : **CHEMICAL ENGINEERING TECHNOLOGY 3A**

CODE : **CMTA321**

DATE : WINTER EXAMINATION
01 JUNE 2018

DURATION : (X-PAPER) 08:30 – 11:30

WEIGHT : 40: 60

TOTAL MARKS : 100

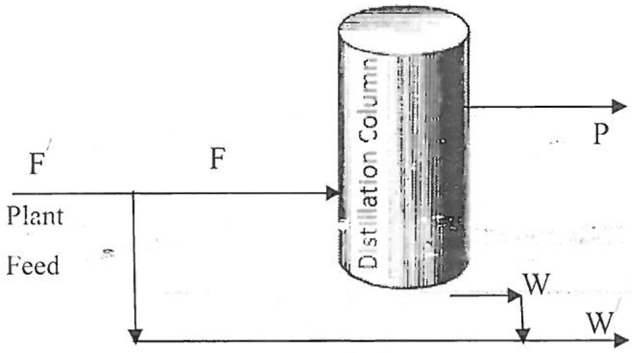
EXAMINER : MS THANDIWE SITHOLE

MODERATOR : DR A. MAMVURA

NUMBER OF PAGES : 4

INSTRUCTIONS : ANSWER ALL QUESTIONS. NON-PROGRAMMABLE CALCULATORS
PERMITTED (ONLY ONE PER CANDIDATE).

QUESTION 1



In the diagram, the total flow rate of the liquid plant feed (F′) is 1mols^{-1} and contains 36mol% of methanol in water at a temperature of 25°C. The greater part of this is fed to a flat ended distillation column as shown, and the excess plant feed that cannot be accommodated joins the waste stream. The distillation column has a height of 5m and a diameter of 0.25m with a grey surface with emissivity of 0.4 which is exposed on all sides. The required liquid product (P) has a temperature of 67°C and a composition of 90mol% of methanol. 75% of the methanol in the plant feed (F′) is to be recovered in this product (P). The bottom liquid stream W, which has a methanol concentration of 9mol% and is at 87 °C, joins the unprocessed plant feed as shown.

1.1. Determine the *flow rate of methanol in stream P*, the *total flow rate in stream P* and then perform a *methanol balance* and a *total balance* over the *distillation column*. What are the flow rates of methanol (as mols^{-1}) in streams F, P, and W. (16)

1.2. What are the flow rates of water (as mols^{-1}) in streams F, P and W. (3)

1.3. Perform an energy balance and calculate how much heat in W needs to be added to operate the distillation column. Assume no heat is lost to the environment and neglect heat of mixing for this calculation. (9)

1.4. Use the temperatures and heat transfer coefficient h=5Wm^{-2}K^{-1} to estimate the total heat loss to the environment in W due to the combined effect of radiation and convection. Take 0°C = 273K. (18)

1.5. Do you think the heat loss to the environment is significant? (2)

Thermodynamic properties:

Component	ΔH_f^0 (J/mol)	Cp (J/(mol.K))
$CH_3OH_{(l)}$	−238 400	79.5
$CH_3OH_{(g)}$	−201 300	52.3
$H_2O_{(l)}$	−285 830	75.3
$H_2O_{(g)}$	−241 830	36.2

Areas: circle: $\pi d^2/4$; sphere: πd^2; cylinder: πdl; rectangle: bh; triangle: bh/2. σ = 5.67×10-8Wm-2K-1

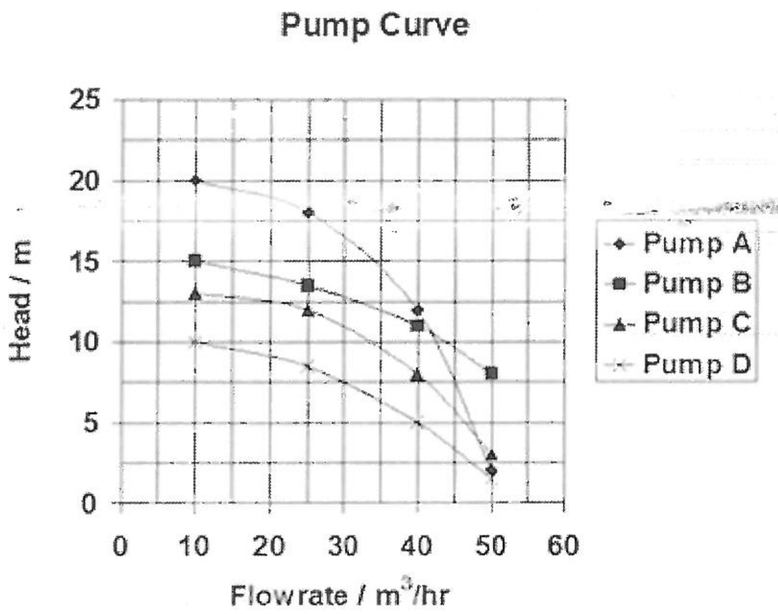
[48]

QUESTION 2

21m^{3}hr^{-1} of water is pumped through a wrought iron pipeline that contains valves and other fittings. Using the Bernoulli equation, with the valves fully open, it was found that the pump head Δhp required was 9.9m. The water has a vapour pressure of 30kPa, a thermal conductivity of 0.6Wm^{-1}K^{-1}, viscosity of 1cP, heat capacity of 4200Wkg^{-1}K^{-1}, and a density of 1000kgm^{-3}. g = 9.81ms^{-2}.

2.1. Which pump (A, B, C, or D) would you choose for the pipeline? (2)

2.2. What is the actual power in W drawn by the pump given the pump efficiency of 40%? (10)



[12]

QUESTION 3

Air is flowing through a smooth pipe 100mm in diameter and 30m long. The upstream pressure is 300kPa, and the downstream pressure is 267kPa, and the flow is isothermal at 273K. The viscosity of air is 0.000015Pas. $R=8.314 Pam^3mol^{-1}K^{-1}$. $MW_{air} = 29gmol^{-1}$.

3.1. What is the % pressure drop over the pipe? (2)

3.2. Is the flow compressible? (2)

3.3. What is the mass flux in $kgm^{-2}s^{-1}$? (15)

3.4. What assumptions are made when deriving the formula for heat added to maintain the temperature of the gas? (5)

3.5. What is the heat that needs to be added to maintain the air temperature of 273K as energy added (in J) per kg of air? (16)

$$\left(\frac{G}{A}\right)^2 \ln\frac{v_2}{v_1} + \frac{P_2^2 - P_1^2}{2P_1v_1} + 2f\frac{L}{d}\left(\frac{G}{A}\right)^2 = 0$$

[40]

TOTAL MARKS = 100

FULL MARKS=100

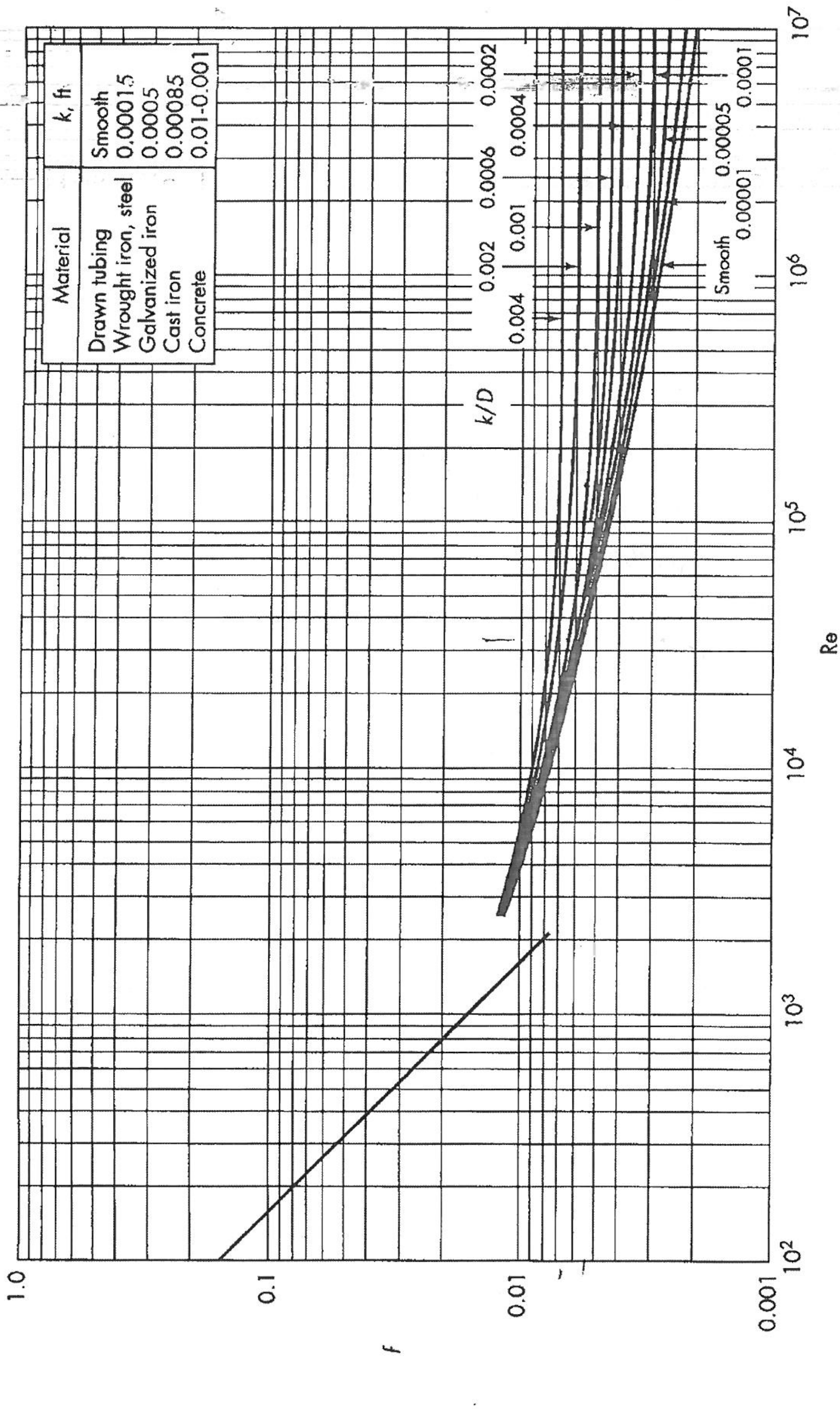


FIGURE 5.10
Friction factor chart.