UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF ENGINEERING TECHNOLOGY *CHEMICAL ENGINEERING*
SUBJECT	:	**CHEMICAL PROCESS TECHNOLOGY 1B**
CODE	:	**CPTCHB1**
DATE	:	SUPPLEMENTARY EXAMINATION JANUARY 2020
DURATION	:	
WEIGHT	:	40 : 60
TOTAL MARKS	:	113

EXAMINER(S)	:	MR P KHANGALE
MODERATOR	:	DR L MEKUTO
NUMBER OF PAGES	:	8 PAGES

REQUIREMENTS : Use of scientific (non-programmable) calculator is permitted (only one per candidate); graph paper

HINTS AND INSTRUCTIONS TO CANDIDATE(S):

- The purpose of this assessment is to determine not only if you can write down an answer, but also to assess whether you understand the concepts, principles and expressions involved. Set out solutions in a logical and concise manner with justification for the steps followed.
- **ATTEMPT ALL QUESTIONS**. Please answer each question to the best of your ability.
- Write your details (module name and code, ID number,student number etc.) on script(s).
- Number each question clearly; questions may be answered in any order.

QUESTION 1

1.1 Explain briefly what needs to be considered when selecting a flow-meter (9)

1.2 List three instruments used to measure pressure (5)

1.3 Briefly outline the difference between the flow-rate and the level (6)

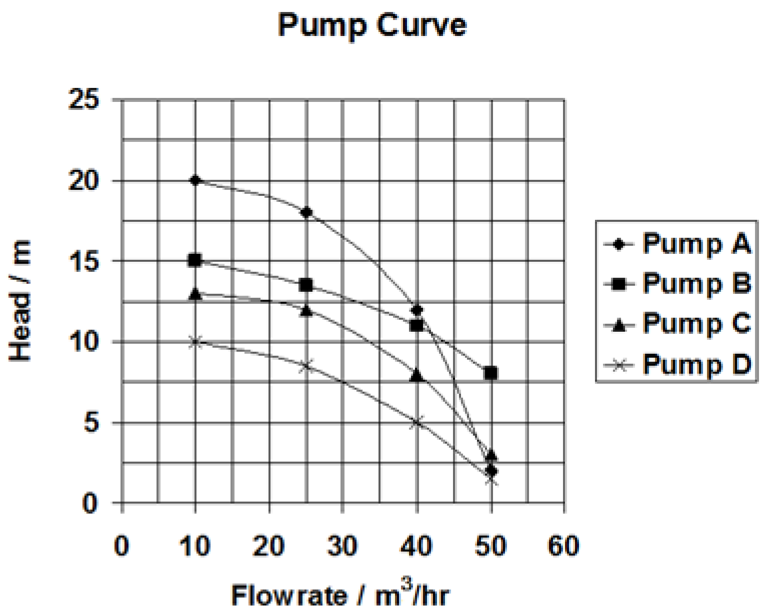
[20]

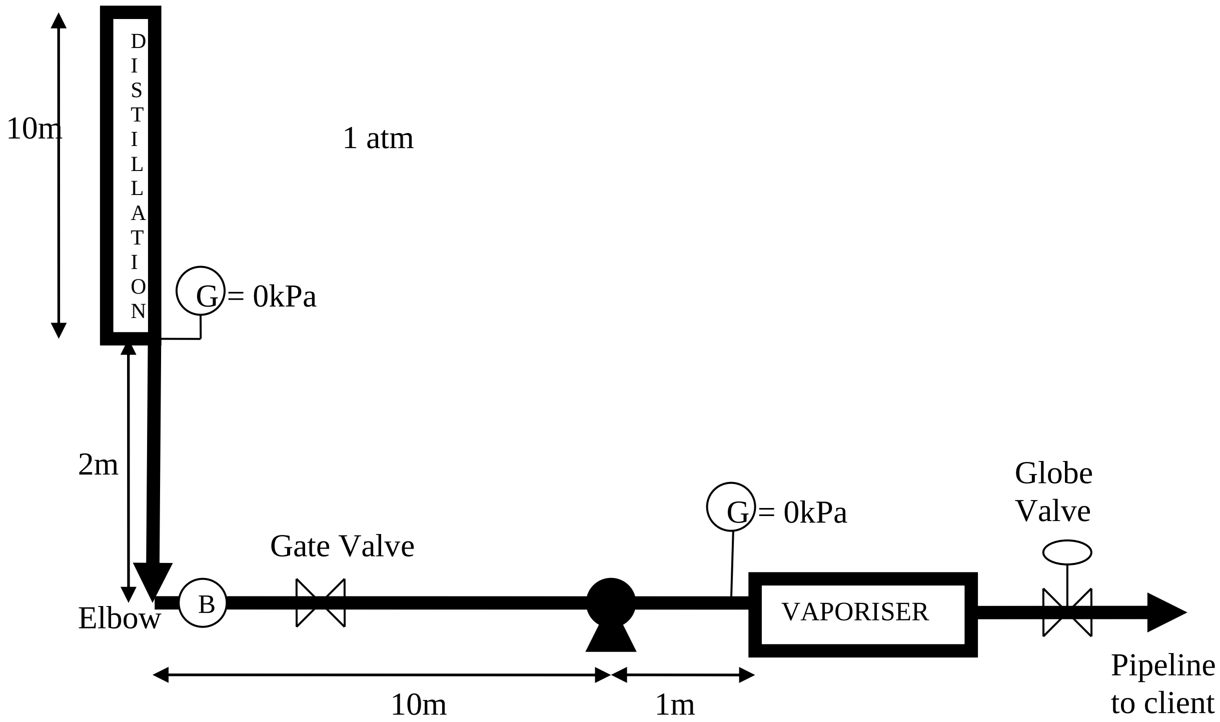
QUESTION 2

$21 m^3.hr^{-1}$ 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 $0.6 W.m^{-1}.K^{-1}$, viscosity of 1cP, heat capacity of $4200 W.kg^{-1}.K^{-1}$, and a density of $1000 kg.m^{-3}$. $g = 9.81 m.s^{-2}$.

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 on Bb? (10)





Before being piped to the client, the ethylene liquid at boiling point (170K) obtained from the distillation process needs to be pumped to a vaporiser that is heated by the hot exit stream of the ethylene reactor using a 1.25 inch schedule 80 pipe.

2.3. Calculate the net positive suction head. (20)

2.4. Will there be cavitation in the pump? (1)

Hints:

Choose suction and discharge points at the pressure gauges.

Not all data given is needed in the calculations.

[33]

QUESTION 3

A heat exchanger is required to cool 25kg.s^{-1} of process water from 365K to 350K by means of 30kg.s^{-1} cooling water entering at 300K. If the overall coefficient of heat transfer is constant at 1.5kW.m^{-2}K^{-1}, calculate the surface area required in a counter heat exchanger. The average Cp value for water is 4,18 kJ.kg^{-1}.K^{-1}

[20]

QUESTION 4

The reaction

$$A \rightarrow B$$

is to be carried out isothermally in a continuous – flow reactor. Calculate the CSTR reactor volume necessary to consume 3 $mol.h^{-1}$ of A when the entering molar flow rate is 5 $mol.h^{-1}$, assuming the reaction rate $-r_A = 0.05\ mol.h^{-1}.dm^{-3}$.

[20]

QUESTION 5

5.1 Explain briefly the importance of PPE. (5)

5.2 Conduct HAZOP study for a heat exchanger in question 3 above. (15)

[20]

TOTAL MARKS =113

FULL MARKS =113

DATA:

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

Material	Coeff. per degree Celsius	Material	Coeff. per degree Celsius
Iron	0.006	Tungsten	0.0045
Nickel	0.005	Platinum	0.00385

$$\Delta h_{fc} = K\frac{u_s^2}{2g}$$

$$K = 0.4\left(1.25 - \left(\frac{d_s}{d_l}\right)^2\right) \quad \text{When} \quad \frac{d_s^2}{d_l^2} \prec 0.715$$

$$K = 0.75\left(1.0 - \left(\frac{d_s}{d_l}\right)^2\right) \quad \text{When} \quad \frac{d_s^2}{d_l^2} \succ 0.715$$

$$\Delta h_{fe} = \frac{(u_s - u_l)^2}{2g}$$

Selected Equivalent Lengths

Fitting	L_e/d
Elbow, 90° standard	35
Tee, flow straight through	20
Tee, flow through bend	60
Globe valve, fully open	340
Gate Valve, fully open	25

TABLE 5.1
Loss coefficients for standard threaded pipe fittings[9b]

Fitting	K_f
Elbow, standard	
45°	0.35
90°	0.75
Tee	
Straight through	0.4
Used as elbow	1.0
Return bend, 180°	1.5
Gate valve	
Half open	4.5
Wide open	0.17
Angle valve, wide open	2.0
Globe valve, wide open	6.0

APPENDIX 3

Dimensions, Capacities, and Weights of Standard Steel Pipe†

Nominal pipe size, in.	Outside diameter, in.	Schedule no.	Wall thickness, in.	Inside diameter, in.	Cross-sectional area of metal, in.^{2}	Inside sectional area, ft^2	Circumference, ft or surface, ft^2/ft of length: Outside	Circumference, ft or surface, ft^2/ft of length: Inside	Capacity at 1 ft/s velocity: U.S. gal/min	Capacity at 1 ft/s velocity: Water, lb/h	Pipe weight, lb/ft
1/8	0.405	40	0.068	0.269	0.072	0.00040	0.106	0.0705	0.179	89.5	0.24
		80	0.095	0.215	0.093	0.00025	0.106	0.0563	0.113	56.5	0.31
1/4	0.540	40	0.088	0.364	0.125	0.00072	0.141	0.095	0.323	161.5	0.42
		80	0.119	0.302	0.157	0.00050	0.141	0.079	0.224	112.0	0.54
3/8	0.675	40	0.091	0.493	0.167	0.00133	0.177	0.129	0.596	298.0	0.57
		80	0.126	0.423	0.217	0.00098	0.177	0.111	0.440	220.0	0.74
1/2	0.840	40	0.109	0.622	0.250	0.00211	0.220	0.163	0.945	472.0	0.85
		80	0.147	0.546	0.320	0.00163	0.220	0.143	0.730	365.0	1.09
3/4	1.050	40	0.113	0.824	0.333	0.00371	0.275	0.216	1.665	832.5	1.13
		80	0.154	0.742	0.433	0.00300	0.275	0.194	1.345	672.5	1.47
1	1.315	40	0.133	1.049	0.494	0.00600	0.344	0.275	2.690	1,345	1.68
		80	0.179	0.957	0.639	0.00499	0.344	0.250	2.240	1,120	2.17
1 1/4	1.660	40	0.140	1.380	0.668	0.01040	0.435	0.361	4.57	2,285	2.27
		80	0.191	1.278	0.881	0.00891	0.435	0.335	3.99	1,995	3.00
1 1/2	1.900	40	0.145	1.610	0.800	0.01414	0.497	0.421	6.34	3,170	2.72
		80	0.200	1.500	1.069	0.01225	0.497	0.393	5.49	2,745	3.63
2	2.375	40	0.154	2.067	1.075	0.02330	0.622	0.541	10.45	5,225	3.65
		80	0.218	1.939	1.477	0.02050	0.622	0.508	9.20	4,600	5.02
2 1/2	2.875	40	0.203	2.469	1.704	0.03322	0.753	0.647	14.92	7,460	5.79
		80	0.276	2.323	2.254	0.02942	0.753	0.608	13.20	6,600	7.66
3	3.500	40	0.216	3.068	2.228	0.05130	0.916	0.803	23.00	11,500	7.58
		80	0.300	2.900	3.016	0.04587	0.916	0.759	20.55	10,275	10.25
3 1/2	4.000	40	0.226	3.548	2.680	0.06870	1.047	0.929	30.80	15,400	9.11
		80	0.318	3.364	3.678	0.06170	1.047	0.881	27.70	13,850	12.51
4	4.500	40	0.237	4.026	3.17	0.08840	1.178	1.054	39.6	19,800	10.79
		80	0.337	3.826	4.41	0.07986	1.178	1.002	35.8	17,900	14.98
5	5.563	40	0.258	5.047	4.30	0.1390	1.456	1.321	62.3	31,150	14.62
		80	0.375	4.813	6.11	0.1263	1.456	1.260	57.7	28,850	20.78
6	6.625	40	0.280	6.065	5.58	0.2006	1.734	1.588	90.0	45,000	18.97
		80	0.432	5.761	8.40	0.1810	1.734	1.508	81.1	40,550	28.57
8	8.625	40	0.322	7.981	8.396	0.3474	2.258	2.089	155.7	77,850	28.55
		80	0.500	7.625	12.76	0.3171	2.258	1.996	142.3	71,150	43.39
10	10.75	40	0.365	10.020	11.91	0.5475	2.814	2.620	246.0	123,000	40.48
		80	0.594	9.562	18.95	0.4987	2.814	2.503	223.4	111,700	64.40
12	12.75	40	0.406	11.938	15.74	0.7773	3.338	3.13	349.0	174,500	53.56
		80	0.688	11.374	26.07	0.7056	3.338	2.98	316.7	158,350	88.57

† Based on ANSI B36.10-1959 by permission of ASME.

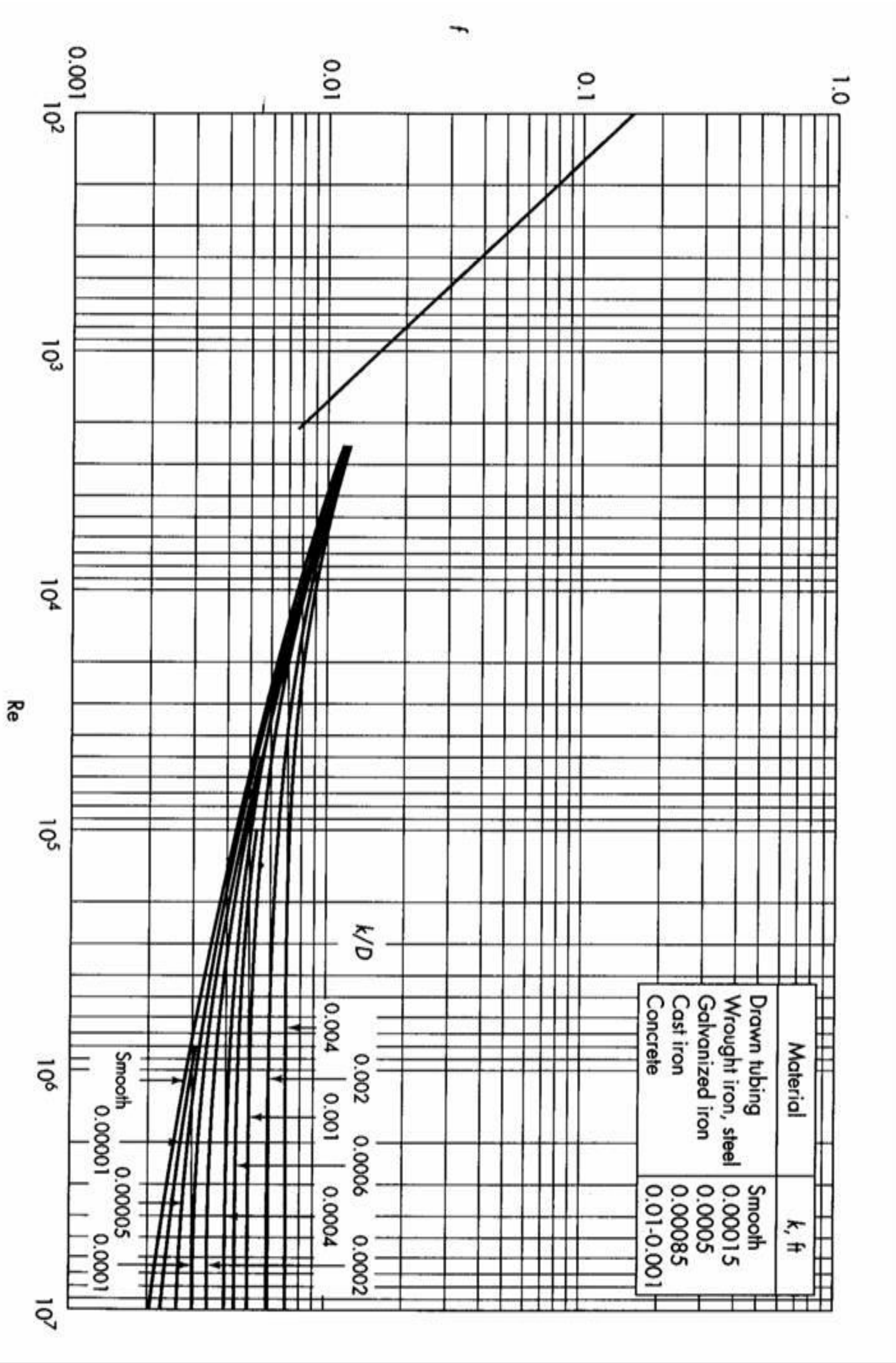


FIGURE 5.10
Friction factor chart.