THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

SECOND SEMESTER EXAMINATION - 2022

FOOD TECHNOLOGY - FIRST YEAR DEGREE

FT 121 INTRODUCTION TO FOOD ENGINEERING

TUESDAY, 1ST NOVEMBER, 2022 - 12:50. P.M.

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATES

1. You have 10 minutes to read the paper. You must not begin writing in the answer book during this time.

2. **ANSWER ALL QUESTIONS.**

3. All answers must be written on the answer book provided.

4. Write your name and number clearly on the front page. Do it now.

5. Calculators are permitted in the examination room. Notes and textbooks are not allowed.

6. Show all workings and calculations in the answer book.

7. Data required is given on the data sheet.

MARKING SCHEME:

Question 1	[26 marks]
Question 2	[23 marks]
Question 3	[10 marks]
Question 4	[12 marks]
Question 5	[12 marks]
Question 6	[17 marks]

ANSWER ALL QUESTIONS

1. (a) Define the terms below and give at least ONE example each.

(i) Dimensions. [1 mark]
(ii) Base units. [1 mark]
(iii) Derived units. [1 mark]

(b) Prove if the following are dimensionally consistent with the dimensions indicated:

(i) Power, $[M][L][\theta]^{-2}$. [2 marks]
(ii) Energy, $[M][L]^2[\theta]^{-3}$ [2 marks]
(iii) Thermal conductivity, $[M][L]^{-1}[\theta]^{-2}$ [2 marks]

(c) (i) Convert 25 $Btu.hr^{-1}$ to S.I. system of units. [2 marks]
(ii) Convert 59 $lb_f .ft.hr$ to S.I. system of units. [2 marks]

(d) Yomi Foods Ltd produces snacks at 100 g ± 1 % per packet and runs 220 shifts per annum at 40 000 packets per shift.

(i) What will be the financial loss if a packet is selling at K1.15? [2 ½ marks]
(ii) What will be the savings if the error is reduced to 100 g ± 0.4%? [2 ½ marks]

(e) A laboratory analysis showed the following results:

Source	Moisture kg)	Fat (kg)	Total weight (kg)
Sapal	60.5	2.5	102
Nangu	50.4	2.6	102
Goka	65.1	4.0	102
Gari	61.2	8.0	102

Note: Total weight = total moisture + total solids

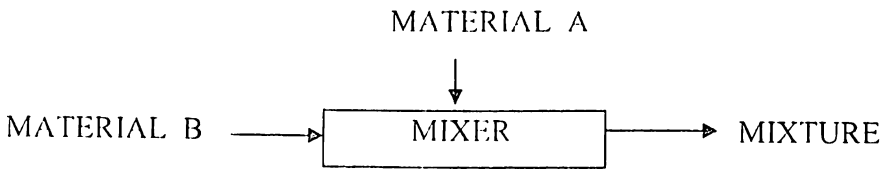
What is the fat content of each staple on "as is basis" and "dry basis"? [8 marks]

(Total = 26 marks)

2. (a) Compare and contrast between unit operations and unit processes. [2 marks]

(b) In food processing, minimizing waste is a target for most operations. Discuss this in relation to canning of fresh fish. [4 marks]

(c) A process company is to make 500 kg of minced meat by mixing ingredients A and B as shown below to give a product containing 30% fat:



Composition:

Material A: 64% water, 15% protein, 4% salt, 21% fat
Material B: 25% water, 20% protein, 2% salt, 42% fat

(i) Estimate the quantities of materials A and B. [4 marks]
(ii) Estimate the water, protein and salt contents of the product. [4 marks]

(d) A continuous membrane filter is used to concentrate a solution containing 6% protein. The final product (retentate) is expected to contain 30% protein. Since the filtration is not perfect, the waste solution (permeate) is expected to have around 4% protein. It is desired to produce around 70 kg of protein per day in the retentate.

Calculate the mass in each flow composition using:

(i) Normal or standard approach. [4 marks]
(ii) Using basis: 100kg feed. [5 marks]

(Total = 23 marks)

3. (a) A pressure gauge in a steam pipe may give a negative, a positive and/or a zero reading. Comment on the condition of each of these readings in the steam line. [3 marks]

(b) Evaporators are used to concentrate products. Designers prefer short instead of long tube evaporators. Explain. [3 marks]

(c) Explain why specific heat capacity is greatly affected by presence of solids. [4 marks]

(Total = 10 marks)

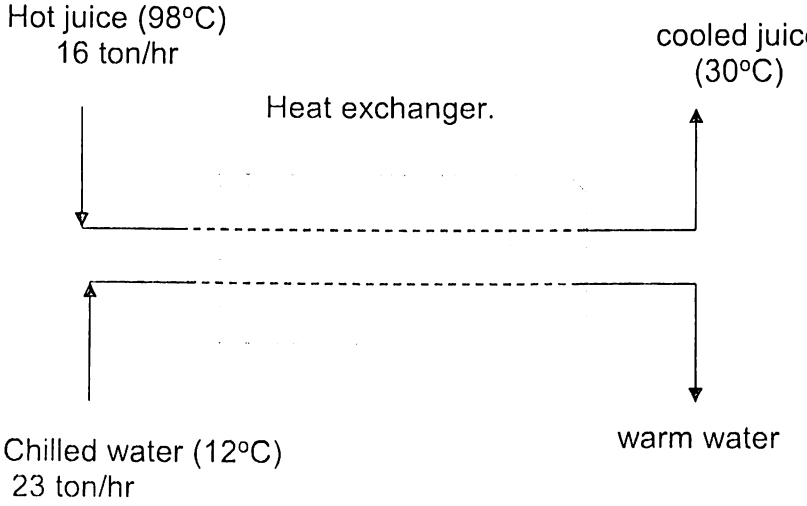
4. (a) Sixty one tonnes per day of fruit juice is pasteurized in a plate heat exchanger. This is then cooled and temporarily stored in a cylindrical stainless steel tank which is 2 m wide and 25 m high. The tank screens off insects with a loosely placed lid. The density of the fluid is 1050 kgm^{-3}. Calculate:

(i) Gauge pressure of the stored juice. [6 marks]
(ii) Absolute pressure at the base of the tank. [3 marks]

(b) What will be the height of each of the fluids with a gauge pressure of 2.5 bars. Mercury with SG of 13.6, water with SG of 1.0 and oil with SG of 0.89. [3 marks]

(Total = 12 marks)

5. (a) An orange juice coming from a pasteurizer is to be cooled in a heat exchanger before packaging as shown below:



The total solid content of feed is 15% of which 7% is fat. Calculate:

(i) Average specific heat capacity of the juice. [2 marks]
(ii) Heat released by the fruit juice. [2 marks]
(iii) Temperature of the outgoing chilled water. [2 marks]

(b) A cool room at 155 Watts operates for 24 hour per day. What is the monthly bill if PNG Power charges at K0.70/kW.h? [6 marks]

(Total = 12 marks)

6. (a) Estimate the latent heat and density of steam at the following temperature/pressure:

(i) 91.65 kPa. [3 marks]
(ii) 130.88 °C. [3 marks]

(b) Calculate the volume of steam that must be condensed at 147.5 °C to yield 144.65 MJ. [5 marks]

(c) It is desired to freeze 7 000 loaves of cassava bread each weighing 0.75 kg from an initial room temperature of 27 °C to a final storage temperature of -18 °C. Estimate the amount of heat to be extracted to achieve this.

Useful data:

Cp above freezing	=	2.93 $kJkg^{-1}{}^{o}C^{-1}$.
Cp below freezing	=	1.42 $kJkg^{-1}{}^{o}C^{-1}$.
Latent heat of freezing	=	115 $kJkg^{-1}$.
Freezing temperature	=	-2 °C.

[6 marks]

(Total = 17 marks)

DATA AND FORMULA SHEET

I. Siebel's Equation:
Above freezing Average C_p = 1674.72 F + 837.36 SNF + 4186.8 M
Below freezing Average C_p = 1674.72 F + 837.36 SNF + 2093.4 M

II. Acceleration due to gravity = 9.81 ms^{-2}

III. Density of water = 1000 kgm^{-3}

IV. Atmospheric pressure = 101.35 kPa

V. Conversion table is supplied

VI Steam table is supplied

VII. volume of cylinder = $\pi D^2 h/4$

VIII. Cp of water = 4.2 $kJkg^{-1}{}^oC^{-1}$

IX. $\%M_W = (Wt_{moisture})/(Wt_{total}) \times 100$

V. $\%M_{db} = (M_w/(100-M_w)) \times 100$

VI. $P = \rho.g.h$

VII. $P_{ab} = P_G + P_{atm}$

UNITS AND CONVERSION FACTORS

	Length	1 inch	=	0.0254 m
		1 ft	=	0.3048 m
	Area	1 ft^2	=	0.0929 m^2
	Volume	1 ft^3	=	0.0283 m^3
		1 gal Imp	=	0.004546 m^3
		1 gal US	=	0.003785 m^3
		1 litre	=	0.001 m^3
	Mass	1 lb	=	0.4536 kg
	Density	1 lb/ft^3	=	16.01 kg m^3
	Velocity	1 ft/sec	=	0.3048 m s^{-1}
	Force	1 lb_f	=	4.4482 N
		1 N	=	1 kg.m.s^2
	Pressure	1 lb/in^2	=	6894 Pa
		1 torr	=	133.3 Pa
		1 bar	=	1.0 x 10^5 Pa
		1 atm	=	1.013 x 10^5 Pa
	Viscosity	1 cP	=	0.001 Ns m^{-2}
		1 lb/ft sec	=	1.488 Ns m^{-2}
	Energy	1 Btu	=	1055 J
		1 Cal	=	4.186 J
	Power	1 kW	=	1 kJ s^{-1}
		1 ton refrigeration	=	3.519 kW
		1 hp	=	745.7 w
Heat-transfer coefficient		1 Btu ft^{-2} h^{-1} $^oF^{-1}$	=	5.678 $Jm^{-2}s^{-1}{}^oC^{-1}$
Thermal conductivity		1 Btu ft^{-1} h^{-1} $^oF^{-1}$	=	1.731 Jm^{-1} $s^{-1}{}^oC^{-1}$
Constants		π	=	3.1416
		R	=	8.314 m^3 kPa $mole^{-1}$ K^{-1} or JK^{-1} $mole^{-1}$
Temperature unit		^oC	=	(^oF-32) / (1.8)
		^oF	=	(^oC x 1.8) + 32
		^oK	=	^oC + 273

STEAM TABLE - SATURATED STEAM

(Temperature Table)

Temperature (°C)	Pressure (kPa)	Enthalpy (sat. vap.) ($kJkg^{-1}$)	Latent heat ($kJkg^{-1}$)	Specific volume ($m^3\ kg^{-1}$)
0	0.611	2501	2501	206
1	0.66	2503	2499	193
2	0.71	2505	2497	180
4	0.81	2509	2492	157
6	0.93	2512	2487	138
8	1.07	2516	2483	121
10	1.23	2520	2478	106
12	1.40	2523	2473	93.8
14	1.60	2527	2468	82.8
16	1.82	2531	2464	73.3
18	2.06	2534	2459	65.0
20	2.34	2538	2454	57.8
22	2.65	2542	2449	51.4
24	2.99	2545	2445	45.9
26	3.36	2549	2440	40.0
28	3.78	2553	2435	36.7
30	4.25	2556	2431	32.9
40	7.38	2574	2407	19.5
50	12.3	2592	2383	12.0
60	19.9	2610	2359	7.67
70	31.2	2627	2334	5.04
80	47.4	2644	2309	3.41
90	70.1	2660	2283	2.36
100	101.35	2676	2257	1.673
105	120.8	2684	2244	1.42
110	143.3	2692	2230	1.21
115	169.1	2699	2217	1.04
120	198.5	2706	2203	0.892
125	232.1	2714	2189	0.771
130	270.1	2721	2174	0.669
135	313.0	2727	2160	0.582
140	361.3	2747	2145	0.509
150	475.8	2734	2114	0.393
160	617.8	2758	2083	0.307
180	1002	2778	2015	0.194
200	1554	2793	1941	0.127