

THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY
SECOND SEMESTER EXAMINATION - 2021
FOOD TECHNOLOGY - FIRST YEAR DEGREE
FT 121 INTRODUCTION TO PROCESS FOOD ENGINEERING
TUESDAY, 2ND NOVEMBER, 2021 - 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	[24 marks]
Question 2	[24 marks]
Question 3	[15 marks]
Question 4	[12 marks]
Question 5	[13 marks]
Question 6	[12 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) Work, $[M][L][\theta]^{-2}$. [2 marks]
(ii) Viscosity, $[M][L]^{-1}[\theta]^{-2}$ [2 marks]
(iii) Thermal conductivity, $[M][L]^{-1}[\theta]^{-2}$ [2 marks]
- (c) (i) Convert $55 \text{ lb}\cdot\text{ft}^{-1}\cdot\text{hr}^{-1}$ to S.I. system of units. [2 marks]
(ii) Convert $114 \text{ lb}\cdot\text{ft}^3$ to S.I. system of units. [2 marks]
- (d) A packaging machine packages potato chips at $100\pm 2\%$ grams. The likely loss (overweight) is 2% of 100 grams. In a production schedule of 12,000 packets per shift, what is the financial implication for a year if the company runs 20 shifts per month, and a packet sells at K0.80? [3 marks]
- (e) A laboratory analysis showed the following results

Source	Moisture (kg)	Fat (kg)	Total wt (kg)
Yam	60.5	2.5	102
Sago	50.4	2.6	102
Sweet Potato	65.1	4.0	102
Cassava	61.2	8.0	102

NB: Total weight = total moisture + total solids

What is the fat content of each staple on "wet" (or "as is basis) and "dry basis"?

[8 marks]

(Total = 24 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) It is convenient to add salt to butter, produced in a continuous butter making machine, by adding a slurry of salt with water containing 62.5% of salt and 41.5% of water by weight. If the final composition of the butter is to be 15.7% moisture and 1.4% salt, estimate the original moisture content of the butter prior to salting. [6 marks]
- (d) James Barnes meat processing plant in Madang is producing minced meat which must contain 15% of fat. If this is to be made up from boneless cow beef with 23% of fat and from boneless bull beef with 5% of fat, what are the proportions in which these should be mixed? [6 marks]
- (e) It is required to produce sweetened concentrated orange juice to 45% total solids. The initial processed juice contains 8% total solids. After evaporation, sugar is added to give a 6.6% added sugar in the concentrated juice. Calculate the quantity of water which must be evaporated and of sugar which is to be added with respect to 1 tonne of pressed juice. [6 marks]

(Total = 24 marks)

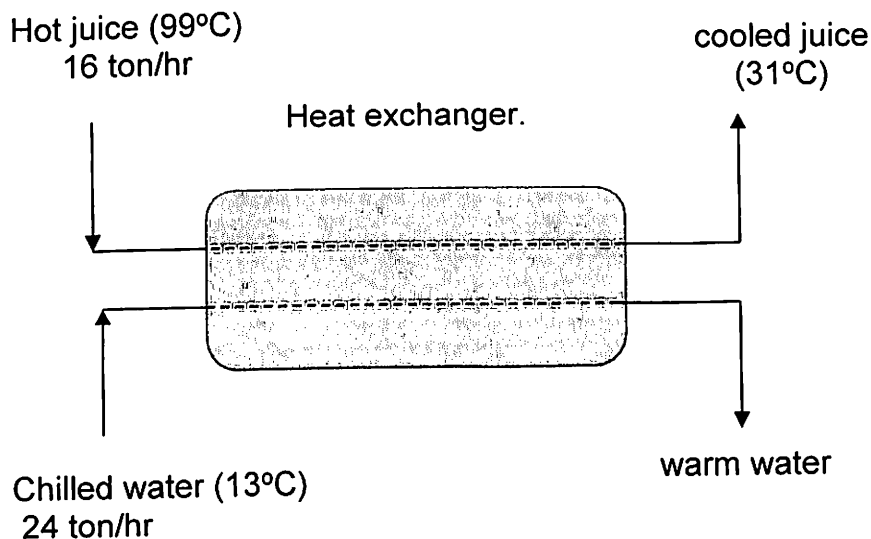
3. (a) Differentiate between normal stress and pressure. [2 marks]
- (b) A pressure gauge in a steam pipe may give a negative, a positive and/or a zero reading. Comment on the condition on each of these readings in the steam line. [3 marks]
- (c) Evaporators are used to concentrate products. Designers prefer short instead of long tube evaporators. Explain. [3 marks]
- (d) Explain why specific heat capacity is greatly affected by presence of solids. [4 marks]
- (e) What is pre-heating and why is it important in energy conservation? Explain. [3 marks]

(Total = 15 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 2.5m wide and 25m high. The tank screens off insects with a loosely placed lid. The density of the fluid is 1050kgm^{-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 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)

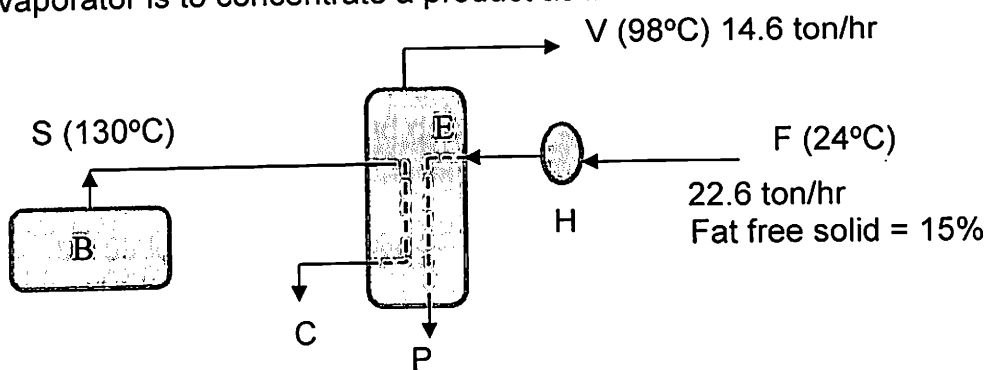
5. (a) An orange juice coming from a pasteurizer is to be cooled in a heat exchanger before packaging as shown below:



The total solid content of feed is 16% of which 8% 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) An evaporator is to concentrate a product as indicated below:



Key: S = steam, P = product, F = feed, H = heater, B = boiler,
E = evaporator, C = condensate, V = vapour

Calculate:

- (i) Solid content of the product. [2 marks]
 (ii) Quantity of heat required if there is no pre-heating. [3 marks]
 (iii) Quantity of heat if feed is pre-heated to evaporation temperature. [2 marks]

(Total = 13 marks)

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

- (i) 91.59 kPa. [3 marks]
 (ii) 131.88 °C. [3 marks]

- (b) It is desired to freeze 10 000 loaves of kaukau bread each weighing 0.70 kg from an initial room temperature of 26°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 °C ⁻¹ .
Cp below freezing	=	1.42 kJkg ⁻¹ °C ⁻¹ .
Latent heat of freezing	=	115 kJkg ⁻¹ .
Freezing temperature	=	-2 °C.

[6 marks]

(Total = 12 marks)

DATA AND FORMULA SHEET

- I. Siebel's Equation:
 Above freezing Average $C_p = 1674.72 F + 837.36 \text{ SNF} + 4186.8 M$
 Below freezing Average $C_p = 1674.72 F + 837.36 \text{ SNF} + 2093.4 M$
- 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. C_p of water = $4.2 \text{ kJkg}^{-1} \text{ } ^\circ\text{C}^{-1}$
- IX. $\%M_w = (W_{t\text{moisture}}) / (W_{t\text{total}}) \times 100$
- V. $\%M_{db} = (M_w / (100 - M_w)) \times 100$
- VI. $P = \rho \cdot g \cdot h$
- 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
	1 ft ³	=	0.0283 m ³
Volume	1 gal Imp	=	0.004546 m ³
	1 gal US	=	0.003785 m ³
	1 litre	=	0.001 m ³
	1 lb	=	0.4536 kg
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 lbf	=	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 °F ⁻¹	=	5.678 Jm ⁻² s ⁻¹ °C ⁻¹
Thermal conductivity	1 Btu ft ⁻¹ h ⁻¹ °F ⁻¹	=	1.731 Jm ⁻¹ s ⁻¹ °C ⁻¹
Constants	π	=	3.1416
	R	=	8.314 m ³ kPa mole ⁻¹ K ⁻¹ or JK ⁻¹ mole ⁻¹
Temperature unit	°C	=	(°F-32) / (1.8)
	°F	=	(°C x 1.8) + 32
	°K	=	°C + 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