THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

SECOND SEMESTER EXAMINATIONS – 2021

FOOD TECHNOLOGY – FOURTH YEAR DEGREE

FT 482 FOOD PROCESS ENGINEERING II

FRIDAY 5TH NOVEMBER 12:50 PM

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 in the answer books 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 laptops and mobile phones are not allowed.

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

MARKING SCHEME

Question 1	[17½ marks]
Question 2	[28½ marks]
Question 3	[21 marks]
Question 4	[33 marks]

ANSWER ALL QUESTIONS.

1. (a) What are the preservation methods in both hot and cold extrusions? [2 marks]

   (b) Among other reasons, extrusion has gained popularity in food processing due to its versatility. Explain all characteristics of extrusion that gave it this quality. [3 marks]

   (c) What influences the shear rate inside and extruder barrel? [2 marks]

   (d) Classify or name the extruder type according to the following descriptions:

   (i) The two screws are rotating apart from each other. [1 mark]
   (ii) Flight of one screw fits loosely into the channel of the other. [1½ marks]
   (iii) One screw rotates in to opposite direction to the other. [1 mark]
   (iv) Constant temperature maintained throughout the barrel. [1½ marks]
   (v) Flight of one screw is the same size and shape to the channel of the other. [1½ marks]

   (e) Discuss the effect of die diameter on the extrudate. [4 marks]

   (Total = 17½ marks)

2. (a) Explain the objectives of process control in food processing. [4 marks]

   (b) In an overview, how should one consider process control? [3 marks]

   (c) Explain dynamic variable and regulation in process control. [4 marks]

   (c) FULLY discuss PID controllers. [6 marks]

   (d) In light of a mercury in glass (MIG) thermometer, discuss its mechanism of operation as a measuring element under the following headings:

   (i) Physical variable. [1½ marks]
   (ii) Primary transducer. [2 marks]
   (iii) Variable conversion element. [2 marks]
   (iv) Signal processing. [2 marks]
   (v) Signal transmission. [2 marks]

(e)   How do you choose your temperature measuring instrument for your particular application?   [2 marks]

(Total = 28½ marks)

3.   (a)   Explain the effect of irradiation in the preservation of ALL types of food.   [3 marks]

(b)   What are the advantages of irradiation in food preservation applications apart from low operational costs and energy requirements?   [5 marks]

(c)   Discuss irradiation of foods in the presence of oxygen.   [3 marks]

(d)   How is an irradiation processing cell shield from personnel?   [2 marks]

(e)   Write notes on irradiation dose distribution and its depth of penetration when treating a food material.   [3 marks]

(f)   Food irradiation is a preferred application in disinfection over other methods. FULLY discuss why.   [5 marks]

(Total = 21 marks)

4.   (a)   Discuss the functions of evaporation?   [3 marks]

(b)   Write notes the factors that affect heat transfer in evaporation under the following headings:

(i)   Liquid boiling point.   [6 marks]
(ii)   Overall heat transfer coefficient.   [4 marks]
(iii)   Liquid feed properties.   [5 marks]

(c)   Explain the advantages and limitations that exist in multi-effect evaporators in reverse feed arrangement.   [5 marks]

(d)   A single effect evaporator is required to concentrate a solution from 10% solids to 30% solids at the rate of 250 kg of feed per hour. The pressure in the evaporator is 77 kPa absolute, the steam is available at 200 kPa gauge and the overall heat transfer coefficient is 1700 Jm^{-2} ^{0}C^{-1} s^{-1}. Assume that the temperature of the feed is 18°C and that the boiling point of the solution under the pressure of 77 kPa absolute is 91°C. The specific heat of the solution is the same as for water, that is 4.186 × 10^{3} Jkg^{-1} ^{0}C^{-1}, and the latent heat of the solution is the same as that for water under the same conditions.

(i)   Estimate the rate of steam requirement in this operation.   [7 marks]

(ii)   What is the area of heat transfer surface?   [3 marks]

(Total = 33 marks)

USEFULL DATA

$$F = P + V$$

$$F_{XF} = P_{XP} + V_{XV}$$

$$Penetration\ (cm) = \frac{0.524\,E - 0.1337}{\rho}$$

$$F_{(1-XF)} = P_{(1-XP)} + V$$

$$Q = S_{LS} = U.A.\Delta\theta$$

$$\Delta\theta = (\theta_s - \theta_e)$$

$$S_{LS} = FCP_F\,(\theta_e - \theta_f) + V_{LV}$$

$$Q = S_{LS} = U.A.(\theta s - \theta e) = FCP_F\,(\theta s - \theta e) + VL_V$$

$$A_1 = A_2 = A_3,\ U_1.\Delta\theta_1 = U_2.\Delta\theta_2 = U_3.\Delta\theta_3$$

$Q_1 = U_1.A.\Delta\theta_1$ where $\Delta\theta_1 = (\theta_s - \theta_1)$
$Q_2 = U_2.A.\Delta\theta_2$ where $\Delta\theta_2 = (\theta_1 - \theta_2)$
$Q_3 = U_3.A.\Delta\theta_3$ where $\Delta\theta_3 = (\theta_2 - \theta_3)$

$$\frac{1}{U} = \frac{1}{h_1} + \frac{x_w}{k_w} + \frac{1}{h_2}$$

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

$A = \pi dL$ (Cylinder Wall) $A = \dfrac{\pi d^2}{4}$ (Cylinder end)

Absolute pressure (kPa, kN/m²)	Temperature (°C)	Specific Volume (m³/kg)	Density - ρ - (kg/m³)	Specific Enthalpy of			Specific Entropy of Steam - s - (kJ/kgK)
				Liquid - h_l - (kJ/kg)	Evaporation - h_e - (kJ/kg)	Steam - h_s - (kJ/kg)	
0.8	3.8	160	0.00626	15.8	2493	2509	9.058
2.0	17.5	67.0	0.0149	73.5	2460	2534	8.725
5.0	32.9	28.2	0.0354	137.8	2424	2562	8.396
10.0	45.8	14.7	0.0682	191.8	2393	2585	8.151
20.0	60.1	7.65	0.131	251.5	2358	2610	7.909
28	67.5	5.58	0.179	282.7	2340	2623	7.793
35	72.7	4.53	0.221	304.3	2327	2632	7.717
45	78.7	3.58	0.279	329.6	2312	2642	7.631
55	83.7	2.96	0.338	350.6	2299	2650	7.562
65	88.0	2.53	0.395	368.6	2288	2657	7.506
75	91.8	2.22	0.450	384.5	2279	2663	7.457
85	95.2	1.97	0.507	398.6	2270	2668	7.415
95	98.2	1.78	0.563	411.5	2262	2673	7.377
100	99.6	1.69	0.590	417.5	2258	2675	7.360
101.33[1]	100	1.67	0.598	419.1	2257	2676	7.355
110	102.3	1.55	0.646	428.8	2251	2680	7.328
130	107.1	1.33	0.755	449.2	2238	2687	7.271
150	111.4	1.16	0.863	467.1	2226	2698	7.223
170	115.2	1.03	0.970	483.2	2216	2699	7.181
190	118.6	0.929	1.08	497.8	2206	2704	7.144
220	123.3	0.810	1.23	517.6	2193	2711	7.095
260	128.7	0.693	1.44	540.9	2177	2718	7.039
280	131.2	0.646	1.55	551.4	2170	2722	7.014
320	135.8	0.570	1.75	570.9	2157	2728	6.969
360	139.9	0.510	1.96	588.5	2144	2733	6.930
400	143.1	0.462	2.16	604.7	2133	2738	6.894
440	147.1	0.423	2.36	619.6	2122	2742	6.862
480	150.3	0.389	2.57	633.5	2112	2746	6.833
500	151.8	0.375	2.67	640.1	2107	2748	6.819
550	155.5	0.342	2.92	655.8	2096	2752	6.787
600	158.8	0.315	3.175	670.4	2085	2756	6.758
650	162.0	0.292	3.425	684.1	2075	2759	6.730
700	165.0	0.273	3.66	697.1	2065	2762	6.705
750	167.8	0.255	3.915	709.3	2056	2765	6.682
800	170.4	0.240	4.16	720.9	2047	2768	6.660
850	172.9	0.229	4.41	732.0	2038	2770	6.639