UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
MAY 2024 SEMESTER

COURSE	:	**CEB2063/CFB2063 - SEPARATION PROCESS II**
DATE	:	**5 AUGUST 2024 (MONDAY)**
TIME	:	**9.00 AM - 12.00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **NINE (9)** pages in this Question Booklet including the cover page and appendices.

ii. **DOUBLE-SIDED** Question Booklet.

iii. **Graph paper will be provided.**

4. In the process of producing dried herbs, two proposed air dryer designs (parallel and perpendicular) will be evaluated. The herbs have an initial free moisture content of 0.25 kg H_2O/kg dry solid. Both dryer types are designed to operate at a constant drying rate with a well-insulated oven and an exposed surface area of 35 m^2. Air with an initial humidity of 0.018 kg water vapor/kg dry air at 50°C will be brought into contact with the wet herbs at a velocity of 1.15 m/s to remove 20% of the free moisture content.

   a. Differentiate between drying and evaporation process.

   [4 marks]

   b. Propose the best type of dryer that could yield high amount of dry herbs. Justify your answer with appropriate calculations.

   [16 marks]

   c. By using the best dryer configuration proposed in **part (b)**, describe the effect of air temperature towards the yield of dried herbs with relevant calculations.

   [6 marks]

– END OF PAPER –

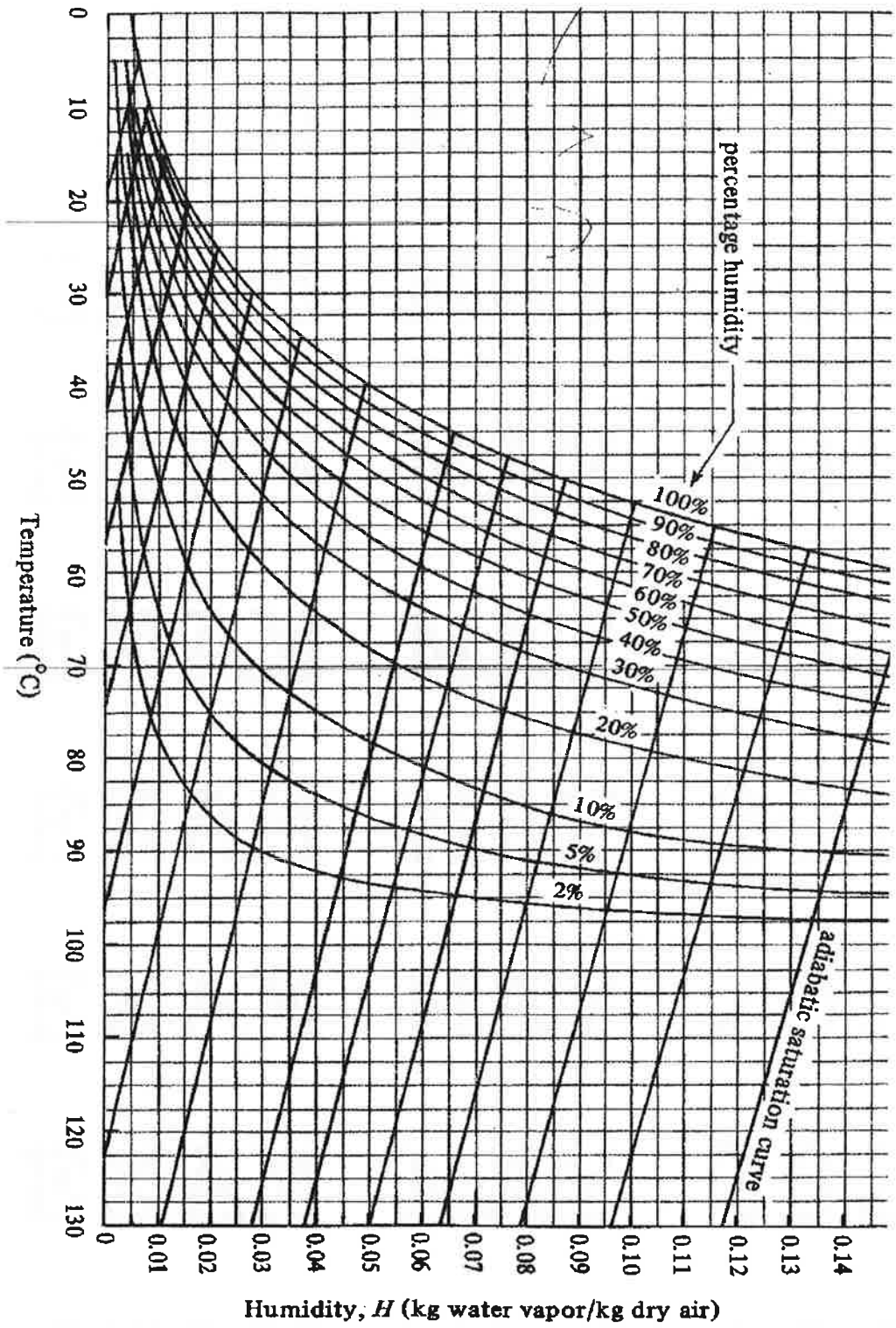
APPENDIX I

Properties of Saturated Steam and Water (Steam Table), SI Units

Temperature (°C)	Vapor Pressure (kPa)	Specific Volume (m^3/kg)		Enthalpy (kJ/kg)		Entropy ($kJ/kg \cdot K$)	
		Liquid	Sat'd Vapor	Liquid	Sat'd Vapor	Liquid	Sat'd Vapor
0.01	0.6113	0.0010002	206.136	0.00	2501.4	0.0000	9.1562
3	0.7577	0.0010001	168.132	12.57	2506.9	0.0457	9.0773
6	0.9349	0.0010001	137.734	25.20	2512.4	0.0912	9.0003
9	1.1477	0.0010003	113.386	37.80	2517.9	0.1362	8.9253
12	1.4022	0.0010005	93.784	50.41	2523.4	0.1806	8.8524
15	1.7051	0.0010009	77.926	62.99	2528.9	0.2245	8.7814
18	2.0640	0.0010014	65.038	75.58	2534.4	0.2679	8.7123
21	2.487	0.0010020	54.514	88.14	2539.9	0.3109	8.6450
24	2.985	0.0010027	45.883	100.70	2545.4	0.3534	8.5794
25	3.169	0.0010029	43.360	104.89	2547.2	0.3674	8.5580
27	3.567	0.0010035	38.774	113.25	2550.8	0.3954	8.5156
30	4.246	0.0010043	32.894	125.79	2556.3	0.4369	8.4533
33	5.034	0.0010053	28.011	138.33	2561.7	0.4781	8.3927
36	5.947	0.0010063	23.940	150.86	2567.1	0.5188	8.3336
40	7.384	0.0010078	19.523	167.57	2574.3	0.5725	8.2570
45	9.593	0.0010099	15.258	188.45	2583.2	0.6387	8.1648
50	12.349	0.0010121	12.032	209.33	2592.1	0.7038	8.0763
55	15.758	0.0010146	9.568	230.23	2600.9	0.7679	7.9913
60	19.940	0.0010172	7.671	251.13	2609.6	0.8312	7.9096
65	25.03	0.0010199	6.197	272.06	2618.3	0.8935	7.8310
70	31.19	0.0010228	5.042	292.98	2626.8	0.9549	7.7553
75	38.58	0.0010259	4.131	313.93	2635.3	1.0155	7.6824
80	47.39	0.0010291	3.407	334.91	2643.7	1.0753	7.6122
85	57.83	0.0010325	2.828	355.90	2651.9	1.1343	7.5445
90	70.14	0.0010360	2.361	376.92	2660.1	1.1925	7.4791
95	84.55	0.0010397	1.9819	397.96	2668.1	1.2500	7.4159
100	101.35	0.0010435	1.6729	419.04	2676.1	1.3069	7.3549
105	120.82	0.0010475	1.4194	440.15	2683.8	1.3630	7.2958
110	143.27	0.0010516	1.2102	461.30	2691.5	1.4185	7.2387
115	169.06	0.0010559	1.0366	482.48	2699.0	1.4734	7.1833
120	198.53	0.0010603	0.8919	503.71	2706.3	1.5276	7.1296
125	232.1	0.0010649	0.7706	524.99	2713.5	1.5813	7.0775
130	270.1	0.0010697	0.6685	546.31	2720.5	1.6344	7.0269

APPENDIX II

Humidity Chart (air + water vapor mixture)



APPENDIX III

Equations

Parameters	Equations
Membrane Separation	
Conversion unit	1 Barrer = 10^{-10} cm^3 (STP) cm / (cm^2 s cmHg)
Permeate composition	$\frac{y_p}{1-y_p}=\frac{\alpha_{AB}\left(x_o-ry_p\right)}{(1-x_o)-r\left(1-y_p\right)}$
Retentate composition	$x_o=\frac{x_f-\theta y_p}{1-\theta}$
Membrane area	$A_m=\frac{\theta L_f y_p}{(P_A/t)\left(p_h x_o-p_l y_p\right)}$
Quadratic equations	$y_p=\frac{-b+\sqrt{b^2-4ac}}{2a}$ $a=1-\alpha$ $b=-1+\alpha+\frac{1}{r}+\frac{x_o}{r}(\alpha-1)$ $c=\frac{-\alpha x_o}{r}$
Drying	
Humid volume	v_H = (2.83 x 10^{-3} + 4.56 x 10^{-3} H) T K
Heat transfer coefficient	h = 0.0204 $G^{0.8}$; h = 1.17 $G^{0.37}$
Drying time	$t=\frac{L_s}{AR_c}(X_1-X_2)$
Constant rate of drying	$R_C=\frac{h}{\Delta H_w^{vap}}(T-T_w)$ $R_{C2}=R_{c1}\frac{H_{w2}-H_2}{H_{w1}-H_1}=R_{c1}\frac{T_2-T_{w2}}{T_1-H_{w1}}$
Mass velocity	$G=\frac{\mu_{avg}}{v_H}$