



TECHNICAL UNIVERSITY OF MOMBASA
FACULTY OF HEALTH AND APPLIED SCIENCES
DEPARTMENT OF PURE AND APPLIED SCIENCES

BACHELOR OF SCIENCE IN FOOD TECHNOLOGY AND QUALITY ASSURANCE

EME. 4330 THERMODYNAMICS

Time 2 hours

INSTRUCTIONS TO CANDIDATES

This paper contains **FIVE** questions. Answer **THREE** questions. Question no. 1 is **Compulsory**.

You should have the following for this examination.

- I. A scientific calculator
- II. Steam tables

QUESTION 1 COMPULSORY 30 MARKS

- a) State the first law of thermodynamics 1 mark
- b) With reference to thermodynamics define the following.
 - i. Thermodynamic System
 - ii. Surroundings
 - iii. Boundary
 - iv. Process
 - v. Cycle5 marks
- c) State the main difference between an open system and a closed system listing one example for each case. 4marks
- d) Describe the following;
 - i. Wet steam
 - ii. Dry saturated steam
 - iii. Superheated steam
 - iv. Wetness fraction

- v. Quality of Steam
- vi. Priming

6 marks

- e) With the help of a well labeled sketch on three dimension showing a combined change of pressure, specific volume and temperature (**p-V-T**), describe the equilibrium states for a pure substance which expands on fusion.

10 marks
- f) 1kg of Nitrogen (molar mass 28kg/kmol) is compressed reversibly and isothermally from 1.01 bar, 20°C to 4.2 bar. Calculate the work done and the heat flow during the process. Assume Nitrogen is a perfect gas.

4 marks

Question 2

Two moles of an ideal gas undergo the following changes in the sequence;

- (a) Reversible isobaric expansion from state x (1.0 bar, 20.0 dm³) to state y (1.0 bar, 40.0 dm³)
- (b) Reversible isochoric change from state y (1.0 bar, 40.0 dm³) to state z (0.5 bar, 40.0 dm³)
- (c) Reversible isothermal compression from state z (0.5 bar, 40.0 dm³) to x (1.0 bar, 20.0 dm³).

Sketch the processes on a PV diagram and calculate

- (i) The work done in each process and the total work (w) done in the cycle
- (ii) Total heat exchanged (q) in the above processes

20 marks

Question 3

A pressure cooker contains 1.5 kg of saturated steam at 5 bar. Calculate the quantity of heat which must be rejected so as to reduce the quality to 60% dry. Determine the pressure and temperature of the steam at the new state.

20marks

Question 4

- a) Explain the importance of Ultimate Analysis of Coal

10 marks
- b) Calculate the specific volume, specific enthalpy and specific internal energy of wet steam at 18 bar, dryness fraction 0.9

10 marks

Question 5

- a) Prove that, the steady- flow energy equation is:

$$\dot{m}(h_1 + c_1^2/2) + z_1 g + Q + W = \dot{m}(h_2 + c_2^2/2) + z_2 g$$

13 marks

- b) In a steady flow system, a fluid flows at the rate of 4 kg/s. It enters at a pressure of 620 kN/m², a velocity of 300 m/s, internal energy 2100 kJ/kg and specific volume 0.37 m³/kg. It leaves the system at a pressure of 130 kN/m², a velocity of 150 m/s, internal energy 1500 kJ/kg and specific volume 1.2 m³/kg. During its passage through the system the fluid has a loss by heat transfer of 30 kJ/kg to the surroundings. Determine the power absorbed/ generated by the system in kiloWatts, stating whether it is from or to the system. Neglect any change in potential energy.

Saturated Water and Steam

p [bar]	T_s [°C]	v_g [m ³ /kg]	u_f u_g [kJ/kg]	h_f h_{fg} h_g [kJ/kg]	s_f s_{fg} s_g [kJ/kg K]
1.0	99.6	1.694	417 2506	417 2258 2675	1.303 6.056 7.359
1.1	102.3	1.549	429 2510	429 2251 2680	1.333 5.994 7.327
1.2	104.8	1.428	439 2512	439 2244 2683	1.361 5.937 7.298
1.3	107.1	1.325	449 2515	449 2238 2687	1.387 5.884 7.271
1.4	109.3	1.236	458 2517	458 2232 2690	1.411 5.835 7.246
1.5	111.4	1.159	467 2519	467 2226 2693	1.434 5.789 7.223
1.6	113.3	1.091	475 2521	475 2221 2696	1.455 5.747 7.202
1.7	115.2	1.031	483 2524	483 2216 2699	1.475 5.707 7.182
1.8	116.9	0.9774	491 2526	491 2211 2702	1.494 5.669 7.163
1.9	118.6	0.9292	498 2528	498 2206 2704	1.513 5.632 7.145
2.0	120.2	0.8856	505 2530	505 2202 2707	1.530 5.597 7.127
2.1	121.8	0.8461	511 2531	511 2198 2709	1.547 5.564 7.111
2.2	123.3	0.8100	518 2533	518 2193 2711	1.563 5.533 7.096
2.3	124.7	0.7770	524 2534	524 2189 2713	1.578 5.503 7.081
2.4	126.1	0.7466	530 2536	530 2185 2715	1.593 5.474 7.067
2.5	127.4	0.7186	535 2537	535 2182 2717	1.607 5.446 7.053
2.6	128.7	0.6927	541 2539	541 2178 2719	1.621 5.419 7.040
2.7	130.0	0.6686	546 2540	546 2174 2720	1.634 5.393 7.027
2.8	131.2	0.6462	551 2541	551 2171 2722	1.647 5.368 7.015
2.9	132.4	0.6253	556 2543	556 2168 2724	1.660 5.344 7.004
3.0	133.5	0.6057	561 2544	561 2164 2725	1.672 5.321 6.993
3.5	138.9	0.5241	584 2549	584 2148 2732	1.727 5.214 6.941
4.0	143.6	0.4623	605 2554	605 2134 2739	1.776 5.121 6.897
4.5	147.9	0.4139	623 2558	623 2121 2744	1.820 5.037 6.857
5.0	151.8	0.3748	639 2562	640 2109 2749	1.860 4.962 6.822
5.5	155.5	0.3427	655 2565	656 2097 2753	1.897 4.893 6.790
6	158.8	0.3156	669 2568	670 2087 2757	1.931 4.830 6.761
7	165.0	0.2728	696 2573	697 2067 2764	1.992 4.717 6.709
8	170.4	0.2403	720 2577	721 2048 2769	2.046 4.617 6.663
9	175.4	0.2149	742 2581	743 2031 2774	2.094 4.529 6.623
10	179.9	0.1944	762 2584	763 2015 2778	2.138 4.448 6.586
11	184.1	0.1774	780 2586	781 2000 2781	2.179 4.375 6.554
12	188.0	0.1632	797 2588	798 1986 2784	2.216 4.307 6.523
13	191.6	0.1512	813 2590	815 1972 2787	2.251 4.244 6.495
14	195.0	0.1408	828 2593	830 1960 2790	2.284 4.185 6.469
15	198.3	0.1317	843 2595	845 1947 2792	2.315 4.130 6.445
16	201.4	0.1237	857 2596	859 1935 2794	2.344 4.078 6.422
17	204.3	0.1167	870 2597	872 1923 2795	2.372 4.028 6.400
18	207.1	0.1104	883 2598	885 1912 2797	2.398 3.981 6.379
19	209.8	0.1047	895 2599	897 1901 2798	2.423 3.936 6.359
20	212.4	0.09957	907 2600	909 1890 2799	2.447 3.893 6.340
22	217.2	0.09069	928 2601	931 1870 2801	2.492 3.813 6.305
24	221.8	0.08323	949 2602	952 1850 2802	2.534 3.738 6.272
26	226.0	0.07689	969 2603	972 1831 2803	2.574 3.668 6.242
28	230.0	0.07142	988 2603	991 1812 2803	2.611 3.602 6.213
30	233.8	0.06665	1004 2603	1008 1795 2803	2.645 3.541 6.186
32	237.4	0.06246	1021 2603	1025 1778 2803	2.679 3.482 6.161
34	240.9	0.05875	1038 2603	1042 1761 2803	2.710 3.426 6.136
36	244.2	0.05544	1054 2602	1058 1744 2802	2.740 3.373 6.113
38	247.3	0.05246	1068 2602	1073 1729 2802	2.769 3.322 6.091
40	250.3	0.04977	1082 2602	1087 1714 2801	2.797 3.273 6.070