TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF HEALTH AND APPLLED SCIECES

DEPARTMENT OF PURE AND APPLIED SCIENCES

BACHELOR OF SCIENCEE 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. Extract of the steam tables attached at the end of this booklet

Question 1 COMPULSORY

(a) State the first law of thermodynamics. **1mark**

(b) State and describe the THREE types of thermodynamic systems **6marks**

(c) Explain any FIVE benefits of Nuclear Energy **10 marks**

(d) Explain the zeroth law of Thermodynamics **3marks**

(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

Question 2

a) A mass of 8 kg gas expands within a flexible container so that the *p*–*v* relationship is of the from $pv^{1.2}$ = constant. The initial pressure is 1000 kPa and the initial volume is 1 m3. The final pressure is 5 kPa. If specific internal energy of the gas decreases by 40 kJ/kg, find the heat transfer in magnitude and direction.

10 marks

b) 0.046 m^3 of gas are contained in a sealed cylinder at a pressure of 300kN/m^2 and a temperature of 45°C. The gas is compressed until the pressure reaches 1.27 MN/m^2 and the temperature is 83°C. If the gas is assumed to be a perfect gas, determine:

I. the mass of gas (kg)
II. the final volume of gas (m^3)

Given: R = 0.29 kJ/kg K

10 marks

Question 3

a) 0.04 kg of a certain perfect gas occupies a volume of 0.0072 m^3 at a pressure 6.76 bar and a temperature of 127 °C. Calculate the molecular weight of the gas (M). When the gas is allowed to expand until the pressure is 2.12 bar the final volume is 0.065 m^3. Calculate the final temperature.

8 marks

b) A mass of 0.18 kg gas is at a temperature of 15°C and pressure 130kN/m^2. If the gas has a value of C_v = 720 J/kg K, calculate the:

i. gas constant
ii. molecular weight
iii. specific heat at constant pressure
iv. specific heat ratio

12 marks

Question 4

Air flows steadily at the rate of 0.5kg/s through an air compressor, entering at 7m/s velocity, 100kPa pressure and 0.95m³/kg volume, and leaving at 5m/s, 700kPa and 0.19m³/kg. The internal energy of the air leaving is 90kJ/kg greater than that of the air entering. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58kW.

a) Compute the rate of shaft work input to the air in kW.
b) Find the ration of the inlet pipe diameter to the outlet pipe diameter. **20 marks**

Question 5

a) State the Carnot's Theorem **2 marks**
b) Since a Carnot Cycle is a reversible cycle, explain the FOUR successive processes as shown in a piston and cylinder machine. **12 marks**
c) Calculate the dryness fraction, specific volume and specific internal energy of steam at 7 bar and specific enthalpy 2600kJ/kg **6 marks**

Saturated Water and Steam

p [bar]	T_s [°C]	v_g [m³/kg]	u_f [kJ/kg]	u_g [kJ/kg]	h_f [kJ/kg]	h_{fg} [kJ/kg]	h_g [kJ/kg]	s_f [kJ/kg K]	s_{fg} [kJ/kg K]	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