# 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 |