BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI

SECOND SEMESTER 2006-2007

ES UC112 THERMODYNAMICS

FINAL COMPREHENSIVE EXAMINATION (CLOSED BOOK)

Duration : 3 hrs ; Maximum Marks : 80, Weightage 40% **Date : 28-5-2007**

Notes:

1. *Answer part A and Part B in separate answer sheets*
2. *Attempt ALL questions*
3. *Standard thermodynamics tables are allowed*
4. ***Assume any missing data suitably and mention the same at appropriate place in your answer***
5. *All the questions should be answered in sequential order.*

PART – A

1. a) Classify and explain the thermodynamic properties. (2)
   b) Define Zeroth law of thermodynamics. (2)
   c) A 5 m^3 container is filled with 900 kg of granite (density of 2400 kg/m^3) and the rest of the volume is air with density equal to 1.15 kg/m^3. Find the mass of air and the overall (average) specific volume. (4)
2. a) Discuss the features of compressibility chart (2)
   b) Prove that $C_P - C_V = R$ (2)
   c) A closed vessel of 0.8 m^3 capacity contains dry saturated steam at 360 kN/m^2. The vessel is cooled until the pressure is reduced to 200 kN/m^2. Calculate
      i) the mass of steam in the vessel
      ii) the final dryness of the steam
      iii) amount of heat transferred during the cooling process (4)
3. a) Derive the equation of work done for a Polytropic process (3)
   b) A quantity of dry saturated steam occupies 0.3951 m^3 at 1.5 MN/m^2. Determine the condition of the steam
      i) after isothermal compression to half its initial volume
      ii) after hyperbolic ($PV = C$) compression to half its initial volume
      iii) In case (i) determine the heat rejected during the compression (5)
4. a) Show that internal energy is a property of a system (3)
   b) A piston in a cylinder with diameter of 100 mm is loaded with a linear spring. The spring exerts no force on the piston when it is at the top of the cylinder and for the state the pressure is 200 kPa with volume 0.4 L. The valve is opened to let some air in, causing the piston to move down 2 cm. Find the new pressure (Neglect the weight of the piston and atmospheric pressure). (5)

5. a) Derive the steady state flow energy equation for a heat exchanger. (3)
b) A vessel having a volume of 7 m^3 contains 0.05 m^3 of saturated liquid water and 4.95 m^3 of saturated water vapour at 0.1 MPa. Heat is transferred until the vessel is filled with saturated vapour. Determine the heat transfer for this process. (5)

PART – B

6. a) Define the thermal efficiency of a heat engine cycle. Can this be 100 %? (2)
b) A reversible heat engine operates between two reservoirs at temperatures of 600^0C and 40^0C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40^0C and -20^0C. The heat transfer to the heat engine is 2000 kJ and the net work output of the combined engine refrigerator plant is 360 kJ.
i) Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40^0C.
ii) Reconsider (i) given that the efficiency of the heat engine and the COP of the refrigerator are each 40 % of their maximum possible values. (6)

7. a) 1 kg of ice at -5^0C is exposed to the atmosphere which is at 25^0C. The ice melts and comes into thermal equilibrium.
i) Determine the entropy increase of the universe.
ii) What is the minimum amount of work necessary to convert the water back into ice at -5^0C? (5)
b) Derive expressions for entropy changes for a closed system in the following cases :
i) General case for change of entropy of a gas
ii) Polytropic process (3)

8. a) State the Principle of Increase of Entropy. (2)
b) A steam turbine receives steam at a pressure of 2 MPa and a temperature of 300^0C. The steam leaves the turbine at a pressure of 15 KPa. The work output of the turbine is measured and is found to be 600 KJ/kg of steam flowing through the turbine. Determine the efficiency of the turbine (6)

9. a) One kg of air is compressed polytropically from 1 bar pressure and temperature of 300 K to a pressure of 6.8 bar and temperature of 370 K. Determine the irreversibility if the sink temperature is 293 K. Assume R = 0.287 kJ/kg K, C_P = 1.004 kJ/kg K and C_V = 0.716 kJ/kg K. (5)
b) Explain the concept of available and unavailable energy. (3)

10. a) Derive an expression for mass fraction in terms of mole fraction. (3)
b) A tank has a volume of 0.6 m^3 and contains nitrogen and water vapour. The temperature of the mixture is 52^0C and the total pressure is 3 MPa. The partial pressure of the water vapour is 8 kPa. Calculate the heat transfer when the contents of the tank are cooled to 12^0C. (5)

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QUIZ – II (CLOSED BOOK)

VERSION - A

DURATION: 30 MINUTES MAXIMUM MARKS: 10 DATE: 1-5-2007

Note :

1. *Answer only in the sheet provided*
2. *Standard thermodynamics tables are allowed*
3. *Assume any missing data suitably and mention the same at appropriate place in your answer*
4. *Return the answer sheet*

ANSWER ALL THE QUESTIONS (1 mark each)

1. Which of the following statements is correct?
   a) The increase in entropy is obtained from a given quantity of heat at a low temperature
   b) The change in entropy may be regarded as a measure of the rate of the availability of heat for transformation into work
   c) The entropy represents the maximum amount of work obtainable per degree drop in temperature
   d) All the above

2. The main cause for the irreversibility is
   a) Mechanical and fluid friction b) unrestricted expansion
   c) Heat transfer with a finite temperature difference
   d) All of the above

3. Entropy may be expressed as a function of
   a) pressure and temperature
   b) temperature and volume
   c) heat and work
   d) all the above

4. To increase work capacity of energy transferred by heat transfer from high temperature to low temperature
   a) lower temperature should be lowered keeping temperature difference same
   b) higher temperature should be increased keeping temperature difference same
   c) temperature difference should be increased
   d) temperature difference should be decreased

5. If a heat source at temperature T_1 transfers heat to a system at temperature T_2 ($T_1 > T_2$), state which of the following statements is not true?
   a) Δ_{system} decreases b) Δ_{source} decreases c) $(\Delta_{system} + \Delta_{source})$ decreases
   d) $(\Delta_{system} + \Delta_{source})$ increases

6. Consider the following statements:
   1. Availability is generally conserved
   2. Availability can either be negative or positive
   3. Availability is the maximum theoretical work obtainable
   4. Availability can be destroyed in irreversibilities.

   Of these statements
   a) 3 and 4 are correct b) 1 and 3 are correct
   c) 1 and 4 are correct d) 2 and 4 are correct.

7. A system of 100 kg mass undergoes a process in which its specific entropy increases from 0.3 kJ/kg-K to 0.4 kJ/kg-K. At the same time the entropy of the surroundings decreases from 80 kJ/K to 75 kJ/K. The process is
   a) Reversible and isothermal b) Irreversible
   c) Reversible d) Impossible

8. The irreversibility of a real process is ---------- to the entropy generation
   a) inversely proportional b) directly proportional c) equal d) all the above

9. A feed water heater has 5 kg/s water at 5 Mpa and 40° C flowing through it, being heated from two sources. One source adds 900 KW from a 100°C reservoir and the other source transfers heat from a 200°C reservoir such that the water exit condition is 5 MPa, 180°C. The irreversibility is ----------

10. Steam enters a steam turbine at a pressure of 1 Mpa, a temperature of 300°C and a velocity of 50 m/s. The steam leaves the turbine at a pressure of 150 kPa and a velocity of 200 m/s. Assume that the process is reversible and adiabatic. The work per kilogram of steam flowing through the turbine is ----------

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ES UC112 THERMODYNAMICS

OPEN BOOK

TEST – 2 ; Date : 15-4-2007

Duration : 50 minutes ; Maximum Marks : 20, Weightage 20%

Notes:

1. *Standard thermodynamics tables are allowed*
2. *Assume any missing data suitably and mention the same at appropriate place in your answer*
3. *All the questions should be answered in sequential order*
4. *Re-check request will not be entertained if point 3 is invalid*
5. *Prescribed text book (mentioned in the hand out) & hand written notes only to be used*
6. *No marks will be given unless the reason is given for Qns 1 & 2.*

ANSWER ALL QUESTIONS

1. In an effort to conserve energy in a heat engine cycle, somebody suggests incorporating a refrigerator that will absorb some of the waste energy Q_1 and transfer it to the energy source of the heat engine. Is this a smart idea? Explain. (3)

2. On a hot summer day, a student turns his fans on when he leaves his room in the morning. When he returns in the evening, will the room be warmer or cooler then the neighboring rooms? Why? Assume all the doors and windows are kept closed. (3)

3. a) One kg of water at 273 K is brought into contact with a heat reservoir at 373 K, find the entropy change of the water, of the heat reservoir and of the universe. (3)

   b) Water flows through turbine in which friction causes the water temperature to rise from 35^0C to 37^0C. If there is no heat transfer, how much does the entropy of the water change in passing through the turbine? (Water is incompressible and the process can be taken to be at constant volume.) (3)

4. A reversible-heat engine in a satellite operates between a hot reservoir at T_1 and a radiating panel at T_2. Radiation from the panel is proportional to its area and to T_2^4. For a given work output and value of T_1 show that the area of the panel will be minimum when $T_2/T_1 = 0.75$. Determine the minimum area of the panel for an out put of 1kW if the constant of proportionality is 5.67×10^{-8} W/m^{2}K^4 and T_1 is 1000 K. (5)

5. An inventor claims at his engine has the following specifications:

Temperature limits	- 750 ^{0}C and 25 ^{0}C
Power developed	- 75 kW
Fuel burned per hour	- 3.9 kg
Heating value of the fuel	- 74500 kJ/Kg

   State whether his claim is valid or not ? (3)

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QUIZ – I (CLOSED BOOK)

VERSION - B

DURATION: 30 MINUTES **MAXIMUM MARKS: 10** **DATE: 27-3-2007**

Note :

5. *Answer only in the sheet provided*
6. *Standard thermodynamics tables are allowed*
7. *Assume any missing data suitably and mention the same at appropriate place in your answer*
8. *Return the answer sheet*

FILL IN THE BLANKS (1 mark each)

1. The heat transfer in a constant-pressure quasi equilibrium process is equal to -----

2. The basic statement of First law of thermodynamics is given by the equation ------

3. The COP of refrigerator which has a refrigeration capacity of 1200 KJ/hr when the power input is 0.75 KW is ----------

4. A gas expands from a pressure P_1 to Pressure P_2 ($P_2 = P_1/10$). If the process of expansion is isothermal, the volume at the end of expansion is $0.55m^3$. If the process of expansion is adiabatic, the volume at the end of expansion will be closer to ----------

TRUE OR FASLSE (0.5 mark each)

5. All reversible engines have the same efficiency.

6. KE and PE are large in Heat exchanger

7. During throttling process enthalpy remains constant

8. Internal energy of a perfect gas depends on temperature only

MULTIPLE CHOICE QUESTIONS (1 mark each)

9. The heat transfer Q, the work done W, and the change in internal energy ΔU are all zero in the case of
   e) a rigid vessel containing steam at 150^0C left in the atmosphere which is at 25^0C.
   f) 1 kg of gas contained in a insulated cylinder expanding as the piston moves slowly outwards.

g) A rigid vessel containing ammonia gas connected through a valve to a evacuated rigid vessel, the vessel, the valve and the connecting pipes being well insulated and the valve being opened and after a time, conditions though the two vessel becoming uniform.

h) 1 kg of air flowing adiabatically from the atmosphere into a previously evacuated bottle.

10. A tank containing a fluid is stirred by a paddle wheel. The work input to the paddle wheel is 5090 KJ. The heat transfer from the tank is 1500 KJ. Consider the tank and the fluid inside a control surface. The change in internal energy of this control mass is

    a) 3590 KJ b) 5390 KJ c) 3510 KJ d) 5490 KJ

11. The compressor in a plant receives CO_2 at 100 Kpa, 280K with a low velocity. At the compressor discharge, the CO_2 exists at 1100 kpa 500 K, with velocity of 25 m/s and then flows into a constant pressure after cooler where it is cooled down to 350 K. The power input to the compressor is 50 KW. The heat transfer rate in the aftercooler is

    a) 35.2 KW b) 53.2 KW c) 30 KW d) 50 KW

12. Match list – 1 with list II and select the correct answer using the codes given below.

List – I	List - II
A. Work done in a polytropic process	1. $\int vdp$
B. Work done in a steady flow process	2. Zero
C. Heat transfer in a reversible adiabatic process	3. $(P_1V_1-P_2V_2)/(\gamma-1)$
D. Work done in an isentropic process	4. $(P_1V_1-P_2V_2)/(n-1)$

a) A-4, B-1, C-3, D-2

b) A-1, B-4, C-2, D-3

c) A-4, B-1, C-2, D-3

d) A-1, B-2, C-3, D-4

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SECOND SEMESTER 2006-2007

ES UC112 THERMODYNAMICS

TEST – 1 ; Date : 4-3-2007

Duration : 50 minutes ; Maximum Marks : 20, Weightage 20%

Notes:

1. *Standard thermodynamics tables are allowed*
2. *Assume any missing data suitably and mention the same at appropriate place in your answer*
3. *All the questions should be answered in sequential order*
4. *Check up request will not be entertained if point 3 is invalid*

PART A

1. Define the general forms of energy? (2 marks)

2. What is the weight of a 2 kg mass at an altitude where the local acceleration to gravity is 9.75 m/s^2? (1 mark)

3. Define saturation temperature and Critical point ? (2 marks)

4. A rigid vessel having a volume of 0.01 m^3 contains 4.5 kg water at 35^{0}C. Calculate the quality of the mixture and the masses of liquid and vapour. The vessel is now slowly heated. Will the liquid level rise to the top or drop to the bottom? What will be the final temperature after heating if water reaches a saturation state? (3 marks)

5. Determine the temperature and quality for water at a pressure of 300 KPa at specific volume 0.5 m^3/kg? (2 marks)

PART - B

6) A household is cooking beef stew for his family in a pan that is (a) uncovered (b) covered with a light lid (c) covered with a heavy lid. For which case will the cooking time be the shortest? Why? (2 Marks)

7) Show that work is a path function, not a property? (2 Marks)

8) A cylinder has a thick piston initially held by a pin as shown in figure 1. The cylinder contains carbon dioxide at 200 kPa and ambient temperature of 290 K. The metal piston has a density of 8000 kg/m^3 and the atmospheric pressure is 101 kPa. The pin is now removed, allowing the piston to move and after a while the gas returns to ambient temperature. Is the piston against the stops? (4 Marks)

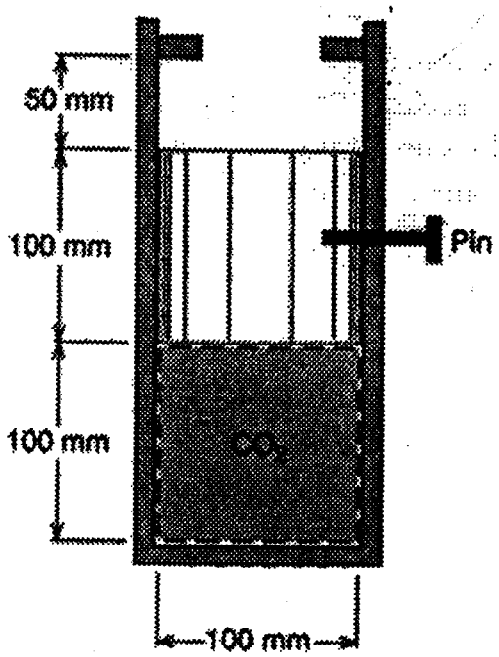

Figure 1

9) A pressure cooker (closed tank) contains water at 100° C with the liquid volume being 1/10 of the vapour volume. It is heated until the pressure reaches 2.0 MPa. Find the final temperature. Has the final state more or less vapour than the initial state?

(2 Marks)