BITS, PILANI – DUBAI
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI
I Year Second Semester -2009-2010
Course: ES C112 Thermodynamics
Comprehensive Examination [Closed Book]

Max.Marks:80 **Date: 25-5-2010**
Weightage: 40 % **COMMON TO ALL BRANCHES** **Time: 3 hours**

Note: (i) Answer all Questions in a sequence (ii) Assume suitable value if required
(iii) Thermodynamics tables are permitted
(iv) Answer Every Question on a fresh page
(v) Answer the questions of part A in BLUE COLOUR , part B in GREEN COLOUR

Part –A

1. Saturated water vapor at 200 kPa is in a constant pressure piston cylinder. At this state the piston is 0.1 m from the cylinder bottom and cylinder area is 0.25 m^2. The temperature is then changed to 200 ° C. Find the work in the process and indicate the process in a P-v diagram .(8 M)

2. A steel tank of cross sectional area 3 m^2 and 16 m tall weighs 10 000 kg and it is open at the top as shown in the *figure.1* We want to float it in the water(Lake) so it sticks 10 m straight down by pouring concrete into the bottom of it. How much concrete should be put in? (8 M)

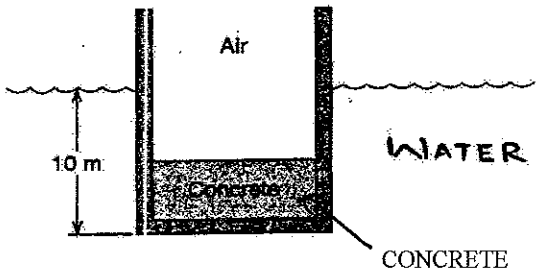

Figure : 1

3. Air at 20° C and 80 kPa enters the diffuser of a jet engine steadily with a velocity of 200 m/s .The inlet area of the diffuser is 0.3m^2 .The air leaves the diffuser with a velocity that is very small compared with the inlet velocity .Determine (a) the mass flow rate of the air and (b) the temperature of the air leaving the diffuser.(12M)

4. Steam flows through three different inlets at 200 kPa , all the three are connected to the same exit duct as shown in *figure 2* and mix without external heat transfer. Flow one has 1 kg/s at 400 ° C, flow two has 3 kg/s at 250 ° C and flow three has 2 kg/s at 700 ° C. Neglect kinetic energies and find the volume flow rate in the exit flow (12M)

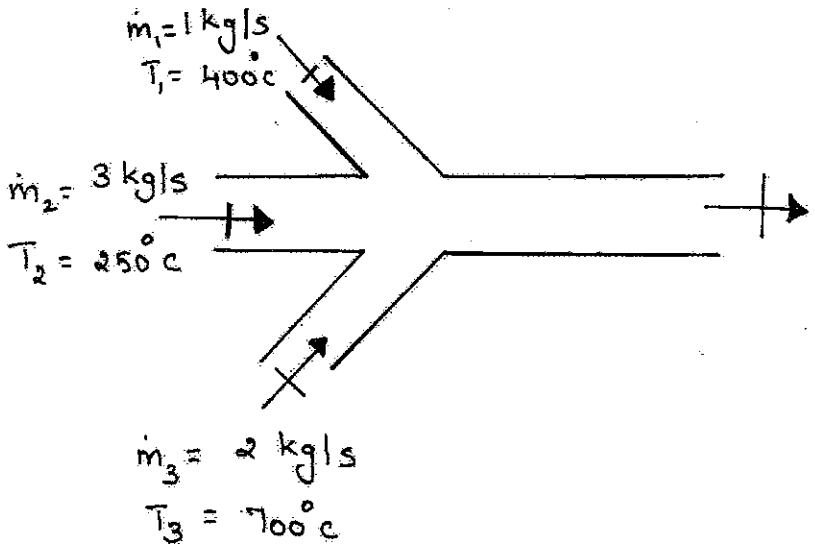

Figure : 2

Part- B

1. A steel bottle of V=0.1m^3 contains R-134a at 20^{0}C and 200kPa.It is placed in a deep freezer where it is cooled to -20^{0}C.The deep freezer sits in a room with ambient temperature of 20^{0}C and has an inside temperature of -20^{0}C. Find the amount of energy the freezer must remove from the R-134a and the extra amount of work input to the freezer to do the process. (10M)

2. Water is used as the working fluid in a Carnot cycle heat engine, where it changes from saturated liquid to saturated vapor at 200^0C as heat is added. Heat is rejected in a constant pressure process (also constant T) at 20kPa.The heat engine powers a Carnot cycle refrigerator that operates between-15^0C and +20^0C. Find the heat added to the water per kg water. How much heat should be added to the water in the heat engine so the refrigerator can remove 1kJ from the cold space?(10M)

3. An expansion in a gas turbine can be approximated with a Polytrophic process with exponent n=1.25. The inlet air is at 1200 K, 800 kPa, and the exit pressure is 125 kPa with a mass flow rate of 0.75 kg/s. Find the turbine heat transfer and power output.(10M)

4(i). Find the availability of 100 kW delivered at 500 K when the ambient temperature is 300 K.(2M)

(ii) A heat pump heats a house in the winter and then reverses to cool it in the summer. The interior temperature should be 20^0C in the winter and 25^0C in the summer. Heat transfer through the walls and ceilings is estimated to be 2400 kJ per hour per degree temperature difference between the inside and outside. a) If the outside winter temperature is 0^0C, what is the minimum power required to drive the heat pump? b) For the same power as in part (a), what is the maximum outside summer temperature for which the house can be maintained at 25^0C? (8M)

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SECOND SEMESTER 2009-10
COURSE : ES C112 Thermodynamics
Test : II (Open Book)

Max. Marks: 40 **Date : 02.05.10**
Weightage : 20% **Time : 50 min**

Note: Answer all Questions and Assume suitable value if required

1 .Show that $COP_{HP} = COP_{REF} + 1$ when both the heat pump and the refrigerator have the same Q_L and Q_H values **(4 marks)**

2. Two different fuels can be used in a heat engine operating between the fuel burning temperature and a low temperature of 350 K. Fuel A burns at 2200 K delivering 30 000kJ/kg and costs Rs1.50/kg. Fuel B burns at 1200 K, delivering 40 000 kJ/kg and costs Rs1.30/kg. Which fuel would you buy and why? **(6 marks)**

3. A Carnot heat engine receives heat from a reservoir at 927 $^{\circ}$C and rejects the waste heat at a rate of 185 kJ/min to the ambient air at 27°C.The net work of the heat engine is used to drive a refrigerator that removes heat from the refrigerated space at -7°C and transfers it to the same ambient air at 27°C. calculate **(a)** the rate of heat received by the heat engine from the source **(b)** rate of heat removed from the refrigerated space **(c)** rate of heat rejected to the ambient air by the refrigerator **(10 marks)**

4. A cylinder fitted with a piston contains ammonia at 50°C and 20% quality with a volume of 1L.The ammonia expands slowly, and during this process heat is transferred to maintain a constant temperature. The process continues until all the liquid is gone. Determine the work and heat transfer for this process. **(10 marks)**

5. A piston/cylinder device loaded so it gives constant pressure has 0.75 kg of saturated vapor water at 200 kPa. It is now cooled so that the volume becomes half the initial volume by heat transfer to the ambient surroundings at 20°C. Find the work, heat transfer, and total entropy generation. **(10 marks)**

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DUBAI INTERNATIONAL ACADEMIC CITY-DUBAI
SECOND SEMESTER 2009-10
COURSE : ES C112 Thermodynamics
Test : I (Closed Book)

Max. Marks: 50 **Date : 21.03.10**
Weightage : 25% **Time : 50 min**

Note: Answer all Question and Assume suitable value if required

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1. A piston/cylinder has 1.5 kg of air at 300 K and 150 kPa. It is now heated up in a two step process. First constant volume to 1000K (state 2) then followed by a constant pressure process to 1500 K, (state 3). Find the final volume and the work in the process. **(13 marks)**

2. A balloon behaves such that the pressure inside is proportional to the diameter squared. It contains 2 kg of ammonia at 0°C, with 60% quality. The balloon and ammonia are now heated so that a final pressure of 600 kPa is reached. Considering the ammonia as a control mass, find the amount of work done in the process **(12 marks)**

3.

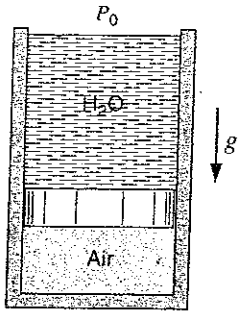

fig.1.

A 10 m high cylinder with a cross sectional area of 0.1 m^2 has a massless piston at the bottom with water at 20°C on top of it as shown in the fig .1.Air at 300K with a volume of 0.3 m^3, under the piston is heated so that the piston moves up spilling the water out over the sides. Find the total heat transferred to the air when all the water has been pushed out if the atmospheric pressure is 101kPa. **(12 marks)**

4.

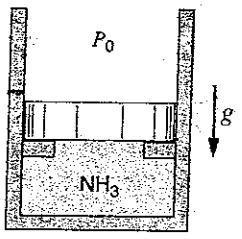

fig. 2.

A piston /cylinder set up contain 1 kg of ammonia at 20°C with a volume of 0.1 m^3 as shown in the figure.2. Initially the piston rests on some stops with the top surface open to the atmosphere, so that a pressure of 1400 kPa is required to lift it.
(a) To what temperature should the ammonia be heated to lift the piston? (b) If it is heated to saturated vapour find the final temperature, volume and heat transfer. **(13 marks)**

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SECOND SEMESTER 2009 – 2010

B

Quiz 2

First YEAR Sections 2,4

Course Code: ES C112 Date: 4. 4 .10

Course Title: THERMODYNAMICS Max Marks: 14

Duration : 20minutes Weightage: 7%

Name: ..... **ID No:** ..... **Sec** .....

Instructions: 1. Attempt all questions
2.Assume suitable value if required

1 Methane at 4 MPa, 300 K is throttled through a valve to 100 kPa. Calculate the exit temperature assuming no changes in the kinetic energy. (2)

2 A compressor in a commercial refrigerator receives R-22 at -25°C, x = 1. The exit is at 800 kPa, 40°C. Neglect kinetic energies and find the specific work. (2)

3 A small expander (a turbine with heat transfer) has 0.05 kg/s helium entering at 1000 kPa, 550 K and it leaves at 250 kPa, 300 K. The power output on the shaft is measured to be 55 kW. Find the rate of heat transfer neglecting kinetic energies. (3)

4 Liquid water at 15° C flows out of a nozzle straight up 15 m. What is the nozzle V_{exit}? (2M)

5 At the inlet of a nozzle, the velocity is 60 m/s, if the inlet area is 800cm^2 and specific volume is 0.213 m^3 / kg .Find mass flow rate. (2M).

6 Air flows into a diffuser with a velocity of 300 m/s at 300 K and 100 kPa. At the exit the velocity is very small but the pressure is high. Find the exit temperature assuming zero heat transfer. (3M)

BITS, PILANI – DUBAI

Second semester 2009 – 2010

B

First YEAR Sections 2&4

Quiz 1

25-2-10

Course Code: ES C112 Course Title: THERMODYNAMICS Date: ~~24.2.10~~

Duration:20 minutes Max Marks: 16 Weightage: 8%

Name: ..... **ID No:** ..... **Sec** .....

Instructions: 1. Attempt all questions
2.Assume suitable value if required

1) Separate the following into intensive and extensive properties: temperature, specific volume, volume, energy, density, viscocity (2)

2) Determine the phase in the following state, ammonia at P=800kPa with $v = 0.2\ m^3/kg$.also indicate the relative position in the P-v ,T-v and P-T diagram.(1+1+1+1)

3) What is the temperature of -5 F in degrees Rankine?(2)

4) A vacuum gauge connected to a chamber read 40kPa at a location where the atmospheric pressure is 100kPa.Determine the absolute pressure in the chamber.(2)

5)Water in a pot boils at 105° C .How heavy a lid should be on a 15 cm diameter pot when the atmospheric pressure is 101kPa.(3)

6) Saturated vapour R134a at 50 ° C changes volume at constant temperature ,find the new pressure if the volumes doubles.(3)