BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI (RAJ)

Second Semester (2016-2017)

Course No: BITS F111 Thermodynamics; Mid semester test (Open book)

Max Marks 90 | Tuesday, 7th March 2017 | Duration 90 min

- The Question paper has two parts: **Part A (3 x 5 = 15 marks) and Part B (25 x 3 = 75 Marks)**
- Answer **Part A** in the **question paper** itself, in the space provided.
- Answer **Part B** in the answer book

Name: Id: Section No:

a) A real gas expands at a constant pressure process. Can the change in internal energy be determined by dU=CvdT? Justify

b) Consider the systems A, B and C as shown in the adjacent figure. Control mass in each system is 1 kg of ideal gas in state 1 (P, V, T) enclosed in the of the cylinder below the piston. Volume of each system was increased infinitesimally by dV. Arrange the systems in ascending order of (a) work done (b) heat transfer required.

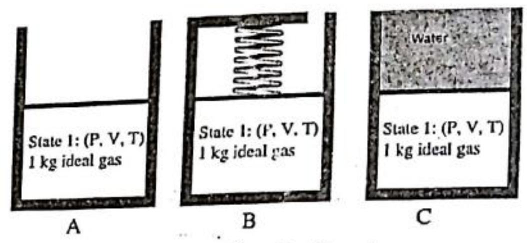

Fig. Q. b)

c) The change of the state of an ideal gas undergoing a non-flow process is presented by the diagram. What is the ratio between work done on the gas during the process 2→3 and work done on the gas during the process 4→1?

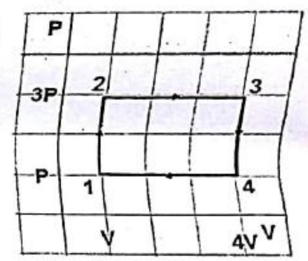

Fig. Q. c)

d) Identify the possible heat (Q) and work (W) interactions between the system and the surroundings and fill the following table. Also determine the sign (positive: 1; negative: -1; none: 0) of Q and W, for all the process.

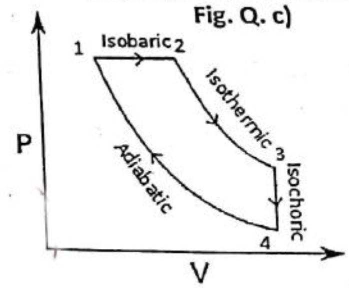

Fig. Q. d)

Process	Q	W	Process	Q	W
1-2					
2-3					

e) The five processes (a-b, b-c, c-d, d-a, and a-c) sketched on the adjacent (p, v) plane are for an ideal gas. Indicate the same processes on the (T, v) plane.

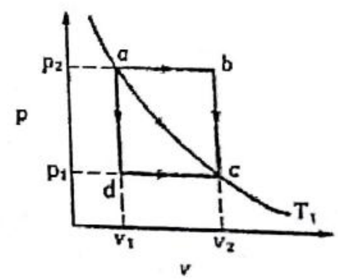

Fig. Q. e)

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- Please write proper unit and highlight the final answer

Name:

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PART B

Q 1. A vertical piston-cylinder assembly contains 0.05 m^3 of argon gas at 100 kPa and 25 ^{0}C. The cross section area of the piston is 0.1 m^2. If the piston hits the stops, then the volume is 0.11 m^3. Initially, the atmospheric pressure of 100 kPa just balances the gas pressure (neglect volume and mass of the piston). There is a linear spring with spring constant 10 kN/m, which is 10 cm above the piston as shown in Figure. The gas is now heated until the pressure reaches 190 kPa. Determine

a) whether the piston touches the stop or not
b) the work done by the gas in kJ
c) the work done on the spring kJ
d) the total heat transfer during the process, in kJ.
e) Draw P-v diagram for the process(es) and highlight the spring work in the P-v diagram.

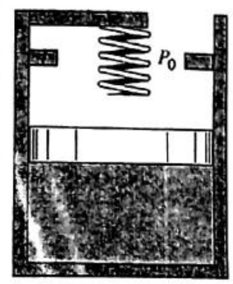

Fig. Q. 1

Q 2. Air and water present in a rigid tank of volume 0.5 m^3, is seperated by an adiabatic, frictionless and massless piston as shown in Figure (neglect the volume occupied by the piston). The air (an ideal gas with constant specific heats) initially at temperature of 25 ^{0}C is present above the piston and 1 kg saturated liquid water at 120 ^{0}C below the piston. The cylinder wall is well insulated whereas heat is supplied to the water from the bottom until water reaches a saturated vapor state at 700 kPa and air exhanges heat with the surrounding through the top surafce of the cylinder. As the piston moves upward compression of air takes place polytropically, according to $Pv^n=C$. For air, assume constant specific heat c_v = 0.718 kJ/kg-K and c_p = 1.005 kJ/kg-K. Determine

a) total work done by water during the process, in kJ
b) heat transfer to the water during the process in kJ
c) heat transfer to or from the air kJ
d) final temperature of water and air.

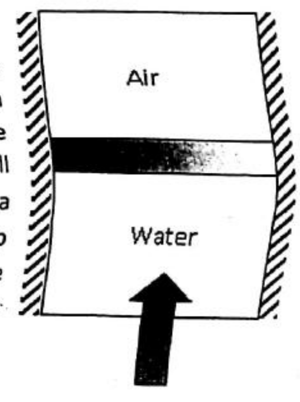

Fig. Q. 2

Q 3. Water at 5 MPa, 350 °C (State 1) leaves the boiler and enters the turbine at 50 m/s and exits as saturated water vapor at 50 kPa with a velocity of 100 m/s (State 2) through an outlet which is 4 m below the inlet. The cross-sectional area of the inlet of the turbine (state 1) is 0.2 m^2.

a) If the rate of heat loss from the turbine in the steady state process is 19.25 kW, determine (i) mass flow rate in the turbine(kg/sec); (ii) power generated by the turbine in MW
b) The water (State 2) from the turbine passes through a condenser at a constant pressure and exits at 50 °C (State 3) with no change in velocity. Calculate rate of the heat loss of water in the condenser MW, ignoring the change in potential energy.
c) The water from condenser (State 3) is adiabatically pumped to the boiler at boiler pressure and 50 °C. Calculate the pumping power in MW required neglecting the changes in kinetic and potential energies.

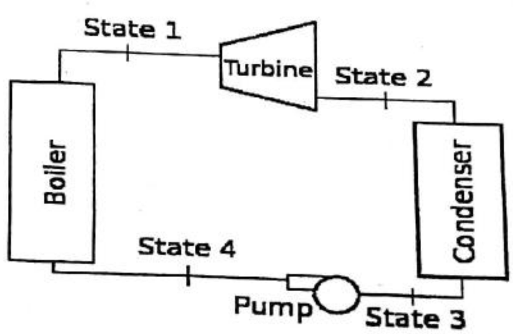

Fig. Q. 3