**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI (RAJ)**

**Second Semester (2015-2016)**

**BITS F111 Thermodynamics**

**Comprehensive Examination (close book)**

**Max Mark 120 Thursday, 5th May 2016 Duration 180 min**

* The Question paper has two parts**: Part A (3x15M=45 marks)+ Part B(3x15M=45 Marks) for 120 min**
* Solve Part A and Part B on separate answer sheets. A and B will be marked on the answer sheets
* Use of Thermodynamics table is permitted
* **Highlight the answers**

**PART A**

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| Q1. A piston-cylinder device (**Fig Q1**), contains 0.2 m3 of R-134a at -20°C and a quality of 20%. The spring is linear and has a spring constant of 100 kN/m. The refrigerant is heated until its temperature reaches 30°C. If the cross-sectional area of the piston is 0.2 m2, determine   1. the mass of the refrigerant 2. the pressure when the piston reaches the pins at a volume of 0.4 m3, 3. the final pressure 4. the work transfer during the process 5. heat transfer during the entire process   Draw T-v diagram for the process | **Fig Q1** |

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| Q2. Water initially a saturated liquid at 95oC is contained in a piston-cylinder assembly. The water undergoes a process to the corresponding saturated vapor state, during which the piston moves freely in the cylinder. The change in state is brought about adiabatically by the stirring action of paddle wheel. Determine on a unit of mass basis, the (a) change in stored exergy (Δ*Φ*), (b) the exergy transfer accompanying work, (c) the exergy transfer accompanying heat and (d) the exergy destruction (*I*). Let *T0* = 20oC and *p0* = 1 bar. | |
| Q3. The high-temperature heat source for a cyclic heat engine is a steady flow heat exchanger as shown in **Fig Q3**, where ammonia enters at 70°C (state 1) in a saturated vapor state and exits at 70°C (state 2) in a saturated liquid state at a flow rate of 1 kg/s from the heat exchanger. Heat is rejected from the heat engine to a steady flow heat exchanger where air enters at 150 kPa and ambient temperature 298.15 K (state 3), and exits at 125 kPa, 340 K (state 4). The rate of irreversibility for the overall process is 105 kW. Calculate **(a)** the mass flow rate of air and **(b)** the thermal efficiency of the heat engine.  If the power output of the heat engine is used to drive an adiabatic compressor, which takes in saturated water vapor at 1 MPa and releases at 40 MPa, 1000°C, determine **(c)** the mass flow rate of water vapour and **(d)** the second law efficiency of the compressor. | **Fig Q3** |

**PART - B**

Q4. Steam enters a turbine steadily at 3 MPa and 400oC at a rate of 8 kg/s and exits at 200 kPa and 150oC. The steam loses heat to the environment air at 100 kPa and 25oC at a rate of 300 kW, and the kinetic and potential changes are negligible. Calculate the

(a) actual power output

(b) maximum possible power output

(c) second law efficiency

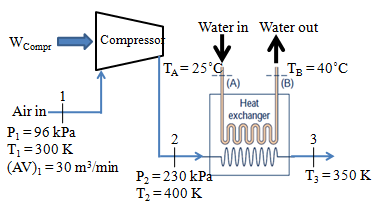
 (d) irreversibility

(e) availability of the steam at the inlet conditions.

(f) first law (isentropic) efficiency considering there is no heat loss.

Q5. A valve connects two rigid tanks. Tank A contains 0.4 m3 of water at 325 kPa and 90 percent quality. Tank B contains 0.5 m3 of water at 200 kPa and 250°C. The valve is now opened, and the two tanks eventually come to equilibrium while exchanging heat with the surroundings at 25°C. Determine (a) the final pressure, (b) heat transfer and (c) the entropy generation during the process.

Q6. Air as an ideal gas flows through the compressor and heat exchanger as shown in **Fig Q6**. A separate liquid water stream also flows through the heat exchanger. The data given are for operation at steady state. Assume all kinetic and potential energy changes are negligible and there is no heat exchange with the surroundings which is at 300K. Determine **(a)** the compressor power, in kW **(b)** the mass flow rate of cooling water, in kg/s **(c)** the rates of entropy generation, in kW/K, for the compressor and heat exchanger **(d)** the reversible work for compressor **(e)** the irreversibility rate **(f)** the second law efficiency for compressor.



**FigQ6**