Final Examination Paper

Answer the following questions:

1-a Define the system and state its types with examples. (4 Marks)

1-b A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas-tight, frictionless piston–cylinder device. Find the boundary work is the air is compressed to a final volume of 1 m³ using
   a. Isothermal process
   b. Isobaric process
   c. Polytropic process with \( pv^{1.4}=c \). (6 Marks)

2-a A thin-walled double-pipe counter-flow heat exchanger is used to cool oil \( (c_p = 2.20 \text{ kJ/kg°C}) \) from 150 to 40°C at a rate of 2 kg/s by water that enters at atmospheric pressure and temperature of 22°C with rate of 1.5 kg/s. Determine the rate of heat transfer in the heat exchanger and the exit temperature of water. (9 Marks)

2-b An insulated piston–cylinder device contains 5 L of saturated liquid water at a constant pressure of 175 kPa. Water is stirred by a paddle wheel while a current of 8 A flows for 45 min through a resistor placed in the water. If one-half of the liquid is evaporated during this constant pressure process and the paddle-wheel work amounts to 400 kJ, determine the voltage of the source. Also, show the process on a P-v diagram with respect to saturation lines. (6 Marks)

3-a Thermodynamic process may be reversible or irreversible. Explain the statement and state sources of irreversibility. (4 Marks)

3-b Water at 1 bar and 20°C enters a mixing chamber at a rate of 1 kg/s where it is mixed steadily with steam entering at 1 bar and 140°C. The mixture leaves the chamber at 1 bar and 80°C, and heat is lost to the surrounding air at 40°C at a rate of 2 kW. Neglecting the changes in kinetic and potential energies, determine the rate of entropy generation during this process. If the heat lost to the surrounding is changed to achieve a reversible process, calculate the modified heat loss. (11 Marks)

With Best Wishes

Dr. Eng. E. Elgendy