MEL 703 Advanced Thermodynamics
Major Test

November 28, 2006

Max. Marks: 50 Duration: 2 hours

1. Molecular hydrogen dissociates into atomic hydrogen as per the reversible reaction given as

$$H_2 \rightleftharpoons 2H$$

In a given reaction, it is found that at equilibrium at a pressure of 10 atm, 9% of H_2 has dissociated. What is the equilibrium composition of the mixture? From the tables of equilibrium constant, whose extract is given below, find the temperature in K for the above equilibrium. Please note that $\log(\kappa_o)$ varies linearly as $(1/T)$ according to van't Hoff equation: Use this for interpolation.

Temp.(K)	298	500	1000	2000	2500	3000	3200	3400	3500
$\log_{10} \kappa_o$	-71.224	-40.316	-17.292	-5.580	-3.202	-1.606	-1.106	-0.664	-0.462

(10 marks)

2. In an industrial furnace, natural gas is used as fuel, and it burns in 200% theoretical air. Natural gas can be approximated to be pure methane. Fuel and air enter the furnace at 1 atm and 25°C, which are also the pressure and temperature of the exergy reference environment. The heat transfer from the furnace happens across a surface maintained at 60°C. The flue gases escape at a pressure of 1 atm and a temperature of 600 K. There are no stray heat losses, and potential and kinetic energy terms can be neglected. The composition of the exergy reference environment is given in table below. Compute the following quantities per kmol of fuel flow through the furnace:
(i) Exergy entering the furnace
(ii) Exergy leaving the furnace with the flue gases
(iii) Rate of exergy destruction
Compute the exergetic efficiency of the furnace.

Component	N_2	O_2	$H_2O(g)$	CO_2	Other
x_i^e	0.7567	0.2035	0.0312	0.0003	0.0083

(25 marks)

3. A compressor is used to compress a mixture of 75% ethylene (C_2H_4) and 25% ethane (C_2H_6) from 0.5 MPa to 2 MPa. The inlet flow rate is 0.01 m^3/s, and the temperatures measured at suction and discharge of the compressor are 43.8°C and 72.6°C respectively. Using Kay's rule to consider the mixture as a pseudo-pure substance, and from the tables of compressibility and enthalpy and entropy departure, compute:
(i) The mass flow rate of the mixture through the compressor
(ii) The rate of heat transfer, indicating clearly the direction of heat transfer using the sign of the term.

(15 marks)