[This question paper contains 4 printed pages.]

Your Roll No. ....

3198 **J**

MEM

Paper—ME.652

OPTIMAL DESIGN OF THERMAL SYSTEMS

Time : 3 *Hours* *Maximum Marks* : 100

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any five questions.

All questions carry equal marks.

1. The volume flow rate Q in (m^3/s) of water in an open channel with a slight downward slope S and a hydraulic radius R is measured to yield the following data :

R(m)	0.5	1.0	1.5	2.0
S				
1.5×10^{-3}	1.91	3.10	4.11	5.03
5×10^{-3}	3.48	6.66	7.51	9.19
9×10^{-3}	4.67	7.59	10.08	12.33

Obtain a best fit to these data, assuming a power law dependence of Q on R and S. 20

2. Draw a combined schematic diagram of a gas turbine cogeneration and vapour absorption refrigeration system.

The exhaust gases from waste heat recovery boiler of cogeneration system is used as a source for generator of VARS. Write various model equations for conservation of mass and energy for different components of the system and describe the information flow diagram of the system. 20

3. Briefly explain the following terms with suitable examples (any four) : $4 \times 5 = 20$

   (a) Optimal design.

   (b) Workable design.

   (c) Modelling.

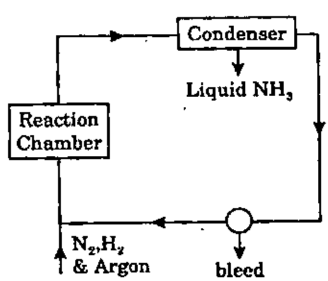
   (d) Simulation.

   (e) Optimization.

   (f) Dynamic Simulation.

4. What are the different types of governing equations used in the mathematical modelling of thermal systems? With the help of suitable examples explain the solution procedures for ODE and PDE models. 20

5. In the ammonia production system in figure, a mixture of 90 moles/s of nitrogen, 270 moles/s of hydrogen and 0.9 moles/s of argon enters the plant and is combined with the residual



mixture crossing a bleed valve. Argon is an impurity and adversely affects the reaction. In the chemical reactor, a fraction of the entering mixture combines to form ammonia, which is removed by condensation. The bleed valve removes 23.5 moles/s of the mixture to avoid build-up of argon. The fraction of the mixture that reacts to give ammonia in the reactor is 0.57 exp (– $0.0155F_1$), where F_1 is the amount of argon entering the reactor in moles/sec. Solve the resulting set of algebraic equations to obtain the flow rates and the amount of ammonia produced. 20

6. (a) Discuss various economic considerations in the development of a thermal system to achieve the desired objectives. 10

   (b) Considering suitable example of a thermal system develop an objective function considering economic and technical parameters. 10

7. (a) Classify various optimization methods. 2

   (b) In an electronic circuitry, the power source may be considered as a thin square with side dimension L in metres. It is desired to minimize the heat transfer from the surface of the power supply to the local surroundings. The heat transfer coefficient h in $W/(m^2k)$ is given by the expression :

$$h = (2 + 10L^{1/2})\Delta T^{1/4}L^{-1}$$

where ΔT is the temperature difference in K from the local ambient. A constraint arises due to the strength of the bond that attaches the power supply to the electronic circuit board as $L \Delta T = 5.6$. Calculate the side dimension L of the square that would minimize the total heat loss, solving the problem as both an unconstrained and a constrained one. 18

8. Classify various constrained and unconstrained search methods with multiple variables. Discuss steepest ascent/descent method in detail. 20