1. A spherical drop of liquid is suspended in an infinite atmosphere as shown in Fig-1. Owing to differences in temperature it is exchanging heat with its surroundings. It also is losing mass by evaporation to the surroundings. The instantaneous rate of heat transfer $\dot{Q}$ is expressed by

$$\dot{Q}=KA(T-T_o)$$

where K is a constant and A is the surface area. The instantaneous rate of mass transfer is given by the symbol $\dot{m}$. It may be assumed that at a given instant of time the sphere is uniform in temperature and always at a pressure equal to that of the surroundings, P_o. The vapor of the evaporating liquid in the region adjacent to the drop is saturated.

(a) Derive an expression for the instantaneous time rate of change of the drop temperature, $\partial T/\partial t$ in terms of the singnificant physical quantities.

(b) Estimate $\partial T/\partial t$ for water drop at $T_o=25^\circ C$, $P_o=2.339$ Kpa, $T=5^\circ C$, r=1.mm $h_{fg}=2489.6$ KJ/Kg, $\dot{m}=12.56\times10^{-3}$ g/min, $K=6.0$ KJ/m² ℃, $Cp=1.0$ KJ/Kg°C, $\rho=1000$ Kg/m³.

2. It is proposed to build a one million kW electric power plant with steam as the working fluid. The condensers are to be cooled with river water (see Fig-2). The maximum steam temperature will be T =550 °C and the pressure in the condensers will be 10 kPa. and temperature $T_L=T_C=45.8^\circ C$. As ans engineering consultant, you are asked to estimate the resulting temperature rise ΔT of the river far downstream of the plant.

(a) What is your estimate?

(b) How the maximum stream temperature T_H affects the river tempere rise $\partial\Delta T/\partial T_H$=?

3. Operation of an MHD converter requires an electrically conducting gas. It is proposed to utilize helium gas "seeded" with y=1.0 mole percent cesium, as shown in Fig-3. The cesium is partly ionized ($Cs \rightleftarrows Cs^+ + e^-$). by heating the mixure to 2500°K, 1 MPa in a nuclear reactor, in order to provide free electrons. No helium is ionized in this process, so that the mixture entering the converter consists of He, Cs, Cs^+, e^-. In order to analyze the converter process, it is necessary to know precisely the mole fraction of electrons in the mixture x.

(a) Determine how this seeded y cesiums affects the electrons in the mixture, $\partial x/\partial y$.

(b) Determine this fraction x. At 2500 °K, ln K = -13.4 for the reaction given above.

4. Steam expands through a turbine in a cogeneration power cycle from 60 bars and 440 °C to 0.08 bar. The turbine has an efficiency of 85 percent and delivers 50 MW of power. Steam is extracted at 5 bars for a heating load of 1×10^6 kJ/min. The steam leaves the heating load as a saturated liquid at 4 bars mixes with the steam leaving the condensate pump at 4 bars (see Fig-4)). The pump efficiencies are both 70 percent. Sketch the TS diagram and explain how can you determine the following quantities:

(a) The mass flow rates, through the heating load and through the condenser,

(b) The heat input in the boiler-superheater section,

(c) The ratio of the heating load plus the turbine output to the heat input.

151

5. A thermoelectric generator such as show in Fig-5 converts heat directly to electrical energy without moving parts. Such a device has been proposed, for thermodynamic analysis, the power supply unit may be represented as shown in Fig-5.

Other data are as follows:

$$\eta_{generator}=\frac{W_{elec}}{Q_H}=0.15$$

$$\eta_{elec,motor}=0.95$$

Electric motor output.=2 kW

Fan requirement=0.1 kW

Volumetric(dry) analysis of combustion products

		$\bar{h}^o_f$ (KJ/Kmol)	$\bar{C}_{p0}$ (KJ/Kmol K)
CO_2	9.0%	−393522.	44.29
CO	1.0	−110529.	29.98
O_2	7.0	0	31.17
N_2	83.0	0	29.77
H_2O	?	−241827.	35.37

(a) Write the combustion equation per mole of octane, and determine the percent theoretical air.

(b) Calculate the octane flow rate.

(c) Calculate the volume flow rate of cooling air required (inlet conditions).

($\bar{h}^o_{f,C_8H_{18}}$=−249952 kJ/k-mol)

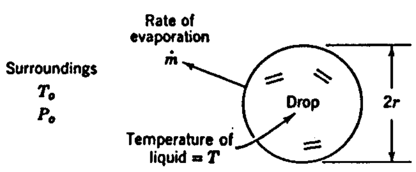

Fig-1

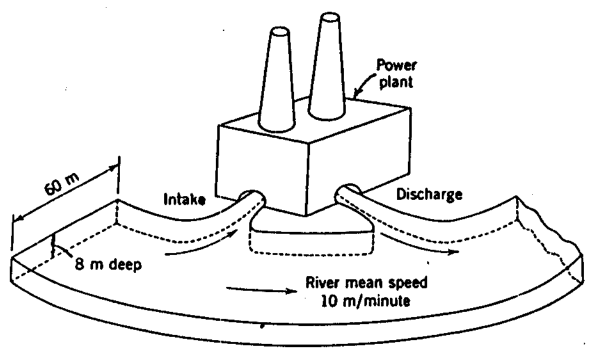

Fig-2

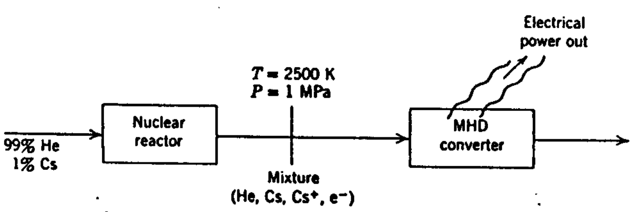

Fig-3

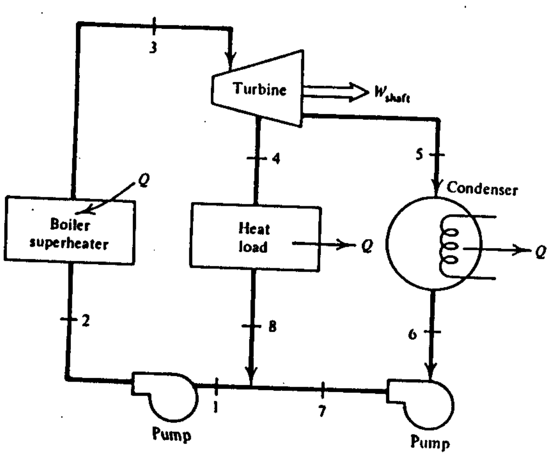

Fig-4

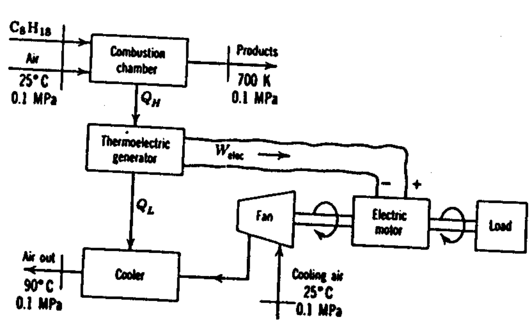

Fig-5