1. a) Show that $C_p - C_v$ can be expressed in terms of the volume expansivity α , the specific volume v, the temperature T, and the isothermal compressibility by the relation

$$C_p - C_v = \frac{\alpha^2 vT}{\beta_T}$$

where $\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_p = \frac{1}{v}\left(\frac{\partial v}{\partial T}\right)_p$, $\beta_T = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T = -\frac{1}{v}\left(\frac{\partial v}{\partial P}\right)_T$

(hint, $S = S(T,p) = S(T,v)$)

b) The pressure on a block of copper having a mass of 1 lbm is increased in a reversible process from 1 atm to 1000 atm while the temperature is held constant at 60 F. Determine the work done on the copper, the heat transfer, the change of internal energy per pound, and the value of $C_p - C_v$ at this temperature.
Over the range of pressures and the temperature involved in this problem the following data can be used:

Volume expansivity = $\alpha = 2.8 \times 10^{-5}\ R^{-1}$
Isothermal compressibility = $\beta_T = 5.9 \times 10^{-8}\ in.^2/lbf$
Specific volume = $1.82 \times 10^{-3}\ ft^3/lbm$

(hint, $w = \int p dv_T$).

2. Consider an ideal cycle in which air enters the compressor at 14.7 $lbf/in.^2$, 60 F. The pressure leaving the compressor is 70 $lbf/in.^2$ and the maximum temperature is 2000 F. The air expands in the turbine to such a pressure that the turbine work is just equal to the compressor work. On leaving the turbine the air expands in a reversible adiabatic process in a nozzle to 14.7 lbf/in. Determine

a) the pressure and temperature at each point in the cycle.
b) the compressor work and turbine work.
c) the velocity of the air leaving the nozzle.

(C_p = 0.24 Btu/F,lbm g = 32.17 ft/sec)

(接下頁)

3. a) Gaseous propane at 77 F is mixed with air at 300 F and burned. What percentage of theoretical air must be used if the temperature of the products is to be 1700 F? Assume an adiabatic process and complete combustion.

   b) with 300% theoretical air is used. What is the adiabatic flame temperature?

Constituent	h_f^0, Btu/lb mole (at 14.7psia 77 F)	$\overline{C}_{pav}$ Btu/lb mole R
C_3H_8	-44,700	64.5
CO_2	-169,300	11.0
$O_{2(g)}$	0	8.8
$N_{2(g)}$	0	8.0
H_2O	-104,000	11.2

4. Operation of an MHD converter requires an electrically conducting gas. It is proposed to utilize one mole of Carbon at 77 F to form an equilibrium mixture of CO_2, CO and O_2 at 3000 K, and "seeded" with 1.0 mole per cent cesium, as shown in Fig. 4. The cesium is partly ionized ($Cs \rightleftharpoons Cs^+ + e^-$) by heating the mixture to 3000 K 1.0 atm in a reactor, in order to provide free electrons. No other is ionized in this process, so that the mixture entering the converter consists of CO_2, CO, O_2, Cs, Cs^+, e^-. In order to analyze the converter process, it is necessary to know precisely the mole fraction of electrons in the mixture. Determine this fraction. At 3000 K, $\ln K_{(CS)} = -13.4$ and $K_{(C)} = 0.328$ for the reactions given above.

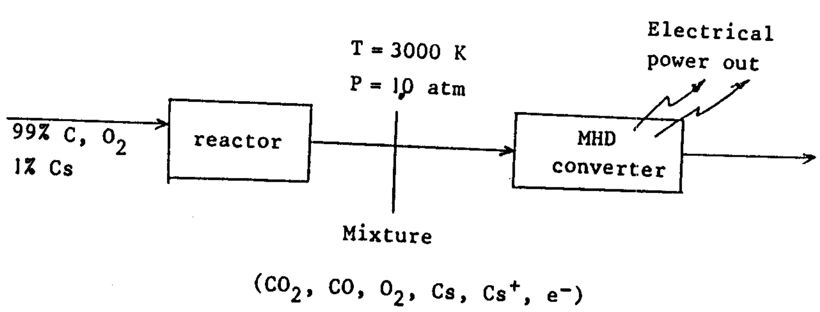

Fig. 4