GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - FALL Semester 2001

Thermodynamics
EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

- **Please sign your name on the back of this page—**

Problem #1: Use only the space provided, and write clearly.

a) What is a reversible process ?

b) How is heat different from work ?

c) What is an irreversible process ?

d) What is entropy ?

e) What is entropy production ?

f) Describe the second law in your own worlds without using the term entropy or the words order/disorder.

g) Is an irreversible isentropic process possible ? If not, why? If possible, give an example.

h) Why is the state principle important ?

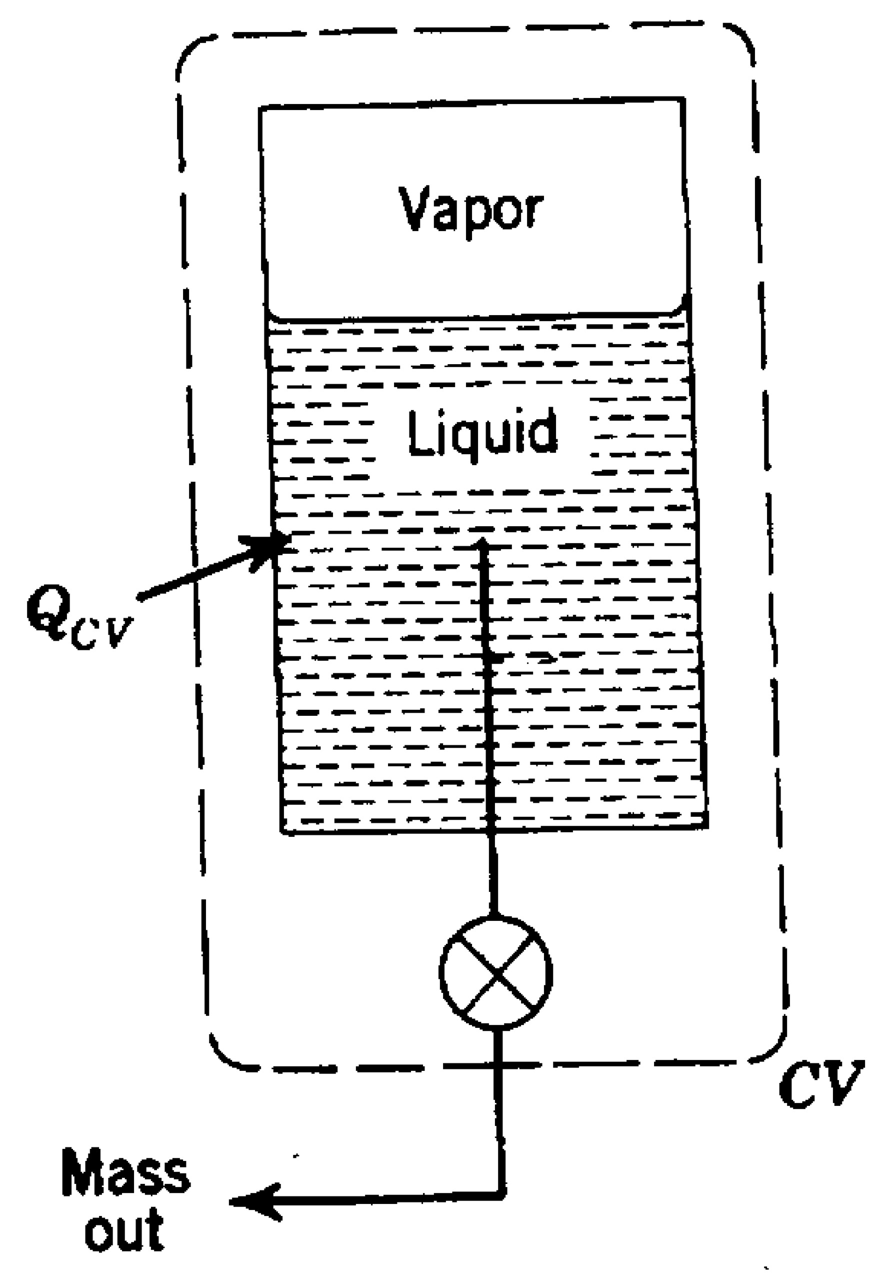
i) What is the significance of the area under a horizontal line on a T-s plane ?

j) Can the COP (coefficient of performance) of a heat pump ever exceed unity ? If so, Why ? If not why ?

Problem 2:

Refrigerant 12 is contained in a 1 m^3 tank at the temperature of the surroundings, 20°C. The tank is three-quarters full of liquid by **volume.** The top of the withdrawal pipe is at the middle of the tank, as shown below. The valve is now opened, and refrigerant 12 is withdrawn very slowing until the tank is one-quarter full of liquid. The process is then stopped. During this process the temperature inside the tank remains constant at 20°C, while the mass withdrawn is throttled across the valve to the lower pressure of 0.2 mPA and then discharged. The control volume is defined as shown below.

Calculate the:
a) Mass withdraw.
a) Heat transferred to the control volume.
b) Entropy change inside the control volume.
c) Entropy generation due to processes occurring inside the control volume.



Problem #3:

The differential property relations may be summarized as follows:

$$du = C_v dT + \left\{ T\left(\frac{\partial P}{\partial T}\right)_v - P \right\} dv \qquad (1)$$

$$ds = \frac{C_v}{T} dT + \left(\frac{\partial P}{\partial T}\right)_v dv \qquad (2)$$

$$dh = C_P \;\; dT + \left\{ v - T\left(\frac{\partial v}{\partial T}\right)_P \right\} dP \qquad (3)$$

$$ds = \frac{C_P}{T} dT - \left(\frac{\partial v}{\partial T}\right)_P dP \qquad (4)$$

(a) Showing all of your work, use some combination of the equations above to show that the difference is specific heats is in general

$$C_P - C_v = T\left(\frac{\partial v}{\partial T}\right)_P \left(\frac{\partial P}{\partial T}\right)_v$$

(b) Find the difference in specific heats for an ideal gas.

(c) Showing all your work, find the difference in specific heats for a van der Waals fluid for which

$$P = \frac{RT}{v - b} - \frac{a}{v^2}$$

(d) Show how the internal energy of an ideal gas with constant specific heat varies with volume by finding,

$\left(\frac{\partial u}{\partial v}\right)_T =$

and explain this finding physically.

(e) Show how the internal energy of a van der Waals gas varies with volume by finding,

$$\left(\frac{\partial u}{\partial v}\right)_T =$$

(f) Explain how you would find the change in enthalpy, not the internal energy, of a van der Waals fluid for the initial state (T_1, P_1) to the final state (T_2, P_2) if you had the equation of state as in part (c) and the appropriate specific heat data