

國立中央大學 109 學年度碩士班考試入學試題

所別： 機械工程學系 碩士班 熱流組(一般生)

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科目： 熱力學

* 計算題需計算過程，無計算過程者不予計分

本科考試可使用計算器，廠牌、功能不拘

* 請在答案卷(卡)內作答

1. (25 %) A piston-cylinder device with a set of stops initially contains 0.5 kg of steam at 1.0 MPa and 600°C. The specific volume is 0.4 m³/kg and the internal energy is 3300 kJ/kg at the initial state. The location of the stops corresponds to 60 percent of the initial volume. The steam is then cooled to reach the final pressure of 500 kPa.

Some properties of steam: At 1.0 MPa, the saturated temperature is 180°C, $v_f = 0.0011$ m³/kg, $v_g = 0.194$ m³/kg, $u_f = 761$ kJ/kg, $u_g = 2583$ kJ/kg. At 500 kPa, the saturated temperature is 152°C, $v_f = 0.001$ m³/kg, $v_g = 0.375$ m³/kg, $u_f = 640$ kJ/kg, $u_g = 2560$ kJ/kg.

(v is the specific volume and u is the internal energy. The subscripts f and g represent saturated liquid and saturated vapor, respectively. P represent pressure.)

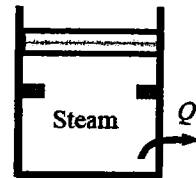
(5%) (a) Determine the phase condition of the steam at the initial state. (i.e. compressed liquid, saturated liquid, saturated vapor, saturated mixture, or superheated vapor.)

(5%) (b) Determine the phase condition of the steam at the final state.

(5%) (c) Determine the boundary work during the process.

(5%) (d) Determine the heat transfer during the process.

(5%) (e) Show the process path and its direction in the P - v property diagram.



2. (15 %) Peter claimed that he has invented a machine that can steadily convert 100 kW thermal energy to 80 kW work. The heat source is maintained at 450 K and the environment is maintained at 300 K during operation.

(5%) (a) Does the machine violate the first law of thermodynamics? Please briefly explain.

(5%) (b) Determine the thermal efficiency of the machine.

(5%) (c) Is Peter's claim reasonable? Please briefly explain.

3. (10 %) In a power plant thermal cycle, the steam (water) needs to be compressed from 100 kPa to 1.0 MPa steadily. Consider the following two cases: (a) steam exists as saturated liquid and (b) steam exists as saturated vapor at the inlet state. Assume the process is steady and isentropic, and the kinetic and potential energy are negligible. Which case requires more compression work? Please briefly explain.

4. (10 %) The Clapeyron equation is expressed as

$$\left(\frac{dP}{dT}\right)_{sat} = \frac{s_{fg}}{v_{fg}} = \frac{h_{fg}}{Tv_{fg}}$$

How can we utilize this equation?

5. (20 %) 家用冰箱只有一個壓縮機，卻可以製造出冷凍室、冷藏室等兩個以上不同溫度的空間，請說明其原理。

6. (20 %) An ideal gas Carnot cycle uses helium as the working fluid and rejects heat to a lake at 15°C. Determine the pressure ratio, compression ratio, and minimum temperature of the heat source for this cycle to have a thermal efficiency of 50 percent.

參考用