※ 考生請注意：本試題可使用計算機

I. Explain the following terms: (30%)
(1) Thermodynamic system
(2) Control volume
(3) Property
(4) Cycle
(5) Zeroth law of thermodynamics
(6) Allotropic transformation
(7) Triple point
(8) Boyle's and Charles's laws
(9) Compressibility factor
(10) The first law of thermodynamics

II. Make a comparison between heat and work. (7%)

III. Make a comparison between thermodynamics and heat transfer. (6%)

IV. The volume coefficient of expansion α is defined as

$$\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_p$$

Prove that $\alpha = 1/T$ for ideal gas. (6%)

V. A cylinder fitted with a piston has a volume of 0.1 m^3 and contains 0.5 kg of steam at 0.4 MPa. Heat is transferred to the steam until the temperature is 300°C, while the pressure remains constant. Determine the heat transfer and the work for this process. At the pressure of 0.4 MPa, v_f = 0.001084 m^3/kg, v_{fg} = 0.4614 m^3/kg, u_f = 604.31 kJ/kg, h_f = 604.74 kJ/kg, u_{fg} = 1949.3 kJ/kg and h_{fg} = 2133.8 kJ/kg. At the pressure of 0.4 MPa and the temperature of 300°C, h = 3066.8 kJ/kg and u = 2804.8 kJ/kg. (12%)

VI. During the charging of a storage battery the current in 20 A (amperes) and the voltage is 12.8 V (volts). The rate of heat transfer from the battery is 10 W. At what rate is the internal energy increasing? (7%)

VII. Prove the inequality of Clausius for a heat engine. (10%)

VIII. Prove that the thermal efficiency of a Carnot cycle is equal to $1 - T_L/T_H$, i.e., (10%)
$\eta = 1 - T_L/T_H$

IX. Nitrogen is compressed in a reversible process in a cylinder from 100 kPa, 20°C, to 500 kPa. During the compression process the relation between pressure and volume is $PV^{1.3}$ = constant. Calculate the work and heat transfer per kilogram, and show this process on P-v and T-s diagrams. Gas constant, R, is equal to 0.29680 kJ/(kg·K) for nitrogen. Assume C_{v0} to be constant over the whole process and C_{v0} is equal to 0.7448 kJ/(kg·K) for nitrogen. (12%)

Hint: $PV = mRT$ and $u_2 - u_1 = C_{v0}(T_2 - T_1)$.