The Open University of Sri Lanka
B.Sc. Degree Programme - Level 04
Final Examination – 2007/2008
PHU 2145 / PHE 4145 – Thermodynamics & Radiation
Duration: Two and Half (2 ½) hours

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Date: 27th June 2008 **Time: 2.00 p.m to 4.30 p.m**

ANSWER FOUR QUESTIONS ONLY

01. Identify the differences among Maxwell-Boltzmann, Fermi-Dirac and Bose Einstein statistics.

Five indistinguishable particles are to be distributed among the four equally spaced energy levels with no restriction on the number of particles in each energy state. If the total energy is to be 12ε.

(a) Specify the occupation number of each level for each macroscopic state, and

(b) Find the number of microscopic states for each macroscopic state.(assume that the degeneracy g_j=3 each)

02. What do you mean by the Polytropic process?

Show that the relationship between pressure P and volume V of a perfect gas which is undergoing a polytropic process is given by PV^n = constant. Where n is the degree of polytropic and it is given by $n = \dfrac{C_P - C}{C_V - C}$, C is the specific heat of the gas and, C_P and C_V have their usual meanings. Deduce an adiabatic process and an isothermal process from the polytropic process.

03. Explain what is meant by entropy of a thermodynamic system.

Show that the change in entropy of an ideal gas subjected to a reversible process A ⟶ B is given by

(a) $S_B - S_A = \int_A^B C_P \dfrac{dT}{T} - nR\ln\left|\dfrac{P_B}{P_A}\right|$ and (b) $S_B - S_A = \int_A^B C_V \dfrac{dT}{T} + nR\ln\left|\dfrac{V_B}{V_A}\right|$

Where the symbols have their usual meaning.

A mass m of water at T_1 is isobarically and adiabatically mixed with an equal mass of water at T_2 ($T_1>T_2$)..

Show that the entropy change of the universe is $2mC_P \ln\left\{\dfrac{T_1+T_2}{2\sqrt{T_1T_2}}\right\}$ and prove that this is positive.

03. What is meant by carnot cycle and carnot engine.

State the coefficient of performance of a carnot cycle refrigerator working between temperatures T_l and T_h ($T_h > T_l$).

A room air conditioner operates as a carnot cycle refrigerator between an outside temperature T_h and a room at a lower temperature T_l. The room gains heat from the outside at a rate $A(T_h - T_l)$ and this heat is removed by the air conditioner. The power supplied to the air conditioner is P.

(i) Show that the steady state temperature of the room is given by

$$T_l = \left(T_h + \frac{P}{2A}\right) - \frac{P}{2A}\left[1 + \frac{4T_h A}{P}\right]^{\frac{1}{2}}$$

(ii) If outside temperature is 30^0C and the room is maintained at 20^0C by an air conditioner with power 2 KW. Find the coefficient A in the room in units WK^{-1}.

05. What are the thermodynamic potentials? Justify your answer.

Establish Maxwell's thermodynamics relations.

Considering the entropy S, as a function of the temperature T and the pressure P, establish the relation $C_P - C_V = -T\left(\frac{\partial V}{\partial T}\right)_P^2\left(\frac{\partial P}{\partial V}\right)_T$

Determine C_V for iron at 30^0C from the following data for iron.

Coefficient of linear expansion $= 1.0 \times 10^{-5}\ {}^0C^{-1}$

Density $= 7.8 \times 10^3\ kgm^{-3}$

Bulk modulus $= 10^{11} Nm^{-2}$

$C_P = 0.5 \times 10^3 Jkg^{-1}K^{-1}$

06 Explain what is meant by "black body radiation".

Assuming that the radiation energy density U and the absolute temperature T of the black body radiation is given by $U = aT^4$ (where a is a constant).
Show that $R = \sigma T^4$. Where R is the total radiation emitted from a unit area of a black body and σ is a constant.

A blackened metal sphere circles round the sun at a distance $D = 3.5 \times 10^7$ km. Find its equilibrium temperature, assuming that the black body temperature of the sun is 6000 K. The radius of the sun is 7×10^5 km.

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