RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree
Second Year – Semester I Examination – March / April 2014

PHY 2101- THERMODYNAMICS AND RADIATION

Answer **Two** Questions Only Time allowed: Two hours

Universal gas constant (R) = $8.314\ J\ K^{-1}\ mol^{-1}$

The use of a non-programmable electronic calculator is permitted.

1. (a) Prove that the work done on the system of a fixed gas mass is given by $-PdV$ for *a* small volume change dV, where "P" is the pressure and "V" is the volume.

   (b) Prove that the work done on a system consisting of ideal gas in an isothermal and quasi-static expansion is given by; (a) $W = nRT \ln(V_1/V_2)$ and (b) $W = nRT \ln (P_2/P_1)$. The symbols have their usual meanings.

   (C) One mole of an ideal gas at temperature T_0 is initially confined to half the volume of an insulated container by an insulated partition. The partition is removed without doing any work. What is the resulting change of entropy?

2. (a) Write down the first law of thermodynamics.

   i. Prove that for an adiabatic and reversible process; $TV^{\gamma-1} = \text{constant}$, where $\frac{C_p}{C_v} = \gamma$,

   C_p is the molar heat capacity at constant pressure, C_v is the molar heat capacity at constant volume.

   ii. Prove that $C_p - C_v = R$ for an ideal gas.

   (b) Write down Stefan-Boltzman law for the black body radiation.

   i. How much more energy is emitted by an object that has a temperature of 100 K compared to an object that has a temperature of 10 K?

3. (a) Give a mathematical expression for the second law of thermodynamics.

(b) Write down the i. *Clausius Statement* and ii. *Kelvin-Planck Statement* of the Second Law of thermodynamics.

(c) Describe the operation of the Carnot ideal gas heat engine step by step with help of pressure versus volume diagrams.

(d) Obtain an equation for efficiency of a cycle of the Carnot engine.

(e) A power station contains a heat engine operating between two reservoirs, one comprising steam at 100 °C and the other comprising water at 20 °C. What is the maximum amount of electrical energy which can be produced for every Joule of heat extracted from the steam?