JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY
UNIVERSITY EXAMINATION 2012/2013

1ST YEAR 1ST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE) WITH IT

(SCHOOL BASED)

COURSE CODE: SPH 302

TITLE: THERMODYNAMICS

DATE: 1/5/2013 **TIME: 14.00-16.00PM**

DURATION: 2 HOURS

INSTRUCTIONS

1. **Answer ALL questions in Section A**
2. **Answer ANY two Questions from Section B**
3. **Use illustrations where possible**

Apply where necessary
Universal gas Constant $R = 8.314 J/K.mol$
Specific heat capacity of water $c = 4186\, J/kg.K$

SECTION A: - COMPULSARY (30 MARKS)

1. (a) State the Kelvin–Planck statement and Clausius statement of the second law of thermodynamics. (3 marks)

(b) Define the heat engine, the work done by a heat engine and the thermal efficiency of a heat engine. (3 marks)

(c) Suppose that 1.00 kg of water at 0.00°C is mixed with an equal mass of water at 100°C. After equilibrium is reached, the mixture has a uniform temperature of 50.0°C. What is the change in entropy of the system? (3 marks)

(d) Draw a PV diagram for an arbitrary cyclic process and use it to define reversible and irreversible process. (3 marks)

(e) Show that for a closed system where the only work is the displacement work the Helmholtz function F, the Gibbs function G and temperature T are related as

$$G = F - V\left(\frac{\partial F}{\partial V}\right)_T$$ (3 marks)

(f) Given that entropy is a function of temperature and volume only, that is $S = S(T,V)$, use the appropriate Maxwell's equation to show that

$$TdS = C_V dT + T\left(\frac{\partial P}{\partial T}\right)_V dV$$ (3 marks)

(g) A 1.0-mol sample of an ideal gas is kept at 0.0°C during an expansion from 3.0 L to 10.0 L. (i) how much work is done by the gas during the expansion? (ii) How much energy transfer by heat occurs with the surroundings in this process? (3 marks)

(h) What is the value for the change in internal energy when a gas undergoes, an adiabatic process, an adiabatic free expansion and an isovolumetric process.
(3 marks)

(i) You are given the following relation for entropy S, volume V, internal energy U, and the number of particles N, of a thermodynamic system: S^3=ANVU, where A is a constant. Derive a relation for (I) U, V, N, and T and (II) P, V, N, and T.
(3 marks)

(j) Show that the efficiency e of the Carnot engine and the performance coefficient K of the Carnot refrigerator are related by

$$K = \frac{1-e}{e}$$ (3 marks)

SECTION B: - ANSWER ANY TWO QUESTIONS FROM THIS SECTION

2. (a) Draw a $P-V$ diagram to describe the Otto cycle, which approximately represents the following processes occurring in an internal combustion engine i.e.

I. An adiabatic compression from V_1 to V_2

II. An isochoric pressure increase

III. An adiabatic expansion from V_2 to V_1

IV. An isochoric pressure decrease.

(12 marks)

(b) Show that the efficiency of the Otto cycle described in 2 (a) is $¦ = 1-\left(\frac{V_2}{V_1}\right)^{¥-1}$.

(8 marks)

3. (a) (i) Consider a container with an ideal gas at constant volume in a heat bath of temperature T. If the temperature is changed by dT, determine the heat capacity of the ideal gas. (5 marks)

(ii) Show that there is a relation $C_p = C_v + R$ between isobaric and isovolumic heat capacity per mole of an ideal gas. (7 marks)

(b) A substance of mass m_1, specific heat c_1 and initial temperature T_1 is placed in thermal contact with a second substance of mass m_2, specific heat c_2 and initial temperature $T_2 > T_1$. The two substances are contained in a calorimeter so that no energy is lost to the surroundings. The system of the two substances is allowed to reach thermal equilibrium. What is the equilibrium temperature and total entropy change for the system? (8 marks)

4. (a) Derive Maxwell's relations using the changes in internal energy, enthalpy, Helmholtz fuction and Gibbs function that takes place when a system undergoes an infinitesimal process from an initial equilibrium state to a final equilibrium state.

(16 marks)

(b) Given that entropy is a function of temperature and pressure only, that is $S = S(T, P)$, use appropriate Maxwell's relation to show that

$$Tds = C_p dT - T\left(\frac{\partial V}{\partial T}\right)_p dp$$

(4 marks)

5. (a) (i) Show that the relation $pV^{¥} =$ constant holds in quasi-static adiabatic process of an ideal gas and derive the work which the gas does in a quasi-static adiabatic process from $p_1V_1T_1$ to $p_2V_2T_2$. Assume the specific heat to be constant. (11 marks)

(ii) A heat engine takes in air at $20^0 C$ and a pressure of $1.01 \times 10^5\ Pa$ and compresses it adiabatically to 0.1 of the original volume. Find the final pressure and temperature.
Take $¥ = 1.14$ (5 marks)

(b) Make a table that outlines a comparison between the change in internal energy and enthalpy for a thermodynamic system. (4 marks)