UNIVERSITY OF NAIROBI

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF EDUCATION

SCIENCE BY DISTANCE LEARNING

FIRST SEMESTER EXAMINATIONS 2011/2012

SPH 302: THERMODYNAMICS

Date: ..... **Time: 1 1/2 Hours**

- **This paper consists of five (5) Questions**
- **Attempt any THREE Questions**

Constants

Gas constant R = 8.31 JK^{-1} mol^{-1}

Atmospheric Pressure = 1.01×10^5 NM^{-2}

Question 1

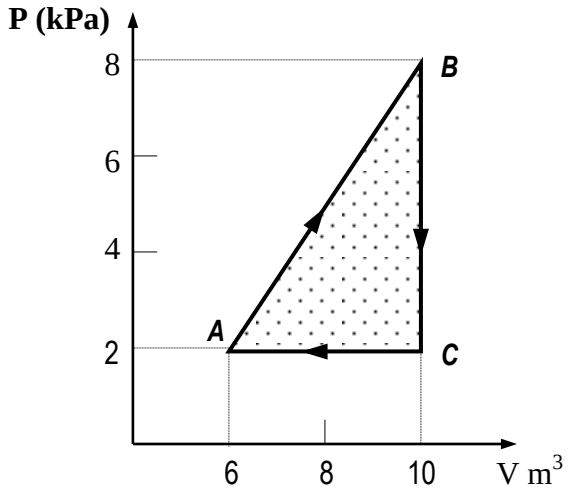
(a) Explain what is thermodynamics and how does this type of study differ from other braches of physics such as quantum mechanics. **[5 marks]**

(b) Differentiate between the following terminologies in thermodynamics
   (i) State variable and state function
   (ii) Closed and open system
   (iii) Reversible and irreversible processes
   (iv) Isothermal and adiabatic processes
   (v) Heat and work **[10 marks]**

(c) An ideal gas is taken through the cyclic process ABCA as shown in the figure below. Determine

   (i) The net heat transferred to the system in one cycle
   (ii) The net heat input for the reversed cycle ACBA.

[5 marks]



Question 2

(a) (i) State the first law of thermodynamics giving its physical significance and its limitations.

(ii) Show that the work done in isothermal expansion of an ideal gas from state (P_1, V_1) to a state (P_2, V_2) can be given by

$$W = nRT \ln \frac{V_2}{V_1}$$ where symbols have their usual meanings

(iii) List any 2 applications of adiabatic processes. **[10 marks]**

(b) Figure 2 below shows an energy cycle with three reversible processes to which 16g of oxygen gas (M_r = 32) are subjected. Calculate

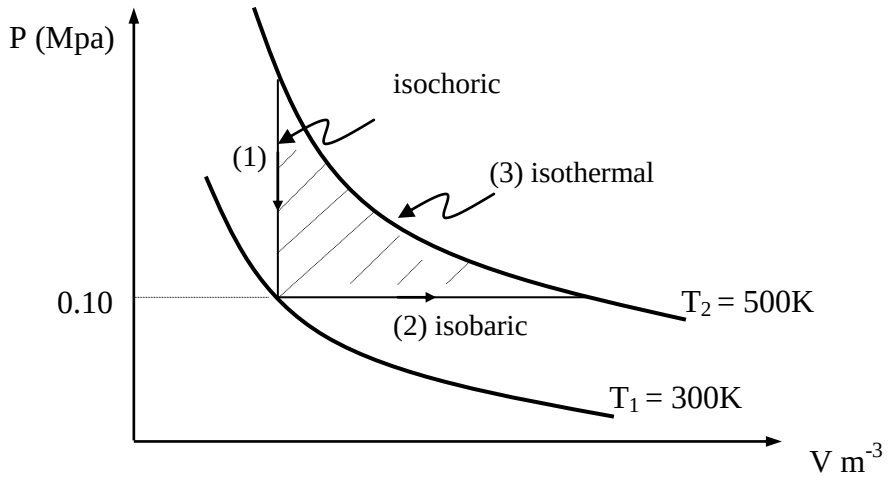
(i) The heat taken from the gas during the isochoric cooling process,

(ii) The gain in internal energy by the gas during process (2).

(iii) The work done by the gas during process (2),

(iv) The heat supplied during process (2), and the work done on the gas while it is compressed isothermally. ($C_{v,m}$ for oxygen is 21 mol^{-1} K^{-1}).

[10 marks]



Question 3

(a) State the "**Engine**" and the "**Refrigerator**" Statements of the second law of thermodynamics and give an example of a perpetual machine of the second kind. **[6 marks]**

(b) (i) Explain what is **Entropy** and state its significance

(ii) Show how the concept of Entropy change leads to the second law of thermodynamics and hence explain the significance of the second law of thermodynamics. **[8 marks]**

(c) A hypothetical refrigerator takes 1000 J of heat from a cold reservoir at 100K and ejects 1200 J of heat to a hot reservoir at 300K.

(i) Determine work done by the refrigerator

(ii) What happens to the entropy of the universe?

(iii) Does this system violate the 2nd Law of thermodynamics? **[6 marks]**

Question 4

(a) Explain the following terms
   (i) A phase
   (j) Phase boundary
   (ii) Component
   (iii) Thermodynamic equilibrium **[6 marks]**

(b) The Clausius-Clapeyron equation for the shape of a phase boundary in a one component system is given by

$$\frac{dP}{dT} = \frac{L}{TdV}$$ where symbols have their usual meanings.

Sketch the P-T projections for a substance which expands on melting and one which contracts on melting and consequently, explain the effect of pressure on the melting point of ice. **[6 marks]**

(c) Calculate the change in the boiling point of water when the pressure is increased by 1 atmosphere. [*Boiling point of water is 373 K at 760 mmHg, Specific volume of steam = 1.671 m^3 kg^{-1} and latent heat of steam is 2.268 $\times$ 10^6 J Kg^{-1}.*] **[4 marks]**

(d) (i) Using examples, explain the importance of thermodynamic potentials in thermodynamics?
   (ii) Internal energy (U) of a system is a function of Entropy (S) and volume (V). From this information, derive the related Maxwell's equation.
[6 marks]

Question 5

(a) (i) What is Carnot engine?
   (ii) Using the concept of entropy change, show that the thermal efficiency of a Carnot engine can be given by

$$\varepsilon = 1 - \frac{Q_c}{Q_h} = 1 - \frac{T_c}{T_h}$$ where symbols have their usual meanings.

   (ii) Explain why efficiency of a real engine is always less than that of a Carnot engine. **[10 marks]**

(b) An inventor claims to have developed an engine which takes in 11×10^7 J at 400K, rejects 5×10^7 J at 200K and delivers 16.67 kW hours of work. Would you advice investing money in this project? Explain **[5 marks]**

(c) Explain the 3RD law of thermodynamics and list at least TWO consequences of the 3RD law of thermodynamics. **[5 marks]**