UNIVERSITY OF NAIROBI

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF EDUCATION

SCIENCE BY DISTANCE LEARNING

FIRST SEMESTER EXAMINATIONS 2010/2011

SPH 302: THERMODYNAMICS

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

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

Physical constants

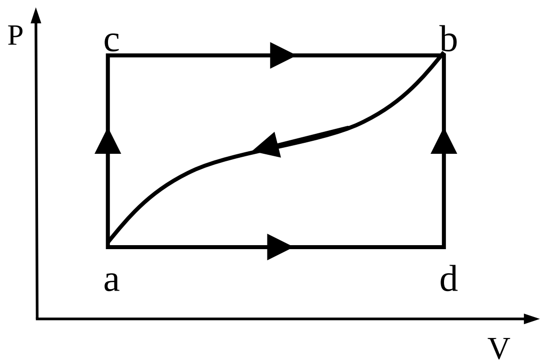
Gas constant R = 8.31 JK^{-1} mol^{-1}

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

Question 1

(a) State the first law of Thermodynamics giving its physical significance. **[3 marks]**

(b) A gas is contained in a cylinder fitted with a frictionless piston and is taken from state **a** to state **b** along the path **acb** as shown in Fig. 1. 80J of heat flow into the system and the system does 30J of work.



(i) How much heat flows into the system along the path **adb** if the work done by the gas system is 10J.

(ii) When the system is returned from state **b** to **a** along the curved path, the work done on the system is 20J. Find the heat transfer.

(iii) If $\mathbf{U_a}$ = 0 and $\mathbf{U_d}$ = 40J, find the heat absorbed in the process **ad** and **db**. **[6 marks]**

(c) (i) Distinguish between isothermal and adiabatic processes.

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

$$W = \frac{1}{\gamma}\left[P_1V_1 - P_2V_2\right]$$

where symbols have their usual meanings **[7 marks]**

(d) Explain why

(i) Gases have two specific heats?

(ii) The specific heat at constant pressure $\boldsymbol{C_P}$ is greater than the specific heat at constant volume, $\boldsymbol{C_V}$. Is there an exception where $\boldsymbol{C_V}$ is greater than $\boldsymbol{C_P}$?. Is so, give example. **[4 marks]**

Question 2

(a) (i) Explain the concept of Entropy and disorder

(ii) What happens to change in the Entropy of a system which undergoes

- A reversible process
- An adiabatic process **[4 marks]**

(b) The figure below shows a Carnot reversible cycle ABCD on a P-V indicator diagram where heat Q_1 enters the system in the isothermal process at T_1 and heat Q_2 is ejected from the system in the isothermal process at T_2.

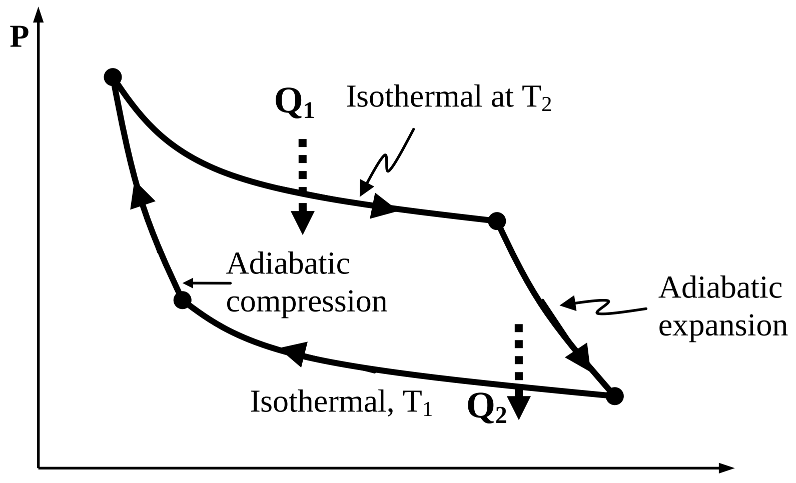


Fig 2

(i) Represent this cycle on a T-S diagram

(ii) Using your T-S diagram, establish the relationship for the efficiency of the Carnot's engine in terms of T_1 and T_2.

(iii) Explain the importance of T-S diagrams. **[6 marks]**

(c) In a refrigerator, the cooling chamber is maintained at 290K while the outside temperature is 305K. The motor (located outside) has compression cylinders operating at 320K and the expansion coils inside the chamber operating at 280K. If the motor operates reversibly

(i) Give a schematic diagram illustrating the sequence of events
(ii) Calculate the efficiency of the refrigerator
(iii) How much work must be done for each transfer of 5000J of heat from the chamber?
(iv) Determine the entropy change inside and outside the chamber for this amount of refrigeration?
(v) Explain why it becomes difficult to obtain cooling at very low temperatures in refrigerator. **[10 marks]**

<u>Question 3</u>

(a) Briefly explain the following
  (i) Second Law of Thermodynamics
  (ii) Carnot's Theorem **[4 marks]**

(b) Figure 3 below shows an operation cycle for an idealized diesel engine where fuel is sprayed into the cylinder at pt B and the combustion occurs in the isobaric process B $\rightarrow$ C. Show that the efficiency of the engine can be given by **[6 marks]**

$$e = 1 - \frac{1}{\gamma}\left(\frac{T_D - T_A}{T_C - T_B}\right)$$ where symbols have their usual meaning

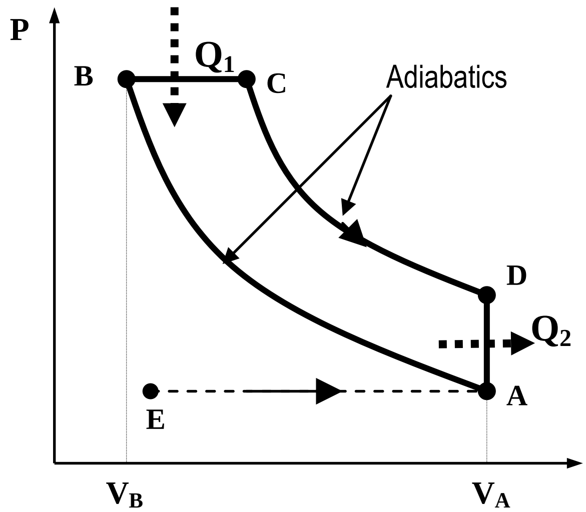


Fig. 3. P-V diagram for an ideal diesel engine

(c) (i) Discuss some of the factors that affect the efficiency of automobile engines
  (ii) Explain why the efficiency of diesel engines is greater than the petrol engines
  (iii) Briefly explain the principle behind Turbochargers and intercoolers. **[6 marks]**

(d) 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 hrs of work. Would you advice investing money in this project? Explain.

[4 marks]

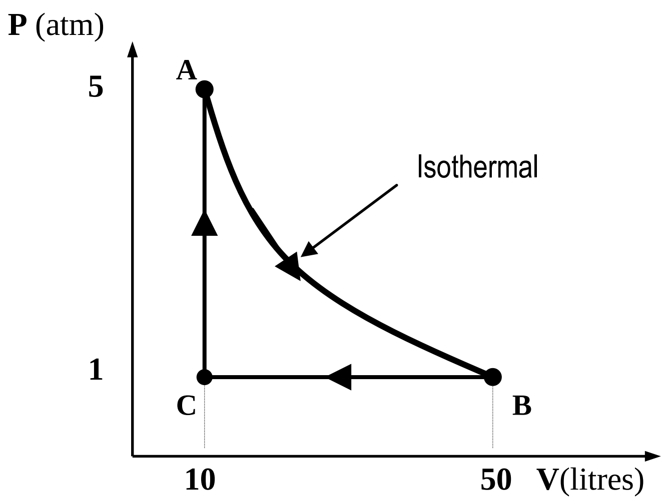
<u>Question 4</u>

(a) Briefly explain the following terms as applied to thermodynamics
- (i) Closed system
- (ii) State function
- (iii) Equation of state
- (iv) Zeroth law of Thermodynamics
- (v) Reversible process **[5 marks]**

(b) What is the difference between heat and thermal energy. Why is heat is not a state function. **[3 marks]**

(c) An ideal monoatomic gas (γ = 5/3) expands reversibly from a state V_1, P_1 to a volume V_2. Calculate the work done by the gas if the change takes place
- (i) isothermally
- (ii) adiabatically **[4 marks]**

(d) A 1.00-mol sample of an ideal monatomic gas is taken through the cycle shown in the Figure below. Calculate
- (i) The net work done by the gas
- (ii) The energy added to the gas by the heat
- (iii) The energy exhausted from the gas by the heat
- (iv) The efficiency of the cycle. **[8 marks]**



<u>Question 5</u>

(a) Define **Entalpy (H)** and **Gibbs Free Energy (G)** in terms of thermodynamic state variables and obtain the related Maxwell's equations respectively.

[4 marks]

(b) When one gram of water is converted to steam at atmospheric pressure, it occupies a volume of 1671 cm3.

(i) Compare the volume of steam with the volume that would be occupied at this temperature and pressure if the water vapour were an ideal gas.

(ii) Compute the increase in the internal energy (U), Entropy (S), Entalpy (H) and Gibbs Free Energy (G) when one gram of water is evaporated at this temperature and pressure.

(iii) Explain the significance of your answer in c(ii). **[10 marks]**

(d) (i) State and explain with example the 3^{RD} law of thermodynamics.

(ii) Explain some of the consequences of the 3^{RD} law of thermodynamics **[6 marks]**
