LUKENYA UNIVERSITY

UNIVERSITY EXAMINATIONS FOR THE AWARD OF THE DEGREE OF BACHELOR OF EDUCATION
2021/2022 ACADEMIC YEAR
MAY SEMESTER 2022

UNIT CODE: LSPH 3102

UNIT TITLE: THERMODYNAMICS

DATE: AUGUST 2022 **TIME: 2 HOURS**

INSTRUCTIONS
1. Answer **question one** and **any other two** questions
2. Do **not** write anything on this question paper
3. Do **not** write in the page margins of the answer booklet
4. Begin each question answer on a new page

Take the Boltzmann's constant $k = 1.387 \times 10^{-23} J/K$ and the universal gas constant $R = 8.315 Jmol^{-1}K^{-1}$

QUESTION ONE (COMPULSORY) (30 MARKS)

(a) State the first law of thermodynamics. What is the implication of this law? (3 marks)

(b) An ideal gas is compressed isothermally from state (P_1,V_1) to state (P_2,V_2). Show that the heat energy given out is given by

$Q = NKTln(^{v_2}/_{v_1})$

Where the terms have their usual meanings (5 marks)

(c) A Carnot's engine working as a refrigerator between 260K and 300K receives 500calories of heat from the reservoir at a lower temperature. Calculate

(i) the amount of heat rejected to the reservoir at a higher temperature (3 marks)

(ii) the efficiency of the engine (3 marks)

(d) define entropy (2 marks)

(e) a piece of ice of mass 0.500kg at a temperature of 273.15k and under constant pressure of 1 atmosphere melts to water at a constant temperature and in so doing

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extracts 170000J of heat from the atmosphere, which is at a temperature slightly higher than that of the ice. Calculate:

(i) the change in the entropy of the ice when it has all melted (3 marks)

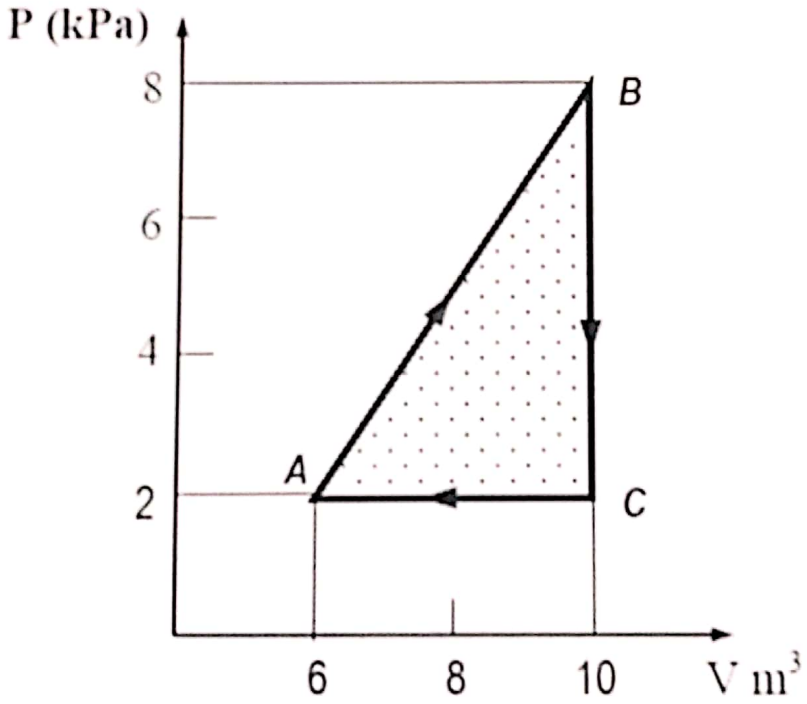
(ii) the corresponding change in the entropy of the atmosphere (3 marks)

(iii) the change in the entropy of the universe resulting from the melting process (3 marks)

(f) 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 (3 marks)

(ii) The net heat input for the reversed cycle (2 marks)



QUESTION TWO (20 MARKS)

(a) Explain the concept of entropy and disorder (2 marks)

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

(i) A reversible process (2 marks)

(ii) An adiabatic process (2 marks)

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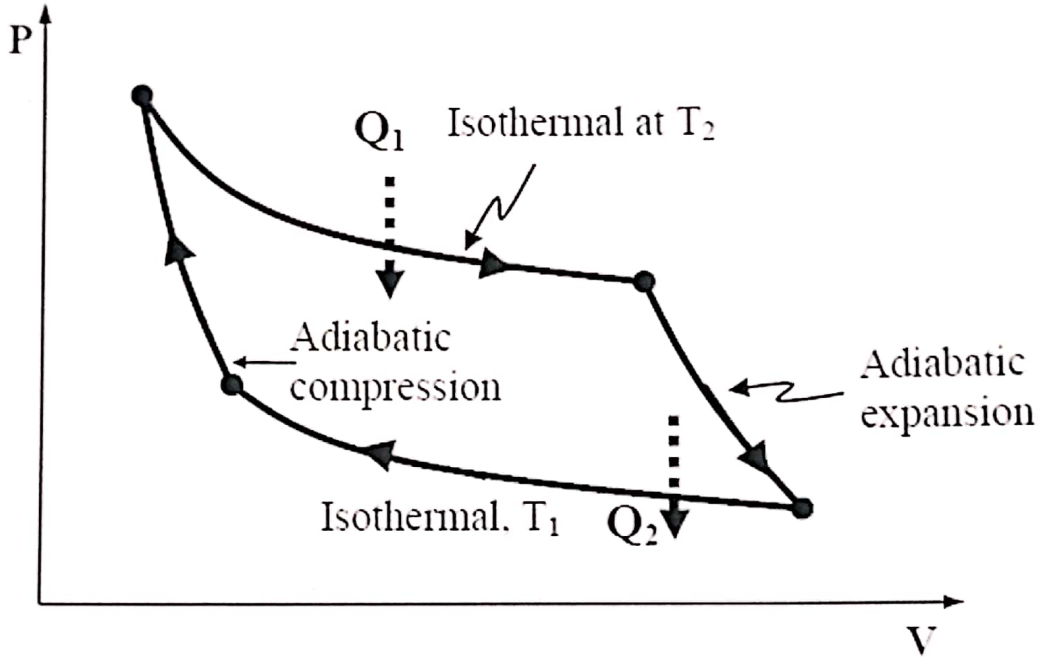
(c) The figure below shows a Carnot reversible cycle ABCD on a P-V indicator diagram where heat Q1 enters the system in the isothermal process at T1 and heat Q2 is ejected from the system in the isothermal process at T2



(i) Represent this diagram in a T-S diagram (2 mark)

(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 (3 marks)

(iii) Explain the importance of the T-S diagram (3 marks)

(d) 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 (3 marks)

(ii) What happens to the entropy of the universe? (2 marks)

(iii) Does this system violate the second law of thermodynamic? (1 mark)

QUESTION THREE (20 MARKS)

(a) Define entropy of a thermodynamic system (2 marks)

(b) Differentiate a reversible thermodynamic process and an irreversible process (4 marks)

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(c) Show that the change in the entropy of a the universe when a system consisting of **n** moles of an ideal gas undergoes a free expansion from an initial equilibrium state ***i*** characterized by pressure p_i, volume v_i, and temperature T_i to a final equilibrium state ***f*** with pressure P_f, volume V_f and temperature T_f is given by

$$\Delta S\ (system) = [P_i V_i \ln(V_f / V_i)]$$

(5 marks)

(d) A Carnot engine operates between heat reservoirs and heat interactions with that reservoir, the working substance absorbs 21000J of heat in each cycle. If the work output of the engine in each cycle is 5025J, calculate the value of T_0.(5 marks)

(e) State the Zeroth law of thermodynamics (2 marks)

(f) Distinguish between an adiabatic and isothermal processes (2 marks)

QUESTION FOUR (20 MARKS)

(a) Define thermodynamic potential functions (2 marks)

(b) The molar Gibbs function G_m for a certain closed hydrostatics system that exerts a pressure P at temperature T is given by

$$G_m = RTlnP + A + BP + \frac{CP^2}{2} + DP^3/3$$

Where R is the molar gas constant and A,B,C and D are functions of temperature only. Derive an expression for the equation of state of this system (6 marks)

(c) State four Maxwell's relations of the thermodynamics (4 marks)

(d) State the third law of thermodynamics. (2 marks)

(e) What is the consequence of application of the third law of thermodynamics? (2 marks)

(f) Calculate the entropy change when 100g of water at 100^0c is mixed with 50g of water at 10^0c. (specific heat capacity of water $c = 4.185 \times 10^3 \frac{J}{kg}/K$)

(4 marks)

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QUESTION FIVE (20 MARKS)

(a) State the Carnot's theorem (2 marks)

(b) Describe the entropy changes in the working substance of the reversible hot engine during a cycle (4 marks)

(c) A Carnot's engine has an efficiency of 50% when its sink temperature is 27^0C. What must be the change in its source temperature to make the efficiency 60%? (4 marks)

(d) Calculate the amount of energy required to remove 700000J of heat from the freezer of a refrigerator operating at a maximum efficiency if the freezer temperature is -5^0C and the room temperature is 20^0C (3 marks)

(e) How much heat is deposited in the room by the refrigerator in (d) above (3 marks)

(f) An ideal monoatomic gas $\gamma = 5/3$ expands reversibly from a state V1, P1 to a volume V2. Calculate the work done by the gas if the change takes place

(i) isothermally (2 marks)

(ii) adiabatically (2 marks)

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