KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER
SUPPLEMENTARY/SPECIAL EXAMINATIONS

FOR THE DEGREE IN BSC (PHYSICS)

COURSE CODE: SPC 413

COURSE TITLE: THERMODYNAMICS

DATE: 14/11/2022 **TIME:** 11:00AM-1:00PM

INSTRUCTIONS TO CANDIDATES

TIME: 2 HOURS

Answer question ONE and any TWO of the remaining

KIBU observes ZERO tolerance to examination cheating

USEFUL CONSTANTS

$R = 8.31J/K.mol$= 0.082L.atm/mol.K

QUESTION ONE [30 MARKS]

(a) State Zeroth law [1 mark]

(b) Differentiate between the following

(i) An open system and a closed system [2 marks]

(ii) Adiabatic wall and diathermic wall [2 marks]

(c) Given the following constants for the Van der Waals equation for carbon dioxide$a = 0.37Nm4mol^{-2}$and $b = 43Cm^3mol^{-1}$.Using the Van der Waals equation find the pressure exerted by carbon dioxide gas at 0^0C if it has a specific volume of $0.55Lmol^{-1}$. [3 marks]

(d) State the first law of thermodynamics. If the internal energy of an ideal gas drops by $4.5\ x\ 10^3J$ when heat energy of $7.5\ x\ 10^3J$ is expelled out of it, find the change in volume at constant pressure of $1.01\ x\ 10^5Pa$. [4 marks]

(e) A fluid of volume $0.05m^3$ is contained behind a piston at pressure of $1.0\ x\ 10^6N/m^2$. After a reversible expansion of constant pressure the final volume is $0.2m^3$. Calculate the work done by the fluid. [3 marks]

(f) When a gas expands adiabatically its volume is doubled while its absolute temperature is decreased by a factor of 1.32. Calculate the degree of freedom for the gas molecule. [3 marks]

(g) State the second law of thermodynamics. A Carnot engine absorbs heat at 227^0C and rejects heat at 27^0C. Determine its efficiency. [4 marks]

(h) State the third law of thermodynamics. Determine the change in entropy for 1kg of water when heated from 0^0C to 50^0C. $[C_V = 4.13x10^3JK^{-1}kg^{-1}]$ [4 marks]

(i) Show that the work done on a gas during an isothermal compression from initial volume V_1 to final volume V_2 is given by:- $W = -nRTln(V_2/V_1)$ [4 marks]

QUESTION TWO [20 MARKS]

(a) $1.0\ x\ 10^{-3}m^3$ of Helium at normal conditions of $P_0 = 1bar$ and $T_0 = 0^0C$ is heated to final temperature of $500K$. What is the entropy change for an isobaric and an isochoric process? $[C_P = 21J/(molK), C_V = 12.7J/(molK)]$ [10 marks]

(B) Show that the work done on a gas during an adiabatic compression from (P_1,V_1) to (P_2,V_2) is given by $W = \frac{1}{\gamma-1}(P_2V_2 - P_1V_1)$. [10 marks]

QUESTION THREE[20 MARKS].

(a) Internal energy, heat, enthalpy, work and Gibbs free energy are all measured in Joules. What is the difference in between these forms of energy? Write down the equations relating these forms of energy. [12 marks]

(b) Show that for a monatomic ideal gas undergoing an adiabatic process $PV^{5/3} = C$ where C is a constant. [8 marks]

QUESTION FOUR [20 MARKS]

(a) Consider a reversible isothermal expansion of an ideal gas in contact with reservoir at temperature T, from an initial volume V_1 to final volume V_2.

i) What is the change in the internal energy of the system? [2 marks]
ii) Calculate the work done by the system [2 marks]
iii) What is the amount of heat absorbed by the system? [2 marks]
iv) Find the entropy change of the system [2 marks]
v) Find the entropy change of the system and the reservoir. [2 marks]

(b) Write down an expression for total work done by a Carnot engine and hence obtain an expression for its efficiency. [10 marks]

QUESTION FIVE [20 MARKS]

(a) A simple heat engine contains an ideal monoatomic gas confined to a cylinder by a movable piston. The gas in the piston at $T = 3x\,10^2$K and V= 5 litres, first undergoes an isochoric process and its pressure changes from 1 atm to 3 atm. Then it passes through an isothermal expansion process where its volume changes from 5 litres to 15 litres after which it goes back to its original state by passing through an isobaric compression process. [4 marks]
Find the number of moles of a gas and temperature at stage II of the gas.

(b) Find the change in thermal energy (ΔU) thermal energy added (Q) and work done (W) between stage I and II. [4 marks]

(c) Repeat (b) above between stage II and III [4 marks]

(d) Repeat (b) above between stage III and I [2 marks]

(e) Find the net change in internal energy. [2 marks]

(f) Find the thermal energy (Qh) transferred to the system and thermal energy rejected (Qc) and hence findthe efficiency of the heat engine. [4 marks]