**OASIS OF KNOWLEDGE**

# JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

## UNIVERSITY EXAMINATION FOR THE DEGREE OF MASTERS OF SCIENCE IN PHYSICS

**MAIN**

**REGULAR**

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**COURSE CODE: SPB 9313**

**COURSE TITLE: THERMODYNAMICS**

**EXAM VENUE:** **STREAM: YEAR THREE**

**DATE:** **EXAM SESSION:**

**TIME: 3:00HRS**

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**Instructions:**

1. **Answer question one (1) (Compulsory) in Section A and ANY other 2 questions in Section B.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

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## Question 1 (30 Marks)

a. Define state functions [2marks]

b. State the fist law of thermodynamics [2marks]

c. Show that $pV = nRT$ for ideal gas [5marks]

d. How many moles of ideal gas are there in a room of volume 50$m^3$ at atmospheric pressure and 300K? [5marks]

e. Discuss the four kinds of thermodynamic processes [4marks]

f. By defining entropy, state the second law of thermodynamics [4marks]

g. 0.2 $m^3$ of air at 4 bar and 130°C is contained in a system. A reversible adiabatic expansion takes place till the pressure falls to 1.02 bar. The gas is then heated at constant pressure till enthalpy increases by 72.5 kJ. Calculate :

i. The work done [4marks]

ii. The index of expansion, if the above processes are replaced by a single reversible polytropic process giving the same work between the same initial and final states. Take $c_p$ = 1 kJ/kg K, $c_v$ = 0.714 kJ/kg K [4marks]

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## Question 2 [20 marks]

a. A stone of 20 kg mass and a tank containing 200 kg water comprise a system. The stone is 15 m above the water level initially. The stone and water are at the same temperature initially. If the stone falls into water, then determine $\Delta U$, $\Delta PE$, $\Delta KE$, Q and W, when:

i. the stone is about to enter the water [4marks]

ii. the stone has come to rest in the tank [4marks]

iii. the heat is transferred to the surroundings in such an amount that the stone and water come to their initial temperature [4marks]

b. Differentiate between heat capacity and specific heat capacity [4marks]

c. Compute the heat capacity of ideal gas at constant volume $C_V$ and heat capacity at constant pressure $C_p$ and $C_p = C_v + nR$ where R is the universal gas constant [4marks]

## Question 3 [20 marks]

a. spherical air bubble of radius 2cm is released 30m below the surface of a pond at 280K. What is its volume when it reaches the surface, which is at 300K assuming it is in thermal equilibrium the whole time? Ignore the size of the bubble compared to other dimensions like 30m. [5marks]

b. One mole of ideal Nitrogen gas is at 2 atmospheres and occupies a volume of 10m3 . Find T in Kelvin, U the internal energy (assumed to be just kinetic energy) in Joules, and the typical velocity of the gas molecules which have a mass $4.65\text{x}10^{-26}$kg? [7marks]

c. Explain the four processes in the Carnot cycle [4marks]

d. Show the Maxwell relation $\partial T/\partial V)_S = -(\partial p/\partial S)_V$ [4marks]

## Question 4 [20 marks]

a. Define **adiabatic expansion** [2marks]

b. . 90 kJ of heat are supplied to a system at a constant volume. The system rejects 95 kJ of heat at constant pressure and 18 kJ of work is done on it. The system is brought to original state by adiabatic process. Determine :

   i. The adiabatic work [3marks]

   ii. The values of internal energy at all end states if initial value is 105 kJ. [3marks]

c. A cylinder contains 0.45 $m^3$ of a gas at $1 \times 10^5$ $N/m^2$ and 80°C. The gas is compressed to a volume of 0.13 $m^3$, the final pressure being $5 \times 10^5$ $N/m^2$.

   Determine :

   i. The mass of the gas [3marks]

   ii. The value of index ‘n’ for compression [3marks]

iii. The increase in internal energy of the gas [3marks]

iv. The heat received or rejected by the gas during compression [3marks]

Take $\gamma = 1.4$, R = 294.2 J/kg°C.

## Question 5 [20 marks]

a. Show that for an ideal gas,

i. $pV^{\gamma} = Constant$ during an adiabatic process where $\gamma = \frac{C_p}{C_v}$ [6marks]

ii. $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1} = Constant$ during an adiabatic process [6marks]

b. Discuss the four processes of the Carnot cycle [8marks]