NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT OF TECHNICAL AND ENGINEERING EDUCATION AND TRAINING

THERMODYNAMICS

PTE 2246

Main Examination Paper

May 2019

This examination paper consists of 4 pages

Time Allowed:	**3 hours**
Total Marks:	**100**
Special Requirements:	**Nil**
Examiner's Name:	**Eng B. Sarema**

INSTRUCTIONS AND INFORMATION TO CANDIDATE

1. Answer Question 1 and any other three (3) questions
2. Each question carries 25 marks
3. There are six (6) questions
4. Use of calculators is permissible
5. Thermodynamic Steam Tables may be used

QUESTION 1

Using the different power cycles, their schematic diagrams and relevant practical examples, discuss the role played by thermodynamics in the energy mix of a country like Zimbabwe. [25]

QUESTION 2

(a) Define thermodynamics as a field of study [4]

(b) Explain the following thermodynamic systems giving a practical example of each system;

(i) Open system [2]

(ii) Closed system [2]

(iii) Isolated system [2]

(c) Explain the meaning of the different laws of thermodynamics [8]

(d) In a steady-flow open system a fluid substance flows at the rate of 4 kg/s. It enters the system at a pressure of 600 kN/m^2, a velocity of 220 m/s, internal energy of 2200 kJ/kg and specific volume 0.42 m^3/kg. It leaves the system at a pressure of 150 kN/m^2, a velocity of 145 m/s, internal energy 1650 kJ/kg and specific volume 1.5 m^3/kg. During its passage through the system, the substance has a loss by heat transfer of 40 kJ/kg to the surroundings. Determine the power of the system, stating whether it is done by the system or on the system, Neglect any change in gravitational potential energy [7]

QUESTION 3

(a) Explain the following terms used in thermodynamics;

(i) Heat energy [2]

(ii) Temperature [2]

(iii) Internal energy [2]

(iv) Entropy [4]

(b) A quantity of steam at a pressure of 21 Bars and dryness fraction 0.9 occupies a volume of 0.427 m^3. It is expanded according to the law $PV^{1.25} = C$ to a pressure of 7 Bars. Determine

(i) The mass of the steam present [3]

(ii) The work transfer [3]

(iii) The change in internal energy [4]

(iv) The heat exchange between the steam and the surroundings, stating the direction of flow. [5]

QUESTION 4

(a) Describe the following thermodynamic processes;

(i) Adiabatic process [2]

(ii) Isobaric process [2]

(iii) Isochoric process [2]

(iv) Isothermal process [2]

(v) Isentropic process [2]

(b) A boiler delivers 5400 kg of steam/h at a pressure of 750 kN/m^2 and with a dryness fraction of 0.98. The feed water to the boiler is at a temperature of 41.5 °C. The coal used for firing the boiler has a calorific value of 31 000 kJ/kg and is used at a rate of 670 kg/h. Determine;

(i) The thermal efficiency of the boiler [4]

(ii) The equivalent evaporation of the boiler in kg/ coal [5]

(iii) An economizer is fitted to the boiler which raises the feed water temperature to 100°C and the thermal efficiency of the boiler is increased by 5 %, all other conditions remaining unchanged. Determine the new coal consumption and hence the savings obtained from the economizer. [6]

QUESTION 5

(a) Distinguish between the different ways in which heat energy can be transferred. [9]

(b) Construct a Sankey diagram to represent energy flow in a steam turbine power plant. [9]

(c) Distinguish between the Carnot efficiency and Thermal efficiency in a thermodynamic process. [7]

QUESTION 6

(a) Using sketches, describe the principle of operation of the following refrigeration cycles;

(i) Vapour compression cycle [4]

(ii) Vapour absorption cycle [5]

(iii) Vapour adsorption cycle [3]

(iv) Steam jet refrigeration cycle [4]

(v) Evaporative cooling cycle [4]

(b) Discuss the resolutions of the Montreal Protocol relating to some of the refrigerants. [5]

APPENDIX

EXTRACT FROM STEAM TABLES

Press MN/m^2	Sat. temp. t_f °C	Spec. enthalpy kJ/kg h_f	h_{fg}	h_g	Spec. vol. v_g m^3/kg
0·7	165	697·1	2064·9	2762·0	0·273
2·1	214·9	920·0	1878·2	2798·2	0·0949