BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

AEH205

Department of Engineering and Physics

Bachelor of Science (Honours) Degree in Agricultural Engineering

Thermodynamics and Heat Transfer

3 HOURS (100 Marks)

INSTRUCTIONS

This paper contains 6 questions.

Answer any **FOUR** questions. Each carries **25 marks**

Question 1

Refrigerant 134a enters a compressor with a mass flow rate of 5 kg/s and a negligible velocity. The refrigerant enters the compressor as a saturated vapor at 10 °C and leaves the compressor at 1400 kPa at a velocity of 50 m/s . The rate of work done on the refrigerant is measured to be 132.4 kW. If the elevation change between the compressor inlet and exit is negligible.

a) Determine the inlet and outlet properties of the compressor with the use of the refrigerant diagram 143a. **[12 marks]**

b) Determine the rate of heat transfer associated with this process. **[13 marks]**

Question 2

An air-conditioning system operates at a total pressure of 1 atm and consists of a heating section and an evaporative cooler. Air enters the heating section at 15 °C and 55 percent relative humidity at a rate of 30 m3/min, and it leaves the evaporative cooler at 25 °C and 45 percent relatively humidity.

a) Sketch the psychrometric diagram for the process and determine the properties of the air in each state. **[9 marks]**

b) Determine the rate of heat transfer in the heating section. **[8 marks]**

c) Determine the rate of water added to air in the evaporative cooler. **[8 marks]**

Question 3

In the locality of Mt Hampden (Chinhoyi), it is desired to build a cold chamber of 25 tons of refrigeration to conserve potatoes at 10 °C. The proposed system will operate according to the real vapor compression refrigeration cycle, with an overheating of 15 °C and an environmental temperature equal to 35 °C.

a) Represent the real vapor compression cycle in the pressure-enthalpy diagram. **[5 marks]**

b) Calculate:

i. Mass flow of refrigerant flowing through the system. **[5 marks]**

ii. Total heat given up in the condenser. **[5 marks]**

iii. Total power consumed in the compression. **[5 marks]**

iv. Efficiency of the second law of the cycle. **[5 marks]**

$T_L = T_c - 10\ °C$ $\qquad$ $T_H = T_{air} + 10\ °C$

Question 4

In a combustion chamber, ethane (C_2H_6) is burned at a rate of 8 kg/h with air that enters the combustion chamber at a rate of 176 kg/h .

a) Write the stoichiometric combustion equation. **[5 marks]**

b) Write the balanced reaction equation for complete combustion. **[5 marks]**

c) Determine the percentage of excess air used during this process. **[5 marks]**

d) Determine the air-fuel ratio. **[5 marks]**

e) Determine the percentage of theoretical air used during this process. **[5 marks]**

Question 5

An ideal Diesel cycle has a compression ratio of 17 and a cutoff ratio of 1.3. This cycle produces 140 kW of power and the state of the air at the beginning of the compression is 90 kPa and 57 °C . Use constant specific heats at room temperature. Determine:

a) The maximum temperature of the air. **[10 marks]**

b) The thermal efficiency **[5 marks]**

c) The rate of heat addition **[10 marks]**

$$\eta_{th} = 1 - \frac{1}{r^{k-1}} \frac{r_c^k - 1}{k(r_c - 1)}$$

Question 6

Consider a steam power plant that operates on a reheat Rankine cycle and has a net power output of 80 MW . Steam enters the high-pressure turbine at 10 MPa and temperature of 500 °C and the low-pressure turbine at 1 MPa and 500 °C . Steam leaves the condenser as a saturated liquid at a pressure of 10 kPa . The isentropic efficiency of the turbine is 80 percent, and that of the pump is 95 percent. Show the cycle on a T-s diagram with respect to saturation lines, and determine:

a) The quality (or temperature, if superheated) of the steam at the turbine exit. **[8 marks]**

b) The thermal efficiency of the cycle. **[9 marks]**

c) The mass flow rate of the steam. **[8 marks]**