GIET MAIN CAMPUS AUTONOMOUS GUNUPUR – 765022

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4th Semester Regular Examination-April-May 2019

BMEPC4010 ENGINEERING THERMODYNAMICS

(Regulations 2017) MECHANICAL ENGG.

Time : 3 Hours Maximum : 100 Marks

Answer ALL Questions

The figures in the right hand margin indicate marks.

PART – A: (Multiple Choice Questions) 10 x 2=20 Mark

Q.1. Answer *All* Questions.

a If C_H is the COP of a reversible heat pump and C_R is that of a reversible refrigerator, both working between the same temperature limits, then [CO1][PO1]
(a) $C_H < C_R$ (b) $C_H > C_R$ (c) $C_H = C_R$ (d) None of these

b At the critical point the latent heat of vaporization is: [CO1][PO2]
(a) Infinitely large (b) Zero (c) Finite but unknown (d) None of these

c The internal energy of an ideal gas is equal to [CO1][PO1]
(a) $RT/(\gamma-1)$ (b) $\gamma RT/(\gamma-1)$ (c) γRT (d) None of these

d The saturation temperature of water: (a) Is independent of its pressure [CO2][PO1]
(b) Increases with pressure (c) Decreases with pressure (d) Is a constant at all pressures.

e Reheat factor depends upon (a) Initial pressure and superheat (b) Exit pressure (c) Turbine stage efficiency (d) All of the above [CO2][PO2]

f Reheating of steam in a turbine decreases (a) dryness fraction of steam (b) blade erosion (c) thermal efficiency (d) none of these [CO2][PO2]

g Rankine cycle efficiency for a power plant is 29%. The Carnot cycle efficiency will be (a) less (b) more (c) equal (d) none of these

h For constant maximum pressure and heat input, the air standard efficiency of gas power cycles is in the order (a) Diesel, Dual, Otto cycle (b) Otto, Diesel, Dual cycle (c) Dual, Otto, Diesel cycle (d) Diesel, Otto, Dual cycle [CO3][PO1]

i A reversible engine has ideal thermal efficiency of 30%. when it is used as a refrigerating machine with all other conditions unchanged, the coefficient of performance will be (a) 3.33 (b) 3 (c) 2.33 (d) 1.33 [CO3][PO1]

j The intermediate pressure of a two stage reciprocating air compressor is [CO4][PO1]
(a) $\sqrt{P_1 P_2}$ (b) $\frac{1}{2}\sqrt{P_1 P_2}$ (c) $2\sqrt{P_1 P_2}$ (d) None of these

PART – B: (Short Answer Questions) 10x2=20 Marks

Q.2. Answer *ALL* questions

a Ninety kg of ice at zero degree centigrade are completely melted. Find the entropy change if ambient temperature is 0^oC? (Latent Heat of Ice = 320 kJ/kg) [CO1][PO1]

b Find out the Joule Thomson coefficient of an ideal gas having equation Pv=RT? [CO1][PO2]

c A refrigerating machine working on reversed Carnot cycle takes out 2kW of heat per minute of heat from the system while working between temperature limits of 300 K and 200 K. calculate the COP and power consumed by the cycle? [CO3][PO1]

d For two cycles coupled in series, the topping cycle has an efficiency of 30% and the bottoming cycle has an efficiency of 20%. Calculate the overall combined cycle efficiency? [CO3][PO2]

e Why is Carnot cycle not practicable for steam power plant? [CO3][PO2]

f What do you understand by the mean temperature of heat addition? [CO2][PO1]

g What is binary vapor cycle? [CO2][PO2]

h	An ideal Diesel cycle operates on 1kg of standard air with an initial pressure of 0.98 bar and a temperature of 35^{0}C. The pressure at the end of compression is 33 bar and the cutoff is 6% of the stroke, find the compression ratio?	[CO3][PO1]
i	An engine working on the Otto cycle has a suction pressure of 1bar and a pressure of 13.5 bar at the end of compression. Find the thermal efficiency?	[CO3][PO1]
j	Air is compressed in a reversible isothermal steady flow process from 1 bar and 40^{0}C to 10 bar. Calculate the work done per kg on the gas.	[CO4][PO1]

PART – C: (Long Answer Questions) 4x15=60 Marks

Answer *ALL* questions

Q.3

a Show that there is a decrease in available energy when heat is transferred through a finite temperature difference. [05][CO1][PO2]

b Air enters a compressor at 1 bar, 30 ^{0}C, which is also the state of the environment. It leaves at 3.5 bar, 141 ^{0}C and 90 m/sec. Neglecting inlet velocity and P.E. effect, determine (a) whether the compression is adiabatic or polytropic, (b) if not adiabatic, the polytropic index, (c) the thermal efficiency, (d) the minimum work input and irreversibility, and (e) the second law efficiency. [[10][CO] [PO]

OR

c Derive the equations, [10][CO1][PO2]

$$C_V = -T\left(\frac{\partial P}{\partial T}\right)_v \left(\frac{\partial v}{\partial T}\right)_s \quad \text{and} \quad C_P = T\left(\frac{\partial v}{\partial T}\right)_p \left(\frac{\partial P}{\partial T}\right)_s$$

Hence show that for an ideal gas, $C_p - C_v = R$

d Show that the slope on a T-S diagram of (i) an isobaric curve is T/C_P and (ii) an isochoric curve is T/C_V . [05][CO1][PO2]

Q.4

a Why is Carnot cycle not practicable for a steam power plant? [05][CO2][PO1]

b A steam power station uses following cycle: [10][CO2][PO1]
Steam at boiler outlet 150 bar, 550^{0}C
Reheat at 50 bar, 550 ^{0}C
Condenser at 0.1 bar.
Using the Mollier chart and assuming ideal processes, find the (a) quality at turbine exhaust, (b) cycle efficiency, and (c) steam rate.

OR

c For a given condenser temperature, show how the Rankine cycle efficiency depends on the mean temperature of heat addition. [05][CO2][PO2]

d A cyclic steam power is to be designed for a steam temperature at turbine inlet of 360 ^{0}C and an exhaust pressure of 0.08 bar. After isentropic expansion of steam in the turbine, the moisture content at the turbine exhaust is not to exceed 15%. Determine the greatest allowable steam pressure at the turbine inlet, and calculate the Rankine cycle efficiency for these steam conditions. Estimate also the mean temperature of heat addition. [10][CO2][PO2]

Q.5

a For the same compression ratio and heat rejection, which cycle is most efficient: Otto, Diesel or Dual? Explain with p-v and T-s diagrams. [05][CO3][PO1]

b The compression ratio used in Otto cycle is 5. The pressure and temperature at the [10][CO3] [PO1] beginning of the compression are 97 kN/m^2 and 50 ^{0}C respectively. The heat supplied during the cycle is 930 kJ/kg of air. Determine,

- i) The maximum temperature attained in the cycle.
- ii) The thermal efficiency of the cycle.
- iii) Work done during the cycle per kg of air.

OR

c Explain the ammonia-water vapour absorption refrigeration cycle with neat diagrams? [05][CO3][PO2]

d In an aircraft cooling system, air enters the compressor at 0.1MPa, 4 ^{0}C and is compressed to 0.3MPa with an isentropic efficiency of 72%. After being cooled to 55 ^{0}C at constant pressure in a heat exchanger the air then expands in a turbine to 0.1 MPa with an isentropic efficiency of 78%. The low temperature air absorbs a cooling load of 3 tonnes of refrigeration at constant pressure before re-entering the compressor which is driven by the turbine. Assuming air to be an ideal gas, determine the COP of the refrigerator, the driving power required and the air mass flow rate. [10][CO3][PO1]

Q.6

a Define the volumetric efficiency of a compressor. On what factors does it depend? [05][CO4][PO1]

b Air is drawn into a LP cylinder of a two-stage single acting (without clearance) air compressor at a pressure of 0.1 MPa and 20 ^{0}C and compressed adiabatically to 0.3 MPa. The bore and stroke of LP cylinder are 50 cm and 75 cm respectively. The air is then delivered to an intercooler where it is cooled at constant pressure to 35 ^{0}C and is then further compressed to 1 MPa in HP cylinder. Determine the required power of the compressor. The compressor operates at 120 rpm. [10][CO4][PO1]

OR

c What is the need of staging the compression process? [05][CO4][PO2]

d A single acting two-stage reciprocating air compressor with complete intercooling delivers 10.5 kg/min of air at 16 bar. The suction occurs at 1 bar and 27^{0}C. The compression and expansion processes have polytropic index equals to 1.3. Calculate, [10][CO4][PO2]

- i) The power required to drive the compressor.
- ii) Free air delivered at suction condition.
- iii) Volumetric efficiency for each stage, if clearance ratios for L.P. and H.P. cylinders are 0.04 and 0.06 respectively.

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