Q.5 i. Enlist the air-standard assumptions made for analysis of air-standard cycles. (at least four assumption) **2**

ii. Air enters the compressor of an air-standard Brayton cycle at 100 kPa, 300 K with a volumetric flow ratio of 5 m^3/s. The compressor pressure ratio is 10 and turbine inlet temperature is 1400 K. Determine: **8**
(a) Thermal efficiency of cycle
(b) Back work ratio
(c) Net power developed in kW.

OR iii. Compare Otto, diesel and dual cycle with help of p-v & T-s charts: **8**
(a) For same compression ratio
(b) For same maximum temperature & maximum pressure.

Q.6 Attempt any two:

i. Express Dalton's law of partial pressure. Does this law hold exactly for ideal gas mixtures? **5**

ii. What do you understand by Maxwell relations? Also derive the Maxwell relations. **5**

iii. A vessel of volume 0.4 m^3 contains 0.45 kg f carbon monoxide and 1 kg of air, at 15 ^oC. Calculate the partial pressure of each constituents and the total pressure in the vessel. The air contains 23.3% oxygen and 76.6% nitrogen by mass. Take the molar masses of carbon monoxide, oxygen and nitrogen as 28, 32 and 28 kg/k mol respectively. **5**

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Total No. of Questions: 6 *Total No. of Printed Pages:4*

Enrollment No.....

Faculty of Engineering

End Sem (Odd) Examination Dec-2018

AU3CO04 / FT3CO04 / ME3CO04

Engineering Thermodynamics

Programme: B.Tech. Branch/Specialisation: AU/FT/ME

Duration: 3 Hrs. **Maximum Marks: 60**

Note: (i) All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.
(ii) Use of steam table should be allowed.

Q.1 i. In a reversible adiabatic process, the work transfer is equal to **1**
(a) Decrease in enthalpy
(b) Decrease in internal energy
(c) Heat transfer
(d) The product of pressure & change in volume

ii. During a heating process, the temperature of an object rises by 20 ^oC. This temperature rise is equivalent to **1**
(a) 20 ^oF (b) 52 ^oF (c) 36 ^oF (d) 68 ^oF

iii. In a thermal power plant, turbine does 10,000 kJ of work, pump consumes 10 kJ of work. The boiler receives 30,000 kJ of heat. Thermal efficiency of the plant is **1**
(a) 27 % (b) 33.334% (c) 35 % (d) 40 %

iv. A refrigerator & heat pump operates between same temperature limits. If the COP of the refrigerator is four, what is the COP of heat pump? **1**
(a) 3 (b) 3.4 (c) 5 (d) 4

v. The total enthalpy of steam at 10 bar is 2000 kJ/kg. The condition of steam is **1**
(a) Wet (b) Dry & saturated
(c) Superheated (d) None of these

vi. Internal latent heat of steam is given by **1**
(a) $h_{fg} + pv_g$ (b) $h_g - pv_g$ (c) $h_{sup} - pv_g$ (d) $h_{fg} - pv_g$

vii. The efficiency of air standard Diesel cycle depends on **1**
(a) Cut-off ratio in cycle
(b) Compression ratio in the cycle
(c) Both (a) and (b)
(d) None of these

viii. For given compression, among Otto, Diesel and Dual cycles **1**
(a) Diesel cycle is most efficient
(b) Otto cycle is most efficient
(c) Dual cycle is most efficient
(c) None of these

ix. Which one of the following is true statement **1**
(a) m = n M (b) $m = \sum x_i n_i$ (c) $m = \frac{n}{M}$ (d) None of these

x. Partial pressure of a gas in a gas mixture is defined as **1**
(a) Pressure exerted by a gas at mixture volume
(b) Pressure exerted by a gas at mixture temperature
(c) Pressure exerted by a gas at mixture volume & temperature
(d) None of these

Q.2 i. What are the limitations of the First Law of Thermodynamics? **2**

ii. A centrifugal pump delivers 50 kg of water per second. The inlet and outlet pressure are 1 bar & 4.2 bar respectively. The suction is 2.2 m below the centre of pump and delivery is 8.5 m above the same level. The suction and delivery pipe diameters are 20 cm & 10 cm respectively. Determine the capacity of electric motor to run the pump. **8**

OR iii. 0.2 m^3 of a mixture of a fuel and air at 1.2 bar and 60 ^oC is compressed till its pressure becomes 12 bar and temperature 270 ^oC. Then it is ignited suddenly at constant volume and its pressure becomes twice the pressure at the end of compression. Find the maximum temperature reached and heat transfer during compression process. Assume the mixture as perfect gas. **8**

Q.3 i. Define refrigerator and heat pump with the help of line diagram. **2**

ii. A heat pump maintains a space at 22 ^oC on a day, when outdoor air temperature is 0 ^oC. The heating requirement of space is 100,000 kJ/h and power consumed by the pump is 5 kW. Calculate the rate at which heat is extracted from outside air and COP of the heat pump. Also calculate the maximum COP. Does it violate the second law of thermodynamics? **8**

OR iii. A reversible refrigerator is used to maintain a space at the temperature of 0 ^oC, when it rejects heat to surroundings at 27 ^oC, If the heat removal rate from refrigerator is 90 MJ/h, determine the COP of the system. **8**
If the required input to run the refrigerator is supplied by a reversible engine which receives heat at 400 ^oC and rejects heat to surroundings, determine the overall COP of the system.

Q.4 i. Define the terms: sub-cooled liquid, saturated liquid, saturated vapour and superheated vapours. **2**

ii. A certain boiler generates 1000 kg of stem per hour at 10 bar and 0.97 dry. The steam is then taken to a super heater and is heated to a temperature of 280 ^oC keeping pressure constant. The feed water is available at 30 ^oC. Find **8**
(a) Heat supplied per hour in boiler
(b) Heat supplied per hour in super heater
(c) Internal energy of super heated steam
(d) Change in internal energy of steam

OR iii. A combined separating and throttling calorimeter was used to determine the dryness fraction of steam through steam main at a pressure of 9 bar. The pressure and temperature of steam after throttling were 1.25 bar and 115 ^oC respectively. The mass of steam condensed after throttling was 2.2 kg and mass of water collected in separator was 0.20 kg. Estimate the dryness fraction of steam in main. **8**
Take specific heat for super heated steam as 2.1 kJ/kgK.

Marking Scheme
AU3CO04 / FT3CO04 / ME3CO04
Engineering Thermodynamics

Q.1	i.	In a reversible adiabatic process, the work transfer is equal to (b) Decrease in internal energy		**1**
	ii.	During a heating process, the temperature of an object rises by 20 ^{o}C. This temperature rise is equivalent to (d) 68 ^{o}F		**1**
	iii.	In a thermal power plant, turbine does 10,000 kJ of work, pump consumes 10 kJ of work. The boiler receives 30,000 kJ of heat. Thermal efficiency of the plant is (b) 33.334%		**1**
	iv.	A refrigerator & heat pump operates between same temperature limits. If the COP of the refrigerator is four, what is the COP of heat pump? (c) 5		**1**
	v.	The total enthalpy of steam at 10 bar is 2000 kJ/kg. The condition of steam is (a) Wet		**1**
	vi.	Internal latent heat of steam is given by (d) h_{fg} - pv_g		**1**
	vii.	The efficiency of air standard Diesel cycle depends on (c) Both (a) and (b)		**1**
	viii.	For given compression, among Otto, Diesel and Dual cycles (b) Otto cycle is most efficient		**1**
	ix.	Which one of the following is true statement (a) m = n M		**1**
	x.	Partial pressure of a gas in a gas mixture is defined as (c) Pressure exerted by a gas at mixture volume & temperature		**1**
Q.2	i.	At least four limitations of the First Law of Thermodynamics 0.5 marks for each	(0.5 mark *4)	**2**
	ii.	Fully labelled diagram Capacity of electric motor to run the pump = -22.2 kW	2 marks 6 marks	**8**
OR	iii.	Fully labelled pv diagram n = 1.27 R = 0.3 kJ/kgK m = 0.24 kg Maximum temperature = 813 ^{o}C Cn = -0.36 kJ/kgK Heat transfer during comp. process = -14.2 kJ	2 marks 3 marks 3 marks	**8**
Q.3	i.	Definition with line diagram of refrigerator Definition with line diagram of heat pump	1 mark 1 mark	**2**
	ii.	Fully labelled block diagram Rate of heat extraction = 22.78 kW COP hp = 5.56 COP hp max. = 13.4 As COP hp max. > COP hp, hence it does not violates	2 marks 2 marks 1 mark 1 mark 2 marks	**8**
OR	iii.	Fully labelled block diagram COP_R = 10.11 $W_{in\ R} = W_{out\ HE}$ = 2.473 kW η_{rev} = 55.42 % Q_h = 4.462 kW $COP_{overall} = \frac{\text{sole effect from system}}{\text{energy input to system}} = \frac{\text{Refrigerating effect}}{\text{heat input rate}}$ $COP_{overall}$ = 5.60	2 marks 2 marks 2 marks 2 marks	**8**
Q.4	i.	Define the terms: sub-cooled liquid, saturated liquid, saturated vapour and superheated vapours. 0.5 mark for each term	(0.5 mark *4)	**2**
	ii.	For each correct answer give 2 marks (a) heat supplied per hour in boiler = 2591.04 MJ/h (b) heat supplied per hour in super heater = 406.26 MJ/h (c) internal energy of super heated steam = 2759.89 kJ/kg (d) change in internal energy of steam = 2635.4 kJ/kg	(2 marks *4)	**8**
OR	iii.	x_1 = 0.9167 x_2 = 0.9657 x_{final} = 0.885	1 mark 4 marks 3 marks	**8**
Q.5	i.	Air-standard assumptions made for analysis of air-standard cycles. (at least four assumption) 1 mark for each	(1 mark *4)	**2**

	ii.	Fully labelled pv diagram	2 marks	**8**
		(a) thermal efficiency of cycle = 48.2 %	2 marks	
		T_2 = 592.2 K,		
		T_4 = 721.1 K		
		(b) back work ratio = 0.417	2 marks	
		density = 1.161 kg/m^3		
		mass flow rate = 5.8 kg/s		
		(c) net power developed = 2309.34 kW	2 marks	
OR	iii.	Compare Otto, diesel and dual cycle with help of p-v & T-s charts:		**8**
		(a) For same compression ratio	4 marks	
		(b) For same maximum temperature & maximum pressure.	4 marks	
Q.6		Attempt any two:		
	i.	Express Dalton's law	3 marks	**5**
		Does this law hold exactly	2 marks	
	ii.	What do you understand	2 marks	**5**
		derive the Maxwell	3 marks	
	iii.	P_{co} = 0.9623 bar	1 mark	**5**
		P_{O2} = 0.4345 bar	1 mark	
		P_{N2} = 1.64 bar	1 mark	
		P_{tot} = 3.03 bar	2 marks	

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