IES COLLEGE OF TECHNOLOGY, BHOPAL

B.E. (3rd SEM) ASSIGNMENT

THERMODYNAMIC (ME-304) SET-A

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UNIT -1

Q. NO.1

$0.3 m^3$ of an ideal gas at a pressure of 2 MPa and 500 K is expanded isothermally to 4 times the initial volume. It is then cooled to 300 K at constant volume and then compressed back polytropically to its initial state. Determine the

i) Network done and

ii) Heat transfer during the cycle. 7

Q. NO. 2

In a gas turbine the gas enters at the rate of 5 kg/s with a velocity of 50 m/s and enthalpy of 860 kJ/kg and leaves the turbine with a velocity of 150 m/s and enthalpy of 350 kJ/kg. The loss of heat from the gases to the surroundings is 20 kJ/kg. Assume for gas R = 0.286 kJ/kg and c_p = 1.005 kJ/kgK and the inlet conditions to be at 100 kPa and 27°C. Determine the

i) Power output of the turbine and

ii) Diameter of the inlet pipe. 7

Q.NO.3

In a gas turbine, the gas enters at the rate of 5kg/sec with a velocity of 50m/s and enthalpy of 900kJ/kg and leaves the turbine with a velocity of 150m/s and enthalpy of 400 kJ/kg. The loss of heat from the gases to the surroundings is 25 kJ/kg. Assume for gas R = 0.285 kJ/kg K and C_p = 1.004 kJ/kg K and the inlet conditions to be at 100 kPa and 27°C. Determine the power output of the turbine and diameter of inlet pipe.

Q. NO. 4

A perfect gas flows through a nozzle where it expends in a reversible adiabatic manner. The inlet conditions are 20 bar, 500°C, 38m/sec. At exit, the pressure is 2 bar. Determine the exit velocity and exit area if the flow rate is 5Kg/s. Take R = 190 J/Kg K and Y = 1.35.

Q. NO. 5

A certain mass of gas in a closed system is undergoing polytrophic expansion in accordance with the expression $p\gamma^n$ = constant. Show that the ratio-

ΔQ; Δu; Δw : : $(\gamma - n)$; $(h-1)$: $(\gamma - 1)$

Where ΔQ is the heat rejected

Δu in the gain in internal energy

Δw is the work done

Q. NO6

A certain mass of ideal gas is heated from 325K to 355K at a

a) Constant volume b) Constant pressure

For which case do you think the energy required will be greater? Explain.

Q. NO 7

A perfect gas expands such that its pressure varies in linear relationship with volume :

$$P = aV + b$$

where 'a' and 'b' are constants.

If the initial and final states of the gas are 4 bar/0·1 m^3 and 2 bar/0·2 m^3, determine :

(a) heat interactions

(b) work interactions

UNIT -2

Q. NO. 8

A heat pump working on the Carnot cycle takes in heat from a reservoir at 12°C and delivers heat to a reservoir which takes in heat from a reservoir at 850°C and rejects heat to a reservoir at 70°C. The reversible heat engine also drives a machine that absorbs 30kW. If the heat pump extracts 20kJ/s from the 12°C reservoir, determine the

i) Rate of heat supply from the 850°C source and

ii) Rate of heat rejection to the 70°C sink. 7

Q. NO.9

An inventor claims to have developed an engine that takes in 105MJ at a temperature of 400K and rejects 42MJ at a temperature of 200K and delivers 15 kWh of mechanical work. Would you advise money to put this engine in the market?

Q. NO 10

State the Kelvin-Planck and clausius statements of the second law of thermodynamics and establish the equivalence between them.

Q. NO. 11

A heat engine, a heat pump and a refrigerator receive 500 kJ of heat each, but they reject 250 kJ, 600 kJ and 700 kJ of heat respectively. Determine :

(a) The efficiency of heat engine

(b) COP of heat pump

(c) COP of the refrigerator

Q. NO. 12

(a) Distinguish between reversible and irreversible processes.

(b) Are all natural processes irreversible ? Cite *two* examples of real processes that can reasonably be regarded as close to reversible processes.

(c) Why can heat not be converted into work ?

(d) Describe an imaginary process that violates both first law and second law of thermodynamics.

UNIT 3

Q. NO13

One kg-mole of oxygen at 350K undergoes a reversible non-flow isothermal expansion and the volume increases from $0.08 m^3/kg$ to $0.20 m^3/kg$. For oxygen, coefficients a and b are $139.35 \times 10^3 \ Nm^2/(kg\text{-}mol)^2$ and $0.0314 m^3/kg\text{-}mol$ respectively. Using Vander Waals equation of state, calculate the

i) Final pressure and

ii) Work done during the process. 7

Q. NO. 14

Derive the following relations for the difference in heat capacities

$$C_p - C_v = -T\left(\frac{\partial v}{\partial T}\right)_p^2 \left(\frac{\partial p}{\partial v}\right)_T = \frac{vT\beta^2}{\alpha}$$

Where α and β are isothermal compressibility and volume expansivity respectively and other symbols have their usual meanings. 7

Q. NO.15

a) Write down the Vander Waals equation of state. How does it differ from the ideal gas equation of state? 2

b) What is the law of corresponding states? 2

c) Derive Maxwell's relation and state their importance in thermodynamics. 3

Q NO 16

One kg of CO_2 has a volume of $1 m^3$ at 100°C compute the pressure by

i) Van der Waal's equation.

ii) Perfect gas equation.

The values of a and b of CO_2 are as given:

$a = 362850\ Nm^4/(Kg\ mol.)^2$

$b = 0.0423\ m^3/Kg\ mol.$

$R_o = 8314\ Nm/Kg\ mol\ k$

Q. NO 17

Prove that a) $T_C = \frac{8a}{27^{-} Rb}$ b) $P_C = \frac{a}{27b^2}$

Where on T_c & P_c are temperature and pressure at critical points, 'a' and 'b' are van der Waal's gas constants, R = characteristic gas constant.

Q. NO. 18

a) What is compressibility factor 'Z'? What is the physical significance of the compressibility factor?

b) What is the physical significance of two constants that appear in the Van der Waals Equation of state.

Q. NO.19

Prove that :

(a) $a = \frac{RT_c}{8 P_c}$ (b) $b = \frac{27}{64}\frac{R^2 T_c^2}{P_c}$

where 'a' and 'b' are van der Waals constants, k is characteristic gas constant. T_c, P_c are temperature and pressure at critical points.

Q. NO. 20

(a) What is compressibility factor 'z' ? What is the physical significance of this factor ?

(b) What is the principle of corresponding states ?

(c) What is the significance of two constants that appear in the van der Waals equation ?

UNIT -4

Q. NO 21

A pressure cooker of $0.15 m^3$ capacity contains dry and saturated steam at a pressure of 12 bar. Calculate the quantity of heat which must be rejected so that the quality of the steam becomes 40%. 7

Q. NO> 22

A steam boiler initially contains $5m^3$ of steam and $5m^3$ of water at 10 bar. Steam is taken out at constant pressure until $4m^3$ of water is left. What is the heat transferred during the process? 7

q. no

In a laboratory experiment, the following observations were recorded to find the dryness fraction of steam by combined separating and throttling calorimeter. Total quantity of steam passed = 36kg.

Water drained from separator = 1.8kg

Steam pressure before throttling = 12 bar

Temperature of steam after throttling = 110°C

Pressure of steam after throttling = 1.013 bar

Specific heat of steam = 2.1 kJ/kg K

Determine the dryness fraction of steam before inlet to the calorimeter.

Q.NO. 24

What is the main feature of triple point? State the values of pressure and temperature at the triple point of water.

Draw a phase equilibrium diagram for a pure substance on H-S plot with relevant constant property lines.

Q. NO.25

. 1 ton of ice at − 5°C is heated to produce steam at 300°C. The entire process is carried out at 1·0132 bar i. e. 1 atm. pressure. Calculate the entropy changes in all possible stages.

Q. NO26

A steam sample at 2 MPa has a specific volume of 0·09 m^3/kg. Determine the dryness fraction of the steam. Also calculate the specific enthalpy and specific entropy of the sample.

Q. NO 27

An ideal SI engines operates between two temperature limits 300K and 1700K. If operates with compression ratio of 6. The ambient air pressure in 1 atm. Assuming C_p and C_v remains constant over its operating temperature range, determine the

a) Pressure and temperature at each point in the cycle.

b) Thermal efficiency of engine

c) MEP. Assume $\gamma = 1.4$

UNIT 5

Q. NO 28

A vessel contains 12kg of oxygen, 10kg of nitrogen and 28kg of carbon dioxide at 375 K temperature and 250kPa pressure. Determine the

i) Capacity of the vessel, and

ii) Partial pressure of each gas present in the vessel.

7

Q. NO.29

In an air-standard diesel cycle with compression ratio 17, the conditions of air at the start of compression stroke are 1 bar and 300K. After addition of heat at constant pressure, the temperature rises to 2700K. Determine the

i) Thermal efficiency of the cycle and

ii) Mean effective pressure. 7

Q. NO 30

An engine working on Otto cycle has temperature and pressure, at the beginning of isentropic compression at 25°C and 1.5 bar. Find the compression ratio if Y = 1.4 and thermal efficiency of the engine = 48%. Also find temperature and pressure at the end of compression.

Q. NO 31

a) Derive an expression for the efficiency of the carnot engine.

b) For a given compression ratio; the air standard Diesel cycle is less efficient than air standard Otto cycle explain.

Q. NO 32

An ideal SI engines operates between two temperature limits 300K and 1700K. If operates with compression ratio of 6. The ambient air pressure in 1 atm. Assuming C_p and C_v remains constant over its operating temperature range, determine the

a) Pressure and temperature at each point in the cycle.

b) Thermal efficiency of engine

c) MEP. Assume $\gamma = 1.4$

Or

Q. NO. 33

An ideal diesel engine operates within the temperature limits of 1700 K and 300K with a compression ratio of 16. Determine

a) Pressure and temperature at each point in the cycle.

b) Thermal Efficiency of Engine c) MEP

Given C_p = 1.005 KJ/Kg.K

C_v = 0.717 KJ/Kg.K and γ = 1.4

Q. NO. 34

. Half kg helium and half kg nitrogen are mixed in a mixing chamber at 293 K and 100 kPa of total pressure. Calculate the :

(a) Mole fraction of the components

(b) Volume of the mixture

(c) Volume fraction of the components

(d) Partial pressures of the components

Q. NO.35

For an air standard dual cycle, the following data are available :

Air intake at 1 bar and 323 K.

Maximum pressure is 70 bar.

Heat addition at constant pressure = Heat addition at constant volume.

Determine :

(a) Pressure and temperatures at all the points of the cycle

(b) Code efficiency

(c) MEP