SUMMER – 2023

UNIT-1

Q.1. a) State difference between extensive and intensive properties of a thermodynamic system. Give three example of each. **(3)**

b) Define the law that forms the basis for temperature measurement. **(3)**

c) A 2.5 m^3 of tank contains N_2 gas at a pressure of 100 kPa and 30°C. What is mass of N_2 in the tank of temperature of air surrounding tank is raised and temperature of tank is maintained at 150°C. What is new pressure in the tank? **(7)**

Q.2. a) Define thermodynamic work. Prove that it is a path function. **(4)**

b) A gas for which γ = 1.4 is initially at 300 kPa pressure with specific volume of 0.48 m^3/kg. The initial temperature is 500 k. If expanded adiabatically to pressure of 100 kPa. What is final volume, final temp and work done? **(9)**

UNIT-2

Q.3. a) State the first law applied to cyclic process and change of state for a closed system. **(4)**

b) 4 kg of air initially at absolute pressure of 110 kPa and 300 K is compressed polytropically until pressure and temperature becomes 1500 kPa and 500 K respectively. Evalute polytropic exponent, final volume, work of compression and heat interaction. **(9)**

Take R = 287 J/kg k.

Q.4. a) Prove that for adiabatic process, Pv^{γ} = constant. **(5)**

b) An ideal gas with a mass of 0.8 kg has characteristic gas constant of 287 J/kg k. It is heated at constant pressure of 8 bar from 30°C to 200°C. If specific heat at constant pressure is 1.005 kJ/kg k. **(8)**

Determine:

i. Specific heat at constant at constant volume.

ii. Heat supplied to gas

iii. Increase in internal energy

iv. Workdone during the process

b) An ideal gas with a mass of 0.8 kg has characteristic gas constant of 287 J/kg k. It is heated at constant pressure of 8 bar from 30°C to 200°C. If specific heat at constant pressure is 1.005 kJ/kg k. **(8)**

Determine:

i. Specific heat at constant at constant volume.

ii. Heat supplied to gas

iii. Increase in internal energy

iv. Workdone during the process

UNIT-3

Q.5. a) Derive 'steady flow energy equation'. Apply same to-

i) Turbine ii) Throttling device **(6)**

b) A perfect gas flows through a nozzle where it expands in a reversible adiabatic manner the inlet conditions are 22 bar 500°C and 38 m/s. At exit, pressure is 2 bar. hine the exit velocity and exit area, if the flow rate is ec. Take R = 190 J/kg k and γ = 1.35. **(8)**

Q.6. a) Show that work done by steady flow process is given by $WD = -\int Vdp$. **(5)**

b) A blower handles 1 kg/sec of air at 25°C and consumes a power of 16 kw. The inflow and outflow velocities are 95 m/s and 160 m/s respectively. Find exit air temperature assuming adiabatic condition of air Cv = 0.7187 kJ/kg k.

(9)

UNIT-3

Q.7. a) State the two statements of second law of thermodynamics and prove their equivalence. **(7)**

b) A refrigerating machine works on a reversed Carnot cycle. It consumes 6 kw and the refrigerating effect is 1000 kJ/min. The sink temperature is -40°C. **(6)**

i) Source Temperature ii) COP of the refrigerating machine.

Q.8. a) Describe Carnot cycle and obtain expression for its efficiency as applied to a heat engine. **(7)**

b) An inventor claims to have developed an IC engine which gives which gives high efficiency of 77% which operates in a atmosphere at 343 k with an addition of heat from

UNIT-3

Q.7. a) State the two statements of second law of thermodynamics and prove their equivalence. **(7)**

b) A refrigerating machine works on a reversed Carnot cycle. It consumes 6 kw and the refrigerating effect is 1000 kJ/min. The sink temperature is -40°C. **(6)**

i) Source Temperature ii) COP of the refrigerating machine.

Q.8. a) Describe Carnot cycle and obtain expression for its efficiency as applied to a heat engine. **(7)**

b) An inventor claims to have developed an IC engine which gives which gives high efficiency of 77% which operates in a atmosphere at 343 k with an addition of heat from combustion gases burning at 1473 k. Comment on the claim of inventor. **(6)**

UNIT-5

Q.9. a) Define: **(4)**

i) Sensible heat ii) Latent heat

iii) Enthalpy of wet steam iv) Critical Point

b) Using phase diagram (P-t) discuss various phase changes for water. **(4)**

c) A vessel of volume 0.05 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250°C. The mass of water present is 9 kg. Find mass, specific volume and enthalpy of the steam. **(6)**

Q.10. a) What is meant by quality of steam? Outline the procedure followed to determine its value by using a throttling calorimeter? **(6)**

b) A rigid vessel of volume 0.86 m^3 contains 1 kg of steam at a pressure of 2 bar. Evaluate the specific volume, temperature, dryness fraction, enthalpy, internal energy and entropy of steam. **(8)**

UNIT-6

Q.11. Derive an expression for air standard efficiency of Brayton cycle. **(6)**

b) With the help of P-V and T-S diagrams, compare the thermal efficiencies of Otto, Diesel and dual cycle for same maximum pressure and temperature and heat rejection. **(7)**

Q.12. a) Explain Rankine cycle with P-V and T-S diagrams. Derive an expression for efficiency of Rankine cycle. **(7)**

b) Derive the expression for air standard efficiency of diesel cycle. **(6)**

WINTER – 2022

UNIT-1

Q.1 a) Explain the concept of macroscopic and microscopic view points applied to the study of thermodynamics. **(6)**

b) In a reversible non-flow process, the works is done by a substance in accordance with $V = \frac{2.80}{P} m^3$,

Where P – pressure in bar.

Find the work done on or by the system as pressure increases from 0.7 bar to 7 bar. **(7)**

Q.2 a) Differentiate between

i) Open system & closed system.

ii) Homogeneous & Heterogeneous system. **(6)**

b) Estimate the rise in temperature of water when it falls through a height of 50 m. Assume that all the heat generated stays in water. The specific heat of water may be taken as 4.2 kJ/kg°k. **(7)**

UNIT-2

Q.3 a) Define an adiabatic process. Show that a reversible adiabatic process for a given mass of perfect gas is PV^{γ} = constant. **(6)**

b) A cylinder contains 0.12m³ of air at 1 bar & 90° C. It is compressed to 0.035 m³, the final pressure being 6 bar. Find the index of compression, increase in internal energy & heat transferred. **(7)**

Q.4 a) Show that the work transfer per kg of a perfect gas during an adiabatic process is given by $W_{1-2} = \frac{R(T_1 - T_2)}{\gamma - 1}$

Where, T_1 & T_2 are initial & final temperatures

R – Characteristics gas constant. **(6)**

b) An internal combustion engine has a cylinder diameter of 15 cm & a stroke of 20 com. The pressure & temperature of gas at the beginning of compression stroke are 1 bar & 30°C, respectively. If the clearance volume is 1.147 lit &

the law of compression is $pv^{1.2}$ = constant, determine pressure & temperature at the end of compression. If the working substance is air, determine change in internal energy of air during compression. Take Cv = 0.718 kJ/kg°k & R = 0.287 kJ/kg°k. **(7)**

UNIT-3

Q.5 a) Derive steady flow energy equation for

i) Boiler ii) Centrifugal pump. **(6)**

b) Steam enters turbine with a velocity of 40 m/s & sp. Enthalpy of 2500 kJ/kg & leaves with a velocity of 90 m/s & specific enthalpy of 2030 kJ/kg. Heat losses from the turbine to surroundings are 240 kJ/min. & the steam flow

b) An internal combustion engine has a cylinder diameter of 15 cm & a stroke of 20 com. The pressure & temperature of gas at the beginning of compression stroke are 1 bar & 30°C, respectively. If the clearance volume is 1.147 lit & the law of compression is $pv^{1.2}$ = constant, determine pressure & temperature at the end of compression. If the working substance is air, determine change in internal energy of air during compression. Take Cv = 0.718 kJ/kg°k & R = 0.287 kJ/kg°k. **(7)**

UNIT-3

Q.5 a) Derive steady flow energy equation for

i) Boiler ii) Centrifugal pump. **(6)**

b) Steam enters turbine with a velocity of 40 m/s & sp. Enthalpy of 2500 kJ/kg & leaves with a velocity of 90 m/s & specific enthalpy of 2030 kJ/kg. Heat losses from the turbine to surroundings are 240 kJ/min. & the steam flow rate if 5040 kg/hr. Neglect the change of potential energy. Find power developed by the turbine. **(8)**

Q.6 a) Derive steady flow energy equation for

i) Reciprocating compressor ii) Steam turbine. **(6)**

b) Air flows at the rate of 2.3 kg/s in a 15 cm diameter ... t has a pressure of 7 bar & a temperature of 95°C, ... it is throttled by a value to 3.5 bar, Find the velocity of air at exit. **(8)**

UNIT-4

Q.7 a) What is heat pump. How does it differ from a refrigerator? **(6)**

b) A cyclic heat engine operates between a source temperature of 800°C & a sink temperature of 30°C. What is the least rate of heat rejection per kW net output of the engine. **(7)**

Q.8 a) What do you mean by coefficient of performance? Show that $(COP)_{HP} = 1 + (COP)_{Ref.}$ **(6)**

b) A heat pump is used to maintain an auditorium hall at 25°C, when the atmospheric temperature is 10°C. The heat load of hall is 1500 kJ/min. Calculate the power required to run the heat pump, if its COP is 30% if COP of Carnot heat pump, working between the same temperatures. **(7)**

UNIT-5

Q.9 a) Define.

i) Sensible heat.

ii) Latent heat.

iii) S...

Q.8 a) What do you mean by coefficient of performance. Show that $(COP)_{HP} = 1 + (COP)_{Ref.}$ **(6)**

b) A heat pump is used to maintain an auditorium hall at 25°C, when the atmospheric temperature is 10°C. The heat load of hall is 1500 kJ/min. Calculate the power required to run the heat pump, if its COP is 30% if COP of Carnot heat pump, working between the same temperatures. **(7)**

UNIT-5

Q.9 a) Define.

i) Sensible heat.

ii) Latent heat.

iii) Super heat. **(6)**

b) Calculate volume, density, enthalpy of 2 kg steam at 80°C and having dryness fraction of 0.85. **(7)**

Q.10 a) Define.

i) Triple point

ii) Sublimation point &

iii) Critical point. **(6)**

b) Calculate the amount of heat to be supplied to produce 5 kg, of steam at a pressure of 8 bar & a temperature of 320°C from a water at 30°C. Take sp. Heat of superheated steam as 2.2 kJ/kg°k. **(7)**

UNIT-6

Q.11 a) Sketch & explain otto cycle with its P – V & T – S diagram & find its efficiency. **(7)**

b) A diesel engine has a compression ratio of 18 & cut off takes place. At 5% of the stroke. Calculate the air std. efficiency of diesel engine. **(7)**

Q.12 a) Explain Rankine cycle with P – V & T – S diagram. **(7)**

b) Compare otto, Diesel & Dual cycle for a given compression ratio. **(7)**

WINTER – 2019

UNIT-1

Q.1 a) Define thermodynamic system? Classify them. **(3)**

b) Differentiate between open and closed system with suitable example. **(3)**

c) Estimate the rise in temperature of water when it falls through a height of 50 m. Assume that all the heat generated stays in water. The specific heat of water may be taken as $4.2 \frac{kJ}{kg^{\circ}k}$. **(7)**

Q.2 a) State Zeroth law of thermodynamics and also state its significance. **(3)**

b) The power station has an output of 800 mw and thermal efficiency is 30 %. Determine the coal consumed per hour if the calorific value of coal is 30 mJ/kg. **(3)**

c) A electric heater draws 10A when the voltage is 230V. Determine the units of energy used in $\frac{1}{2}$ an hour. **(7)**

UNIT-2

Q.3 a) Differentiate between mechanical & thermodynamic work. Show that work is a path function. **(7)**

b) In a reversible non-flow process the work is done by a substance in accordance with $V = \frac{280}{p} m^3$, where, p – is pressure is bar. Find work done on or by the system as pressure increases from 0.7 bar to 7 bar. **(6)**

Q.4 a) State first law of thermodynamics. **(3)**

b) Air initially at 60 kPa pressure, 800°k temp. And $0.1 m^3$ volume is compressed isothermally unit the volume is half and subsequently the air is cooled at constant pressure till the volume is half again. Sketch process on P – V plane and determine.

i) Total work interaction and

ii) Total heat interaction. Assume Cp = 1.005 kJ/kg°k. **(10)**

UNIT-3

Q.5 a) What is steady flow process and what are assumption mode in study flow process. **(3)**

b) State significance of $-\int v\,dp$. **(3)**

c) Air is compressed steadily at a rate of 0.46 kg/s from 100kPa. 20°C to a final pressure of 320 kPa. The compression is polytrophic index of 1.32. The volume of air changes from $3 m^3/kg$ to $0.8 m^3/kg$. The inlet velocity is 25 m/s, while the exit velocity is 130 m/s. The delivery connection is 12 m above the inlet. What is the shaft power of the compressor? Is it power absorbing or power producing device? **(8)**

Q.6 a) Deduce steady flow energy equation for: **(6)**

i) Boiler

ii) Reciprocating compressor.

b) 75 kg/min air enters the control volume of a steady flow system at 2 bar and 100°C at an elevation of 100 m above the datum. The same

Q.4 a) State first law of thermodynamics. **(3)**

b) Air initially at 60 kPa pressure, 800°k temp. And $0.1m^3$ volume is compressed isothermally unit the volume is half and subsequently the air is cooled at constant pressure till the volume is half again. Sketch process on P – V plane and determine.

i) Total work interaction and

ii) Total heat interaction. Assume Cp = 1.005 kJ/kg°k. **(10)**

UNIT-3

Q.5 a) What is steady flow process and what are assumption mode in study flow process. **(3)**

b) State significance of - $\int v\, dp$. **(3)**

c) Air is compressed steadily at a rate of 0.46 kg/s from 100kPa. 20°C to a final pressure of 320 kPa. The compression is polytrophic index of 1.32. The volume of air changes from $3m^3/kg$ to $0.8m^3/kg$. The inlet velocity is 25 m/s, while the exit velocity is 130 m/s. The delivery connection is 12 m above the inlet. What is the shaft power of the compressor? Is it power absorbing or power producing device? **(8)**

Q.6 a) Deduce steady flow energy equation for: **(6)**

i) Boiler

ii) Reciprocating compressor.

75 kg/min air enters the control volume of a steady flow system at 2 bar and 100°C at an elevation of 100 m above datum. The same mass leaves the control volume at 150 m elevation from datum with pressure of 10 bar and at a temperature of 300°C. The entrance velocity is 40 m/s and exit velocity is 20 m/s. During the process 54,000 kJ/hr of heat is transferred to control volume and rise in enthalpy is 8 kJ/kg. Calculate power developed. **(8)**

UNIT-4

Q.7 a) State and explain two statements of second law of thermodynamics. Show that both statements are equivalent. **(6)**

b) A reversible heat enquire operate between two thermal reservoirs at 600°C. and 40°C. The engine drives a refrigerator working between 40°C and -15°C. The heat transfer to engine is 2000 kJ and network output of the combined refrigerator plant is 360 kJ. Evaluate the heat transfer to the refrigerator and net heat transfer to the reservoir at 40°C. **(7)**

Q.8 a) What do you mean by coefficient of performance. Show that $(COP)_{HP} = (COP)_{refrigerator} + 1$. **(6)**

b) The efficiency of Carnot engine is 20%. The efficiency gets doubled when the sink temperature is reduced by 60°C. Estimate source and sink temperature. **(7)**

UNIT-5

Q.9 a) State and prove Clausius theorem. **(7)**

system at 2 bar and 100°C at an elevation of 100 m above the datum. The same mass leaves the control volume at 150 m elevation from datum with pressure of 10 bar and at a temperature of 300°C. The entrance velocity is 40 m/s and exit velocity is 20 m/s. During the process 54,000 kJ/hr of heat is transferred to control volume and rise in enthalpy is 8 kJ/kg. Calculate power developed. **(8)**

UNIT-4

Q.7 a) State and explain two statements of second law of thermodynamics. Show that both statements are equivalent. **(6)**

b) A reversible heat enquire operate between two thermal reservoirs at 600°C. and 40°C. The engine drives a refrigerator working between 40°C and -15°C. The heat transfer to engine is 2000 kJ and network output of the combined refrigerator plant is 360 kJ. Evaluate the heat transfer to the refrigerator and net heat transfer to the reservoir at 40°C. **(7)**

Q.8 a) What do you mean by coefficient of performance. Show that $(COP)_{HP} = (COP)_{refrigerator} + 1$. **(6)**

b) The efficiency of Camot engine is 20%. The efficiency gets doubled when the sink temperature is reduced by 60°C. Estimate source and sink temperature. **(7)**

UNIT-5

Q.9 a) State and prove Clausius theorem. **(7)**

b) 4 kg of water at 27°C is mixed with 1 kg of ice at 0°C. Assuming adiabatic mixing, determine final temp. Of mixture of water and ice. Calculate net change in entropy. Assume enthalpy of fusion of ice as 335 kJ/kg. **(6)**

Q.10 a) What is irreversibility? What are the effects of irreversibility on work output of a system. **(3)**

b) Define Helmholtz and Gibbs function. **(4)**

c) 25 kg of water at 90°C is mixed with 40 kg of water at 40°C, at constant pressure. The atmospheric pressure is 1 bar & 20°C. Calculate the decrease in available energy. **(6)**

UNIT-6

Q.11 a) Sketch and explain Otto cycle with P – V, T – S diagram. **(10)**

b) A diesel cycle has a compression ratio of 14 and cut off takes place at 6% of the stroke. Find air standard efficiency of diesel cycles. **(4)**

Q.12 a) Show that efficiency of Brayton cycle depends pressure ratio. **(7)**

b) Derive expression for efficiency of Ranking Cycle. **(7)**

SUMMER-2019

UNIT-1

Q.1 a) Explain the concept of macroscopic and microscopic view points applied to study of thermodynamics. **(7)**

b) The compression ratio of an engine is 15 (i.e. $V_1 = 15 V_2$). The pressure of gas at the beginning of stroke is 100 kPa and temperature is 30°C. Calculate absolute pressure at the end of compression stroke, if the temperature is to be 980°C. **(6)**

Q.2 a) Explain the following terms with neat sketch.

i. State,

ii. Property,

iii. Process,

iv. Quasi-static process. **(7)**

b) An electric potential of 100 V is impressed on a certain resistor such that a current of 12 A is drawn. Calculate the energy dissipated in 3 min. **(6)**

UNIT-2

Q.3 a) Define Enthalpy. Why does the enthalpy of ideal gas depend only on temperature? **(7)**

b) Air initially at 60 kPa pressure, 800° K temp. and 0.1 m^3 volume is compressed isothermally until the volume is half and subsequently the air is cooled at constant pressure till its volume is half again. Sketch the process on P-V diagram and determine

i. Total work interaction,

ii. Total heat interaction. **(6)**

Q.4 a) Define an adiabatic process: Show that a reversible process for given mass of a perfect gas is PV^γ = constant. **(7)**

b) A system is composed of gas contained in a cylinder fitted with a piston. The gas expands from the state 1 for which E_1 = 75 kJ to a state 2 for which E_2 = -25 kJ. During expansion, the gas dies the work of 60 kJ, on the surrounding. Determine heat transferred to or from the system during the process. **(7)**

UNIT-3

Q.5 a) What is steady flow process? Write the steady flow energy equation and state the significance of various terms involved. **(7)**

b) Air is compressed steadily at a rate of 0.46 kg/s from 100 kPa 20°C to a final pressure of 320 kPa. The compression is polytropic with polytropic index of 1.32 the volume of air changes from 3m^3/kg to 0.8 m^3/kg. The inlet velocity is 25 m/s while the exit velocity is 130 m/s. The delivery connection is 12 m above the inlet. What is shaft power of the compressor? Is it power absorbing or power

Q.4 a) Define an adiabatic process: Show that a reversible process for given mass of a perfect gas is PV^{γ} = constant. **(7)**

b) A system is composed of `gas contained in a cylinder fitted with a piston. The gas expands from the state 1 for which E_1 = 75 kJ to a state 2 for which E_2 = -25 kJ. During ansion, the gas dies the work of 60 kJ, on the rounding. Determine heat transferred to or from the tem during the process. **(7)**

UNIT-3

Q.5 a) What is steady flow process? Write the steady flow energy equation and state the significance of various terms involved. **(7)**

b) Air is compressed steadily at a rate of 0.46 kg/s from 100 kPa 20°C to a final pressure of 320 kPa. The compression is polytropic with polytropic index of 1.32 the volume of air changes from $3m^3/kg$ to $0.8\ m^3/kg$. The inlet velocity is 25 m/s while the exit velocity is 130 m/s. The delivery connection is 12 m above the inlet. What is shaft power of the compressor? Is it power absorbing or power producing device. **(7)**

Q.6 a) Deduce the steady flow energy equation for:

i. Boiler

ii. Reciprocating compressor. **(7)**

b) Steam enters a turbine with a velocity of 40 m/s and Sp. enthalpy of 2500 kJ/kg and leaves with a velocity of 90 m/s and Sp. enthalpy of 2030 kJ/kg. Heat losses from the turbine to surroundings are 240 kJ/min and steam flow rate is 5040 kg/hr. Neglect the change of potential energy. Find power developed by the turbine. **(7)**

UNIT-4

Q.7 a) State Kelvin Plank and Clausius statement of second law of Thermodynamics? Also that they are equivalent to each other. **(7)**

b) A cyclic heat engine operates between a source temperature of 800°C and sink temperature of 30°C. What is the least rate of heat rejection per kW net output of the engine? **(6)**

UNIT-4

Q.7 a) State Kelvin Plank and Clausius statement of second law of Thermodynamics? Also that they are equivalent to each other. **(7)**

b) A cyclic heat engine operates between a source temperature of 800°C and sink temperature of 30°C. What is the least rate of heat rejection per kW net output of the engine? **(6)**

Q.8 a) What is Carnot cycle? Explain its working with P.V. and T-S diagram. **(7)**

b) A heat is used to drive a heat pump. The heat transfers from heat pump and heat engine is used to heat the water circulating through a building. The efficiency of heat engine is 27% and the COP of the heat pump is 4. Evaluate the ratio of heat transfer to circulating water to heat transfer to the engine. **(6)**

UNIT-5

Q.9 a) Show that $ds = \frac{\delta Q}{T}$ for a reversible process and show that the entropy is a property of a system. **(7)**

b) 1.5 kg of air at 1 bar, 300° K is contained in a rigid insulated tank. During the process. 18 kJ of work is done on the gas through a paddle wheel mechanism. Determine the final temperature, final pressure of air in the tank and change in entropy. Assume Sp. heats of air to be constant. **(6)**

Q.10 a) Derive an expression of available energy from finite ...rgy. source at temperature T when the environment ...perature is T_0. **(7)**

3

...25 kg of water at 90°C is mixed with 40 kg of water at 40°C at constant pressure. The atmospheric pressure is 1 bar and 20°C. Calculate the decrease in available energy. **(6)**

UNIT-6

Q.11 a) Derive an expression for thermal efficiency of Otto cycle. **(7)**

b) Discuss the effect of pressure variation on thermal efficiency of Brayton cycle. **(7)**

Q.12 a) Sketch and Explain ideal Rankine cycle with P-V and T-S diagram. **(7)**

b) What are methods which can lead to increase in thermal

Q.9 a) Show that $ds = \frac{\delta Q}{T}$ for a reversible process and show that the entropy is a property of a system. **(7)**

b) 1.5 kg of air at 1 bar, 300° K is contained in a rigid insulated tank. During the process. 18 kJ of work is done on the gas through a paddle wheel mechanism. Determine the final temperature, final pressure of air in the tank and change in entropy. Assume Sp. heats of air to be constant. **(6)**

Q.10 a) Derive an expression of available energy from finite energy source at temperature T when the environment temperature is T_0. **(7)**

b) 25 kg of water at 90°C is mixed with 40 kg of water at 40°C at constant pressure. The atmospheric pressure is 1 bar and 20°C. Calculate the decrease in available energy. **(6)**

UNIT-6

Q.11 a) Derive an expression for thermal efficiency of Otto cycle. **(7)**

b) Discuss the effect of pressure variation on thermal efficiency of Brayton cycle. **(7)**

Q.12 a) Sketch and Explain ideal Rankine cycle with P-V and T-S diagram. **(7)**

b) What are methods which can lead to increase in thermal efficiency of Rankine cycle. **(7)**

WINTER-2018

UNIT 1

Q.1 a) What is system and surrounding. What are types of thermodynamics system explain them with suitable examples. **(7)**

b) A vehicle of mass 1200 kg is running at a speed of 50 km/hr. The brakes are applied and the vehicle is brought to rest. Calculate the rise in temp of brakes if their mass is 13 kg. Take specific heat of brake material = 0.45 kJ/kg° K. **(6)**

Q.2 a) Prove the expression

$C_p - C_v = R$

where, C_p – S_p heat at constant pressure

C_v – S_p heat at constant volume. **(7)**

b) Estimate the rise in temperature of water when it falls through a height of 50 m. Assume that all the heat generated stays in water. The Sp. heat of water may be taken as 4.2 kJ/kg° K. **(6)**

UNIT 2

Q.3 a) State first law of thermodynamics? And apply it adiabatic process. **(7)**

b) A quantity of gas occupying 0.14 m³ at a pressure of 1400 kPa and 300°C is expanded is entropically to 280 kPa. Calculate **(6)**

i. Mass of gas, **ii.** Final temperature,

iii. Work transfer.

Q.4 a) For polytropic process, derive

$$Q_{1-2} = \frac{\gamma - n}{\gamma - 1} \times \text{Polytropic work transfer.}$$

where, Q_{1-2} – Polytropic heat transfer

γ – adiabatic index

n – polytropic index **(7)**

b) 0.5 kg of air is compressed reversibly and adiabatically from 80 kPa and 60°C to 0.4 MPa and is then expanded at constant pressure to the original volume. Sketch the process on P – V and T – S diagram. Find work transfer and heat transfer. **(6)**

UNIT 3

Q.5 a) Derive steady flow energy equation for **(7)**

i. Condenser, **ii.** Rotary compressor.

b) In gas turbine the gas enters at the rate of 5 kg/s with a velocity of 50 m/s and enthalpy of 900 kJ/kg and leaveAs the turbine with a velocity of 150 m/s and enthalpy of 400 kJ/kg. The loss of heat from gases to surrounding is 25 kJ/kg. Assume $R = 0.285 \frac{kJ}{kg^0K}$ and $C_p = 1.004$ kJ/kg°K and inlet conditions are 100 kPa at 27°C. **(7)**

Q.6 a) Apply steady flow energy equation to **(7)**

i. Steam turbine **ii.** Evaporator.

b) Air enters a convergent nozzle with a velocity of 40 m/s. The enthalpy of air decrease by 180 kJ/kg. Determine exit

Q.4 a) For polytropic process, derive

$$Q_{1-2} = \frac{\gamma - n}{\gamma - 1} \times \text{Polytropic work transfer.}$$

where, Q_{1-2} – Polytropic heat transfer

γ – adiabatic index

n – polytropic index **(7)**

b) 0.5 kg of air is compressed reversibly and adiabatically from 80 kPa and 60°C to 0.4 MPa and is then expanded at constant pressure to the original volume. Sketch the process on P – V and T – S diagram. Find work transfer and heat transfer. **(6)**

UNIT 3

Q.5 a) Derive steady flow energy equation for **(7)**

i. Condenser, **ii.** Rotary compressor.

b) In gas turbine the gas enters at the rate of 5 kg/s with a velocity of 50 m/s and enthalpy of 900 kJ/kg and leaveAs the turbine with a velocity of 150 m/s and enthalpy of 400 kJ/kg. The loss of heat from gases to surrounding is 25 kJ/kg. Assume $R = 0.285 \frac{kJ}{kg^0K}$ and C_p = 1.004 kJ/kg°K and inlet conditions are 100 kPa at 27°C. **(7)**

Q.6 a) Apply steady flow energy equation to **(7)**

i. Steam turbine **ii.** Evaporator.

ir enters a convergent nozzle with a velocity of 40 m/s. enthalpy of air decrease by 180 kJ/kg. Determine exit velocity. Assume adiabatic condition in the nozzle. **(7)**

UNIT 4

Q.7 a) Sketch and explain carnot cycle with P-V and T-S diagram and prove that $\eta_{carnot} = 1 - \frac{T_L}{T_H}$. **(7)**

b) The efficiency of carnot engine is 20%. The efficiency gets doubled, when the sink temperature is reduced by 60°C. Estimate source and sink temperatures. **(6)**

Q.8 a) What is heat pump? How does it differ from a refrigerator? Show that $(COP)_{HP}$ = 1 + (COP) Ref. **(7)**

b) A heat pump delivers 2 kW of heat to a room temperature. Maintained at 25°C and receives heat from a reservoir at - 10°C. If the actual COP is 50% of that of an ideal heat pump operating between same temperature limits, what is the actual power required in kW to run the heat pump. **(6)**

UNIT 5

Q.9 a) State and prove Clausius Theorem. **(7)**

b) 4 kg of water at 27°C is mixed with 1 kg of ice at 0°C. Assume adiabatic mixing, determine the final temperature of mixture of water and ice. **(6)**

Q.10 a) State Helmholtz and Gibbs function? **(4)**

b) What is irreversibility? What are the effects of irreversibility on work output of a system. **(4)**

velocity. Assume adiabatic condition in the nozzle. (7)

UNIT 4

Q.7 a) Sketch and explain carnot cycle with P-V and T-S diagram and prove that $\eta_{carnot} = 1 - \frac{T_L}{T_H}$. (7)

b) The efficiency of carnot engine is 20%. The efficiency gets doubled, when the sink temperature is reduced by 60°C. Estimate source and sink temperatures. (6)

Q.8 a) What is heat pump? How does it differ from a refrigerator? Show that $(COP)_{HP} = 1 + (COP)_{Ref.}$ (7)

b) A heat pump delivers 2 kW of heat to a room temperature. Maintained at 25°C and receives heat from a reservoir at - 10°C. If the actual COP is 50% of that of an ideal heat pump operating between same temperature limits, what is the actual power required in kW to run the heat pump. (6)

UNIT 5

Q.9 a) State and prove Clausius Theorem. (7)

b) 4 kg of water at 27°C is mixed with 1 kg of ice at 0°C. Assume adiabatic mixing, determine the final temperature of mixture of water and ice. (6)

Q.10 a) State Helmholtz and Gibbs function? (4)

b) What is irreversibility? What are the effects of irreversibility on work output of a system. (4)

c) Air enters the compressor in steady flow manner at 140 kPa, 17°C and 70 m/s and leaves it at 350 kPa, 127°C and 110 m/s. The environment is at 100 kPa and 7°C.

Calculate per kg of air (5)

i. Actual amount of work required.

ii. Minimum amount of work required.

iii. The irreversibility of the process.

UNIT 6

Q.11 a) Sketch and explain Diesel cycle with P – V and T – S diagram. (7)

b) Derive expression for efficiency of Stirling cycle. (7)

Q.12 a) Sketch and explain modified Rankine cycle with P – V and T – S diagram. (7)

b) Explain Brayton cycle with neat sketch. Also derive its efficiency. (7)

SUMMER-2018

UNIT-1

Q.1 a) Define the terms state, property, Process and cycle of a thermodynamic system. **(4)**

b) Define quasi-static process. State its salient features. **(3)**

c) Two spheres, each of capacity $2m^3$, are connected by a pipe with a valve inserted in between. When the valve lies in the closed position one sphere contains oxygen at 50 kPa and 320 K and the other contains oxygen at 45 kPa and 290 K. Subsequently the valve is opened and the entire system is allowed to attain the equilibrium conditions. At this state, the final temperature is noted to be 300 K. Presuming that the volume of the connecting pipe is negligible, determine the final pressure of the composite system. **(6)**

Q.2 a) Prove the characteristics gas equation pv = mRT. **(4)**

b) What do you understand by thermodynamic equilibrium? **(4)**

c) An automobile vehicle of 1500 kg mass is running at a speed of 60 km/hr. the brakes are applied and the vehicle is brought to rest. Calculate the rise in temperature of the brakes if their mass is 15 kg. Take specific heat of the brake material = 0.46 kJ/kgK. **(5)**

UNIT-2

Q.3 a) Define the following:

i. Enthalpy **ii.** Internal Energy **iii.** Flow work **(4)**

b) State first law of thermodynamics. Apply is to reversible adiabatic process and show that: pv^r = constant for adiabatic process. **(5)**

c) 5-kg of air at 150 kPa and 300°C is compressed polytropically until the pressure and temperature becomes 1500 kPa and 500°C respectively Evaluate polytropic workdone and heat transferred during the process. **(5)**

Q.4 a) Show that for a polytropic process the heat transfer is given by: $Q_{1-2} = \frac{r-n}{r-1} \times$ polytropic workdone. **(6)**

b) A ideal gas with a mass of 0.9 kg has characteristic gas constant of 287 J/kgK. It is heated at constant pressure of 8 bar from 30°C to 200°C. If specific heat at constant pressure is 1.005 kJ/kgK.

Determine:

i. Specific heat constant volume.

ii. Heat supplied to gas.

iii. Increase in internal energy.

iv. Workdone during the process. **(7)**

UNIT-3

Q.5 a) State the limitations of first law of thermodynamics. **(3)**

b) Defined steady flow process. What are the conditions for a steady flow process?

adiabatic process. **(5)**

c) 5-kg of air at 150 kPa and 300°C is compressed polytropically until the pressure and temperature becomes 1500 kPa and 500°C respectively Evaluate polytropic workdone and heat transferred during the process. **(5)**

2 **a)** Show that for a polytropic process the heat transfer iven by: $Q_{1-2} = \frac{r-n}{r-1} \times$ polytropic workdone. **(6)**

b) A ideal gas with a mass of 0.9 kg has characteristic gas constant of 287 J/kgK. It is heated at constant pressure of 8 bar from 30°C to 200°C. If specific heat at constant pressure is 1.005 kJ/kgK.

Determine:

i. Specific heat constant volume.

ii. Heat supplied to gas.

iii. Increase in internal energy.

iv. Workdone during the process. **(7)**

UNIT-3

Q.5 a) State the limitations of first law of thermodynamics. **(3)**

b) Defined steady flow process. What are the conditions for a steady flow process? **(3)**

c) 2 kg/s of air at 15°C is raised to 800°C by passing it through heat exchanger. Ata the exit of heat exchanger air possesses a velocity of 30 m/s. Then the air enters a nozzle where it expands until the temperature has fallen to 700°C. On leaving the nozzle air enters a turbine and gets expanded until the temperature has fallen to 450°C and velocity of 60 m/s. **(8)**

Determine:

1. Rate of heat transfer to air H.E.
2. Power output from turbine assuming no heat loss and
3. Velocity at exit from nozzle assuming no heat loss.

Take the enthalpy of air h = cpt, where C_p is the specific heat equal to 1.005 kJ/kgK and t is the temperature in °C.

Q.6 a) Derive general energy equation for variable flow process. **(5)**

b) A perfect gas flow through a nozzle where it expands in a reversible adiabatic manner. The inlet conditions are 22 bar, 500°C, 38 m/s At exit the pressure is 2 bar. Determine the exit velocity and exit area if the flow rate is 4 kg/s. Take R = 190 J/kgK and r = 1.35. **(5)**

2. Power output from turbine assuming no heat loss and

3. Velocity at exit from nozzle assuming no heat loss.

Take the enthalpy of air h = cpt, where C_p is the specific heat equal to 1.005 kJ/kgK and t is the temperature in °C.

Q.6 a) Derive general energy equation for variable flow process. **(5)**

b) A perfect gas flow through a nozzle where it expands in a reversible adiabatic manner. The inlet conditions are 22 bar, 500°C, 38 m/s At exit the pressure is 2 bar. Determine the exit velocity and exit area if the flow rate is 4 kg/s. Take R = 190 J/kgK and r = 1.35. **(5)**

UNIT-4

Q.7 a) What is thermal energy reservoir? Explain the terms "source" and "sink". **(3)**

b) What is heat pump? How does it differ from refrigerator? Show that cop of a heat pump is greater than COP of refrigerator by unity. **(4)**

c) A cold storage is maintained at 268°K, while the surroundings is at 308°K. The heat leakage from the surroundings into the cold storage is estimated as 29 kJ/s. ermine the power required to run the cold storage plant e actual COP is 30% of the ideal COP between the same perature limits. **(6)**

Q.8 a) State the two statement of second law of thermodynamics and prove their equivalence. **(7)**

b) A reversed carnot cycle operating as a refrigerator has a refrigeration capacity of 100 kJ/s while operating between temperature limits of 20°C and 35°C.

Determine: **i.** Power output **ii.** COP

If the system is used for heating purpose only find its COP. What would be its efficiency if it runs as an engine? **(6)**

UNIT-5

Q.9 a) Explain "entropy" and prove claysius inequality with proper diagram. **(5)**

b) 2 m^3 at hydrogen at a pressure of 1 bar and 20°C is compressed isentropically to 4 bar. The same gas is expanded isothermally to original volume finally the gas pressure is restored to the original value by constant volume heat

UNIT-5

Q.9 a) Explain "entropy" and prove claysius inequality with proper diagram. **(5)**

b) 2 m^3 at hydrogen at a pressure of 1 bar and 20°C is compressed isentropically to 4 bar. The same gas is expanded isothermally to original volume finally the gas pressure is restored to the original value by constant volume heat rejection process. Determine the change in internal energy and entropy during each process. R = 4.206 kJ/kgK and C_p = 14.25 kJ/kgK for hydrogen. **(8)**

Q.10 a) What are Helmholtz function and Gibb's function? **(4)**

b) Show that the transfer of heat through finite temperature difference is irreversible. **(4)**

c) A single stage air turbine is to operate with an inlet pressure and temperature of 6 bar and 800 K. The outlet pressure and temperature are 1.0 bar and 500 K. During expansion the turbine loses 25 kJ/kg to the surroundings which are at 1 bar and 300 K. For unit mass flow rate, determine the decrease in availability, the maximum work and the irreversibility.

For air take C_p = 1.005 kJ/kgK and R = 0.287 kJ/kgK. **(5)**

UNIT-6

Q.11 a) Derive an expression for air standard efficiency of a dual combustion cycle. **(8)**

b) An engine working on Otto cycle is supplied with air at 0.1 MPa, 35°C, the compression ratio is 8. Heat supplied is 2100 kJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency and the mean effective pressure. **(6)**

Q.12 a) Derive expression for thermal efficiency of Brayton cycle? **(5)**

b) Compare η^{th} of Otto diesel and dual cycle for same maximum pressure and temperature and same heat rejection. **(6)**

c) Plot efficiency of air standard Otto cycle as function of compression ratio for compression ratios from 4 to 16. **(5)**

expansion the turbine loses 25 kJ/kg to the surroundings which are at 1 bar and 300 K. For unit mass flow rate, determine the decrease in availability, the maximum work and the irreversibility.

For air take C_p = 1.005 kJ/kgK and R = 0.287 kJ/kgK. **(5)**

UNIT-6

Q.11 a) Derive an expression for air standard efficiency of a dual combustion cycle. **(8)**

b) An engine working on Otto cycle is supplied with air at 0.1 MPa, 35°C, the compression ratio is 8. Heat supplied is 2100 kJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency and the mean effective pressure. **(6)**

Q.12 a) Derive expression for thermal efficiency of Brayton cycle? **(5)**

b) Compare η^{th} of Otto diesel and dual cycle for same maximum pressure and temperature and same heat rejection. **(6)**

c) Plot efficiency of air standard Otto cycle as function of compression ratio for compression ratios from 4 to 16. **(5)**