UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF MECHANICAL ENGINEERING
MID-SEMESTER EXAMINATIONS
ME 261: THERMODYNAMICS I
APRIL 18, 2009
ATTEMPT ALL QUESTIONS.

(1)

Attempt all questions. Time Allowed: 1hour

1. A fluid in piston-cylinder assembly expanded at a pressure of 21.0 bars and volume of 0.380 m^3/kg to a final volume of 0.683 m^3/kg. Calculate the amou of work done in KJ per kilogram of fluid if
   i) The process occurs at constant pressure
   ii) The process occurs at constant temperature.

   If the fluid behaves as an ideal gas and the process occurs at constant temperature, find the heat transfer during the process.

2. Water, initially a saturated liquid at 100^0C, is contained in a piston cylinder assembly. The water undergoes a process to the corresponding saturated vapou state, during which the piston moves freely in the cylinder. If the change of state is brought about by heating the water as it undergoes the process at constant temperature and pressure determine the work and heat transfer per uni mass, each in Kj/kg. If the heating continues at constant pressure to a final stat where the temperature of the system is 250^0C, calculate the total change in internal energy and the total heat transfer of the system from the initial state to the final state. Illustrate the processes on a T-v or P-v diagram.

3. Air in a piston –cylinder assembly is compressed polytropically, index of compression being 1.40, from an initial state with a temperature and pressure o 27^0 C and 3.0 bars respectively to a final state with a pressure of 45.0 bars. Determine the change in internal energy of the system and the heat transfer, each in KJ per Kg of air. Assume that the air behaves like an ideal gas. For air, C_v = 0.7165 kJ/Kg.k, C_p = 1.0035 kJ/kg.k, R=0.287kJ/kg.k

VERSITY OF NIGERIA, NSUKKA
PARTMENT OF MECHANICAL ENGINEERING
ID – SEMESTER EXAMINATIONS
ME 261: THERMODYNAMICS I

JUNE 5, 2010

Attempt all questions. *Time Allowed: 1¼ Hours*

1. A gas in a piston –cylinder assembly is compressed from p_1 = 3.4 bar, V_1 = 0.0283 m^3 to p_2 = 8.2 bar in a process for which the relation between pressure and volume is $pV^{1.2}$ = constant. The mass of the gas is 0.183 kg. During the process, the heat transfer from the gas is 2.2 kJ. Determine the change in specific internal energy of the gas, in kJ/kg. Kinetic and potential energy effects are negligible.

2. A quantity of air occupying 0.14 m³ at 9.65 bar and 371 °C in a piston – cylinder assembly is heated during a constant volume process until the pressure reaches 41.4 bar. The air is then expanded adiabatically and polytropically with index of expansion, n, being 1.4 to a pressure of 2.76 bar and temperature of 984 °C. Assuming that the air behaves like an ideal gas and kinetic and potential energy effects are negligible, calculate;
   (a) the temperature of the air at the end of the heating process, in °C.
   (b) the heat transfer during each process; in kJ
   (c) the total work produced for the two processes, in kJ

   For air, C_v = 0.7165 kJ/kg.K, C_p = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K

3. Steam in a closed vessel initially at 7 bar, 250 °C is cooled at constant pressure until it becomes saturated vapour. Determine the temperature at which condensation first occurs, in °C. and calculate the heat lost in kJ per kg of steam to the surroundings during this process. If the steam is finally brought to saturated liquid condition, calculate the change in internal energy of the system from the initial state to the final state, in kJ/kg of steam.

   Sketch the processes on a T-v or p-v diagram.

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF MECHANICAL ENGINEERING
MID-SEMESTER EXAMINATIONS

(3)

Q-W=ΔU

ME 261: THERMODYNAMICS I

January 31, 2015

Attempt all questions ***Time Allowed: 1 Hour***

1. A gas in a closed system undergoes two processes in series:

Diagram

Process 1 – 2: constant volume process from initial pressure, P_1 = 3.45 bar to a pressure, P_2 = 0.69 bar

Process 2 – 3: compression process with $pV^{1.3}$ = constant from state 2 to state 3 where the pressure, P_3 = 3.45 bar and the volume, V_3 = 0.283 m^3

mcv(T

Sketch the processes on a p – V diagram and determine the total work done on or by the gas for the two processes, in kJ.

(2) Air is compressed adiabatically in a piston – cylinder assembly from P_1 = 1.013 bar, T_1 = 27 ^oC to a state where the pressure is 15 bar and the specific volume is 0.12284 m^3/kg. Assuming ideal gas behaviour, and ignoring kinetic and potential energy effects, calculate the work input, in kJ per kg of air. If the air is then cooled at constant volume to a temperature of 27 ^oC, determine the heat transfer for this cooling process, in kJ per kg of air. Sketch the two processes on a p-V or T-v diagram.

For air, Cv = 0.7165 kJ/kg.K, C_P = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K

(3) Saturated water vapour initially at 2.8 bar is contained in a closed, rigid tank with volume 1.70 m^3. The water vapour is cooled and its pressure drops to 1.4 bar. Calculate the amount of energy lost by heat transfer, in kJ, by the cooling process and the mass of saturated vapour present at the final state, in kg. Kinetic and potential energy effects are negligible. Sketch the process on a T-v or p-V diagram.

mcv

UNIVERSITY OF NIGERIA,
DEPARTMENT OF MECHANICAL ENGINEERING
MID-SEMESTER EXAMINATIONS 2018/2019 SESSION

APRIL 6, 2019

Attempt All Questions *Time Allowed: 1 Hour*

1(a) Differentiate between

i) Closed system and control volume
ii) Adiabatic process and isothermal process
iii) Zeroth Law of Thermodynamics and First Law of Thermodynamics

(b) A closed rigid and well-insulated tank contains a two-phase mixture of 0.014 m^3 of saturated liquid water and 3.40 m^3 of saturated water vapour, initially at 1.0135 bar. A paddle wheel turned by an external motor stirs the mixture until only saturated vapour remains in the tank. Kinetic and potential energy effects are negligible. Determine the energy transfer by work into the system, in MJ. Indicate the initial and final states of the system on a T-v or p-v diagram.

(2) A certain gas contained in a piston-cylinder system is initially at 1.035 bar and 21 ^{o}C with a specific volume of 0.75 m^3/kg. It undergoes polytropic compression during which the work input is 37.0 kJ and its final temperature and pressure become 316 ^{o}C and 6.21 bar, respectively. Assume that the gas behaves like an ideal gas and that kinetic and potential energy effects are negligible. Sketch the process on a T-v or p-v diagram and calculate

a) the value of the index of compression, n

b) the mass of the gas involved in the process, in kg

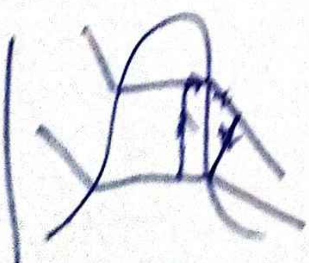
c) the final volume of the gas, in m^3

(3) Five kilograms of saturated water vapour at 4.9 bar contained in a piston-cylind system is superheated at constant volume until it attains a pressure of 10 bar. T system is then cooled at constant pressure and the water returns to saturated vapc Neglect changes in kinetic and potential energies. Sketch the processes on a T-v p-v diagram and determine

a) the maximum temperature reached by the system during the heating pro in ^{o}C

b) the total work done for the entire process, in kJ

c) the total heat transfer for the entire process, in kJ.



$v_1 = v_f + x(v_g - v_f)$

4.9

$Q - W = \Delta U$

TIME ALLOWED: 3 Hours

Attempt any FOUR Questions

1. A certain gas contained in a closed system is initially at 1.035 bar and 21 °C with a specific volume of 0.75 m^3/kg. It undergoes adiabatic polytropic compression with index of compression, n = k, through a volume ratio of 6:1. During the compression, the work input is 7.4 kJ and the final temperature of the gas is 316 °C. Assume that the gas behaves like an ideal gas and that kinetic and potential energy effects are negligible. Calculate the values of R, Cv and Cp of the gas each in kJ/kg K and also determine the mass of the gas involved in the process, in kg. Sketch the process on a p-v diagram.

2. One kilogram of saturated water vapour at 5.9 bar is contained in a piston – cylinder assembly. It is allowed to expand reversibly according to a law pv = constant to a pressure of 0.8 bar. Find the final temperature, in °C, of the water vapour. Calculate also the work done by the steam and the heat transfer to or from the cylinder walls, each in kJ per kg of steam. Sketch the process on a T-v or p-v diagram.

3. Air initially at 17 °C, 5.0 bar enters a compressor operating at steady state with a mass flow rate of 5 kg/s and a velocity of 160 m/s and is compressed polytropically with index of compression, n = 1.3. It exits at a pressure of 25.0 bar with a velocity of 50 m/s. Change in potential energy is negligible. If the air behaves like an ideal gas, evaluate the work required and the heat transfer, each in kW.

For air, Cv = 0.7165 kJ/kg.K, Cp = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K

4. Steam enters a turbine operating at steady state at a pressure of 30 bar, a temperature of 400 °C, and with a velocity of 180 m/s through a flow area of 0.00832 m^2. The steam leaves the turbine at 100 °C as saturated vapour and with a velocity of 100 m/s. Heat transfer from the turbine to the surroundings occurs at a rate of 2.52×10^6 kJ/hr. Neglecting potential energy effects, determine the power developed by the turbine, in kW and the volumetric flow rate of the steam at the exit, in m^3/s.

5(a) State the two Carnot Corollaries in respect of power cycles

(b) At steady state, a system undergoing a power cycle has a thermal efficiency of 40% while developing 100 MW of power. It discharges energy by heat transfer to cooling water at a temperature of 21 °C. The temperature of the hot reservoir for the system is 480 °C. Determine (i) the rate at which energy is actually discharged to the cooling water, in kJ/s. (ii) the minimum theoretical rate at which energy could be discharged to the cooling water, in kJ/s if the heat addition from the hot source remains constant under the same temperature limits.

(c) (i) Define the Coefficient of Performance of a refrigeration system. (ii) Under what condition does this Coefficient attain its maximum for the system? (iii) Write down the equation for the maximum Coefficient identifying your symbols

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF MECHANICAL ENGINEERING
FIRST SEMESTER EXAMINATIONS
ME 261: THERMODYNAMICS I

April 12, 2011 — Time Allowed: 2½ Hours

Attempt all questions.

1. A cylinder contains 0.28 m^3 of an ideal gas at 1.035 bar and 29 °C. The gas is compressed according to the law $pV^{1.3}$ = constant until the volume is reduced to 0.028 m^3. Energy by heat transfer is then supplied at constant pressure until the volume becomes 0.056 m^3. Sketch the processes on a p – V diagram and determine:
   (a) the temperature, in K, and pressure, in bar, at the end of each process,
   (b) the total change in internal energy, in kJ,
   (c) the work done, in kJ, during each process, and
   (d) the total heat transfer into or out of the system, in kJ.
   For the gas, C_v = 0.75 kJ/kg.K, C_p = 1.06 kJ/kg.K, R = 0.31 kJ/kg.K

2. Air enters at a rate of 7.2 kg/s into a compressor operating at steady state at unknown temperature but with a pressure of 1.013 bar and a velocity of 6.0 m/s. At exit, the pressure of the air is 7.0 bar, the temperature and velocity are 177 °C and 2.0 m/s, respectively. Heat transfer from the compressor to its surroundings occurs at a rate of 30 kJ/s and the power input to the compressor is 1.186 MW. Determine the temperature of the air at the inlet of the compressor, in °C. Assume that the air behaves like an ideal gas and ignore any changes in potential energy.
   For air, C_v = 0.7165 kJ/kg.K, C_p = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K.

3. Steam enters a turbine with a negligible velocity at 40 bar and 420 °C and leaves with a high velocity where the pressure is 0.15 bar and its quality is 0.92. It flows at a rate of 9000 kg/hr. The turbine is well insulated and operates at steady state and develops a power output of 2.0 MW. Neglecting potential energy effects, determine the velocity of the steam at the exit of the turbine, in m/s.

4a. What are the two major differences between a heat engine and a refrigerator?

b. What does the Second Law of Thermodynamics say with respect to:
   (i) a heat engine,
   (ii) a refrigerator?

c. A heat engine is designed to operate several cycles in a second. At steady state, the system develops a power output of 18 kW. Heat addition is at a rate of 20 kJ <u>per cycle</u> and comes from a high temperature source of 927 °C. Energy is rejected by heat transfer to cooling water at 27 °C. Determine the minimum theoretical number of cycles required per minute.

d. A refrigerator achieves a coefficient of performance of 2.5 while operating between a low temperature source or compartment of 10 °C and outside temperature of 35 °C. At steady state, the quantity of heat (or heat load) which it removes from the low temperature compartment amounts to 36000 kJ/hr. Determine the actual power, in kW, required by this refrigerator. What is the <u>minimum</u> <u>theoretical</u> power, in kW, required for any refrigeration cycle operating under these conditions?

2010/12

16

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF MECHANICAL ENGINEERING
FIRST SEMESTER EXAMINATIONS
ME 261 THERMODYNAMICS I

APRIL 2, 2012

ATTEMPT ALL QUESTIONS TIME ALLOWED: 2½ HOURS

1. A piston-cylinder assembly contains 100 kg of air with temperature and pressure of 127 °C and 1 bar, respectively. The air is compressed polytropically with index of compression, n=2, from the initial state to a final state where the pressure is 9 bar. Assuming that the air behaves like an ideal gas, determine the work done and the heat transfer in MJ, during the process. If the compression is done isothermally, calculate the heat transfer to or from the system, in MJ. For air, Cv=0.7165 kJ/kg.K, Cp=1.0035 kJ/kg.K, R=0.287 kJ/kg.K

2. Water vapour at a pressure of 8.0 bar and with quality of 0.806 expanded at constant pressure in a cylinder behind a piston on supply of heat. Its temperature rose to 200 °C. For the process, calculate the change in internal energy, the work done and the heat transfer; all in kJ/kg. If the heating is done at constant volume, at what temperature and pressure will the water vapour become saturated vapour? Calculate the new quantity of heat supplied to the piston-cylinder assembly, in kJ/kg. Sketch the two different processes on T-v or p-v diagram(s).

3. Air enters an adiabatic compressor operating at steady state at a rate of 1.44 kg/s with a temperature of 27 °C, a pressure of 2.5 bar and a velocity of 12.0 m/s. At the exit, the pressure of the air is 10.0 bar, the temperature and velocity are 187 °C and 2.0 m/s, respectively. Calculate the power required by the compressor, in kW. Assume that the air behaves like an ideal gas and ignore any changes in potential energy. For air, Cv=0.7165 kJ/kg.K, Cp=1.0035 kJ/kg.K, R=0.287 kJ/kg.K.

4. A turbine is driven by steam which enters the turbine at 45 bar and 400 °C with a velocity of 65 m/s. At steady state, the system leaves the turbine exhaust at a pressure of 1.0 bar with a temperature and a velocity of 115 °C and 400 m/s, respectively. The heat loss from the turbine to the surroundings amounts to 10^5 kJ/hr and the power developed by the turbine is 1.44 MW. Neglect changes in potential energy and determine the mass flow rate of the steam, in kg/s.

5.(a) State any four applications of the Second Law of Thermodynamics

(b) At steady state, a Carnot power cycle generates a net electrical power of 100 MW of heat to a cooling water with a temperature of 30 °C acting as a cold reservoir. Determine the thermal efficiency of the power cycle. If the average temperature of the hot source which provides the working steam is 780 °C, and the heat supply [redacted] remain constant, what is the minimum theoretical rate at which the energy could be discharged to the cold reservoir, in MW?

(c) A Carnot vapour power cycle uses 4.0 kg of steam as a working fluid. During the isothermal expansion, the water is heated from its initial saturated liquid where the pressure and temperature are 40 bar and 250.4 °C, respectively until it is saturated vapour. The vapour then expands to a pressure of 3.0 bar while doing 650 kJ/kg of work. Calculate the work and heat transfer, in kJ, for each of the expansion processes of the cycle. Sketch the cycle on a p-v diagram.

ME 02

UNIVERSITY OF NIGERIA
FACULTY OF ENGINEERING

University of Nigeria, Nsukka
Department of Mechanical Engineering
First Semester Examinations 2018/2019 Session
ME 261: Thermodynamics I
May 31, 2019
Attempt any four Questions ***Time Allowed: 2 Hours***

constant volume

1(a) A closed rigid tank, with a volume of 0.973 m^3, contains air initially at 1.35 bar, 32 ^oC. If the air receives a heat transfer of magnitude 67.71 kJ, determine the final temperature, in ^oC and the final pressure, in bar. Assume that the air behaves like an ideal gas.

For air, Cv = 0.7165 kJ/kg.K, Cp = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K

(b) A piston-cylinder assembly contains 3 kg of carbon monoxide gas. The gas expands from an initial state where the temperature and pressure are 427 ^oC and 5 bar, respectively, to a final state where the pressure is 2 bar. During the process, the pressure and specific volume are related by $pv^{1.3}$ = constant. The carbon monoxide gas behaves like an ideal gas and kinetic and potential energy effects are negligible. Determine the heat transfer during the process, in kJ. For carbon monoxide gas, Cv = 0.7445 kJ/kg.K, Cp.= 1.0413 kJ/kg.K, R = 0.2968 kJ/kg.K. $P_1V_1 = mRT_1$

2. A piston-cylinder system containing 1 kg of saturated water vapour at 12 bar undergoes a power cycle composed of the following four processes:

Process 1 – 2: Constant pressure heating at 12 bar from saturated vapour to attain a specific volume of 0.392 m^3/kg

Process 2 – 3: Constant volume cooling to a pressure of 5 bar and temperature of 170^{0}C.

Process 3 – 4: Isothermal compression with heat loss of 801.15 kJ to a two-phase liquid-vapour mixture with quality of 67.1%.

Process 4 – 1: Constant volume heating to original state.

Kinetic and potential energy effects are negligible. Sketch the cycle on a T-v or p-v diagram and determine the net work and heat transfer for the cycle, in kJ and the thermal efficiency of the power cycle.

3. Nitrogen gas is compressed at steady state from a pressure of 1.5 bar and a temperature of 27 ^oC to a pressure of 5.0 bar and a temperature of 60 ^oC. The gas enters the compressor through a 0.3 m diameter pipe with a velocity of 13 m/s and leaves with a velocity of 30 m/s. Heat transfer rate from the compressor to its surroundings occurs at a rate of 32 kJ per kg of nitrogen flowing. Assume that the nitrogen gas behaves like an ideal gas and neglect potential energy effects. Calculate the mass flow rate of the nitrogen gas, in kg/s and the compressor power input, in kW.

For nitrogen, Cv = 0.7448 kJ/kg.K, Cp = 1.0416 kJ/kg.K, R = 0.2968 kJ/kg.K

4. A steam power plant has a turbine operating at steady state. Steam at 52 bar, 510 ^oC enters the turbine with a volumetric flow rate of 0.4008 m^3/s and with a velocity of 70

0.248 555

E 02

UNIVERSITY OF NIGERIA
FACULTY OF ENGINEERING
DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
Course Title: Material Science
Date: July 7, 2010.

m/s. The steam leaves the turbine exhaust at a temperature of 105 °C with specific volume of 1.170 m^3/kg and with a velocity of 450 m/s. The resulting power outpout of the turbine is 5.76 MW. Neglect changes in potential energy and sketch the process on a T-v or p-v diagram. Determine

(a) the volumetric flow rate of the steam at the turbine exit, in m^3/s

(b) the heat transfer from the turbine to its surroundings, in MJ/min

5(a) The Second Law of Thermodynamics is important in engineering practice. State four major applications of the Law in engineering.

(b) A system operating at steady state and undergoing a power cycle has a thermal efficiency of 40% with a net power output of 200 kW. It discharges energy by heat transfer to cooling water at a temperature of 21 °C. The temperature of the system's hot reservoir is 480 °C. Determine the rate at which energy is discharged to the cooling water, in kJ/s. If the system eventually is able to attain Carnot efficiency while the energy drawn from the hot reservoir remains constant under the same temperature limits, calculate the power developed by the system, in kW and the minimum theoretical rate at which energy is discharged to the cooling water, in kJ/s.

(c) At steady state, a refrigeration system removes 300 kJ/min of energy by heat transfer from a cold space maintained at -20 °C and discharges energy by heat transfer to its surroundings at 30 °C. If the coefficient of performance of the cycle is 25% of that of a reversible refrigeration cycle operating between thermal reservoirs at these two temperatures, determine the power input to the cycle, in kW and the heat transfer to the surroundings, in kJ/min.

m = 1.35 × 0.973 / 0.287 (303) × 100

Win / power in × 100

(b)

To find T_2

$T_2 = \left[\frac{2.6}{5}\right]^{\frac{0.3}{1.3}} [700]$

for refrigerator = $\frac{Q_{ab}}{Q_{rej} - Q_{ab}} \times 100$

$T_2 = 566.59K$

1.5(0.7165)(T_2 - 303)

$W_2 = \frac{mR(T_2 - T_1)}{1-n}$

$W_{02} = 3(0.2968)(-133.41)$

66K

$\frac{Q_{in}}{Q} \times \frac{100}{1}$

... 5.96KJ

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF MECHANICAL ENGINEERING
ME 261: THERMODYNAMICS I

FIRST SEMESTER EXAMINATIONS
February 18, 2013

Attempt any FOUR questions.

Time Allowed: 2 Hours

1. $0.14\ m^3$ of air at 1.38 bar, 38 °C is compressed polytropically in a piston-cylinder assembly according to the law $pV^{1.35}$ = constant to a pressure of 20.7 bar. Assume that the air behaves like an ideal gas and determine the work of compression and the heat transfer, in kJ. If the compression was done adiabatically with index of compression, n = k = 1.4, calculate the work done, the heat transfer and the change in internal energy of the system, all in kJ.
For air, C_v = 0.7165 kJ/kg.K, C_p = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K

2. A system consisting of 1.0 kg of saturated water vapour at 100 bar and contained in a piston-cylinder assembly undergoes as cycle composed of the following processes:
Process 1-2: expansion with pv = constant from the saturated state at 100 bar to 10 bar.
Process 2-3: constant-pressure process at 10 bar to original volume, i.e. $v_3 = v_1$
Process 3-1: constant-volume heating from 10 bar to 100 bar to complete the cycle.
Sketch the cycle on a p-v or T-v diagram.
Determine the net work for the cycle and the heat transfer for each process, all in kJ/kg.

3. Air enters a compressor, operating at steady state with a flow rate of 0.72 kg/s. The inlet air temperature and pressure are 17 °C and 1.0 bar respectively and its velocity is 6.0 m/s. At the exit, the pressure is 7.0 bar and the temperature is 177 °C. The compressor loses heat to its surroundings at a rate of 10.8 MJ/hr while the power input to the compressor is 118.618 kW. Assume that the air behaves like an ideal gas and ignore any changes in potential energy. Determine the velocity of the air, in m/s, at the [illegible]
For air, C_v = 0.7165 kJ/kg.K, C_p = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K

4. Steam enters a turbine with a volumetric flow rate of 218.42 m^3/hr at 60 bar, 400 °C and with velocity of 10 m/s. The turbine operates at steady state with the steam leaving its exhaust at a pressure of 0.3 bar with a quality of 0.88 and a velocity of 50 m/s. The rate of heat loss from the turbine to its surroundings is 63.68 kW. Neglect changes in potential energy and calculate the power output developed by the turbine, in MW.

5(a) State the Second Law of Thermodynamics as promulgated by Clausius. Does this statement relate to heat engine or to a refrigerator?

(b) With a sketch of p-v diagram state the processes executed by a Carnot gas refrigeration cycle.

(c) At steady state, a refrigerator whose coefficient of performance is 3.0 removes heat from a freezer compartment at 0 °C at the rate of 6.0 MJ/hr and discharges heat to the surroundings which are at 20 °C.

(i) Calculate the heat transfer to the surroundings, in kW.
(ii) Is the refrigerator operating reversibly or irreversibly? Give reasons for your answer.
(iii) Determine the power input to the refrigerator, in kW, when the system operates reversibly and when it operates irreversibly, if the heat removed from the freezer compartment remains constant under the same temperature limits.

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF MECHANICAL ENGINEERING
FIRST SEMESTER EXAMINATIONS
ME 261: THERMODYNAMICS I

2010/ [illegible]

APRIL 2, 2012

ATTEMPT ALL QUESTIONS. TIME ALLOWED: 2½ HOURS

1. A piston-cylinder assembly contains 100 kg of air with temperature and pressure of 127 °C a[illegible] bar, respectively. The air is compressed polytropically with index of compression, n=2, from initial state to a final state where the pressure is 9 bar. Assuming that the air behaves like ideal gas, determine the work done and the heat transfer, in MJ, during the process. If compression is done isothermally, calculate the heat transfer to or from the system, in MJ. [illegible] air, Cv=0.7165 kJ/kg.K, Cp=1.0035 kJ/kg.K, R=0.287 kJ/kg.K

2. Water vapour at a pressure of 8.0 bar and with quality of 0.806 expanded at constant press[illegible] in a cylinder behind a piston on supply of heat. Its temperature rose to 300 °C. For the proc[illegible] calculate the change in internal energy, the work done and the heat transfer, all in kJ/kg. If heating is done at constant volume, at what temperature and pressure will the water vap[illegible] become saturated vapour? Calculate the new quantity of heat supplied to the piston-cylin[illegible] assembly, in kJ/kg. Sketch the two different processes on T-v or p-v diagram(s).

3. Air enters an adiabatic compressor operating at steady state at a rate of 1.44 kg/s wit[illegible] temperature of 27 °C, a pressure of 2.5 bar and a velocity of 12.0 m/s. At the exit, the pres[illegible] of the air is 10.0 bar, the temperature and velocity are 187 °C and 2.0 m/s, respecti[illegible] Calculate the power required by the compressor, in kW. Assume that the air behaves lik[illegible] ideal gas and ignore any changes in potential energy. For air, Cv=0.7165 kJ/kg.K, Cp=[illegible] kJ/kg.K, R=0.287 kJ/kg.K.

Adiabatic, Q=0

4. A turbine is driven by steam which enters the turbine at 45 bar and 450 °C with a velocity [illegible] m/s. At steady state, the system leaves the turbine exhaust at a pressure of 1.0 bar wi[illegible] temperature and a velocity of 115 °C and 400 m/s, respectively. The heat loss from the tur[illegible] to the surroundings amounts to 10^5 kJ/hr and the power developed by the turbine is 1.44 [illegible] Neglect changes in potential energy and determine the mass flow rate of the steam, in kg/s.

5.(a) State any four applications of the Second Law of Thermodynamics

(b) At steady state, a Carnot power cycle generates a net electrical power of 100 MW of heat [illegible] cooling water with a temperature of 30 °C acting as a cold reservoir. Determine the the [illegible]fficiency of the power cycle. If the average temperature of the hot source which provide[illegible] [illegible]ng steam is 780 °C, and the heat supply [redacted] remain constant, wi[illegible] [illegible]um theoretical rate at which the energy could be discharged to the cold reservo[illegible]

[illegible] power cycle uses 4.0 kg of steam as a working fluid. During the isoth[illegible] water is heated from its initial saturated liquid where the pressure [illegible] 10 bar and 250.4 °C, respectively until it is saturated vapour. The vapour [illegible]ure of 3.0 bar while doing 650 kJ/kg of work. Calculate the [illegible] and [illegible] each of the expansion processes of the cycle. Sketch the cycle on [illegible]

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF MECHANICAL ENGINEERING — ME 261: THERMODYNAMI[illegible]
FIRST SEMESTER EXAMINATIONS — May 6, 2014
Attempt any Four questions — Time Allowed: 2 Hours

1(a) State the Zeroth Law of Thermodynamics and mention one specific area it is applied in practice.

(b) A rigid, well – insulated tank, with a volume of 5.66 m^3 contains air at a temperature and pressure of 627 ^oC and 1.36 bar, respectively. The air is stirred by a paddle wheel, resulting in an energy transfer by work to the gas of magnitude 678 kJ. Assuming ideal gas behaviour for the air, determine the final temperature, in ^oC, and the final pressure, in bar. Neglect kinetic and potential energy effects.
For air, C_v = 0.7165 kJ/kg.K, C_p = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K.

2. A closed system consisting of 2 kg of carbon dioxide gas, initially at state 1, has a temperature of 27 ^oC and a pressure of 1.0 bar. The system undergoes a power cycle consisting of the following processes:
Process 1 – 2: constant volume with heat addition to a pressure of 4.0 bar.
Process 2 – 3: polytropic expansion with $pv^{1.28}$ = constant to original pressure of 1.0 bar.
Process 3 – 1: constant pressure compression to original volume.
Assuming the ideal gas model for carbon dioxide gas and neglecting kinetic and potential energy effects,
(a) Sketch the cycle on a p – v diagram
(b) Calculate the thermal efficiency of the cycle.
For carbon dioxide, C_v = 0.6529 kJ/kg.K, C_p = 0.8418 kJ/kg.K, R = 0.1889 kJ/kg.K.

3. Air enters a compressor with a pressure of 1.0135 bar and a temperature of 21 ^oC. The volume flow rate at the inlet is 4.7 m^3/s and the flow area is 0.024154 m^2. At the exit, the pressure is 2.413 bar, the temperature is 137 ^oC, and the velocity is 152.4 m/s. Heat transfer from the compressor to the surroundings occurs at a rate of 780 kJ/min. Potential energy effects are negligible, and the ideal gas model can be assumed for the air. Determine the power input to the compressor, in kW, for steady state operation.
For air, C_v = 0.7165 kJ/kg.K, C_p = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K.

4. Steam enters a turbine operating at steady state at 320 ^oC and 14 bar with a velocity of 25 m/s and leaves as saturated vapour at 0.34 bar with a velocity of 92 m/s. The power developed by the turbine is 300 kW. Heat transfer from the turbine to the surroundings occurs at a rate of 105.5 MJ/hr. Neglecting potential energy effects, determine the mass flow rate of the steam, in kg/s. Calculate also the volume flow rates of steam at the inlet and exit of the turbine, in m^3/s. Sketch the process on a p-v or T-S diagram.

5(a) Carnot power cycle obeys the Second Law of Thermodynamics and yields the highest thermal efficiency. Clearly state this famous law applicable in engineering practice.

(b) One kilogram of air as an ideal gas in a piston – cylinder assembly executes a Carnot power cycle. The isothermal expansion occurs at 838 ^oC from a pressure of 1.87 bar to a pressure of 130 bar. The isothermal compression occurs at 25 ^oC from a pressure of 1,013 bar to a pressure of 1.46 bar. Determine
(a) The heat transfer to the air during the isothermal expansion, in kJ.
(b) The work done by, or on, the air during each of the four processes, in kJ.
(c) The cycle thermal efficiency.
[illegible] cycle on a p – v diagram.
[illegible] 0.7165 kJ/kg.K, C_p = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K.

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF MECHANICAL ENGINEERING
FIRST SEMESTER EXAMINATIONS
MARCH 9, 2015

ME 261: THERMODYNAMICS I

Attempt any FOUR Questions.

TIME ALLOWED: 2 Hours

1. A certain gas contained in a closed system is initially at 1.035 bar and 21 °C with a specific volume of 0.75 m³/kg. It undergoes adiabatic polytropic compression with index of compression, n = k, through a volume ratio of 6:1. During the compression, the work input is 7.4 kJ and the final temperature of the gas is 316 °C. Assume that the gas behaves like an ideal gas and that kinetic and potential energy effects are negligible. Calculate the values of R, Cv and Cp of the gas, each in kJ/kg.K, and also determine the mass of the gas involved in the process, in kg. Sketch the process on a p-v diagram.

2. One kilogram of saturated water vapour at 5.9 bar is contained in a piston – cylinder assembly. It is allowed to expand reversibly according to a law pv = constant to a pressure of 0.8 bar. Find the final temperature, in °C, of the water vapour. Calculate also the work done by the steam and the heat transfer to or from the cylinder walls, each in kJ per kg of steam. Sketch the process on a T-v or p-v diagram.

3. Air initially at 17 °C, 5.0 bar enters a compressor operating at steady state with a mass flow rate of 5 kg/s and a velocity of 160 m/s and is compressed polytropically with index of compression, n = 1.3. It exits at a pressure of 25.0 bar with a velocity of 50 m/s. Change in potential energy is negligible. If the air behaves like an ideal gas, evaluate the work required and the heat transfer, each in kW.

   For air, Cv = 0.7165 kJ/kg.K, Cp = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K.

4. Steam enters a turbine operating at steady state at a pressure of 30 bar, a temperature of 400 °C, and with a velocity of 180 m/s through a flow area of 0.00332 m². The steam leaves the turbine at 100 °C as saturated vapour and with a velocity of 100 m/s. Heat transfer from the turbine to the surroundings occurs at a rate of 2.52×10^6 kJ/hr. Neglecting potential energy effects, determine the power developed by the turbine, in kW and the volumetric flow rate of the steam at the exit, in m³/s.

5(a) State the two Carnot Corollaries in respect of power cycles.

(b). At steady state, a system undergoing a power cycle has a thermal efficiency of 40% while developing 100 MW of power. It discharges energy by heat transfer to cooling water at a temperature of 21 °C. The temperature of the hot reservoir for the system is 460 °C. Determine (i) the rate at which energy is actually discharged to the cooling water, in kJ/s. (ii) the minimum theoretical rate at which energy could be discharged to the cooling water, in kJ/s if the heat addition from the hot source remains constant under the same temperature limits.

ersity of Nigeria, Nsukka
artment of Mechanical Engineering
st Semester Examinations
larch 9, 2016
ME 261: Thermodynamics I
Attempt any FOUR QUESTIONS **Time Allowed: 2 Hours**

1(a) A certain gas in a piston-cylinder assembly with initial pressure of 1.38 bar undergoes a process to state 2 where the pressure and volume are 4.14 bar and 0.0425 m^3, respectively. The pressure – volume relation during the process is pV = constant. The internal energy of the gas increases by 13.56 kJ. Determine the heat transfer during the process, in kJ. If this gas were to be air which behaves like an ideal gas and it undergoes the same process from state 1 to state 2 and obeying the same pressure – volume relation, calculate the change in internal energy and the heat transfer during the process, each in kJ.

b(i) Define a refrigeration system.

(ii) A refrigeration cycle operates continuously and removes energy from the refrigerated space at a rate of 12,672 kJ/hr. For a coefficient of performance of 2.5, determine the amount of heat rejected, in kJ/s and the net power required, in kW.

(2) A closed system consisting of 2.5 kg of superheated water vapour, initially at 3.0 bar and occupying a volume of 1.585 m^3, is compressed isothermally to a volume of 0.72 m^3. The system is then heated at constant volume to a final pressure of 8.5 bar. During the isothermal compression, there is work input of magnitude 95.8 kJ into the system. Kinetic and potential energy effects are negligible. Determine the heat transfer, in kJ, for each process and sketch the two processes on a T–v diagram.

(3) Carbon dioxide gas is compressed at steady state from a pressure of 1.40 bar and a temperature of 19 ^0C to a pressure of 3.45 bar and a temperature of 90 ^0C. The gas enters the compressor through an area of 0.075 m^2 with a velocity of 10 m/s and leaves with a velocity of 25 m/s. The magnitude of the heat transfer from the compressor to its surroundings is 20% of the compressor power input. Assuming that the carbon dioxide gas behaves like an ideal gas and neglecting potential energy effects, determine the compressor power, in kW and the heat rejected, in kJ/s.
For carbon dioxide gas, $C_V = 0.6529$ kJ/kg.K, $C_P = 0.8418$ kJ/kg.K, $R = 0.1889$ kJ/kg.K.

(4) A turbine operates at steady state. Steam at 52 bar, 510 ^0C enters the turbine with volumetric flow rate of 0.2004 m^3/s and with a velocity of 70 m/s. The steam leaves the turbine exhaust at a pressure of 1.2 bar with a velocity of 450 m/s. The turbine loses heat to the surroundings at the rate of 19.2 MJ/min and the power developed by the turbine is 2.88 MW. Neglect changes in potential energy. Sketch the process on a T-v diagram and determine (a) the enthalpy and quality of the steam leaving the turbine (b) the temperature of the exit steam, in ^0C.

5(a) State any four uses of the *Second Law of Thermodynamics*.

(b) Five kilograms of air executes a Carnot power cycle while operating between thermal reservoirs at 232 ^0C and 37 ^0C. The pressures at the initial and final states of the isothermal expansion are 28.0 bar and 14.0 bar, respectively. The index of adiabatic compression and expansion, k, is 1.4. Assuming that the air behaves like an ideal gas, sketch the cycle on a p-V diagram identifying the processes, and determine (a) the work done during the adiabatic compression and isothermal expansion, each in kJ (b) the initial and final pressures of the isothermal compression, each in bar.

$C_V = 0.7165$ kJ/kg.K, $C_P = 1.0035$ kJ/kg.K, $R = 0.287$ kJ/kg.K.

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF MECHANICAL ENGINEERING
MID-SEMESTER EXAMINATIONS
ME 261: THERMODYNAMICS I
January 23, 2016

Attempt all questions **Time Allowed: 1 Hour**

1. A certain gas is contained in a closed cylinder of an internal combustion engine. The gas has a specific volume of 0.06 m^3/kg and its internal energy is 900 kJ/kg with a pressure of 55 bar. From this initial state, the gas expanded to a pressure of 1.4 bar obeying the polytropic law $pv^{1.5}$ = constant. The internal energy after the expansion is 330 kJ/kg. Neglecting changes in kinetic energy and potential energy, calculate the heat transfer during the process in kJ per kg of gas. Is the heat transfer to or from the system? State your reason.

2. A two-phase liquid-vapour mixture of water at 100 ^{0}C with a quality of 75% is contained in a piston-cylinder assembly. The water undergoes a process to the corresponding saturated vapour state, during which the piston moves freely in the cylinder. If the change of state is brought about by heating the water as undergoes the process at constant temperature and pressure, determine the w and heat transfer per unit mass, each in kJ/kg. If the heating continues at cons pressure to a final state where the temperature of the system is 250^{0}C, cal the total change in internal energy and the total heat transfer of the system the initial state to the final state. Illustrate the processes on a T-v or p-v diagram.

3. Five kilograms of air in a piston-cylinder assembly is compressed polytropicall index of compression being 1.40, from an initial state with a temperature a pressure of 27 ^{0}C and 3.0 bar, respectively, to a final state with a pressure of 4 bar. Determine the change in internal energy of the system and the heat trans each in kJ. Assume that the air behaves like an ideal gas.
For air, Cv = 0.7165 kJ/kg.K, Cp = 1.0035 kJ/kg.K, R = 0.287 kJ/kg.K

University of Nigeria, Nsukka
Department of Mechanical Engineering
First Semester Examinations
ME 261: Thermodynamics I
March 9, 2017
Attempt any four Questions **Time Allowed: 2 Hours**

1. A piston-cylinder assembly contains 0.3 m^3 of nitrogen gas at high temperature and pressure of 330 ^oC and 20.65 bar, respectively. The gas is allowed to expand polytropically according to the law $pV^{1.3}$ = constant until its volume becomes 3.0 m^3. Heat is then added at constant volume until the pressure reaches 5.0 bar. Sketch the two processes on a p-V diagram. Assuming that the nitrogen gas behaves like an ideal gas and kinetic and potential energy effects are negligible, determine
   (a) the temperature, in ^oC, at the end of each process
   (b) the total change in internal energy, in kJ
   (c) the work done, in kJ, during each process
   (d) the total heat transfer to or from the system, in kJ
   For nitrogen, Cv = 0.745 kJ/kg.K, Cp = 1.04 2kJ/kg.K, R = 0.297 kJ/kg.K

2. Steam initially at a pressure and temperature of 8 bar and 660 ^oC, respectively, is contained in a closed rigid cylinder with a volume of 1.074 m^3. It is cooled at constant volume and the temperature and pressure dropped gradually. Determine the temperature at which condensation first occurs (state 2). The temperature at the final state (state 3) when the cooling is stopped is 95 ^oC. Calculate the total amount of heat lost, in kJ, at this final state as a result of the cooling process. Calculate also the mass, in kg, and volume, in m^3, of the saturated vapour in the cylinder at the final state. Sketch the processes on a T-v or p-v diagram.

3. Compressed air at a pressure of 15 bar and a temperature of 727 ^oC enters a turbine with negligible velocity and expands in the turbine. It leaves the turbine with a pressure and temperature of 1.5 bar, 227 ^oC, respectively, with a velocity of 150 m/s. The turbine operates adiabatically and at steady state and develops a power output of 5.0 MW. If the air behaves like an ideal gas and changes in potential energy are negligible, determine the volume flow rate of the air, in m^3/s, at the turbine inlet. Calculate also the exit area of the turbine, in m^2.
   For air, Cv = 0.7165 kJ/kg.K, Cp = 1.0028 kJ/kg.K, R = 0.287 kJ/kg.K

4. Superheated water vapour enters a turbine operating at steady state with a volume flow rate of 3.64 m^3/min at a pressure and temperature of 60 bar, 400 ^oC, respectively, and with a velocity of 10 m/s. The steam leaves the turbine exhaust at a low pressure of 1.20 bar with a quality of 90% and a velocity of 50 m/s. The turbine loses heat to the surroundings at the rate of 46.4 kW per kg of steam flowing. Changes in potential energy are negligible. Calculate the power output developed by the turbine, in kW. Sketch the process on a T-v or p-v diagram.

5(a) Define thermodynamic cycle. How many processes does a system undergo to accomplish a thermodynamic cycle?

(b) What does the Second Law of Thermodynamics postulate with respect to (i) a power cycle, and (ii) a refrigeration cycle?

(c) Nsukka Engineer designed a heat engine capable of developing a power output of 3000kW. High temperature boiler at 927 ^oC supplies heat to the engine at a rate of 4800 kJ/s while the engine loses some heat to the surroundings at 27 ^oC. Does this machine operate reversibly or irreversibly? Show your working. Compute the maximum power this ingenious machine can deliver when operating under the same conditions.

(d) The coefficient of performance of a refrigerator operating between a low temperature source (ice making compartment) of 0 ^oC and outside hot environment with a temperature of 37 ^oC is 3.2. The rate of heat energy removed from the low temperature compartment is 7.2 MJ/hr. Determine the actual power, in kW, required by this refrigerator. Calculate the minimum theoretical power, in kW, required by any refrigeration system operating under these conditions.

UNIVERSITY OF NIGERIA
DEPARTMENT OF MECHANICAL ENGINEERING
MID-SEMESTER EXAMINATIONS
ME 261: THERMODYNAMICS I
December 3, 2016

Attempt All Questions

Time Allowed: 1 hour

1(a) State the Zeroth Law of Thermodynamics. Mention one main area the law is applied in engineering practice.

(b) A gas in a closed system has initially a pressure of 1.013 bar with a volume measuring 1.5 m^3 and an internal energy of 512 kJ. It undergoes an isothermal compression, with pV = *constant*, to state 2 where the pressure is 2.026 bar and internal energy is 690 kJ. Assuming that kinetic and potential energy changes are negligible, calculate the heat transfer, in kJ, for this process. If this gas were to behave like an ideal gas and undergoes the same isothermal process to state 2 with the same pressure of 2.026 bar, determine the internal energy of the gas at this state and the heat transfer for the process, each in kJ.

2. A piston-cylinder assembly initially contains 4.81 m^3 of saturated water vapour at 8.0 bar. The system undergoes an adiabatic expansion to a lower pressure of 2.0 bar resulting in a two-phase liquid-vapour mixture of water with quality of 85%. Kinetic and potential energy effects are negligible. Determine the work done by the system, in MJ and the change in volume of the system, in m^3. Sketch the process on a T-v or p-v diagram.

3. Carbon dioxide (CO_2) gas in a piston-cylinder assembly is initially at a
temperature of 25 ^oC, pressure of 1.013 bar and volume measuring 0.25 m^3. It
is compressed polytropically with $pV^{1.\text{[illegible]}}$ = *constant*. During the process, the
amount of work input to the gas is 95 kJ. Assuming that CO_2 behaves like an
ideal gas, and kinetic and potential energy changes are negligible, determine
the final temperature, in ^oC and the heat transfer, in kJ. State whether the heat
transfer is <u>to</u> or <u>from</u> the system, giving your reason(s).

For CO_2, Cv = 0.6529 kJ/kg.K, Cp = 0.8418 kJ/kg.K, R = 0.1889 kJ/kg.K

$PW_1 = MRT_2$

Thermodynamic cycle of processes that begins the same state.

UNIVERSITY OF NIGERIA, NSUKKA
DEPARTMENT OF MECHANICAL ENGINEERING
MID-SEMESTER EXAMINATIONS
ME 261: THERMODYNAMICS I
JANUARY 27, 2018

Attempt all questions. *Time Allowed: 1 Hour*

1(a)i. Define a thermodynamic cycle.

ii. State two major differences between a power cycle and a refrigeration cycle.

(b) A heat engine operating in a cycle develops work output of 150 kW and has a thermal efficiency rating of 30%. Determine for this engine the amount of heat transfer to the system and also the heat rejected by the system, each in kW, when operating in a steady state.

(c) A refrigeration system operating in a cycle and at steady state achieves a cooling effect of 17,500 kW while it loses 22,500 kW of heat to its surroundings. Calculate the work input or output of this refrigerator, in kW and determine its coefficient of performance.

2. Steam occupying a volume of 3.3 m^3 is contained in a piston-cylinder assembly at 10 bar, 450 ^oC. It is cooled down at constant pressure until its specific volume becomes 0.1 m^3/kg. At what temperature does condensation first occur? Determine the work done and the heat transfer during the process, each in MJ. Sketch the process on a T-v or p-v diagram.

3. A quantity of air with a volume of 0.14 m^3 at a temperature and pressure of 371 ^oC and 9.65 bar, respectively, is enclosed in a piston-cylinder assembly. The air behaves like an ideal gas. The system is first heated at constant volume until its pressure reaches 41.4 bar. The air is then allowed to expand polytropically, with index of expansion being 1.4, to a pressure of 2.76 bar. Sketch the two processes on a T-v or p-v diagram and calculate

a) the temperature of the air at the end of each process, in ^oC

b) the total heat transfer for the two processes, in kJ

c) the total work produced for the two processes, in kJ.

For air, C_v = 0.7165 kJ/kg.K. C_p = 1.0031 kJ/kg.K. R = 0.2866 kJ/kg.K.

University of Nigeria, Nsukka
Department of Mechanical Engineering
2017/2018 First Semester Examinations
ME 261: Thermodynamics I

April 12, 2018

Attempt any **four** questions

Time Allowed: $2^1/_4$ Hours

1\. (a) Define the following terms used in Engineering Thermodynamics

i. Closed system
ii. Isothermal process
iii. Adiabatic process
iv. Isobaric process
v. Polytropic process

(b) A fluid in a piston-cylinder assembly expanded at a pressure of 7.0bar and volume of $1.140m^3/kg$ to a final volume of $2.049m^3/kg$. , If the fluid behaves as an ideal gas, and the process occurs at constant temperature, calculate the work done and the heat transfer during the process in KJ per kilogram of fluid.

(c) 2 kg of air is compressed adiabatically (polytropic index of compression n = k = 1.4) from state 1 with a pressure and temperature of 1.0 bar and 300K, respectively, to state 2 with a pressure of 15. 0 bar. The air is the cooled at constant volume to state 3 with temperature. T_3 = 300K. Assuming Ideal gas behavior, and ignoring kinetic and potential energies effects, calculate the work done for the first process and the heat transfer for the second process, each in KJ. Sketch the two processes on T-v or P-v diagram.
For air, C_p = 1.0035 KJ/kg.K, C_v =0.7165 KJ/kg.K, R = 0.287 KJ/kg.K.

2\. Steam initially at a pressure and temperature of 5.0 bar and temperature of 380°C respectively is contained in a closed rigid container with a volume of $1.024m^3$. It is cooled at constant volume, pressure and temperature drops gradually as a result of heat transfer to a saturated vapour state 2. Determine the temperature at which condensation occur at this state, in °C. Calculate the fraction of the total mass of the steam that has condensed to a final state 3 in a two-phase liquid-vapour mixture when the pressure reaches 0.55 bar. Calculate also the mass in kg of saturated vapour and saturated liquid present in the mixture at this final state, the volume in m^3 occupied by saturated vapour and that of saturated liquid at this final state. Sketch the processes on a T-v or P-v diagram.

3\. Air enters an adiabatic compressor operating at steady state at a rate of 1.5kg/s with a temperature of 27°C, a pressure of 2.5 bar and a velocity of 12.0m/s. At the exit, the pressure of the air is 10.0 bar, the temperature and velocity are 187 °C and 2.0m/s, respectively. Calculate the power required by the compressor, in kW. Assume that the air behaves like an ideal gas and ignore any changes in potential energy. For air, C_v =0.7165 KJ/kg.K, C_p = 1 0035 KJ/kg.K, R = 0.287 KJ/kg.K.

4\. Steam enters a turbine with negligible velocity at 40.0 bar and 450 °C and leaves with a high velocity where the pressure is 0.12 bar and quality 90 %. It flows at a rate of 9000kg/hr. The turbine is well insulated and operates at steady state and develops a power output of 2.0 MW. Neglecting potential energy effects, determine the velocity of the steam at the exit of the turbine, in m/s.

5a. (i) State the Clausius statement of the Second law and two corollaries for a refrigeration Cycle
(ii) List four causes of irreversibilities in a thermodynamic System.

(b) A carnot heat engine rejects 230KJ of energy by heat transfer to a cold reservoir at a temperature of 25 °C. The net cycle work developed by the system is 375KJ. Determine the thermal efficiency of the system and the cycle high temperature, in °C. ~~Determine the thermal efficiency of the system and the cycle high temperature, in °C.~~

(c) A refrigerator achieves a coefficient of performance of 2.5 while operating between a low temperature compartment source of 10 °C and outside temperature 35 °C. At steady state, the quantity of heat(or heat load) which it removes from low temperature compartment is 600KJ/min. Determine the actual power, in kW, required by this refrigerator. What is the minimum theoretical power, in kW, required for any refrigeration cycle operating under these conditions?