Code No: R21032 **R10** SET - 1

II B. Tech I Semester Supplementary Examinations, September - 2014
THERMODYNAMICS
(Com. to ME, AE, AME, MM)

Time: 3 hours Max. Marks: 75

Answer any **FIVE** Questions
All Questions carry **Equal** Marks
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Note: Steam Tables, Refrigeration Tables with Psychrometric Chart are allowed.

1. a) What is the concept of continuum? How will you define density using this concept?
   b) An elastic sphere initially has a diameter of 1m and contains a gas at a pressure of 1 atm. Due to heat transfer the diameter of the sphere increases to 1.1m. During the heating process the gas pressure inside the sphere is proportional to the sphere diameter. Calculate the work done by the gas. (6M+9M)

2. a) Explain why only in constant pressure non flow process, the enthalpy change is equal to heat transfer.
   b) An LPG cylinder, initially evacuated, was filled with 15 kg of LPG (specific enthalpy =625 kJ/kg-1) from the supply main in a gas bottling plant. After filling, the gas pressure rose to 10 bar, its specific enthalpy increased to 750kJ/kg and the specific volume became 0.0487m3/kg. Determine the quantity of heat that got into the cylinder during the filling. (6M+9M)

3. a) How does the energy value provide a useful measure of the quality of energy?
   b) One kg of ice at -50^{0}C is exposed to the atmosphere which is at 20^{0}C. The ice melts and comes into thermal equilibrium with the atmosphere. i) Determine the entropy increase of the universe. ii) What is the minimum amount of work necessary to convert the water back into ice at -5^{0}C? C_p of ice is 2.093 kJ/kg K and the latent heat of fusion of ice is 333.3 kJ/kg. (5M+10M)

4. a) What is critical point? Explain the terms critical pressure, critical temperature and critical volume of water?
   b) 10 kg of water is heated at a constant pressure of 15 bar and from temperature of 40^{0}C. Calculate the change in entropy and enthalpy when water is converted into the following qualities of steam in each case
   i) wet steam at x = 0.90 ii) Super heated steam at 300^{0}C. (6M+9M)
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5. a) What is compressibility factor? What is the physical significance of compressibility factor?
   b) i) The specific heats of a gas are given by cp = a + kT and cv = b + kT, where a, b, and k are constants and T is in Kelvin. Show that for an isentropic expansion of this gas $T^b v^{a-b} e^{kT}$ = constant ii) 1.5 kg of this gas occupying a volume of 0.06 m3 at 5.6 MPa expands isentropically until the temperature is 240^0C. If a = 0.946, b = 0.662, and k = 10-4, calculate the work done in the expansion. (6M+9M)

6. a) Consider a mixture of several gases of identical masses. Show whether all mass fractions and mole fractions will be identical or not?
   b) Write short notes on psychometric chart. (8M+7M)

7. a) Compare with the help of P-V and T-S diagram air standard Otto, Diesel and Dual cycles with respect to i) same compression ratio and same heat input ii)same maximum pressure and same heat input.
   b) A Diesel engine has a compression ratio of 14 and cut-off takes place at 6% of the stroke. Find the air standard efficiency. (8M+7M)

8. A simple R-12 plant is to develop 5 tonnes of refrigeration. The condenser and evaporator temperatures are to be 40^0C and -10^0C respectively. Determine: i) the refrigerant flow rate in kg/s, ii) the volume flow rate handled by the compressor in m^3/s, iii) the compressor discharge temperature, iv) the pressure ratio, v) the heat rejected to the condenser in kW, vi) the flash gas percentage after throttling, vii) the COP, and viii) the power required to drive the compressor. How does this COP compare with that of a Carnot refrigerator operating between 40^0C and -10^0C? (15M)

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Note: Steam Tables, Refrigeration Tables with Psychrometric Chart are allowed.

1. a) Explain the similarities and dissimilarities between heat and work.
   b) A fluid, contained in a horizontal cylinder fitted with a frictionless leak proof piston, is continuously agitated by means of a stirrer passing through the cylinder cover. The cylinder diameter is 0.40 m. During the stirring process lasting 10 minutes, the piston slowly moves out a distance of 0.485m against the atmosphere. The net work done by the fluid during the process is 2 kJ. The speed of the electric motor driving the stirrer is 840 rpm. Determine the torque in the shaft and the power output of the motor. (6M+9M)

2. a) Define internal energy. How is energy stored in molecules and atoms?
   b) The steam supply to an engine comprises two streams which mix before entering the engine. one stream is supplied at the rate of 0.01kg/s with an enthalpy of 2952 kJ/kg and a velocity of 20m/s. the other stream is supplied at the rate of 0.1kg/s with an enthalpy of 2569kJ/kg and a velocity of 120 m/s. At the exit from the engine the fluid leaves as two streams, one of water at the rate of 0.001kg/s with an enthalpy of 420 kJ/kg and the other of steam; the fluid velocities at the exit are negligible. The engine develops a shaft power of 25kW. The heat transfer is negligible. Evaluate the enthalpy of the second exit stream. (6M+9M)

3. a) Explain the statement: The energy of an isolated system can never increase. How is it related to the principle of increase of entropy?
   b) Air expands through a turbine from 500 kPa, 520^0C to 100 kPa, 300^0C. During expansion 10 kJ/kg of heat is lost to the surroundings which is at 98 kPa, 20^0C. Neglecting the K.E. and P.E. changes, determine per kg of air i) the decrease in availability, ii) the maximum work, and iii) the irreversibility.
   For air, take cp = 1.005 kJ/kg K. (6M+9M)
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4. a) Draw and explain the phase diagram for a pure substance on P-T chart. Why does the fusion line for water have negative slope?
   b) Ten kg of water at 45^0C is heated at a constant pressure of 10 bar until it becomes superheated vapor at 300^0C. Find the change in volume, enthalpy, internal energy and entropy. (7M+8M)

5. a) Derive an expression of work transfer for an ideal gas in a polytrophic process of the gas in i) Closed system and ii) Steady flow system.
   b) From an experimental determination the specific heat ratio for acetylene (C_2H_2) is found to 1.26. Find the two specific heats. (10M+5M)

6. a) State Daltons law of partial pressures. How is the partial pressure of a component in a gaseous mixture related to the mole fraction of that component?
   b) Explain what you understand by adiabatic saturation. (9M+6M)

7. Show that efficiency of Lenoir cycle depends on the pressure ratio and specific heat ratio. Also find the expression for Mean Effective Pressure. (15M)

8. An air refrigerator operates in a Bell-Coleman cycle.
   Compressor inlet: air is at 1 bar/270 K
   Compressor outlet: air pressure = 5 bar
   Cooler outlet: air temperature 290 K
   After the air is cooled to 290 K at a constant pressure in the cooler, it is allowed to expand polytropically ($Pv^{1.25} = C$) to 1 bar in the expansion cylinder whereupon the air temperature falls to the lowest temperature limit of the cycle. The cold air is then sent to the cold chamber (refrigerated space) to extract heat (refrigerating effect).
   Determine the
   a) Refrigerating effect and air circulation rate
   b) Compressor work
   c) COP of the refrigerator
   d) Capacity of the plant in terms of tons of refrigeration if the mass flow rate of the air is 100 kg/h. Assume isentropic compression. Neglect friction losses, and clearance in the compressor and expander. (15M)

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Note: Steam Tables, Refrigeration Tables with Psychrometric Chart are allowed.

1. a) Is the state of the air in an isolated room completely specified by the temperature and pressure. Explain?
   b) A milk chilling unit can remove heat from the milk at the rate of 41.87 MJ/h. Heat leaks into the milk from the surroundings at an average rate of 4.187MJ/h. Find the time required for cooling a batch of 500kg of milk from 45^0C to 5^0C. Take the cp of milk to be 4.187kJ/kg K. (6M+9M)

2. a) Define enthalpy. Why does enthalpy of an ideal gas depend only on temperature?
   b) A reciprocating air compressor takes in 2 m^3/min at 0.11MPa, 20^0C which it delivers at 1.5MPa, 111^0C to an after cooler where the air is cooled at constant pressure to 25^0C. The power absorbed by the compressor is 4.15kW. Determine the heat transfer in i) the compressor, and ii) the cooler. State your assumptions. (6M+9M)

3. a) The Carnot cycle assures maximum efficiency for a heat engine. Still it cannot be implemented in practice. Why?
   b) A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to it. If the efficiency of the engine is 40% of the maximum possible and the COP of the heat pump is 50% of the maximum possible, what is the temperature of the reservoir to which the heat pump rejects heat? What is the rate of heat rejection from the heat pump if the rate of heat supply to the engine is 50 kW? (6M+9M)

4. a) What do you understand by degree of superheat and degree of sub cooling?
   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, internal energy, enthalpy, and entropy of steam. (6M+9M)
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5. a) Express the changes in internal energy and enthalpy of an ideal gas in a reversible adiabatic process in terms of pressure ratio.
   b) Show that for an ideal gas, the slope of the constant volume line on the T-s diagram is more than that of the constant pressure line. (8M+7M)

6. a) Using the definitions of mass fraction and mole fraction, derive a relation between them.
   b) A closed rigid cylinder is divided by a diaphragm into two equal compartments, each of volume 0.1 m^3. Each compartment contains air at a temperature of 20^0C. The pressure in one compartment is 2.5 MPa and in the other compartment is 1 MPa. The diaphragm is ruptured so that the air in both the compartments mixes to bring the pressure to a uniform value throughout the cylinder which is insulated. Find the net change of entropy for the mixing process. (8M+7M)

7. a) Mention the merits and demerits of Stirling and Ericsson cycles?
   b) A perfect gas undergoes a cycle which consists of the following processes taken in order:
   i) Heat rejection at constant pressure.
   ii) Adiabatic compression from 1 bar and 27^0C to 4 bar.
   iii) Heat addition at constant volume to a final pressure of 16 bar.
   iv) Adiabatic expansion to 1 bar.
   Calculate: A) Work done/kg of gas; B) Efficiency of the cycle.
   Take: cp = 0.92kJ/kg.K, cv = 0.75 kJ/kg.K. (6M+9M)

8. a) Define work ratio .Derive an expression for efficiency of a ideal Brayton cycle in terms of pressure ratio?
   b) Air enters the compressor of a gas turbine plant operating on Brayton cycle at 1 bar, 27^0C. The pressure ratio in the cycle is 6. If W_T=2.5W_C, where W_T and W_C are the turbine and compressor work respectively, calculate the maximum temperature and the cycle efficiency. (6M+9M)

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Note: Steam Tables, Refrigeration Tables with Psychrometric Chart are allowed.

1. a) Distinguish between stored energy and energy in transit.
   b) It is required to melt 5 tonnes/h of iron from a charge at 15^0C to molten metal at 1650^0C. The melting point is 1535^0C, and the latent heat is 270 kJ / kg. The specific heat in the solid state is 0.502 and in the liquid state(29.93 /atomic weight) kJ/kg K. If an electric furnace has 70% efficiency , find the kW rating needed. If the density in molten state is 6900 kg/m^3 and the bath volume is three times the hourly melting rate, find the dimensions of the cylindrical furnace if the length to diameter ratio is 2. The atomic weight of iron is 56. (6M+9M)

2. a) When you wind a spring up in a toy or stretch a rubber band, what happens in terms of work, energy and heat transfer? Later when they are released, what happens then?
   b) A room for four persons has two fans, each consuming 0.18kW power, and three 100W lamps. Ventilation air at the rate of 80 kg/h enters with an enthalpy of 84 kJ/kg and leaves with an enthalpy of 59 kJ/kg. if each person puts out heat at the rate of 630kg/h determine the rate at which heat is to be removed by a room cooler, so that a steady state is maintained in the room. (6M+9M)

3. a) What do you understand by internal irreversibility and external irreversibility.
   b) A reversible engine operates between temperatures T_1 and $T(T_1>T)$. The energy rejected from this engine is received by a second reversible engine at the same temperature T. The second engine rejects energy at temperature $T_2(T_2<T)$. Show that (i) temperature T is the arithmetic mean of temperature T_1 and T_2 if the engines produce the same amount of work output, and (ii) temperature T is the geometric mean of temperatures T_1 and T_2 if the engines have the same cycle efficiencies. (6M+9M)

4. a) Draw a neat sketch of throttling calorimeter and explain how dryness fraction of steam is determined. Clearly explain its limitations.
   b) A vessel of volume 0.04m^3 contains a mixture of saturated water and saturated stem at a temp of 250^0C. The mass of liquid present is 9 Kg. Find the pressure, the mass the specific volume, the enthalpy, the enthalpy and the internal energy. (8M+7M)
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5. a) Explain why do the specific heats of an ideal gas depend only on the atomic structure of the gas.
   b) A constant volume chamber of 0.3 m^3 capacity contains 1 kg of air at 5^0C. Heat is transferred to the air until the temperature is 100^0C. Find the work done, heat transferred, and the changes in internal energy, enthalpy and entropy. (6M+9M)

6. a) Explain the differences between dry bulb, wet bulb and dew point temperatures?
   b) Consider a gas mixture that consists of 3 kg of O_2, 5 kg of N_2, and 12 kg of CH_4.Determine i) the mass fraction of each component, ii) the mole fraction of each component, and iii) the average molar mass and gas constant of the mixture. (6M+9M)

7. a) Discuss the effect of compression ratio and specific heat ratio on the efficiency of otto cycle.
   b) In an air standard Diesel cycle, the compression ratio is 16, and at the beginning of isentropic compression, the temperature is 15^0C and the pressure is 0.1 MPa. Heat is added until the temperature at the end of the constant pressure process is 1480^0C. Calculate i) the cut-off ratio, ii) the heat supplied per kg of air, iii) the cycle efficiency, and iv) the mean effective pressure. (6M+9M)

8. a) Describe the various operations of a Simple Rankine cycle. Derive its expression for thermal efficiency.
   b) A steam power plant operates ideally in the simple ideal Rankine cycle. Steam (3MPa/623K) enters the turbine and after expansion is exhausted to a total condenser operating at a pressure of 75kPa. Determine the thermal efficiency of this cycle. (8M+7M)