JEPPIAAR ENGINEERING COLLEGE

Jeppiaar Nagar, Rajiv Gandhi Salai – 600 119

DEPARTMENT OF

MECHANICAL ENGINEERING

QUESTION BANK

III SEMESTER

ME8391 – Engineering Thermodynamics

Regulation – 2017

JEPPIAAR ENGINEERING COLLEGE

Vision of Institution

To build Jeppiaar Engineering College as an institution of academic excellence in technological and management education to become a world class university.

Mission of Institution

- To excel in teaching and learning, research and innovation by promoting the principles of scientific analysis and creative thinking.
- To participate in the production, development and dissemination of knowledge and interact with national and international communities.
- To equip students with values, ethics and life skills needed to enrich their lives and enable them to meaningfully contribute to the progress of society.
- To prepare students for higher studies and lifelong learning, enrich them with the practical and entrepreneurial skills necessary to excel as future professionals and contribute to Nation's economy.

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO1	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

JEPPIAAR ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

Vision of the Department

To create excellent professionals in the field of Mechanical Engineering and to uplift the quality of technical education on par with the International Standards.

Department Mission

1. **To reinforce** the fundamentals of Science and Mathematics to Mechanical Engineering **and critically and relatively investigate co**mplex mechanical systems and processes.
2. To engage in the **production, expansion and practice** of advanced engineering applications through knowledge sharing activities by interacting with global communities and industries.
3. To**equip** students with **engineering ethics, professional roles, corporate social responsibility** and life skills and **apply** them for the betterment of society.
4. **To promote** higher studies and lifelong learning and entrepreneurial skills and **develop** excellent professionals for empowering nation's economy.

PEO's

1. To **enrich** the technical knowledge of design, manufacturing and management of mechanical systems and **develop creative and analytical thinking** in research.
2. To **relate, strengthen and develop** the theoretical knowledge of the Mechanical Engineering by exhibiting various concepts applied through diverse industrial exposures and experts' guidance.
3. **Facilitate** the students to communicate effectively on complex social, professional and engineering activities with strict adherence to ethical principles.
4. **Create awareness for independent and lifelong learning and develop the ability to keep abreast of modern trends and adopt them for personal technological growth of the nation.**

PSO's

1. To understand the basic concept of various mechanical engineering field such as design, manufacturing, thermal and industrial engineering.
2. To apply the knowledge in advanced mechanical system and processes by using design and analysis techniques.
3. To develop student's professional skills to meet the industry requirements and entrepreneurial skills for improving nation's economy stronger.

ME8391- ENGINEERING THERMODYNAMICS

COURSE OUTCOMES

On successful completion of the course, the student will be able to:

C202.1	Define the fundamental definitions associated with laws of thermodynamics and explain their application to a wide range of systems.
C202.2	Explain the statements of second law of thermodynamics and prove the equivalence of the statements.
C202.3	Illustrate the T-v, P-T diagrams and P-v-T surfaces of pure substances. Analyze the processes to solve advanced engineering problems.
C202.4	Evaluate and apply basic thermodynamic relations in ideal and real gases
C202.5	Design and create the various air-conditioning systems by applying the knowledge of different psychometric processes.

JEPPIAAR ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

ME8391-ENGINEERING THERMODYNAMICS

SYLLABUS

ME8391 ENGINEERING THERMODYNAMICS **LT P C**
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OBJECTIVES:

To familiarize the students to understand the fundamentals of thermodynamics and to perform thermal analysis on their behavior and performance.

(Use of Standard and approved Steam Table, Mollier Chart, Compressibility Chart and Psychrometric Chart permitted)

UNIT I BASIC CONCEPTS AND FIRST LAW **9**

Basic concepts - concept of continuum, comparison of microscopic and macroscopic approach. Path and point functions. Intensive and extensive, total and specific quantities. System and their types. Thermodynamic Equilibrium State, path and process. Quasi-static, reversible and irreversible processes. Heat and work transfer, definition and comparison, sign convention. Displacement work and other modes of work .P-V diagram. Zeroth law of thermodynamics – concept of temperature and thermal equilibrium– relationship between temperature scales –new temperature scales. First law of thermodynamics –application to closed and open systems – steady and unsteady flow processes.

UNIT II SECOND LAW AND AVAILABILITY ANALYSIS **9**

Heat Reservoir, source and sink. Heat Engine, Refrigerator, Heat pump. Statements of second law and its corollaries. Carnot cycle Reversed Carnot cycle, Performance. Clausius inequality. Concept of entropy, T-s diagram, Tds Equations, entropy change for - pure substance, ideal gases - different processes, principle of increase in entropy. Applications of II Law. High and low grade energy. Available and non-available energy of a source and finite body. Energy and irreversibility. Expressions for the energy of a closed system and open systems. Energy balance and entropy generation. Irreversibility. I and II law Efficiency.

UNIT III PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE **9**

Formation of steam and its thermodynamic properties, p-v, p-T, T-v, T-s, h-s diagrams. p-v-T surface. Use of Steam Table and Mollier Chart. Determination of dryness fraction. Application of I and II law for pure substances. Ideal and actual Rankine cycles, Cycle Improvement Methods - Reheat and Regenerative cycles, Economizer, preheater, Binary and Combined cycles.

UNIT IV IDEAL AND REAL GASES, THERMODYNAMIC RELATIONS **9**

Properties of Ideal gas- Ideal and real gas comparison- Equations of state for ideal and real gases-Reduced properties-.Compressibility factor-.Principle of Corresponding states. -Generalised Compressibility Chart and its use-. Maxwell relations, Tds Equations, Difference and ratio of heat capacities, Energy equation, Joule-Thomson Coefficient, Clausius Clapeyron equation, Phase Change Processes. Simple Calculations.

UNIT V GAS MIXTURES AND PSYCHROMETRY 9

Mole and Mass fraction, Dalton's and Amaga's Law. Properties of gas mixture – Molar mass, gas constant, density, and change in internal energy, enthalpy, entropy and Gibbs function. Psychrometric properties, Psychrometric charts. Property calculations of air vapour mixtures by using chart and expressions. Psychrometric process – adiabatic saturation, sensible heating and cooling, humidification, dehumidification, evaporative cooling and adiabatic mixing. Simple Applications

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of this course, the students can able to apply the Thermodynamic Principles to Mechanical Engineering Application.

Apply mathematical fundamentals to study the properties of steam, gas and gas mixtures.

TEXT BOOKS:

1. Nag.P.K., "Engineering Thermodynamics", 4thEdition, Tata McGraw-Hill, New Delhi, 2008.
2. Natarajan E., "Engineering Thermodynamics: Fundamentals and Applications", Anuragam Publications, 2012.

REFERENCES:

1. Cengel. Y and M.Boles, "Thermodynamics - An Engineering Approach", 7th Edition, Tata McGraw Hill, 2010.
2. Holman.J.P., "Thermodynamics", 3rd Edition, McGraw-Hill, 1995.
3. Rathakrishnan. E., "Fundamentals of Engineering Thermodynamics", 2nd Edition, PrenticeHall of India Pvt. Ltd, 2006
4. Chattopadhyay, P, "Engineering Thermodynamics", Oxford University Press, 2010.
5. Arora C.P, "Thermodynamics", Tata McGraw-Hill, New Delhi, 2003.
6. Van Wylen and Sonntag, "Classical Thermodynamics", Wiley Eastern, 1987
7. Venkatesh. A, "Basic Engineering Thermodynamics", Universities Press (India) Limited, 2007.
8. Kau-Fui Vincent Wong, "Thermodynamics for Engineers", CRC Press, 2010 Indian Reprint.
9. Prasanna Kumar: Thermodynamics "Engineering Thermodynamics" Pearson Education, 2013

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DEPARTMENT OFMECHANICAL ENGINEERING

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Subject : ME8391– Engineering Thermodynamics

Year / Sem : II / III

UNIT I BASIC CONCEPTS AND FIRST LAW

Basic concepts - concept of continuum, comparison of microscopic and macroscopic approach. Path and point functions. Intensive and extensive, total and specific quantities. System and their types. Thermodynamic Equilibrium State, path and process. Quasi-static, reversible and irreversible processes. Heat and work transfer, definition and comparison, sign convention. Displacement work and other modes of work.P-V diagram. Zeroth law of thermodynamics – concept of temperature and thermal equilibrium– relationship between temperature scales – new temperature scales. First law of thermodynamics –application to closed and open systems – steady and unsteady flow processes.

PART-A

CO Mapping : C202.1

Q.No.	Questions	BT Level	Competence	PO
1	Define thermodynamic system.	**BTL-1**	Remembering	**PO1**
2	Name the different types of system.	**BTL-1**	Remembering	**PO1**
3	Should the automobile radiator be analyzed as a closed system or as an open system? Explain.	**BTL-2**	Understanding	**PO1**
4	Define thermodynamic equilibrium.	**BTL-1**	Remembering	**PO1**
5	What do you mean by quasi-static process?	**BTL-1**	Remembering	**PO1**
6	Differentiate between point function and path function.	**BTL-2** **BTL-4** **BTL-5**	Understanding Analyzing Evaluating	**PO1**
7	Name and explain the two types of properties	**BTL-1** **BTL-2**	Remembering Understanding	**PO1**
8	Explain homogeneous and heterogeneous system.	**BTL-2**	Understanding	**PO1**
9	What is a steady flow process?	**BTL-1**	Remembering	**PO1**
10	Prove that for an isolated system, there is no change in internal energy.	**BTL-5**	Evaluating	**PO1**
11	Indicate the practical application of steady flow energy equation.	**BTL-2**	Understanding	**PO1**
12	Define system.	**BTL-1**	Remembering	**PO1**

Q.No.	Questions	BT Level	Competence	PO
13	Define cycle.	**BTL-1**	Remembering	**PO1**
14	Explain Mechanical equilibrium.	**BTL-2**	Understanding	**PO1**
15	Explain Chemical equilibrium.	**BTL-2**	Understanding	**PO1**
16	Explain Thermal equilibrium.	**BTL-2**	Understanding	**PO1**
17	Define Zeroth law of Thermodynamics.	**BTL-1**	Remembering	**PO1**
18	What are the limitations of first law of thermodynamics?	**BTL-1**	Remembering	**PO1**
19	What is perpetual motion machine of first kind?	**BTL-1**	Remembering	**PO1**
20	Define: Specific heat capacity at constant pressure.	**BTL-1**	Remembering	**PO1**
21	Define: Specific heat capacity at constant volume.	**BTL-4**	Analyzing	**PO1**
22	Define the term enthalpy?	**BTL-1**	Remembering	**PO1**
23	Define the term internal energy	**BTL-1**	Remembering	**PO1**
24	What is meant by thermodynamic work?	**BTL-1**	Remembering	**PO1**
25	What is meant by reversible and irreversible process?	**BTL-1**	Remembering	**PO1**
26	Enlist the similarities between work and heat.	**BTL-1**	Remembering	**PO1**
27	Why does free expansion have zero work transfer?	**BTL-1**	Remembering	**PO1**
28	Distinguish between 'Macroscopic energy' and 'Microscopic energy'.	**BTL-1**	Remembering	**PO1**
29	Show that the energy of an isolated system remains constant.	**BTL-1**	Remembering	**PO1**
30	What are the conditions for steady flow process?	**BTL-2** **BTL-1**	Understanding Remembering	**PO1**
PART-B&PART-C				
1	A gas of mass 1.5 kg undergoes a quasi-static expansion, which follows a relationship p=a+bV, where 'a' and 'b' are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volumes are 0.2 m^3 and 1.2 m^3. The specific internal energy of the gas is given by the relation U = (1.5pV – 85) kJ/kg, where p is in kPa and V is in m^3. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion. .	**BTL-5**	Evaluating	**PO1,PO2**
2	A piston – cylinder device contains 0.15 kg of air initially at 2 MPa and 350^0C. The air is first expanded isothermally to 500 kPa, then compressed polytropically with a polytropic exponent of 1.2 to the initial pressure, and finally compressed at the constant pressure to the initial state. Determine the boundary work for each process and the network of the cycle.	**BTL-1BTL-4** **BTL-5**	Remembering Analyzing Evaluating	**PO1,PO2**

Q.No.	Questions	BT Level	Competence	PO
3	A gas undergoes a thermodynamic cycle consisting of the following processes: (i) Process 1-2: Constant Pressure P_1=1.4 bar, V_1=0.028 m^3, W_{1-2}=10.5 kJ. (ii) Process 2-3: Compression with pV=constant, U_3=U_2. (iii) Process 3-1: Constant volume, U_1-U_3= - 26.4 kJ. There are no significant changes in KE and PE (1) Sketch the cycle on a p-V diagram. (2) Calculate the network for the cycle in kJ. (3) Calculate the heat transfer for process 1-2. Show that Q_{cycle}=$W_{cycle.}$	**BTL-1** **BTL-4** **BTL-5**	Remembering Analyzing Evaluating	**PO1,PO2**
4	A three cycle operating with nitrogen as the working substance has constant temperature compression at 34^{0}C with initial pressure 100kPa. Then the gas undergoes a constant volume heating and then polytrophic expansion with 1.35 as index of compression. The isothermal compression requires -67 kJ/kg of work. Determine: (i) p,v and T around the cycle (ii) Heat in and out (iii) Network. For nitrogen gas Cv = 0.731 kJ/kgK	**BTL-1** **BTL-4** **BTL-5**	Remembering Analyzing Evaluating	**PO1,PO2**
5	(i) Air enters the compressor of a gas-turbine plant at ambient conditions of 100 kPa and 25^{0}C with a low velocity and exists at 1 MPa and 347^{0}C with a velocity of 90 m/s. The compressor is cooled at the rate of 1500 kJ/min, and the power input to the compressor is 250 kW. Determine the mass flow rate of air through the compressor. Assume Cp=1.005 kJ/kg K. (ii) Derive steady flow energy equation.	**BTL-1** **BTL-4** **BTL-5** **BTL-5**	Remembering Analyzing Evaluating Creating	**PO1,PO2**
6	In a gas turbine installation air is heated inside heat exchanger up to 750^{O}C from ambient temperature of 27^{O}C. Hot air then enters into gas turbine with the velocity of 50 m/sec and leaves at 600^{O}C. Air leaving the turbine enters a nozzle at 60 m/sec velocity and leaves nozzle at temperature of 500^{O}C. For unit mass flow rate of air, determine the following assumptions adiabatic expansion in turbine and nozzle, (i) heat transfer to air in heat exchanger (ii) power output from turbine (iii) velocity at exit of nozzle. Take Cp for air as 1.005 kJ/kgK.	**BTL-1** **BTL-4** **BTL-5**	Remembering Analyzing Evaluating	**PO1,PO2**

Q.No.	Questions	BT Level	Competence	PO
7	Air flows steadily at the rate of 0.4 kg/s though an air compressor, entering at 6 m/s with a pressure of 1 bar and specific volume of 0.85 m^3/kg and leaving at 4.5 m/s with a pressure of 6.9 bar and a specific volume of 0.16 m^3/kg. The internal energy of air leaving is 88 kJ/kg greater than that of air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 59 kW. Calculate the power required to drive the compressor and the ratio of inlet and outlet cross sectional area.	**BTL-4 BTL-5**	Analyzing Evaluating	**PO1,PO2**
8	Derive the steady flow energy equation and stating the assumptions made.	**BTL-1 BTL-4 BTL-6**	Remembering Analyzing Create	**PO1**

UNIT II SECOND LAW AND AVAILABILITY ANALYSIS

Heat Reservoir, source and sink. Heat Engine, Refrigerator, Heat pump. Statements of second law and its corollaries. Carnot cycle Reversed Carnot cycle, Performance. Clausius inequality. Concept of entropy, T-s diagram, Tds Equations, entropy change for - pure substance, ideal gases - different processes, principle of increase in entropy. Applications of II Law. High and low grade energy. Available and non-available energy of a source and finite body. Energy and irreversibility. Expressions for the energy of a closed system and open systems. Energy balance and entropy generation. Irreversibility. I and II law Efficiency.

PART-A

CO Mapping : C202.2

Q.No.	Questions	BT Level	Competence	PO
1	Define Clausius statement.	**BTL-1**	Remembering	**PO1**
2	What is Perpetual motion machine of the second kind?	**BTL-1**	Remembering	**PO1**
3	Define Kelvin Planck Statement	**BTL-1**	Remembering	**PO1**
4	Define Heat pump.	**BTL-1**	Remembering	**PO1**
5	Define Heat engine.	**BTL-1**	Remembering	**PO1**
6	A heat engine with a thermal efficiency of 45 percent rejects 500 kJ/kg of heat. How much heat does it receive?	**BTL-1 BTL-3 BTL-6**	Remembering Applying Creating	**PO1,PO2**
7	What is a reversed heat engine	**BTL-1**	Remembering	**PO1**
8	What are the assumptions made on heat engine?	**BTL-1**	Remembering	**PO1**
9	State Carnot theorem.	**BTL-1**	Remembering	**PO1**
10	What is meant by reversible process?	**BTL-1**	Remembering	**PO1**

11	What is meant by irreversible process?	**BTL-1**	Remembering	**PO1**
12	Explain entropy?	**BTL-1**	Remembering	**PO1**
13	What is absolute entropy?	**BTL-1**	Remembering	**PO1**
14	When a system is adiabatic, what can be said about the entropy change of the substance in the system?	**BTL-1**	Remembering	**PO1**
15	Define availability.	**BTL-1**	Remembering	**PO1**
16	Define available energy and unavailable energy.	**BTL-4**	Analyzing	**PO1**
17	What is a thermal energy reservoir? Explain the term source and sink.	**BTL-1**	Remembering	**PO1**
18	What do you understand by the entropy principle?	**BTL-1**	Remembering	**PO1**
19	What are the important characteristics of entropy?	**BTL-1**	Remembering	**PO1**
20	What is reversed Carnot heat engine? What are the limitations of Carnot cycle?	**BTL-1**	Remembering	**PO1**
21	Define an isentropic process.	**BTL-1**	Remembering	**PO1**
22	Explain the throttling process.	**BTL-1**	Remembering	**PO1**
23	What are the Corollaries of Carnot theorem?	**BTL-1**	Remembering	**PO1**
24	Define – PMM of second kind.	**BTL-1**	Remembering	**PO1**
25	What is the difference between a heat pump and a refrigerator?	**BTL-1**	Remembering	**PO1**
26	Define the term COP?	**BTL-1**	Remembering	**PO1**
27	Write the expression for COP of a heat pump and a refrigerator?	**BTL-4**	Analyzing	**PO1**
28	Why Carnot cycle cannot be realized in practical?	**BTL-1** **BTL-4**	Remembering Analyzing	**PO1**
29	Why a heat engine cannot have 100% efficiency?	**BTL-1** **BTL-4**	Remembering Analyzing	**PO1**
30	What are the processes involved in Carnot cycle.	**BTL-1**	Remembering	**PO1**
31	What are the causes of irreversibility?	**BTL-1**	Remembering	**PO1**
32	State Clausius statement of II law of thermodynamics.	**BTL-1**	Remembering	**PO1**
PART-B&PART-C				
1	(i) A heat pump operates on a Carnot heat pump cycle with a COP of 8.7. It keeps a space at 24^0C by consuming 2.15 kW of power. Determine the temperature of the reservoir from which the heat is absorbed and the heating load provided by the heat pump. (ii) An inventor claims to have developed a refrigeration system that removes heat from the closed region at -12^0C and transfers it to the surrounding air at 25^0C while maintaining a COP of 6.5. Is this claim reasonable? Why?	**BTL-1** **BTL-4** **BTL-5**	Remembering Analyzing Evaluating	**PO1,PO2**

Q.No.	Questions	BT Level	Competence	PO
2	A reversible heat engine operates between two reservoirs at temperature of 600^0C and 40^0C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40^0C and -20^0C. The heat transfer to the heat engine is 2000kJ and the network output for the combined engine refrigerator is 360kJ. Calculate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40^0C.	**BTL-3 BTL-4 BTL-5**	Applying Analyzing Evaluating	**PO1,PO2**
3	(a) Two Carnot engines A and B are operated in series. The first one receives heat at 870 K and rejects to a reservoir at T. B receives heat rejected by the first engine and in turn rejects to a sink at 300 K. Find the temperature T for (i) Equal work outputs of both engines (ii) Same Efficiencies. (b) Mention the Clausius inequality for open, closed and isolated systems.	**BTL-4 BTL-5**	Analyzing Evaluating	**PO1,PO2**
4	(i) A 30 kg iron block and a 40 kg copper block, both initially at 80^0C, are dropped into a large lake at 15^0C. Thermal equilibrium is established after a while as a result of heat transfer between the blocks and the lake water. Determine the total entropy change for this process. (ii) How much of the 100 kJ of thermal energy at 650 K can be converted to useful work? Assume the environment to be at 25^0C.	**BTL-2 BTL-5**	Understanding Evaluating	**PO1,PO2**
5	5 m^3 of air at 2 bar, 27^OC is compressed up to 6 bar pressure following $Pv^{1.3}$= constant. It is subsequently expanded adiabatically to 2 bar. Considering the two processes to be reversible, determine the network, net heat transfer and change in entropy. Also plot the processes on T-s and p-V diagrams.	**BTL-1 BTL-3 BTL-4 BTL-5**	Understanding Applying Analyzing Evaluating	**PO1,PO2**
6	One kg of air is contained in a piston cylinder assembly at 10 bar pressure and 500 K temperature. The piston moves outwards and the air expands to 2 bar pressure and 350K temperature. Determine the maximum work obtainable. Assume the environmental conditions to be1 bar and 290 K. Also make calculations for the availability in the initial and final states.	**BTL-2 BTL-5**	Understanding Evaluating	**PO1,PO2**
7	(i) State and Prove Clausius inequality. (ii) Prove Entropy-A property of the system	**BTL-1 BTL-5**	Remembering Creating	**PO1**
8	3 kg of air at 500 kPa, 90^0C expands adiabatically in a closed system until its volume doubled and its temperature becomes equal to that of surroundings at	**BTL-2 BTL-5**	Understanding Evaluating	**PO1,PO2**

	100 kPa and 10^0C. Find the maximum work, change in availability and the irreversibility.			

UNIT III PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE

Formation of steam and its thermodynamic properties, p-v, p-T, T-v, T-s, h-s diagrams. p-v-T surface. Use of Steam Table and Mollier Chart. Determination of dryness fraction. Application of I and II law for pure substances. Ideal and actual Rankine cycles, Cycle Improvement Methods - Reheat and Regenerative cycles, Economizer, preheater, Binary and Combined cycles.

PART-A

CO Mapping : C202.3

Q.No.	Questions	BT Level	Competence	PO
1	What do you understand by pure substance?	**BTL-1**	Remembering	**PO1**
2	Draw a p-T diagram for a pure substance?	**BTL-2** **BTL-3**	Understanding Applying	**PO1**
3	Is iced water a pure substance? Why?	**BTL-4** **BTL-1**	Analyzing Remembering	**PO1**
4	Distinguish between flow process and non-flow process.	**BTL-2**	Understanding	**PO1**
5	Why Rankine cycle is modified?	**BTL-1**	Remembering	**PO1**
6	Name the various vapour power cycle.	**BTL-1**	Remembering	**PO1**
7	Define efficiency ratio.	**BTL-1**	Remembering	**PO1**
8	Define overall efficiency.	**BTL-1**	Remembering	**PO1**
9	Define specific steam consumption of an ideal Rankine cycle.	**BTL-1**	Remembering	**PO1**
10	Name the different components in steam power plant working on Rankine cycle.	**BTL-1**	Remembering	**PO1**
11	What are the effects of condenser pressure on the Rankine Cycle?	**BTL-1**	Remembering	**PO1**
12	Mention the improvements made to increase the ideal efficiency of Rankine cycle.	**BTL-1**	Remembering	**PO1**
13	What is the effect of reheat on (a) the network output, (b) the cycle efficiency and (c) steam rate of a steam power plant?	**BTL-1** **BTL-2**	Remembering Understanding	**PO1**
14	Why reheat cycle is not used for low boiler pressure?	**BTL-1**	Remembering	**PO1**
15	What are the disadvantages of reheating?	**BTL-1**	Remembering	**PO1**
16	What are the advantages of reheat cycle?	**BTL-1**	Remembering	**PO1**
17	Define latent heat of evaporation or Enthalpy of evaporation.	**BTL-1**	Remembering	**PO1**
18	Explain the term super-heated steam and super heating.	**BTL-2**	Understanding	**PO1**
19	Explain heat of super heat or super heat enthalpy.	**BTL-2**	Understanding	**PO1**
20	Explain the term critical point, critical temperature and critical pressure.	**BTL-2**	Understanding	**PO1**

Q.No.	Questions	BT Level	Competence	PO
21	Define dryness fraction (or) what is the quality of steam?	**BTL-1**	Remembering	**PO1**
22	Define enthalpy of steam.	**BTL-1**	Remembering	**PO1**
23	How do you determine the state of steam?	**BTL-1**	Remembering	**PO1**
24	Define triple point.	**BTL-1**	Remembering	**PO1**
25	How is Triple point represented in the p-V diagram?	**BTL-1**	Remembering	**PO1**
26	Define heat of vaporization.	**BTL-1**	Remembering	**PO1**
27	Explain the terms, Degree of super heat, degree of sub-cooling.	**BTL-2**	Understanding	**PO1**
28	When is reheat recommended in a steam power plant?	**BTL-4**	Analyzing	**PO1**
29	What are the processes that constitute a Rankine cycle?	**BTL-1**	Remembering	**PO1**
30	State the advantages of using superheated steam in turbines.	**BTL-1**	Remembering	**PO1**
31	Draw the p-T diagram for water and label all salient points.	**BTL-2**	Understanding	**PO1**
	PART-B& PART-C			
1	Explain steam formation with relevant sketch and label all salient points and explain every point in detail.	**BTL-1** **BTL-3**	Understanding Applying	**PO1**
2	(a) Define specific steam consumption, specific heat rate and work ratio. (b) A vessel of volume 0.04 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250^oC. The mass of the liquid present is 9 kg. Find the pressure, the mass, the specific volume, the enthalpy, and entropy, and the internal energy of the mixture.	**BTL-1** **BTL-5**	Remembering Evaluating	**PO1,PO2**
3	Steam at a pressure of 15 bar and 250^OC expands according to the law $PV^{1.25}$=C to a pressure of 1.5 bar. Evaluate the final conditions, work done, heat transfer and change in entropy. The mass of the system is 0.8 kg.	**BTL-4** **BTL-5**	Analyzing Evaluating	**PO1,PO2**
4	A steam power plant operates on a theoretical reheat cycle. Steam at boiler at 150 bar, 550^OC expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to 550^OC and expands through the low pressure turbine to a condenser at 0.1 bar. Draw T-s and h-s diagrams. Find (i) Quality of steam at turbine exhaust (ii) Cycle efficiency (iii) Steam rate in kg/kWh.	**BTL-3** **BTL-4** **BTL-5**	Applying Analyzing Evaluating	**PO1,PO2**

Q.No.	Questions	BT Level	Competence	PO
5	Consider a steam power plant operating on the Ideal Rankine cycle. Steam enters the turbine at 3 MPa and 623 K and is condensed in the condenser at a pressure of 10 kPa. Determine (i) the thermal efficiency of this power plant (ii) the thermal efficiency, if steam is super-heated to 873 K instead of 623 K, and (iii) the thermal efficiency, if the boiler pressure is raised to 15 MPa while the turbine inlet temperature is maintained at 873 K.	**BTL-3 BTL-4 BTL-5**	Applying Analyzing Evaluating	**PO1,PO2**
6	In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. The flow rate of steam is 0.2 kg/s. Determine (i) the pimp work (ii) the turbine work (iii) Rankine efficiency (iv) Condenser heat flow (v) work ratio and (vi) specific steam consumption.	**BTL-3 BTL-4 BTL-5**	Applying Analyzing Evaluating	**PO1,PO2**
7	A steam power plant operates on an ideal regenerative Rankine cycle, Steam enters the turbine at 6 MPa and 450^0C and is condensed in the condenser at 20 kPa. Steam is extracted from the turbine at 0.4 MPa to heat the feed water in an open feed water heater. Water leaves the feed water heater. Water leaves the feed water heater as a saturated liquid. Show the cycle on a T-s diagram, and determine (i) The network output per kilogram of steam flowing through the boiler and (ii) the thermal efficiency of the cycle.	**BTL-3 BTL-4 BTL-5**	Applying Analyzing Evaluating	**PO1,PO2**

UNIT IV IDEAL AND REAL GASES, THERMODYNAMIC RELATIONS

Properties of Ideal gas- Ideal and real gas comparison- Equations of state for ideal and real gases-Reduced properties-.Compressibility factor-.Principle of Corresponding states. -Generalised Compressibility Chart and its use-. Maxwell relations, Tds Equations, Difference and ratio of heat capacities, Energy equation, Joule-Thomson Coefficient, Clausius Clapeyron equation, Phase Change Processes. Simple Calculations.

PART-A

CO Mapping : C202.4

Q.No.	Questions	BT Level	Competence	PO
1	Define Ideal gas.	**BTL-1**	Remembering	**PO1**
2	What are the properties of ideal gas?	**BTL-1**	Remembering	**PO1**
3	Define Real gas.	**BTL-1**	Remembering	**PO1**
4	What is equation of state?	**BTL-1**	Remembering	**PO1**
5	State the Vander Waal’s equation of state.	**BTL-1**	Remembering	**PO1**

Q.No.	Questions	BT Level	Competence	PO
6	State Boyle's law.	**BTL-1**	Remembering	**PO1**
7	State Charle's law.	**BTL-1**	Remembering	**PO1**
8	Explain the construction and give the use of generalized compressibility chart..	**BTL-1**	Remembering	**PO1**
9	What do you mean by reduced properties?	**BTL-1**	Remembering	**PO1**
10	Explain law of corresponding states.	**BTL-2**	Understanding	**PO1**
11	Explain Dalton's law of partial pressure.	**BTL-2**	Understanding	**PO1**
12	State Avogadro's Law.	**BTL-1**	Remembering	**PO1**
13	What is compressibility factor?	**BTL-1**	Remembering	**PO1**
14	What is partial pressure?	**BTL-1**	Remembering	**PO1**
15	Define Dalton's law of partial pressure.	**BTL-1**	Remembering	**PO1**
16	How does the Vander Waal's equation differ from the ideal gas equation of state?	**BTL-1** **BTL-2**	Remembering Understanding	**PO1**
17	Explain Joule-Kelvin effect. What is inversion temperature?	**BTL-2**	Understanding	**PO1**
18	What is the law of corresponding states?	**BTL-1**	Remembering	**PO1**
19	In what way the Clausius Clapeyron equations is useful?	**BTL-1** **BTL-3**	Remembering Applying	**PO1**
20	What are the assumptions made to derive ideal gas equation analytically using the kinetic theory of gases?	**BTL-1** **BTL-4**	Remembering Analyzing	**PO1**
21	Write down the two Tds equations.	**BTL-1**	Remembering	**PO1**
22	What is Clausius Clapeyron Equation?	**BTL-1**	Remembering	**PO1**
23	State Helmholtz function.	**BTL-1**	Remembering	**PO1**
24	State Gibbs Function.	**BTL-1**	Remembering	**PO1**
25	Have you ever encountered any ideal gas? If so, where?	**BTL-4** **BTL-3**	Analyzing Applying	**PO1**
26	What are Maxwell relations?	**BTL-1**	Remembering	**PO1**
27	What is meant by equation of state? Write the same for an ideal gas.	**BTL-1** **BTL-3**	Remembering Applying	**PO1**
28	Determine the molecular volume of any perfect gas at 600 N/m^2 and 30^0C. Universal gas constant may be taken as 8314 kJ/kg mole-k.	**BTL-4** **BTL-5**	Analyzing Evaluating	**PO1,PO2**
29	State Charle's law.	**BTL-1**	Remembering	**PO1**
30	State Regnault's law.	**BTL-1**	Remembering	**PO1**
PART-B& PART-C				
1	(i)What is joule – Thomson co-efficient? Why is it zero for an ideal gas? (ii)Derive an expression for Clausius Clapeyron equation applicable to fusion and vaporization.	**BTL-3** **BTL-4** **BTL-5**	Applying Analyzing Creating	**PO1**
2	Derive the Maxwell relations and explain their importance in thermodynamics.	**BTL-3** **BTL-4** **BTL-5**	Applying Analyzing Creating	**PO1**

Q.No.	Questions	BT Level	Competence	PO
3	(i) Derive the Clausius – Clapeyron equation and discuss its significance. (ii) Draw a neat sketch of a compressibility chart and indicate its salient features.	**BTL-3** **BTL-4** **BTL-5** **BTL-2**	Applying Analyzing Creating Understanding	**PO1**
4	(a) From the basic principles, prove the following $C_p - C_v = -T\left(\frac{\partial v}{\partial T}\right)^2_p \left(\frac{\partial P}{\partial v}\right)_T$ (b) Derive the TdS equation taking T and C as independent variables.	**BTL-3** **BTL-4** **BTL-5**	Applying Analyzing Creating	**PO1**
5	(a) Explain the physical significance of the compressibility factor Z. (b) Derive the Joule – Thomson co-efficient equation and draw the inversion curve.	**BTL-2** **BTL-3** **BTL-4** **BTL-5**	Understanding Applying Analyzing Creating	**PO1**
6	Determine the pressure of nitrogen gas at T=175 K and v=0.00375 m^3/kg on the basis of (i) The ideal-gas equation of state (ii) the Vander Waals equation of state. The vanderwaals constants for nitrogen are a=0.175 m^6kPa/kg^2, b=0.00138 m^3/kg.	**BTL-5**	Evaluating	**PO1,PO2**
7	(i) State the conditions under which the equation of state will hold good for gas. (ii) State the main reasons for the deviation of behavior of real gases from ideal gases. (iii)Explain irreversibility with respect to flow and non-flow process. (iv) Explain the effectiveness of a system.	**BTL-1** **BTL-2** **BTL-5**	Remembering Understanding	**PO1**
8	(i)One kg of CO_2 has a volume of 1 m^3 at 100^0C. Compute the pressure by (1) Van der Waals' equation (2) Perfect gas equation.The Van der Waals' constants a=362850 $Nm^4/(kg\text{-}mol)^2$ and b=0.0423 m^3/(kg-mol). (ii) Write the Berthelot and Dieterici equations of state.	**BTL-5**	Evaluating	**PO1,PO2**

UNIT V GAS MIXTURES AND PSYCHROMETRY				
Mole and Mass fraction, Dalton's and Amaga's Law. Properties of gas mixture – Molar mass, gas constant, density, and change in internal energy, enthalpy, entropy and Gibbs function. Psychrometric properties, Psychrometric charts. Property calculations of air vapour mixtures by using chart and expressions. Psychrometric process – adiabatic saturation, sensible heating and cooling, humidification, dehumidification, evaporative cooling and adiabatic mixing. Simple Applications				
PART-A				
CO Mapping : C202.5				
Q.No.	**Questions**	**BT Level**	**Competence**	**PO**
1	What is humidification and dehumidification?	**BTL-1**	Remembering	**PO1**
2	Differentiate absolute humidity and relative humidity.	**BTL-2**	Understanding	**PO1**
3	What is effective temperature?	**BTL-1**	Remembering	**PO1**
4	Define Relative humidity.	**BTL-2**	Understanding	**PO1**
5	Define specific humidity.	**BTL-1**	Remembering	**PO1**
6	Define degree of saturation.	**BTL-1**	Remembering	**PO1**
7	What is dew point temperature?	**BTL-1**	Remembering	**PO1**
8	What is meant by dry bulb temperature (DBT)	**BTL-1**	Remembering	**PO1**
9	What is meant by wet bulb temperature (WBT)?	**BTL-1**	Remembering	**PO1**
10	Define dew point depression.	**BTL-1**	Remembering	**PO1**
11	What is meant by adiabatic saturation temperature (or) thermodynamic wet bulb?Temperature?	**BTL-1**	Remembering	**PO1**
12	What is psychrometer?	**BTL-1**	Remembering	**PO1**
13	What is Psychrometric chart?	**BTL-2**	Understanding	**PO1**
14	Define sensible heat and latent heat.	**BTL-1**	Remembering	**PO1**
15	What are the important Psychrometric processes?	**BTL-1**	Remembering	**PO1**
16	What is meant by adiabatic mixing?	**BTL-1**	Remembering	**PO1**
17	What are the assumptions made in Vander Waal's equation of state?	**BTL-1**	Remembering	**PO1**
18	Define coefficient of volume expansion.	**BTL-2**	Understanding	**PO1**
19	State Helmholtz function.	**BTL-1**	Remembering	**PO1**
20	What are thermodynamic properties?	**BTL-1**	Remembering	**PO1**
21	Define throttling process.	**BTL-1**	Remembering	**PO1**
22	Define Molecular mass.	**BTL-1**	Remembering	**PO1**
23	Define isothermal compressibility.	**BTL-1**	Remembering	**PO1**
24	Define psychrometry.	**BTL-1**	Remembering	**PO1**
25	What is by-pass factor?	**BTL-1**	Remembering	**PO1**
26	Define Apparatus Dew Point (ADP) of cooling coil?	**BTL-1**	Remembering	**PO1**
27	Explain the following terms: (a) Mole fraction (b) Mass fraction.	**BTL-2**	Understanding	**PO1**
28	What is compressibility factor? What does it signify? What is its value for Vander Waals at critical point?	**BTL-4**	Analyzing	**PO1**
29	State Dalton's law of partial pressure.	**BTL-1**	Remembering	**PO1**

Q.No.	Questions	BT Level	Competence	PO
30	What is the significance of compressibility factor?	**BTL-1**	Remembering	**PO1**
PART-B& PART-C				
1	An air-water vapour mixture enters an air-conditioning unit at a pressure of 1.0 bar, 38^{O}C DBT, and a relative humidity of 75%. The mass of dry air entering is 1 kg/s. The air-vapour mixture leaves the air-conditioning unit at 1.0 bar, 18^{O}C, 85% relative humidity. The moisture condensed leaves at 18^{O}C. Determine the heat transfer rate for the process.	**BTL-3** **BTL-5**	Applying Evaluating	**PO1,PO2**
2	(a) One kg of air at 40^{O}C dry bulb temperature and 50% relative humidity is mixed with 2 kg of air at 20^{O}C dry bulb temperature and 20^{O}C dew point temperature. Calculate the temperature and specific humidity of the mixture. (b) With the aid of model Psychrometric chart explain the following processes. (i) Adiabatic mixing (ii) Evaporative cooling.	**BTL-2** **BTL-3** **BTL-4** **BTL-5**	Understanding Applying Analyzing Creating	**PO1,PO2**
3	Atmospheric air at 1.0132 bar has 20^{0}C DBT and 65% RH. Find the humidity ratio, wet bulb temperature, dew point temperature, degree of saturation, enthalpy of the mixture, density of air and density of vapour in the mixture.	**BTL-1BTL-5**	Remembering Evaluating	**PO1,PO2**
4	It is required to design an air-conditioning plant for a small office room for following winter conditions: Outdoor conditions…..14^{0}C DBT and 10^{0}C WBT Required conditions……20^{0}C DBT and 60% RH Amount of air circulation…0.30 m^3/min/person. Seating capacity of office….60. The required condition is achieved first by heating and then by adiabatic humidifying. Determine the following: (i) Heating capacity of the coil in kW and the surface temperature required if the by pass factor of coil is 0.4. (ii) The capacity of the humidifier.	**BTL-2** **BTL-3** **BTL-4** **BTL-5**	Understanding Applying Analyzing Creating	**PO1,PO2**
5	A perfect gas mixture consists of 4 kg of N_2 and 6 kg of CO_2 at a pressure of 4 bar and a temperature of 25^{0}C. For N_2; C_v=0.745 kJ/kg K and C_p=1.041 kJ/kg K. For CO_2; C_v=0.653 kJ/kg K and C_p=0.842 kJ/kg. Find C_p, C_v and R of the mixture. If the mixture is heated at constant volume to 50^{0}C, find the changes in internal energy, enthalpy and entropy of the mixture.	**BTL-1** **BTL-3** **BTL-4**	Remembering Applying Evaluating	**PO1,PO2**

Q.No.	Questions	BT Level	Competence	PO
6	An insulated rigid tank is divided into two compartments by a partition. One compartment contains 7kg of oxygen gas at $40^{O}C$ and 100 kPa and the other compartment contains 4kg of nitrogen gas at $20^{O}C$ and 150kPa. C_V, N_2=0.743 kJ/kgK and C_V, O_2=0.658 kJ/kgK. If the partition is removed and the two gases are allowed to mix, determine (i) The mixture temperature (ii) The mixture pressure after equilibrium has been established.	BTL-1 BTL-3 BTL-4	Remembering Applying Evaluating	PO1,PO2
7	A mixture of hydrogen (H_2) and Oxygen (O_2) is to be made so that the ratio of H_2 to O_2 is 2:1 by volume. If the pressure and temperature are 1 bar and $25^{0}C$ respectively, Calculate: (i) The mass of O_2 required (ii) The volume of the container.	BTL-2 BTL-3 BTL-4	Understanding Applying Evaluating	PO1,PO2
8	A rigid tank that contains 2kg of N_2 at $25^{0}C$ and 550 kPa is connected to another rigid tank that contains 4kg of O_2 at $25^{0}C$ and 150 kPa. The valve connecting the two tanks is opened, and the two gases are allowed to mix. If the final mixture temperature is $25^{0}C$, determine the volume of each tank and the final mixture pressure.	BTL-1 BTL-3 BTL-4	Remembering Applying Evaluating	PO1,PO2

UNIT I BASIC CONCEPTS AND FIRST LAW

Basic concepts - concept of continuum, comparison of microscopic and macroscopic approach. Path and point functions. Intensive and extensive, total and specific quantities. System and their types. Thermodynamic Equilibrium State, path and process. Quasi-static, reversible and irreversible processes. Heat and work transfer, definition and comparison, sign convention. Displacement work and other modes of work.P-V diagram. Zeroth law of thermodynamics – concept of temperature and thermal equilibrium– relationship between temperature scales –new temperature scales. First law of thermodynamics –application to closed and open systems – steady and unsteady flow processes.

PART-A

1. Define thermodynamic system.

A thermodynamic system is defined as a quantity of matter or a region in space, on which the analysisof the problem is concentrated.

2. Name the different types of system.

1. Closed system (only energy transfer and no mass transfer)
2. Open system (Both energy and mass transfer)
3. Isolated system (No mass and energy transfer)

3. Should the automobile radiator be analyzed as a closed system or as an open system? Explain. (Nov/Dec 2016)

Automobile radiator system is analyzed as closed system. In this no mass (water) cross the boundary.

4. Define thermodynamic equilibrium. (Nov/Dec 2014) (May/June 2014)

If a system is in Mechanical, Thermal and Chemical Equilibrium then the system is in

Thermodynamically equilibrium. (or)
If the system is isolated from its surrounding there will be no change in the macroscopic property, thenthe system is said to exist in a state of thermodynamic equilibrium.

5. What do you mean by quasi-static process? (Nov/Dec 2012)
Infinite slowness is the characteristic feature of a quasi-static process. A quasi-static process is that asuccession of equilibrium states. A quasi-static process is also called as reversible process.

6. Differentiate between point function and path function. (May/June 2014)

Point Function	Path Function
1. Any quantity whose change is independent of the path is known as point function.	1. Any quantity, the value of which depends on the path followed during a change of state is known as path function.
2. The magnitude of such quantity in a process depends on the state.	2. The magnitude of such quantity in a process is equal to the area under the curve on a property diagram.
3. These are exact differential.	3.These are inexact differential. Inexact differential is denoted by δ
4. Properties are the examples of point function like pressure(P), volume(V),Temp.(T),Energy etc.	4. Ex: Heat and work

7. Name and explain the two types of properties. (Nov/Dec 2013)(Nov/Dec 2016)
The two types of properties are intensive property and extensive property.
Intensive Property: It is independent of the mass of the system.
Example: pressure, temperature, specific volume, specific energy, density.
Extensive Property: It is dependent on the mass of the system.
Example: Volume, energy. If the mass is increased the values of the extensive properties also Increase.

8. Explain homogeneous and heterogeneous system.
The system consist of single phase is called homogeneous system and the system consist of more thanone phase is called heterogeneous system.

9. What is a steady flow process?
Steady flow means that the rates of flow of mass and energy across the control surface are constant.

10. Prove that for an isolated system, there is no change in internal energy.
In isolated system there is no interaction between the system and the surroundings. There is no masstransfer and energy transfer. According to first law of thermodynamics as dQ = dU + dW; dU = dQ –dW; dQ = 0, dW = 0, Therefore dU = 0 by integrating the above equation U = constant, therefore the internal energy isconstant for isolated system.

11. Indicate the practical application of steady flow energy equation.
1. Turbine, 2. Nozzle, 3. Condenser, 4. Compressor.

12. Define system.
It is defined as the quantity of the matter or a region in space upon which we focus attention to studyits property.

13. Define cycle.
It is defined as a series of state changes such that the final state is identical with the initial state.

14. Explain Mechanical equilibrium.
If the forces are balanced between the system and surroundings are called Mechanical equilibrium

15. Explain Chemical equilibrium.
If there is no chemical reaction or transfer of matter form one part of the system to another is calledChemical equilibrium.

16. Explain Thermal equilibrium.
If the temperature difference between the system and surroundings is zero then it is in Thermal Equilibrium.

17. Define Zeroth law of Thermodynamics. (Nov/Dec 2014)
When two systems are separately in thermal equilibrium with a third system then they themselves is inthermal equilibrium with each other.

18. What are the limitations of first law of thermodynamics? (Nov/Dec 2012)
1. According to first law of thermodynamics heat and work are mutually convertible during any cycleof a closed system. But this law does not specify the possible conditions under which the heat isconverted into work.
2. According to the first law of thermodynamics it is impossible to transfer heat from lowertemperature to higher temperature.
3. It does not give any information regarding change of state or whether the process is possible or not.
4. The law does not specify the direction of heat and work.

19. What is perpetual motion machine of first kind?
It is defined as a machine, which produces work energy without consuming an equivalent of energyfrom other source. It is impossible to obtain in actual practice, because no machine can produce energyof its own without consuming any other form of energy.

20. Define: Specific heat capacity at constant pressure.
It is defined as the amount of heat energy required to raise or lower the temperature of unit mass of thesubstance through one degree when the pressure kept constant. It is denoted by Cp.

21. Define: Specific heat capacity at constant volume.
It is defined as the amount of heat energy required to raise or lower the temperature of unit mass of thesubstance through one degree when volume kept constant.

22. Define the term enthalpy?
The Combination of internal energy and flow energy is known as enthalpy of the system. It may alsobe defined as the total heat of the substance.
Mathematically, enthalpy (H) = U + pv KJ)
Where, U – internal energy
p – Pressure
v – Volume
In terms of Cp& T → H = mCp (T2-T1) KJ

23. Define the term internal energy
Internal energy of a gas is the energy stored in a gas due to its molecular interactions. It is also definedas the energy possessed by a gas at a given temperature.

24. What is meant by thermodynamic work?
It is the work done by the system when the energy transferred across the boundary of the system. It ismainly due to intensive property difference between the system and surroundings.

25. What is meant by reversible and irreversible process?
A process is said to be reversible, it should trace the same path in the reverse direction when the process is reversed. It is possible only when the system passes through a continuous series of equilibrium state.

26. Enlist the similarities between work and heat. (Nov/Dec 2014)

Heat	Work
Form of energy	Form of energy

Across a boundary	Across a boundary
Cross the boundary whenever there is a change of state of a body	Cross the boundary whenever there is a change of state of a body
It is a path function and hence is an exact differential	It is a path function and hence is an exact differential

27. Why does free expansion have zero work transfer? (April/May 2015)

In free expansion there is no external force acting on the gas so that the energy given to the gas can be utilized to produce heat and to overcome the repulsions between the gases which does not happen in free expansion therefore there is no work transfer.

28. Distinguish between 'Macroscopic energy' and 'Microscopic energy'. (Nov/Dec 2012)

Statistical Thermodynamics is microscopic approach in which, the matter is assumed to be made of numerous individual molecules. Hence, it can be regarded as a branch of statistical mechanics dealing with the average behaviour of a large number of molecules.

Classical thermodynamics is macroscopic approach. Here, the matter is considered to be a continuum without any concern to its atomic structure.

29. Show that the energy of an isolated system remains constant. (Nov/Dec 2015)

A system which does not exchange energy with its surroundings through work and heat interactions is called an isolated system. That is for an isolated system dW = 0 and dQ=0.
The first law of thermodynamics gives dE = dQ – dW
Hence, for an isolated system, the first law of thermodynamics reduces to dE = 0 or $E_2 = E_1$. In other words, the energy of an isolated thermodynamic system remains constant.

30. What are the conditions for steady flow process? (May/June 2013)

- No properties within the control volume change with time. That is
  m_{cv} = constant E_{cv} = constant
- No properties change at the boundaries with time. Thus, the fluid properties at an inlet or exit will remain the same during the whole process. They can be different at different opens.
- The heat and work interactions between a steady-flow system and its surroundings do not change with time.

PART-B

1. **A gas of mass 1.5 kg undergoes a quasi-static expansion, which follows a relationship p=a+bV, where 'a' and 'b' are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volumes are 0.2 m^3 and 1.2 m^3. The specific internal energy of the gas is given by the relation U = (1.5pV – 85) kJ/kg, where p is in kPa and V is in m^3. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion. (Nov/Dec 2012).**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

2. **A piston – cylinder device contains 0.15 kg of air initially at 2 MPa and 3500C. The air is first expanded isothermally to 500 kPa, then compressed polytropically with a polytrophic exponent of 1.2 to the initial pressure, and finally compressed at the constant pressure to the initial state. Determine the boundary work for each process and the network of the cycle. (Nov/Dec 2016)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

3. A gas undergoes a thermodynamic cycle consisting of the following processes:

(i) Process 1-2: Constant Pressure P_1=1.4 bar, V_1=0.028 m^3, W_{1-2}=10.5 kJ.

(ii) Process 2-3: Compression with pV=constant, $U_3=U_2$.

(iii) Process 3-1: Constant volume, U_1-U_3= - 26.4 kJ.

There are no significant changes in KE and PE

1. Sketch the cycle on a p-V diagram.
2. Calculate the network for the cycle in kJ.
3. Calculate the heat transfer for process 1-2.
4. Show that $Q_{cycle}=W_{cycle}$. **(April/May 2015)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

4. A three cycle operating with nitrogen as the working substance has constant temperature compression at 34^{0}C with initial pressure 100kPa. Then the gas undergoes a constant volume heating and then polytropic expansion with 1.35 as index of compression. The isothermal compression requires - 67 kJ/kg of work. Determine: (i) p,v and T around the cycle (ii) Heat in and out (iii) Network. For nitrogen gas Cv = 0.731 kJ/kgK.**(May/June 2013)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

5. (i) Air enters the compressor of a gas-turbine plant at ambient conditions of 100 kPa and 25^{0}C with a low velocity and exists at 1 MPa and 347^{0}C with a velocity of 90 m/s. The compressor is cooled at the rate of 1500 kJ/min, and the power input to the compressor is 250 kW. Determine the mass flow rate of air through the compressor. Assume Cp=1.005 kJ/kg K.

(ii) Derive steady flow energy equation.**(Nov/Dec 2016)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

6. In a gas turbine installation air is heated inside heat exchanger up to 750^{O}C from ambient temperature of 27^{O}C. Hot air then enters into gas turbine with the velocity of 50 m/sec and leaves at 600^{O}C. Air leaving the turbine enters a nozzle at 60 m/sec velocity and leaves nozzle at temperature of 500^{O}C. For unit mass flow rate of air, determine the following assumptions adiabatic expansion in turbine and nozzle, (i) heat transfer to air in heat exchanger (ii) power output from turbine (iii) velocity at exit of nozzle. Take Cp for air as 1.005 kJ/kgK. **(May/June 2014).**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

7. Air flows steadily at the rate of 0.4 kg/s though an air compressor, entering at 6 m/s with a pressure of 1 bar and specific volume of 0.85 m^3/kg and leaving at 4.5 m/s with a pressure of 6.9 bar and a specific volume of 0.16 m^3/kg. The internal energy of air leaving is 88 kJ/kg greater than that of air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 59 kW. Calculate the power required to drive the compressor and the ratio of inlet and outlet cross sectional area. **(May/June 2012)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

8. Derive the steady flow energy equation and stating the assumptions made.**(May/June 2014).**

Refer: "P.K NAG Engineering Thermodynamics for derivation"

UNIT II SECOND LAW AND AVAILABILITY ANALYSIS

Heat Reservoir, source and sink. Heat Engine, Refrigerator, Heat pump. Statements of second law and its corollaries. Carnot cycle Reversed Carnot cycle, Performance. Clausius inequality. Concept of entropy, T-s diagram, Tds Equations, entropy change for - pure substance, ideal gases - different processes, principle of increase in entropy. Applications of II Law. High and low grade energy. Available and non-available energy of a source and finite body. Energy and irreversibility. Expressions for the energy of a closed system and open systems. Energy balance and entropy generation. Irreversibility. I and II law Efficiency.

PART-A

1. Define Clausius statement. (Nov/Dec 2013)

It is impossible for a self-acting machine working in a cyclic process, to transfer heat from a body atlower temperature to a body at a higher temperature without the aid of an external agency.

2. What is Perpetual motion machine of the second kind?

A heat engine, which converts whole of the heat energy into mechanical work is known as Perpetualmotion machine of the second kind.

3. Define Kelvin Planck Statement. (May/June 2014) (Nov/Dec 2014) (May/June 2013)

It is impossible to construct a heat engine to produce network in a complete cycle if it exchanges heatfrom a single reservoir at single fixed temperature.

4. Define Heat pump.

A heat pump is a device, which is working in a cycle and transfers heat from lower temperature tohigher temperature.

5. Define Heat engine.

Heat engine is a machine, which is used to convert the heat energy into mechanical work in a cyclicprocess.

6. A heat engine with a thermal efficiency of 45 percent rejects 500 kJ/kg of heat. How much heat does it receive? (Nov/Dec 2016)

Thermal efficiency=(Qs-Qr)/Qs

0.45=(Qs-500)/Qs

Qs=909 kJ/kg

7. What is a reversed heat engine? (April/May 2015)

The reversed heat engine works on the principle of reversed Carnot cycle. The heat engine produces work by absorbing heat from source and liberating some heat to sink. The reversed heat engine transfers the heat from sink to the source with the help of external work.

8. What are the assumptions made on heat engine?

1. The source and sink are maintained at constant temperature.
2. The source and sink has infinite heat capacity.

9. State Carnot theorem. (May/June 2014)

It states that no heat engine operating in a cycle between two constant temperature heat reservoir canbe more efficient than a reversible engine operating between the same reservoir.

10. What is meant by reversible process?

A reversible process is one, which is performed in such a way that at the conclusion of process, bothsystem and surroundings may be restored to their initial state, without producing any changes in rest ofthe universe.

11. What is meant by irreversible process?

The mixing of two substances and combustion also leads to irreversibility. All spontaneous process isirreversible.

12. Explain entropy?(Nov/Dec 2014) (Nov/Dec 2015)

It is an important thermodynamic property of the substance. It is the measure of molecular disorder. Itis denoted by S. The measurement of change in entropy for reversible process is obtained by thequantity of heat received or rejected to absolute temperature.

13. What is absolute entropy?

The entropy measured for all perfect crystalline solids at absolute zero temperature is known asabsolute entropy.

14. When a system is adiabatic, what can be said about the entropy change of the substance in the system? (Nov/Dec 2016)

Entropy change of the substance in a adiabatic system is always constant. (S=C)

$S_1=S_2$

15. Define availability.

The maximum useful work obtained during a process in which the final condition of the system is thesame as that of the surrounding is called availability of the system.

16. Define available energy and unavailable energy.

Available energy is the maximum thermal useful work under ideal condition. The remaining part,which cannot be converted into work, is known as unavailable energy.

17. What is a thermal energy reservoir? Explain the term source and sink. (April/May 2015)

A thermal reservoir, a short-form of thermal energy reservoir, or thermal bath is a thermodynamic system with a heat capacity that is large enough that when it is in thermal contact with another system of interest or its environment, its temperature remains effectively constant.

Source is a thermal reservoir, which supplies heat to the system and sink is a thermal reservoir, which takes the heat from the system.

18. What do you understand by the entropy principle?

The entropy of an isolated system can never decrease. It always increases and remains constant onlywhen the process is reversible. This is known as principle of increase in entropy or entropy principle.

19. What are the important characteristics of entropy?

1. If the heat is supplied to the system then the entropy will increase.
2. If the heat is rejected to the system then the entropy will decrease.
3. The entropy is constant for all adiabatic frictionless process.
4. The entropy increases if temperature of heat is lowered without work being done as in throttlingprocess.
5. If the entropy is maximum, then there is a minimum availability for conversion in to work.
6. If the entropy is minimum then there is a maximum availability for conversion into work.

20. What is reversed Carnot heat engine? What are the limitations of Carnot cycle?

1. No friction is considered for moving parts of the engine.
2. There should not be any heat loss.

21. Define an isentropic process.

Isentropic process is also called as reversible adiabatic process. It is a process which follows the lawof $pV^y= C$ is known as isentropic process. During this process entropy remains constant and no heatenters or leaves the gas.

22. Explain the throttling process.

When a gas or vapour expands and flows through an aperture of small size, the process is called asthrottling process.

23. What are the Corollaries of Carnot theorem? (May/June 2014)

(i) In the entire reversible engine operating between the two given thermal reservoirs with fixedtemperature, have the same efficiency.

(ii) The efficiency of any reversible heat engine operating between two reservoirs is independent of thenature of the working fluid and depends only on the temperature of the reservoirs.

24. Define – PMM of second kind.

Perpetual motion machine of second kind draws heat continuously from single reservoir and convertsit into equivalent amount of work. Thus it gives 100% efficiency.

25. What is the difference between a heat pump and a refrigerator?

Heat pump is a device which operating in cyclic process, maintains the temperature of a hot body at atemperature higher than the temperature of surroundings.

A refrigerator is a device which operating in a cyclic process, maintains the temperature of a cold bodyat a temperature lower than the temperature of the surroundings.

26. Define the term COP?

Co-efficient of performance is defined as the ratio of heat extracted or rejected to work input.

$$COP = \frac{\text{Heat extracted or rejected}}{\text{Work input}}$$

27. Write the expression for COP of a heat pump and a refrigerator?

COP of heat pump,

$$COP_{HP} = \frac{\text{Heat Supplied}}{\text{Work input}} = \frac{T_2}{T_2 - T_1}$$

COP of Refrigerator,

$$COP_{Ref} = \frac{\text{Heat extracted}}{\text{Work input}} = \frac{T_1}{T_2 - T_1}$$

28. Why Carnot cycle cannot be realized in practical?

(i) In a Carnot cycle all the four process are reversible but in actual practice there is no process isreversible.

(ii) There are two processes to be carried out during compression and expansion. For isothermalprocess the piston moves very slowly and for adiabatic process the piston moves as fast as possible.This speed variation during the same stroke of the piston is not possible.

(iii) It is not possible to avoid friction moving parts completely.

29. Why a heat engine cannot have 100% efficiency?

For all the heat engines there will be a heat loss between system and surroundings. Therefore we can'tconvert all the heat input into useful work.

30. What are the processes involved in Carnot cycle.

Carnot cycle consist of

i) Reversible isothermal compression

ii) Isentropic compression

iii) Reversible isothermal expansion

iv) Isentropic expansion

31. What are the causes of irreversibility? (Nov/Dec 2015)

Four of the most common causes of irreversibility are friction, unrestrained expansion of a fluid, heat transfer through a finite temperature difference, and mixing of two different substances.

32. State Clausius statement of II law of thermodynamics. (Nov/Dec 2013)

Clausius statement states "it is impossible for a self-acting machine working in a cyclic process without any external force, to transfer heat from a body at a lower temperature to a body at a higher temperature. It considers transformation of heat between two heat reservoirs.

PART-B& PART-C

1. (i) A heat pump operates on a Carnot heat pump cycle with a COP of 8.7. It keeps a space at 24^0C by consuming 2.15 kW of power. Determine the temperature of the reservoir from which the heat is absorbed and the heating load provided by the heat pump.
(ii) An inventor claims to have developed a refrigeration system that removes heat from the closed region at -12^0C and transfers it to the surrounding air at 25^0C while maintaining a COP of 6.5. Is this claim reasonable? Why? **(Nov/Dec 2016)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

2. A reversible heat engine operates between two reservoirs at temperature of 600^0C and 40^0C. The engine drives a reversible refrigerator which operates between reservoirs at temperatures of 40^0C and -20^0C. The heat transfer to the heat engine is 2000kJ and the network output for the combined engine refrigerator is 360kJ. Calculate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40^0C. **(April/May 2015)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

3. (a) Two Carnot engines A and B are operated in series. The first one receives heat at 870 K and rejects to a reservoir at T. B receives heat rejected by the first engine and in turn rejects to a sink at 300 K. Find the temperature T for (i) Equal work outputs of both engines (ii) Same Efficiencies.
(b) Mention the Clausius inequality for open, closed and isolated systems. **(Nov/Dec 2013)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"228.

4. (i) A 30 kg iron block and a 40 kg copper block, both initially at 80^0C, are dropped into a large lake at 15^0C. Thermal equilibrium is established after a while as a result of heat transfer between the blocks and the lake water. Determine the total entropy change for this process.

(ii) How much of the 100 kJ of thermal energy at 650 K can be converted to useful work? Assume the environment to be at 25^0C. **(Nov/Dec 2016)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

5. 5 m^3 of air at 2 bar, 27^OC is compressed up to 6 bar pressure following $Pv^{1.3}$= constant. It is subsequently expanded adiabatically to 2 bar. Considering the two processes to be reversible, determine the network, net heat transfer and change in entropy. Also plot the processes on T-s and p-V diagrams. **(May/June 2014)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

6. One kg of air is contained in a piston cylinder assembly at 10 bar pressure and 500 K temperature. The piston moves outwards and the air expands to 2 bar pressure and 350K temperature. Determine the maximum work obtainable. Assume the environmental conditions to be 1 bar and 290 K. Also make calculations for the availability in the initial and final states. **(Nov/Dec 2009)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

7. (i) State and Prove Clausius inequality.
(ii) Prove Entropy-A property of the system. **(Nov/Dec 2012)**

Refer: "P.K NAG Engineering Thermodynamics for derivation"

8. 3 kg of air at 500 kPa, 90^0C expands adiabatically in a closed system until its volume doubled and its temperature becomes equal to that of surroundings at 100 kPa and 10^0C. Find the maximum work, change in availability and the irreversibility. **(Nov/Dec 2013)**

Refer: Refer: "P.K NAG Engineering Thermodynamics for similar problems"

UNIT III PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE

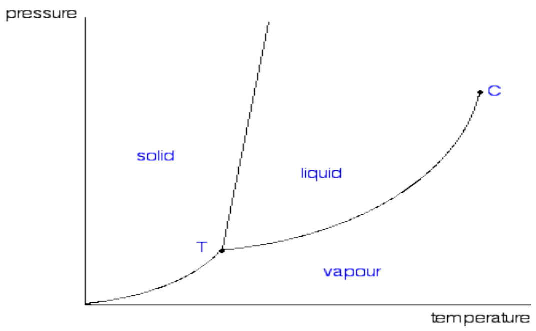
Formation of steam and its thermodynamic properties, p-v, p-T, T-v, T-s, h-s diagrams. p-v-T surface. Use of Steam Table and Mollier Chart. Determination of dryness fraction. Application of I and II law for pure substances. Ideal and actual Rankine cycles, Cycle Improvement Methods - Reheat and Regenerative cycles, Economizer, preheater, Binary and Combined cycles.

PART-A

1. What do you understand by pure substance? (Nov/Dec 2013)

A pure substance is defined as one that is homogeneous and invariable in chemical compositionthroughout its mass.

2. Draw a p-T diagram for a pure substance? (May/June 2014)



3. Is iced water a pure substance? Why?(Nov/Dec 2016)

Yes iced water is a pure substance.

Explanation:
Both ice and liquid water are the same substance. H2O Though ice water is a mixture of both solid and liquid it is a pure substance, based on the molecular structure of its components.

4. Distinguish between flow process and non-flow process. (Nov/Dec 2012)

Flow process : It is one in which fluid enters the system and leaves it after work interaction, which means that such processes occur in the systems having open boundary permitting mass interaction across the system boundary.
Non flow process: It is the one in which there is no mass interaction across the system boundaries during the occurrence of process.

5. Why Rankine cycle is modified?

The work obtained at the end of the expansion is very less. The work is too inadequate to overcomethe friction.

Therefore the adiabatic expansion is terminated at the point before the end of theexpansion in the turbine and pressure decreases suddenly, while the volume remains constant.

6. Why Rankine cycle is modified?

The work obtained at the end of the expansion is very less. The work is too inadequate to overcomethe friction. Therefore the adiabatic expansion is terminated at the point before the end of theexpansion in the turbine and pressure decreases suddenly, while the volume remains constant.

7. Define efficiency ratio.

The ratio of actual cycle efficiency to that of the ideal cycle efficiency is termed as efficiency ratio.

8. Define overall efficiency.

It is the ratio of the mechanical work to the energy supplied in the fuel. It is also defined as the productof combustion efficiency and the cycle efficiency.

9. Define specific steam consumption of an ideal Rankine cycle.

It is defined as the mass flow of steam required per unit power output.

10. Name the different components in steam power plant working on Rankine cycle.

Boiler, Turbine, Cooling Tower or Condenser and Pump.

11. What are the effects of condenser pressure on the Rankine Cycle?

By lowering the condenser pressure, we can increase the cycle efficiency. The main disadvantage islowering the back pressure in release the wetness of steam. Isentropic compression of a very wetvapour is very difficult.

12. Mention the improvements made to increase the ideal efficiency of Rankine cycle. (Nov/Dec 2014) (May/June 2014)

1. Lowering the condenser pressure.
2. Superheated steam is supplied to the turbine.
3. Increasing the boiler pressure to certain limit.
4. Implementing reheat and regeneration in the cycle.

13. What is the effect of reheat on (a) the network output, (b) the cycle efficiency and (c) steam rate of a steam power plant? (Nov/Dec 2016)

(a) The network output - increase
(b) The cycle efficiency - increase
(c) Steam rate of a steam power plant – decrease

14. Why reheat cycle is not used for low boiler pressure?

At the low reheat pressure the heat cycle efficiency may be less than the Rankine cycle efficiency.Since the average temperature during heating will then be low.

15. What are the disadvantages of reheating?

Reheating increases the condenser capacity due to increased dryness fraction, increases the cost of theplant due to the reheats and its very long connections.

16. What are the advantages of reheat cycle?

1. It increases the turbine work.
2. It increases the heat supply.
3. It increases the efficiency of the plant.
4. It reduces the wear on the blade because of low moisture content in LP state of the turbine.

17. Define latent heat of evaporation or Enthalpy of evaporation.

The amount of heat added during heating of water up to dry steam from boiling point is known asLatent heat of evaporation or enthalpy of evaporation.

18. Explain the term super-heated steam and super heating.

The dry steam is further heated its temperature raises, this process is called as superheating and thesteam obtained is known as superheated steam.

19. Explain heat of super heat or super heat enthalpy.

The heat added to dry steam at 100oC to convert it into super-heated steam at the temperature Tsup iscalled as heat of superheat or super heat enthalpy.

20. Explain the term critical point, critical temperature and critical pressure.

In the T-S diagram the region left of the waterline, the water exists as liquid. In right of the dry steamline, the water exists as a super-heated steam. In between water and dry steam line the water exists as awet steam. At a particular point, the water is directly converted into dry steam without formation ofwet steam. The point is called critical point. The critical temperature is the temperature above which asubstance cannot exist as a liquid; the critical temperature of water is $374.15^{o}C$. The correspondingpressure is called critical pressure.

21. Define dryness fraction (or) what is the quality of steam?

It is defined as the ratio of mass of the dry steam to the mass of the total steam.

22. Define enthalpy of steam.

It is the sum of heat added to water from freezing point to saturation temperature and the heat absorbed during evaporation.

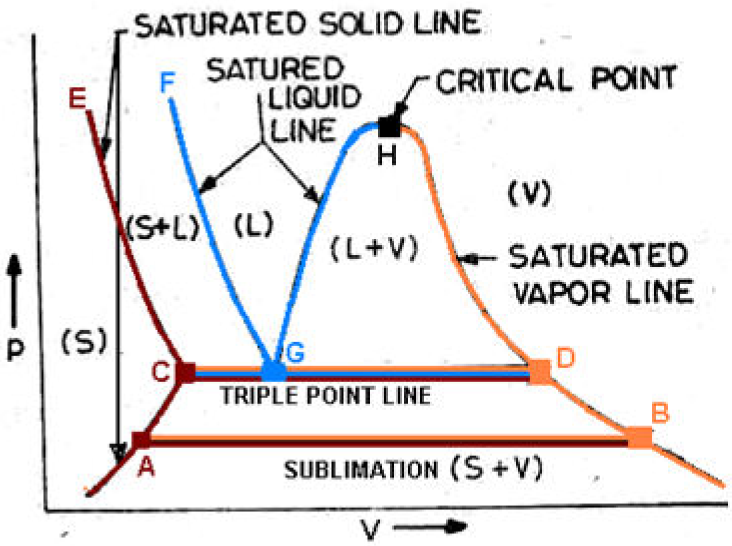
23. How do you determine the state of steam?

If V>vg then super-heated steam, V= vg then dry steam and V< vg then wet steam.

24. Define triple point.

The triple point is merely the point of intersection of sublimation and vaporization curves.

25. How is Triple point represented in the p-V diagram? (Nov/Dec 2013)



26. Define heat of vaporization.

The amount of heat required to convert the liquid water completely into vapour under this condition iscalled the heat of vaporization.

27. Explain the terms, Degree of super heat, degree of sub-cooling.

The difference between the temperature of the superheated vapour and the saturation temperature atthe same pressure. The temperature between the saturation temperature and the temperature in the subcooled region of liquid.

28. When is reheat recommended in a steam power plant? (Nov/Dec 2015)

The purpose of reheating is to increase the dryness fraction of the steam passing out of the later stages of the turbine.

29. What are the processes that constitute a Rankine cycle?

Process 1–2: Isentropic expansion of the working fluid through the turbine from saturated vapor atstate 1 to the condenser pressure.

Process 2–3: Heat transfer from the working fluid as it flows at constant pressure through thecondenser with saturated liquid at state 3.

Process 3–4: Isentropic compression in the pump to state 4 in the compressed liquid region.

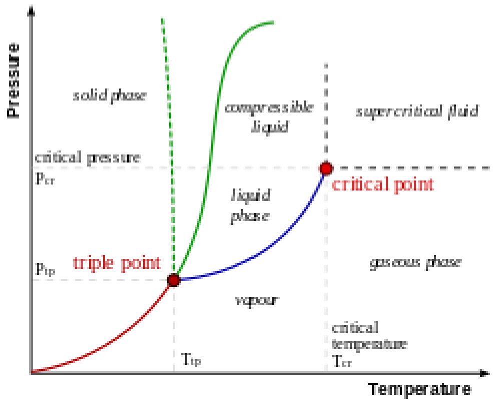
Process 4–1: Heat transfer to the working fluid as it flows at constant pressure through the boiler tocomplete the cycle.

30. State the advantages of using superheated steam in turbines. (Nov/Dec 2014)

Superheated steam is a steam at a temperature higher than its vaporization (boiling) point at the absolute pressure where the temperature is measured.

The steam can therefore cool (lose internal energy) by some amount, resulting in a lowering of its temperature without changing state (i.e., condensing) from a gas, to a mixture of saturated vapor and liquid.

31. Draw the p-T diagram for water and label all salient points. (Nov/Dec 2014)



PART-B& PART-C

1. Explain steam formation with relevant sketch and label all salient points and explain every point in detail. **(Nov/Dec 2014)**

Refer: "P.K NAG Engineering Thermodynamics for the description"

2. (a) Define specific steam consumption, specific heat rate and work ratio. **(Nov/Dec 2012)**
(b) A vessel of volume 0.04 m^3 contains a mixture of saturated water and saturated steam at a temperature of 250°C. The mass of the liquid present is 9 kg. Find the pressure, the mass, the specific volume, the enthalpy, and entropy, and the internal energy of the mixture. **(Apr/May 2015)**

Refer: "P.K NAG Engineering Thermodynamics for description"

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

3. Steam at a pressure of 15 bar and 250°C expands according to the law $PV^{1.25}=C$ to a pressure of 1.5 bar. Evaluate the final conditions, work done, heat transfer and change in entropy. The mass of the system is 0.8 kg. **(Nov /Dec 2008)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

4. A steam power plant operates on a theoretical reheat cycle. Steam at boiler at 150 bar, 550°C expands through the high pressure turbine. It is reheated at a constant pressure of 40 bar to 550°C and expands through the low pressure turbine to a condenser at 0.1 bar. Draw T-s and h-s diagrams. Find (i) Quality of steam at turbine exhaust (ii) Cycle efficiency (iii) Steam rate in kg/kWh. **(May/June 2014)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

5. Consider a steam power plant operating on the Ideal Rankine cycle. Steam enters the turbine at 3 MPa and 623 K and is condensed in the condenser at a pressure of 10 kPa. Determine (i) the thermal efficiency of this power plant (ii) the thermal efficiency, if steam is super-heated to 873 K instead of 623 K, and (iii) the thermal efficiency, if the boiler pressure is raised to 15 MPa while the turbine inlet temperature is maintained at 873 K. **(Nov/Dec 2009)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

6. In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. The flow rate of steam is 0.2 kg/s. Determine (i) the pimp work (ii) the turbine work (iii) Rankine efficiency (iv) Condenser heat flow (v) work ratio and (vi) specific steam consumption. **(Nov/Dec 2011)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

7. A steam power plant operates on an ideal regenerative Rankine cycle, Steam enters the turbine at 6 MPa and 450°C and is condensed in the condenser at 20 kPa. Steam is extracted from the turbine at 0.4 MPa to heat the feed water in an open feed water heater. Water leaves the feed water heater. Water leaves the feed water heater as a saturated liquid. Show the cycle on a T-s diagram, and determine (i) The network output per kilogram of steam flowing through the boiler and (ii) the thermal efficiency of the cycle. **(Nov/Dec 2016)**

Refer: "P.K NAG Engineering Thermodynamics for similar problems"

UNIT IV IDEAL AND REAL GASES, THERMODYNAMIC RELATIONS

Properties of Ideal gas- Ideal and real gas comparison- Equations of state for ideal and real gases-Reduced properties-.Compressibility factor-.Principle of Corresponding states. -Generalised Compressibility Chart and its use-. Maxwell relations, Tds Equations, Difference and ratio of heat capacities, Energy equation, Joule-Thomson Coefficient, Clausius Clapeyron equation, Phase Change Processes. Simple Calculations.

PART-A

1. Define Ideal gas.

It is defined as a gas having no forces of intermolecular attraction. These gases will follow the gaslaws at all ranges of pressures and temperatures.

2. What are the properties of ideal gas? (Nov/Dec 2014)

1. An ideal gas consists of a large number of identical molecules.
2. The volume occupied by the molecules themselves is negligible compared to the volume occupied by the gas.
3. The molecules obey Newton's laws of motion, and they move in random motion.

. The molecules experience forces only during collisions; any collisions are completely elastic, and take a negligible amount of time.

3. Define Real gas. (Nov/Dec 2013)

It is defined, as a gas having the forces of attraction between molecules tends to be very small atreduced pressures and elevated temperatures.

4. What is equation of state? (Nov/Dec 2012)

The relation between the independent properties such as pressure, specific volume and temperature fora pure substance is known as the equation of state.

5. State the Vander Waal's equation of state. (Nov/Dec 2014)

The van der Waals equation (or van der Waals equation of state) is an equation relating the density of gases and liquids (fluids) to the pressure (*p*), volume (*V*), and temperature (*T*) conditions (*i.e.*, it is a thermodynamic equation of state).

6. State Boyle's law.

It states that volume of a given mass of a perfect gas varies inversely as the absolute pressure whentemperature is constant.

7. State Charle's law.

It states that if any gas is heated at constant pressure, its volume changes directly as its absolutetemperature.

8. Explain the construction and give the use of generalized compressibility chart.

The general compressibility chart is plotted with Z versus Pr for various values of Tr. This isconstructed by plotting the known data of one of mole gases and can be used for any gas. This chartgives best results for the regions well removed from the critical state for all gases.

9. What do you mean by reduced properties? (Nov/Dec 2016)

The ratios of pressure, temperature and specific volume of a real gas to the corresponding criticalvalues are called the reduced properties.

10. Explain law of corresponding states.

If any two gases have equal values of reduced pressure and reduced temperature, then they have samevalues of reduced volume.

11. Explain Dalton's law of partial pressure.

The pressure of a mixture of gases is equal to the sum of the partial pressures of the constituents. Thepartial

pressure of each constituent is that pressure which the gas would expect if it occupied alone thatvolume occupied by the mixtures at the same temperatures. m = mA+mB+mC+……. = mi
mi = mass of the constituent.
P=PA+PB+PC+……. = Pi, Pi – the partial pressure of a constituent.

12. State Avogadro's Law.

The number of moles of any gas is proportional to the volume of gas at a given pressure andtemperature.

13. What is compressibility factor?

The gas equation for an ideal gas is given by (PV/RT) = 1, for real gas (PV/RT) is not equal to 1
(PV/RT) = Z for real gas is called the compressibility factor.

14. What is partial pressure?

The partial pressure of each constituent is that pressure which the gas would exert if it occupied alonethat volume occupied by the mixtures at the same temperature.

15. Define Dalton's law of partial pressure.

The total pressure exerted in a closed vessel containing a number of gases is equal to the sum of thepressures of each gas and the volume of each gas equal to the volume of the vessel.

16. How does the Vander Waal's equation differ from the ideal gas equation of state?

The ideal gas equation pV=mRT has two important assumptions,
1. There is little or no attraction between the molecules of the gas.
2. That the volume occupied by the molecules themselves is negligibly small compared to the volumeof the gas.
This equation holds good for low pressure and high temperature ranges as the
Intermolecular attraction and the volume of the molecules are not of much significance.
As the pressure increases, the inter molecular forces of attraction and repulsion increases and the
volume of the molecules are not negligible. The real gas deviates considerably from the ideal gas
equation [p+(a/V2)](V-b) = RT

17. Explain Joule-Kelvin effect. What is inversion temperature?(April/May 2015)

When a gas (not ideal gas) is throttled, the temperature increases up to a point and then decreases. Thisis known as Joule Kelvin effect. The temperature at which the slope of a throttling curve in T-pdiagram is zero is inversion temperature.

18. What is the law of corresponding states? (April/May 2015)

According to Vander Waals, the theorem of corresponding states (or principle of corresponding states) indicates that all fluids, when compared at the same reduced temperature and reduced pressure, have approximately the same compressibility factor and all deviate from ideal gas behaviour to about the same degree.

19. In what way the Clausius Clapeyron equations is useful? (Nov/Dec 2012)

- Apply the Clausius-Clapeyron equation to estimate the vapor pressure at any temperature.
- Estimate the heat of phase transition from the vapor pressures measured at two temperatures.

20. What are the assumptions made to derive ideal gas equation analytically using the kinetic theory of gases? (May/June 2014)

The assumptions are:

- Gases are made up of molecules which are in constant motion in straight lines.
- The molecules behave as rigid spheres.

- Pressure is due to collisions between the molecules and the walls of the container.
- All collisions, both between the molecules themselves, and between the molecules and the walls of the container, are perfectly elastic.
- The temperature of the gas is proportional to the average kinetic energy of the molecules.

21. Write down the two Tds equations. **(Nov/Dec 2016)**

$$TdS = C_V dT + T\left(\frac{\partial p}{\partial T}\right)_V dV \quad \text{(first } TdS \text{ equation)}$$

$$TdS = C_P dT - T\left(\frac{\partial V}{\partial T}\right)_P dP \quad \text{(second } TdS \text{ equation)}$$

22. What is Clausius Clapeyron Equation?

Clapeyron equation which involves in the relationship between the saturation pressure, saturation temperature, the enthalpy of evaporation and the specific volume of the two phases involved.

$$\frac{d_p}{d_T} = \frac{h_{fg}}{Tv_{fg}}$$

23. State Helmholtz function.

Helmholtz function is property of system and it is given by subtracting the product of absolute temperature (T) and entropy (s) from the internal energy u.

i.e. Helmholtz function = u-Ts

24. State Gibbs Function.

Gibbs function is property of system and is given by

G = u – Ts + pv = h – Ts {since h=u+pv}

Where h = enthalpy

T = Temperature

S = Entropy

25. Have you ever encountered any ideal gas? If so, where?(Apr/May 2008)

No. In actual practice, there is no ideal gas which strictly follows the gas laws over the entire range of temperature and pressure. However, hydrogen, oxygen, nitrogen and air behave as an ideal gas under certain temperature and pressure limits.

26. What are Maxwell relations? (Nov/Dec 2006, Nov/Dec 2008)

$$\left(\frac{\partial T}{\partial v}\right)_s = -\left(\frac{\partial p}{\partial s}\right)_v$$

$$\left(\frac{\partial T}{\partial p}\right)_s = \left(\frac{\partial v}{\partial s}\right)_p$$

$$\left(\frac{\partial p}{\partial T}\right)_v = \left(\frac{\partial s}{\partial v}\right)_T \text{ and } \left(\frac{\partial v}{\partial T}\right)_p = -\left(\frac{\partial s}{\partial p}\right)_T$$

These are known as Maxwell relations. These equations are derived by using first law of thermodynamics, Helmholtz function(a=u-Ts) and Gibbs function (G=h-Ts)

27. What is meant by equation of state? Write the same for an ideal gas. (Nov/Dec 2007, 2011 & 2012)

The relationship which exists for the state variables of the system in equilibrium is called equation of state.

The equation of state for ideal is given by pV=mRT

Where p – Pressure of gas, V – Volume of gas, m- Mass of gas, R – Gas constant, T – Temperature.

28. Determine the molecular volume of any perfect gas at 600 N/m^2 and 30^{0}C. Universal gas constant may be taken as 8314 kJ/kg mole-k.

Given:

P = 600 N/m^2

T = 30^{0}C = 303 K

R = 8314 kJ/kg mole-k

Solution:

Ideal Gas equation, pV=mRT

V=mRT/p=1 x 8314 x 303/600= 4198 m^3/kg-mole.

29. State Charle's law.

Charle's law states that "the volume of a given mass of a gas varies directly as its absolute temperature, when the pressure remains constant". $v \; \alpha \; T$

30. State Regnault's law.

Regnault's law states that specific heats of a gas always remains constant.

PART-B& PART-C

1. **(i)** What is joule – Thomson co-efficient? Why is it zero for an ideal gas?

(ii) Derive an expression for Clausius Clapeyron equation applicable to fusion and vaporization. **(Nov/Dec 2016)**

Refer: "P.K NAG Engineering Thermodynamics for the derivation"

2. Derive the Maxwell relations and explain their importance in thermodynamics. **(May/June 2014)**

Refer: "P.K NAG Engineering Thermodynamics for the derivation"

3. (i) Derive the Clausius – Clapeyron equation and discuss its significance.

(ii) Draw a neat sketch of a compressibility chart and indicate its salient features. **(Nov/Dec 2013)**

Refer: "P.K NAG Engineering Thermodynamics for the derivation"

4. (a) From the basic principles, prove the following $C_p - C_v = -T\left(\frac{\partial v}{\partial T}\right)^2_p\left(\frac{\partial P}{\partial v}\right)_T$ **(May/June 2013)**

(b) Derive the TdS equation taking T and C as independent variables. **(Nov/Dec 2012)**

Refer: "P.K NAG Engineering Thermodynamics for the derivation"

5. (a) Explain the physical significance of the compressibility factor Z. **(Nov/Dec 2012)**

(b) Derive the Joule – Thomson co-efficient equation and draw the inversion curve.**(Nov/Dec 2014)**

Refer: "P.K NAG Engineering Thermodynamics for the description and derivation"

6. Determine the pressure of nitrogen gas at T=175 K and v=0.00375 m^3/kg on the basis of

(i) The ideal-gas equation of state

(ii) the Vander Waals equation of state. The vanderwaals constants for nitrogen are a=0.175 m^{6}kPa/kg^2, b=0.00138 m^3/kg. **(April/May 2015)**

Refer: "P.K NAG Engineering Thermodynamics for the similar problem"

7. (i) State the conditions under which the equation of state will hold good for gas.

(ii) State the main reasons for the deviation of behavior of real gases from ideal gases.

(iii)Explain irreversibility with respect to flow and non-flow process.
(iv) Explain the effectiveness of a system. **(Nov/Dec 2014)**

Refer: Refer: "P.K NAG Engineering Thermodynamics for the description"

8. **(i)** One kg of CO_2 has a volume of 1 m^3 at 100^0C. Compute the pressure by (1) Van der Waals' equation (2) Perfect gas equation. The Van der Waals' constants a=362850 $Nm^4/(kg\text{-}mol)^2$ and b=0.0423 $m^3/(kg\text{-}mol)$.
(ii) Write the Berthelot and Dieterici equations of state. **(Nov/Dec 2016)**

Refer: "P.K NAG Engineering Thermodynamics for the problem"

UNIT V GAS MIXTURES AND PSYCHROMETRY

Mole and Mass fraction, Dalton's and Amaga's Law. Properties of gas mixture – Molar mass, gas constant, density, and change in internal energy, enthalpy, entropy and Gibbs function. Psychrometric properties, Psychrometric charts. Property calculations of air vapour mixtures by using chart and expressions. Psychrometric process – adiabatic saturation, sensible heating and cooling, humidification, dehumidification, evaporative cooling and adiabatic mixing. Simple Applications

PART-A

1. What is humidification and dehumidification?

The addition of water vapour into air is humidification and the removal of watervapour from air is dehumidification.

2. Differentiate absolute humidity and relative humidity.

Absolute humidity is the mass of water vapour present in one kg of dry air.
Relative humidity is the ratio of the actual mass of water vapour present in one kg of dry air at thegiven temperature to the maximum mass of water vapour it can withhold at the same temperature.Absolute humidity is expressed in terms of kg/kg of dry air. Relative humidity is expressed in terms ofpercentage.

3. What is effective temperature?

The effective temperature is a measure of feeling warmth or cold to the human body in response to theair temperature, moisture content and air motion. If the air at different DBT and RH condition carriesthe same amount of heat as the heat carried by the air at temperature T and 100% RH, then thetemperature T is known as effective temperature.

4. Define Relative humidity.

It is defined as the ratio of partial pressure of water vapour (pw) in a mixture to the saturation pressure(ps) of pure water at the same temperature of mixture.

5. Define specific humidity.

It is defined as the ratio of the mass of water vapour (ms) in a given volume to the mass of dry air in agiven volume (ma).

6. Define degree of saturation. (Nov/Dec 2013)

It is the ratio of the actual specific humidity and the saturated specific humidity at the sametemperature of the mixture.

7. What is dew point temperature? (Nov/Dec 2015)(Nov/Dec 2016)

The temperature at which the vapour starts condensing is called dew point temperature. It is also equalto the saturation temperature at the partial pressure of water vapour in the mixture. The dew pointtemperature is an indication of specific humidity.

8. What is meant by dry bulb temperature (DBT)?

The temperature recorded by the thermometer with a dry bulb. The dry bulb thermometer cannot affectby the moisture present in the air. It is the measure of sensible heat of the air.

9. What is meant by wet bulb temperature (WBT)?

It is the temperature recorded by a thermometer whose bulb is covered with cotton wick (wet)saturated with water. The wet bulb temperature may be the measure of enthalpy of air. WBT is thelowest temperature recorded by moistened bulb.

10. Define dew point depression.

It is the difference between dry bulb temperature and dew point temperature of air vapour mixture.

11. What is meant by adiabatic saturation temperature (or) thermodynamic wet bulb?Temperature? (May/June 2014)

It is the temperature at which the outlet air can be brought into saturation state by passing through thewater in the long insulated duct (adiabatic) by the evaporation of water due to latent heat ofvaporization.

12. What is psychrometer? (Nov/Dec 2014)

Psychrometer is an instrument which measures both dry bulb temperature and wet bulb temperature.

13. What is Psychrometric chart?

It is the graphical plot with specific humidity and partial pressure of water vapour in y axis and drybulb temperature along x axis. The specific volume of mixture, wet bulb temperature, relativehumidity and enthalpy are the properties appeared in the Psychrometric chart.

14. Define sensible heat and latent heat. (April/May 2015)

Sensible heat is the heat that changes the temperature of the substance when added to it or whenabstracted from it. Latent heat is the heat that does not affect the temperature but change of stateoccurred by adding the heat or by abstracting the heat.

15. What are the important Psychrometric processes?

1. Sensible heating and sensible cooling,
2. Cooling and dehumidification,
3. Heating and humidification,
4. Mixing of air streams,
5. Chemical dehumidification,
6. Adiabatic evaporative cooling.

16. What is meant by adiabatic mixing?

The process of mixing two or more stream of air without any heat transfer to the surrounding is knownas adiabatic mixing. It is happened in air conditioning system.

17. What are the assumptions made in Vander Waal's equation of state?

1. There is no inter molecular forces between particles.
2. The volume of molecules is negligible in comparison with the gas.

18. Define coefficient of volume expansion.

The coefficient of volume expansion is defined as the change in volume with the change intemperature per unit volume.

19. State Helmholtz function.

Helmholtz function is the property of a system and is given by subtracting the product of absolutetemperature (T) and entropy (S) from the internal energy (U).

Helmholtz function = U – TS

20. What are thermodynamic properties?

Thermodynamic properties are pressure (p), temperature (T), volume (V), internal energy (U),
Enthalpy(H), entropy (S), Helmholtz function and Gibbs function.

21. Define throttling process.

When a fluid expands through a minute orifice or slightly opened valve, the process is called asthrottling process. During this process, pressure and velocity are reduced.

22. Define Molecular mass.

Molecular mass is defined as the ratio between total mass of the mixture to the total number of molesavailable in the mixture.

23. Define isothermal compressibility.

Isothermal compressibility is defined as the change in volume with change in pressure per unit volumekeeping the temperature constant.

24. Define psychrometry.

The science which deals with the study of behavior of moist air (mixture of dry air and water vapour)is known as Psychrometry.

25. What is by-pass factor? (May/June 2014)

The ratio of the amount of air which does not contact the cooling coil (amount of bypassing air) to the amount of supply air is called BPF.

26. **Define Apparatus Dew Point (ADP) of cooling coil?**

For dehumidification, the cooling coil is to be kept at a mean temperature which is below the dew point temperature (DPT) of the entering. This temperature of the coil is called ADP Temperature.

27. **Explain the following terms: (a) Mole fraction (b) Mass fraction.**

(a) Mole fraction:

It is the ratio of the mole number of a component to the mole number of the mixture. The total number of moles of mixture is the sum of its components.

$N_m=N_1+N_2+N_3+\ldots\ldots N_i=\sum_{i=1}^{k} N_i$

(b) Mass fraction

If a gas mixture consists of gases 1,2,3 and so, on, the mass of the mixture is the sum of the masses of the component gases

$M_m=m_1+m_2+m_3+\ldots\ldots. m_i=\sum_{i=1}^{k} m_i$

28. **What is compressibility factor? What does it signify? What is its value for Vander Waals at critical point?**

We know that perfect equation is Pv = RT. But for real gas, a correction factor had to be introduced in the perfect gas equation to take into account the deviation of real gas from the perfect gas equation. This factor is known as compressibility factor (Z) and is defined by

$$Z = \frac{pv}{RT}$$

It signifies (i) Intermolecular attractive study is made. (ii) Shape factor is considered.

At critical point, the Vander Waals equation

$$\frac{pv}{RT} = 1 \; for\ ideal\ gases.$$

29. **State Dalton's law of partial pressure.(Nov/Dec 2016)**

Dalton's law of partial pressure states that "the pressure of a gas mixture is equal to the sum of pressures of its each components if each component is exerted alone of the temperature and volume of the mixture".

30. **What is the significance of compressibility factor?**

The gases deviate from ideal gas behavior significantly at high pressures and low temperatures. This deviation from ideal gas behavior at a given temperature and pressure can be determined by the introduction of a correction factor called the compressibility factor, defined as

$$Z = \frac{Pv}{RT}$$

PART-B& PART-C

1. An air-water vapour mixture enters an air-conditioning unit at a pressure of 1.0 bar, 38^{O}C DBT, and a relative humidity of 75%. The mass of dry air entering is 1 kg/s. The air-vapour mixture leaves the air-conditioning unit at 1.0 bar, 18^{O}C, 85% relative humidity. The moisture condensed leaves at 18^{O}C. Determine the heat transfer rate for the process. (May/June 2014)

Refer: "P.K NAG Engineering Thermodynamics for similar problem"

2. (a) One kg of air at $40^{O}C$ dry bulb temperature and 50% relative humidity is mixed with 2 kg of air at $20^{O}C$ dry bulb temperature and $20^{O}C$ dew point temperature. Calculate the temperature and specific humidity of the mixture.

(b) With the aid of model psychrometric chart explain the following processes.(i) Adiabatic mixing (ii) Evaporative cooling. (May /June 2013)

Refer: "P.K NAG Engineering Thermodynamics for similar problem"

3. **Atmospheric air at 1.0132 bar has $20^{0}C$ DBT and 65% RH. Find the humidity ratio, wet bulb temperature, dew point temperature, degree of saturation, enthalpy of the mixture, density of air and density of vapour in the mixture. (Nov/Dec 2012)**

Refer: "P.K NAG Engineering Thermodynamics for similar problem"

4. It is required to design an air-conditioning plant for a small office room for following winter conditions:

Outdoor conditions…..$14^{0}C$ DBT and $10^{0}C$ WBT
Required conditions……$20^{0}C$ DBT and 60% RH
Amount of air circulation…0.30 m^3/min/person.
Seating capacity of office….60.

The required condition is achieved first by heating and then by adiabatic humidifying. Determine the following:

(i) Heating capacity of the coil in kW and the surface temperature required if the by pass factor of coil is 0.4.

(ii) The capacity of the humidifier. (Nov/Dec 2016)

Refer: "P.K NAG Engineering Thermodynamics for similar problem"

5. A perfect gas mixture consists of 4 kg of N_2 and 6 kg of CO_2 at a pressure of 4 bar and a temperature of $25^{0}C$. For N_2; C_v=0.745 kJ/kg K and C_p=1.041 kJ/kg K. For CO_2; C_v=0.653 kJ/kg K and C_p=0.842 kJ/kg. Find C_p, C_v and R of the mixture. If the mixture is heated at constant volume to $50^{0}C$, find the changes in internal energy, enthalpy and entropy of the mixture. (Nov/Dec 2011)

Refer: "P.K NAG Engineering Thermodynamics for similar problem"

6. An insulated rigid tank is divided into two compartments by a partition. One compartment contains 7kg of oxygen gas at $40^{O}C$ and 100 kPa and the other compartment contains 4kg of nitrogen gas at $20^{O}C$ and 150kPa. C_V, N_2=0.743 kJ/kgK and C_V, O_2=0.658 kJ/kgK. If the partition is removed and the two gases are allowed to mix, determine (i) The mixture temperature (ii) The mixture pressure after equilibrium has been established. (Nov/Dec 2012)

Refer: "P.K NAG Engineering Thermodynamics for similar problem"

7. A mixture of hydrogen (H_2) and Oxygen (O_2) is to be made so that the ratio of H_2 to O_2 is 2:1 by volume. If the pressure and temperature are 1 bar and $25^{0}C$ respectively, Calculate: (i) The mass of O_2 required (ii) The volume of the container. (Nov/Dec 2014)

Refer: "P.K NAG Engineering Thermodynamics for similar problem"

8. A rigid tank that contains 2kg of N_2 at $25^{0}C$ and 550 kPa is connected to another rigid tank that contains 4kg of O_2 at $25^{0}C$ and 150 kPa. The valve connecting the two tanks is opened, and the two gases are allowed to mix. If the final mixture temperature is $25^{0}C$, determine the volume of each tank and the final mixture pressure. (Nov/Dec 2016)

Refer: "P.K NAG Engineering Thermodynamics for similar problem"