**Question Bank**

**Thermodynamics (ESC209)**

**Unit-1: Basic Concepts**

**Unit-2: First law of thermodynamics**

1. Explain the difference between (a) macroscopic approach and microscopic approach (b) intensive properties and extensive properties and (c) work transfer and heat transfer.
2. For a system to be in thermodynamic equilibrium, do the temperature and the pressure have to be the same everywhere?
3. What is a quasi-equilibrium process? What is its importance in engineering?
4. What is the state postulate?
5. What is the concept of continuum?
6. What is a steady-flow process?
7. What is the zeroth law of thermodynamics? What are the ordinary and absolute temperature scales in the SI and the English system?
8. A spherical balloon of 1m diameter contains a gas at 200 kPa and 300 K. The gas inside balloon is heated until the pressure reaches 500 kPa. During the process of heating the pressure is proportional to the diameter of balloon. Determine the work done by the gas inside the balloon.
9. A closed cylinder of 0.25 m diameter is fitted with a light frictionless piston. The piston is retained in position by a catch in the cylinder wall and the volume on one side of the piston contains air at a pressure of 750 kN/m2. The volume on the other side of the piston is evacuated. A helical spring is mounted coaxially with the cylinder in this evacuated space to give a force of 120 N on the piston in this position. The catch is released and the piston travels along the cylinder until it comes to rest after a stroke of 1.2 m. The piston is then held in its position of maximum travel by a ratchet mechanism. The spring force increases linearly with the piston displacement to a final value of 5 kN. Calculate the work done by the compressed air on the piston.
10. A cylinder closed at both ends is thermally insulated from the surrounding. It contains a movable, thermally insulated, frictionless and leak proof piston. Initially the pressure, volume ant temperature on each side of the piston are, and. The number of moles of gas on each side is n. Heat is now slowly supplied to the gas on the left side of the piston by an electric heating coil. As a result the gas on the left hand side expands and displaces the piston, compressing the gas on the right hand side until its pressure reaches (27/8). If the ratio of specific heats is 1.5 and the molecular weight of the gas is M. Determine, in terms of n, M and

(i) the work done on the gas on the right hand side,

(ii) the final temperature of the gas on the right hand side,

(iii) the final temperature of the gas on the left hand side and

(iv) the heat supplied to the gas on the left hand side.

All assumption made must be clearly stated.

1. An ideal gas is heated at constant volume until its temperature is 3 times the original temperature, then it is expanded isothermally till it reaches its original pressure. The gas is then cooled at constant pressure till it is restored to the original state. Determine the heat transfer and change in internal energy with each process and the net work done per kg of gas if the initial temperature is 350 K. Also, represent the cycle on P-v plane.
2. What are the different mechanisms for transferring energy to or from a control volume?
3. What is flow energy? Do fluids at rest possess any flow energy?
4. How do the energies of a flowing fluid and a fluid at rest compare? Name the specific forms of energy associated with each case.
5. Write the first law of thermodynamics for steady flow process of a gas. Apply this law to the throttling process and show that the enthalpy of the fluid remains constant.
6. A compressor takes in 500 kg/min of air at 0.98 bar and 291 K and deliver it at 5.5 bar and 341 K. The diameters of inlet and delivery pipes are respectively 450 mm and 200 mm. The power input is 1000 kW. Determine the rate and direction of heat flow.
7. An evacuated bottle ofvolume is slowly filled from atmospheric air at 1.0135 bars until the pressure inside the bottle also becomes 1.0135 bar. Due to heat transfer, the temperature of air inside the bottle after filling is equal to the atmospheric air temperature. Determine the amount of heat transfer.
8. A tank contains 50 kg of water at the rate of 200 kg/h and temperature of enters the tank through an inlet pipe. A cooling coil immersed in the tank removes heat energy from water at the rate of 8 kW. Mechanical stirrer ensures through mixing of water in the tank so as to maintain a uniform temperature of water at any instant and in the process add heat energy at the rate of 0.2 kW to water. Neglecting kinetic and potential energy changes and taking average specific heat of water as 4.2 kJ/kg-K, derive an expression for the variation of instantaneous temperature of water in the tank with respect to time.
9. A 2-m3 rigid tank initially contains air at 100 kPa and 22°C. The tank is connected to a supply line through a valve. Air is flowing in the supply line at 600 kPa and 22°C. The valve is opened, and air is allowed to enter the tank until the pressure in the tank reaches the line pressure, at which point the valve is closed. A thermometer placed in the tank indicates that the air temperature at the final state is 77°C. Determine (*a*) the mass of air that has entered the tank and (*b*) the amount of heat transfer.
10. How does energy conversion affect the environment? What are the primary chemicals that pollute the air? What is the primary source of these pollutants?
11. What is smog? What does it consist of? How does ground-level ozone form? What are the adverse effects of ozone on human health?
12. What is acid rain? Why is it called a “rain”? How do the acids form in the atmosphere? What are the adverse effects of acid rain on the environment?
13. What is the greenhouse effect? How does the excess CO2 gas in the atmosphere cause the greenhouse effect? What are the potential long-term consequences of greenhouse effect? How can we combat this problem?
14. Why is carbon monoxide a dangerous air pollutant? How does it affect human health at low and at high levels?

**Unit-3: Second law of thermodynamics**

1. State Kelvin-Planck’s and Clausius’ statements of the second law of thermodynamics and show that the violation of Clausius statement violates Planck’s statement.
2. What is the difference between a refrigerator and a heat pump? Derive an expression for the performance factor for both, if they are running on reversed Carnot cycle and show that COP of heat pump is greater than COP of refrigerator by unity.
3. Show that no heat engine working between two fixed temperatures can have efficiency greater than that of a reversible engine working between the same temperature limits.
4. A reversible heat engine operates between 873 K and 313 K and derives a reversible refrigerator operating between 313 K and 255 K. Still there is a net output of work equal to 370 kJ, while the heat received by the engine is 2100 kJ. Determine the cooling effect.
5. 0.5 kg of air (ideal gas) executes a Carnot power cycle having a thermal efficiency of 50 percent. The heat transfer to the air during the isothermal expansion is 40 kJ. At the beginning of the isothermal expansion the pressure is 7 bar and the volume is. Determine the maximum and minimum temperatures for the cycle, in K, the volume at the end of isothermal expansion, in, and the work and heat transfer for each of the four processes, in kJ.
6. Show that the cyclic integral of  for a reversible cycle is equal to zero.
7. State the Clausius inequality in words. An inventor claims that he has developed a heat engine which absorbs 1200 kJ and 800 kJ from reservoirs at 800 K and 600 K respectively and rejects 600 kJ and 200 kJ as heat to reservoir at 400 K and 300 K respectively. It delivers 1200 kJ work. Determine whether the heat engine is theoretically possible.
8. A certain mass of air is initially at and and occupies. The air is expanded at constant pressure to. A polytropic process with is then carried out, followed by a constant temperature process which completes the cycle. All the processes are reversible processes.

(i) Sketch the cycle on P-v and T-s plane and

(ii) Find the efficiency of the cycle.

1. During some integral number of complete cycles a reversible heat engine absorbs 2800 kJ from a heat reservoir at 1000 K and performs 800 kJ of mechanical work. The engine exchanges heat with two other heat reservoirs one of which is 5400 K and the other at 600 K. Determine the heat exchanged (whether absorbed or rejected) with these two reservoir, the change in entropy of each of the three reservoirs and the change in the entropy of the universe. Draw a neat sketch of the system.
2. What is entropy hill? Explain with diagram.
3. A reversible cycle using an ideal gas as the working substance consists of a isentropic compression from an initial temperature 555 K, a constant volume process from 555 K to 835 K, a reversible adiabatic expansion to 555 K, a constant pressure expansion from 555 K to 835 K followed by a constant volume process to the initial temperature. Draw the cycle on P-v and T-s diagrams and determine the initial temperature, . Also compute the workdone.
4. Two identical bodies of constant heat capacity are at the same initial temperature. A refrigerator operates between these two bodies until one body is cooled to the temperature. If the bodies remain at constant pressure and undergo no change of phase, obtain an expression for the minimum amount of work required to achieve this.
5. Two blocks of metal each of mass m and specific heat c, initially at absolute temperature and respectively, are brought to the same final temperature by means of a reversible process. Derive an expression for the amount of work obtained during the process in terms of m, c, and.
6. An inventor claims to have developed a device which requires no energy transfer by work or heat transfer, yet able to produce hot and cold stream of air from a single stream of air at an intermediate temperature of and pressure of 5.2 bar, separate streams of air exit at temperature of 1 bar. Sixty percent of mass entering the device exists at the lower temperature. Evaluate the inventor’s claim, assuming ideal gas as working fluid and neglecting changes in kinetic and potential energy.
7. Steel balls used in ball bearing are quenched by suddenly dropping the hot balls in cold oil bath. Steel ball of 50 kg mass initially at and with specific heat 0.45 kJ/kg.K are quenched in an oil bath of initial temperature and specific heat 2.8kJ/kg.K. During the quenching, a paddle wheel driven by 200 W motor is activated to stir the oil. Thermal equilibrium is established after 20 minutes, when the final temperature is. Determine the mass of the oil and entropy generated during the process. Consider the tank containing the oil to be well insulated and of negligible mass.

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Flash Evaporator

A geothermal supply of hot water at is fed to an insulated flash evaporator at the rate of 1.5 kg/s. A stream of saturated liquid at 200 kPa is drained from the bottom of the chamber and a stream of saturated vapour at 200 kPa is drawn from the top and fed to a turbine. Find the rate of entropy generation in the flash evaporator. Properties of water are given in the table below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| P, kPa | t,  |  kJ/kg |  kg/kg |  kJ/kg.K |  kJ/kg.K |
| 200 | 120.20  | 504.68 | 2706.63 | 1.5300 | 7.1271 |
| 500 | 151.53 | 640.08 | 2746.60 | 1.8603 | 6.8202 |
| 500 | 150 | 632.18 |  | 1.8417 |  |

1. What are available and unavailable energy? A system maintained at constant volume is initially at temperature If a heat reservoir at temperature , which is less than, is available, determine the maximum work obtainable as the system is cooled toin terms of ,and 
2. 500 kJ of heat is removed from a constant temperature heat reservoir maintained at 835K. The heat is received by a system at constant temperature of 720K. The temperature of the surrounding, the lowest available temperature is 280K. Illustrate the problem by T-S diagram and calculate the net loss of available energy as a result of this irreversible heat transfer.
3. A rigid tank contains air at 1.5 bar and. The pressure of air is raised to 2.5 bar by transfer of heat from a constant temperature reservoir at. The temperature of surrounding isDetermine per kg of air, the loss of available energy due to heat transfer.
4. A closed system contains 0.5 kg of air. It expands from 2 bar,to 1 bar,During expansion it receives 2 kJ of heat from a reservoir atAssuming condition to be atmospheric at 0.95 bar and calculate (i) the maximum work, (ii) work done on atmosphere, and (iii) change in availability.
5. Steam flows through an adiabatic steady flow turbine. The enthalpy at entrance is 4142 kJ/kg and at exit 2585 kJ/kg. The values of flow availability of steam at entrance and exit are 1787kJ/kg and -140 kJ/kg, respectively. If the dead state temperature is 300 K, determine, per kg of steam, the actual work, the maximum possible work for the given change of state of steam and change of entropy of steam. Neglect change in kinetic and potential energy.
6. State Gouy-Stodola theorem of irreversibility. Estimate the irreversibility associated with the expansion process of air through a very small constriction in a pipe from pressure and temperature, respectively of 8 bar and 600 K to pressure of 1.2 bar. Assume air to be an ideal gas. The temperature of surrounding is
7. A lead storage battery used in an automobile is able to deliver 5.2 MJ of electric energy. This energy is available for starting the car. Let compressed air be considered for doing an equivalent amount of work in starting the car. The compressed air is to be stored at 7 MPa, What is the volume of the tank that would be required to let the compressed air have an availability of 5.2 MJ? For air, pv=0.287T, where T is in K, p in kPa and v in 

**Unit-4:** **Properties of pure substances**

**Unit-5: Helmholtz and Gibb’s function (Thermodynamic Relations)**

**Unit-7: Vapour cycle**

1. Explain the followings:
2. Pure Substance
3. Saturation states
4. Critical states (critical pressure, critical temperature and critical volume of water)
5. Degree of superheat and degree of subcooling
6. Quality of steam
7. Draw the phase equilibrium diagram on p-v and p-T coordinates for a substance which shrinks in volume on melting and then for a substance which expands in volume on melting. Indicates thereon the relevant constant property lines.
8. Draw the phase equilibrium diagram for a pure substance on T-s and h-s plot with relevant constant property lines.
9. Why do the isobars on Mollier diagram diverge from one another and isotherms become horizontal in the superheated region at low pressure?
10. A cylinder contains one kg of water and steam at a pressure of 4 bar and 0.4 dry. Heat is supplied at constant volume until the pressure reaches to 10 bar. The steam is then expanded according to the law PV= constant, until the pressure is 2 bar. Calculate (i) heat transfer during constant volume heating, (ii) heat transfer during PV= constant and (iii) temperature of steam after the expansion.
11. A cylinder having a piston restrained by a linear spring (of spring constant 15 kN/m) contains 0.5 kg of saturated vapour water at as shown in the figure. Heat is transferred to the water, causing the piston to rise. If the piston cross-sectional area is and the pressure varies linearly with volume until a final pressure of 500 kPa is reached. Find the final temperature in the cylinder and the heat transfer for the process. The properties of water are given in the table below:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| t,  | p, kPa |  |  |  |
| 120 | 198.50 | 0.89186 | 2529.2 | 2705.9 |
| 151.83 | 500.00 | 0.37477 | 2559.5 | 2746.6 |
| 801 | 500.00 | 0.99055 | 3664.2 | 4159.2 |
| 802 | 500.00 | 0.99147 | 3666.1 | 4161.6 |
| 803 | 500.00 | 0.99240 | 3668.0 | 4163.9 |
| 804 | 500.00 | 0.99333 | 3669.9 | 4166.3 |
| 805 | 500.00 | 0.99425 | 3671.8 | 4168.6 |

1. A vessel of volume contains a mixture of saturated water and saturated steam at a temperature of . The mass of the liquid present is 9 kg. Find the pressure, mass, specific volume, enthalpy, entropy and internal energy.
2. A closed system consists of 1 kg of steam. This system undergoes three different reversible processes to constitute a thermodynamic cycle. The initial condition of steam pressure is 10 bar and dryness fraction is 0.40. The process 1-2 is constant volume heating till pressure becomes 35 bar. The process 2-3 is isothermal expansion up to pressure of 10 bar. The process 3-1 is constant pressure cooling to bring the system back to its initial state. Sketch the cycle on Mollier diagram. For each process, calculate (i) entropy change, (ii) heat transfer, and (iii) work done. Also find the cycle efficiency.
3. What are the Gibbs function and Helmholtz function? Derive Maxwell relations.
4. Derive the Clapeyron and Clausius-Clapeyron equations and explain the physical significance of these equations.
5. Derive Mayer relation and show that specific heat at constant pressure is always equal to or greater than the specific heat at constant volume.
6. Explain Joule-Kelvin effect. What is inversion temperature?
7. What is Joule-Thomson coefficient? What does its value indicates?
8. Does always temperature decrease during throttling process? Explain the reason.
9. Derive the relation:



Using this relation show that Joule-Thomson coefficient is zero for ideal gas.

1. Why does the hydrogen gas need to be precooled before being throttled to get the cooling effect?
2. Show that the properties at the critical state for a gas obeying Vander Walls equation of stateare given byand show that coefficient ‘a’ and ‘b’ are expressed as and the critical coefficient of the Vander Walls gas is 2.66.
3. What is the reversible cycle that represents the simple power plant? Draw the flow, p-v, T-s and h-s diagrams of this cycle.
4. Why is Carnot cycle not practicable for a steam power plant?
5. What do you understand by the mean temperature of heat addition? For a given lower temperature , show that the Rankine cycle efficiency depends on the mean temperature of heat addition.
6. What do you mean by steam rate , heat rate, work ratio and back work ratio?
7. When is reheating of steam recommended in steam power plant? With the help of T-s diagram explain the effect of reheat on (a) the specific output (b) the cycle efficiency (c) steam rate and (d) heat rate of a steam power plant.
8. What is the purpose of regeneration? With the help of T-s diagram explain the effect of regeneration on (a) the specific output (b) the cycle efficiency (c) steam rate and (d) heat rate of a steam power plant.
9. With the help of flow, T-s and h-s diagram explain reheat and regeneration of steam power cycle.
10. Discuss the desirable characteristics of a working fluid in a vapour power cycle.
11. Explain the followings
12. Binary vapour cycle
13. Topping and bottoming cycles
14. Cogeneration plant
15. Back pressure turbine
16. Pass-out turbine
17. Steam at 20 bar; is expanded in a steam turbine to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler. (a) Assuming ideal processes, find per kg of steam the net work and the cycle efficiency. (b) if the turbine and the pump have each 80% efficiency, find the percentage reduction in the net work and cycle efficiency.
18. A cyclic steam power plant is to be designed for a steam temperature at turbine inlet ofand an exhaust pressure of 0.08 bar. After isentropic expansion of steam in the turbine, the moisture content at the turbine exhaust is not to exceed 15%. Determine the greatest allowable steam pressure at the turbine inlet and calculate the Rankine cycle efficiency for these steam conditions. Estimate also the mean temperature of heat addition.
19. A steam power station uses the following cycle:

Steam at boiler outlet- 150 bar, 

Reheat at 40 bar to 

Condenser at 0.1 bar.

Using the Mollier chart and assuming ideal process, find the (a) quality at turbine exhaust, (b) cycle efficiency, and (c) steam rate.

1. In a single-heater regenerative cycle the steam enters the turbine at 30 bar, and the exhaust pressure is 0.10 bar. The feedwater heater is a direct-contact type which operates at 5 bar. Find (a) the efficiency and steam rate of the cycle, and (b) the increase in mean temperature of heat addition, efficiency and steam rate, as compared to the Rankine cycle (without regeneration). Neglect Pump work.

**Unit-6:** **Ideal cycles**

**Unit-8: Non reacting mixture**

**Unit-9: Psychrometry**

1. What is an air standard cycle? What are the assumptions made in air standard cycles?
2. What is SI engine? What is the air standard cycle of such an engine? What are its four processes?
3. What is CI engine? What is the air standard cycle of such an engine? What are its four processes?
4. Derive the expression of efficiency for (a) Otto cycle (b) Diesel Cycle and (c) Dual cycle.
5. How does the thermal efficiency of an ideal Otto cycle change with the compression ratio of the engine and the specific heat ratio of the working fluid?
6. An ideal Otto cycle with a specified compression ratio is executed using (*a*) air, (*b*) argon, and (*c*) ethane as the working fluid. For which case will the thermal efficiency be the highest? Why?
7. An ideal Otto cycle has a compression ratio of 8. At the beginning of the compression process, air is at 95 kPa and 27°C, and 750 kJ/kg of heat is transferred to air during the constant-volume heat-addition process. Using constant specific heats at room temperature, determine (*a*) the pressure and temperature at the end of the heat addition process, (*b*) the net work output, (*c*) the thermal efficiency, and (*d*) the mean effective pressure for the cycle.
8. The compression ratio of an air-standard Otto cycle is9.5. Prior to the isentropic compression process, the air is at 100 kPa, 35°C, and 600 cm3. The temperature at the end of the isentropic expansion process is 800 K. Using specific heat values at room temperature; determine (*a*) the highest temperature and pressure in the cycle; (*b*) the amount of heat transferred in, in kJ; (*c*) the thermal efficiency; and (*d*) the mean effective pressure.
9. What is the cut-off ratio? How do compression and cut-off ratio affect the thermal efficiency of a Diesel cycle?
10. A Diesel cycle has compression ratio 14 and heat supply up to 5% of the stroke; Calculate the air-standard efficiency of the cycle. If the compression ratio is increased from 14 to 19 and the cut-off is adjusted to give the same air standard efficiency obtained above, find the required change in the cut-off.
11. An air-standard Diesel cycle has a compression ratio of 16 and a cutoff ratio of 2. At the beginning of the compression process, air is at 95 kPa and 27°C. using constant specific heats at

room temperature, determine (*a*) the temperature after the heat-addition process, (*b*) the thermal efficiency, and (*c*) the mean effective pressure.

1. An ideal diesel engine has a compression ratio of 20 and uses air as the working fluid. The state of air at the beginning of the compression process is 95 kPa and 20°C. If the maximum temperature in the cycle is not to exceed 2200 K, determine (*a*) the thermal efficiency and (*b*) the mean effective pressure. Assume constant specific heats for air at room temperature.
2. The compression ratio of an ideal dual cycle is 14. Air is at 100 kPa and 300 K at the beginning of the compression process and at 2200 K at the end of the heat-addition process. Heat transfer to air takes place partly at constant volume and partly at constant pressure, and it amounts to 1520.4 kJ/kg. Using constant specific heats at room temperature, determine (*a*) the fraction of heat transferred at constant volume and (*b*) the thermal efficiency of the cycle.
3. With the help of p-v and T-s diagram, compare the efficiency of Otto, Diesel and Dual cycle on the basis of (a) same compression ratio and (b) same maximum pressure & temperature.
4. Why are the back work ratios relatively high in gas turbine engines?
5. A simple Brayton cycle using air as the working fluid has a pressure ratio of 8. The minimum and maximum temperatures in the cycle are 310 and 1160 K. Assuming an isentropic efficiency of 75 percent for the compressor and 82 percent for the turbine, determine (*a*) the air temperature at the turbine exit, (*b*) the net work output, and (*c*) the thermal efficiency.
6. Air is used as the working fluid in a simple ideal Brayton cycle that has a pressure ratio of 12, a compressor inlet temperature of 300 K, and a turbine inlet temperature of 1000 K. Determine the required mass flow rate of air for a net power output of 70 MW, assuming both the compressor and the turbine have an isentropic efficiency of (*a*) 100 percent and (*b*) 85 percent. Assume constant specific heats at room temperature.
7. Air enters the compressor of a gas-turbine engine at 300 K and 100 kPa, where it is compressed to 700 kPa and 580 K. Heat is transferred to air in the amount of 950 kJ/kg before it enters the turbine. For a turbine efficiency of 86 percent, determine (*a*) the fraction of the turbine work output used to drive the compressor and (*b*) the thermal efficiency.
8. A gas-turbine power plant operates on the simple Brayton cycle with air as the working fluid and delivers 32 MW of power. The minimum and maximum temperatures in the cycle are 310 and 900 K, and the pressure of air at the compressor exit is 8 times the value at the compressor inlet. Assuming an isentropic efficiency of 80 percent for the compressor and 86 percent for the turbine, determine the mass flow rate of air through the cycle.
9. What are mass and mole fractions?
10. Using the definitions of mass and mole fractions derive a relation between them.
11. Consider a mixture of several gases of identical masses. Will all the mass fractions be identical? How about the mole fractions?
12. An insulated rigid tank is divided into two compartments by a partition. One compartment contains 7 kg of oxygen gas at 40°C and 100 kPa, and the other compartment contains 4 kg of nitrogen gas at 20°C and 150 kPa. Now the partition is removed, and the two gases are allowed to mix. Determine (*a*) the mixture temperature and (*b*) the mixture pressure after equilibrium has been established.
13. A mixture of ideal gases at a pressure of 150 kPa and 40°C contains 8 kg of nitrogen and 5 kg of oxygen. Determine for the mixture (i) average molecular weight, (ii) specific gas constant, and (iii) the two specific heats. for nitrogen may be taken as 0.70 kJ/kg-K and 1.037 kJ/kg-K, whereas for oxygen it is 0.75 kJ/kg-K and 1.04 kJ/kg-K.
14. Two vessels, A and B, both containing nitrogen are connected by a valve which is opened to allow the contents to mix and achieve an equilibrium temperature of 27°C. Before mixing the following information is known about the gases in the two vessels.

Vessel A

P=1.5 MPa

T=50°C

Contents=0.5 kg mol

Vessel B

P=0.6 MPa

T=20°C

Contents=2.5 kg

1. Calculate the final equilibrium pressure, and the amount of heat transferred to the surroundings. If the vessels have been perfectly insulated, calculate the final temperature and pressure which would have been reached. Take γ=1.4
2. What is the difference between dry air and atmospheric air?
3. Can the water vapor in air be treated as an ideal gas? Explain.
4. What is the difference between the specific humidity and the relative humidity?
5. What is the dew-point temperature?
6. In summer, the outer surface of a glass filled with iced water frequently “sweats.” How can you explain this sweating?
7. When are the dry-bulb and dew-point temperatures identical?
8. When are the adiabatic saturation and wet-bulb temperatures equivalent for atmospheric air?
9. How do constant-enthalpy and constant-wet-bulbtemperature lines compare on the psychrometric chart?
10. At what states on the psychrometric chart are the dry-bulb, wet-bulb, and dew-point temperatures identical?
11. How is the dew-point temperature at a specified state determined on the psychrometric chart?
12. How do relative and specific humidities change during a simple heating process? Answer the same question for a simple cooling process.
13. Why does a simple heating or cooling process appear as a horizontal line on the psychrometric chart?
14. What are humidification and dehumidification? Why is heated air sometimes humidified?
15. Two unsaturated airstreams are mixed adiabatically. It is observed that some moisture condenses during the mixing process. Under what conditions will this be the case?
16. Consider the adiabatic mixing of two airstreams. Does the state of the mixture on the psychrometric chart have to be on the straight line connecting the two states?
17. A 5 m X 5 m X 3 m room contains air at 25°C and 100 kPa at a relative humidity of 75 percent. Determine (*a*) the partial pressure of dry air, (*b*) the specific humidity, (*c*) the enthalpy per unit mass of the dry air, and (*d)* the masses of the dry air and water vapour in the room.
18. In cold weather, condensation frequently occurs on the inner surfaces of the windows due to the lower air temperatures near the window surface. Consider a house that contains air at 20°C and 75 percent relative humidity. At what window temperature will the moisture in the air start condensing on the inner surfaces of the windows?
19. Consider a room that contains air at 1 atm, 35°C, and 40 percent relative humidity. Using the psychrometric chart, determine (*a*) the specific humidity, (*b*) the enthalpy, (*c*) the wet-bulb temperature, (*d*) the dew-point temperature, and (*e*) the specific volume of the air.
20. Saturated air leaving the cooling section of an air-conditioning system at 14°C at a rate of 50 m3/min is mixed adiabatically with the outside air at 32°C and 60 percent relative humidity at a rate of 20 m3/min. Assuming that the mixing process occurs at a pressure of 1 atm, determine the specific humidity, the relative humidity, the dry-bulb temperature, and the volume flow rate of the mixture.