## UBMCC11 - THERMODYNAMICS

## B.E (Marine Engineering) - B 16

## UNIT I BASIC CONCEPTS AND FIRST LAW

## PART- A

1. What do you understand by pure substance?
2. Define thermodynamic system.
3. Name the different types of system.
4. Define thermodynamic equilibrium.
5. What do you mean by quasi-static process?
6. Define path function.
7. Define point function.
8. Explain homogeneous and heterogeneous system.
9. What is a steady flow process?
10. State Zeroth law of thermodynamics.
11. Indicate the practical application of steady flow energy equation.
12. Define the term enthalpy?
13. Define the term internal energy.
14. State first law of Thermodynamics.
15. What are the limitations of first law of thermodynamics?
16. Compare intensive and extensive properties
17. Differentiate open system and closed system
18. What is absolute temperature?
19. State the sign conversion of heat and work
20. Differentiate between reversible and irreversible processes

## PART B

1. Explain about thermodynamic system and different types of thermodynamic system with examples.
2. Define (1) property (2) state (3) path (4) process (5) cycle (6) pure substance
3. Prove that difference in specific heat capacities equal to Universal gas constant $\left(\mathrm{C}_{\mathrm{p}}-\mathrm{C}_{\mathrm{v}}=\mathrm{R}\right)$.
4. Explain Quasi-static process with a p-V diagram.
5. Sketch $\mathrm{p}-\mathrm{V}$ diagram for all the thermodynamic process.
6. Derive the relation between $\mathrm{p}, \mathrm{v}, \mathrm{t}$ for the following process, (1) Isochoric (2) Isobaric (3) Isothermal
7. State the work done and heat transfer for (1) Isochoric (2) Isobaric (3) Isothermal
8. Derive the relation between $\mathrm{p}, \mathrm{v}, \mathrm{t}$ for the isentropic process
9. Derive an expression for work done for reversible adiabatic process?
10. Derive an expression for the heat transfer of polytrophic process?
11. Derive an expression to determine the value of polytrophic index.
12. 0.25 Kg of air at a pressure of 1 bar occupies a volume of $0.3 \mathrm{~m}^{3}$ which expands isothermally to a volume of $0.9 \mathrm{~m}^{3}$. Find (a) Initial temperature (b) final temperature (c) external Work done (d) heat transfer (e) change in internal energy and (f) change in enthalpy.
13. A boiler produces steam from water at $35^{\circ} \mathrm{C}$. The enthalpy of steam is $2675 \mathrm{~kJ} / \mathrm{kg}$. Calculate
the heat transfer per Kg. Take specific heat capacity of water is $4.19 \mathrm{~kJ} / \mathrm{kg} \mathrm{K}$. Neglect potential energy and kinetic energy.
14. In a steady flow of air through a nozzle, the enthalpy decreases by 50 kJ between two sections. Assuming that there are no other energy changes than the kinetic energy. Determine the increases in velocity at section 2 , if the initial velocity is $90 \mathrm{~m} / \mathrm{s}$.
15 . At the inlet of the nozzle, the enthalpy and velocity of the fluid are $300 \mathrm{~kJ} / \mathrm{kg}$ and $50 \mathrm{~m} / \mathrm{s}$ respectively. There is negligible heat loss from the nozzle. At the outlet of the nozzle enthalpy is $2450 \mathrm{~kJ} / \mathrm{kg}$. if the nozzle is horizontal, find the velocity of the fluid at exit.

## PART C

1. A Piston and cylinder machine contains a fluid system which process through a complete cycle of four processes. During a cycle, the sum of all heat transfer is -170 KJ . The system completes 100 cycles $/ \mathrm{min}$.complete the following table showing the method for item and completes the net rate of work output in KW.

| Process | $\mathrm{Q} \mathrm{kJ} / \mathrm{min}$ | $\mathrm{W} \mathrm{kJ} / \mathrm{min}$ | $\Delta \mathrm{E} \mathrm{kJ} / \mathrm{min}$ |
| :---: | :---: | :---: | :---: |
| $1-2$ |  |  | 2500 |
| $2-3$ | 20000 |  |  |
| $3-4$ |  | 2200 | 30,000 |
| $4-1$ |  |  |  |

2. (i) Five kg of air at $40^{\circ} \mathrm{C}$ and 1 bar is heated in a reversible non-flow constant pressure until the volume is doubled. Find
(i) Change in volume
(ii) Work done
(iii)Change in internal energy and
(iv)Change in enthalpy.
(ii) In a vessel 10 kg of O 2 is heated in a reversible non-flow constant volume process, so that the pressure of O 2 is increased two times that of initial value. The initial temperature is $20^{\circ} \mathrm{C}$. Calculate (a) final temperature (b) change in internal energy (c) change in enthalpy (d) heat transfer and (e) work done. Take $\mathrm{R}=0.259 \mathrm{~kJ} . \mathrm{kg} \mathrm{K}$ and $\mathrm{C}_{\mathrm{v}}=0.625 \mathrm{~kJ} / \mathrm{kg} \mathrm{K}$ for $\mathrm{O}_{2}$
3. A Cylinder contains 1 m 3 of gas at $100 \mathrm{kPa} 100^{\circ} \mathrm{C}$, the gas is polytropically compressed to a volume of $0.25 \mathrm{~m}^{3}$. The final pressure is 600 kPa . Determine
(i) mass of the gas
(ii) value of index " $n$ " for compression
(iii)change in the internal energy of the gas
(iv)heat transfer by the gas during the compression.

Assume $\mathrm{R}=0.287 \mathrm{~kJ} / \mathrm{kg} \mathrm{K}$ and $\gamma=1.4$
4. Air at a temperature of $15^{\circ} \mathrm{C}$ passes through a heat exchanger at a velocity of $30 \mathrm{~m} / \mathrm{s}$ where its temperature is raised to $800^{\circ} \mathrm{C}$. It then enters a turbine with the same velocity of $30 \mathrm{~m} / \mathrm{s}$ and expands until the temperature falls to $650^{\circ} \mathrm{C}$. On leaving the turbine, the air is taken at a velocity of $60 \mathrm{~m} / \mathrm{s}$ to a nozzle where it expands until the temperature has fallen to $500^{\circ} \mathrm{C}$. If the air flow rate is $2 \mathrm{~kg} / \mathrm{s}$, calculate
(1) The rate of heat transfer to the air in the heat exchanger
(2) The power output from the turbine assuming no heat losses
(3) The velocity at exit from the nozzle, assuming no heat loss.

Take the enthalpy of air as $\mathrm{h}=\mathrm{CpT}$ where Cp is the specific heat equals to $1.005 \mathrm{~kJ} / \mathrm{kg} \mathrm{K}$ and ' T ' is the temperature.
5. Describe steady flow energy equation and deduce expression for the expansion of gas in a gas turbine with suitable assumptions.
6. (i) Reduce the steady flow energy equation for a compressor with the assumptions made.
(ii) Air flows steadily at the rate of $0.5 \mathrm{~kg} / \mathrm{s}$ through an air compressor, entering at $7 \mathrm{~m} / \mathrm{s}$ velocity, 100 kPa pressure and $0.95 \mathrm{~m}^{3} / \mathrm{kg}$ volume and leaning at $5 \mathrm{~m} / \mathrm{s}, 700 \mathrm{kPa}$ and $0.19 \mathrm{~m}^{3} / \mathrm{kg}$. The internal energy of the air leaving is $90 \mathrm{~kJ} / \mathrm{kg}$ greater than that of the air entering. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW . Compute the rate of shaft work input to the air in kW .

## UNIT II SECOND LAW AND AVAILABILITY ANALYSIS

## PART - A

1. Define thermal energy reservoir.
2. Define heat source and heat sink.
3. Define COP
4. Define PMM of kind II.
5. Why heat engines can't have $100 \%$ efficiency?
6. Why Carnot engine can't be practical?
7. What is a refrigerator and heat pump?
8. Define heat engine.
9. Explain the term reversibility
10. State Carnot theorem.
11. What is meant by reversible process?
12. What is meant by irreversible process?
13. Explain entropy?
14. Define availability.
15. State Clausius inequality.
16. Explain the term source and sink.
17. What is the principle of increase in entropy?
18. Sketch the p-V for Carnot cycle?
19. What are the processes involved in Carnot cycle?
20. Write the expression for COP of a heat pump and a refrigerator.

## PART B

1. State the Kelvin - Planks and Clausius statement of second law of thermodynamics.
2. (a) Define reversible process and irreversible process.
(b) Mention various causes of irreversibility.
3. Explain the working of Carnot cycle with $\mathrm{p}-\mathrm{V}$ and $\mathrm{T}-\mathrm{s}$ diagram
4. Differentiate between (a) heat engine, heat pump, and refrigerator (b) Source and Sink
5. Explain Carnot engine and different process carried in it.
6. State and Explain Carton theorem. What are the corollaries of carton theorem?
7. If the thermal efficiency of a Carnot engine is $1 / 4$, find the COP of a Carnot refrigerator.
8. Explain the working of reversed Carnot cycle with p-V and T-s diagram
9. State Clausius inequality. What are the inferences from Clausius inequality?
10. Prove entropy is a property of a system.
11. Draw the p-V and T-s diagram for isochoric, isobaric, Isothermal, adiabatic and polytropic process.
12. 0.2 kg of air at 1.5 bar and $27^{\circ} \mathrm{C}$ is compressed to a pressure of 15 bar according to the law $\mathrm{pv}^{1.25}$ $=\mathrm{C}$, determine the work done, heat flow to or from the air, increase or decrease in entropy.
13. Define available energy, unavailable energy and irreversibility of a system.
14. A Carnot heat engine works at maximum and minimum temperature of $1000{ }^{\circ} \mathrm{C}$ \& $40{ }^{\circ} \mathrm{C}$ respectively. Calculate the thermal efficiency if the heat supplied is 1010 kJ .
15. Explain availability, unavailability and irreversibility.

## PART C

1. Derive an expression for thermal efficiency of Carnot cycle with $\mathrm{p}-\mathrm{V}$ and $\mathrm{T}-\mathrm{s}$ diagram. Also show that Carnot efficiency is the maximum efficiency for any cycle.
2. A reversible heat engine operates between two reservoirs at $600^{\circ} \mathrm{C}$ and $40^{\circ} \mathrm{C}$. The engine derives a reversible refrigerator which operates between reservoir of $40^{\circ} \mathrm{C}$ and $-20^{\circ} \mathrm{C}$. The heat transfer to the heart engine is 2000 kJ and the network output of the combined engine refrigerator plant is 360 kJ . Evaluate the heat transfer to the refrigerant and heat transfer to the reservoir at $40^{\circ} \mathrm{C}$.
3. Two Carnot engines A and B are operated in series. The first one receives heat at 870 K and rejects to a reservoir at B . B receives heat rejected by the first engine and in turn rejects to a sink 300 K . calculate the intermediate temperature T for following cases,
(i) Work output of both engines are equal
(ii) Efficiencies of both engines are same.
4. Derive the expression for change in entropy of ideal gas,
(i) In terms of temperature and volume
(ii) In terms of pressure and temperature
(iii) In terms of pressure and volume
5. 1.6 kg of air compressed according to the law $\mathrm{PV}^{1.3}=\mathrm{C}$ from a pressure of 1.2 bar and temperature of $20^{\circ} \mathrm{C}$ to a pressure of 17.5 bar. Calculate
(i) the final volume
(ii) final temperature
(iii)work done
(iv)heat transfer
(v) change in entropy.
6. In certain heat exchanger $45 \mathrm{~kg} / \mathrm{min}$ of water is to be heated from $60^{\circ} \mathrm{C}$ to $115^{\circ} \mathrm{C}$ by the hot gases which enter hart exchanger at $225^{\circ} \mathrm{C}$ at the flow rate of $90 \mathrm{~kg} / \mathrm{min}$. compute the net change of entropy assume specific heat for water and gases as 4.18 and $1.045 \mathrm{~kJ} / \mathrm{kg} \mathrm{K}$ ?

## UNIT III PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE

## PART - A

1. Define latent heat of fusion
2. Define latent heat of vaporization
3. Define sensible heat.
4. What is saturation temperature?
5. What is wet and dry steam?
6. Define dryness fraction of steam
7. Define wetness fraction of steam
8. Explain the term: degree of super heat, degree of sub cooling?
9. Explain about super heated steam
10. Define enthalpy of steam.
11. Define triple point.
12. Explain about critical temperature
13. What do you mean by latent heat?
14. Define specific steam consumption of an ideal Rankine cycle
15. Name the different components in steam power plant working on Rankine cycle.
16. What is the purpose of reheating?
17. What are the effects of condenser pressure on the Rankine Cycle?
18. What is the purpose of reheating?
19. What is the purpose of regenerator?

20 . What is the purpose of pre heater?

## PART B

1. Draw $\mathrm{p}-\mathrm{v}, \mathrm{p}-\mathrm{T}, \mathrm{T}-\mathrm{v}$ and h -s diagram for water.
2. Write the expression for work done, heat transfer enthalpy ,entropy and Internal energy of wet, dry and superheated steam
3. Draw p-v-t surface of substance that shrinks on freezing and expands on freezing.
4. Find the specific volume and enthalpy of steam at 9 bar when the condition of steam is (a) wet with dryness fraction 0.9 , (b) dry saturated and (c) super heated temperature of $240^{\circ} \mathrm{C}$.
5. Find the internal energy of unit mass of steam at a pressure of 7 bar when the quality of steam is (i) 0.8 dry (ii) dry and saturated (iii) super heated with degree of super heat as $65^{\circ} \mathrm{C}$. Take $\mathrm{C}_{\mathrm{p}}$ of steam as $2.277 \mathrm{~kJ} / \mathrm{kg}$.
6. Find the enthalpy and entropy of steam when the pressure is 20 bar and the specific volume is $0.09 \mathrm{~m}^{3} / \mathrm{Kg}$.
7. Determine the state of steam, entropy and its enthalpy at a pressure of 12 bar with its specific volume of $0.0175 \mathrm{~m}^{3} / \mathrm{Kg}$.
8. Determine the condition of steam at a temperature of $220^{\circ} \mathrm{C}$ and its enthalpy of $2750 \mathrm{~kJ} / \mathrm{Kg}$.
9. Find the enthalpy, entropy and specific volume of steam at 14 bar and $380^{\circ} \mathrm{C}$ ?
10. A boiler generates steam at 3 bar and 0.85 dry from water at $45^{\circ} \mathrm{C}$ and $540 \mathrm{~kJ} / \mathrm{s}$ of heat is added during the evaporation. Calculate the amount of steam generated.
11. Explain the four basic components of steam power plant?
12. Explain the methods used to improve the efficiency of ideal Rankine cycle?
13. Draw a schematic diagram and p-v diagram for reheat Rankine cycle?
14. Draw the T-s diagram for reheat and regenerative Rankine cycle?
15. What is the purpose of Economizer and Air-preheater in the boiler?

## PART C

1. 2 Kg of steam initially at 5 bar and 0.6 dry is heated at constant pressure until the temperature becomes $350^{\circ} \mathrm{C}$. find
(i) Change in internal energy
(ii) Change in entropy
2. Steam is expanded as per the law $\mathrm{pv}^{1.25}=\mathrm{C}$ from 10 bar and 0.92 dry to 3 bar. Find the work done and heat transfer from a non-flow system
3. A steam initially at a pressure of 15 bar and 0.95 dry expands isentropically to 7.5 bar and is then throttled until it is dry, determine per kg of steam
(i) Change in entropy
(ii) Change in enthalpy
(iii) Change in internal energy.
4. Explain and derive the expression for efficiency of Rankine cycle with suitable $\mathrm{p}-\mathrm{V}$ and $\mathrm{T}-\mathrm{s}$ diagram?
5. Explain the methods of improving the efficiency of Rankine cycle with neat sketch.
6. A steam turbine receives steam at pressure 20 bar and superheated to $300^{\circ} \mathrm{C}$. The exhaust pressure is 0.07 bar and the expansion of steam takes place isentropically. Using steam table, calculate the following.
(i) Heat rejected
(ii) Heat supplied, assuming that the feed pump supplies water to the boiler at 20 bar
(iii) Net work done
(iv) Thermal efficiency

## UNIT IV IDEAL AND REAL GASES AND THERMODYNAMIC RELATIONS

## PART A

1. Define Ideal gas.
2. Define Real gas.
3. What is equation of state?
4. State Boyle's law.
5. State Charle's law.
6. Explain the use of generalized compressibility chart.
7. What do you mean by reduced properties?
8. Explain law of corresponding states.
9. Explain Dalton's law of partial pressure.
10. State Avogadro's Law.
11. What is Joule-Thomson coefficient?
12. What is compressibility factor?
13. What is partial pressure?
14. State Dalton's law of partial pressure.
15. What assumptions are made in Clausius - Clapeyron's equation?
16. State Gay-Lussac's law
17. What is significance of compressibility factor?
18. Write the maxwell equation and its significance?
19. Is water vapour is ideal gas? Why?
20. Define isothermal Compressibility.

## PART - B

1. Derive characteristic gas equation.
2. State Gay-Lussac's law, Joule's law and Avagadro's law
3. State and explain the significance Clausius clapeyron equation?
4. State the importance and the limitation of Van der Waal's equation of state?
5. Derive an expression for the gas constant of a gas mixture.
6. Explain about compressibility factor and compressibility chart
7. What is compressibility factor? What does it signify? What is its value for an ideal gas at critical point.
8. Describe Joule Thomson effect with the help of t-p diagram
9. Derive an expression for the specific heat relations.
10. Write the Maxwell equation and its significance?
11. A vessel of volume $0.3 \mathrm{~m}^{3}$ contains 15 kg of air at 303 K . Determine the pressure exerted by the air using (a) perfect gas equation (b) Vander Waal's equation (c) generalized compressibility chart. Take the critical temperature of air as 132.8 K and critical pressure of air as 37.7 bars.
12. Explain intermolecular forces between molecules and Shape factor.
13. A Vander Waals gas is compressed reversibly at constant temperature from volume $v_{1}$ to $v_{2}$. The equation of state is given by pressure $(p)=((R T) /(v-b))-\left(a / v^{2}\right)$. Determine the work done per mole of the gas.
14. Compute the specific volume of steam at 0.9 bar and 550 K , using Vander Waals equation. Take critical temperature of steam as 647.3 K and critical pressure as 220.9 bars.
15. Entropy is a function of any two properties like p-v, p-T etc., for a pure substance with the help of Maxwell's Equation. Prove Tds $=[\mathrm{KCv} / \beta] \mathrm{dp}+[\mathrm{Cp} / \mathrm{v} \beta] \mathrm{dv}$.

## PART -C

1. Derive Maxwell's relations.
2. Derive Tds equation when $\mathrm{t}, \mathrm{p} \mathrm{v}$ and $\mathrm{t} p$ as independent properties
3. Describe Joule Thomson effect in detail. Show that the Joule - Thomson co efficient of an ideal gas is zero.
4. Derive Clausius clapeyron equation.
5. Explain the following
(i) Ideal and real gas comparison.
(ii) Boyle's law
(iii)Charles Law
(iv) Avogadro's law
(v) Principle of corresponding state
6. A vessel of volume $0.25 \mathrm{~m}^{3}$ contains 16 kg of air at 303 K . Determine the pressure exerted by the air using,
(i) Perfect gas equation,
(ii) Generalized compressibility chart
(iii)Using Van der waal's equation of state

## UNIT V GAS MIXTURES AND PSYCHROMETRY

## PART - A

1. What is humidification?
2. What is dehumidification?
3. What is effective temperature?
4. What do you mean by saturation capacity of air?
5. Define Relative humidity.
6. Define degree of saturation.
7. What is meant by dry bulb temperature (DBT)?
8. What is meant by wet bulb temperature (WBT)?
9. Define dew point temperature.
10. Define dew point depression (DPP).
11. What is meant by saturation temperature?
12. Define sensible heat and latent heat.
13. What are the factors that affect the bypass factor of a coil?
14. Define bypass factor.
15. Define partial pressure.
16. Define partial volume.
17. Explain throttling process.
18. Define dew point temperature.
19. Define psychometry.
20. Define mole fraction.

## PART-B

1. Define specific humidity and relative humidity.
2. Explain about sensible heating and sensible cooling.
3. Explain about heating and humidification.
4. Explain about cooling and dehumidification.
5. Explain about adiabatic mixing of airstreams.
6. What is dew point temperature? How is it related to dry bulb and wet bulb temperature at the saturation condition?
7. On a psychometric chart, show all the property lines.
8. What is degree of saturation and what are its limitations.
9. State the effect of very high and a very low bypass factor.
10. Explain by pass factor of cooling coil and its effects.
11. Explain about adiabatic evaporative cooling.
12. Explain about dry air, moist air and moisture.
13. State Dalton's law of partial pressure and Amagat's law.
14. Explain about sensible heat load and latent heat load.
15. Explain about mass fraction, mass fraction, partial pressure and partial volume.

## PART-C

1. A mixture of ideal gases consists of 2.5 kg of $\mathrm{N}_{2}$ and 4.5 kg of $\mathrm{CO}_{2}$ at a pressure of 4 bars and a temperature of $25^{\circ} \mathrm{C}$. Determine:
(i) Mole fraction of each constituent
(ii) Equivalent molecular weight of the mixture
(iii)Equivalent gas constant of the mixture
(iv)The partial pressure and partial volumes.
2. A mixture of ideal gas contains 3 kg of nitrogen and 5 kg of carbon dioxide at a pressure of 300 kPa and temperature of $20^{\circ} \mathrm{C}$, find
(i) The mole fraction of each constituent
(ii) The equivalent molecular weight of the mixture
(iii)The equivalent gas constant of the mixture
(iv) The partial pressures and partial volumes
3. 0.45 Kg of CO and 1 Kg of air is contained in a vessel of volume $0.4 \mathrm{~m}^{3}$ at $15^{\circ} \mathrm{C}$. Air has $23.2 \%$ of $\mathrm{O}_{2}$ and $76.7 \%$ of $\mathrm{N}_{2}$ by mass. Calculate the partial pressure of each constituent and total pressure in the vessel. Molar mass of $\mathrm{CO}, \mathrm{CO}_{2}$ and $\mathrm{N}_{2}$ are 28,32 and $28 \mathrm{~kg} / \mathrm{k} \mathrm{mol}$.
4. In a laboratory test, a sling psychrometer recorded dry bulb and wet bulb temperatures as 303 K and 298 K respectively. Calculate,
(i) Vapor pressure
(ii) Relative humidity
(iii)Specific humidity
(iv) Degree of saturation
(v) Dew point temperature
(vi)Enthalpy of the mixture.
5. Explain any four psychometric processes in detail with neat sketches.
6. Explain about,
(i) Relative humidity,
(ii) Specific humidity,
(iii)Degree of saturation,
(iv)Dew point temperature
(v) How specific humidity is related to DBT and WBT.
