the temperature T_2 for 1. equal efficiency of both the engines, and 2. equal output of both the engines.
[Ans. 276.2°C, 304.5°C]

8. A domestic food freezer is to be maintained at temperature of – 15°C. The ambient air temperature is 30°C. If the heat leaks into the freezer at the continuous rate of 1.75 kJ/s, find the power required to pump this heat out continuously. [Ans. 0.305 kJ/s]

9. A heat pump is used for heating the interior of a house in a cold climate. The ambient temperature is – 5°C and the desired interior temperature is 25°C. The compressor of the heat pump is to be driven by a heat engine working between 1000°C and 25°C. Treating both the cycles as reversible, calculate the ratio in which the heat pump and the heat engine share the heating load. [Ans. 7.606]

10. A heat engine is used to drive a heat pump. The heat transfer from the heat engine and from the heat pump are used to heat the water circulating through the radiators of a building. The efficiency of the heat engine is 27% and C.O.P of the heat pump is 4. Show that the ratio of the heat transfer to the circulating water to the heat transfer to the engine is 1.81.

QUESTIONS

1. Define a thermodynamic system. Explain its different types.
2. What do you understand by property of a system ? Distinguish between extensive and intensive properties of a system.
3. Define the following properties :
   (*a*) Specific weight (*b*) Pressure (*c*) Volume
   (*d*) Temperature (*e*) Specific volume (*f*) Density
4. What is a thermodynamic process and a cyclic process ?
5. Explain the non-equilibrium and quasi-static process. Is the quasi-static process a reversible process ?
6. Define temperature. Name the different temperature scales in common use. Establish relation between Celsius and Fahrenheit scales ?
7. What is absolute temperature ? How it is obtained for Celsius and Fahrenheit scales ?
8. Distinguish between gauge pressure and absolute pressure. How the gauge pressure is converted into absolute pressure ?
9. What do you understand by N.T.P. and S.T.P. ? What are their values ?
10. Define energy. What is stored energy and transit energy ? Discuss the types of stored energy.
11. How heat and work is defined ? Are these quantities a path function or point function ?
12. Explain the three laws of thermodynamics.

OBJECTIVE TYPE QUESTIONS

1. A definite area or a space where some thermodynamic process takes place, is known as
   (*a*) thermodynamic cycle (*b*) thermodynamic process
   (*c*) thermodynamic system (*d*) thermodynamic law
2. When neither mass nor energy is allowed to cross the boundary of a system, it is then called
   (*a*) closed system (*b*) open system
   (*c*) isolated system (*d*) none of these
3. Which of the following is the extensive property of a thermodynamic system ?
   (*a*) pressure (*b*) volume
   (*c*) temperature (*d*) density

4. Which of the following is an intensive property of a thermodynamic system ?

(*a*) volume (*b*) temperature

(*c*) mass (*d*) energy

5. Which of the following is not a thermodynamic property ?

(*a*) pressure (*b*) temperature

(*c*) heat (*d*) specific volume

6. When a process or processes are performed on a system in such a way that the final state is identical with the initial state, it is then known as

(*a*) thermodynamic cycle (*b*) thermodynamic property

(*c*) thermodynamic process (*d*) zeroth law of thermodynamics

7. Atmospheric pressure is equal to

(*a*) 1.013 bar (*b*) 101.3 kN/m^2

(*c*) 760 mm of Hg (*d*) all of these

8. First law of thermodynamics deals with

(*a*) conservation of heat (*b*) conservation of momentum

(*c*) conservation of mass (*d*) conservation of energy

9. Second law of thermodynamics defines

(*a*) heat (*b*) work

(*c*) entropy (*d*) internal energy

10. Kelvin-Planck's law deals with

(*a*) conservation of work (*b*) conservation of heat

(*c*) conservation of mass (*d*) conversion of heat into work

ANSWERS

1. (*c*)	2. (*c*)	3. (*b*)	4. (*b*)	5. (*c*)
6. (*a*)	7. (*d*)	8. (*d*)	9. (*c*)	10. (*d*)

10. The heated nitrogen gas expands from 0.2 m^3 to 0.85 m^3 in a quasi-static process at a constant pressure of 1000 kPa. For 1 kg mass of gas, determine the amount of workdone by the gas and the final temperature. R = 296.8 J/kg K, for nitrogen. [Ans. 650 kJ ; 2863.86 K]

11. The gas constant for atmospheric air is 0.287 kJ/kg K and the specific heat at constant volume is 0.713 kJ/kg K. Find the specific heat at constant pressure and the ratio of specific heats. [Ans. 1 kJ/kg K ; 1.403]

12. A certain quantity of gas occupies 0.14 m^3 at 12.6 bar and 100° C. Calculate the change in internal energy if the gas is heated to a temperature of 300° C. Take c_p = 1 kJ/kg K and c_v = 0.72 kJ/kg K. [Ans. 245 kJ]

13. The temperature of 3.5 kg of gas is raised from 95° C to 225° C at a constant pressure. Find the amount of heat supplied to the gas and the amount of the external workdone. The specific heats at constant pressure and volume are 1 kJ/kg K and 0.72 kJ/kg K respectively. [Ans. 455 kJ ; 127.4 kJ]

14. An ideal gas 0.9 kg having gas constant 287 J/kg K is heated at constant pressure of 8 bar from 30° C to 200° C. If the specific heat at constant volume is 0.72 kJ/kg K, find 1. specific heat at constant pressure, 2. total heat supplied to the gas, 3. increase in internal energy, and 4. workdone in expansion. [Ans. 1.007 kJ/kg K ; 154.1 kJ ; 110.16 kJ ; 43.94 kJ]

15. One kg mole of nitrogen (molecular mass = 28) is contained in a vessel of volume 2.5 m^3 at 100° C. 1. Evaluate the mass, the pressure and the specific volume of the gas ; 2. If the ratio of specific heats is 1.4, evaluate c_p and c_v. 3. If the gas cools to the atmospheric temperature of 30° C, evaluate the final pressure of the gas. 4. Find the increase in specific internal energy and the increase in specific enthalpy. [Ans. 28 kg, 12.4 bar, 0.089 m^3/kg ; 1.04 kJ/kg K, 0.7425 kJ/kg K ; 10.07 bar ; 52 kJ/kg, 72.8 kJ/kg]

QUESTIONS

1. What is a perfect gas ? Under what conditions does a real gas behave as a perfect gas?
2. Name the variables which control the physical properties of a perfect gas.
3. State Boyle's law and Charles' law and prove that the characteristic gas equation is $p.v = m R T$.
4. What is the difference between universal gas constant and characteristic gas constant ?
5. Define the specific heat at constant volume and at constant pressure.
6. What do you understand by enthalpy ? Show that for a constant pressure process, the heat supplied to the gas is equal to the change of enthalpy.
7. Prove that the difference between two specific heats (c_p and c_v) is equal to characteristic gas constant (R).
8. What is an adiabatic index ? Why its value is always greater than unity ?

OBJECTIVE TYPE QUESTIONS

1. If the temperature remains constant, the volume of a given mass of a gas is inversely proportional to the pressure. This is known as

   (*a*) Charles' law (*b*) Boyle's law (*c*) Joule's law (*d*) Gay-Lussac's law

2. The state of a substance whose evaporation from its liquid state is complete, is known as

   (*a*) steam (*b*) vapour (*c*) air (*d*) perfect gas

3. The characteristic equation of a gas is

   (*a*) pv = constant (*b*) $pv = mR$ (*c*) $pv = mRT$ (*d*) $pv = RT^m$

   where p, v, T and m = Pressure, volume, temperature and mass of the gas respectively, and R = Gas constant.

4. The value of gas constant (R) is

   (*a*) 287 J/kg K (*b*) 28.7 J/kg K (*c*) 2.87 J/kg K (*d*) 0.287 J/kg K

5. The value of universal gas constant (R_u) is

   (*a*) 8.314 J/kg K (*b*) 83.14 J/kg K (*c*) 831.4 J/kg K (*d*) 8314 J/kg K

6. The gas constant (R) is equal to the.....of two specific heats.

   (*a*) sum (*b*) difference (*c*) product (*d*) ratio

7. The specific heat at constant pressure is .....that of specific heat at constant volume.

   (*a*) equal to (*b*) less than (*c*) more than

8. The ratio of specific heat at constant pressure (c_p) and specific heat at constant volume (c_v) is

   (*a*) equal to one (*b*) less than one (*c*) more than one (*d*) none of these

9. The value of c_p/c_v for air is

   (*a*) 1 (*b*) 1.4 (*c*) 1.8 (*d*) 2.3

10. When the gas is heated at constant pressure, then the heat supplied

    (*a*) raises the temperature of the gas

    (*b*) increases the internal energy of the gas

    (*c*) does some external work during expansion

    (*d*) both (*a*) and (*b*)

    (*e*) both (*b*) and (*c*)

ANSWERS

1. (*b*)	2. (*d*)	3. (*c*)	4. (*a*)	5. (*d*)
6. (*b*)	7. (*c*)	8. (*c*)	9. (*b*)	10. (*e*)

OBJECTIVE TYPE QUESTIONS

1. When a gas is heated at constant volume,
   (*a*) its temperature will increase
   (*b*) its pressure will increase
   (*c*) both temperature and pressure will increase
   (*d*) neither temperature nor pressure will increase
2. The heating of a gas at constant pressure is governed by
   (*a*) Boyle's law (*b*) Charles' law (*c*) Gay-Lussac law (*d*) Joule's law
3. A process, in which the gas is heated or expanded in such a way that the product of its pressure and volume remains constant, is called
   (*a*) isothermal process (*b*) isobaric process
   (*c*) adiabatic process (*d*) polytropic process
4. The hyperbolic process is governed by
   (*a*) Boyle's law (*b*) Charles' law (*c*) Gay-Lussac law (*d*) Joule's law
5. The heating of gas at constant .....is governed by Boyle's law.
   (*a*) volume (*b*) pressure (*c*) temperature
6. In an isothermal process,
   (*a*) internal energy increases
   (*b*) internal energy decreases
   (*c*) there is no change in internal energy
   (*d*) internal energy first decreases and then increases
7. The expansion ratio (r) is the ratio of

   (*a*) $\frac{v_1}{v_2}$ (*b*) $\frac{v_2}{v_1}$ (*c*) $\frac{v_1 + v_2}{v_1}$ (*d*) $\frac{v_1 + v_2}{v_2}$

   where v_1 = Volume at the beginning of expansion, and
   v_2 = Volume at the end of expansion.
8. When the expansion or compression of the gas takes places according to the law $pv^n = C$, then the process is known as
   (*a*) isothermal process (*b*) isobaric process
   (*c*) adiabatic process (*d*) polytropic process
9. An adiabatic process is one in which
   (*a*) no heat enters or leaves the gas
   (*b*) the temperature of the gas changes
   (*c*) the change in internal energy is equal to the workdone
   (*d*) all of the above
10. The general law of expansion or compression is $pv^n = C$. The process is said to be hyperbolic, if n is equal to
    (*a*) 0 (*b*) 1 (*c*) γ (*d*) ∞
11. If the value of $n = 0$ in the general law $pv^n = C$, then the process is called
    (*a*) isochoric process (*b*) isobaric process
    (*c*) isothermal process (*d*) isentropic process

12. The workdone in a free expansion process is
(*a*) zero (*b*) minimum (*c*) maximum (*d*) positive

13. In a steady flow process,
(*a*) the mass flow rate is constant (*b*) the heat transfer rate is constant
(*c*) the work transfer rate is constant (*d*) all of the above

14. The workdone in steady flow process is given by
(*a*) $\int_1^2 p\,dv$ (*b*) $-\int_1^2 p\,dv$ (*c*) $\int_1^2 v\,dp$ (*d*) $-\int_1^2 v\,dp$

15. The throttling process is a
(*a*) non-flow process (*b*) steady flow process
(*c*) non-steady flow process

ANSWERS

1. (*c*)	2. (*b*)	3. (*a*)	4. (*a*)	5. (*c*)
6. (*c*)	7. (*b*)	8. (*d*)	9. (*d*)	10. (*b*)
11. (*b*)	12. (*a*)	13. (*d*)	14. (*d*)	15. (*b*)

10. Derive an expression for the approximate heat absorbed by a gas when heated from an absolute temperature T_1 to T_2 and an initial entropy of S_1 to S_2.

OBJECTIVE TYPE QUESTIONS

1. The heat absorbed or rejected by the working substance is given by

(*a*) $\delta Q = TdS$ (*b*) $\delta Q = T/dS$ (*c*) $\delta Q = dS/T$

where δQ = Heat absorbed or rejected,

dS = Increase or decrease of entropy, and

T = Absolute temperature.

2. The property of a working substance which increases or decreases as the heat is supplied or removed in a reversible manner, is known as

(*a*) enthalpy (*b*) internal energy (*c*) entropy (*d*) external energy

3. The entropy may be expressed as a function of

(*a*) pressure and temperature (*b*) temperature and volume

(*c*) heat and work (*d*) all of these

4. The entropy of water at 0° C is assumed to be

(*a*) 1 (*b*) 0 (*c*) – 1 (*d*) 10

5. The change of entropy when heat is absorbed by the gas is

(*a*) positive (*b*) negative (*c*) positive or negative

ANSWERS

1. (*a*) 2. (*c*) 3. (*a*) 4. (*b*) 5. (*a*)

(*c*) Boltzmann's constant, absolute temperature and mass of a gas molecule.

(*d*) Characteristic gas constant and absolute temperature of the gas.

7. Derive an expression for the average kinetic energy possessed by a gas molecule.

8. Derive the following gas laws as per kinetic theory of gases :

(*a*) Boyle's law, (*b*) Charles' law, (*c*) Gay-Lussac law, (*d*) Perfect gas equation, and (*e*) Avogadro's law.

9. What is meant by degrees of freedom possessed by a body ?

10. State the law of equipartition of energy. What is the amount of energy associated with each degree of freedom ?

OBJECTIVE TYPE QUESTIONS

1. The velocity of molecules

(*a*) increases with the increase of temperature

(*b*) increases with the decrease of temperature

(*c*) decreases with the increase of temperature

(*d*) remain constant at all temperatures

2. The root mean square velocity of the gas molecules (C) is given by

(*a*) $\sqrt{\frac{3m\,T}{k}}$ (*b*) $\sqrt{\frac{3\,T}{m\,k}}$ (*c*) $\sqrt{\frac{3k\,T}{m}}$ (*d*) $\sqrt{\frac{m\,k}{3T}}$

where m = Mass of one molecule of a gas,

k = Boltzmann's constant, and

T = Absolute temperature.

3. The ratio of root mean square velocity to average velocity of gas molecules at a particular temperature is

(*a*) 0.086 (*b*) 1.086 (*c*) 3.086 (*d*) 4.086

4. The pressure exerted by an ideal gas is ..... of the kinetic energy of all the molecules contained in a unit volume of gas.

(*a*) one-half (*b*) one-third (*c*) two-third (*d*) three-fourth

5. The kinetic energy per kg molecule of any gas at absolute temperature T is equal to

(*a*) $\frac{1}{2} R_u T$ (*b*) $\frac{3}{4} R_u T$ (*c*) $R_u T$ (*d*) $\frac{3}{2} R_u T$

ANSWERS

1. (*a*) 2. (*c*) 3. (*b*) 4. (*c*) 5. (*d*)

3. What are the conditions of reversibility ? Prove that all reversible engines are equally efficient between the same temperature limits.

4. Do you agree with the statement that the conception of thermodynamic reversibility is purely hypothetical ? Explain fully.

5. Prove that the efficiency of the Carnot engine working between the temperature limits T_1 and T_2 is equal to $\frac{T_1 - T_2}{T_1}$, and show that no engine can be more efficient than this when working over the same temperature range.

6. Derive an expression for the efficiency of a Stirling air engine with the aid of *p-v* and *T-S* diagrams.

7. Deduce an expression for thermal efficiency of Joule's air engine and show that it is less than Carnot efficiency.

8. Explain briefly Otto cycle with the help of *p-v* and *T-S* diagram, and derive an expression for the ideal efficiency of Otto cycle.

9. Show that the efficiency of Otto cycle is a function of compression ratio only.

10. Explain briefly the Diesel cycle with the help of *p-v* and *T-S* diagrams and derive an expression for the ideal efficiency of a Diesel cycle.

11. For a given compression ratio ; the air standard Diesel cycle is less efficient than air standard Otto cycle. Explain.

12. Derive an expression for the ideal efficiency of dual combustion cycle, using ideal air as the working fluid.

OBJECTIVE TYPE QUESTIONS

1. Carnot cycle consists of
   (*a*) two constant volume and two reversible adiabatic processes
   (*b*) two isothermal and two reversible adiabatic processes
   (*c*) two constant pressure and two reversible adiabatic processes
   (*d*) one constant volume, one constant pressure and two reversible adiabatic processes
2. The efficiency of Carnot cycle may be increased by
   (*a*) increasing the highest temperature (*b*) decreasing the highest temperature
   (*c*) increasing the lowest temperature (*d*) decreasing the lowest temperature
3. A cycle consisting of two constant volume and two isothermal processes is known as
   (*a*) Carnot cycle (*b*) Joule cycle (*c*) Diesel cycle (*d*) Stirling cycle
4. The efficiency of Ericsson cycle is .....Carnot cycle.
   (*a*) greater than (*b*) less than (*c*) equal to
5. Otto cycle is also known as
   (*a*) constant pressure cycle (*b*) constant volume cycle
   (*c*) constant temperature cycle (*d*) constant entropy cycle
6. For the same compression ratio, the efficiency of Diesel cycle is ..... Otto cycle.
   (*a*) greater than (*b*) less than (*c*) equal to
7. The efficiency of Diesel cycle approaches to Otto cycle efficiency when
   (*a*) cut-off is increased (*b*) cut-off is decreased
   (*c*) cut-off is zero (*d*) cut-off is constant

8. The air standard efficiency of an Otto cycle is given by

(*a*) $1 - \frac{1}{r^{\gamma-1}}$ (*b*) $1 + \frac{1}{r^{\gamma-1}}$ (*c*) $1 - r^{\gamma-1}$ (*d*) $1 + r^{\gamma-1}$

9. The efficiency of the dual combustion cycle, for the same compression ratio, is .... Diesel cycle.

(*a*) greater than (*b*) less than (*c*) equal to

10. For the same maximum pressure and temperature of Otto, Diesel and dual combustion air standard cycles,

(*a*) the compression ratios will be same

(*b*) the heat supplied to the cycles will be same

(*c*) the air standard efficiency will have the same value

(*d*) the heat rejected by the engine will be the same

ANSWERS

1. (*b*)	2. (*b*)	3. (*d*)	4. (*c*)	5. (*b*)
6. (*b*)	7. (*b*)	8. (*a*)	9. (*a*)	10. (*d*)

9. Two boilers, one with a superheater and the other without a superheater are delivering equal quantities of steam into a common mains. The pressure in the boiler and the mains is 14.7 bar. The temperature of steam from the boiler with superheater is 325° C and that of steam mains 250° C. Estimate the quality of steam supplied by the other boiler. **[Ans.** 0.97]

10. Steam for a small boiler is discharged through a pipe into a barrel containing water and after a few minutes, observations were taken of the mass and temperature of the water. From the collected data given below, calculate the dryness fraction of the steam.

Mass of empty barrel = 25 kg ; Mass of barrel + cold water = 135 kg ; Mass of barrel + cold water + steam = 140 kg ; Initial temperature of water = 15° C ; Final temperature of water = 42° C ; Steam pressure = 8 bar ; Specific heat of the material of barrel = 0.4 kJ/kg K **[Ans.** 0.96]

11. In an experiment, it was found that the steam enters a throttling calorimeter at a pressure of 12.25 bar. After throttling, the pressure and temperature was measured as 1.013 bar and 115° C respectively. Estimate the dryness fraction of steam. **[Ans.** 0.96]

12. In a combined separating and throttling calorimeter, the following observations were made :

Total quantity of steam = 23.4 kg ; Water drained from separator = 1.2 kg ; Steam pressure before throttling = 8.25 bar ; Temperature of steam on leaving = 111.4° C ; Steam pressure on leaving = 1.013 bar.

Find the dryness fraction of steam on entry. Specific heat of superheated steam is 2 kJ/kg K. **[Ans.** 0.92]

QUESTIONS

1. What is meant by saturation temperature and saturation pressure ?
2. Explain how the wet steam, dry saturated steam and superheated steam is produced.
3. Define the following terms :
   (*i*) Sensible heat of water ; (*ii*) Latent heat of vaporisation ;
   (*iii*) Total heat of steam ; (*iv*) Dryness fraction of steam ; and
   (*v*) Volume of superheated steam.
4. List out the advantages of superheated steam.
5. Derive an expression for the external work done during evaporation :
   (*i*) when the steam is wet ; (*ii*) when the steam is dry ; and
   (*iii*) when the steam is superheated.
6. What is meant by the internal energy of steam ?

OBJECTIVE TYPE QUESTIONS

1. Water at standard atmospheric conditions
   (*a*) behaves as an ideal gas (*b*) is mostly liquid
   (*c*) is far above its critical state (*d*) is far below its critical state
2. The locus of saturated liquid line and saturated vapour line meets at
   (*a*) boiling point (*b*) critical point (*c*) ice point (*d*) triple point
3. For steam
   (*a*) the critical temperature is 221.2° C and critical pressure is 374.15 bar
   (*b*) the critical temperature is 374.15° C and critical pressure is 221.2 bar
   (*c*) the critical temperature is 221.2° C and critical pressure is 221.2 bar
   (*d*) the critical temperature is 374.15° C and critical pressure is 374.15 bar
4. The latent heat of steam at atmospheric pressure is
   (*a*) 1535 kJ/kg (*b*) 1875 kJ/kg (*c*) 2257 kJ/kg (*d*) 2685 kJ/kg
5. With the increase in pressure
   (*a*) the boiling point of water decreases and enthalpy of evaporation increases

(*b*) the boiling point of water increases and enthalpy of evaporation decreases

(*c*) both the boiling point of water and the enthalpy of evàporation decreases

(*d*) both the boiling point of water and the enthalpy of evaporation increases.

6. The dryness fraction of steam is equal to

(*a*) $\frac{m_g}{m_g + m_f}$ (*b*) $\frac{m_f}{m_g + m_f}$ (*c*) $\frac{m_g}{m_f}$ (*d*) $\frac{m_f}{m_g}$

where m_g = Mass of dry steam, and

m_f = Mass of water in suspension.

7. The specific volume of water when heated from 0° C

(*a*) increases steadily (*b*) decreases steadily

(*c*) first decreases and then increases (*d*) first increases and then decreases

8. The enthalpy of dry saturated steam. . . . . .with the increase in pressure.

(*a*) decreases (*b*) increases (*c*) remains constant

9. The amount of heat absorbed to evaporate 1 kg of water from its saturation temperature, without change of temperature, is called

(*a*) sensible heat of water (*b*) latent heat of vaporisation

(*c*) enthalpy of steam (*d*) entropy of steam

10. The internal energy (u) of a dry steam is given by

(*a*) $u = h_g + 100\, p\, v_g$ (*b*) $u = h_g - 100\, p\, v_g$

(*c*) $u = h_g / 100\, p\, v_g$ (*d*) $u = 100\, p\, v_g / h_g$

where h_g = Enthalpy of 1 kg of dry steam in kJ/kg,

p = Pressure of steam in bar, and

v_g = Specific volume of 1 kg of dry steam in m^3/kg.

ANSWERS

1. (*d*) 2. (*b*) 3. (*b*) 4. (*c*) 5. (*b*)
6. (*a*) 7. (*c*) 8. (*a*) 9. (*b*) 10. (*b*)

OBJECTIVE TYPE QUESTIONS

1. The entropy of water at 0° C is

(*a*) 0 (*b*) 1 (*c*) 2.3 (*d*) 4.2

2. When water is heated from the freezing point to the boiling point, then the increase in entropy is given by

(*a*) $c_w \log (273)$ (*b*) $c_w \log (T)$ (*c*) $c_w \log_e \left(\frac{T}{273} \right)$ (*d*) $c_w \log_e \left(\frac{273}{T} \right)$

where c_w = Specific heat of water, and

T = Boiling temperature in K.

3. The entropy of dry steam (s_g) is given by

(*a*) $s_f + \frac{T}{h_{fg}}$ (*b*) $s_f + \frac{h_{fg}}{T}$ (*c*) $s_f - \frac{T}{h_{fg}}$ (*d*) $s_f - \frac{h_{fg}}{T}$

where s_f = Entropy of water,

T = Absolute temperature, and

h_{fg} = Latent heat of vaporisation.

4. When dry steam at a temperature T is heated upto a temperature of superheated steam (T_{sup}), then the increase in entropy ($s_{sup} - s_g$) is given by

(*a*) $c_p \log_e \left(\frac{T_{sup}}{T} \right)$ (*b*) $2.3\, c_p \log_e \left(\frac{T_{sup}}{T} \right)$

(*c*) $c_p \log_e \left(\frac{T}{T_{sup}} \right)$ (*d*) $2.3\, c_p \log_e \left(\frac{T}{T_{sup}} \right)$

where c_p = Specific heat of superheatedsteam.

5. The isentropic process, on the Mollier diagram, is represented by a

(*a*) horizontal line (*b*) vertical line (*c*) inclined line (*d*) curve

6. The throttling process, on the *h*-*s* diagram, will be a

(*a*) horizontal line (*b*) vertical line (*c*) inclined line (*d*) curve

ANSWERS

1. (*a*) 2. (*c*) 3. (*b*) 4. (*a*) 5. (*b*)
6. (*a*)

17. Dry saturated steam at a pressure of 11 bar expands polytropically according to $pv^{1.13}$ = constant to a pressure of 1 bar. Determine 1. the final condition of steam ; 2. the amount of heat transferred per kg of steam ; and 3. the change of entropy. [**Ans.** 0.874 ; 325.7 kJ/kg ; 0.075 kJ/kg K]

18. Steam at a pressure of 15 bar and 250° C expands according to $p\,v^{1.25}$ = constant, to a pressure of 1.5 bar. Find 1. the final condition of steam ; 2. the workdone ; 3. the heat transferred ; and 4. change in entropy. [**Ans.** 0.827 ; 336 kJ/kg ; – 195 kJ/kg ; – 0.487 kJ/kg K]

19. Steam is throttled from a pressure of 11.5 bar to a pressure 1.4 bar. If the steam is dry saturated at the end of expansion, what is its dryness fraction at the beginning ? By how much is the entropy of the steam increased by throttling ? [**Ans.** 0.954 ; 0.912 kJ/kg K]

20. Steam at a pressure of 10 bar and 200° C is throttled to a pressure of 3 bar and then expanded isentropically to a pressure of 0.5 bar. By using Mollier chart, find out the change in entropy and enthalpy during these two processes. Also find the quality of steam at the end of each process. [**Ans.** 0.54 kJ/kg K, 0 ; 0, – 300 kJ/kg ; 184° C, 0.94]

QUESTIONS

1. Show that the heat supplied is equal to the change of internal energy, when steam is expanded at a constant volume.

2. Is the expansion of superheated steam isothermal ? If not, state the reason.

3. Prove that during expansion of steam according to $pv = C$, the change in internal energy is equal to the change in total heat of steam.

4. What are the characteristics of adiabatic expansion ?

5. Find the amount of heat absorbed or rejected through the cylinder walls when the steam expands polytropically.

6. Explain throttling process of steam.

7. Show the throttling expansion of steam on a *h-s* plane.

OBJECTIVE TYPE QUESTIONS

1. In a constant volume process, heat transferred is equal to

(*a*) workdone (*b*) change in internal energy

(*c*) change in enthalpy (*d*) none of these

2. The process in which heat transferred is equal to the change of enthalpy, is known as

(*a*) constant pressure process (*b*) constant volume process

(*c*) constant temperature process (*d*) constant entropy process

3. The heating of wet steam at a constant temperature till it becomes dry saturated is similar to that of heating at a

(*a*) constant volume (*b*) constant pressure

(*c*) constant entropy (*d*) none of these

4. The superheating of steam at ..... may be regarded as hyperbolic.
   (*a*) constant volume (*b*) constant pressure
   (*c*) constant entropy (*d*) constant temperature

5. In an isentropic process,
   (*a*) workdone is zero (*b*) change in internal energy is zero
   (*c*) change in entropy is zero (*d*) change in enthalpy is zero

6. The non-flow process, in which the workdone is equal to the change in internal energy, is known as
   (*a*) isentropic process (*b*) isothermal process
   (*c*) isobaric process (*d*) isochroic process

7. In a steady flow reversible adiabatic process, workdone is equal to
   (*a*) change in internal energy (*b*) change in entropy
   (*c*) change in enthalpy (*d*) heat transferred

8. The isentropic process on *h-s* diagram will be a
   (*a*) vertical line (*b*) horizontal line (*c*) curve

9. In a throttling process ..... remains constant.
   (*a*) enthalpy (*b*) temperature (*c*) entropy

10. The throttling process on *h-s* diagram will be a
   (*a*) vertical line (*b*) horizontal line (*c*) curve

ANSWERS

1. (*b*) 2. (*a*) 3. (*b*) 4. (*d*) 5. (*c*)
6. (*a*) 7. (*c*) 8. (*a*) 9. (*a*) 10. (*b*)

draw the mechanical system to show different processes of the Rankine cycle.

4. Draw the Rankine cycle on *T-s* diagram using dry saturated steam and obtain an expression for the Rankine cycle efficiency.

5. Describe briefly the Rankine cycle using superheated steam and show in what respect this cycle differs from Carnot cycle between the same temperatures.

6. Prove that the efficiency of a Rankine cycle using superheated steam is greater than the efficiency of a corresponding Rankine cycle using steam without superheat. Both the cycles operate between the same boiler and condenser pressure limits.

7. State the reasons for modifying the Rankine cycle for operation of steam engines.

8. Explain with the help of *p-v* and *T-s* diagrams, the sequence of operations in the modified Rankine cycle.

OBJECTIVE TYPE QUESTIONS

1. The ideal cycle on which a steam engine works, is
   (*a*) Carnot cycle (*b*) Rankine cycle (*c*) Otto cycle (*d*) Joule cycle
2. Rankine cycle comprises
   (*a*) two isothermal and two isentropics (*b*) two isobarics and two isothermals
   (*c*) two isobarics and two isentropics (*d*) two isothermals and two isochorics
3. The Rankine cycle, as compared to Carnot cycle, has ..... work ratio,
   (*a*) high (*b*) low
4. In a Rankine cycle with superheated steam,
   (*a*) the workdone increases
   (*b*) the dryness fraction of steam after isentropic expansion increases
   (*c*) the specific steam consumption decreases
   (*d*) all of the above
5. In the operation of steam engines, the vapour cycle adopted is
   (*a*) Carnot cycle (*b*) Rankine cycle
   (*c*) modified Rankine cycle (*d*) Regenerative cycle

ANSWERS

1. (*b*) 2. (*c*) 3. (*a*) 4. (*d*) 5. (*c*)

Initial temperature of water = 170 g
Final temperature of water = 23.3° C
Determine the calorific value of the sample of the coal. = 26.2° C

4. A bomb calorimeter is used to determine the calorific value of a sample of coal and the following results are obtained : [Ans. 14 494 kJ/kg]

Mass of coal burnt = 1 g
Mass of water in the calorimeter = 2.5 kg
Water equivalent of the apparatus = 0.75 kg
Initial temperature of water = 17.5° C
Maximum observed temperature of water = 20° C
Cooling correction = + 0.015° C
If the fuel contains 4% of hydrogen, find the lower calorific value of the fuel. [Ans. 33 442 kJ/kg]

5. The following observations were made during a test on coal gas :

Volume of gas used = 0.06 m^3
Mass of cooling water circulated = 9.3 kg
Mass of condensed steam collected = 0.009 kg
Rise in temperature of cooling water = 6.3° C
Pressure of gas tested above atmosphere = 45 mm of water
Temperature of gas tested = 14° C
Barometric pressure = 750 mm of Hg
Calculate the higher and lower calorific values at N.T.P. [Ans. 4581 kJ/m^3 ; 4189 kJ/m^3

QUESTIONS

1. What is meant by the term fuel ? What are its constituents ?
2. List out the merits and demerits of liquid fuels over solid fuels.
3. What are the advantages of gaseous fuels ?
4. Define the calorific value of a solid fuel and also that of a gaseous fuel.
5. Distinguish between higher and lower calorific value of a fuel.
6. Explain, briefly, the method used to determine the higher calorific value of the liquid fue

OBJECTIVE TYPE QUESTIONS

1. The principal constituents of a fuel are

(*a*) carbon and hydrogen
(*b*) oxygen and hydrogen
(*c*) sulphur and oxygen
(*d*) sulphur and hydrogen

2. The fuel mostly used in boilers is
(*a*) brown coal (*b*) peat
(*c*) caking bituminous coal (*d*) non-caking bituminous coal

3. Which of the following fuel has the highest calorific value ?
(*a*) Peat (*b*) Coke
(*c*) Bituminous coal (*d*) Anthracite coal

4. The fuel mostly used in blast furnace for extracting pig iron from iron ores is
(*a*) hard coke (*b*) soft coke
(*c*) pulverised coal (*d*) bituminous coal

5. Steam coal is a
(*a*) pulverised coal (*b*) brown coal
(*c*) caking bituminous coal (*d*) non-caking bituminous coal

6. A process of heating crude oil to a high temperature under a very high pressure to increase the yield of lighter distillates, is known as
(*a*) cracking (*b*) carbonisation
(*c*) fractional distillation (*d*) full distillation

7. Petrol is distilled at
(*a*) 65° to 220° C (*b*) 220° to 345° C (*c*) 345° to 470° C (*d*) 470° to 550° C

8. Which of the following gas has the highest calorific value ?
(*a*) Producer gas (*b*) Coal gas (*c*) Mond gas (*d*) Blast furnace gas

9. A bomb calorimeter is used for finding the . . . calorific value of solid and liquid fuels.
(*a*) higher (*b*) lower

10. Which of the following statement is incorrect ?
(*a*) The liquid fuels consist of hydrocarbons.
(*b*) The liquid fuels have higher calorific value than solid fuels.
(*c*) The solid fuels have higher efficiency than liquid fuels.
(*d*) A good fuel should have low ignition point.

ANSWERS

1. (*a*)	2. (*d*)	3. (*c*)	4. (*a*)	5. (*d*)
6. (*a*)	7. (*a*)	8. (*b*)	9. (*a*)	10. (*c*)

4. Give chemical reactions and numerical values for estimating the air requirement for complete combustion of coal.
5. Lay down the procedure for determination of minimum air required for complete combustion of coal.
6. Sketch and explain the use of Orsat apparatus used in determining the percentage of flue or exhaust gases. Does this help in controlling combustion ?

OBJECTIVE TYPE QUESTIONS

1. The smallest quantity of a substance, which can exist by itself in a chemically recongnizable form is known as
   (*a*) element (*b*) compound (*c*) atom (*d*) molecule
2. The molecular mass of oxygen is
   (*a*) 12 (*b*) 14 (*c*) 16 (*d*) 32
3. The molecular mass of nitrogen is ..... oxygen.
   (*a*) equal to (*b*) less than (*c*) more than
4. Which of the following has minimum molecular mass ?
   (*a*) Oxygen (*b*) Nitrogen (*c*) Hydrogen (*d*) Water
5. One kg of carbon monoxide (CO) requires 4/7 kg of oxygen and produces
   (*a*) 11/3 kg of CO_2 (*b*) 7/3 kg of CO (*c*) 11/7 kg of CO_2 (*d*) 8/3 kg of CO
6. One kg of carbon requires ..... of oxygen and produces 7/3 kg of carbon monoxide.
   (*a*) 4/3 (*b*) 7/3 (*c*) 8/3 (*d*) 11/3
7. One kg of ethylene (C_2H_4) requires 2 kg of oxygen and produces 22/7 kg of carbon dioxide and
   (*a*) 9/7 kg of water (*b*) 11/7 kg of water
   (*c*) 7/4 kg of water (*d*) 11/4 kg of water
8. The mass of carbon per kg of flue gas is given by
   (*a*) $\frac{3}{11}CO_2 + \frac{3}{7}CO$ (*b*) $\frac{3}{7}CO_2 + \frac{11}{3}CO$
   (*c*) $\frac{7}{3}CO_2 + \frac{3}{11}CO$ (*d*) $\frac{3}{11}CO_2 + \frac{7}{3}CO$
9. The mass of flue gas per kg of fuel is the ratio of the
   (*a*) mass of oxygen in 1 kg of flue gas to the mass of oxygen in 1 kg of fuel
   (*b*) mass of oxygen in 1 kg of fuel to the mass of oxygen in 1 kg of flue gas
   (*c*) mass of carbon in 1 kg of flue gas to the mass of carbon in 1 kg of fuel
   (*d*) mass of carbon in 1 kg of fuel to the mass of carbon in 1 kg of flue gas
10. The mass of excess air supplied is equal to
   (*a*) $\frac{23}{100}$ × Mass of excess carbon (*b*) $\frac{23}{100}$ × Mass of excess oxygen
   (*c*) $\frac{100}{23}$ × Mass of excess carbon (*d*) $\frac{100}{23}$ × Mass of excess oxygen

ANSWERS

1. (*a*) 2. (*d*) 3. (*b*) 4. (*c*) 5. (*c*)
6. (*a*) 7. (*a*) 8. (*a*) 9. (*c*) 10. (*d*)

6. Explain with a neat sketch the working of a La-Mont boiler.
7. Describe with a neat line sketch of a Benson boiler mentioning its distinguishing features. State the advantages for this type of boilers.
8. What are the differentiating features between a water tube and a fire tube boiler ?

OBJECTIVE TYPE QUESTIONS

1. The water tubes in a simple vertical boiler are
   (*a*) horizontal (*b*) vertical (*c*) inclined
2. Lancashire boiler is a
   (*a*) stationary fire tube boiler (*b*) internally fired boiler
   (*c*) horizontal boiler (*d*) natural circulation boiler
   (*e*) all of the above (*f*) none of the above
3. The diameter of internal flue tubes of a Lancashire boiler is about .... that of its shell.
   (*a*) one-fourth (*b*) one-third (*c*) two-fifth (*d*) one-half
4. Locomotive boiler is a
   (*a*) single tube, horizontal, internally fired and stationary boiler
   (*b*) single tube, vertical, externally fired and stationary boiler
   (*c*) multi-tubular, horizontal, internally fired and mobile boiler
   (*d*) multi-tubular, horizontal, externally fired and stationary boiler
5. Which of the following is a water tube boiler ?
   (*a*) Lancashire boiler (*b*) Babcock and Wilcox boiler
   (*c*) Locomotive boiler (*d*) Cochran boiler
6. In fire tube boilers
   (*a*) water passes through the tubes which are surrounded by flames and hot gases
   (*b*) the flames and hot gases pass through the tubes which are surrounded by water
   (*c*) forced circulation takes place
   (*d*) none of the above
7. Which of the following boiler is best suited to meet the fluctuating demand of steam ?
   (*a*) Locomotive boiler (*b*) Lancashire boiler
   (*c*) Cornish boiler (*d*) Babcock and Wilcox boiler
8. Water tube boilers produce steam at a ..... pressure than that of fire tube boilers.
   (*a*) lower (*b*) higher
9. The locomotive boiler has
   (*a*) 137 fire tubes and 44 superheated tubes
   (*b*) 147 fire tubes and 34 superheated tubes
   (*c*) 157 fire tubes and 24 superheated tubes
   (*d*) 167 fire tubes and 14 superheated tubes
10. La-Mont boiler, is a ..... pressure water tube steam boiler working on forced circulation.
    (*a*) low (*b*) high

ANSWERS

1. (*c*) 2. (*e*) 3. (*c*) 4. (*c*) 5. (*b*)
6. (*b*) 7. (*a*) 8. (*b*) 9. (*c*) 10. (*b*)

14.18. Air Preheater

An air preheater is used to recover heat from the exhaust flue gases. It is installed between the economiser and the chimney. The air required for the purpose of combustion is drawn through the air preheater where its temperature is raised. It is then passed through ducts to the furnace. The air is passed through the tubes of the heater internally while the hot flue gases are passed over the outside of the tubes.

The following advantages are obtained by using an air preheater :

1. The preheated air gives higher furnace temperature which results in more heat transfer to the water and thus increases the evaporative capacity per kg of fuel.
2. There is an increase of about 2% in the boiler efficiency for each 35-40° C rise in temperature of air.
3. It results in better combustion with less soot, smoke and ash.
4. It enables a low grade fuel to be burnt with less excess air.

QUESTIONS

1. Describe with a neat sketch, water level indicator for a boiler.
2. Explain how the flow of steam of water is automatically stopped when the glass tube breaks.
3. Why the safety valves are needed in a boiler ? Sketch and describe a Ramsbottom spring loaded safety valve.
4. Differentiate between lever safety valve and dead weight safety valve.
5. What is the purpose of a steam stop valve ? Explain its working.
6. Explain the functions of blow off cock and feed check valve.
7. What is the function of a superheater ? Describe Sugden's superheater.
8. Discuss, briefly, the working of an economiser in a boiler plant giving a neat sketch.
9. Explain why air preheaters are used in a high pressure boiler.

OBJECTIVE TYPE QUESTIONS

1. A device attached to the steam chest for preventing explosions due to excessive internal pressure of steam is called

(*a*) safety valve
(*b*) water level indicator
(*c*) pressure gauge
(*d*) fusible plug

2. A safety valve mainly used with locomotive and marine boilers is
(*a*) lever safety valve (*b*) high pressure and low water safety valve
(*c*) dead weight safety valve (*d*) spring loaded safety valve

3. A device used in a boiler to control the flow of steam from the boiler to the main pipe and to shut off the steam completely when required, is known as
(*a*) blow off cock (*b*) fusible plug (*c*) stop valve (*d*) economiser

4. A device used to put off fire in the furnace of the boiler when the level of water in the boiler falls to an unsafe limit, is called
(*a*) blow off cock (*b*) fusible plug (*c*) superheater (*d*) economiser

5. A device used to increase the temperature of saturated steam without raising its pressure, is called
(*a*) blow off cock (*b*) fusible plug (*c*) superheater (*d*) economiser

6. A device used to heat feed water by utilising the heat in the exhaust flue gases before leaving through the chimney, is known as
(*a*) superheater (*b*) economiser (*c*) blow off cock (*d*) stop valve

7. Which of the following are boiler accessories ?
(*a*) safety valve (*b*) pressure gauge (*c*) superheater (*d*) economiser
(*e*) both (*a*) and (*b*) (*f*) both (*c*) and (*d*)

8. An economiser ..... the steam raising capacity of a boiler.
(*a*) increases (*b*) decreases (*c*) has no effect on

9. The pressure of feed water has to be raised before its entry into the boiler. The pressure is raised by a device known as
(*a*) feed check valve (*b*) feed pump (*c*) pressure gauge (*d*) injector

10. An air preheater
(*a*) increases evaporative capacity of the boiler
(*b*) increases the efficiency of the boiler
(*c*) enables low grade fuel to be burnt
(*d*) all of the above

ANSWERS

1. (*a*)	2. (*d*)	3. (*c*)	4. (*b*)	5. (*c*)
6. (*b*)	7. (*f*)	8. (*a*)	9. (*b*)	10. (*d*)

QUESTIONS

1. What do you understand by the evaporative capacity of a boiler ?
2. Explain clearly the equivalent evaporation from and at 100° C.
3. Discuss briefly the term boiler efficiency.
4. Enlist the various heat losses in a boiler. Which is the biggest loss ?
5. Draw the heat balance sheet of a boiler.

OBJECTIVE TYPE QUESTIONS

1. The equivalent evaporation is defined as the
   (*a*) ratio of heat actually used in producing the steam to the heat liberated in the furnace
   (*b*) amount of water evaporated or steam produced in kg per kg of fuel burnt.
   (*c*) amount of water evaporated 'from and at 100° C' into dry and saturated steam
   (*d*) none of the above

2. When the enthalpy or total heat of steam is h kJ/kg and the enthalpy or sensible heat of feed water is h_{f1} kJ/kg, then the factor of evaporation is given by

   (*a*) $\frac{h - h_{f1}}{2257}$ (*b*) $\frac{h + h_{f1}}{2257}$ (*c*) $\frac{h \times h_{f1}}{2257}$ (*d*) $\frac{h}{h_{f1} \times 2257}$

3. The amount of water evaporated in kg per kg of fuel burnt is called
   (*a*) equivalent evaporation 'from and at 100° C'
   (*b*) evaporative capacity of a boiler
   (*c*) boiler efficiency
   (*d*) none of the above

4. The ratio of heat actually used in producing the steam to the heat liberated in the furnace is called
   (*a*) equivalent evaporation 'from and at 100° C'
   (*b*) evaporative capacity of a boiler
   (*c*) boiler efficiency
   (*d*) none of the above

5. In a boiler, various heat losses take place. The biggest loss is due to
   (*a*) moisture in fuel (*b*) dry flue gases (*c*) steam formation (*d*) unburnt carbon

ANSWERS

1. (*c*) 2. (*a*) 3. (*b*) 4. (*c*) 5. (*b*)

estimate : 1. Draught in mm of water , and 2. Velocity of flue gases passing through the chimney with 50% loss of draught in friction. [Ans. 13.24 mm of water ; 14 m/s]

7. A chimney 30 m high is full of hot gases at a temperature of 307° C. The air required for the complete combustion of 1 kg of fuel is 18 kg. If the temperature of atmospheric air is 27° C, find the draught : 1. in terms of water column, and 2. in terms of column of hot gases. [Ans. 16 mm of water ; 25 m]

8. A chimney has a height of 60 metres. The temperature of air is 27° C. Find the draught in mm of water when the temperature of chimney gases is such as to cause the mass of these gases discharged in a given time to be maximum. [Ans. 35.3 mm of water]

9. Calculate the efficiency of chimney from the following data :

Temperature of flue gases with natural draught = 350° C ; Temperature of waste gases with artificial draught = 150° C ; Temperature of atmospheric air = 38° C ; Amount of air supplied/kg of fuel = 20 kg ; Height of chimney = 40 m ; Specific heat of flue gases = 1.005 kJ/kg K. [Ans. 0.177%]

QUESTIONS

1. What is the significance of draught in boiler practice ?
2. What are the functions of a boiler chimney ? Why is no chimney provided on a locomotive boiler ?
3. Describe briefly various types of artificial draught system used in steam boilers indicating their main advantages.
4. Explain the terms forced draught, induced draught and balanced draught.
5. What are the advantages of artificial draught system over natural draught system ?
6. Deduce a relation for the calculation of natural draught in a boiler plant and state the parameters on which the draught depends.
7. Prove that for maximum mass of hot gases discharged through the chimney,

$$\frac{T_2}{T_1} = \frac{2\,(m+1)}{m}$$

where T_1 = Absolute temperature of cold air,

T_2 = Absolute temperature of hot air, and

m = Mass of air supplied in kg/kg of fuel.

8. Show that under maximum discharge conditions, the draught produced in terms of hot gas column is equal to the height of chimney.
9. What is the relation between draught pressure (h), height of chimney (H) and absolute temperature of outside air (T_1), when the discharge of hot gases is maximum.
10. Deduce an expression for the power required to drive (a) a forced draught fan, and (b) an induced draught fan.
11. Define efficiency of chimney and write the expression to calculate the same.

OBJECTIVE TYPE QUESTIONS

1. The air pressure at the fuel bed is reduced below that of atmosphere by means of a fan placed at or near the bottom of the chimney to produce a draught. Such a draught is called

(a) natural draught (b) induced draught

(c) forced draught (d) balanced draught

2. The draught may be produced by a

(a) mechanical fan (b) chimney (c) steam jet (d) all of these

3. The draught in locomotive boilers is produced by a
   (*a*) chimney (*b*) centrifugal fan (*c*) steam jet (*d*) none of these
4. The draught produced by a steam jet issuing from a nozzle placed in the chimney, is called
   (*a*) induced steam jet draught (*b*) forced steam jet draught
   (*c*) chimney draught (*d*) none of these
5. The chimney draught varies with
   (*a*) climatic conditions (*b*) temperature of furnace gases
   (*c*) height of chimney (*d*) all of these
6. The mechanical draught produces ..... draught than natural draught.
   (*a*) more (*b*) less
7. The mechanical draught ..... the amount of smoke.
   (*a*) increases (*b*) decreases (*c*) does not effect
8. The efficiency of the plant ..... with the mechanical draught.
   (*a*) increases (*b*) decreases (*c*) remains constant
9. The velocity of flue gases (V) through the chimney under a static draught of H' metres is given by
   (*a*) $4.43\ H'$ (*b*) $4.43\ \sqrt{H'}$ (*c*) $(4.43\ H')^2$ (*d*) $4.43\ (H')^2$
10. Which of the following statement is wrong ?
   (*a*) The mechanical draught reduces the height of chimney.
   (*b*) The natural draught reduces the fuel consumption.
   (*c*) A balanced draught is a combination of induced and forced draught.
   (*d*) all of the above
   (*e*) none of the above

ANSWERS

1. (*b*)	2. (*d*)	3. (*c*)	4. (*a*)	5. (*d*)
6. (*a*)	7. (*b*)	8. (*a*)	9. (*b*)	10. (*b*)

6. Discuss, with the help of pressure-volume diagram, the effect of clearance and compression on the workdone per stroke in a steam engine.
7. What is diagram factor ? State the reasons why its value is less than unity.
8. Differentiate between indicated power and brake power of a steam engine.
9. Describe the effect of piston rod in a double acting steam engine.
10. Explain the method of measuring brake power of a steam engine.

OBJECTIVE TYPE QUESTIONS

1. All steam engines work on
   (*a*) Zeroth law of thermodynamics (*b*) first law of thermodynamics
   (*c*) second law of thermodynamics (*d*) none of these
2. A single acting steam engine produces ..... power than that of double acting steam engine.
   (*a*) half (*b*) double (*c*) four times
3. The function of a D-slide valve in a steam engine is
   (*a*) to guide motion of the piston rod and prevent it from bending
   (*b*) to transfer motion from the piston to the crosshead
   (*c*) to convert heat energy of the steam into mechanical work
   (*d*) to exhaust steam from the cylinder at proper moment
4. The ratio of clearance volume to the swept volume is called
   (*a*) cut-off ratio (*b*) expansion ratio
   (*c*) clearance ratio (*d*) none of these
5. In case of condensing steam engines, the pressure of steam in the cylinder during exhaust stroke is ..... condenser pressure.
   (*a*) equal to (*b*) lower than (*c*) higher than
6. The clearance in the engine cylinder
   (*a*) increases the mean effective pressure (*b*) increases the workdone
   (*c*) decreases the efficiency of the engine (*d*) all of these
7. The diagram factor is the ratio of the
   (*a*) area of the actual indicator diagram to the area of theoretical indicator diagram
   (*b*) actual workdone per stroke to the theoretical workdone per stroke
   (*c*) actual mean effective pressure to the theoretical mean effective pressure
   (*d*) all of the above
8. The average value of diagram factor lies between
   (*a*) 0.2 to 0.5 (*b*) 0.6 to 0.65 (*c*) 0.65 to 0.9 (*d*) 0.9 to 1.2
9. For the same length of stroke and speed of crankshaft, the piston speed for a double acting steam engine is ..... the piston speed of single acting steam engine.
   (*a*) equal to (*b*) twice (*c*) four times
10. The actual power supplied by the engine crankshaft is called
   (*a*) indicated power (*b*) brake power (*c*) frictional power

ANSWERS

1. (*b*)	2. (*a*)	3. (*d*)	4. (*b*)	5. (*c*)
6. (*d*)	7. (*d*)	8. (*c*)	9. (*b*)	10. (*b*)

OBJECTIVE TYPE QUESTIONS

1. In a compound steam engine, the last stage of expansion is carried out in a
   (*a*) low pressure cylinder (*b*) high pressure cylinder
   (*c*) Intermediate pressure cylinder (*d*) none of these
2. By compounding the expansion of steam in two or more cylinders, the ratio of expansion
   (*a*) increases (*b*) decreases (*c*) does not change
3. By compounding the expansion of steam in two or more cylinders, the length of stroke
   (*a*) increases (*b*) decreases (*c*) does not change
4. A compound steam engine requires ..... flywheel than simple steam engine.
   (*a*) lighter (*b*) heavier
5. In a compound steam engine, the diameter of high pressure cylinder is ..... the low pressure cylinder.
   (*a*) equal to (*b*) less than (*c*) greater than
6. In a Tandem type compound steam engine, the high pressure and low pressure cylinders
   (*a*) have common piston rod (*b*) are set at 90°
   (*c*) have separate piston rods (*d*) are set in V-arrangement
7. The high pressure and low pressure cylinders in a Woolf type compound steam engine are regarded as having cranks
   (*a*) 180° to each other (*b*) 90° to each other
   (*c*) 0° to each other (*d*) none of these
8. In a receiver type compound steam engine, the high pressure and low pressure cylinders
   (*a*) have common piston rod (*b*) are set at 90°
   (*c*) have separate piston rods (*d*) are set in V-arrangement
9. A compound steam engine in which the piston rods of high and low pressure cylinders are attached to two different cranks set at 180° to each other, is called
   (*a*) receiver type compound engine (*b*) Woolf type compound engine
   (*c*) Tandem type compound engine (*d*) both (*a*) and (*b*)
10. The high pressure and low pressure cylinders in a receiver type compound steam engine are regarded as having cranks
   (*a*) 180° to each other (*b*) 90° to each other
   (*c*) 0° to each other (*d*) none of these

ANSWERS

1. (*a*)	2. (*b*)	3. (*b*)	4. (*a*)	5. (*b*)
6. (*a*)	7. (*a*)	8. (*c*)	9. (*b*)	10. (*b*)

OBJECTIVE TYPE QUESTIONS

1. There is always some steam left in the clearance space from the previous stroke. This steam left in the clearance space is known as

(*a*) wet steam (*b*) saturated steam (*c*) superheated steam (*d*) cushion steam

2. The missing equality per stroke is equal to

(*a*) cylinder feed – indicated mass of steam

(*b*) cylinder feed + indicated mass of steam

(*c*) mass of cushion steam + indicated mass of steam

(*d*) mass of cushion steam – cylinder feed

3. The throttle governing of steam engines is a method of controlling the engine output by varying

(*a*) volume of intake steam (*b*) pressure of intake steam

(*c*) temperature of intake steam (*d*) all of these

4. Willian's line for a steam engine is a straight line relationship between the steam consumption per hour and

(*a*) indicated power (*b*) brake power (*c*) efficiency (*d*) pressure of steam

5. Wilian's law holds good for ..... governed engine.

(*a*) cut-off (*b*) throttle

ANSWERS

1. (*d*) 2. (*a*) 3. (*b*) 4. (*a*) 5. (*b*)

dryness fraction of steam entering the condenser, and 2. The mass of circulating water per hour.

[**Ans.** 0.965 ; 391 870 kg/h]

15. The following observations refer to a surface condenser :

Mean temperature of condensation = 34.9° C ; Temperature of hot well = 29.7° C ; Condenser vacuum = 701 mm of Hg ; Barometer = 763 mm of Hg ; Mass of cooling water = 45 500 kg/h ; Inlet temperature of cooling water = 16.5° C ; Outlet temperature of cooling water = 30.6° C ; Mass of condensate = 1180 kg/h.

Find : 1. the mass of air present per m^3 of condenser volume ; 2. the state of steam entering the condenser ; and 3. the vacuum efficiency. [**Ans.** 0.03 kg/m^3 ; 0.935 ; 97.24%]

QUESTIONS

1. What are functions of the condenser in a steam plant ?

2. Describe the principle requirements of a steam condensing plant.

3. Explain the principles of operation of different types of jet condensers. Describe with a sketch a low level jet condenser of the counter flow type.

4. Describe with a neat sketch the working of a surface condenser.

5. Compare the merits and demerits of surface condenser over jet condenser.

6. State Dalton's law of partial pressures.

7. What do you understand by the term vacuum efficiency of a condensing plant ? On what factors does this efficiency depend ?

8. Prove with the help of an example that the vacuum efficiency decreases with the increase in barometric pressure.

9. What are the various sources of air leakage into a steam condenser ? How does it affect the performance of the condensing plant ?

10. Explain the construction and working of Edward's air pump.

11. What part is played by a cooling tower ? What are the different types of cooling towers ? Mention advantage and disadvantage of each type.

OBJECTIVE TYPE QUESTIONS

1. A condenser in a steam power plant

(*a*) increases expansion ratio of steam (*b*) reduces back pressure of steam

(*c*) reduces temperature of exhaust steam (*d*) all of these

2. The temperature of condensate is ..... on leaving the condenser than that of circulating water at inlet.

(*a*) higher (*b*) lower

3. A condenser where circulating water flows through tubes which are surrounded by steam, is known as

(*a*) surface condenser (*b*) jet condenser

(*c*) barometric condenser (*d*) evaporative condenser

4. The ratio of actual vacuum to the ideal vacuum in a condenser is called

(*a*) condenser efficiency (*b*) vacuum efficiency

(*c*) boiler efficiency (*d*) nozzle efficiency

5. The actual vacuum in a condenser is equal to

(*a*) barometric pressure + actual pressure (*b*) barometric pressure – actual pressure

(*c*) gauge pressure + atmospheric pressure (*d*) gauge pressure – atmospheric pressure

ANSWERS

1. (*d*) 2. (*a*) 3. (*a*) 4. (*b*) 5. (*b*)

7. Derive an expression for maximum discharge through convergent divergent nozzle for steam.

8. Draw the 'discharge' versus 'ratio of pressures at outlet to inlet' curve for a convergent steam nozzle. Discuss the physical significance of critical pressure ratio.

9. Explain the supersaturated or metastable flow of steam through a nozzle and the significance of Wilson's line.

10. What are the effects of supersaturation on discharge and heat drop ?

OBJECTIVE TYPE QUESTIONS

1. The steam leaves the nozzle at a

(*a*) high pressure and low velocity (*b*) high pressure and high velocity

(*c*) low pressure and low velocity (*d*) low pressure and high velocity

2. The effect of friction in a nozzle ..... dryness fraction of steam.

(*a*) increases (*b*) decreases

3. The velocity of steam leaving the nozzle (V) is given by

(*a*) $V = 44.72\, K\, h_d$ (*b*) $V = 44.72\, K \sqrt{h_d}$

(*c*) $V = 44.72 \sqrt{K\, h_d}$ (*d*) $V = 44.72\, h_d \sqrt{K}$

where K = Nozzle coefficient, and

h_d = Enthalpy drop during expansion.

4. The critical pressure ratio for initially dry saturated steam is

(*a*) 0.528 (*b*) 0.546 (*c*) 0.577 (*d*) 0.582

5. The critical pressure ratio for initially superheated steam is ..... as compared to initially dry saturated steam.

(*a*) more (*b*) less

6. The flow of steam is super sonic

(*a*) at the entrance to the nozzle (*b*) at the throat of the nozzle

(*c*) in the convergent portion of the nozzle (*d*) in the divergent portion of the nozzle

7. The difference of supersaturated temperature and saturation temperature at that pressure is known as

(*a*) degree of supersaturation (*b*) degree of superheat

(*c*) degree of undercooling (*d*) none of these

8. In a nozzle, the effect of supersaturation is to

(*a*) decrease the dryness fraction of steam (*b*) decrease the specific volume of steam

(*c*) increase the entropy (*d*) increase the enthalpy drop

9. The density of supersaturated steam is about .... that of the ordinary saturated vapour at the corresponding pressure.

(*a*) same as (*b*) 2 times (*c*) 4 times (*d*) 8 times

10. When the back pressure of a nozzle is below the designed value of pressure at exit of nozzle, the nozzle is said to be

(*a*) choked (*b*) under damping (*c*) over damping

ANSWERS

1. (*d*)	2. (*a*)	3. (*c*)	4. (*c*)	5. (*b*)
6. (*d*)	7. (*c*)	8. (*c*)	9. (*d*)	10. (*b*)

5. The steam enters an impulse wheel having a nozzle angle of 20° at a velocity of 450 m/s. The exit angle of the moving blade is 20° and the relative velocity of the steam may be assumed to remain constant over the moving blades. If the blade speed is 180 m/s, determine :

1. Blade angle at inlet, 2. Work done per kg of steam, and 3. Power of the wheel, when the turbine is supplied with 1.8 kg of steam per second. **[Ans.** 33° ; 92.7 kN-m ; 167 kW]

6. A De-Lavel turbine it supplied with dry steam and works on a pressure range from 10.5 bar to 0.3 bar. The nozzle angle is 20° and the blade exit angle is 30°. The mean blade speed is 270 m/s. If there is a 10% loss due to friction in the nozzle and blade velocity coefficient 0.82, find the thrust on the shaft per kW power developed. **[Ans.** 0.154 N/kW]

7. Steam issues from the nozzles of single stage impulse turbine at 1000 m/s and the nozzles are inclined at 24° to the direction of motion of the blades, which have a speed of 400 m/s. The blade angles at inlet and outlet are equal. If the steam enters and leaves the blades without shock and the flow over the blades is frictionless, find the inlet blade angle. Also determine the force exerted on the blades in the direction of their motion and power developed when the steam flows at the rate of 4000 kg/h. **[Ans.** 39° ; 1.135 kN ; 454 kW]

8. The following particulars refer to a velocity compounded impulse turbine having two rows of moving blades with a fixed row of guide blades between them :

The velocity of steam leaving the nozzle is 1250 m/s, nozzle angle is 20° and blade speed is 300 m/s. The blade angles of the first moving blade are symmetrical and the blade output angle of the second moving blade is 30°. The friction factor for all rows is 0.9.

Draw the velocity diagram and determine the power developed and the axial thrust on the rotor for a steam rate of 5000 kg/h. **[Ans.** 871 kW ; 173.6 N]

QUESTIONS

1. What is a turbine ? How does it differ from a steam engine ?

2. Give the classification of steam turbines.

3. Explain the principle of impulse turbine.

4. Show by graphical method, variation in the pressure and velocity of steam in an impulse turbine.

5. Describe the use of combined velocity triangle of an impulse turbine.

6. Describe a relation for the power developed by an impulse turbine.

7. What do you understand by the term 'friction' in an impulse turbine. How does it effect the combined velocity triangle.

8. Define two-stage impulse turbine. How will you draw the combined velocity triangle for such a turbine ?

OBJECTIVE TYPE QUESTIONS

1. The action of steam in a steam turbine is

(*a*) static
(*b*) dynamic
(*c*) static and dynamic
(*d*) neither static nor dynamic

2. In an impulse turbine

(*a*) the steam is expanded in nozzles only and there is a pressure drop and heat drop
(*b*) the steam is expanded both in fixed and moving blades continuously
(*c*) the steam is expanded in moving blades only
(*d*) the pressure and temperature of steam remains constant.

3. De-Laval turbines are mostly used

(*a*) where low speeds are required
(*b*) for small power purposes and low speeds

(*c*) for small power purposes and high speeds

(*d*) for large power purposes

4. In impulse turbines, when friction is neglected, the relative velocity of steam at outlet tip of the blade is ..... the relative velocity of steam at inlet tip of the blade.

(*a*) equal to (*b*) less than (*c*) greater than

5. The blade friction in the impulse turbine reduces the velocity of steam by ..... while it passes over the blades.

(*a*) 10 to 15% (*b*) 15 to 20% (*c*) 20 to 30% (*d*) 30 to 40%

ANSWERS

1. (*b*) 2. (*a*) 3. (*c*) 4. (*a*) 5 (*a*)

2. A reaction turbine running at 360 r.p.m. consumes 5 kg of steam per second. The leakage is 10%. The discharge blade tip angle for both moving and fixed blades is 20°. The axial velocity of flow is 0.75 times blade velocity. The power developed by a certain pair is 4.8 kW where the pressure is 2 bar and dryness fraction is 0.95. Find the drum diameter and blades height. **[Ans.** 0.931 m ; 83 mm]

3. A 50% reaction turbine (with symmetrical velocity triangles) running at 400 r.p.m. has the exit angle of the blades as 20° and the velocity of steam relative to the blades at exit is 1.35 times the mean blade speed. The steam flow rate is 8.33 kg/s and at a particular stage, the specific volume is 1.381 m^3/kg. Calculate for this stage 1. a suitable blade height, assuming the rotor mean diameter 12 times the blade height, and 2. the diagram work. **[Ans.** 138 mm ; 153.14 N-m/s]

4. The outlet angle of a blade of Parson's turbine is 20° and the axial velocity of flow of steam is 0.5 times the mean blade velocity. Draw the velocity diagram for a stage consisting of one fixed and one moving row of blades.

It is given that mean diameter = 710 mm and speed of rotation = 3000 r.p.m. Find the inlet angle of blades if the steam is to enter the blade channels without shock.

If the blade height is 64 mm, the mean steam pressure 5.6 bar, the steam dry saturation (v_g = 0.3434 m^3/kg) ; find the power developed in the stage. **[Ans.** 50° ; 516.9 kW]

5. At a particular ring of a reaction turbine, the blade speed is 66 m/s and the flow of steam is 4 kg/s dry saturated at 1.4 bar. Both fixed and moving blades have inlet and exit angles of 35° and 20° respectively. Calculate : 1. the required blade height which is to be one-tenth of the mean blade ring diameter, 2. the power developed by the pair of rings, and 3. the heat drop required by the pair if the steam expand with an efficiency of 80 percent.

[Ans. 55 mm ; 57 kW ; 71.3 kJ/s]

6. The blade angles of both fixed and moving blades of a reaction steam turbine are 35° at the receiving tips and 20° at the discharging tips. At a certain point in the turbine, the drum diameter is 1.37 m and the blade height is 127 mm. The pressure of steam supply to a ring of fixed blades at this point is 1.25 bar and the dryness fraction is 0.925. Find the workdone in next row of moving blades for 1 kg of steam at 600 r.p.m., the steam passing through the blades without shock.

Assuming an efficiency of 85% for the pair of rings of fixed and moving blades, find the heat drop in the pair and the state of steam at entrance to the next row of fixed blades. **[Ans.** 6.77 kN-m/s ; 7.962 kJ/s]

QUESTIONS

1. Distinguish between impulse and reaction turbine.

2. Explain the functions of the blading of a reaction turbine.

3. Draw the combined velocity triangle for a single stage reaction turbine and derive an expression for workdone per stage.

4. Define the term 'degree of reaction' as applied to a reaction turbine. Show that for a Parson's reaction turbine, the degree of reaction is 50 percent.

5. What do you understand by the term 'height of blades' as applied to a reaction turbine.

OBJECTIVE TYPE QUESTIONS

1. In a reaction turbine

(*a*) the steam is allowed to expand in the nozzle, where it gives a high velocity before it enters the moving blades

(*b*) the expansion of steam takes place partly in the fixed blades and partly in the moving blades

(*c*) the steam is expanded from a high pressure to a condenser pressure in one or more nozzles

(*d*) the pressure and temperature of steam remains constant.

2. The Parson's reaction turbine has
   (*a*) only moving blades (*b*) only fixed blades
   (*c*) identical fixed and moving blades (*d*) fixed and moving blades of different shape
3. The degree of reaction is defined as the ratio of
   (*a*) heat drop in the fixed blades to the heat drop in the moving blades
   (*b*) heat drop in the moving blades to the heat drop in the fixed blades
   (*c*) heat drop in the moving blades to the total heat drop in the fixed and moving blades
   (*d*) total heat drop in the fixed and moving blades to the heat drop in the moving blades
4. For a Parson's reaction turbine, the degree of reaction is
   (*a*) 20% (*b*) 30% (*c*) 40% (*d*) 50%
5. In a reaction turbine, when the degree of reaction is zero, then there is
   (*a*) no heat drop in the moving blades
   (*b*) no heat drop in the fixed blades
   (*c*) maximum heat drop in the moving blades
   (*d*) maximum heat drop in the fixed blades

ANSWERS

1. (*b*) 2. (*c*) 3. (*c*) 4. (*d*) 5. (*a*)

1. the axial thrust on the blades ; 2. the power developed ; and 3. the efficiency of the wheel. [Ans. 142.5 N ; 390 kW ; 73.8%]

9. An impulse stage of a turbine has two rows of moving blades separated by fixed blades. The steam leaves the nozzles at an angle of 20° with the direction of the motion of blades. The blade exit angles are : first moving 30°, fixed 22° and second moving 30°.

If the isentropic heat drop for the nozzle is 186 kJ/kg and the nozzle efficiency 90%, find the blade speed necessary if the final velocity of steam is to be axial. Assume a loss of 15 percent in relative velocity for all blade passages. Find also the blade efficiency and the stage efficiency. [Ans. 117.2 m/s ; 71.9% ; 64.7%]

10. In a reaction turbine pair, the fixed and moving blades are of the same shape but reversed in direction. The angles of the receiving tips are 35° and of discharging tip, 20°. The mean velocity of the blades is 37.5 m/s and steam flows at the rate of 64 kg/s. If the isentropic heat drop for this turbine pair is 6 kJ/kg, calculate the diagram power and efficiency of the pair. [Ans. 285.6 kW ; 74.3%]

QUESTIONS

1. Define the following terms :
   (*a*) Diagram efficiency, and (*b*) Stage efficiency.
2. Derive the condition for maximum efficiency of an impulse turbine and show that the maximum efficiency is $\cos^2 \alpha$, where α is the angle at which the steam enters the blade.
3. Determine the condition for maximum efficiency of a 50 percent reaction turbine and show that the maximum efficiency for such a turbine is $2 \cos^2 \alpha / (1 + \cos^2 \alpha)$, where α is the angle at which the steam enters the blades.
4. Explain the term 'Compounding of steam turbine'. What are the different methods of reducing rotor speed ?
5. Discuss the method of velocity compounding of an impulse turbine for achieving rotor speed reduction.
6. Enumerate the different losses in a steam turbine.
7. What are the methods of governing a steam turbine ? Describe any one method of governing steam turbines.

OBJECTIVE TYPE QUESTIONS

1. The ratio of workdone on the blades per kg of steam to the energy supplied to the blades is called
   (*a*) diagram or blading efficiency (*b*) nozzle efficiency
   (*c*) gross or stage efficiency (*d*) mechanical efficiency
2. The stage efficiency (η_s) is given by
   (*a*) η_b / η_n (*b*) η_n / η_b (*c*) $\eta_b \eta_n$

   where η_b = Blading efficiency, and
   η_n = Nozzle efficiency.
3. The maximum efficiency of a De-Laval turbine is
   (*a*) $\sin^2 \alpha$ (*b*) $\cos^2 \alpha$ (*c*) $\tan^2 \alpha$ (*d*) $\cot^2 \alpha$

   where α = Nozzle angle.
4. The maximum efficiency of a reaction turbine is
   (*a*) $\frac{2 \sin^2 \alpha}{1 + \sin^2 \alpha}$ (*b*) $\frac{1 + \sin^2 \alpha}{2 \sin^2 \alpha}$ (*c*) $\frac{2 \cos^2 \alpha}{1 + \cos^2 \alpha}$ (*d*) $\frac{1 + \cos^2 \alpha}{2 \cos^2 \alpha}$

5. The pressure-velocity compounded impulse turbine allows a bigger pressure drop and hence ..... number of stages are required.
   (*a*) more (*b*) less

6. Rateu turbine is a
   (*a*) simple impulse turbine (*b*) simple reaction turbine
   (*c*) velocity compounded turbine (*d*) pressure compounded turbine

7. Curtis turbine is a
   (*a*) velocity compounded turbine (*b*) pressure compounded turbine
   (*c*) pressure-velocity compounded turbine (*d*) none of these

8. De-Laval turbine is a
   (*a*) impulse reaction turbine (*b*) single rotor impulse turbine
   (*c*) multi-rotor impulse turbine (*d*) none of these

9. The compounding of turbines is done is order to
   (*a*) reduce speed of rotor (*b*) improve efficiency
   (*c*) reduce exit losses (*d*) all of these

10. The purpose of governing in steam turbines is to
   (*a*) reduce the effective heat drop
   (*b*) reheat the steam and improve its quality
   (*c*) completely balance against end thrust
   (*d*) maintain the speed of the turbine

ANSWERS

1. (*a*)	2. (*c*)	3. (*b*)	4. (*c*)	5. (*b*)
6. (*d*)	7. (*c*)	8. (*b*)	9. (*a*)	10. (*d*)

heating occurs at 1.4 bar and 177° C. A third extraction occurs at 0.35 bar and 93° C. The actual exhaust is dry and saturated steam. The actual temperatures of the feed water leaving the heaters are 71° C, 107° C and 167°C respectively. Assuming no losses in and between the heaters, find the actual percentage extracted at each point and the thermal efficiency. Represent the processes on *T-s* and *h-s* plane.

[**Ans.** 0.105 kg, 0.0533 kg, 0.0347 kg ; 30%]

8. A steam power plant using regenerative feed heating generates 27 MW. The steam at 60 bar and 450° C is supplied to the steam turbine. The condenser pressure is 0.07 bar. The steam is bled from the steam turbine at 3 bar. The heating of feed water is done in the direct contact heater and the condensate temperature is raised to 110° C.

The pumps absorb 9 percent of the alternator output, the boiler efficiency is 87 percent, the efficiency ratio of each section of turbine is 85 percent and the alternator efficiency is 97 percent. Ignoring all other losses, calculate : 1. the mass tapped to the feed heater per kg of steam to the condenser ; 2. the steam to be generated per hour, and 3. the overall thermal efficiency of the plant, neglecting the boiler feed pump work in calculating input to the boiler.

[**Ans.** 0.13 kg ; 100 630 kg/h ; 26.94%]

QUESTIONS

1. Explain the process and purpose of reheating steam in steam turbine application.
2. What is reheat factor ? Explain it with the *h-s* diagram.
3. Describe regenerative feed heating as used in thermal power plants. List its advantages.
4. Explain the purpose of bleeding steam turbines, in detail.
5. Describe, with the help of diagram the binary vapour cycle of a thermal power plant ? What are its advantages.
6. Explain with suitable schematic diagram, the following :
   (*a*) Pass out turbine ; (*b*) Back pressure turbine ; and (*c*) Exhaust turbine.

OBJECTIVE TYPE QUESTIONS

1. The efficiency of steam turbines may be improved by
   (*a*) reheating of steam
   (*b*) regenerative feed heating
   (*c*) binary vapour plant
   (*d*) any one of these
2. The reheating of steam in a turbine
   (*a*) increases the workdone through the turbine
   (*b*) increases the efficiency of the turbine
   (*c*) reduces wear on the blades
   (*d*) all of the above
3. The ratio of isentropic heat drop to the heat supplied is called
   (*a*) Rankine efficiency
   (*b*) stage efficiency
   (*c*) reheat factor
   (*d*) internal efficiency
4. The ratio of total useful heat drop to the total isentropic heat drop is called
   (*a*) internal efficiency
   (*b*) efficiency ratio
   (*c*) Rankine efficiency
   (*d*) stage efficiency
   (*e*) both (*a*) and (*b*)
   (*f*) both (*c*) and (*d*)
5. The reheat factor is the ratio of
   (*a*) cumulative heat drop to the isentropic heat drop
   (*b*) isentropic heat drop to the heat supplied
   (*c*) total useful heat drop to the total isentropic heat drop
   (*d*) none of the above

6. The reheat factor depends upon

(*a*) initial pressure and superheat (*b*) exit pressure

(*c*) turbine stage efficiency (*d*) all of these

7. The value of reheat factor varies from

(*a*) 1.02 to 1.06 (*b*) 1.08 to 1.10 (*c*) 1.2 to 1.6 (*d*) 1.6 to 2.0

8. The process of draining steam from the turbine, at certain points during its expansion and using this steam for heating the feed water in feed water heaters and then supplying it to the boiler, is known as

(*a*) regenerative feed heating (*b*) reheating of steam

(*c*) bleeding (*d*) none of these

9. The effect of bleeding is that

(*a*) it increases the thermodynamic efficiency of the turbine

(*b*) boiler is supplied with hot water

(*c*) it decreases the power developed by the turbine

(*d*) all of the above

10. A binary vapour plant consists of

(*a*) steam turbine (*b*) steam condenser

(*c*) mercury boiler (*d*) economiser

(*e*) superheater (*f*) all of these

ANSWERS

1. (*d*) 2. (*d*) 3. (*a*) 4. (*e*) 5. (*a*)
6. (*d*) 7. (*a*) 8. (*c*) 9. (*d*) 10. (*f*)

12. Discuss the cooling requirement of an I.C. engine. Describe the different methods of cooling and give specific examples where each method is employed.

13. Explain the need and methods of supercharging in I.C. Engines.

14. Discuss the lubrication system in I.C. engines.

15. What is the function of a carburettor in an S.I. engine ? Briefly explain with a neat sketch the operation of a simple float type carburettor.

16. Write short notes on the following :

(*a*) Scavenging ; (*b*) Fuel pump ; (*c*) Atomiser ; and (*d*) Spark plug.

OBJECTIVE TYPE QUESTIONS

1. In a four stroke engine, the working cycle is completed in

(*a*) one revolution of the crankshaft (*b*) two revolutions of the crankshaft

(*c*) three revolutions of the crankshaft (*d*) four revolutions of the crankshaft

2. A two stroke cycle engine gives.....the number of power strokes as compared to the four stroke cycle engine, at the same engine speed.

(*a*) half (*b*) same (*c*) double (*d*) four times

3. The thermal efficiency of a two stroke cycle engine is.....a four stroke cycle engine.

(*a*) equal to (*b*) less than (*c*) greater than

4. The theoretically correct mixture of air and petrol is

(*a*) 10 : 1 (*b*) 15 : 1 (*c*) 20 : 1 (*d*) 25 : 1

5. The thermodynamic cycle on which the petrol engine works, is

(*a*) Otto cycle (*b*) Joule cycle (*c*) Rankine cycle (*d*) Stirling cycle

6. A diesel engine has

(a) one valve (b) two valves (c) three valves (d) four valves

7. If petrol is used in a diesel engine, then

(*a*) low power will be produced (*b*) efficiency will be low

(*c*) higher knocking will occur (*d*) black smoke will be produced

8. A petrol engine has compression ratio from

(*a*) 6 to 10 (*b*) 10 to 15 (*c*) 15 to 25 (*d*) 25 to 40

9. The function of a distributor in a coil ignition system of I.C. engines is

(*a*) to distribute the spark (*b*) to distribute the power

(*c*) to distribute the current (*d*) to time the spark

10. Supercharging.....the power developed by the engine.

(*a*) has no effect on (*b*) increases (*c*) decreases

11. A carburettor is used to supply

(*a*) petrol, air and lubricating oil (*b*) air and diesel

(*c*) petrol and lubricating oil (*d*) petrol and air

12. A spark plug gap is kept from

(*a*) 0.3 to 0.7 mm (*b*) 0.2 to 0.8 mm

(*c*) 0.4 to 0.9 mm (*d*) 0.6 to 1.0 mm

13. The knocking tendency in spark ignition engines may be decreased by

(*a*) controlling the air fuel mixture (*b*) controlling the ignition timing

(*c*) reducing the compression ratio (*d*) all of these

14. The violent sound pulsations within the cylinder of an I.C. engine are due to
(*a*) detonation (*b*) turbulence (*c*) pre-ignition (*d*) none of these

15. Which of the following does not relate to a spark ignition engine ?
(*a*) Ignition coil (*b*) Spark plug (*c*) Distributor (*d*) Fuel injector

ANSWERS

1. (*b*)	2. (*c*)	3. (*b*)	4. (*b*)	5. (*a*)
6. (*c*)	7. (*c*)	8. (*a*)	9. (*d*)	10. (*b*)
11. (*d*)	12. (*a*)	13. (*c*)	14. (*a*)	15. (*d*)

OBJECTIVE TYPE QUESTIONS

1. The power actually developed by the engine cylinder of an I.C. engine is known as
   (*a*) brake power (*b*) indicated power (*c*) actual power
2. The number of working strokes per minute for a four stroke cycle engine are....the speed of the engine in r.p.m.
   (*a*) equal to (*b*) one-half (*c*) twice (*d*) four times
3. If the speed of the engine is increased, the indicated power will
   (*a*) increase (*b*) decrease (*c*) remain same
4. The brake power of the engine is the power available
   (*a*) at the crank pin (*b*) in the engine cylinder
   (*c*) at the crankshaft (*d*) none of these
5. The brake power of an engine is always.....the indicated power.
   (*a*) equal to (*b*) less than (*c*) greater than
6. The ratio of the indicated thermal efficiency to the air standard efficiency is called
   (*a*) mechanical efficiency (*b*) overall efficiency
   (*c*) volumetric efficiency (*d*) relative efficiency
7. The ratio of the volume of charge admitted at N.T.P. to the swept volume of the piston is called
   (*a*) mechanical efficiency (*b*) overall efficiency
   (*c*) volumetric efficiency (*d*) relative efficiency
8. The thermal efficiency of petrol engines is about
   (*a*) 15% (*b*) 30% (*c*) 50% (*d*) 70%
9. The volumetric efficiency of a well designed engine may be
   (*a*) 30 to 40% (*b*) 40 to 60% (*c*) 60 to 70% (*d*) 75 to 90%
10. The Morse test is used to find the indicated power of a
    (*a*) single cylinder petrol engine (*b*) single cylinder diesel engine
    (*c*) multi-cylinder engine (*d*) none of these

ANSWERS

1. (*b*)	2. (*b*)	3. (*a*)	4. (*c*)	5. (*b*)
6. (*d*)	7. (*c*)	8. (*b*)	9. (*d*)	10. (*c*)

7. A two stage air compressor takes in 22.5 kg of air per minute at 15°C and 1 bar and delivers it at 16.5 bar. At the intermediate pressure, it is cooled to initial temperature. Assuming an ideal diagram with no clearance and compression according to $pv^{1.2}$ = constant, determine the intermediate pressure that gives least work. Also find the heat rejected in the intercooler per minute and minimum power required to run the compressor. Take c_p = 1 kJ/kg K; and R = 287 J/kg K [**Ans.** 4.06 bar ; 1701 kJ/min ; 97.8 kW]

8. A single acting compressor is required to deliver air at 70 bar from a suction pressure of 1 bar at the rate of 2.3 m³/min. measured at free air conditions of 1.013 bar and 15° C. The temperature at the end of the suction stroke is 32° C. Calculate the indicated power required if the compression is carried out in two stages with an ideal intermediate pressure and complete intercooling. The index of compression and expansion for both stages is 1.25. Also calculate the heat rejected per minute to the intercooler and the saving in power over single stage compression. For air, c_p = 1 kJ/kg K and c_v = 0.718 kJ/kg K. Neglect clearance volume.

[**Ans.** 22 kW ; 461.2 kJ/min ; 5.84 kW]

9. A two stage reciprocating air compressor delivers 40.5 kg/min at 9.8 bar. The intake pressure is 1 bar and the intake temperature is 15.5° C. The compression follows $p\,v^{1.31}$ = constant and the intercooler cools the air back to the intake temperature. Neglecting clearance, calculate 1. the optimum intermediate pressure ; 2. the power to be delivered to each cylinder ; and 3. the rate of heat transfer from the cylinders and intercooler.

[**Ans.** 3.13 bar ; 73.2 kW ; 3625 kJ/min]

10. A three stage reciprocating compressor compresses air from 1 bar and 26° C to 36 bar. The law of compression is $pv^{1.3}$ = constant and is same for all the three stages of compression. Assuming perfect intercooling and neglecting clearance, find the minimum power required to compress 0.25 m³/s of free air. Also find the intermediate pressures. [**Ans.** 103.12 kW ; 3.302 bar ; 10.903 bar]

QUESTIONS

1. Classify air compressors. Describe the working of a single stage reciprocating air compressor.

2. Draw p-v and T-s diagram for a single stage reciprocating air compressor, without clearance. Derive the expression for the workdone when compression is (*a*) isothermal, and (*b*) isentropic.

3. Sketch the theoretical indicator diagram for a single stage, single cylinder reciprocating compressor with clearance volume showing the various processes. For such a compressor, derive the expression for workdone in terms of mass rate of flow of air, initial temperature, pressure ratio and index of compression.

4. When is multi-stage compression used for air ? What are its advantages ?

5. Explain the effect of intercooling in a multistage reciprocating compressor.

6. Discuss briefly a two stage air compressor with intercooler. Draw the ideal p-v diagram. Derive the expression for work done per unit mass of air. Establish that the workdone is minimum when the pressure ratio for each stage is the same and there is complete intercooling.

7. In a two stage air compressor, in which intercooling is perfect, prove that the work done in compression is a minimum when the pressure in the intercooler is the geometric mean between the initial and final pressures. Draw the indicator diagram for two stage compression.

8. Discuss the procedure for obtaining the ratio of cylinder dimensions in an air compressor.

OBJECTIVE TYPE QUESTIONS

1. The volume of air delivered by the compressor is called

(*a*) free air delivery (*b*) compressor capacity

(*c*) swept volume (*d*) none of these

2. The volume of air sucked by the compressor during its suction stroke is called

(*a*) free air delivery (*b*) compressor capacity

(*c*) swept volume (*d*) none of these

3. The ratio of workdone per cycle to the stroke volume of the compressor is known as
(*a*) compressor capacity (*b*) compression ratio
(*c*) compressor efficiency (*d*) mean effective pressure

4. In a single stage, single acting reciprocating air compressor without clearance volume, the workdone is minimum during
(*a*) isothermal compression (*b*) isentropic compression
(*c*) polytropic compression (*d*) none of these

5. The pressure of air at the beginning of the compression stroke is .....atmospheric pressure.
(*a*) equal to (*b*) less than (*c*) more than

6. A 3 m^3/min compressor means that it
(*a*) compresses 3 m^3/min of standard air (*b*) compresses 3 m^3/min of free air
(*c*) delivers 3 m^3/min of compressed air
(*d*) delivers 3 m^3/min of compressed air at delivery pressure.

7. The multi-stage compression of air as compared to single stage compression
(*a*) improves volumetric efficiency for the given pressure ratio
(*b*) reduces workdone per kg of air (*c*) gives more uniform torque
(*d*) reduces cost of compressor (*e*) all of the above

8. The intercooling in multi-stage compressors is done
(*a*) to cool the air during compression (*b*) to cool the air at delivery
(*c*) to enable compression in two stages (*d*) to minimise the work of compression

9. The intercooler pressure (p_2) for minimum work required, for a two stage reciprocating air compressor, is given by
(*a*) $p_2 = p_1 p_3$ (*b*) $p_2 = p_1/p_3$ (*c*) $p_2 = \sqrt{p_1 p_3}$ (*d*) $p_2 = p_3 / p_1$

where p_1 = Intake pressure of air, and

p_3 = Delivery pressure of air.

10. The ratio of cylinder diameters for a single acting, two stage reciprocating air compressor with complete intercooling, is given by
(*a*) $D_1/D_2 = \sqrt{p_1 p_2}$ (*b*) $D_1/D_2 = \sqrt{p_1/p_2}$
(*c*) $D_1/D_2 = \sqrt{p_2/p_1}$ (*d*) none of these

where D_1 = Diameter of L.P. cylinder, and

D_2 = Diameter of H.P. cylinder.

ANSWERS

1. (*b*) 2. (*c*) 3. (*d*) 4. (*a*) 5. (*b*)
6. (*b*) 7. (*e*) 8. (*d*) 9. (*c*) 10. (*c*)

4. Explain, with a neat sketch, the working of a centrifugal compressor and obtain an expression for the workdone.
5. Discuss the method of finding the width of impeller blades in a rotary air compressor.
6. Define 'prewhirl'. Explain its effect on the impeller of a centrifugal pump.
7. Explain, with a neat sketch, the working of an axial flow compressor.
8. Differentiate between centrifugal compressor and axial flow compressor.

OBJECTIVE TYPE QUESTIONS

1. The positive displacement compressor is
   (*a*) roots blower compressor (*b*) vane blower compressor
   (*c*) centrifugal compressor (*d*) axial flow compressor
   (*e*) both (*a*) and (*b*) (*f*) both (*c*) and (*d*)
2. The rotary compressors are used for delivering
   (*a*) small quantities of air at high pressures (*b*) large quantities of air at high pressures
   (*c*) small quantities of air at low pressures (*d*) large quantities of air at low pressures
3. The maximum delivery pressure in a rotary air compressor is
   (*a*) 10 bar (*b*) 20 bar (*c*) 30 bar (*d*) 40 bar
4. The speed of a rotary compressor is ..... as compared to reciprocating air compressor.
   (*a*) high (*b*) low
5. The type of rotary compressor used in gas turbines is of
   (*a*) centrifugal type (*b*) axial flow type (*c*) radial flow type (*d*) none of these
6. If the flow of air through the compressor is perpendicular to its axis, then it is a
   (*a*) reciprocating compressor (*b*) centrifugal compressor
   (*c*) axial flow compressor (*d*) turbo compressor
7. In a centrifugal compressor, an increase in speed at a given pressure ratio causes
   (*a*) increase in flow (*b*) decrease in flow
   (*c*) increase in efficiency (*d*) decrease in efficiency
   (*e*) increase in flow and decrease in efficiency
8. In an axial flow compressor, the ratio of pressure in the rotor blades to the pressure rise in the compressor in one stage is known as
   (*a*) work factor (*b*) slip factor (*c*) degree of reaction (*d*) pressure coefficient
9. A compressor mostly used for supercharging of I.C. engines is
   (*a*) radial flow compressor (*b*) axial flow compressor
   (*c*) roots blower (*d*) reciprocating compressor
10. Which of the following statement is correct as regard to centrifugal compressors ?
   (*a*) The flow of air is parallel to the axis of the compressor.
   (*b*) The static pressure of air in the impeller increases in order to provide centripetal force on the air.
   (*c*) The impeller rotates at high speeds.
   (*d*) The maximum efficiency is higher than multi-stage axial flow compressors.

ANSWERS

1. (*e*)	2. (*d*)	3. (*a*)	4. (*a*)	5. (*b*)
6. (*b*)	7. (*e*)	8. (*c*)	9. (*a*)	10. (*b*)

OBJECTIVE TYPE QUESTIONS

1. The ratio of the indicated power to the shaft power or brake power of the motor or engine required to drive the compressor, is called

(*a*) compressor efficiency (*b*) volumetric efficiency

(*c*) isentropic efficiency (*d*) mechanical efficiency

2. The ratio of the volume of free air delivery per stroke to the swept volume of the piston, is known as

(*a*) compressor efficiency (*b*) volumetric efficiency

(*c*) isentropic efficiency (*d*) mechanical efficiency

3. If the clearance ratio for a reciprocating air compressor is K, then its volumetric efficiency is given by

(*a*) $1 - K + K\left(\frac{p_1}{p_2}\right)^{1/n}$ (*b*) $1 + K - K\left(\frac{p_1}{p_2}\right)^{1/n}$

(*c*) $1 + K - K\left(\frac{p_2}{p_1}\right)^{1/n}$ (*d*) $1 - K + K\left(\frac{p_2}{p_1}\right)^{1/n}$

4. The volumetric efficiency of a compressor

(*a*) increases with decrease in compression ratio

(*b*) decreases with decrease in compression ratio

(*c*) increases with increase in compression ratio

(*d*) decreases with increase in compression ratio

5. The volumetric efficiency for reciprocating air compressors is about

(*a*) 10 to 40% (*b*) 40 to 60% (*c*) 60 to 70% (*d*) 70 to 90%

ANSWERS

1. (*d*) 2. (*b*) 3. (*c*) 4. (*d*) 5. (*d*)

QUESTIONS

1. What is air motor ? On what principle does it work ?
2. Obtain expression for the workdone by air in an air motor.
3. Explain the working of compressed air system.
4. Derive an expression for the overall efficiency of a compressed air system.
5. What is preheating of air ? Explain its uses.

OBJECTIVE TYPE QUESTIONS

1. The operation of a reciprocating air motor is similar to that of

   (*a*) reciprocating steam engine (*b*) reciprocating air compressor

   (*c*) both (*a*) and (*b*) (*d*) none of these

2. Air motors work on the cycle which is the ..... of the reciprocating air compressor cycle.

   (*a*) same as that (*b*) reverse

3. In a compressed air system, the temperature of air discharged from the air motor is ..... than the initial compressor intake temperature.

   (*a*) more (*b*) less

4. The overall efficiency of the compressed air system is

   (*a*) the ratio of shaft output of the air motor to the shaft input to the compressor

   (*b*) the ratio of shaft input to the compressor to the shaft output of the air motor

   (*c*) the product of the shaft output of the air motor and the shaft input to the compressor

   (*d*) none of the above

ANSWERS

1. (*a*) 2. (*b*) 3. (*b*) 4. (*a*)

4. Draw the layout of a gas turbine plant which has two stage compression with complete intercooling. The high pressure turbine develops power enough only to drive the high pressure compressor. The L.P. turbine drives both the L.P. compressor and the load. Indicate the ideal process of this plant on a *T-s* diagram.
5. What are the essential components of a simple open cycle gas turbine plant ?
6. Differentiate clearly between a closed cycle gas turbine and an open cycle gas turbine.
7. Write a short note on semi-closed cycle gas turbine.

OBJECTIVE TYPE QUESTIONS

1. A closed cycle gas turbine works on
   (*a*) Carnot cycle (*b*) Rankine cycle
   (*c*) Ericsson cycle (*d*) Joule cycle
2. In a closed cycle gas turbine, the air is compressed
   (*a*) isothermally (*b*) isentropically
   (*c*) polytropically (*d*) none of these
3. The gas in cooling chamber of a closed cycle gas turbine is cooled at
   (*a*) constant volume (*b*) constant temperature
   (*c*) constant pressure (*d*) none of these
4. A closed cycle gas turbine gives....efficiency as compared to an open cycle gas turbine.
   (*a*) same (*b*) lower (*c*) higher
5. Reheating in a gas turbine
   (*a*) increases the thermal efficiency (*b*) increases the compressor work
   (*c*) increases the turbine work (*d*) decreases the thermal efficiency

ANSWERS

1. (*d*) 2. (*b*) 3. (*c*) 4. (*c*) 5. (*a*)

QUESTIONS

1. State the assumptions made for thermal efficiency of a gas turbine plant.
2. Derive an expression for the thermal efficiency of a gas turbine plant, and show that it is independent of the mass of air circulated in it.
3. Describe the difference between an ideal gas turbine plant and an actual gas turbine plant. Give relations for the isentropic efficiencies of compressor and turbine.
4. What is heat exchanger ? Describe its utility.
5. Obtain an expression for the effectiveness of a heat exchanger.
6. Write briefly the uses of gas turbines.

OBJECTIVE TYPE QUESTIONS

1. In an ideal gas turbine plant, it is assumed that the compression and expansion processes are

   (*a*) isothermal (*b*) isentropic (*c*) polytropic

2. The thermal efficiency of an ideal gas turbine plant is given by

   (*a*) $r^{\gamma-1}$ (*b*) $1 - r^{\gamma-1}$ (*c*) $1 - \left(\frac{1}{r}\right)^{\frac{\gamma}{\gamma-1}}$ (*d*) $1 - \left(\frac{1}{r}\right)^{\frac{\gamma-1}{\gamma}}$

3. The gas turbine cycle with regenerator improves

   (*a*) thermal efficiency (*b*) work ratio

   (*c*) avoids pollution (*d*) none of these

4. High air-fuel ratio is gas turbines

   (*a*) increases power output (*b*) improves thermal efficiency

   (*c*) reduces exhaust temperature (*d*) do not damage turbine blades

ANSWERS

1. (*b*) 2. (*d*) 3. (*a*) 4. (*c*)

QUESTIONS

1. What are the three methods of heat transfer ?
2. How do you define the thermal conductivity of a material ?
3. Deduce an expression for the quantity of heat flow through solid bodies when joined together.
4. Derive an expression for the quantity of heat flow through a thick cylindrical pipe.
5. Define the overall coefficient of heat transfer.

OBJECTIVE TYPE QUESTIONS

1. The process of heat transfer from one particle of the body to another is called conduction, when the particles of the body
   (*a*) move actually (*b*) do not move actually
   (*c*) affect the intervening medium (*d*) does not affect the intervening medium
2. The heat transfer takes place according to
   (*a*) zeroth law of thermodynamics (*b*) first law of thermodynamics
   (*c*) second law of thermodynamics (*d*) Stefan's law
3. The rate of heat flow through a body is $Q = \frac{k A (T_1 - T_2)}{x}$. The term $x/k A$ is known as
   (*a*) thermal coefficient (*b*) thermal resistance
   (*c*) thermal conductivity (*d*) none of these
4. The thermal conductivity of sold metals ..... with rise in temperature.
   (*a*) remains same (*b*) decreases (*c*) increases
5. The overall coefficient of heat transfer is used in problems of
   (*a*) conduction (*b*) convection
   (*c*) radiation (*d*) conduction and convection
   (*e*) conduction and radiation.

ANSWERS

1. (*b*) 2. (*c*) 3. (*b*) 4. (*b*) 5. (*d*)

3. What is the difference between a refrig[illegible] the performance factor for both if they are running on reversed Carnot cycle.

4. Describe the Bell-Coleman cycle and obtain an expression for the C.O.P. of the cycle.

5. Show that C.O.P. of a Bell-Coleman cycle is given by the expression :

$$\text{C.O.P.} = \frac{1}{\left(\frac{1}{r_p}\right)^{\frac{\gamma-1}{\gamma}} - 1}$$

where r_p is the compression ratio and γ is the usual ratio of specific heats.

OBJECTIVE TYPE QUESTIONS

1. One tonne of refrigeration is equal to
   (*a*) 21 kJ/min (*b*) 210 kJ/min (*c*) 420 kJ/min (*d*) 620 kJ/min
2. One tonne refrigerating machine means that
   (*a*) one tonne is the total mass of the machine
   (*b*) one tonne of refrigerant is used
   (*c*) one tonne of water can be converted into ice
   (*d*) one tonne of ice when melts from and at 0° C in 24 hours, the refrigeration effect produced is equivalent to 210 kJ/min
3. The coefficient of performance is always ..... one.
   (*a*) equal to (*b*) less than (*c*) greater than
4. The relative coefficient of performance is equal to
   (*a*) $\frac{\text{Theoretical C.O.P.}}{\text{Actual C.O.P.}}$ (*b*) $\frac{\text{Actual C.O.P.}}{\text{Theoretical C.O.P.}}$
   (*c*) Theoretical C.O.P. × Actual C.O.P.
5. In a closed or dense air refrigeration cycle, the operating pressure ratio can be reduced, which results in ..... coefficient of performance.
   (*a*) lower (*b*) higher
6. Air refrigeration cycle is used in
   (*a*) commercial refrigerators (*b*) domestic refrigerators
   (*c*) air-conditioning (*d*) gas liquefaction
7. In a refrigerating machine, heat rejected is ..... heat absorbed.
   (*a*) equal to (*b*) less than (*c*) greater than
8. Air refrigerator works on
   (*a*) Carnot cycle (*b*) Rankine cycle
   (*c*) reversed Carnot cycle (*d*) Bell-Coleman cycle
   (*e*) both (*a*) and (*b*) (*f*) both (*c*) and (*d*)
9. In air-conditioning of aeroplanes, using air as a refrigerant, the cycle used is
   (*a*) reversed Carnot cycle (*b*) reversed Joule cycle
   (*c*) reversed Brayton cycle (*d*) reversed Otto cycle

ANSWERS

1. (*b*)	2. (*d*)	3. (*c*)	4. (*b*)	5. (*b*)
6. (*d*)	7. (*c*)	8. (*f*)	9. (*c*)	

QUESTIONS

1. Mention the advantages of vapour compression refrigeration system over air refrigeration system.
2. Draw the layouts of a vapour compression refrigerating system. State the function of each of the component and show the thermodynamic processes on a pressure-enthalpy diagram.
3. Sketch the *T-s* and *p-h* diagrams for the vapour compression cycles when the vapour after compression is (*i*) dry saturated, and (*ii*) wet.
4. Why in practice a throttle valve is used in vapour compression refrigerator rather than an expansion cylinder to reduce pressure between the condenser and the evaporator ?
5. What is sub-cooling and superheating ? Explain with the help of diagram. Why is superheating considered to be good in certain cases ?
6. Establish how an actual cycle differs from a theoretical vapour compression cycle.
7. Describe briefly with the help of a diagram, the vapour absorption system of refrigeration. In what way this system is advantageous over the vapour compression system ?
8. State the properties of a good refrigerant. What are the normal refrigerants used.

OBJECTIVE TYPE QUESTIONS

1. During a refrigeration cycle, heat is rejected by the refrigerant in a
   (*a*) compressor (*b*) condenser (*c*) evaporator (*d*) expansion valve
2. In a vapour compression system, the condition of refrigerant before entering the compressor is
   (*a*) saturated liquid (*b*) wet vapour
   (*c*) dry saturated liquid (*d*) superheated vapour
3. The highest temperature during the cycle, in a vapour compression system, occurs after
   (*a*) compression (*b*) condensation (*c*) expansion (*d*) evaporation
4. In a vapour compression system, the lowest temperature during the cycle occurs after
   (*a*) compression (*b*) condensation (*c*) expansion (*d*) evaporation
5. The sub-cooling in a refrigeration cycle
   (*a*) does not alter C.O.P. (*b*) increases C.O.P. (*c*) decreases C.O.P.
6. The refrigerant, commonly used in vapour absorption refrigeration systems, is
   (*a*) sulphur dioxide (*b*) ammonia (*c*) freon (*d*) aqua-ammonia
7. In ammonia-hydrogen refrigerator,
   (*a*) ammonia is absorbed in hydrogen (*b*) ammonia is absorbed in water
   (*c*) ammonia evaporates in hydrogen (*d*) hydrogen evaporates in ammonia
8. The boiling point of ammonia is
   (*a*) – 10.5° C (*b*) – 30° C (*c*) – 33.3° C (*d*) – 77.6° C
9. Which of the following refrigerant has the lowest boiling point ?
   (*a*) Ammonia (*b*) Carbon dioxide (*c*) Sulphur dioxide (d) Freon-12
10. Which of the following refrigerant is highly toxic and flammable ?
    (*a*) Ammonia (*b*) Carbon dioxide (*c*) Sulphur dioxide (*d*) Freon-12

ANSWERS

1. (*b*)				
6. (*d*)	2. (*d*)	3. (*a*)	4. (*d*)	5. (*b*)
	7. (*c*)	8. (*c*)	9. (*b*)	10. (*a*)

QUESTIONS

1. What do you understand by the term 'psychrometry'.
2. Define the following :
   1. Specific humidity ; 2. Absolute humidity ;
   3. Relative humidity ; and 4. Dew point temperature.
3. What is a sling psychrometer ? Make a neat sketch and explain its use.
4. Establish the following expression for air-vapour mixture :

$$\text{Specific humidity, } W = 0.622 \times \frac{p_v}{p_b - p_v}$$

where p_v = Partial pressure of water vapour,

and p_b = Barometric pressure.

5. How does the wet bulb temperature differ from thermodynamic wet bulb temperature ?
6. Prove that the partial pressure of water vapour in the atmospheric air remains constant as long as the specific humidity remains constant.
7. Prove that the enthalpy of the humid air remains constant along a wet bulb temperature line on the psychrometric chart.
8. When is dehumidification of air necessary and how it is achieved.
9. Define sensible heat factor.
10. Show the following processes on the skeleton psychrometric chart :
    (*a*) Dehumidification of moist air by cooling ; and
    (*b*) Adiabatic mixing of two streams.

OBJECTIVE TYPE QUESTIONS

1. A mixture of dry air and water vapour, when the air has diffused the maximum amount of water vapour into it, is called
   (*a*) dry air (*b*) moist air (*c*) saturated air (*d*) specific humidity
2. The temperature of air recorded by a thermometer, when it is not effected by the moisture present in it, is called
   (*a*) wet bulb temperature (*b*) dry bulb temperature
   (*c*) dew point temperature (*d*) none of these
3. For unsaturated air, the dew point temperature is ..... wet bulb temperature.
   (*a*) equal to (*b*) less than (*c*) more than
4. The difference between dry bulb temperature and wet bulb temperature, is called
   (*a*) dry bulb depression (*b*) wet bulb depression
   (*c*) dew point depression (*d*) degree of saturation
5. The vertical and uniformly spaced lines on a psychrometric chart indicates
   (*a*) dry bulb temperature (*b*) wet bulb temperature
   (*c*) dew point temperature (*d*) specific humidity
6. The curved lines on a psychrometric chart indicates
   (*a*) dry bulb temperature (*b*) wet bulb temperature
   (*c*) specific humidity (*d*) relative humidity
7. During sensible cooling of air, the specific humidity
   (*a*) increases (*b*) decreases (*c*) remains constant

8. During sensible cooling of air, the dry bulb temperature

(*a*) increases (*b*) decreases (*c*) remains constant

9. During sensible cooling of air, the wet bulb temperature

(*a*) increases (*b*) decreases (*c*) remains constant

10. The process generally used in winter air conditioning to warm and humidify the air, is called

(*a*) humidification (*b*) dehumidification

(*c*) heating and humidification (*d*) cooling and dehumidification

ANSWERS

1. (*c*)	2. (*b*)	3. (*b*)	4. (*b*)	5. (*a*)
6. (*d*)	7. (*c*)	8. (*b*)	9. (*b*)	10. (*c*)

QUESTIONS

1. Define comfort. What are the factors which affect comfort air conditioning ?
2. How does industrial air conditioning is different from comfort air conditioning ?
3. Draw a line diagram of air conditioning system required in winter season. Explain the working of different components in the circuit.
4. Draw a block diagram of a simple year round air conditioning system and briefly explain the process on a psychrometric chart.
5. Describe unitary and central air conditioning systems.

OBJECTIVE TYPE QUESTIONS

1. For summer air conditioning, the relative humidity should not be less than
   (*a*) 40% (*b*) 60% (*c*) 75% (*d*) 90%
2. For winter air conditioning, the relative humidity should not be more than
   (*a*) 40% (*b*) 60% (*c*) 75% (*d*) 90%
3. The sensible heat factor for auditorium or cinema hall is generally kept as
   (*a*) 0.6 (*b*) 0.7 (*c*) 0.8 (*d*) 0.9
4. The conditioned air supplied to the room must have the capacity to take up
   (*a*) room sensible heat load only
   (*b*) room latent heat load only
   (*c*) both room sensible heat and latent heat loads

ANSWERS

1. (*b*) 2. (*a*) 3. (*b*) 4. (*c*)

4. Show that for specific helmholtz function, $a = u - T_s$

$(a)\left(\frac{\partial a}{\partial v_s}\right)_T = -p$ $(b)\left(\frac{\partial a}{\partial T}\right)_{v_s} = -s$

$(c)\ u = a - T\left(\frac{\partial a}{\partial T}\right)_{v_s}$ $(d)\ c_v = -T\left(\frac{\partial^2 a}{\partial T^2}\right)_{v_s}$

5. Show that for specific Gibbs function, $g = h - Ts$

$(a)\left(\frac{\partial g}{\partial T}\right)_p = -s$ $(b)\left(\frac{\partial g}{\partial p}\right)_T = -v_s$

$(c)\ u = g - T\left(\frac{\partial g}{\partial T}\right)_p - p\left(\frac{\partial g}{\partial p}\right)_T$ $(d)\ c_v = -T\left(\frac{\partial^2 g}{\partial T^2}\right)_{v_s}$

6. Show that the equation of state of a substance may be written in the form

$$\frac{dv}{v} = -K\,dp + \beta\,dT$$

7. A substance has the volume expansivity (β) and isothermal compressibility (K) as

$$\beta = \frac{1}{T} \quad \text{and} \quad K = \frac{1}{p}$$

Show that the equation of state is $p\,v_s/T$ = constant.

8. Using the cyclic relation, prove that

$$\left(\frac{\partial p}{\partial T}\right)_v = \frac{\beta}{KT}$$

9. Derive the following thermodynamic relations

$(a)\left(\frac{\partial h}{\partial p}\right)_T = -T\left(\frac{\partial v_s}{\partial T}\right)_{v_s} + v_s = -c_p\left(\frac{\partial T}{\partial p}\right)_h$ $(b)\left(\frac{\partial h}{\partial v_s}\right)_T = T\left(\frac{\partial p}{\partial T}\right)_{v_s} + v_s\left(\frac{\partial p}{\partial v_s}\right)_T$

$(c)\left(\frac{\partial h}{\partial s}\right)_{v_s} = T - v_s\left(\frac{\partial T}{\partial v_s}\right)_s$ $(d)\left(\frac{\partial u}{\partial v_s}\right) = T\left(\frac{\partial p}{\partial T}\right)_{v_s} - p$

10. Show that for a Van der Waal's gas

$$\left(\frac{\partial c_v}{\partial v}\right)_T = 0$$

OBJECTIVE TYPE QUESTIONS

1. Helmholtz function (A) is given as

$(a)\ A = U - TS$ $(b)\ A = U + TS$

$(c)\ A = TS - U$ $(d)\ A = U - T/S$

2. Gibbs function (G) is given as

(*a*) $G = H + TS$ (*b*) $G = H - TS$

(*c*) $G = TS - H$ (*d*) $G = H + T/S$

3. Difference in specific heat at constant pressure (c_p) and specific heat at constant volume (c_v) *i.e.* ($c_p - c_v$) is

(*a*) $\frac{T\beta^2}{K v_s}$ (*b*) $\frac{T\beta^2 K}{v_s}$

(*c*) $\frac{T v_s}{\beta^2 K}$ (*d*) $\frac{T\beta^2 v_s}{k}$

4. TdS equation taking temperature (T) and volume (v) as independent variables is

(*a*) $m c_v dT + T\frac{K}{\beta} dv$ (*b*) $m c_v dT + T\beta K dv$

(*c*) $m c_v dT + T\frac{\beta}{K} dv$ (*d*) $m c_v dT + T\beta dv$

5. Van der Waal's equation of state is

(*a*) $p v_s = R T$ (*b*) $p v_s = 1 + \frac{B}{v_s} + \frac{C}{v_s^2}$

(*c*) $p = \frac{R T}{v_s - b} - \frac{a}{v_s^2}$ (*d*) $v_s = \frac{R T}{p} - \frac{K}{T^3}$

ANSWERS

1. (*a*) 2. (*b*) 3. (*d*) 4. (*c*) 5. (*c*)

2. A certain quantity of gas having a volume of $4\ m^3$ at 1.2 bar and 30°C is heated at constant pressure to 50°C. Determine : 1. Mass of the gas ; 2. Heat transfer during the process and 3. Change of entropy.

Take $c_p = 0.946 + 0.184 \times 10^{-3}\ T$ kJ/kg K and $c_v = 0.946 + 0.184 \times 10^{-3}\ T$ kJ/kg K

[**Ans.** 5.41 kg ; 108.2 kJ]

3. A mass of 1.8 kg and volume of $0.15\ m^3$ of certain gas at 45 bar is expanded isentropically such that the temperature falls to 600 K. Determine : 1. Initial temperature of the gas, 2. Work done during the process, and 3. Pressure at the end of expansion.

Take $c_p = 0.946 + 0.000\,184\ T$ kJ/kg K and $c_v = 0.653 + 0.000\,184\ T$ kJ/kg K

[**Ans.** 1279.86 K ; 1010.82 kJ ; 2.532 bar]

4. In an air standard Otto cycle, the compression ratio is 7.5. Calculate the change in efficiency if the specific heat at constant volume increases by 3%. Take $\gamma = 1.4$ [**Ans.** –1.95%]

5. In an air standard Diesel cycle, the compression ratio is 18 and the fuel is cut-off at 5% of the stroke. Calculate the change in efficiency if the specific heat at constant volume increases by 2.5%. Take $\gamma = 1.4$. [**Ans.** –1.44%]

QUESTIONS

1. What do you understand by molar specific heat?
2. Explain the effect of variation of specific heat with temperature.
3. Describe how moisture content of air affects the specific heats of air.
4. Derive the relations for the change in internal energy and enthalpy during a process with variable specific heats.
5. The specific heats of a gas are of the form $c_p = a + K\,T$ and $c_v = b + K\,T$, where a, b and K are constants and T is in K. Derive the formula $T^b\ v_s^{a-b}\ e^{KT}$ = constant, for the adiabatic expansion of the gas.
6. Explain the effect of variable specific heat on air standard efficiencies of Otto and Diesel cycle.
7. Derive the following relation for Otto cycle, by taking variation of specific heat in account :

$$\frac{d\eta}{\eta} = -\left[\frac{1-\eta}{\eta}\right] \frac{R}{c_v} \log_e r \times \frac{dc_v}{c_v}$$

OBJECTIVE TYPE QUESTIONS

1. Gases have

(*a*) one specific heat (*b*) two specific heats

(*c*) three specific heats (*d*) four specific heats

2. The value of specific heat at constant pressure (c_p) ..... with increase in temperature.

(*a*) increases (*b*) decreases (*c*) remains same

3. Molar specific heat at constant pressure (c_{mp}) is

(a) $M + c_p$ (b) $M - c_p$ (c) $M\,c_p$ (d) M/c_p

where M = Molecular mass of gas, and

c_p = Specific heat at constant pressure.

4. Molar specific heat at constant volume (c_{mv}) is

(a) $M + c_v$ (b) $M - c_v$ (c) $M\,c_v$ (d) M/c_v

where M = Molecular mass of gas, and

c_v = Specific heat at constant volume.

5. The ratio of specific heats $\left(\gamma = \frac{c_p}{c_v}\right)$ for air

(a) increases with increase in moisture content in air

(b) decreases with increase in moisture content in air

(c) remains constant irrespective of the increase in moisture content of air

(d) increases first and then decreases later with moisture content in air

6. The ratio of specific heats $\left(\gamma = \frac{c_p}{c_v}\right)$ for real gas

(a) increases with increase in temperature

(b) decreases with increase in temperature

(c) remains same irrespective of increase in temperature

(d) increases first with increase in temperature and then decreases with further increase in temperature

7. The gas constant (R) is equal to

(a) ratio of two specific heats

(b) sum of two specific heats

(c) difference of two specific heats

(d) product of two specific heats

8. The change in internal energy during a process with variable specific heats is equal to

(a) $m\,c_v\,(T_2 - T_1)$ (b) $m\,c_{vm}/(T_2 - T_1)$

(c) $m\,c_v/(T_2 - T_1)$ (d) $m\,c_{vm}\,(T_2 - T_1)$

9. The efficiency of Otto cycle

(a) increases with increase in specific heat

(b) decreases with increase in specific heat

(c) remains same with increase in specific heat

(d) first increases then decreases with increase in specific heat

10. The efficiency of Diesel cycle

(*a*) increases with increase in specific heat

(*b*) decreases with increase in specific heat

(*c*) remains same with increase in specific heat

(*d*) first increases and then decreases with increase in specific heat

ANSWERS

1. (*b*)	2. (*a*)	3. (*c*)	4. (*c*)	5. (*b*)
6. (*b*)	7. (*c*)	8. (*d*)	9. (*b*)	10. (*b*)