

COMPETITIVE EXAMINATIONS QUESTIONS

(Including ESE and CSE Questions, from 1996 onwards)

A. THERMODYNAMICS

- 1.** Match List I with List II and select the correct answer using the codes given below the lists :

List I

- A. Work done in a polytropic process
- B. Work done in a steady flow process
- C. Heat transfer in a reversible adiabatic process
- D. Work done in an isentropic process

List II

- 1. $\int v dp$
- 2. Zero
- 3. $\frac{p_1V_1 - p_2V_2}{\gamma - 1}$
- 4. $\frac{p_1V_1 - p_2V_2}{n - 1}$

Codes : (a) A B C D

4 1 3 2

(c) A B C D

4 1 2 3

(b) A B C D

1 4 2 3

(d) A B C D

1 2 3 4

- 2.** Match the curves in Fig. 1 with the curves in Fig. 2 and select the correct answer using the codes given below the diagrams :

Process on *p-V* plane

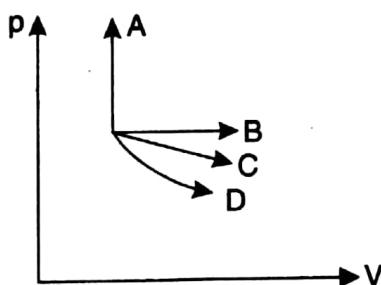


Fig. 1

Process on *T-s* plane

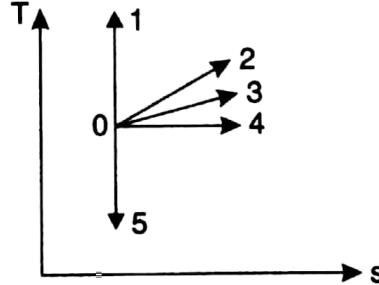


Fig. 2

Codes : (a) A B C D

3 2 4 5

(c) A B C D

2 3 4 1

(b) A B C D

2 3 4 5

(d) A B C D

1 4 2 3

- 3.** The heat transfer Q , the work done W and the change in internal energy ΔU are all zero in the case of

- (a) a rigid vessel containing steam at 150°C left in the atmosphere which is at 25°C
- (b) 1 kg of gas contained in a insulated cylinder expanding as the piston moves slowly outwards
- (c) a rigid vessel containing ammonia gas connected through a valve to a evacuated rigid vessel, the vessel, the valve and the connecting pipes being well insulated and the valve being opened and after a time, conditions though the two vessel becoming uniform
- (d) 1 kg of air flowing adiabatically from the atmosphere into a previously evacuated bottle.

4. Zeroth Law of thermodynamics states that
- two thermodynamic system are always in thermal equilibrium with each other
 - if two systems are in thermal equilibrium, then the third system will also be in thermal equilibrium
 - two systems not in thermal equilibrium with a third system are also not in thermal equilibrium with each other
 - when two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other.
5. Which one the following statements applicable to a perfect gas will also be true for an irreversible process ? (Symbols have the usual meanings)
- $dQ = du + p dV$
 - $dQ = Tds$
 - $T ds = du + p dV$
 - None of the above.
6. The throttling process undergone by a gas across an orifice is shown by its states in Fig. 3.

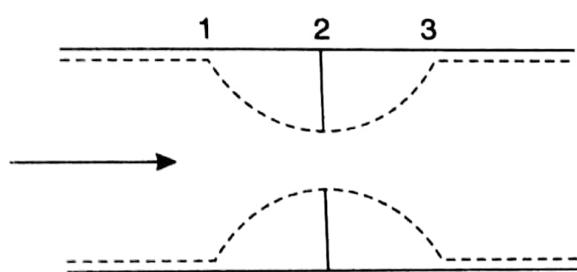


Fig. 3

It can be represented on the $T-s$ diagram as

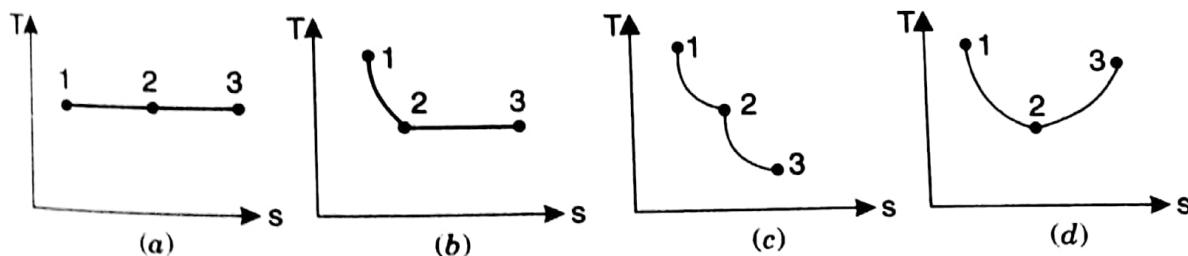


Fig. 4

7. Which one of the following temperature-entropy diagrams of steam shows the reversible and irreversible process correctly ?

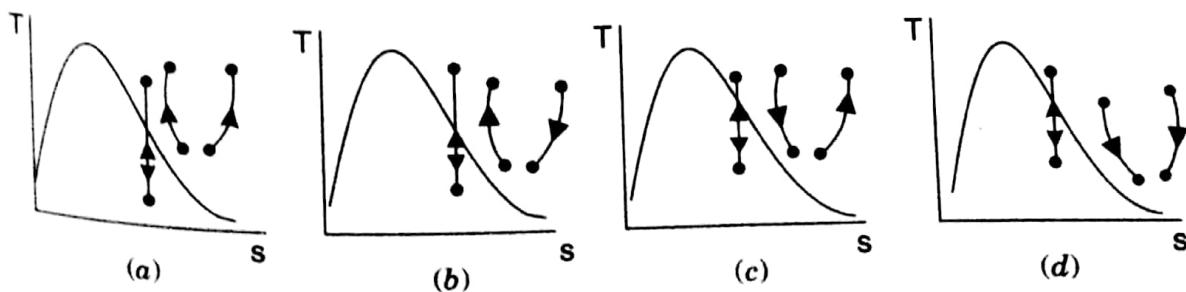


Fig. 5

8. Consider the following statements :
- Availability is generally conserved.

2. Availability can either be negative or positive.
 3. Availability is the maximum theoretical work obtainable.
 4. Availability can be destroyed in irreversibilities.

Of these statements

- (a) 3 and 4 are correct (b) 1 and 3 are correct
 (c) 1 and 4 are correct (d) 2 and 4 are correct.

9. For a given volume of dry saturated steam, Clapeyron's equation is given by

$$(a) V_g - V_t = \frac{dT_s}{dp} \times \frac{T}{h_g - h_f}$$

$$(b) \quad V_g - V_f = \frac{dT_s}{dp} \times \frac{h_g - h_f}{T_s}$$

$$(c) V_g - V_f = \frac{dp}{dT_s} \times \frac{h_g - h_f}{T_s}$$

$$(d) \quad V_g - V_f = \frac{dp}{dT_s} \times \frac{T_s}{h_g - h_f} .$$

- 10.** The Joule-Thomson coefficient is the

- (a) $\left(\frac{\partial T}{\partial p}\right)_V$ of pressure-temperature curve of real gases

- (b) $\left(\frac{\partial T}{\partial s}\right)_n$ of temperature entropy curve of real gases

- (c) $\left(\frac{\partial h}{\partial s}\right)_T$ of enthalpy entropy curve of real gases

- (d) $\left(\frac{\partial v}{\partial T}\right)_p$ of pressure volume curve of real gases.

11. Which one of the following p - T diagrams illustrates the otto-cycle of an ideal gas?

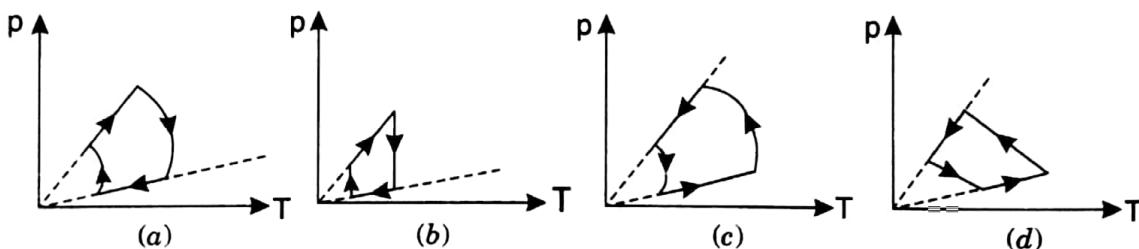


Fig. 6

- 12.** When a system is taken from state A to state B along the path A-C-B 180 kJ of heat flows into the system and it does 130 kJ of work (see figure given) :

How much heat will flow into the system along the path A-D-B if the work done by it along the path is 40 kJ?

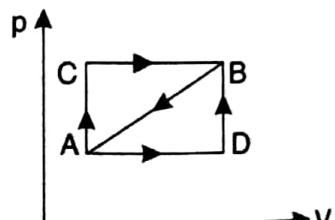


Fig. 7

- *13. A gas expands from pressure p_1 to pressure p_2 ($p_2 = \frac{p_1}{10}$). If

the process of expansion is isothermal, the volume at the end of expansion is 0.55 m^3 . If the process of expansion is adiabatic, the volume at the end of expansion will be closer to

*14. A standard vapour is compressed to half its volume without changing its temperature. The result is that :

- (a) All the vapour condenses to liquid
- (b) Some of the liquid evaporates and the pressure does not change
- (c) The pressure is double its initial value
- (d) Some of the vapour condenses and the pressure does not change.

*15. A system of 100 kg mass undergoes a process in which its specific entropy increases from 0.3 kJ/kg-K to 0.4 kJ/kg-K. At the same time, the entropy of the surroundings decreases from 80 kJ/K to 75 kJ/K. The process is

- | | |
|-------------------------------|------------------|
| (a) Reversible and isothermal | (b) Irreversible |
| (c) Reversible | (d) Impossible. |

16. The thermodynamic parameters are :

- | | |
|----------------|---------------------|
| I. Temperature | II. Specific volume |
| III. Pressure | IV. Enthalpy |
| V. Entropy | |

The Clapeyron equation of state provides relationship between

- | | |
|-------------------|------------------------|
| (a) I and II | (b) II, III and V |
| (c) III, IV and V | (d) I, II, III and IV. |

17. The work done in compressing a gas isothermally is given by :

- | | |
|---|--|
| (a) $\frac{\gamma}{\gamma - 1} \cdot p_1 V_1 \left[\left(\frac{p_2}{p_1} \right)^{\frac{\gamma - 1}{\gamma}} \right]$ | (b) $mRT_1 \log_e \frac{p_2}{p_1}$ Nm |
| (c) $mc_p (T_2 - T_1)$ kJ | (d) $mRT_1 \left(1 - \frac{T_2}{T_1} \right)$ kJ. |

18. An ideal air standard cycle is shown in the given temperature entropy diagram.

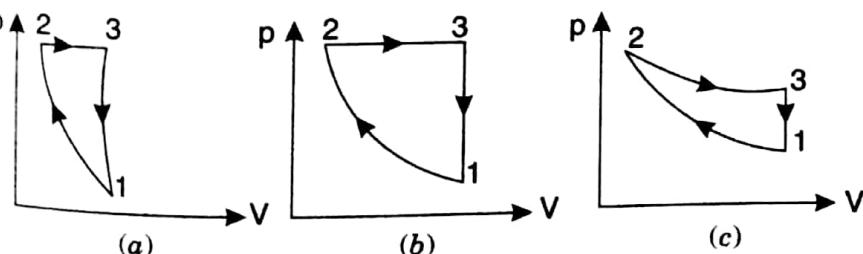
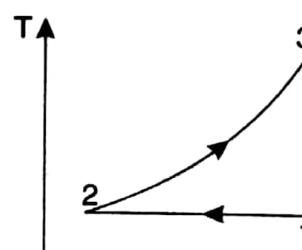


Fig. 8

19. In a Rankine cycle, with the maximum steam temperature being fixed from metallurgical considerations, as the boiler pressure increases

- (a) the condenser load will increase
- (b) the quality of turbine exhaust will decrease
- (c) the quality of turbine exhaust will increase
- (d) the quality of turbine exhaust will remain unchanged.

20. Match List-I (details of the processes of the cycle) with List-II (name of the cycle) and select the correct answer using the code given below the Lists :

List-I

- A. Two isothermals and two adiabatics
- B. Two isothermals and two constant volumes
- C. Two adiabatics and two constant pressures
- D. Two adiabatics and two constant volumes

List-II

- 1. Otto
- 2. Joule
- 3. Carnot
- 4. Stirling

Codes : (a) A B C D

4 3 1 2

(c) A B C D
3 4 1 2

(b) A B C D

4 3 2 1

(d) A B C D
3 4 2 1

21. Two blocks which are at different states are brought into contact with each other and allowed to reach a final state of thermal equilibrium. The final temperature attained is specified by the

- (a) Zeroth law of thermodynamics
- (c) Second law of thermodynamics

- (b) First law of thermodynamics

- (d) Third law of thermodynamics.

22. A control mass undergoes a process from state 1 to state 2 as shown in Fig. 9. During this process, the heat transfer to the system is 200 kJ. If the control mass is returned adiabatically from state 2 to state 1 by another process, then the work interaction during the return process (in kNm) would be

- (a) - 400
- (b) - 200
- (c) 200
- (d) 400.

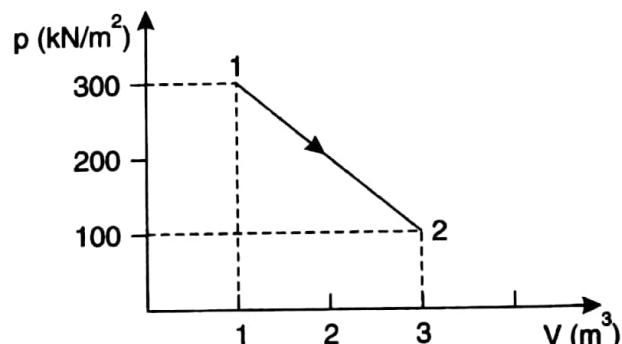


Fig. 9

23. Four processes of a thermodynamic cycle are shown above in Fig. 10 on the *T-s* plane in the sequence 1-2-3-4. The corresponding correct sequence of these process in the *p-V* plane as shown in Fig. 11 will be

- (a) (C-D-A-B)
- (b) (D-A-B-C)
- (c) (A-B-C-D)
- (d) (B-C-D-A).

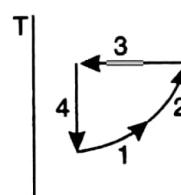


Fig. 10

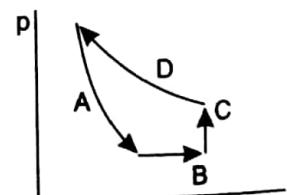


Fig. 11

24. Fig. 12 shows an isometric cooling process 1-2 of a pure substance. The ordinate and abscissa are respectively

- (a) pressure and volume
- (b) enthalpy and entropy

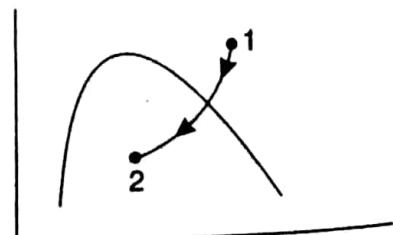
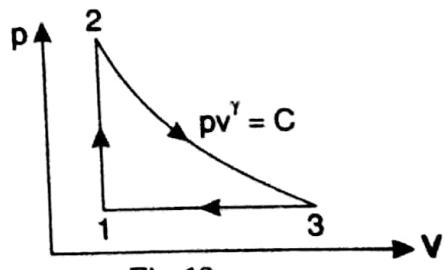


Fig. 12

- (c) temperature and entropy
 (d) pressure and enthalpy.
25. For a thermodynamic cycle to be irreversible, it is necessary that
- (a) $\int \frac{\delta Q}{T} = 0$
 (b) $\int \frac{\delta Q}{T} < 0$
 (c) $\int \frac{\delta Q}{T} > 0$
 (d) $\int \frac{\delta Q}{T} \geq 0$.
26. Neglecting changes in kinetic energy and potential energy, for unit mass the availability in a non-flow process becomes $a = \phi - \phi_0$ where ϕ is the availability function of the
- (a) open system
 (b) closed system
 (c) isolated system
 (d) steady flow process.
27. It can be shown that for a simple compressible substance, the relationship
- $$c_p - c_v = -T \left(\frac{\partial p}{\partial V} \right)_p^2 \left(\frac{\partial p}{\partial V} \right)_T \text{ exists}$$
- where c_p and c_v are specific heats at constant pressure and constant volume respectively, T is temperature, V is volume and p is pressure.
 Which one of the following statements is *not* true ?
- (a) c_p is always greater than c_v
 (b) The right side of the equation reduces to R for an ideal gas
 (c) Since $\left(\frac{\partial P}{\partial V} \right)_T$ can be either positive or negative, and $\left(\frac{\partial V}{\partial T} \right)_p^2$ must be positive, T must have a sign that is opposite of that of $\left(\frac{\partial p}{\partial V} \right)_T$
 (d) c_p is very nearly equal to c_v for liquid water.
28. Consider the following statements : In an irreversible process
1. entropy always increases.
 2. the sum of the entropy of all the bodies taking part in a process always increases.
 3. once created, entropy cannot be destroyed.
- Of these statements
- (a) 1 and 2 are correct
 (b) 1 and 3 are correct
 (c) 2 and 3 are correct
 (d) 1, 2 and 3 are correct.
29. An ideal cycle is shown in Fig. 13. Its thermal efficiency is given by
- (a) $1 - \frac{\left(\frac{v_3}{v_1} - 1 \right)}{\left(\frac{p_2}{p_1} - 1 \right)}$
 (b) $1 - \frac{1}{\gamma} \frac{\left(\frac{v_3}{v_1} - 1 \right)}{\left(\frac{p_2}{p_1} - 1 \right)}$
 (c) $1 - \gamma \frac{(v_3 - v_1)}{(p_2 - p_1)} \frac{p_1}{v_1}$
 (d) $1 - \frac{1}{\gamma} \frac{(p_2 - p_1)}{(v_3 - v_1)} \frac{v_1}{p_1}$.
- 
- Fig. 13
30. Consider the following statements regarding Otto cycle :
1. It is not a reversible cycle.

2. Its efficiency can be improved by using a working fluid of higher value of ratio of specific heats.
3. The practical way of increasing its efficiency is to increase the compression ratio.
4. Carburetted gasoline engines working on Otto cycle can work with compression ratios more than 12.

Of these statements

- (a) 1, 3 and 4 are correct
 (c) 1, 2 and 4 are correct

- (b) 1, 2 and 3 are correct
 (d) 2, 3 and 4 are correct.

31. Consider the following statements : The difference between higher and lower heating values of the fuels is due to

1. heat carried by steam from the moisture content of fuel.
2. sensible heat carried away by the flue gases.
3. heat carried away by steam from the combustion of hydrogen in the fuel.
4. heat lost by radiation.

Of these statements

- (a) 2, 3 and 4 are correct
 (c) 3 alone is correct

- (b) 1 and 2 are correct
 (d) 1, 2, 3 and 4 are correct.

32. Match List I (Gadgets undergoing a thermodynamic process) with List II (Property of the system that remains constant) and select the correct answer using the codes given below the Lists :

List I

- A. Bomb calorimeter
 B. Exhaust gas calorimeter
 C. Junker gas calorimeter
 D. Throttling calorimeter

Codes : (a) A B C D

3 4 1 2

(c) A B C D

3 1 4 2

List II

1. Pressure
 2. Enthalpy
 3. Volume
 4. Specific heats

(b) A B C D

2 4 1 3

(d) A B C D

4 3 2 1

33. Consider the following statements :

The maximum temperature produced by the combustion of a unit mass of fuel depends upon

1. LCV
2. ash content
3. mass of air supplied
4. pressure in the furnace.

Of these statements

- (a) 1 alone is correct
 (c) 2 and 4 are correct

- (b) 1 and 3 are correct
 (d) 3 and 4 are correct.

34. The graph shown in Fig. 14 represents the emission of a pollutant from an SI engine for different fuel/air ratios. The pollution in question is

- (a) CO
 (b) CO_2
 (c) hydrocarbon
 (d) NO_x

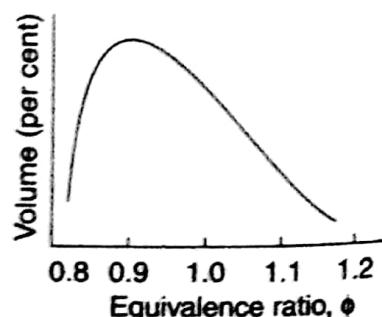


Fig. 14

35. Which of the following are the assumptions involved in the auto-ignition theory put forth for the onset of knock in SI engines ?

1. Flame velocity is normal before the onset of auto-ignition.

2. A number of end-gas elements autoignite simultaneously.

3. Preflame reactions are responsible for preparing the end-gas to ignite.

Select the correct answer using the codes given below :

(a) 1 and 2

(b) 1 and 3

(c) 2 and 3

(d) 1, 2 and 3.

B. I.C. ENGINES

36. Consider the following statements regarding *n*-cetane :

1. It is a standard fuel used for knock rating of diesel engines.

2. Its chemical name is *n*-hexadecane.

3. It is a saturated hydrocarbon of paraffin series.

4. It has long carbon chain structure.

Of the above statements

(a) 1, 3 and 4 are correct

(b) 1, 2 and 3 are correct

(c) 1, 2 and 4 are correct

(d) 2, 3 and 4 are correct.

37. List gives the different terms related to combustion while List II gives the outcome of the events that follow. Match List I with List II and select the correct answer using the codes given below the lists

List I

A. Association

B. Dissociation

C. Flame front

D. Abnormal combustion

Codes : (a) A B C D

3 4 1 2

(c) A B C D

3 4 2 1

List II

1. Pseudo shock

2. Knock

3. Endothermic

4. Exothermic.

(b) A B C D

4 3 1 2

(d) A B C D

4 3 2 1

- *38. Which one of the following engines will have heavier flywheel than the remaining ones ?

(a) 40 H.P. four-stroke petrol engine running at 1500 rpm.

(b) 40 H.P. two-stroke petrol engine running at 1500 rpm.

(c) 40 H.P. two-stroke diesel engine running at 750 rpm.

(d) 40 H.P. four-stroke diesel engine running at 750 rpm.

39. Consider the following statements :

Knock in the SI engine can be reduced by

1. supercharging.

2. retarding the spark.

3. using a fuel of long straight chain structure.

4. increasing the engine speed.

Of these statements

(a) 1 and 2 are correct

(c) 1, 3 and 4 are correct

(b) 2 and 3 are correct

(d) 2 and 4 are correct.

40. Consider the following statements :

The injector nozzle of a CI engine is required to inject fuel at a sufficiently high pressure in order to

1. be able to inject fuel in a chamber of high pressure at the end of the compression stroke.
2. inject fuel at high velocity to facilitate atomisation.
3. ensure that penetration is not high.

Of the above statements

- | | |
|-------------------------|-----------------------------|
| (a) 1 and 2 are correct | (b) 1 and 3 are correct |
| (c) 2 and 3 are correct | (d) 1, 2 and 3 are correct. |

41. Match List I with List II and select the correct answer using the codes given below the lists :

List I

(SI engine operating mode)

- A. Idling
- B. Cold starting
- C. Cruising
- D. Full throttle

Codes : (a) A B C D

4 3 2 1

(c) A B C D

4 2 1 3

List II

(Desired air-fuel ratio)

1. 13.0
2. 4.0
3. 16.0
4. 9.0

(b) A B C D

2 4 1 3

(d) A B C D

2 4 3 1

42. Compensating jet in a carburettor supplies almost constant amount of petrol at all speeds because

- (a) the jet area is automatically varied depending on the suction.
- (b) the flow from the main jet is diverted to the compensating jet with increase in speed.
- (c) the diameter of the jet is constant and the discharge coefficient is invariant.
- (d) the flow is produced due to the static head in the float chamber.

43. In the context of performance evaluation of I.C. Engine, match List I with List II and select the correct answer using the codes given below lists :

List I

(Parameter)

- A. Brake power (B.H.P.)
- B. Engine speed
- C. Calorific value of fuel
- D. Exhaust emissions

Codes : (a) A B C D

3 1 2 4

(c) A B C D

3 2 1 4

List II

(Equipment for measurement)

1. Bomb calorimeter
2. Electrical tachometer
3. Hydraulic dynamometer
4. Flame ionisation detector.

(b) A B C D

4 2 1 3

(d) A B C D

2 3 4 1

44. Consider the following statements :

In open cycle turbo-jet engines used in military aircraft, reheating the exhaust gas from the turbine by burning, more fuel is used to increase

1. thrust
2. the efficiency of engine
3. the range of aircraft.

Of these statements

- (a) 1 and 3 correct
- (b) 1 and 2 are correct
- (c) 2 and 3 are correct
- (d) 1, 2 and 3 are correct.

45. In a turbojet engine, subsequent to heat addition to compressed air, to get the power output, the working substance is expanded in
- (a) turbine blades, which is essentially an isentropic process
 - (b) turbine blades, which is essentially an isentropic process
 - (c) exit nozzle, which is essentially an isentropic process
 - (d) exit nozzle, which is a constant volume process.

46. Consider the following statements relating to rocket engines :

1. The combustion chamber in a rocket engine is directly analogous to the reservoir of a supersonic wind tunnel.
2. Stagnation conditions exist at the combustion chamber.
3. The exit velocities of exhaust gases are much higher than those in jet engines.
4. Efficiency of rocket engines is higher than that of jet engines.

Of these statements

- (a) 1, 3 and 4 are correct
- (b) 2, 3 and 4 are correct
- (c) 1, 2 and 3 are correct
- (d) 1, 2 and 4 are correct.

47. Only rocket engines can be propelled to 'SPACE' because

- (a) they can generate very high thrust
- (b) they have high propulsion efficiency
- (c) these engines can work on several fuels
- (d) they are not air-breathing engines.

48. Items given in List I and List II pertain to gas analysis. Match List I with List II and select the correct answer using the codes given below the lists :

List I

- A. CO_2
- B. Orsat apparatus
- C. CO
- D. O_2

List II

- 1. Alkaline pyrogallol
- 2. KOH solution
- 3. Wet analysis
- 4. Ammoniacal cuprous chloride
- 5. Dry analysis.

Codes : (a) A B C D
 2 3 1 4
 (c) A B C D
 1 5 4 2

(b) A B C D
 1 3 2 4
 (d) A B C D
 2 5 4 1

49. Which of the following factors are responsible for the formation of NO_x in spark ignition engine combustion ?

- 1. Incomplete combustion
- 2. High temperature
- 3. Availability of oxygen

Select the correct answer using the codes given below :

Codes :

- (a) 2 and 3
- (b) 1 and 3
- (c) 1 and 3
- (d) 1, 2 and 3.

50. Consider the following statements :

1. Gas cooled thermal reactors use CO_2 or helium as coolant and require no separate moderator.
 2. Fast reactors use heavy water as moderator and coolant.
 3. Liquid metal fast breeder reactors use molten sodium as coolant.
- Of these statements
- | | |
|-------------------------|--------------------------|
| (a) 1 and 3 are correct | (b) 2 and 4 are correct |
| (c) 3 and 4 are correct | (d) 1 and 2 are correct. |

51. Match-List I with List II and select the correct answer using the codes given below the lists :

List I

- A. Plutonium-293
- B. Thorium-233
- C. Cadmium
- D. Graphite

Codes : (a) A B C D
 (b) 1 2 3 4
 (c) A B C D
 (d) 1 2 4 3

List II

- 1. Fissile material
- 2. Fissionable material
- 3. Moderator
- 4. Poison

(b) A B C D
 (c) 2 1 3 4
 (d) A B C D
 (e) 2 1 4 3

52. If methane undergoes combustion with the stoichiometric quantity of air, the air-fuel ratio on molar basis would be

- | | |
|---------------|---------------|
| (a) 15.22 : 1 | (b) 12.30 : 1 |
| (c) 14.56 : 1 | (d) 9.52 : 1. |

53. The presence of nitrogen in the products of combustion ensures that

- (a) complete combustion of fuel takes place
- (b) incomplete combustion of fuel occurs
- (c) dry products of combustion are analysed
- (d) air is used for the combustion.

54. For maximum specific output of a constant volume cycle (otto cycle)

- | | |
|---|------------------------------|
| (a) the working fluid should be air | (b) the speed should be high |
| (c) suction temperature should be high | |
| (d) temperature of the working fluid at the end of compression and expansion should be equal. | |

55. A two-stroke engine has a speed of 750 rpm. A four-stroke engine having an identical cylinder size runs at 1500 rpm. The theoretical output of the two-stroke engine will be

- (a) twice that of the four-stroke engine
- (b) half that of the four-stroke engine
- (c) the same as that of the four-stroke engine
- (d) depend upon whether it is a C.I. or S.I. engine.

56. For same power output and same compression, as compared to two-stroke engines, four-stroke S.I. engines have

- | | |
|---------------------------------|--------------------------------|
| (a) higher fuel consumption | (b) lower thermal efficiency |
| (c) higher exhaust temperatures | (d) higher thermal efficiency. |

57. In a S.I. Engine, which one of the following is the correct order of the fuels with increasing detonation tendency ?
- Paraffins, Olefins, Naphthenes, Paraffins, Olefins
 - Aromatics, Naphthenes, Paraffins, Olefins
 - Naphthenes, Olefins, Aromatics, Paraffins
 - Aromatics, Naphthenes, Olefins, Paraffins.
58. Consider the following statements :
- Detonation in the S.I. engine can be suppressed by
- retarding the spark timing.
 - increasing the engine speed.
 - using 10% rich mixture.
- Of these statements
- 1 and 3 are correct
 - 2 and 3 are correct
 - 1, 2 and 3 are correct
 - 1 and 2 are correct.
59. Which one of the following figures correctly represents the variation of thermal efficiency (y-axis) with mixture strength (x-axis) ?

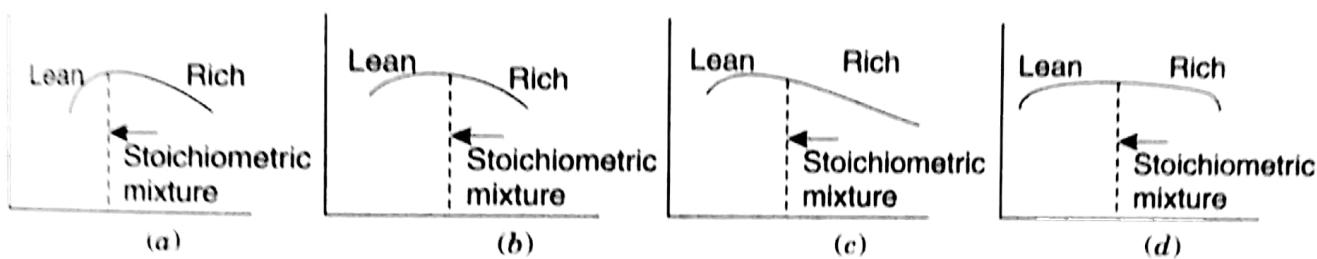


Fig. 15

60. Match List-I with the performance curves and select the correct answer using the codes given below the List :

List-I

*(Performance parameter
of an I.C. engine)*

- Indicated power
- Volumetric efficiency
- Brake power
- Specific fuel consumption

Codes : (a) A B C D

(b) A B C D

(c) A B C D

(d) A B C D

2 1 4 3

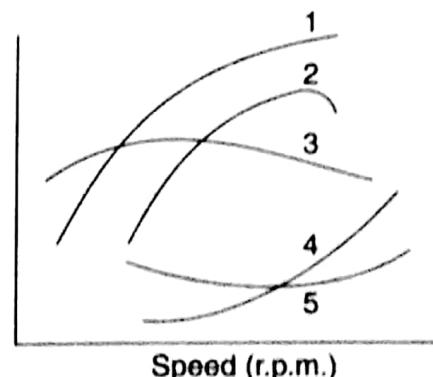
Performance curves

Fig. 16

61. Consider the following statements :

- Volumetric efficiency of diesel engines is higher than that of S.I. engines.
- When a S.I. engine is throttled, its mechanical efficiency decreases.

3. Specific fuel consumption increases as the power capacity of the engine increases.
 4. In spite of higher compression ratios, the exhaust temperature in diesel engines is much lower than that in SI engines.

Of these statements

- | | |
|---------------------------|-----------------------------|
| (a) 1, 2, 3 and 4 correct | (b) 1, 2 and 3 are correct |
| (c) 3 and 4 are correct | (d) 1, 2 and 4 are correct. |

62. Consider the following statements about a rocket engine :

1. It is very simple in construction and operation.
2. It can attain very high vehicle velocity.
3. It can operate for very long duration.

Of these statements

- | | |
|-------------------------|-----------------------------|
| (a) 1 and 3 are correct | (b) 1 and 2 are correct |
| (c) 2 and 3 are correct | (d) 1, 2 and 3 are correct. |

63. Hypothetical pressure diagram for a compression ignition engine is shown in the Fig. 17. The diesel knock is generated during the period

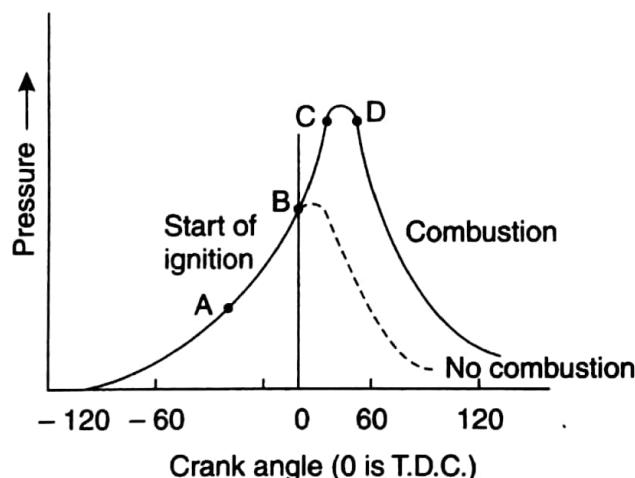


Fig. 17

- (a) AB
- (b) BC
- (c) CD
- (d) after D.

C. STEAM BOILERS, ENGINES, NOZZLES AND TURBINES

ESE 1996

- *64. In forced circulation boilers, about 90% of water is recirculated without evaporation. The circulation ratio is
- | | |
|---------|---------|
| (a) 0.1 | (b) 0.9 |
| (c) 9 | (d) 10 |

65. Given that,

h is draught in mm of water,
 H is chimney height in metres,

T is atmospheric temperature in K ,

The maximum discharge of gases through a chimney is given by

- (a) $h = 176.5 T_1/H$ (b) $h = H/176.5 T_1$
 (c) $h = 1.756 H/T_1$ (d) $h = 176.5 H/T_1$

- When solid fuels are burned, the nitrogen content of the flue gas by volume is about

- The excess air required for combustion of pulverised coal is of the order of

- (a) 100 to 150% (b) 30 to 60%
(c) 15 to 40% (d) 5 to 10%

- (c) 15 to 16% (d) 8 to 10%.

- (c) Mechanical efficiency

- Consider the following:

 1. Increasing evaporation rate using convection heat transfer from hot gases.
 2. Increasing evaporation rate using radiation.
 3. Protecting the refractory walls of the furnace.
 4. Increasing water circulation rate.

The main reasons for providing water wall enclosures in high pressure boiler furnaces would include:

70. Running speeds of steam turbines can be brought down to practical limits by which of the following method (s) ?

- 1. By using heavy flywheel**
2. By using a quick response governor.
3. By compounding.
4. By reducing fuel feed to the furnace.

Choose the correct answer using the codes given below :

71. Consider the following statements :

Expansion joints in steam pipelines are installed to

1. allow for future expansion of plant.
 2. take stresses away from flanges and fittings.
 3. permit expansion of pipes due to temperature rise.

Of these statements

- (a) 1, 2 and 3 are correct (b) 1 and 2 are correct
 (c) 2 and 3 are correct (d) 1 and 3 are correct.

72. In a surface condenser used in a steam power station, undercooling of condensate is undesirable as this would

- (c) increase the cooling water requirements (d) increase thermal stresses in the condenser.

*82. An impulse turbine produces 50 kW of power when the blade mean speed is 400 m/s. What is the rate of change of momentum tangential to the rotor ?

- (a) 200 N
- (b) 175 N
- (c) 150 N
- (d) 125 N.

*83. At a particular section of a reaction turbine, the diameter of the blade is 1.8 m, the velocity of flow of steam is 49 m/s and the quantity of steam flow is 5.4 m³/s. The blade height at this section will be approximately

- (a) 4 cm
- (b) 2 cm
- (c) 1 cm
- (d) 0.5 cm.

84. Consider the following statements :

If steam is reheated during the expansion through turbine stages

1. erosion of blade will decrease.
2. the overall pressure ratio will increase.
3. the total heat drop will increase.

Of these statements

- | | |
|----------------------------|--------------------------|
| (a) 1, 2 and 3 are correct | (b) 1 and 2 are correct |
| (c) 2 and 3 are correct | (d) 1 and 3 are correct. |

85. Which of the following power plants use heat recovery boilers (unfired) for steam generation ?

- | | |
|---------------------------------|---|
| 1. Combined cycle power plants. | 2. All thermal power plants using coal. |
| 3. Nuclear power plants. | 4. Power plants using fluidised bed combustion. |

Select the correct answer using the codes given below :

- | | |
|-------------|--------------|
| (a) 1 and 2 | (b) 3 and 4 |
| (c) 1 and 3 | (d) 2 and 4. |

86. Under ideal conditions, the velocity of steam at the outlet of a nozzle for a heat drop of 400 kJ/kg will be approximately

- | | |
|--------------|-------------------------------------|
| (a) 1200 m/s | (b) 900 m/s |
| (c) 600 m/s | (d) the same as the sonic velocity. |

87. In an impulse-reaction turbine stage, the heat drop in fixed and moving blades are 15 kJ/kg and 30 kJ/kg respectively. The degree of reaction for this stage will be

- | | |
|---------|----------|
| (a) 1/3 | (b) 1/2 |
| (c) 2/3 | (d) 3/4. |

88. If 'D' is the diameter of the turbine wheel and 'U' is its peripheral velocity, then the disc friction loss will be proportional to

- | | |
|---------------|--------------|
| (a) $(DU)^3$ | (b) D^2U^3 |
| (c) $D^3 U^2$ | (d) DU^4 . |

89. Once-through boilers will *not* have

- | | |
|---|---|
| (a) drums, headers and pumps | (b) drums, steam separators and pumps |
| (c) drums, headers and steam separators | (d) drums, headers, steam separators and pumps. |

D. COMPRESSORS, GAS TURBINES AND JET PROPULSION

$$p_b/p_1 = \left[\frac{2}{\gamma + 1} \right]^{\gamma/\gamma - 1}$$

If the back pressure is lower than p_b , given by the above equation,

- (a) the flow in the nozzle is supersonic
 (b) a shock wave exists inside the nozzle
 (c) the gases expand outside the nozzle and a shock wave appears outside the nozzle
 (d) a shock wave appears at the nozzle exit.

105. Consider the following statements :

Across the normal shock, the fluid properties change in such a manner that the

1. velocity of flow is subsonic.
2. pressure increases.
3. specific volume decreases.
4. temperature decreases.

Of these statements

- | | |
|----------------------------|-----------------------------|
| (a) 2, 3 and 4 are correct | (b) 1, 2 and 4 are correct |
| (c) 1, 3 and 4 are correct | (d) 1, 2 and 3 are correct. |

106. When a system undergoes a process such that $\int \frac{dQ}{T} = 0$ and $\Delta S > 0$, the process is

- | | |
|----------------------------|--------------------------|
| (a) irreversible adiabatic | (b) reversible adiabatic |
| (c) isothermal | (d) isobaric |

107. Consider the following statements :

When a perfect gas enclosed in cylinder-piston device executes a reversible adiabatic expansion process.

1. its entropy will increase.
2. its entropy change will be zero
3. the entropy change of the surroundings will be zero.

Of these statements

- | | |
|-------------------------|-------------------------|
| (a) 1 and 3 are correct | (b) 2 alone is correct |
| (c) 2 and 3 are correct | (d) 1 alone is correct. |

108. The heat rejection by a reciprocating air compressor during the reversible compression process AB, shown in the following temperature entropy diagram, is represented by the area

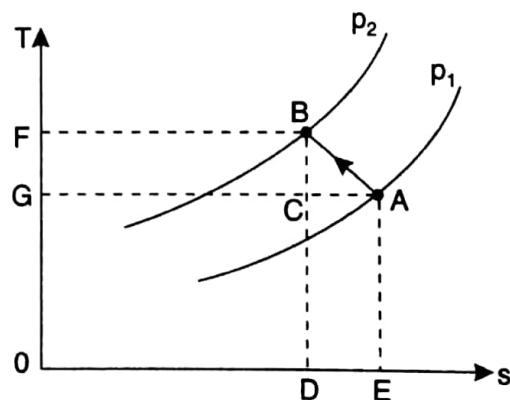


Fig. 18

- (a) ABC
(c) ABFG

- (b) ABDE
(d) ABFOE.

109. Centrifugal compressors are suitable for large discharge and wider mass flow range, but at a relatively low discharge pressure of the order of 10 bar, because of
- (a) low pressure ratio
 - (b) limitation of size of receiver
 - (c) large speeds
 - (d) high compression index.

110. Given : V_{w_2} = Velocity of whirl at outlet, and
 u_2 = Peripheral velocity of the blade tips.

The degree of reaction in centrifugal compressor is equal to

$$(a) 1 - \frac{V_{w_2}}{2u_2}$$

$$(c) 1 - \frac{2V_{w_2}}{u_2}$$

$$(b) 1 - \frac{u_2}{2V_{w_2}}$$

$$(d) 1 - \frac{V_{w_2}}{u_2}.$$

111. Match List I with List II (pertaining to blower performance) and select the correct answer using the codes given below the Lists :

List-I

- A. Slip
- B. Stall
- C. Choking

List-II

- 1. Reduction of whirl velocity
- 2. Fixed mass flow rate regardless of pressure ratio
- 3. Flow separation
- 4. Flow area reduction

Codes : (a) A B C

4 3 2

(b) A B C

1 3 2

(c) A B C

4 1 3

(d) A B C

2 3 4

- *112. In a gas turbine cycle, the turbine output is 600 kJ/kg, the compressor work is 400 kJ/kg and the heat supplied is 1000 kJ/kg. The thermal efficiency of cycle is

- (a) 80%
- (b) 60%
- (c) 40%
- (d) 20%.

113. In a single-stage open-cycle gas turbine the mass flow through the turbine is higher than the mass flow through compressor because

- (a) the specific volume of air increases by use of intercooler
- (b) the temperature of air increases in the reheat
- (c) the combustion of fuel takes place in the combustion chamber
- (d) the specific heats at constant pressure for incoming air and exhaust gases are different.

114. The given figure shows the effect of the substitution of an isothermal compression process for the isentropic compression process on the gas turbine cycle. The shaded area (1-5-2-1) in the p-v diagram represents

- (a) reduction in the compression work
- (b) reduction in the specific volume
- (c) increment in the compression work
- (d) increment in the specific volume.

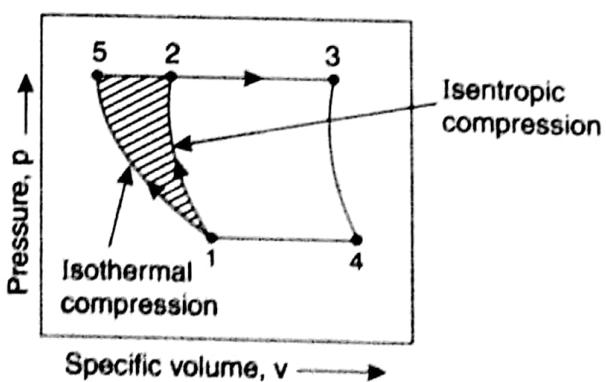


Fig. 18 (a)

- *115. A reaction turbine discharge 3 m³/s of water under a head of 10 m with an overall efficiency of 92%. The power developed is

- (a) 295.2 kW
- (b) 287.0 kW
- (c) 270.7 kW
- (d) 265.2 kW.

116. A gas turbine develops 120 kJ of work while the compressor absorbs 60 kJ of work and the heat supplied is 200 kJ. If a regenerator which would recover 40% of the heat in the exhaust were used, then the increase in the overall thermal efficiency would be

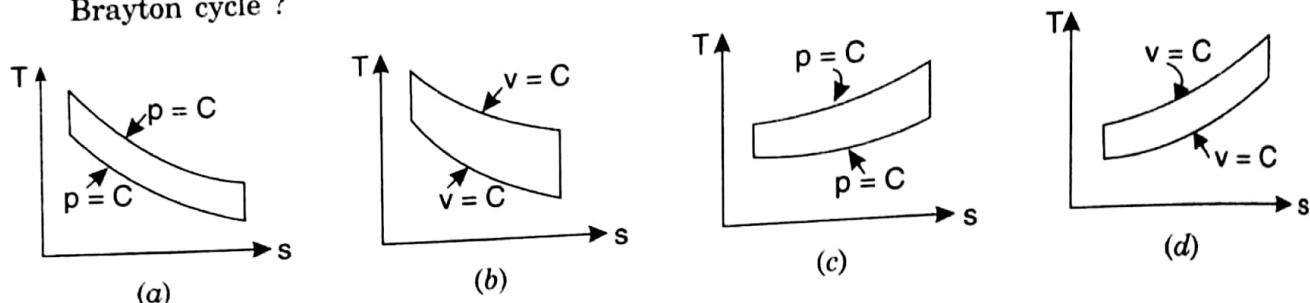


Fig. 19

matched :		
1. Turbojet	...	Efficiency increases with flight speed
2. SI engine	...	Lowest specific fuel consumption
3. Turboprop	...	Suitable for low flight speeds

3. Turbo-prop ...
Select the correct answer using the codes given below :

Codes :

- 120.** Which one of the following is the correct sequence of the position of the given components in a turbo-prop ?

- (a) Propeller, Compressor, Turbine, Burner
 (c) Propeller, Compressor, Burner, Turbine

1. effective jet velocity.
3. rate of propellant consumption.

Of these statements

1. increasing the jet

- 123.** The effective jet exit velocity from a rocket is 2700 m/s. The forward flight velocity is 1350 m/s. The propulsive efficiency of the unit is

(c) 1 and 3 are correct	(d) 1, 2 and 3 are correct.
(a) 200%	(b) 100%
(c) 66.66%	(d) 33.33%.

- 124.** Consider the following statements regarding nuclear reactors :
1. In a gas-cooled thermal reactor, if CO_2 is used as the coolant, a separate moderator is not necessary as the gas contains carbon.
 2. Fast reactors using enriched uranium fuel do not require a moderator.
 3. In liquid metal-cooled fast breeder reactors, molten sodium is used as the coolant because of its high thermal conductivity.
 4. Fast reactors rely primarily on slow neutrons for fission.
- Of these statements
- | | |
|-------------------------|--------------------------|
| (a) 1 and 2 are correct | (b) 2 and 4 are correct |
| (c) 2 and 3 are correct | (d) 1 and 3 are correct. |
- 125.** Which of the following form part(s) of boiler mountings ?
- | | |
|---------------|---------------------|
| 1. Economiser | 2. Feed check valve |
| 3. Steam trap | 4. Superheater |
- Select the correct answer using the codes given below :
- Codes :**
- | | |
|----------------|--------------------|
| (a) 2 alone | (b) 1 and 3 |
| (c) 2, 3 and 4 | (d) 1, 2, 3 and 4. |
- 126.** The energy transfer process is
- | |
|--|
| (a) continuous in a reciprocating compressor and intermittent in an axial compressor |
| (b) continuous in an axial compressor and intermittent in a reciprocating compressor |
| (c) continuous in both reciprocating and axial compressors |
| (d) intermittent in both reciprocating and axial compressors. |
- 127.** In an axial flow compressor stage, air enters and leaves the stage axially. If the whirl component of the air leaving the rotor is half the mean peripheral velocity of the rotor blades, then the degree of reaction will be
- | | |
|----------|-----------|
| (a) 1.00 | (b) 0.75 |
| (c) 0.50 | (d) 0.25. |
- 128.** If an axial flow compressor is designed for a constant velocity through all stages, then the area of annulus of the succeeding stages will
- | | |
|----------------------------|---------------------------------------|
| (a) remain the same | (b) progressively decrease |
| (c) progressively increase | (d) depend upon the number of stages. |
- 129.** What will be the shape of the velocity triangle at the exit of a radial bladed centrifugal impeller, taking into account the slip ?
- | | |
|-------------------------------------|---|
| (a) Right-angled | (b) Isosceles |
| (c) All angles less than 90° | (d) One angle greater than 90° . |
- 130.** Which one of the following statements is *true* ?
- | |
|--|
| (a) In a multi-stage compressor, adiabatic efficiency is less than stage efficiency |
| (b) In a multi-stage turbine, adiabatic efficiency is less than the stage efficiency |
| (c) Preheat factor for a multi-stage compressor is greater than one |
| (d) Preheat factor does not affect the multi-stage compressor performance. |
- 131.** At constant efficiency, the horse power of a fan is
- | | |
|--------------------------------------|--------------------------------------|
| (a) proportional to rpm | (b) proportional to $(\text{rpm})^2$ |
| (c) proportional to $(\text{rpm})^3$ | (d) a polynomial function of rpm. |

E. REFRIGERATION AND AIR-CONDITIONING

- 141.** In a vapour compression refrigeration system, a throttle valve is used in place of an expander because

 - it considerably reduces the system weight
 - it improves the COP, as the condenser is small
 - the positive work in isentropic expansion of liquid is very small
 - it leads to significant cost reduction.

142. A cube at high temperature is immersed in a constant temperature bath. It loses heat from its top, bottom and side surfaces with heat transfer coefficient of h_1 , h_2 and h_3 respectively. The average heat transfer coefficient for the cube is

 - $h_1 + h_2 + h_3$
 - $(h_1 h_2 h_3)^{1/3}$
 - $\frac{1}{h_1} + \frac{1}{h_2} + \frac{1}{h_3}$
 - none of the above.

- 143.** Match items in List I with those in List II and III and select the correct answer using the codes given the lists :

<i>List I</i>	<i>List II</i>	<i>List III</i>
A. Reversed Carnot engine	1. Condenser	6. Generator
B. Sub-cooling	2. Evaporator	7. Increase in refrigerating effect
C. Superheating	3. Vortex refrigerator	8. Highest COP
D. Constant enthalpy	4. Throttling	9. Adiabatic
	5. Heat pump	10. Dry compression
Codes :	A	B
(a)	3, 10	1, 7
		2, 9
		4, 6
(b)	A	B
		C
		D
	5, 8	1, 7
		2, 10
		4, 9
(c)	A	B
		C
		D
	4, 10	3, 8
		3, 10
		1, 6
(d)	A	B
		C
		D
	2, 7	5, 8
		4, 6
		1, 9

- 144.** Consider the following statements :

In ammonia refrigeration systems, oil separator is provided because

1. oil separation in evaporator would lead to reduction in heat transfer coefficient,
 2. oil accumulation in the evaporator causes choking of evaporator.
 3. oil is partially miscible in the refrigerant.
 4. oil causes choking of expansion device.

Of these statements

- *145. Consider the following statements :

Moisture should be removed from refrigerants to avoid :

3. restriction to refrigerant flow

On these statements

(a) 1, 2, 3 and 4 are correct

(c) 2, 3 and 4 are correct

4. corrosion of steel parts.

(b) 1 and 2 are correct

(d) 1, 3 and 4 are correct.

*146. Consider the following statements :

1. Practically all common refrigerants have approximately the same COP and power requirement.
2. Ammonia mixes freely with lubricating oil and this helps lubrication of compressors
3. Dielectric strength of refrigerants is an important property in hermetically sealed compressor units.
4. Leakage of ammonia can be detected by halide torch method.

Of these statements

(a) 1, 2 and 4 are correct

(b) 2 and 4 are correct

(c) 1, 3 and 4 are correct

(d) 1 and 3 are correct.

147. The most commonly used method for the design of duct size is the

(a) velocity reduction method

(b) equal friction method

(c) static regain method

(d) dual or double method.

148. The refrigerant used for absorption refrigerators working on heat from solar collectors is a mixture of water and

(a) carbon dioxide

(b) sulphur dioxide

(c) lithium bromide

(d) freon-12.

149. During the adiabatic cooling of moist air

(a) DBT remains constant

(b) specific humidity remains constant

(c) relative humidity remains constant

(d) WBT remains constant.

150. When a stream of moist air is passed over a cold and dry cooling coil such that no condensation takes place, then the air stream will get cooled along the line of

(a) constant wet bulb temperature

(b) constant dew point temperature

(c) constant relative humidity

(d) constant enthalpy.

151. For large tonnage (more than 200 tons) air-conditioning applications, which one of the following types of compressors is recommended ?

(a) Reciprocating

(b) Rotating

(c) Centrifugal

(d) Screw.

152. In a cooling tower, "approach" is the temperature difference between the

(a) hot inlet water and cold outlet water

(b) hot inlet water and WBT

(c) cold outlet water and WBT

(d) DBT and WBT

153. When the discharge pressure is too high in a refrigeration system, high pressure control is installed to

(a) stop the cooling fan

(b) stop the water circulating pump

(c) regulate the flow of cooling water

(d) stop the compressor.

154. A refrigerating machine working on reversed Carnot cycle takes out 2 kW of heat from the system while working between temperature limits of 300 K and 200 K. COP and power consumed by the cycle will be respectively

(a) 1 and 1 kW

(b) 1 and 2 kW

(c) 2 and 1 kW

(c) 2 and 2 kW.

155. Consider the following statements :

In the case of a vapour compression machine, if the condensing temperature of the refrigerant is closer to the critical temperature, then there will be

- 1. excessive power consumption
- 2. high compression
- 3. large volume flow.

Of these statements

- (a) 1, 2 and 3 are correct
- (b) 1 and 2 are correct
- (c) 2 and 3 are correct
- (d) 1 and 3 are correct.

156. Hydrogen is essential in an Electrolux refrigeration system, because

- (a) it acts as a catalyst in the evaporator
- (b) the reaction between hydrogen and ammonia is endothermic in evaporator and exothermic in absorber
- (c) the cooled hydrogen leaving the heat exchanger cools the refrigerant entering the evaporator
- (d) it helps in maintaining a low partial pressure for the evaporating ammonia.

*157. In an ideal refrigeration (reversed Carnot) cycle, the condenser and evaporator temperatures are 27°C and -13°C respectively. The COP of this cycle would be

- (a) 6.5
- (b) 7.5
- (c) 10.5
- (d) 15.0.

158. A single-stage vapour compression refrigeration system cannot be used to produce ultra low temperatures because

- (a) refrigerants for ultra-low temperatures are not available
- (b) lubricants for ultra-low temperatures are not available
- (c) volumetric efficiency will decrease considerably
- (d) heat leakage into the system will be excessive

159. Vapour absorption refrigeration system works using the

- (a) ability of a substance to get easily condensed or evaporated
- (b) ability of a vapour to get compressed or expanded
- (c) affinity of a substance for another substance
- (d) absorptivity of a substance.

160. Which one of the following statements regarding ammonia absorption system is *correct* ?

The solubility of ammonia in water is

- (a) a function of the temperature and pressure of the solution
- (b) a function of the pressure of the solution irrespective of the temperature
- (c) a function of the temperature of the solution alone
- (d) independent of the temperature and pressure of the solution.

161. Consider the following statements :

In thermoelectric refrigeration, the coefficient of performance is a function of

- 1. electrical conductivity of materials.
- 2. Peltier coefficient.
- 3. Seebeck coefficient.
- 4. temperature at cold and hot junctions.
- 5. thermal conductivity of materials.

Of these statements

- (a) 1, 3, 4 and 5 are correct
- (b) 1, 2, 3 and 5 are correct
- (c) 1, 2, 4 and 5 are correct
- (d) 2, 3, 4 and 5 are correct.

162. Air cooling is used for freon compressors whereas water jacketing is adopted for cooling ammonia compressors. This is because

- (a) latent heat of ammonia is higher than that of a freon
- (b) thermal conductivity of water is higher than that of air
- (c) specific heat of water is higher than that of air
- (d) of the larger superheat horn of ammonia compression cycle.

163. Consider the following statements :

- A psychrometer measures
1. wet bulb temperature
 2. dew point temperature
 3. dry bulb temperature.

Of these statements :

- (a) 1 alone is correct
- (b) 2 and 3 are correct
- (c) 1 and 3 are correct
- (d) 1, 2 and 3 are correct.

164. Hot coffee in a cup is allowed to cool. Its cooling rate is measured and found to be greater than the value calculated by conduction, convection and radiation measurements. The difference is due to

- (a) properties of coffee changing with temperature
- (b) currents of air flow in the room
- (c) underestimation of the emissivity of coffee
- (d) evaporation.

165. For an air-conditioning plant above 300 ton, which one of the following systems would normally be preferred ?

- (a) Ammonia reciprocating compressor
- (b) Centrifugal chiller
- (c) Absorption refrigeration system
- (d) Hermetic compressor

166. Fresh air intake (air change per hour) recommended for ventilation purposes in the air-conditioning system of an office building is

- (a) 1/2
- (b) 3/2
- (c) 9/2
- (d) 25/2.

167. Give that

- Nu = Nusselt number,
 Re = Reynolds number,
 Pr = Prandtl number,
 Sh = Sherwood number,
 Sc = Schmidt number

and Gr = Grashoff number,

the functional relationship for free convective mass transfer is given as :

- (a) Nu = $f(Gr, Pr)$
- (b) Sh = $f(Sc, Gr)$
- (c) Nu = $f(Re, Pr)$
- (d) Sh = $f(Re, Sc)$

168. Air refrigeration cycle is used in

- (a) commercial refrigerators
- (b) domestic refrigerators
- (c) gas liquefaction
- (d) air-conditioning.

- 169.** The flash chamber in single-stage simple vapour compression cycle
 (a) increases the refrigerating effect
 (c) increases the work of compression (b) decrease the refrigerating effect
 (d) has no effect on refrigerating effect.

170. Consider the following statements :
 In a vapour compression system, a thermometer placed in the liquid line can indicate whether the
 1. refrigerant flow is too low
 3. condenser is fouled
 Of these statements :
 (a) 1, 2 and 3 are correct
 (c) 1, 3 and 4 are correct (b) 1, 2 and 4 are correct
 (d) 2, 3 and 4 are correct.

171. Match List I with List II and select the correct answer using the codes given below the Lists :

List I	List II
A. Bell Coleman refrigeration	1. Compressor
B. Vapour compression refrigeration	2. Generator
C. Absorption refrigeration	3. Flash chamber
D. Jet refrigeration	4. Expansion cylinder
Codes :	
(a) A B C D	(b) A B C D
1 4 3 2	4 1 3 2
(c) A B C D	(d) A B C D
1 4 2 3	4 1 2 3

172. The maximum COP for the absorption cycle is given by (T_G = generator temperature, T_C = environment temperature, T_E = refrigerated space temperature)
 (a) $\frac{T_E(T_G - T_C)}{T_G(T_C - T_E)}$ (b) $\frac{T_G(T_C - T_E)}{T_E(T_G - T_C)}$
 (c) $\frac{T_C(T_G - T_E)}{T_G(T_C - T_E)}$ (d) $\frac{T_G(T_C - T_E)}{T_C(T_G - T_E)}$

173. In milk chilling plants, the usual secondary refrigerant is
 (a) ammonia solution (b) sodium silicate
 (c) glycol (d) brine.

174. The desirable combination of properties for a refrigerant include
 (a) high specific heat and low specific volume
 (b) high heat transfer coefficient and low latent heat
 (c) high thermal conductivity and low freezing point
 (d) high specific heat and high boiling point.

175. Which of the following method(s) is/are adopted in the design of air duct system ?
 1. Velocity reduction method 2. Equal friction method 3. Static regain method.
 Select the correct answer using the codes given below :
Codes :
 (a) 1 alone (b) 1 and 2
 (c) 2 and 3 (d) 1, 2 and 3.

176. To fix the state point in respect of air-vapour mixtures, three intrinsic properties are needed. Yet, the psychrometric chart requires only two because

- (a) water vapour is in the superheated state
- (b) the chart is for a given pressure
- (c) the chart is an approximation to true values
- (d) the mixtures can be treated as a perfect gas.

177. During sensible cooling of air

- (a) its wet bulb temperature increases and dew point remains constant
- (b) its wet bulb temperature decreases and the dew point remains constant
- (c) its wet bulb temperature increases and the dew point decreases
- (d) its wet bulb temperature decreases and dew point increases.

178. The expression $\frac{0.622 p_v}{p_t - p_v}$ is used to determine

- | | |
|--------------------------|-----------------------|
| (a) relative humidity | (b) specific humidity |
| (c) degree of saturation | (d) partial pressure. |

179. The effective temperature is a measure of the combined effects of

- (a) dry bulb temperature and relative humidity
- (b) dry bulb temperature and air motion
- (c) wet bulb temperature and air motion
- (d) dry bulb temperature, relative humidity and air motion

180. In air-conditioning design for summer months, the condition inside a factory where heavy work is performed as compared to a factory in which light work is performed should have

- (a) lower dry bulb temperature and lower relative humidity
- (b) lower dry bulb temperature and higher relative humidity
- (c) lower dry bulb temperature and same relative humidity
- (d) same dry bulb temperature and same relative humidity.

ANSWERS

1. (c)	2. (b)	3. (c)	4. (d)	5. (a)	6. (d)
*7. (c)	8. (a)	9. (b)	10. (a)	11. (a)	12. (c)
*13. (a)	*14. (c)	*15. (b)	16. (d)	17. (b)	18. (a)
19. (a)	20. (c)	21. (a)	22. (c)	23. (d)	24. (c)
25. (b)	26. (a)	27. (b)	28. (c)	29. (c)	30. (b)
31. (c)	32. (a)	33. (b)	34. (d)	35. (d)	36. (b)
37. (b)	*38. (a)	39. (d)	40. (d)	41. (a)	42. (d)
43. (c)	44. (a)	45. (a)	46. (c)	47. (d)	48. (d)
49. (a)	50. (c)	51. (c)	52. (a)	53. (d)	54. (d)
55. (c)	56. (d)	57. (d)	58. (c)	59. (c)	60. (b)
61. (a)	62. (b)	63. (b)	*64. (d)	65. (d)	66. (c)
67. (b)	68. (d)	69. (a)	70. (b)	71. (c)	72. (c)
73. (a)	74. (d)	75. (d)	76. (c)	77. (a)	78. (c)
79. (d)	80. (d)	81. (a)	*82. (d)	*83. (b)	84. (a)
85. (d)	86. (b)	87. (c)	88. (c)	89. (c)	90. (b)
91. (d)	92. (a)	*93. (c)	94. (d)	95. (a)	96. (c)
97. (b)	98. (c)	99. (d)	*100. (d)	101. (b)	102. (d)
103. (a)	104. (c)	105. (d)	106. (a)	107. (b)	108. (b)

109. (c)	110. (a)	111. (b)	*112. (d)	113. (c)	114. (a)
*115. (c)	116. (b)	117. (c)	118. (c)	119. (c)	120. (c)
121. (b)	122. (d)	123. (a)	124. (d)	125. (a)	126. (b)
127. (b)	128. (c)	129. (d)	130. (a)	131. (c)	132. (a)
133. (a)	134. (c)	135. (d)	136. (c)	137. (a)	138. (d)
139. (a)	140. (a)	141. (c)	142. (d)	143. (b)	144. (d)
*145. (c)	*146. (d)	147. (c)	148. (c)	149. (d)	150. (b)
*151. (c)	152. (c)	153. (d)	*154. (c)	155. (b)	156. (d)
*157. (a)	158. (d)	159. (c)	160. (a)	161. (b)	162. (c)
163. (a)	164. (b)	165. (c)	166. (b)	167. (c)	168. (d)
169. (a)	170. (a)	171. (d)	172. (a)	173. (d)	174. (d)
175. (d)	176. (b)	177. (a)	178. (b)	179. (d)	180. (a).

SOLUTIONS — COMMENTS

13. For isothermal process, $T_1 = T_2$

$$\text{or } p_1 V_1 = p_2 V_2 \Rightarrow V_1 = \frac{p_2 V_2}{p_1}$$

Given : $\frac{p_1}{p_2} = 10$ and $V_2 = 0.55 \text{ m}^3$

$$\therefore V_1 = \frac{0.55}{10} = 0.055 \text{ m}^3$$

For adiabatic expansion, $pV^\gamma = \text{constant}$

$$\text{or } p_1 V_1^\gamma = p_2 V_2^\gamma \Rightarrow v_2 = \left(\frac{p_1}{p_2} \right)^{\frac{1}{\gamma}} \times V_1 = (10)^{\frac{1}{1.4}} \times 0.055 = 0.2848 \text{ m}^3$$

14. $T_1 = T_2 ; V_2 = \frac{V_1}{2}$... Given

From $p_1 V_1 = p_2 V_2, p_1 V_1 = p_2 \times \frac{V_1}{2} \Rightarrow p_2 = 2p_1$

15. Since $(\Delta s)_{\text{system}} > (\Delta s)_{\text{surrounding}}$, where both $(\Delta s)_{\text{system}}$ and $(\Delta s)_{\text{surrounding}} > 0$

38. Because four-stroke engines require heavier flywheels as power stroke comes only once every four strokes and also petrol engine is running at the highest r.p.m.

64. Circulation ratio is defined as reciprocal of per cent of the steam supplied in drum.

$$\therefore \text{Circulation ratio} = \frac{1}{0.1} = 10$$

74. The deaerator is used for removal of oxygen and CO_2 from boiler feed water and process water at elevated temperature to remove chances of corrosion.

82. Given : $P = 50 \times 10^3 \text{ watts}$; Blade speed = 400 m/s

$$\text{Rate of change of momentum tangential to rotor} = \frac{50 \times 10^3}{400} = 125.$$

83. From continuity equation, $Q = AV$

or

$$5.4 = \pi d h \times V = \pi \times 1.8 \times h \times 49$$

or

$$h = \frac{5.4}{\pi \times 1.8 \times 49} \times 100 = 2 \text{ cm.}$$

93. The polypropic efficiency is defined as the isentropic efficiency of an elemental stage of compressor which is constant throughout the whole process.

96. As reciprocating compressors are bulky, they are not used except for stationary installation and radial and axial flow compressors are not suitable due to problem of surging and high speed required for operation.

100. Volumetric efficiency = $1 - k \left[\left(\frac{p_2}{p_1} \right)^{\frac{1}{n}} - 1 \right]$

where,

$$k = \text{Clearance volume ratio} = \frac{V_c}{V_s},$$

n = Index of compression/expansion,

$$\frac{p_2}{p_1} = \text{Pressure ratio.}$$

112. Given :

$$W_T = 600 \text{ kJ/kg}, W_C = 400 \text{ kJ/kg}; Q_{in} = 1000 \text{ kJ/kg}$$

$$\therefore \text{Thermal efficiency, } \eta = \frac{W_T - W_C}{Q_{in}} = \frac{600 - 400}{1000} \times 100 = 20\%.$$

115. Given :

$$H = 10 \text{ m}; Q = 3 \text{ m}^3/\text{s}; \eta = 92\%$$

$$\eta = \frac{p}{wQH} \quad \therefore p = \eta w Q H = 0.92 \times 9.81 \times 3 \times 10 = 270.7 \text{ kW.}$$

145. The compressors seal cannot fail due to moisture, all the other conditions do occur due to presence of moisture.

146. All common refrigerants like F_{11} , F_{12} , F_{22} , NH_3 etc., have approximately the same C.O.P. ranging from 4.76 to 5.09 and H.P./ton varies from 0.99 to 1.01.

The electric resistance of the refrigerant is an important factor when it is used in hermetically sealed unit where the motor is exposed to the refrigerant.

151. The reason why centrifugal compressors are used to large tonnage is that they can handle larger volumes of refrigerant, also the part load efficiency of this kind is higher.

154. C.O.P. = $\frac{T_2}{T_1 - T_2} = \frac{200}{300 - 200} = 2$

$$\text{Power consumed} = \frac{R_4 \text{ (net refrigerating effect)}}{\text{C.O.P.}} = \frac{2 \text{ kW}}{2} = 1 \text{ kW.}$$

MISCELLANEOUS OBJECTIVE TYPE QUESTIONS

(With Answers)

SET-I

A. Choose the appropriate answer :

- (i) It is related to supersaturated flow in steam nozzles
 - (a) Reheat factor
 - (b) Wilson line
 - (c) State point locus
 - (d) Mach number.
- (ii) The ideal refrigeration cycle in aircraft is
 - (a) vapour compression cycle
 - (b) vapour absorption cycle
 - (c) steam jet refrigeration
 - (d) reversed Brayton cycle.
- (iii) For supersonic flow the converging duct is a
 - (a) nozzle
 - (b) diffuser
 - (c) venturi
 - (d) duct in which velocity remains constant.
- (iv) Morse test measures the indicated power of a
 - (a) SI engine
 - (b) CI engine
 - (c) Steam engine
 - (d) Steam turbine.
- (v) It has zero cetane number
 - (a) Normal heptane
 - (b) Alpha-methylnaphthalene
 - (c) Cetane
 - (d) Iso-octane.

B. State whether the statements are correct or wrong :

- (i) An isentropic process is always adiabatic.
- (ii) There is no pressure drop across a reaction turbine stage.
- (iii) The maximum velocity that can be achieved with an incompressible fluid is the sonic velocity.
- (iv) The function of a governor is to maintain the shaft speed constant as the load varies.
- (v) A convergent nozzle is used to obtain supersonic velocity.
- (vi) The integral $\int pdv$ gives work for any process.

C. Fill in the blanks :

- (i) COP of a refrigerator is defined as
- (ii) Mach number is defined as
- (iii) Equivalent evaporation of a boiler is defined as
- (iv) A boiler is specified by
- (v) Isothermal efficiency of a compressor is defined as
- (vi) Degree of reaction is defined as

D. Match the sets :

Set A

- 1. Fusible plug
- 2. Pre-whirl
- 3. Fuel injection

Set B

- (a) SI engine
- (b) CI engine
- (c) Steam turbine

- | | |
|---|---|
| 4. Capillary tube
5. Otto cycle
6. Labyrinth glands | (d) Fire tube boiler
(e) Centrifugal compressor
(f) Vapour compression refrigeration plant. |
|---|---|

ANSWERS

- A.** (i) Wilson line (ii) Reversed Brayton cycle
 (iii) Diffuser (iv) SI engine (v) Alpha-methyl naphthalene.

B. (i) Correct (ii) Wrong (iii) Correct
 (iv) Correct (v) Wrong (vi) Wrong.

C. (i) COP of refrigerator =
$$\frac{\text{Net refrigerating effect } (R_n)}{\text{Work done } (W)}$$

(ii) *Mach number is the ratio of the actual velocity to the sonic velocity.*

(iii) *Equivalent evaporation of a boiler is defined as the amount of water evaporated from feed water at 100°C and formed into dry and saturated system at 100°C at normal pressure. It is usually written as “from and at 100°C”.*

(iv) A boiler is specified by : (a) Pressure, temperature, rate of steam generation (b) Fire tube or water tube (c) Fuel used and method of firing.

(v) *Isothermal efficiency is the ratio of isothermal power to shaft power.*

(vi) *Degree of reaction of a reaction turbine (R_d) is defined as the ratio of heat drop over moving blades to the total heat drop in the stage.*

$$i.e., R_d = \frac{\text{Heat drop in moving blades}}{\text{Heat drop in the stage}} = \frac{\Delta h_m}{\Delta h_f + \Delta h_m}$$

(where surfaces f and m stand for fixed and moving blades respectively)

- D.** (1) (d) (2) (e) (3) (b) (4) (f) (5) (a) (6) (c).

SET-II

A. Choose the correct answer :

- (i) Cycle efficiency of a modern thermal power plant is approximately

 - (a) 29%
 - (b) 60%
 - (c) 80%
 - (d) 44%
 - (e) none of the above.

(ii) Three similar diesel engines (stroke to bore ratio same) have diameters of 10 cm, 25 cm and 35 cm and they run at speeds of (1) 2000 r.p.m., (2) 700 r.p.m. and (3) 570 r.p.m. respectively. Compression ratio and all other conditions of operation of the engines to be the same, which engine will have more tendency to knocking ?

 - (a) 3
 - (b) 2
 - (c) 1
 - (d) None of the above.

(iii) In the above question (ii), which engine will have more tendency for smoky exhaust ?

 - (a) 1
 - (b) 2
 - (c) 3
 - (d) none of the above.

Justify in one sentence.

- (iv) Amyl nitrite, ethyl nitrate or ether added in small quantities with diesel fuel alters the rate of preflame reaction
 (a) decreases (b) increases
 (c) remains the same (d) none of the above.

(v) Some metal organic compounds (tetraethyl lead or iron carbonyl) added to gasoline in some quantities alter the ignition delay of the mixture appreciably
 (a) decreases (b) increases
 (c) remains the same (d) none of the above.

(vi) Overall thermal efficiency of a modern thermal plant is approximately
 (a) 50% (b) 44%
 (c) 20% (d) 30%
 (e) none of the above.

(vii) Otto cycle is efficient
 (a) more than (b) less than
 (c) equal to (d) none of the above.

The diesel cycle for the same compression ratio. Prove mathematically.

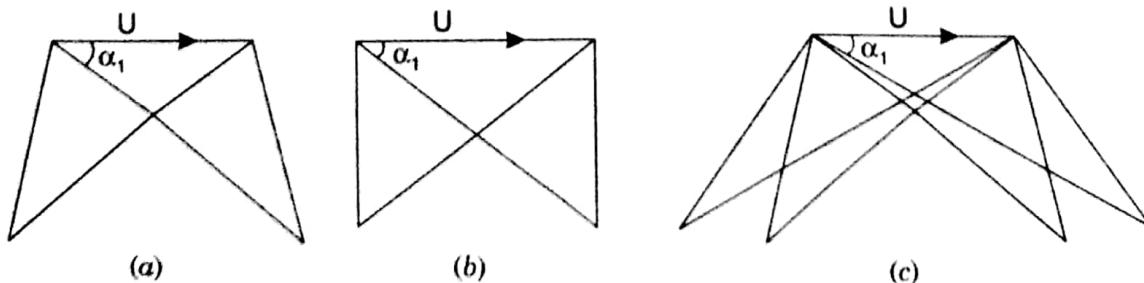
(viii) The work done per stage for two-row impulse turbine at optimum blade speed ratio and unit mass flow is
 (a) mU^2 (b) $2mU^2$
 (c) $4mU^2$ (d) $8mU^2$.
 where m = mass flow, U = peripheral speed.

(ix) The cooling range of a cooling tower is the difference in
 (a) temperature between the hot water entering the cooling tower and the cooled water leaving the tower
 (b) temperature between the hot water entering the cooling tower and the wet bulb temperature
 (c) temperature between the hot water entering the cooling tower and dry bulb temperature
 (d) none of the above.

(x) The approach of cooling tower is the difference in temperatures between
 (a) cold water leaving cooling tower and wet bulb temperature
 (b) cold water leaving cooling tower and dry bulb temperature
 (c) hot water coming to the cooling tower and dry bulb temperature
 (d) hot water coming into the cooling tower and wet bulb temperature.

(xi) The turbine of a gas turbine plant uses
 (a) simple impulse (b) two-row velocity compounded impulse stage
 (c) impulse stage followed by reaction stage
 (d) reaction stage.

(xii) Three velocity diagrams are given below for optimum U/C_1 ratios, same values of U and α_1 . Identity which is reaction stage



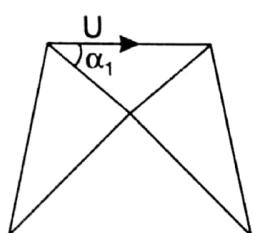
B. Answer the following :

- (i) In steam turbine, there is 'reheat factor'. Why in turbine of a gas turbine engine, 'reheat factor' is omitted but accounted for otherwise ?
- (ii) When a gas is compressed, the work done per unit mass flow may be given by

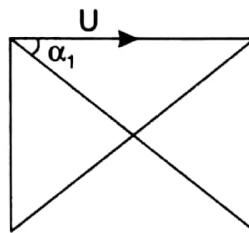
$$(a) (h_2 - h_1) \quad (b) - \int_{v_1}^{v_2} v \cdot dp$$

State precisely in which cases (a) and in which cases (b) can be applied.

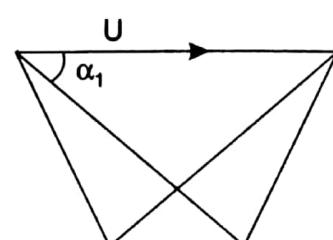
- (iii) What is the difference between hot and cold insulation, i.e., insulations for a steam pipe and for chilled brine line ?
- (iv) The velocity diagrams (reaction stage) for blade speed ratio less than, equal to, and greater than the nominal optimum value are given below :



(a)



(b)



(c)

Mark each of them with any one of $\frac{U}{C_1} > \cos \alpha_1$ with usual notations.

ANSWERS

- A. (i) Cycle efficiency of a modern thermal power plant is 44% (app.).
- (ii) (a) In *diesel engine*, the *knocking depends on slow preflame reaction*. At slower speeds these reactions are slow due to less swirl and knocking can occur.
- (iii) (c) Larger diameter engines are *more smoky due to less penetration of fuel to find oxygen*. Slow speed will also give less turbulence.
- (iv) (b) Diesel fuel additives reduce delay period by increasing the rate of preflame reactions.
- (v) (b) Gasoline engine additives increase the delay period to avoid ignition of end charge before flame reaches there.
- (vi) (c) Overall thermal efficiency of modern thermal plant is about 20%.
- (vii) (a) The efficiency of diesel cycle is given by :

$$\eta_{diesel} = 1 - \frac{1}{\gamma(r)\gamma - 1} \left[\frac{\rho^\gamma - 1}{\rho - 1} \right]$$

where, ρ = cut-off ratio and r = compression ratio.

The value of ρ more than one increases numerator faster than denominator and efficiency decreases. Hence for a *given compression ratio*, the *Otto cycle is more efficient*.

- (viii) (b) $\frac{U}{C_1} = \frac{\cos \alpha}{2}$, Work done per stage = $2U(C_1 \cos \alpha - U) \times m = 2U(2U - U) \times m = 2U^2m$

- (ix) (b) is the correct choice.

(x) (a) is true.

(xi) (b) Pressure ratio is sufficiently low (5) and two row velocity compounded impulse stage can be used to reduce speed.

(xii) (b) is the correct choice since in a reaction turbine, the velocity ratio $\frac{U}{C_1} = \cos \alpha$ is satisfied by Fig. (b).

(i) The term reheat factor does not come into effect in gas turbines due to the fact that pressure ratio is low and there is single (nozzle) expansion. However, in a turbo-jet engine it can come into existence. Adiabatic efficiency of turbine accounts for it.

(ii) (a)adiabatic flow process :
 (b)isothermal process ($pV = \text{constant}$).

(iii) There should not be any change in the structure of insulating material at the temperatures involved.

(iv) (a) $\frac{U}{C_1} < \cos \alpha_1$ (b) $\frac{U}{C_1} = \cos \alpha_1$ (c) $\frac{U}{C_1} > \cos \alpha_1$.

SET-III

- A. Are the following statement correct ? Rectify the incorrect statements changing only the wrong part of the sentence :**

 - (i) Stoichiometric air is required for complete combustion.
 - (ii) The most important characteristics for effective combustion of liquid fuels are flame point and power point.
 - (iii) Alkali is mainly responsible for water side corrosion in boilers.
 - (iv) In large high pressure boilers, a high degree of steam purity is necessary to prevent deposits in the circuit.
 - (v) A high temperature of flue gases at boiler exit means a too rich mixture of fuel and air.

B. With respect to a steam plant, who do you understand by :

 - (i) Metallurgical limit
 - (ii) Attemperator
 - (iii) Non-return valve
 - (iv) Condensate pump
 - (v) Low temperature corrosion.

C. Differentiate between the following :

 - (i) Land based gas turbines and 'aircraft turbine engines' ;
 - (ii) Deaerator and demineralizer ;
 - (iii) Intercooling in 'reciprocating compressor' and in 'rotary compressor' ;
 - (iv) Ejector and injector ;
 - (v) Regeneration in Brayton cycle and in Rankine cycle.

ANSWERS

- A.** (i) Stoichiometric air is the *theoretical* air required for complete combustion.
 (ii) The most important characteristic for effective combustion of liquid fuels are *ignition delay* and *auto-ignition temperature*.

- (iii) Acid is mainly responsible for water side corrosion in boilers.
- (iv) In large high pressure boilers, a high degree of *water* purity is necessary to prevent deposits in the circuit.
- (v) A high temperature of fuel gases at boiler exit means a rich mixture of fuel and air.

- B.** (i) **Metallurgical limit.** The maximum/highest temperature which boiler and turbine can withstand is decided by the metallurgy of the material of which these components are made.
- (ii) **Attemperator.** An attemperator (or desuperheater) is an apparatus employed to *reduce the temperature of superheat steam*. Normally attemperators are 'spray type'.
- (iii) **Non-return valve.** A valve which allows flow to take place in one direction (and reverse flow does not occur) is known as non-return valve. *Example :* Feed check valve (water can enter into it but cannot go from it).
- (iv) **Condensate pump.** A pump which is used to extract condensate from the condenser (to the hot well) is known as condensate pump.
- (v) **Low temperature corrosion.** Low temperature corrosion is the corrosion of condenser tubes and is due to the *deposits of alkali and iron sulphates* which slowly eat the tube metal and eventually cause failure. This type of corrosion is more dangerous than scale formation. It can be *minimised by :*
- (a) using a liquid base additive ;
 - (b) epoxy coatings applied to the water surface ; and
 - (c) intermittent chlorination of water.

C. (i) Land based gas turbines

Used in rear oil fields where natural gas is available ; used in industry where gas is available as by-product ; used in electric generating stations (as base load and peak load plants).

In industrial gas turbine, a life of 1000000 working hours (without major overhaul) is common.

(ii) Deaerator and demineralizer
Deaerator

In a *deaerator* water is heated for the boiler feed. The entering water is sprayed through the nozzles in the atmosphere of steam filling the heater. The heating steam is the bled steam from the turbine.

(iii) Intercooling in reciprocating and rotary compressors

Reciprocating compressors

The compressed air from L.P. cylinder passes into the *intercooler* where it gets cooled to initial temperature.

Aircraft turbine engines

The jet aircraft plant makes use of kinetic energy of gases by expansion of turbine exhaust gases to atmospheric pressure in a propelling nozzle (in an industrial gas turbine, kinetic energy of leaving the turbine is wasted).

The life of aircraft gas turbines may be only 500 working hours.

Demineralizer

In a *demineralizer*, water is freed from its mineral content by evaporation or by a series of cation and anion exchangers to produce essentially distilled water.

Demineralizing process, perhaps is the most economical method of producing make up water for high pressure boilers.

Rotary compressors

Generally, cooling is not adopted in rotary compressors.

In *centrifugal compressors* cooling results in very complicated construction. In *axial flow compressors*, the only method of cooling is to pass cooling fluid (generally air) at low temperature through hollow blades which results in costly construction.

(iv) Ejector and Injector

Ejector

Steam operated air ejectors find very wide field of application for the *production of high vacuum*.

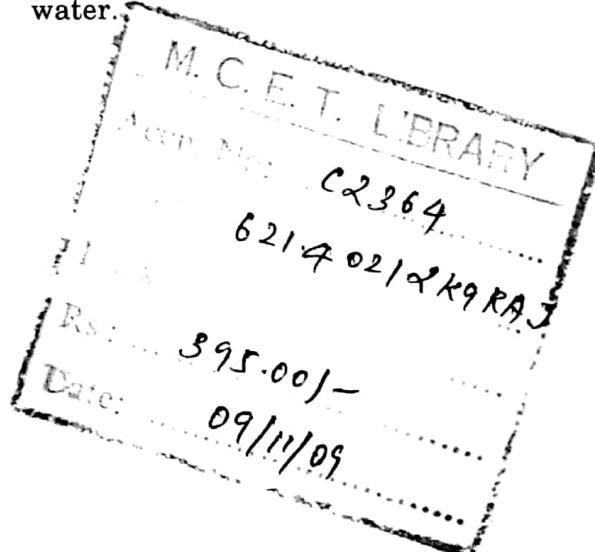
The operation of ejector consists in utilizing the various drag of high velocity steam jet for the ejection of air and other incondensable gases from a chamber ; it is chiefly used for exhausting the air from steam condensers. The steam jet flows through an air chamber where it entrains the air and any other gases which are adjacent to its surface ; the kinetic energy of the resulting mixture is then converted to pressure energy by being pushed through a diverging cone, or diffuser. The increase of pressure thus obtained enables the mixture to be discharged against a pressure which is higher than that of the entertaining chamber. The entertaining operation is due to the viscous drag between the air and steam jet.

For steam plants where a high vacuum pressure is maintained it is imperative to use a multi-stage ejector.

Injector

A steam injector is employed to force water into the boiler under pressure.

It makes use of the principle of a steam nozzle by which it utilizes the kinetic energy of a steam jet for increasing the pressure and velocity of a corresponding quantity of water.



(v) Regeneration in Brayton cycle and in Rankine cycle

Brayton cycle

The temperature of the gases coming out from the turbine (in Brayton cycle) is quite high and this energy is utilized in a regenerator to heat the air coming from the compressor to the combustion chamber. This regeneration will require *less amount of heat supplied* for the same maximum temperature at turbine inlet thereby *improving the cycle efficiency*.

Rankine cycle

In a Rankine cycle, energy possessed in the steam itself is utilised for heating the feed water. The steam is extracted from the steam turbine during the expansion and its energy is utilized in heating the feed water in the feed water heaters. This energy regenerated requires less amount of heat in the boiler, thereby improving the efficiency of the cycle.

SET-IV**A. Choose the appropriate answers :**

- (i) In a reciprocating compressor, as the clearance volume increases
 - (a) work of compression increases
 - (b) amount of air delivered increases
 - (c) amount of air delivered decreases
 - (d) volumetric efficiency increases.
- (ii) The working substance in Rankine cycle
 - (a) is gas
 - (b) is vapour
 - (c) can be gas or vapour.
- (iii) The diagram factor is the ratio of
 - (a) actual mep to inlet pressure
 - (b) actual mep to theoretical mep
 - (c) theoretical mep to actual mep
 - (d) theoretical mep to inlet pressure.
- (iv) In reciprocating steam engines, the point of cut-off is the point at which
 - (a) expansion is stopped
 - (b) cushioning begins
 - (c) cushioning is stopped
 - (d) steam supply is stopped.
- (v) Willan's line gives a linear relationship between steam consumption and
 - (a) thermal efficiency
 - (b) mechanical efficiency
 - (c) brake power
 - (d) indicated power.
- (vi) Parson's turbine is
 - (a) an impulse turbine with degree of reaction = 0
 - (b) an impulse turbine with degree of reaction = 0.5
 - (c) an impulse turbine with degree of reaction = 0.75
 - (d) an impulse turbine with degree of reaction = 1.0.

B. Are the following statements correct ? Rectify the incorrect statements, changing only the wrong part :

- (i) For the saturated air with water vapour, wet bulb temperature is equal to the dew-point temperature.
- (ii) Work done per cycle/stroke volume is the expression for the mean effective pressure of Otto cycle.
- (iii) COP of the reversed Carnot cycle decreases when the upper temperature is increased, the lower temperature is kept constant.
- (iv) Theoretical air is stoichiometric air.
- (v) Reversible constant temperature process is the process during which, heat is added in Rankine vapour power cycle.

ANSWERS

- A.** (i) (c) (ii) (b) (iii) (b) (iv) (d) (v) (d) (vi) (b).
- B.** (i) For the saturated air with water vapour, the wet bulb temperature is equal to dry bulb temperature as well as dew point temperature.
- (ii) 'Work done per cycle/stroke volume' is the expression for mean effective pressure of any cycle.
- (iii) COP of the reversed Carnot cycle decreases when the upper temperature is increased, but the lower temperature is kept constant.
- (iv) Theoretical air is stoichiometric air.

- (v) Irreversible constant pressure process is the process during which heat is added in Rankine vapour power cycle.

SET-V**A. Examine the following statements, and find out whether statement is true or false :**

- (i) Compared with reciprocating compressors, rotary compressors are smaller in size for the same discharge.
- (ii) Babcock and Wilcox boiler is a water-tube boiler, extensively used as a mobile boiler.
- (iii) In expansive steam engine, steam pushes the piston at constant pressure when it is expanded for developing work.
- (iv) Sonic velocity is obtained at the exit of a convergent steam nozzle flowing maximum mass per unit area.
- (v) The steam velocity in a reaction turbine is very high, resulting in a relatively high speed of the turbine.
- (vi) Edward air pump is a reciprocating type wet air pump, where both the air and condensate are removed by a single pump.
- (vii) The overlapping of a 4-stroke petrol engine is quite low, as the higher value would allow more amount of petrol pass-out with the exhaust gases.
- (viii) Higher danger of explosion during transport comes in the way of extensive use of gaseous fuel.
- (ix) Excellent miscibility with lubricating oil of widely used refrigerant, Freon-12 helps in solving the lubrication problem.
- (x) The acceleration of a rocket is highest at the take-off to enable the rocket to lift.

B. Find out the correct answer from among the alternate options :

- (i) The main reason for adopting the axial flow compressor instead of centrifugal compressor in aircraft turbines is that
 - (a) the starting torque for axial flow compressor is high
 - (b) the frontal area of axial flow compressor is considerably less
 - (c) the efficiency at middle speed range is higher.
- (ii) Locomotive boiler is identified with the following outstanding feature :
 - (a) It is very compact
 - (b) It can generate steam in very short time
 - (c) It attains a high combustion efficiency as the combustion space is much larger.
- (iii) In a throttle-governed reciprocating steam engine
 - (a) the steam pressure is maintained constant and the total quantity of steam admitted is reduced
 - (b) the pressure as well as the quantity of steam admitted to the engine is reduced to give better performance at all loads
 - (c) the speed is maintained constant and the pressure of the admitted steam is reduced.
- (iv) The main effect of presence of friction in steam nozzles is
 - (a) to reduce the enthalpy drop
 - (b) to reduce the exit pressure
 - (c) to reduce the dryness fraction

- (v) In a velocity-compounded impulse turbine
 - (a) there is only one set of nozzles and two or more rows of moving blades
 - (b) there is one row of fixed blades at the entry of each row of moving blades
 - (c) the velocity is increased after each stage.
- (vi) In a surface condenser
 - (a) the cooling water and exhaust steam mix with each other and the steam is condensed
 - (b) the cooling water is passed through the tubes and the exhaust steam surrounds the tubes
 - (c) the cooling water is sprayed over the tubes through which exhaust steam is passed.
- (vii) The statement that theoretically, a 2-stroke engine develops twice the power of a 4-stroke engine at the same speed, is derived from the fact that
 - (a) the working cycle is completed in one revolution of the crankshaft in a 2-stroke engine, whereas it takes two revolutions in a 4-stroke engine
 - (b) a 2-stroke engine runs at twice engine speed compared with a 4-stroke engine
 - (c) a 2-stroke engine has a set of two cylinders and pistons.
- (viii) Coal gas is obtained
 - (a) by the partial combustion of coal in a stream of air and steam
 - (b) by passing air and a large amount of steam over waste coal
 - (c) as a by-product during the destructive distillation of coal.
- (ix) Winter air-conditioning implies
 - (a) maintaining the temperature and humidity of the air
 - (b) increasing the temperature and humidity of the air
 - (c) increasing the temperature and maintaining the humidity of the air.
- (x) The thermal efficiency of simple open cycle gas turbine plant is improved by regeneration, as this
 - (a) increases the work output from the same size of plant
 - (b) decreases the temperature of gases at the turbine inlet
 - (c) decreases the quantity of heat supplied.

ANSWERS

- | | | | | | | |
|-----------|-------------|--------------|-------------|-----------|-----------|-----------|
| A. | (i) True | (ii) False | (iii) False | (iv) True | (v) False | (vi) True |
| | (vii) False | (viii) False | (ix) True | (x) True. | | |
| B. | (i) (b) | (ii) (a) | (iii) (b) | (iv) (a) | (v) (a) | (vi) (b) |
| | (vii) (a) | (viii) (c) | (ix) (b) | (x) (c). | | |

SET-VI

- A. Examine the following statements and find out whether the statement is true or false :**
- (i) A two-stroke engine occupies larger floor area than a four-stroke engine.
 - (ii) High speed compression ignition engines operate on dual combustion cycle.
 - (iii) The volume of air sucked by compressor during suction stroke is called swept volume.
 - (iv) An open cycle gas turbine works on same cycle as that of a closed cycle gas turbine.

- (v) The highest temperature during cycle in vapour compression system occurs after evaporation.
- (vi) Refrigerant freon-11 has the lowest freezing point.
- (vii) The ratio of heat actually utilised in producing steam to the heat liberated in furnace is called factor of evaporation.
- (viii) If the relative humidity is low, the rate of evaporation of water will be high.
- (ix) A compound steam engine requires a heavier flywheel.
- (x) The flow through a nozzle is regarded as adiabatic flow.

B. Find out the correct answer from among the alternate options :

- (i) The ratio of the volume charge admitted at NTP to the swept volume of the piston is called
 - (a) overall efficiency
 - (b) volumetric efficiency
 - (c) relative efficiency.
- (ii) Rotary compressors are used for delivering
 - (a) small quantities of air at high pressures
 - (b) large quantities of air at high pressures
 - (c) large quantities of air at low pressures.
- (iii) The efficiency of a jet engine is higher at
 - (a) high speeds
 - (b) low altitudes
 - (c) high altitudes.
- (iv) In SI units one tonne of refrigeration is equal to
 - (a) 210 kJ/min
 - (b) 420 kJ/min
 - (c) 620 kJ/min.
- (v) In electrolux refrigerator
 - (a) ammonia evaporates in hydrogen
 - (b) hydrogen evaporates in ammonia
 - (c) ammonia is absorbed in water.
- (vi) When the speed of the crankshaft is between 100 r.p.m. and 250 r.p.m., the engine is said to be
 - (a) slow speed steam engine
 - (b) medium speed steam engine
 - (c) high speed steam engine.
- (vii) The average value of diagram factor lies between
 - (a) 0.2 to 0.5
 - (b) 0.5 to 0.65
 - (c) 0.65 to 0.9.
- (viii) De Laval turbines are mostly used
 - (a) for small power purposes and low speeds
 - (b) for small power purposes and high speeds
 - (c) for large power purposes.
- (ix) The ratio of the temperature rise of cooling water to the vacuum temperature minus inlet cooling water temperature is called
 - (a) condenser efficiency
 - (b) vacuum efficiency
 - (c) nozzle efficiency.
- (x) A steam nozzle converts
 - (a) heat energy of steam into potential energy
 - (b) kinetic energy into heat energy of steam
 - (c) heat energy of steam into kinetic energy.

ANSWERS

- | | | | | | | |
|-----------|-------------|-------------|-------------|-----------|-----------|------------|
| A. | (i) False | (ii) True | (iii) False | (iv) True | (v) False | (vi) False |
| | (vii) False | (viii) True | (ix) False | (x) True. | | |
| B. | (i) (b) | (ii) (c) | (iii) (a) | (iv) (a) | (v) (c) | (vi) (b) |
| | (vii) (c) | (viii) (b) | (ix) (a) | (x) (c). | | |

SET-VII**A. Fill in the blanks :**

- (i) If both mass and energy cross the boundary it is called system.
- (ii) Rankine cycle efficiency is given by expression
- (iii) COP is defined as
- (iv) The expression for work done during polytropic process is
- (v) For perfect intercooling in a two-stage air compressor the relation between the pressures p_1 , p_2 and p_3 is for maximum efficiency.

B. Indicate whether the statements are correct or wrong :

- (i) In throttling process entropy remains constant.
- (ii) In jet condenser the coolant water and condensate water mix with each other.
- (iii) In impulse turbine, the expansion of steam takes place in guide vanes.
- (iv) The volumetric efficiency of a compressor increases with increase in compression ratio.
- (v) In open cycle gas turbine the exhaust gas from the turbine is rejected into the atmosphere.

C. Match the set :

- | | |
|-----------------------|---------------|
| (i) Fuel injector | SI engine |
| (ii) Throttle valve | Condenser |
| (iii) Reheat factor | Diesel engine |
| (iv) Brayton cycle | Steam turbine |
| (v) Vacuum efficiency | Gas turbine |

D. Given below are some statements which are applicable either to SI engine or Diesel engine. Classify them as applicable to SI or Diesel engines :

- (i) Air-fuel mixture is sucked inside the cylinder during suction stroke.
- (ii) Compression ratio is 20 : 1.
- (iii) Mechanical efficiency is high.
- (iv) Chances of pre-ignition are existing.
- (v) Running cost is low.

ANSWERS

- | | | | |
|-----------|--|---|--|
| A. | (i) open | (ii) $\frac{(h_1 - h_2)}{(h_1 - h_{f2})}$ | (iii) $\frac{\text{Refrigerating effect}}{\text{Work supplied}}$ |
| | (iv) $\frac{(p_1 v_1 - p_2 v_2)}{(n - 1)}$ | (v) $p_2 = \sqrt{p_1 p_3}$ | |
| B. | (i) Wrong | (ii) Correct | (iii) Correct |
| | (iv) Wrong | (v) Correct | |

SET-VIII

A. Indicate whether the following statements are correct or wrong :

- (i) The two constant entropy lines cannot intersect.
 - (ii) Once-through boilers never have a steam drum.
 - (iii) The clearance volume of a reciprocating compressor is given as a percentage of stroke volume.
 - (iv) In a centrifugal compressor the axial component of the fluid velocity produces rotational effect on the rotor.
 - (v) The suction pipe diameter of a refrigeration plant should be less than the discharge pipe diameter.

B. Fill in the blanks :

- (i) The stoichiometric air fuel ratio in a gas turbine cycle is
 - (ii) In a process the change of entropy is equal to $\delta Q/T$.
 - (iii) If the thermal efficiency of a heat engine becomes 100% it violates law of thermodynamics.
 - (iv) In an ideal throttling process remains constant.
 - (v) In order to have a high COP the pressure range of the compressor should be.....

C. Match the set :

- | | |
|---------------------------|-------------------------|
| (i) Scavenging | (I) Steam turbine |
| (ii) Velocity compounding | (II) SI engine |
| (iii) Rankine cycle | (III) Two-stroke engine |
| (iv) Octane number | (IV) Nozzle |
| (v) Accelerating flow | (V) Curtis stage. |

D. Select the most appropriate answer :

- (i) The internal energy of a system is a function of temperature only, this statement holds good :
(a) for any pure substance ; (b) for a perfect gas only ;
(c) for any gas ; (d) none of the above.

(ii) The critical pressure of the steam is :
(a) 10 bar ; (b) 221.1 bar ;
(c) 100 bar ; (d) 2212 bar.

(iii) In a Freon plant the following material should be used for pipes :
(a) copper ; (b) brass ;
(c) aluminium ; (d) steel.

(iv) In a gas turbine plant reheating is done mainly to :
(a) increase the power output ; (b) decrease the peak temperature ;
(c) reduce the size of turbine ; (d) increase the outlet temperature.

- (v) The speed of the camshaft of a 4-stroke IC engine is :

 - (a) equal to the crankshaft speed
 - (b) half of the crankshaft speed
 - (c) twice the crankshaft speed
 - (d) none of the above.

ANSWERS

- A.** (i) Correct (ii) Correct (iii) Correct
 (iv) Wrong (v) Wrong.

B. (i) never used (ii) reversible (iii) second
 (iv) enthalpy (v) low.

C. (i) Scavenging, two-stroke engine (ii) velocity compounding, curtis stage
 (iii) Rankine cycle, steam turbine (iv) Octane number, SI engine
 (v) Accelerating flow, nozzle.

D. (i) b (ii) b
 (iii) this is wrong, as all are appropriate, (iv) a (v) b .

SET-IX

- A. Give the reasons for the following facts :**

 - (i) Nozzles are more efficient than diffusers.
 - (ii) Impulse reaction steam turbine blading is more efficient than impulse bladings.
 - (iii) Deaerator is invariably used in a steam power plant.
 - (iv) Pressure rise per stage in a centrifugal compressor is more than that of an axial flow compressor.
 - (v) Thermal efficiency of a jet engine increases with decreases in inlet air temperature.

B. Choose the correct answer :

 - (i) Volumetric efficiency of a reciprocating compressor increases due to
 - (a) increase in clearance ratio and pressure ratio ;
 - (b) decrease in clearance ratio and pressure ratio ;
 - (c) decrease in clearance ratio, pressure ratio and exponent of re-expansion ;
 - (d) decrease in clearance ratio and pressure ratio and increase in exponent of re-expansion.
 - (ii) Brake specific fuel consumption of an SI engine is around

(a) 0.1 kg/kWh ;	(b) 0.3 kg/kWh ;
(c) 0.5 kg/kWh ;	(d) 0.7 kg/kWh.
 - (iii) Specific steam consumption in a modern steam power plant is around

(a) 3 kg/kWh ;	(b) 6 kg/kWh ;
(c) 9 kg/kWh ;	(d) 12 kg/kWh.
 - (iv) Two-stroke engine is not used in a passenger car mainly due to

(a) noisy exhaust ;	(b) poor brake specific fuel consumption ;
(c) need of more lubrication ;	(d) overheating of piston.
 - (v) In the gasoline fuel, to produce anti-knock effect, one of the following is added

(a) tetra-ethyl lead ;	(b) tetra-ethyl lead and ethylene dibromide ;
(c) benzyl amino phenol ;	(d) ethylene dibromide and benzyl amino phenol.

ANSWERS

- A.** (i) In diffusers the pressure gradient exists in the direction opposite to that of flow. Also stream lines tend to break away from the diverging walls reversing their direction, in order to flow with a favourable pressure gradient. This results in turbulence. This situation does not arise in nozzles. Hence *nozzles are more efficient than diffusers*.
- (ii) In impulse-reaction turbines the enthalpy drop in each stage is less, and hence the velocities are low. The blade speed can therefore be kept optimum. Further due to low velocities, the blade friction losses are also less. The velocities in impulse bladings are relatively high. Therefore the *impulse-reaction blading is more efficient than impulse blading*.
- (iii) De-aerator is used in steam power plants to reduce the oxygen content of feed water to zero, or practically zero. This is necessary as the oxygen is present in feed water as corrosive agent.
- (iv) In centrifugal compressor, the pressure rise is due to three effects : *impulsive effect* (change in absolute kinetic energy), *reaction effect* (change in relative velocity), and *centrifugal effect*. In axial flow compressor the last effect is absent. This last effect makes a significant contribution to the pressure rise in centrifugal compressors. Also, the average velocities are much higher in centrifugal compressors than in axial flow compressors. Hence, the pressure rise per stage in these compressors is more than that in axial flow compressors.
- (v) With decrease in inlet air temperature, the density of inlet air increases, and hence the mass flow rate too. More fuel could be burned. Both of these effects increase the power and also the thrust produced by the engine. But this will have little effect on the thermal efficiency.

B. The correct answers are :

(i) (d)

(ii) (b)

(iii) (b)

(iv) (b)

(v) (a).