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23-0009-AR TEST BOOKLET

MECHANICAL ENGINEERING

Time Allowed: 3 hours | **PAPER – II** | **Maximum Marks: 300**

INSTRUCTIONS TO CANDIDATES

Read the instructions carefully before answering the questions: -

1. This Test Booklet consists of **20 (twenty) pages** and has **75 (seventy-five) items (questions).**
2. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS BOOKLET *DOES NOT* HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.
3. **Please note that it is the candidate's responsibility to fill in the Roll Number and other required details carefully and without any omission or discrepancy at the appropriate places in the OMR Answer Sheet and the Separate Answer Booklet. Any omission/discrepancy will render the OMR Answer Sheet and the Separate Answer Booklet liable for rejection.**
4. Do not write anything else on the OMR Answer Sheet except the required information. Before you proceed to mark in the OMR Answer Sheet, please ensure that you have filled in the required particulars as per given instructions.
5. Use **only Black Ball Point Pen** to fill the OMR Answer Sheet.
6. This Test Booklet is divided into 4 (four) parts – **Part – I, Part – II, Part - III** and **Part – IV**.
7. All three parts are **Compulsory**.
8. **Part-I consists of Multiple Choice-based Questions.** The answers to these questions have to be marked in the **OMR Answer Sheet** provided to you.
9. **Part-II, Part-III and Part-IV consist of Conventional Essay-type Questions.** The answers to these questions have to be written in the separate **Answer Booklet** provided to you.
10. In Part-I, each item (question) comprises of 04 (four) responses (answers). You are required to select the response which you want to mark on the OMR Answer Sheet. In case you feel that there is more than one correct response, mark the response which you consider the best. In any case, choose *ONLY ONE* response for each item.
11. After you have completed filling in all your responses on the OMR Answer Sheet and the Answer Booklet(s) and the examination has concluded, you should hand over to the Invigilator ***only the OMR Answer Sheet and the Answer Booklet(s)***. You are permitted to take the Test Booklet with you.
12. **Penalty for wrong answers in Multiple Choice-based Questions:**

THERE WIL BE **PENALTY** FOR WRONG ANSWERS MARKED BY A CANDIDATE.

(i) There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, **one-third** of the marks assigned to the question will be deducted as penalty.

(ii) If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to the question.

(iii) If a question is left blank. i.e., no answer is given by the candidate, there will be **no penalty** for that question.

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PART-I
(Multiple Choice-based Questions)

Instructions for Questions 1 to 50:

- *Choose the correct answers for the following questions.*
- *Each question carries 3 marks.*
- *No Data Books/Tables are allowed; assume the data if required anywhere. [3 x 50 = 150]*

1. The first law of thermodynamics for steady flow _____
   (a) accounts for all energy entering and leaving a control volume
   (b) is an energy balance for a specified mass of fluid
   (c) is an expression of the conservation of linear momentum
   (d) is primarily concerned with heat transfer

2. The Carnot cycle comprises of -
   (a) Two isothermal and two isobaric processes.
   (b) Two isothermal and two adiabatic processes.
   (c) Two isothermal and one adiabatic process.
   (d) Two isothermal and one isobaric process.

3. The COP (coefficient of performance) of a heat pump is always _____ that of a refrigerator is:
   (a) less than
   (b) equal to
   (c) greater than
   (d) cannot be compared

4. The concept of entropy is derived from:
   (a) Zeroth Law of Thermodynamics.
   (b) First Law of Thermodynamics.
   (c) Second Law of Thermodynamics.
   (d) Third Law of Thermodynamics.

5. For a reversible cycle, entropy change _____
   (a) is greater than zero
   (b) is less than zero
   (c) increases at first and then decreases
   (d) is equal to zero

6. The surrounding work is zero for:
   (a) Cyclic devices
   (b) System with fixed boundaries
   (c) Steady flow devices
   (d) All of the above

7. Availability function for a closed system is written with usual symbols as:
   (a) $U + pV - TS$
   (b) $U - pV + TS$
   (c) $U - pV - TS$
   (d) $U + pV + TS$

8. The gases are considered incompressible when Mach number _____
   (a) is equal to 1.00
   (b) is equal to 0.50
   (c) is more than 0.30
   (d) is less than 0.20

9. Compressibility is equal to -
   (a) $\frac{\left(\frac{dV}{V}\right)}{dp}$
   (b) $\frac{dp}{-\left(\frac{dV}{V}\right)}$
   (c) $\frac{dp}{d\rho}$
   (d) $\sqrt{\frac{dp}{d\rho}}$

10. The pressure at a height $\boldsymbol{Z}$ in a static compressible fluid undergoing adiabatic compression is given by:
    (Consider $\boldsymbol{p_0}$ = Pressure at ground level, $\boldsymbol{R}$ = Gas constant and $\boldsymbol{T}$ = Absolute temperature)
    (a) $p = p_0\left[1 - \frac{\gamma-1}{\gamma}\frac{RT}{gZ}\right]^{\gamma-1}$
    (b) $p = p_0\left[1 - \frac{\gamma}{\gamma-1}\frac{RT_0}{gZ}\right]^{\frac{\gamma}{\gamma-1}}$
    (c) $p = p_0\left[1 - \frac{\gamma}{\gamma-1}\frac{gZ}{RT_0}\right]^{\frac{\gamma}{\gamma-1}}$
    (d) None of the above

11. Which of the following is not the necessary condition for the Fourier's heat conduction equation $\boldsymbol{Q = -kA\ \frac{dt}{dx}}$?
    (a) Steady state
    (b) One-dimensional heat flow
    (c) Constant value of thermal conductivity
    (d) Constant and uniform temperatures at the wall surfaces

12. The steady state temperature distribution in a very large thin plate with uniform surface temperatures will be
    (a) Linear
    (b) Hyperbolic
    (c) Parabolic
    (d) Logarithmic

13. The heat flow equation through a sphere of inner radius r_1 and outer radius r_2 is to be written in the same form as that for heat flow through a plane wall. For a wall thickness $(r_2 - r_1)$, the equivalent mean radius for the spherical shell is –
    (a) $\frac{r_2+r_1}{2}$
    (b) $r_1 r_2$
    (c) $\sqrt{r_1 r_2}$
    (d) $\frac{r_1+r_2}{\log e(r_2/r_1)}$

14. The temperature distribution during transient heat conduction in a solid does not depend upon:
    (a) Location of point within the solid
    (b) Biot number $\boldsymbol{hl/k}$
    (c) Prandtl number $\boldsymbol{\mu c_p/k}$
    (d) Fourier number $\boldsymbol{\alpha\tau/l^2}$

15. Which of the following is true for a perfectly black body? (*Assume absorptivity* = α, *reflectivity* = ρ *and transmissivity* = τ)
    (a) $\alpha = 1, \rho = 0$ and $\tau = 0$
    (b) $\rho = 1$ and $\alpha = \tau = 0$
    (c) $\tau = 1$ and $\alpha = \rho = 0$
    (d) $\alpha + \tau = 1$ and $\rho = 0$

16. Which of the following is true for an absolutely white or specular body? (*Assume absorptivity* = α, *reflectivity* = ρ *and transmissivity* = τ)
    (a) $\alpha = 1, \rho = 0$ and $\tau = 0$
    (b) $\rho = 1$ and $\alpha = \tau = 0$
    (c) $\tau = 1$ and $\alpha = \rho = 0$
    (d) $\alpha + \tau = 1$ and $\rho = 0$

17. Which of the following is true for a transparent or diathermanous body? (*Assume absorptivity* = α, *reflectivity* = ρ *and transmissivity* = τ)
    (a) $\alpha = 1, \rho = 0$ and $\tau = 0$
    (b) $\rho = 1$ and $\alpha - \tau = 0$
    (c) $\tau = 1$ and $\alpha = \rho = 0$
    (d) $\alpha + \tau = 1$ and $\rho = 0$

18. The law governing the distribution of radiant energy over wavelength for a black body at fixed temperature is referred to as
    (a) Planck's law
    (b) Wien's formula
    (c) Kirchhoff's law
    (d) Lambert's law

19. The Stefan-Boltzmann constant has units of -
    (a) kcal/m²-hr-K⁴,
    (b) kcal/m-hr-K⁴
    (c) kcal/hr-K⁴
    (d) kcal/m²-K⁴

20. Two spheres A and B of the same material have radii $\mathbf{1}\,\boldsymbol{m}$ and $\mathbf{4}\,\boldsymbol{m}$, and temperatures $\mathbf{4000}\,\boldsymbol{K}$ and $\mathbf{2000}\,\boldsymbol{K}$ respectively. The energy radiated by sphere A is _____
    (a) greater than that of sphere B
    (b) less than that of sphere B
    (c) equal to that of sphere B
    (d) exactly equal to double that of sphere B

21. For infinite parallel planes with emissivities ϵ_1 and ϵ_2, the interchange factor for radiation from surface 1 to surface 2 is:
    (a) $\epsilon_1\epsilon_2$
    (b) $\epsilon_1 + \epsilon_2$
    (c) $1/\epsilon_1 + 1/\epsilon_2$
    (d) $(\epsilon_1\epsilon_2)/(\epsilon_1 + \epsilon_2 - \epsilon_1\epsilon_2)$

22. During the process of boiling and condensation, only a phase change takes place and one fluid remains at constant temperature throughout the heat exchanger. In terms of number of transfer units ($\boldsymbol{NTU}$), the effectiveness of such an exchanger would be:
    (a) $\frac{NTU}{1+NTU}$
    (b) $1 - exp(-NTU)$
    (c) $\frac{1-exp(-2NTU)}{2}$
    (d) Cannot be worked out as the heat capacities are not known.

23. The firing order in case of four stroke four-cylinder engines is:
    (a) 1-2-4-3
    (b) 1-3-2-4
    (c) 1-4-3-2
    (d) 1-4-2-3

24. In a two-stroke engine, we get one power stroke in:
    (a) 180° of crank rotation
    (b) 270° of crank rotation
    (c) 360° of crank rotation
    (d) 540° of crank rotation

25. In an automobile, the choke is applied for -
    (a) Increasing speed
    (b) Fuel economy
    (c) Starting in cold weather
    (d) Starting in hot weather

26. In an oil tanker, the exhaust gases are discharged _____
    (a) Beneath the oil tank
    (b) On the top of the oil tank
    (c) In front of the engine
    (d) Sideways

27. For minimizing knocking tendency in SI engines, the spark plug should be located _____
    (a) Near inlet valve
    (b) Away from inlet valve
    (c) Near exhaust valve
    (d) Away from exhaust valve

28. Octane number of petrol available in market is generally:
    (a) 90-100
    (b) 60-70
    (c) 50-60
    (d) 25-40

29. An engine can be easily identified as Petrol or Diesel engine by looking at
    (a) Crankshaft
    (b) Cam shaft
    (c) Lubrication system
    (d) Fuel supply system

30. In S.I. engines, for higher thermal efficiency _____
    (a) the compression ratio should be high
    (b) the heat loss during combustion should be maximum
    (c) the surface to volume ratio should be high
    (d) there should be a long flame travel distance

31. Thermal efficiency of a S.I. engine at full load is usually in the range of:
    (a) 10-25 percent.
    (b) 30-35 percent.
    (c) 50-60 percent.
    (d) 60-75 percent.

32. In a four-stroke cycle, the minimum temperature inside the engine cylinder occurs -
    (a) at the beginning of suction stroke.
    (b) at the end of suction stroke.
    (c) at the end of compression stroke.
    (d) at the beginning of exhaust stroke.

33. Artificial draught is produced by _____
    (a) an induced fan
    (b) a forced fan
    (c) an induced and forced fan
    (d) all of the above

34. Rankine cycle efficiency of a good steam power plant may be in the range of -
    (a) 15 to 20%.
    (b) 70 to 80%.
    (c) 35 to 45%.
    (d) 90 to 95%.

35. The isentropic expansion of steam through nozzle for the steam initially superheated at inlet is approximated by the equation:
    (a) $pv^{1.3} = C$
    (b) $pv^{1.125} = C$
    (c) $pv^{1.4} = C$
    (d) $pv = C$

36. The effect of considering friction losses in steam nozzle for the same pressure ratio leads to:
    (a) increase in exit velocity from the nozzle.
    (b) decrease in exit velocity from nozzle.
    (c) no change in exit velocity from nozzle.
    (d) increase or decrease depending upon the exit quality of steam.

37. Stage efficiency of steam turbine is given by –
    (a) $\eta_{stage} = \eta_{blade}/\eta_{nozzle}$
    (b) $\eta_{stage} = \eta_{nozzle}/\eta_{blade}$
    (c) $\eta_{stage} = \eta_{nozzle} \times \eta_{blade}$
    (d) None of the above

38. The maximum efficiency for Parson's reaction turbine, where α is the angle with the direction of motion of the blade at which steam enters the blade, is given by:
    (a) $\eta_{max} = \frac{\cos\alpha}{1+\cos\alpha}$
    (b) $\eta_{max} = \frac{2\cos\alpha}{1+\cos\alpha}$
    (c) $\eta_{max} = \frac{2\cos^2\alpha}{1+\cos^2\alpha}$
    (d) $\eta_{max} = \frac{1+\cos^2\alpha}{2\cos^2\alpha}$

39. For a multistage steam turbine, the reheat factor is defined as -
    (a) stage efficiency x nozzle efficiency
    (b) commutative enthalpy drop $\times \eta_{nozzle}$
    (c) $\frac{\text{commutative enthalpy drop}}{\text{isentropic enthalpy drop}}$
    (d) $\frac{\text{isentropic enthalpy drop}}{\text{isentropic actual enthalpy drop}}$

40. In a steam power plant, the function of a condenser is -
    (a) To maintain pressure below atmospheric to increase work output from the prime mover
    (b) To receive large volumes of steam exhausted from steam prime mover.
    (c) To condense large volumes of steam to water which may be used again in boiler
    (d) All of the above.

41. The most important solid fuel is -
    (a) Wood.
    (b) Charcoal.
    (c) Coal.
    (d) All of the above.

42. Bomb calorimeter is used to find the calorific value of which of the following type(s) of fuel?
    (a) Solid.
    (b) Gaseous.
    (c) Solid and gaseous.
    (d) None of the above.

43. During sensible heating of moist air, enthalpy _____
    (a) increases
    (b) decreases
    (c) remains constant
    (d) none of the above

44. The relative humidity, during cooling and dehumidification of moist air _____
    (a) increases
    (b) decreases
    (c) can increase or decrease
    (d) remains constant

45. The temperature at which water vapour starts condensing out of air is called the _____.
    (a) Dew point temperature
    (b) Saturated temperature
    (c) Adiabatic temperature
    (d) Unsaturated temperature

46. Both the Dry bulb and Wet bulb temperatures of air are measured in a _____.
    (a) Psychrometer
    (b) Galvanometer
    (c) Temperature sensor
    (d) Resistance heating

47. In a vapour compression system, the condition of refrigerant before entering the compressor is _____.
    (a) saturated liquid
    (b) wet vapour
    (c) dry saturated liquid
    (d) superheated vapour

48. In a vapour compression refrigeration system, the effect of superheating the vapour before suction to compression _____.
    (a) increases the work of compression
    (b) increases the heat rejection in the condenser
    (c) may increase or decrease C.O.P depending upon the refrigerant used
    (d) All of the above

49. The heat rejection factor (HRF) is given by:
    (a) $1 + C.O.P$
    (b) $1 - C.O.P$
    (c) $1 + \frac{1}{C.O.P}$
    (d) $1 - \frac{1}{C.O.P}$

50. The type of evaporator used in house-hold refrigerators is -
    (a) Frosting evaporator.
    (b) Non- frosting evaporator.
    (c) Defrosting evaporator.
    (d) None of these.

PART-II
(Short Answer-type Questions)

Instructions for Questions 51 to 63:

- *Write the answers in short for any 10 (TEN) out of the thirteen questions.*
- *Each question carries 5 marks.*
- *Candidates are required to give their answers in their own words as far as practicable.*
- *No Data Books/Tables are allowed; assume the data if required anywhere.*
- *Unless otherwise mentioned, symbols and notations have their usual meaning.*

[5 x 10 = 50]

51. Write down the general energy equation for steady flow system and simplify when applied for the following systems:
    (i) Centrifugal water pump.
    (ii) Gas turbine.

52. Give the following statements of second law of thermodynamics.
    (i) Clausius statement.
    (ii) Kelvin-Planck statement.

53. Explain the terms absorptivity, reflectivity and transmissivity of radiant energy. How are they related to each other for a black body and an opaque body? Establish the expression:

$$\alpha + \rho + \tau = 1$$

where α = absorptivity, ρ = reflectivity and τ is transmissivity of the body.

54. What do you understand by the hydrodynamic and thermal boundary layers? Illustrate with reference to flow over a flat heated plate.

55. Draw neat sketch of a four-stroke spark ignition engine and label various parts.

56. What are the effects of optimum conditions on detonation in a spark ignition engine? Explain each case with the help of a characteristic curve.

57. Describe with a suitable sketch the two-stroke cycle spark ignition (SI) engine. How does its indicator diagram differ from that of four-stroke cycle engine?

58. Describe with neat sketches, the working of a simple constant pressure open cycle gas turbine.

59. What are the various types of draughts used in usual practice? Give the advantages of artificial draught over natural draught?

60. What is the effect of friction on the flow through a steam nozzle? Explain with the help of *h-s* diagram.

61. Derive the expression for maximum blade efficiency in a single-stage impulse turbine.

62. Describe a simple vapour compression cycle giving clearly its flow diagram.

63. Enumerate methods of duct design and explain in detail the 'equal friction method'.

PART-III
(Long Answer-type Questions)

Instructions for Questions 64 to 71:

- *Answer any 5 (FIVE) out of the eight questions.*
- *Each question carries 10 marks.*
- *No Data Books/Tables are allowed; assume the data if required anywhere.*
- *Unless otherwise mentioned, symbols and notations have their usual meaning.*

[10 x 5 = 50]

64. Atmospheric air at 1.0132 *bar* has a dry bulb temperature (DBT) of 34°C and a wet bulb temperature (WBT) of 28°C.
Compute:
    (i) The partial pressure of the water vapour,
    (ii) The specific humidity,
    (iii) The relative humidity,
    (iv) The degree of saturation.

65. The flat floor of a hemispherical furnace is at **800** K and has an emissivity of **0.5**. The corresponding values for the hemispherical roof are **1200** K and **0.25**. Determine the net radiation heat transfer from the roof to floor.

66. Air moving at **0.3** m/s blows over the top of a chest-type freezer. The top of the freezer measures **0.9** m by **1.5** m and is poorly insulated so that the surface remains at **10°C**. If the temperature of air is **30°C**, make calculations for the maximum heat transfer by forced convection from the top of the freezer.

67. A single cylinder 2-stroke engine has **11.25** cm bore and **15** cm stroke. The compression ratio is **7** to **1**. It develops **7** $kg/cm^2 b.m.e.p.$ at **1800** r.p.m. Take air supply to the engine as **4.5** kg/min at **72°C**, and the air fuel ratio as **14.3**. The exhaust pressure may be taken as **1** kg/cm^2.
Determine:
    (i) Ideal air capacity
    (ii) Scavenging ratio
    (iii) Scavenging efficiency
    (iv) Trapping efficiency
Assume mechanical efficiency as **85%** and thermal efficiency as **30%**. Derive all relations from fundamentals.

68. Air is expanded reversibly and adiabatically in a nozzle from **13** bar and **150°C** to a pressure of **6** bar. The inlet velocity of the nozzle is very small and the process occurs under steady state flow conditions. Calculate the exit velocity of the nozzle.

69. A stream of gases at $\mathbf{7.5\ bar, 750°C}$ and $\mathbf{140\ m/s}$ is passed through a turbine of a jet engine. The stream comes out of the turbine at $\mathbf{2.0\ bar, 550°C}$ and $\mathbf{280\ m/s}$. The process may be assumed adiabatic. The enthalpies of gas at the entry and exit of the turbine are $\mathbf{950\ kJ/kg}$ and $\mathbf{650\ kJ/kg}$ of gas respectively. Determine the capacity of the turbine if the gas flow is $\mathbf{5\ kg/s}$.

70. A single-stage, double-acting compressor has a free air delivery (F.A.D.) of $\mathbf{14\ m^3/min}$. measured at $\mathbf{1.013\ bar}$ and $\mathbf{15°C}$. The pressure and temperature in the cylinder during induction are $\mathbf{0.95\ bar}$ and $\mathbf{32°C}$ respectively. The delivery pressure is $\mathbf{7\ bar}$ and index of compression and expansion, $\boldsymbol{n = 1.3}$. The clearance volume is 5% of the swept volume. Calculate:
    (i) Indicated power required and,
    (ii) Volumetric efficiency.

71. A simple vapour compression plant produces $\mathbf{5\ tonnes}$ of refrigeration. The enthalpy values at the inlet to compressor, at the exit from the compressor and at the exit from the condenser are $\mathbf{183.19\ kJ/kg}$, $\mathbf{209.41\ kJ/kg}$ and $\mathbf{74.59\ kJ/kg}$ respectively.
Estimate:
    (i) The refrigerant flow rate
    (ii) The C.O.P.
    (iii) The power required to drive the compressor
    (iv) The rate of heat rejection to the condenser

PART-IV
(Essay-type Questions)

Instructions for Questions 72 to 75:

- *Answer any 2 (TWO) out of the four questions.*
- *Each question carries 25 marks.*
- *Candidates are required to give their answers in their own words as far as practicable.*
- *No Data Books/Tables are allowed; assume the data if required anywhere.*
- *Unless otherwise mentioned, symbols and notations have their usual meaning.*

[25 x 2 = 50]

72. A steel pipe ($k = 72\ W/m - deg\ C$) of **34 *mm*** outer diameter and **2 *mm*** radial thickness carries dry saturated steam at **120°*C***. The pipe has been provided with asbestos insulation ($k = 0.3\ W/m - deg\ C$) to check and minimise the rate of steam condensation. The pipe is located in surroundings at **25°*C***.
Taking unit length of pipe, calculate:
    (i) Thickness of asbestos insulation for which the rate of steam condensation is same as that when the pipe is un insulated,
    (ii) Mass flow rate of condensation when the above insulation is provided, and
    (iii) Highest rate of condensation and the corresponding insulation thickness.

    Take surface conductance on air-side and steam-side as $13\ W/m^2 - deg\ C$ and $500\ W/m^2 - deg\ C$ respectively and hfg at 120°*C* = 2300 *kJ/kg*.

73. A six-cylinder four stroke petrol engine running at **3960 *rpm*** consumes **0.325 *kg*** of petrol (calorific value **44000 *kJ/kg***) per minute. The cylinder size is **70 *mm*** by **100 *mm*** and clearance volume per cylinder is **67 cm^3**. Torque developed is **140 *Nm***. If the ambient temperature is **30°*C*** and exhaust gas temperature is **350°*C*** with air to fuel ratio **16 *to* 1**, calculate:
    (i) Brake power
    (ii) BMEP
    (iii) Brake thermal efficiency
    (iv) Percentage heat rejected throughout exhaust.
    Takes $C_{pg} = 1.11\ kJ/kg/°K$

74. A stage of a turbine with Parson's blading delivers dry saturated steam at **2.7 *bar*** from the fixed blades at **90 *m/s***. The mean blade height is **40 *mm***, and the moving blade exit angle is **20°**. The axial velocity of steam is **3/4th** of the blade velocity at the mean radius. Steam is supplied to the stage at the rate of **9000 *kg/h***. The effect of blade tip thickness on the annulus area can be neglected.
    Calculate:
    (i) The wheel speed in ***r.p.m.***;
    (ii) The diagram power;
    (iii) The diagram efficiency;
    (iv) The enthalpy drop of the steam in this stage.

75. A food storage locker requires a refrigeration system of $2400\ kJ/min$. capacity at an evaporator temperature of $263\ K$ and a condenser temperature of $303\ K$. The refrigerant used is $freon - 12$ and is subcooled by $6°C$ before entering the expansion valve and vapour is superheated by $7°C$ before leaving the evaporator coil. The compression of refrigerant is reversible adiabatic. The refrigeration compressor is two-cylinder single-acting with stroke equal to $1.25\ times$ the bore and operates at $1000\ r.p.m.$

Saturation Temp (in K)	Absolute pressure (in bars)	Specific volume of vapour (in m^3/kg)	Enthalpy (in kJ/kg)		Entropy (in kJ /kgK)	
			Liquid	Vapour	Liquid	Vapour
263	2.19	0.0767	26.9	183.2	0.1080	0.7020
303	7.45	0.0235	64.6	199.6	0.2399	0.6854

Determine:

(i) Refrigerating effect produced by $per\ kg$ of the refrigerant.
(ii) Mass of Refrigerant to be circulated per minute.
(iii) Theoretical piston displacement per minute.
(iv) Theoretical power required to run the compressor in kW.
(v) Heat removed through condenser per minute.
(vi) Theoretical bore and stroke of compressor.

Take: Liquid specific heat = $1.235\ kJ/kgK$; Vapour specific heat = $0.733\ kJ/kgK$

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