OBJECTIVE TYPE QUESTIONS
(With Answers)

A. CHOOSE THE CORRECT ANSWER:

1. The Fourier's law of heat transfer by conduction is expressed as

(a) $Q = kA \frac{dt}{dx}$ (b) $-kA \frac{dt}{dx}$

(c) $Q = kA \frac{dx}{dt}$ (d) $-kA \frac{dx}{dt}$

2. The heat transfer is constant when
   (a) temperature remains constant with time
   (b) temperature decreases with time
   (c) temperature increases with time.

3. The coefficient of thermal conductivity is defined as
   (a) Quantity of heat transfer per unit area per one degree drop in temperature
   (b) Quantity of heat transfer per one degree temperature drop per unit area
   (c) Quantity of heat transfer per unit time per unit area
   (d) Quantity of heat transfer per unit time per unit area per one degree temperature drop per unit length.

4. The thermal conductivity is expressed as
   (a) W/mK (b) W/m^2K
   (c) W/hmK (d) W/h^2m^2K.

5. Heat transfer from higher temperature to low temperature takes place accroding to
   (a) Fourier law
   (b) First law of thermodynamics
   (c) Second law of thermodynamcis
   (d) Zeroth law of thermodynamics.

6. Conduction through flat composite wall is given by :

(a) $Q = \frac{t_1 - t_4}{\frac{x_1}{k_1 A} + \frac{x_2}{k_2 A} + \frac{x_3}{k_3 A}}$

(b) $Q = \frac{t_1 - t_4}{\frac{k_1 A}{x_1} + \frac{k_2 A}{x_2} + \frac{k_3 A}{x_3}}$

(c) $Q = \frac{(t_1 - t_4)\, A}{\frac{k_1}{x_1} + \frac{k_2}{x_2} + \frac{k_3}{x_3}}$

(d) $Q = \frac{\frac{k_1 A}{x_1} + \frac{k_2 A}{x_2} + \frac{k_3 A}{x_3}}{(t_1 - t_4)}$

where Q = heat transfer, t_1, t_2, t_3 and t_4 temperatures on surfaces of composite wall, x_1, x_2, x_3, x_4 thicknesses of different composite wall layers.

7. Conduction through hollow, radial one dimensional heat transfer is expressed as

(a) $Q = \frac{2\pi l\, (t_1 - t_2)\, k}{\log_e r_2 / r_1}$

(b) $Q = \frac{2\pi l\, (t_1 - t_2)}{k\, (r_2 - r_1)}$

(c) $Q = \frac{2\pi l \log_e (t_1 / t_2)}{(r_2 - r_1)\, k}$

(d) $Q = \frac{2\pi l\, (t_1 - t_2)\, k}{\log_e r_2 / r_1}$.

8. The radial heat transfer rate through hollow cylinder increases as the ratio of outer radius to inner radius
   (a) decreases (b) increases
   (c) constant (d) none of the above.

9. Stefan-Boltzmann's law is expressed as
   (a) $Q = s AT^4$ (b) $Q = s A^2T^4$
   (c) $Q = s AT^2$ (d) $Q = AT^4$

10. The quantity of heat radiation is dependent on
   (a) area of the body only
   (b) shape of the body only
   (c) temperature of the body only
   (d) on all (a), (b) and (c).

11. Conduction is a process of heat transfer from
   (a) a hot body to a cold body, in a straight line, without affecting the intervening medium
   (b) one particle of the body to another without the actual motion of the particles
   (c) one particle of the body to another by the actual motion of the heated particles
   (d) none of the above.

12. The amount of heat flow through a body by conduction is
   (a) dependent upon the material of the body
   (b) directly proportional to the surface area of the body
   (c) directly proportional to the temperature difference on the two faces of the body
   (d) inversely proportional to the thickness of the body
   (e) all of the above.

13. Thermal conductivity of solid metals ..... with rise in temperature.
   (a) decreases (b) increases
   (c) remains same (d) unpredictable.

14. Thermal diffusivity of a substance is
   (a) directly proportional to the thermal conductivity
   (b) inversely proportional to density of substance
   (c) inversely proportinal to specific heat
   (d) all the the above.

15. The overall coefficient of heat transfer is used in the problems of
   (a) radiation
   (b) conduction
   (c) convection
   (d) conduction and convection.

16. Thermal conductivity of non-metallic amorphous solids ..... with decrease in temperature.
   (a) decreases (b) increases
   (c) remains constant (d) unpredictable.

17. Heat transfer takes place as per ..... law of thermodynamics.
   (a) Zeroth (b) first
   (c) second (d) none of the above.

18. Heat is closely related with ..... .
   (a) energy (b) entropy
   (c) enthalpy (d) temperature.

19. Heat flowing from one side to other does not depend directly on
   (a) thermal conductivity
   (b) face area
   (c) temperature difference
   (d) thickness.

20. ..... has least value of conductivity.
   (a) Rubber (b) Air
   (c) Water (d) Glass
   (e) Plastic.

21. ..... has maximum value of thermal conductivity.
   (a) Lead (b) Copper
   (c) Steel (d) Aluminium
   (e) Brass.

22. Heat conduction in gases is due to
   (a) electromagnetic waves
   (b) motion of electrons
   (c) mixing motion of the different layers of the gas
   (d) elastic impact of molecules.

23. Due to which of the following reasons most metals are good conductors of heat ?
   (a) Capacity to absorb free energy of electrons
   (b) Energy transport due to molecular vibration
   (c) Lattice defects
   (d) Migration of neutrons from hot end to cold end.
   (e) Presence of many free electrons and frequent collision of atoms.

24. In which of the following cases most unsteady heat flow occurs?
   (a) Through the walls of a furnace
   (b) Through lagged pipes carrying steam
   (c) Through the wall of a refrigerator
   (d) During annealing of castings.

25. In which of the following cases, molecular transmission of heat is smallest?
(a) Solids (b) Alloys
(c) Gases (d) Liquids.

26. Due to which of the folowing reasons cork is a good insulator?
(a) It is porous (b) Its density is low
(c) It can be powdered (d) All of the above.

27. ..... is the most widely used heat insulating material for pipelines carrying steam.
(a) Sawdust
(b) Cotton
(c) Asbestos
(d) 85% magnesia cement and glass wool.

28. With regard to 'thermal diffusivity' which of the following statements is *incorrect*?
(a) It is a dimensionless quantity
(b) It represents a physical property of the material
(c) It is an important characteristic for unsteady heat conduction
(d) None of the above.

29. The temperature distribution for a plane wall, for steady state heat flow and constant value of thermal conductivity, is
(a) logarithmic (b) parabolic
(c) linear (d) any of the above.

30. The relation $\nabla^2 T = 0$ is referred to as ..... equation.
(a) Poisson's
(b) Laplace
(c) Fourier heat conduction
(d) none of the above.

31. If k is the thermal conductivity, ρ is the mass density and c is the specific heat then the thermal diffusivity of substance is given by
(a) $\frac{\rho c}{k}$ (b) $\frac{k}{\rho c}$
(c) $\frac{kc}{\rho}$ (d) $\frac{k\rho}{c}$.

32. ..... is expected to have highest thermal conductivity.
(a) Water (b) Melting ice
(c) Solid ice (d) Steam.

33. In the heat flow equation $Q = kA\ (t_1 - t_2)/x$, the term $(t_1 - t_2)/x$ is known as
(a) thermal conductivity
(b) thermal coefficient
(c) thermal resistance
(d) temperature gradient.

34. In the heat flow equation $Q = kA\ (t_1 - t_2)/x$, the term x/kA is known as
(a) temperature gradient
(b) thermal coefficient
(c) thermal resistance
(d) thermal coductivity.

35. Film coefficient is defined as
(a) thermal conductivity / equivalent thickness of film
(b) inside diamter of tube / equivalent thickness of film
(c) (specific heat × viscosity) / thermal conductivity
(d) none of the above.

36. Why are fins provided on heat transferring surface?
(a) To increase temperature gradient
(b) To increase heat transfer coefficient
(c) To increase heat transfer area
(d) All of the above.

37. When the thickness of insulation on a pipe exceeds the critical value
(a) the heat flow rate decreases
(b) the heat flow rate increases
(c) the heat flow rate remains constant
(d) none of the above.

38. For spheres, the critical thickness of insulation is given by
(a) $\frac{h}{2k}$ (b) $\frac{2k}{h}$
(c) $\frac{k}{h}$ (d) $\frac{k}{2\pi h}$

where k = thermal conductivity, h = convective heat transfer coeffecient.

39. It is considered appropriate that area of cross-section, for a finned surface, be
(a) reduced along the length
(b) increased along the length
(c) maintained constant along the length
(d) none of the above.

40. What does transient conduction mean?
(a) Heat transfer for a short time
(b) Conduction when the temperature at a point varies with time

(c) Very little heat transfer
(d) Heat transfer with a very small temperature difference.

41. How can the temperature drop in a plane wall with uniformly distributed heat generation be decreased?
(a) By reducing thermal conductivity of wall material
(b) By reducing wall thickness
(c) By reducing convection coefficient at the surface
(d) By reducing heat generation rate.

42. The temperature variation with time, in the lumped parameter model, is
(a) exponential (b) sinusoidal
(c) cubic (d) linear.

43. In transient heat conduction, the two significant dimensionless parameters are ..... number and ..... number.
(a) Fourier, Reynolds
(b) Reynolds, Prandtl
(c) Biot, Fourier
(d) Reyonlds, Biot.

44. ..... number is relevant in transient heat condition.
(a) Reynolds (b) Fourier
(c) Grashoff (d) Prandtl.

45. ..... number is generally associated with natural convection heat transfer.
(a) Prandtl (b) Weber
(c) Nusselt (d) Grashoff.

46. The degree of approach, in heat exchangers, is defined as the difference between temperatures of
(a) hot medium outlet and cold water outlet
(b) hot medium outlet and cold water inlet
(c) cold water inlet and outlet
(d) hot medium inlet and outlet.

47. Two insulating materials (put over each other) are used to insulate a steam pipe, best result would be obtained if
(a) inferior insulation is put over pipe and better one over it
(b) better insulation is put over pipe and inferior one over it
(c) both may be put in any order
(d) none of the above.

48. Compared to parallel flow heat exchanger, LMTD in case of counter-flow heat exchanger is
(a) lower (b) higher
(b) same (d) unpredictable.

49. Thermal diffusivity is a
(a) dimensionless parameter
(b) mathematical formula only
(c) physical property of the material
(d) function of temperature.

50. Transient heat flow occurs in
(a) melting of ice
(b) heating and cooling of buildings due to sun
(c) insulated pipes carrying superheated steam
(d) all of the above.

51. Transmission of heat by molecular collision is
(a) scattering (b) conduction
(c) convection (d) radiation.

52. In which of the following cases heat is transferred by conduction, convection and radiation?
(a) Boiler furnaces
(b) Refrigerator freezer coils
(c) Melting of ice
(d) All of the above.

53. ..... is generally used to measure the temperature inside a furnance.
(a) Gas thermometer
(b) Optical pyrometer
(c) Alcohol thermometer
(d) Mercury thermometer.

54. ..... is not the assumption of Fourier's equation of heat conduction.
(a) Constant temperature difference
(b) Uniform area of cross-section
(c) Steady heat flow
(d) Homogeneous substance.

55. A substance above critical temperature exists as
(a) liquid (b) solid
(c) gas (d) wet vapour.

56. ..... is a non-dimensional number which generally finds application in mass transfer problem.
(a) Grashoff number (b) Mach number
(c) Stanton number (d) Weber number.

57. By which of the following modes of heat transfer heat is mainly transferred from an insulated pipe to the surrounding still air ?

(a) Radiation (b) Free convection
(c) Forced convection (d) Conduction.

58. ..... will radiate heat to a large extent.
(a) Black polished surface
(b) White rough surface
(c) White polished surface
(d) Black rough surface.

59. When metallic surfaces are oxidised the emissivity
(a) decreases (b) increases
(c) remains unaltered (d) unpredictable.

60. Shape of an ideal thermometer should be .....
(a) cubical (b) rectangular
(c) spherical (d) cylindrical.

61. Planck's law of radiation is applicable to ..... radiation.
(a) monochromatic (b) thermal
(c) temperature (d) none of the above.

62. Which of the folowing factors affect nucleate pool boiling?
(a) Pressure
(b) Material of heating surface
(c) Physical properties of liquid
(d) Surface condition of heating surface
(e) All of the above.

63. The monochromatic emissivity of a white body at all wavelengths and temperatures is equal to
(a) zero (b) 0.1 to 0.4
(c) 0.6 (d) unity.

64. A ..... body reflects entire radiation incident on it.
(a) transparent (b) black
(c) gray (d) white.

65. ..... method is used to find the thermal conductivity of rubber.
(a) Searle's (b) Lee's disc
(c) Cylindrical shell (d) Laby and Hercus

66. "All bodies above absolute zero temperature emit radiation". This statement is based on
(a) Stefan's law (b) Planck's law
(c) Prevost theory (d) Wien's law.

67. An automobile radiator is ..... type of heat exchanger.
(a) cross-flow (b) regenerator
(c) counter-flow (d) recuperator.

68. The wavelength for maximum emissive power is given by
(a) Kirchhoff's law
(b) Stefan Boltzmann's law
(c) Fourier's law
(d) Wien's law.

69. The emissive power of a body depends on
(a) physical nature
(b) nature of body
(c) temperature of body
(d) all of the above.

70. A hollow sphere with uniform interior temperature and a small hole behaves very nearly as a ..... body.
(a) black (b) opaque
(c) white (d) transport.

71. ..... rays have the least wavelength.
(a) Infrared (b) Ultraviolet
(c) Radio (d) Cosmic.

72. Dropwise condensation occurs on a ..... surface.
(a) oily (b) smooth
(c) glazed (d) coated.

73. Why are floating heads provided in heat exchangers?
(a) To regulate the flow
(b) To increase the pressure drop
(c) To decrease the pressure drop
(d) To avoid deformation of tubes due to thermal expansion.

74. Why is entrainment separator used in evaporators?
(a) To separate liquid droplets from vapour
(b) To prevent foaming
(c) To increase the boiling point
(d) To decrease the boiling point.

75. Least value of Prandtl number can be expected in case of
(a) water (b) liquid metals
(c) salt solution (d) sugar solution.

76. Agitated film evaporator is suitable for concentrating ..... liquids.
(a) viscous (b) low temperature
(c) corrosive (d) high temperature.

77. The multiple pass heat exchangers are used to
(a) increase the rate of heat transfer

(*b*) reduce pressure drop
(*c*) increase pressure drop
(*d*) reduce fluid flow friction losses.

78. "The boiling point of a solution is a linear function of water at the same pressure." This statement is associated with
(*a*) Fick's rule (*b*) Reynolds law
(*c*) Dubring's rule (*d*) none of the above.

79. A correction of LMTD is necessary in case of ..... heat exchanger.
(*a*) cross flow (*b*) parallel flow
(*c*) counter current (*d*) all of the above.

80. Pecelet number is the ratio of ..... number to ..... number.
(*a*) Reynolds, Schemdit
(*b*) Prandtl, Weber
(*c*) Prandtl, Schemdit
(*d*) Reynolds, Prandtl.

81. The temperature of sun can be measured by using a
(*a*) radiation pyrometer
(*b*) standard thermometer
(*c*) mercury thermometer
(*d*) none of the above.

82. An increase in convective coefficient over a fin ..... effectiveness.
(*a*) decreases (*b*) increases
(*c*) does not influence (*d*) none of the above.

83. An increase in fin effectiveness is caused by high value of
(*a*) thermal conductivity
(*b*) circumference
(*c*) both (*a*) and (*b*)
(*d*) sectional area.

84. At higher temperatures, the energy distribution of an ideal reflector is largely in the range of
(*a*) longer wavelength
(*b*) shorter wavelength
(*c*) remains same at all wavelengths
(*d*) unpredictable.

85. Thermal diffusivity of a substance is ..... proportional to .....
(*a*) inversely, specific heat
(*b*) inversely, density of substance
(*c*) directly, thermal conductivity
(*d*) all of the above.

86. "The ratio of the emissive power and absorptive power of all bodies is the same and is equal to the emissive power of a perfectly black body". This statement is known as.
(*a*) Planck's law (*b*) Stefan's law
(*c*) Kirchhoff's law (*d*) Black body law.

87. Which of the follwing properties of air does not increase with rise in temperature?
(*a*) Thermal diffusivity
(*b*) Dynamic viscosity
(*c*) Density
(*d*) Thermal conductivity.

88. According to Wien's law, the wavelength corresponding to maximum energy is proportional to
(*a*) T (*b*) T^2
(*c*) T^3 (*d*) T^4
(where T is the absolute temperature).

89. At thermal equilibrium absorptivity is ..... emissivity.
(*a*) greater than (*b*) lesser than
(*c*) equal to (*d*) none of the above.

90. The total emissivity power is defined as the total amount of radiation emitted by a black body .....
(*a*) per unit time
(*b*) per unit temperature
(*c*) per unit area
(*d*) per unit thickness.

91. ..... is the ratio of the energy absorbed by the body to total energy falling on it.
(*a*) Emissivity
(*b*) Emissive power
(*c*) Absorptive power
(*d*) Absorptivity.

92. A gray body is one whose absorptivity
(*a*) varies with temperature
(*b*) varies with the wavelength of incident ray
(*c*) varies with temperature and wavelength of incident ray
(*d*) does not vary with temperature and wavelength of incident ray.

93. How does heat transfer take place in regenerator type heat exchanger?
(*a*) By generation of heat again and again
(*b*) By indirect transfer
(*c*) By direct mixing of hot and cold fluids
(*d*) By flow of hot and cold fluids alternately over a surface.

94. Planck's law holds good for ..... bodies.
(a) polished (b) black
(c) all coloured (d) any of the above.

95. On which of the following factors does the amount of radiation mainly depend?
(a) Temperature of body
(b) Type of surface of body
(c) Nature of body
(d) All of the above.

96. On which of the following factors does the emissive power of a body depend?
(a) Wavelength (b) Temperature
(c) Physical nature (d) All of the above.

97. For a cylinderical rod with uniformly distributed heat sources, the thermal gradient *dt/dr* at half the radius location will be .....of that at the surface.
(a) one-fourth (b) one-half
(c) twice (d) four times.

98. Which of the following is the notable example of uniform generation of heat within the conducting medium?
(a) Resistance heating in electrical appliances
(b) Energy generated in the fuel element of a nuclear reactor
(c) Liberation of energy due to some exothermic chemical reactions
(d) All of the above.

99. Thermal radiations occur in the portion of electromagnetic spectrum between the wavelengths
(a) 10^{-2} to 10^{-4} micron
(b) 10^{-1} to 10^{-2} micron
(c) 0.1 to 10^{2} micron
(d) none of the above.

100. Gases have poor .....
(a) transmissivity (b) absorptivity
(c) reflectivity (d) all of the above.

101. ..... is the ratio of total emissive power of body to total emissive power of a black body at the same temperature.
(a) Emissivity (b) Absoptivity
(c) Transmissivity (d) Reflectivity.

102. In which of the following cases, heat transfer by radiation is encountered least ?
(a) Electric bulb
(b) Nuclear reactor
(c) Boiler furnace
(d) Insulated steam pipe.

103. For a perfectly black body
(a) $\alpha = 1, \rho = 0, \tau = 0$
(b) $\alpha = \tau = 0, \rho = 1$
(c) $\alpha = \rho = 0, \tau = 1$
(d) none of the above.
where α = absorptivity, ρ = reflectivity and τ = transmissivity.

104. The emissivity is likely to be higher in case of
(a) iron oxide (b) paper
(c) carbon (d) rubber.

105. In the formulation of Stefan-Boltzmann's law, which of the following parameters does not appear?
(a) Radiation flux (b) Emissivity
(c) Absorptivity (d) Radiating area.

106. For solar collectors, what combination of surface characteristics is required ?
(a) High absorptivity and high reflectivity.
(b) High reflectivity and high emissivity
(c) High emissivity and low absorptivity
(d) High absorptivity and low emissivity.

107. The value of radiation shape factor for the same type of shapes will be higher when surfaces are .....
(a) large and held closer
(b) moved futrher apart
(c) more closer
(d) smaller and held closer.

108. For a radiation shield which of the following parameters should be highest?
(a) Emissivity (b) Reflectivity
(c) Absorptivity (d) Transmissivity.

109. The receprocity theorem states that
(a) $A_1 F_{1-2} = A_2 F_{2-1}$
(b) $A_2 F_{1-2} = A_1 F_{2-1}$
(c) $F_{1-2} = F_{2-1}$
(d) $a_1 F_{1-2} = a_2 F_{2-1}$

110. Which of the following statements is *incorrect* ?
(a) At thermal equilibrium, the emissivity and absorptivity are same
(b) Glasses are transparent to thermal radiations at short wavelengths
(c) The emissivity of a smooth surface is lower compared to a rough surface of the same material
(d) Selective surfaces have same value of emissivity throughout the entire range of wavelength.

111. For infinite parallel planes with emissivities ε_1 and ε_2, the interchange factor for radiation from surface 1 to surface 2 is

(a) $\frac{1}{\varepsilon_1 + \varepsilon_2}$ (b) $\varepsilon_1 + \varepsilon_2$

(c) $\varepsilon_1 - \varepsilon_2$ (d) $\frac{\varepsilon_1 \varepsilon_2}{\varepsilon_1 + \varepsilon_2 - \varepsilon_1 \varepsilon_2}$.

112. The intensity of solar radiation on earth is ..... kW/m^2.

(a) 1 (b) 3

(b) 6 (d) 8

113. The relationship $\lambda_{max} T$ = constant, between the temperature of a black body and the wavelength at which maximum value of monochromatic emissive power occurs is known as ..... law.

(a) Lambert's (b) Kirchhoff's

(c) Planck's (d) Wien's displacement.

114. For a gray surface which of the following statements is correct ?

(a) Reflectivity equals emissivity

(b) Emissivity is constant

(c) Absorptivity equals reflectivity

(d) Emissivity equals transmittivity.

115. With regard to a diathermanous body which of the following statements is correct ?

(a) It allows all the incident radiation to pass through it

(b) It shines as a result of incident radiation

(c) It gets heated up as a result of absorption of incident radiation

(d) It partly absorbs and partly reflects the incident radiation.

116. A body which partly absorbs and partly reflects but does not allow any radiation to pass through it is called

(a) specular (b) gray

(c) Opaque (d) none of the above.

117. Which one of the following approximates to the black body condition?

(a) Lamp black (b) Water

(c) Ice (d) All of the above.

118. With regard to 'Fouling factor' which of the following statements is correct ?

(a) It is used when a liquid exchanges heat with a gas

(b) It is used only in case of Newtonian fluids

(c) It is dimensionless

(d) It is virtually a factor of safety in heat exchanger design.

119. In a shell and tube heat exchanger, the corrosive liquid is normally passed through

(a) tube side (b) shell side

(c) either of the above (d) none of the above.

120. In ..... flow maximum heat transfer rate can be expected.

(a) laminar (b) turbulent

(c) counter current (d) co-current.

121. The nusselt number, in case of natural convection, is a function of

(a) Weber number and Mach number

(b) Grashoff's number and Prandtl number

(c) Reynolds number

(d) Reynolds number and Prandtl number.

122. When the bubbles formed on a submerged hot surface get absorbed in the mass of liquid, the process of boiling is known as ..... boiling.

(a) film (b) pool

(c) nucleate (d) none of the above.

123. ..... provides maximum contact surface for a liquid vapour system.

(a) Packed tower

(b) Wetted wall column

(c) Bubble cap tower

(d) None of the above.

124. What does 1-2 heat exchanger mean?

(a) Two tubes of hot fluid pass through one tube of cold fluid

(b) Single pass on tube side and double pass on shell side

(c) Single pass on shell side and double pass on tube side

(d) None of the above.

125. Why are baffles provided in heat exchangers ?

(a) To reduce heat transfer rate

(b) To increase heat transfer rate

(c) To remove dirt

(d) To reduce vibrations.

126. Which of the following evaporators will be preferred for handling severly scaling liquids ?

(a) Agitated film type

(b) Short vertical tube type

(c) Horizontal tube type

(d) Long vertical tube type.

127. The emissivity of a gray body is

(a) 0.5 (b) 1

(c) less than 1 (d) more than 1.

128. What does a high value of Prandtl number indicate?
(a) Rapid heat transfer by forced convection to natural convection.
(b) Rapid diffusion of momentem by viscous action compared to diffusion of energy.
(c) Relative heat transfer by conduction to convection.
(d) All of the above.

129. For gases, Prandtl number is
(a) near unity
(b) between 5 and 50
(c) between 60 and 100
(d) between 150 and 300.

130. ..... number is the ratio of heat transfer coefficient to the flow of heat per unit temperature rise due to the velocity of the fluid.
(a) Grashoff (b) Weber
(c) Stanton (d) Prandtl.

131. In ..... ablation heat transfer method is used.
(a) nuclear war heads (b) satellites
(c) rockets (d) none of the above.

132. Which mode of heat transfer plays insignificant role in a cooling tower?
(a) Radiation
(b) Evaporative cooling
(c) Convective cooling
(d) All of the above.

133. In which of the following heat exchange processes the value of overall heat transfer coefficient will be highest?
(a) Steam to oil (b) Steam condensers
(c) Air to heavy tars (d) Air to CO_2.

134. How can radiation heat transfer between two surfaces be reduced?
(a) By bringing the surfaces closer together
(b) By introducing radiation shield between the surfaces
(c) By polishing the surfaces
(d) All of the above.

135. ..... correlates the relative thickness of the hydrodynamic and thermal boundary layers.
(a) Mach number (b) Nusselt number
(c) Grashoff number (d) Prandtl number.

136. ..... number can be used for convective heat trnasfer.
(a) Mach (b) Froude
(c) Nusselt (d) None of the above.

137. The ratio of thermal conductivity ice to that of water is nearly
(a) 2 (b) 3
(c) 4 (d) 6

138. Which of the following can be used to a measure a temperature around – 45°C?
(a) Thermocouple
(b) Mercury thermometer
(c) Alcohol thermometer
(d) None of the above.

139. Which of the following statements is incorrect ?
(a) Black surfaces are better absorbers than white ones
(b) Black surfaces are better radiators than white ones
(c) Rough surfaces are better radiators than smooth surfaces
(d) Highly polished mirror like surfaces are very good radiators.

140. Due to which of the following reasons hydrogen cannot be liquified at room temperature?
(a) It is diatomic gas
(b) It has high specific heat
(c) Its critical temperature is less than the room temperature
(d) All of the above.

141. ..... have the same units.
(a) Planck's constant and angular momentum
(b) Planck's constant and Stefan's constant
(c) Boltzmann's constant and Planck's constant
(d) Stefan's constant and Boltzmann's constant

142. In air preheater for boiler, heat is least transferred by
(a) radiation
(b) conduction
(c) convectioin
(d) conduction and convection.

143. In which of the following cases non-isotropic conductivity is exhibited?.
(a) Lead (b) Wood
(c) Copper (d) Brass.

144. ..... is suitable for low temperature applications.
(a) Fused alumina bricks
(b) Asbestos paper
(c) Cork
(d) Diatomaceous earth.

145. A dimensionless number which is the ratio of kinematic viscosity to thermal diffusivity is known as ..... number.
(a) Grashoff (b) Prandtl
(c) Mach (d) Nusselt.

146. In Boltzmann's law which of the following quantities does not figure?
(a) Absorptivity
(b) Radiating area
(c) Absolute temperature
(d) Radiant flux
(e) Emissivity.

147. A perfect black body is the one which
(a) is coated with lamp black
(b) absorbs most of the incident radiation
(c) absorbs all incident radiation
(d) reflects all incident radiation.

148. Which of the following statements is correct?
(a) A substance will emit radiation at a particular wavelength only
(b) All substances emit radiation, the quality and quantity depend on the absolute temperature and the properties of the material composing the radiating body
(c) Only some substances emit radiation
(d) Bodies black in colour are known as black bodies.

149. The radiation from flames consists which of the following?
(a) Non-equilibrium radiation associated with the combustion process
(b) Continuous radiation from burning soot particles of microscopic and submicroscopic dimensions
(c) Infrared radiation from water vapour and CO_2
(d) Radiation from suspended larger particles of coal, coke, or ash contributing to flame luminosity
(e) All of the above.

150. A perfect ..... surface is the surface which diffusely reflects and emits the same amount of energy which it receives by radiation.
(a) radiating (b) gray
(c) black (d) white.

151. If ε is the emissivity of surfaces and shields and n is the number of shields introduced between the two surfaces, then overall emissivity is given by
(a) n/ε (b) $n\varepsilon$
(c) $1/(2n - \varepsilon)$ (d) $\varepsilon/[(n + 1)(2 - \varepsilon)]$.

152. Pyrometers which react to all wavelengths of incident radiant energy are known as ..... pyrometers.
(a) polarising
(b) total radiation
(c) optical
(d) disappearing filament type.

153. Fog is formed due to
(a) humidity
(b) low pressure
(c) temperature fall of atmosphere
(d) all of above.

154. Which of the following is a very good insulator?
(a) Saw dust
(b) A hard wood board
(c) An asbestos sheet
(d) A porcelain sheet.

155. Thermal conductivity of liquids can be determined by
(a) Searles method
(b) Guarded plate method
(c) Laby and Hercas method
(d) None of the above.

156. ..... is likely to have highest thermal conductivity.
(a) Boiling water (b) Steam
(c) Solid ice (d) Rain water.

157. The phenomenon of boiling the milk in an open container when milk spills over the vessel is termed as ..... boiling.
(a) subcooled (b) pool
(c) film (d) nuclear.

158. .....body transmits all the radiations falling on it.
(a) Transparent (b) Gray
(c) Black (d) White.

159. A radiation shield should have
(a) high emissivity (b) low reflectivity
(c) high reflectivity (d) none of the above.

160. ..... are generally diathermanous.
(a) Gases (b) Liquids
(c) Solids (d) All of the above.

161. The reflectance of a black body is
(a) zero (b) less than 1.0
(c) 1.0 (d) infinity.

162. Grashoff number has significant role in heat transfer by .....
(a) conduction (b) radiation
(c) natural convection (d) forced convection.

163. Heat transfer in liquids and gases takes place by
(a) conduction
(b) convection
(c) radiation
(d) conduction and radiation.

164. Metals are good conductors of heat because
(a) they contain free electrons
(b) they have high density
(c) their atoms collide frequently
(d) all of the above.

165. Temperature of steam around 550°C can be measured by .....
(a) thermopile
(b) thermocouple
(c) thermometer
(d) radiation pyrometer.

166. Flow of heat from one body to other takes place when they have different .....
(a) specific heats (b) heat contents
(c) temperatures (d) all of the above.

167. Due to which of the following reasons thermal conductivity of glass wool varies from sample to sample?
(a) Variation in porosity
(b) Variation in density
(c) Variation in composition
(d) Variation in structure.

168. In which of the following cases heat is transferred by all three modes of heat transfer, viz., conduction, convection and radiation?
(a) Steam condenser (b) Boiler
(c) Electric heater (d) None of the above.

169. ..... is the rate of energy emission from unit surface area through unit solid angle, along a normal to the surface.
(a) Absorptivity
(b) Transmissivity
(c) Intensity of radiation
(d) Emissivity.

170. For which of the following cases Fourier's law of heat conduction in valid ?
(a) Irregular surfaces
(b) One dimensional cases only
(c) Two dimensional cases only
(d) Three dimensional cases only.

171. Compared to parallel flow heat changer log mean temperature diffirence (LMTD) in case of counter flow heat exchanger will be
(a) less (b) same
(c) more (d) impredictable.

172. A gray body is one whose absorptivity ..... .
(a) is equal to its emissivity
(b) varies with temperature
(c) varies with wavelength of the incident ray
(d) none of the above.

173. Joule-sec. is the unit of ..... .
(a) thermal conductivity
(b) kinematic viscosity
(c) universal gas constant
(d) Planck's constant.

174. Compared to black body, total emissivity of polished silver is
(a) very much lower (b) same
(c) very much higher (d) more or less same.

175. The heat transfer equation $\frac{\partial^2 t}{\partial x^2} + \frac{\partial^2 t}{\partial y^2} + \frac{\partial^2 t}{\partial z^2} = 0$ is known as
(a) General equation of heat transfer
(b) Poisson's equation
(c) Fourier's equation
(d) Laplace's equation.

176. Absorptivity of a body will be equal to its emissivity
(a) at critical temperature
(b) for a polished body
(c) at all temperatures
(d) when the system is under thermal equilibrium.

177. Which of the follwing statements is incorrect?
(a) A temperature gradient must exist for heat exchange
(b) Heat flow is always from a higher temperature to a lower temperature in accordance with the second law of thermodynamics
(c) A material medium is always necessary for heat transmission
(d) The process of heat transfer is thermodynamically an irreversible process.

178. The material medium between the heat source and receiver is not affected during the process of heat transmission by
(a) convection
(b) radiation
(c) conduction
(d) conduction as well as convection.

179. With regard to the Fourier's law, which of the following statements is incorrect?
(a) It helps to define thermal conductivity of the heat conducting medium
(b) It is valid for all matter regardless of its state
(c) It is a vector representation indicating heat flow in the direction of decreasing temperature
(d) It can be derived from first principles.

180. The rate of heat transfer per unit area per unit thickness of wall when a unit temperature difference is maintained across the opposite faces of the wall is called ..... .
(a) heat flux
(b) thermal resistance
(b) thermal loading
(d) thermal conductivity.

181. The average thermal conductivities of water and air conform to the ratio
(a) 8 : 1 (b) 12 : 1
(c) 25 : 1 (d) 40 : 1

182. Which of the following statements is incorrect ?
(a) Thermal conductivity decreases with increase in the density of the substance
(b) Heat treatment causes considerable variation in thermal conductivity
(c) Thermal conductivity is always higher in the purest form of metal
(d) Thermal conductivity of a damp material is considerably higher than the thermal conductivity of the dry material and water taken individually.

183. The steady state temperature distribution in the very large thin plate with uniform surface temperature will be
(a) logarithmic (b) parabolic
(c) hyperbolic (d) linear.

184. The thermal resistance for heat conduction through a hollow sphere of inner radius r_1 and outer radius r_2 is
(a) $\frac{4\pi k (r_2 - r_1)}{r_1 r_2}$ (b) $\frac{r_2 - r_1}{4\pi k r_1 r_2}$
(c) $\frac{(r_2 - r_1) r_1 r_2}{4\pi k}$ (d) none of the above.

(where k is the thermal conductivity of the material of the sphere)

185. Which of the following statements is incorrect?
(a) A certain thickness of lagging on a steam pipe may increase the rate of heat flow rather than reduce it
(b) Addition of insulation does not always bring about a decrease in the heat transfer rate for geometries with non-constant cross-sectional area
(c) Critical radius of insulation refers to the outer radius of insulation for which there is maximum thermal resistance and consequently maximum heat flow rate.
(d) Rubber insulated wires can carry more current than a bare wire for the same rise in temperature.

186. With regard to 'fin effectiveness' which of the following statements is incorrect?
(a) It is improved if the fin is made from a material of low thermal conductivity
(b) It represents the ratio of heat transfer rate from the fin to the heat that would be dissipated if the entire fin surface area were maintained at the base temperature
(c) both (a) and (b)
(d) It is imprved by having thin but closely spaced fins.

187. ..... number gives an indication of the ratio of internal (conduction) resistance to the surface (convection) resistance.
(a) Stanton (b) Biot
(c) Nusselt (d) Fourier.

188. The characteristic length, in the non-dimensional Biot number, is the ratio of
(a) perimeter to surface area of solid
(b) volume of solid to its surface area
(c) surface area to perimeter of solid
(d) none of the above.

189. Heat transfer by radiation is characterised by
(a) circulation of fluid motion by buoyancy effects
(b) movement of discrete packets of energy as electromagnetic waves
(c) energy transport as a result of bulk fluid motion
(d) all of the above.

190. With regard to `thermal radiations' which of the following statements is *incorrect*?
(*a*) These occur in the portion of electromagnetic spectrum between the wavelengths 10^{-2} to 10^{-4} micron.
(*b*) These travel in space with a velocity 3×10^8 m/s.
(*c*) These are electromagnetic waves
(*d*) None of the above.

191. Which of the following heat flow situations pertains to free or natural convection?
(*a*) Cooling of billets in atmosphere
(*b*) Cooling of I.C. engines
(*c*) Flow of water inside the condenser tubes
(*d*) All of the above.

192. ..... causes forced convection in a liquid bath.
(*a*) Flow of electrons in a random fashion
(*b*) Intense stirring by an external agency
(*c*) Molecular energy interaction
(*d*) All of the above.

193. ..... number has a significant role in forced convection.
(*a*) Mach (*b*) Reynolds
(*c*) Prandtl (*d*) Peclet.

194. In convective heat transfer, the Nusselt number
(*a*) represents the ratio of viscous to inertia force
(*b*) signifies the velocity gradient at the surface
(*c*) is the ratio of molecular momentum diffusivity to thermal diffusivity
(*d*) is the ratio of conduction to convection resistance.

195. Nusselt number, for forced convection, is a function of ..... number and ..... number.
(*a*) Reynolds, Prandtl
(*b*) Reynolds, Grashoff
(*c*) Prandtl, Grashoff
(*d*) None of the above.

196. In case of laminar flow over a plate, the convective heat transfer co-efficient
(*a*) decreases with increase in free stream velocity
(*b*) increases with distance
(*c*) increases if a higher viscosity fluid is used
(*d*) increases if a denser fluid is used.

197. The temperature gradient in the fluid flowing over a heated plate will be
(*a*) zero at the top of thermal boundry layer
(*b*) very steep at the surface
(*c*) zero at the plate surface
(*d*) positive at the surface.

198. The ratio of hydrodynamic to thermal boundary layer thicknesses
(*a*) varies as one-third power of Prandtl number
(*b*) varies as two-third power of Stanton number
(*c*) varies as four-fifth power of Nusselt number
(*d*) varies as root of Prandtl number.

199. When Prandtl number is equal to ..... the hydrodynamic and thermal boundary layers are identical.
(*a*) 0.2 (*b*) 1
(*c*) 15 (*d*) 30.

200. The convective coefficients for boiling and condensation usually lie in the range
(*a*) 50-500 W/m^2K
(*b*) 200-2500 W/m^2K
(*c*) 300-5000 W/m^2K
(*d*) 2500–10000 W/m^2K.

201. With which of the following `Leiden-frost effect' is associated?
(*a*) Condensation of vapour on a cold surface
(*b*) Boiling of liquid on a hot surface
(*c*) Evaporation of a solution
(*d*) Exchange of heat between two fluids
(*e*) None of the above.

202. On which of the following factors does the heat flux in nucleate pool boiling depend?
(*a*) Material of the surface only
(*b*) Material and roughness of the surface
(*c*) Liquid properties and material of the surface
(*d*) Liquid properties, material and condition of the surface.

203. How is the requirement of transfer of a large heat usually met?
(*a*) By decreasing the diameter of tube
(*b*) By increasing the length of tube
(*c*) By increasing the number of tubes
(*d*) By having multiple tube or shell passes.

204. Why are multipass heat exchangers used?
(*a*) To obtain high heat transfer coefficient
(*b*) To reduce the pressure drop
(*c*) To get a compact unit
(*d*) All of the above.

205. ..... does not pertain to transient heat conduction.
(a) Fourier number (b) Interchange factor
(c) Error function (d) Biot number.

206. Due to which of the following reasons heat flux increases with temperature excess beyond the Leiden-fost point?
(a) Radiation effect becomes predominant
(b) Occurence of subcooled boiling
(c) Promotion of nucleate boiling
(d) None of the above.

207. Which of the following statements is incorrect?
(a) Film boiling region is usually avoided in commercial equipment
(b) In subcooled boiling, the temperature of the heating surface is more than the boiling point of the liquid
(c) There occurs transition from nucleate to film boiling at burn-out point on the boiling curve
(d) Nucleate boiling gets promoted on a smooth surface.

208. The steam condenser in a thermal power plant is a heat exchanger of the type
(a) recuperator (b) direct contact
(c) regenerator (d) none of the above.

209. Why are expansion bellows provided in the shell of a tubular heat exchanger ?
(a) To reduce the pressure drop
(b) To impart structural strength to exchanger
(c) To facilitate increase in length of boiler shell
(d) To account for uneven expansion of shell and tube bundles.

210. Which of the following terms does not pertain to radiation heat transfer?
(a) Configuration factor
(b) Spectral distribution
(c) Solid angle
(d) Reynolds analogy.

211. The value of convection coefficient, in condensation over a vertical surface, varies as
(a) $k^{0.5}$ (b) $k^{0.35}$
(c) $k^{0.75}$ (d) $k^{0.9}$.
(where k is the thermal conductivity of the liquid).

NUMERICAL QUESTIONS

*212. The inner surface of a plane brick wall is at 50°C and the outer surface is at 25°C. Calculate the rate of heat transfer per m^2 of the surface area of the wall, which is 220 mm thick. The thermal conductivity of the bricks is 0.51 W/m K.
(a) 20.65 W/m^2 (b) 32.75 W/m^2
(c) 47.62 W/m^2 (d) 57.95 W/m^2.

*213. A mild steel tank of wall thickness 12 mm contains water at 100°C. Calculate the rate of heat loss per m^2 of tank surface area when the atmospheric temperature is 20°C. The thermal conductivity of mild steel is 50 W/m K, and the heat transfer coefficients for the inside and outisde the tank are 2850 and 10 W/m^2 K, respectively. Calculate also the temperature of the outside surface of the tank.
(a) 300.5 W/m^2, 45.5°C
(b) 495.2 W/m^2, 67.6°C
(c) 602.6 W/m^2, 80.6°C
(d) 795.2 W/m^2, 99.52°C.

*214. A spherical shaped vessel of 1.4 m diameter is 90 mm thick. Find the rate of heat leakage, if the temperaturre difference between the inner and outer surfaces is 220°C. Thermal conductivity of the material of the sphere is 0.083 W/mK.
(a) 0.2 kW (b) 0.5 kW
(c) 1.0886 kW (d) 1.6 kW.

215 Liquid air at −147° C is stored in the space of two concentric spheres of 0.2 m and 0.3 m diameters. The surface emissivities are 0.028. Assume the outer surface temperature is 25° C. Considering only
(a) W/m-s-K (b) cal/m-s-°C.

215. Choose the *wrong* statement about thermal diffusivity :
(a) It represents a physical property of the material
(b) It is a dimensionless quantity.
(c) It is an important characteristic for unsteady heat conduction
(d) It is the ratio of thermal conductivity to thermal storage capacity of a material.

216. A body which partly absorbs and partly reflects but does not allow any radiation to pass through it (a + r = 1 and t = 0) is called
(a) diamthermanous (b) opaque
(c) gray (d) specular.

217. The heat flow equation through a cylinder of inner radius r_1 and other radius r_2 is desired to be written in the same form as that for heat flow through a plane wall. For wall thickness $(r_2 - r_1)$, the equivalent area A_m would be

(a) $\frac{A_1 + A_2}{2}$ (b) $\frac{A_1 + A_2}{2 \log_e (A_2 / A_1)}$

(c) $\frac{A_2 - A_1}{\log_e (A_2 / A_1)}$ (d) $\frac{A_2 - A_1}{2 \log_e (A_2 / A_1)}$.

where A_1 and A_2 are the inner and outer surface areas of the cylindrical tube.

218. A gas turbine blade (idealised as a flat plate of surface area A, thickness d and thermal conductivity k) has hot gases at temperature T_1 on one side and cooling air ar temperature T_2 on the other side. If h_1 and h_2 are the corresponding surface coefficients of heat transfer, then the overall heat transfer coefficient U is given by

(a) $\frac{1}{U} = \frac{1}{h_1} + \frac{\delta}{k} + \frac{1}{h_2}$

(b) $\frac{1}{U} = \frac{1}{h_1} + \frac{k}{\delta} + \frac{1}{h_2}$

(c) $U = h_1 + \frac{\delta}{k} + h_2$

(d) $U = \frac{1}{h_1} + \frac{\delta}{k} + \frac{1}{h_2}$.

219. Which of the following is the wrong value of characteristic length l which appears in the Biot number hl/k and the Fourier number at $/ l^2$?

(a) $l = R/3$ in case of a sphere of radius R

(b) $l = R/2$ in case of a cylinder of radius R and length L

(c) $l = R/6$ in case of a cube with each side of length L

(d) $l = b/2$ for a flat plate of thickness d breadth b and height h.

220. A solid cement wall of a building having thermal conductivity k and thickness d is heated by convection on the inner side and cooled by convection on the outside. The heat flux through the wall can be expressed as

(a) $\frac{(t_1 - t_2)}{1/h_1 + \delta/k + 1/h_2}$ (b) $\frac{(t_1 - t_2)}{h_1 + \delta/k + h_2}$

(c) $\frac{k (t_1 - t_2) (h_1 + h_2)}{\delta}$ (d) none of the above.

221. The heat dissipation from an infinitely long find is given by

(a) $\sqrt{PkhA_{cs}}\ (t_o - t_a)$

(b) $hPl\ (t_o - t_a)$

(c) $\sqrt{PkhA_{cs}}\ (t_o - t_a) \tanh ml$

(d) $\sqrt{PkhA_{cs}}\ (t_o - t_a) \frac{\tanh ml + (h/k)\, m}{l + (h/km) \tanh ml}$

The symbols have their usual meanings.

222. 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 wall thickness $(r_2 - r_1)$, the equivalent mean radius for the spherical shell is

(a) $\frac{r_1 + r_2}{2}$ (b) $r_1 r_2$

(c) $\sqrt{r_1 / r_2}$ (d) $\frac{r_1 + r_2}{\log_e (r_2 / r_1)}$.

223. The variation in thermal conductivity of a wall material is stated to conform to the relation $k = k_o (1 + aT)$. In that case the temperature at the mid-plane of the heat conducting wall would be

(a) average of the temperatures at the wall faces

(b) more than the average of the temperatures at the wall faces

(c) less than the average of the temperatures at the wall faces

(d) depends upon the temperature difference between the wall faces.

224. The Fourier's conduction heat equation $Q = - KA\, dt/dx$ presumes

(a) steady state, one-dimensional heat flow

(b) constant value of thermal conductivity

(c) constant and uniform temperatures at the wall surfaces

(d) all of the above.

225. A hollow sphere has inner and outer surface areas of 2 m^2 and 8 m^2 respectively. For a given temperature difference across the surfaces, it is desired to calculate heat flow by considering the material of the sphere as a plane wall of the same thickness. The equivalent mean area normal to the direction of heat flow should be

(a) 6 m^2 (b) 5 m^2

(c) 4 m^2 (d) 3 m^2.

226. The relation $\nabla^2 t = 0$ is referred to as

(a) Fourier heat conduction equation

(*b*) Laplace equation
(*c*) Poisson's equation
(*d*) Lumped parameter solution for transient conduction.

227. Heat is transferred from a hot fluid (temperature T_1 and heat transfer coefficient h_2) through a plane wall of thickness d, surface area A and thermal conductivity k. The thermal resistance for the set up is

(*a*) $\frac{1}{A}\left(\frac{1}{h_1}+\frac{\delta}{k}+\frac{1}{h_2}\right)$

(*b*) $A\left(\frac{1}{h_1}+\frac{\delta}{k}+\frac{1}{h_2}\right)$

(*c*) $\frac{1}{A}\left(h_1+\frac{k}{\delta}+h_2\right)$

(*d*) $A\left(h_1+\frac{k}{\delta}+h_2\right)$.

228. Which of the following is *not a correct* statement?
(*a*) The dimensions of thermal conductivity are $MLT^{-3}\,\theta^{-1}$
(*b*) The thermal conductivity of glass wool varies from sample to sample because of variation in its structure, composition and porosity etc.
(*c*) Metals and gases have a relativitely small value of thermal conductivity where as this parameter is relatively large for non-metallic solids and liquids
(*d*) Thermal conductivity is the ability of solids to conduct heat, and thermal diffusivity is a measure of thermal inertia.

229. Considering a composite wall comprising two layers of thermal conductivities k and $2k$, and equal surface areas normal to the direction of heat flow. The outer surfaces of the composite wall are maintained at 100°C and 200°C respectively. If surface temperature at the junction is desired to be 150°C and conduction is the only mode of heat transfer, then ratio of thickness should be
(*a*) 1:1 (*b*) 2:1
(*c*) 1:2 (*d*) 2:3

230. Most unsteady heat flow occurs
(*a*) through the wall of a refrigerator
(*b*) during annealing of castings
(*c*) through the walls of a furnace
(*d*) through lagged (insulated) pipes carrying steam.

231. A thin cylinder of radius r is lagged to an outer radius r_o with an insulating layer of thermal conductivity k. If h_o is the film coefficient at the outer surface of lagging, then minimum resistance and consequently maximum heat flow rate occurs when r_o equals

(*a*) $\sqrt{kh_o}$ (*b*) $\frac{k}{h_o}$
(*c*) $\frac{2k}{h_o}$ (*d*) $\frac{h_o}{k}$.

232. For a long cylindere of radius R with uniformly distributed heat sources, the temperature distribution in the dimensionless form is

(*a*) $\frac{t-t_w}{t_{max}-t_w}=1-\frac{r}{R}$

(*b*) $\frac{t-t_w}{t_{max}-t_w}=1-\left(\frac{r}{R}\right)^2$

(*c*) $\frac{t-t_w}{t_{max}-t_w}=1-\left(\frac{r}{R}\right)^3$

(*d*) $\frac{t-t_w}{t_{max}-t_w}=1-\left(\frac{r}{R}\right)^4$.

where t_w is the temperature at the outer surface of the cylinder and t_{max} is the temperature along the cylinder axis.

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

234. Two long parallel surfaces, each of emissivity 0.7, are maintained at different temperatures and accordingly have radiation heat exchange between them. It is desired to reduce 75% of this radiant heat transfer by inserting thin parallel shields of emissivity on both sides. The number of shields should be
(*a*) one (*b*) two
(*c*) three (*d*) four.

235. For laminar conditions, the thickness of thermal boundary layer increases with its distance from the leading edge in proportion to
(*a*) x (*b*) $x^{1/2}$
(*c*) $x^{1/3}$ (*d*) $x^{1/4}$.

236. The intensity of Solar radiation on earth is
(*a*) 1 kW/m^2 (*b*) 2 kW/m^2
(*c*) 4 kW/m^2 (*d*) 8 kW/m^2.

237. For a transport of diathermanous body
(*a*) absorptivity $\alpha = 1$. transmissivity $\tau = 0$ and reflectivity $\rho = 0$
(*b*) $\rho = 1$ and $\alpha = \tau = 0$
(*c*) $\tau = 1$ and $\alpha = \rho = 0$
(*d*) $\alpha + \rho = 1$ and $\tau = 0$

238. Choose the *false* statement :
(*a*) The unit of heat transfer coefficient is kcal/m^2-hr-°C
(*b*) The overall heat transfer coefficient has units of W/m^2-deg
(*c*) In M-L-T-θ system, the dimensions of convective heat transfer coefficient and the overall heat transfer coefficient are $MT^{-3}\,\theta^{-1}$
(*d*) The overall heat transfer coefficient is the reciprocal of overall thermal resistance to heat flow.

239. Three fins of equal length and diameter but made of aluminium, brass and cost iron are heated to 200°C at one end. If the fins dissipate heat to the surrounding air at 25°C, the temperature at the free end will be least in case of
(*a*) aluminium fin
(*b*) brass fin
(*c*) cast iron fin
(*d*) each fin will have the same temperature at the free end.

240. Which of the following heat flow situations pertains to free or natural convection ?
(*a*) Cooling of internal combustion engines
(*b*) Flow of water inside the condenser tubes
(*c*) Cooling of billets in atmosphere
(*d*) Air-conditioning installations and nuclear reactors.

241. The requirement of transfer of a large heat is usually met by
(*a*) increasing the length of tube
(*b*) decreasing the diameter of tube
(*c*) increasing the number of tubes
(*d*) having multiple tube or shell passes.

242. Which of the following parameters does not appear in the formulation of Stefan-Boltzman law?
(*a*) Absorptivity (*b*) Emissivity
(*c*) Radiating area (*d*) Radiation flux.

243. Heisler charts are used to determine the transient heat flow rate and temperature distribution when
(*a*) solids possess infinitely large thermal conductivity
(*b*) internal conduction resistance is small and the convective resistance is large
(*c*) internal conduction resistance is large and the convective resistance is small
(*d*) both conduction and convection resistance are almost of equal importance.

244. A body cooling from 80°C to 70°C takes 10 minutes when left exposed to environmental conditions. If the body is to cool further from 70°C to 60°C under the same external conditions, it will take
(*a*) same time of 10 minutes
(*b*) more than 10 minutes
(*c*) less than 10 minutes
(*d*) time will depend upon the environmental conditions.

245. The dimensionless parameter $(b\,g\,r^2\,l^3\,D\,t)/m^2$ is referred to as
(*a*) Stanton number (*b*) Schmidt number
(*c*) Grashoff number (*d*) Peclet number.

246. For a plane wall of thickness l with uniformly distributed heat generation q_s per unit volume, the temperature t_o at the mid-plane is given by

(*a*) $t_o = \dfrac{q_g\,l^2}{2k} + t_w$ (*b*) $t_o = \dfrac{q_g\,l^2}{4k} + t_w$

(*c*) $t_o = \dfrac{q_g\,l^2}{8k} + t_w$ (*d*) $t_o = \dfrac{q_g\,l^2}{16k} + t_w$.

where t_w is the temperature on either side of the wall and k is the thermal conductivity of the wall material.

247. The temperature distribution $(t - t_a)/(t_o - t_a)$ for a fin with insulated tip is given by
(*a*) $\exp(-mx)$
(*b*) $\dfrac{\exp(mx) + \exp(-mx)}{2}$
(*c*) $\dfrac{\cosh m\,(l - x)}{\cosh ml}$
(*d*) $\cosh m\,(l - x) + \cosh ml$.

The symbols have their usual meanings.

248. The Nusselt number for convective heat transfer between a horizontal tube and water surrounding it is prescribed by the relation

$$Nu = 0.52\,(Gr.Pr)^{0.25}$$

For a 4 cm diameter tube, the heat transfer coefficient is stated to be 1412 kcal/m^2-hr-deg. Subsequently the tube is replaced by one with 16 cm diameter tube. If temperature and surface of the fluid remains same, the heat transfer

coefficient will change to

(*a*) 706

(*b*) 1000

(*c*) 2824

(*d*) 5648 kcal/m^2-hr-°C

249. Radiation heat transfer is characterised by

(*a*) energy transport as a result of bulk fluid motion

(*b*) thermal energy transfer as vibrational energy in the lattice structure of the material

(*c*) movement of discrete packets of energy as electromagnetic waves

(*d*) circulation of fluid motion by bouyancy effects.

250. Choose the *false* statement :

(*a*) Thermal conductivity is always higher in the purest form of metal

(*b*) Heat treatment causes considerable variation in thermal conductivity

(*c*) Thermal conductivity of a damp material is considerably higher than the thermal conductivity of the dry material and water taken individually

(*d*) Thermal conductivity decreases with increase in the density of the substance.

251. The emissive power is multiplied with the factor ... to obtain the intensity of normal radiation for a unit surface.

(*a*) $\frac{1}{\sqrt{\pi}}$ (*b*) $\frac{1}{\pi}$

(*c*) $\frac{1}{2\pi}$ (*d*) $\sqrt{\pi}$.

252. Thermal radiations occur in the portion of electromagnetic spectrum between the wavelengths

(*a*) 10^{-2} to 10^{-4} micron

(*b*) 10^{-1} to 10^{-2} micron

(*c*) 0.1 to 10^2 micron

(*d*) 10^2 micron onwards.

253. The thermal radiation propagates in the forum of discrete quanta; each quanta having an energy of $E = h\nu$ where ν is the frequency of quantum. The Planck's constant h has the dimensions.

(*a*) MLT (*b*) MLT^{-1}

(*c*) MLT^{-2} (*d*) ML^2T^{-1}.

254. Identify the *wrong* statement with respect to boiling heat transfer :

(*a*) Boiling occurs when a heated surface is exposed to a liquid and maintained at a temperature lower than the saturation temperature of the liquid.

(*b*) The steam boilers employing natural convection have steam raised through pool boiling.

(*c*) The nucleation boiling is characterised by the formation of bubbles at the nucleation sites and the resulting liquid agitation.

(*d*) "Leidenfrost effect" refers to the phenomenon of stable film boiling.

(*e*) The boiling crisis or the burn out point on the boiling curve (surface heat flux as a function of excess temperatures) represents the maximum heat flux at which transition occurs from nucleate to film boiling.

255. Two walls of same thickness and cross-sectional area have thermal conductivities in the ratio 1:2. If same temperature difference is maintained across the wall faces, the ratio of heat flow Q_1/Q_2 will be

(*a*) 1/2 (*b*) 1

(*c*) 2 (*d*) 4.

256. Consider development of laminar thermal boundary layer for a moving non-reacting fluid in contact with a flat plate of length l along the flow direction. The average value of heat transfer coefficient can be obtained by multiplying the local heat transfer coefficient at the trailing edge by the factor

(*a*) 0.75 (*b*) 1.0

(*c*) 1.5 (*d*) 2.0.

257. The emissivity and the absorptivity of a real surface are equal for radiation with identical temperature and wavelength. This law is referred to as

(*a*) Lambert's law

(*b*) Kirchhoff's law

(*c*) Planck's law

(*d*) Wien's displacement law.

258. The unit of thermal diffusivity is

(*a*) m^2/hr°C (*b*) kcal/m^2-hr

(*c*) m/hr°C (*d*) m^2/hr.

259. Choose the *wrong statement* with respect to Nusselt number and convective heat transfer coefficient :

(*a*) Nusselt number represents the ratio of temperature gradient at the surface to an overall or reference temperature gradient.

(*b*) Nusselt number represents the dimensionless slope of the temperature distribution curve at the surface.

(*c*) The convective coefficient can be evaluated from a knowledge of fluid temperature. distribution in the neighbourhood of the surface.

(*d*) For a given Nusselt number, the convective coefficient is inversely proportional to thermal conductivity of the fluid.

260. 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.

261. The convective coefficients for boiling and condensation usually lie in the range

(*a*) 30-300

(*b*) 60-3000

(*c*) 300-10000

(*d*) 2500-10000 W/m^2K.

262. In *M-L-T*-q system, the dimensions of thermal diffusivity are

(*a*) L^2T^{-1} (*b*) $LT^{-1}q^{-1}$

(*c*) ML^2T^{-1} (*d*) $L^2T^{-1}q^{-1}$.

263. Choose the *false* statement :

(*a*) The monochromatic emissive power is the rate of energy radiated per unit area of the surface per unit wavelength.

(*b*) The distribution of monochromatic emissive power across the wavelength is continuous but non-uniform.

(*c*) At elevated temperatures, much of the energy is emitted in shorter wavelengths.

(*d*) The area under the monochromatic emissive power versus wavelength curve represents the total emissive power per unit area radiated from the surface.

(*e*) None of the above.

264. A thermally transparent surface of transmissivity 0.15 receives 500 kcal/min of radiation and reflects back 200 kcal/min out of it. The emissivity of the surface is then

(*a*) 0.15 (*b*) 0.4

(*c*) 0.45 (*d*) 0.55.

265. Peclet number is defined as

(*a*) $\dfrac{\text{kinematic viscosity}}{\text{thermal diffusivity}}$

(*b*) $\dfrac{\text{convective heat transfer viscosity}}{\text{conduction heat transfer}}$

(*c*) $\dfrac{\text{bouyancy force} \times \text{inertia force}}{\text{viscous force}}$

(*d*) $\dfrac{\text{wall heat transfer rate}}{\text{convection heat transfer}}$.

266. Which of the following is anisotropic, *i.e.*, exhibits change in thermal conductivity due to directional preferences ?

(*a*) Wood (*b*) Glass wool

(*c*) Concrette (*d*) Masonry brick.

267. The temperature of a body at any time during newtonian heating or cooling is stated as

(*a*) $\dfrac{t - t_a}{t_i - t_a} = \exp(-B_i F_o)$

(*b*) $\dfrac{t - t_a}{t_i - t_a} = \exp[(-B_i F_o)/2]$

(*c*) $\dfrac{t - t_a}{t_i - t_a} = \exp[-\sqrt{B_i F_o}]$

(*d*) $\dfrac{t - t_a}{t_i - t_a} = \exp[-(B_i F_o)^2]$.

where t_i is the body temperature at the commencement of heating or cooling process, t_a is the temperature of the surroundings, B_i and F_o are the non-dimensional Biot number and Fourier number respectively.

268. In a convective heat transfer situation, Reynolds number is very large but the Prandtl number is so small that the product (Re . Pr) is less than one. In such a situation

(*a*) thermal boundary layer does not exist

(*b*) viscous boundary layer thickness equals the thermal boundary layer thickness

(*c*) viscous boundary layer thickness is less than the thermal boundary layer thickness

(*d*) viscous boundary layer thickness is greater than the thermal boundary layer thickness.

269. All the three modes of transmission are involved in

(*a*) melting of ice

(*b*) cooling of a small metal casting in a quenching bath

(*c*) heat flow through the walls of a refrigerator

(*d*) automobile engine equipped with a thermo-syphon cooling system.

270. Mark the wrong statement with respect to laminar film condensation on a vertical plate :

(*a*) The rate of condensation heat transfer is maximum at the upper edge of the plate and progressively decreases as the lower edge is approached.

(*b*) At a definitte point on the heat transfer surface, the film coefficient is directly proportional to thermal conductivity and inversely proportional to thickness of film at that point.

(*c*) The average heat transfer coefficient is two-third of the local heat transfer coefficient at the lower edge of the plate.

271. A heat exchanger with heat transfer surface area A and overall heat transfer coefficient U handles two fluids of heat capacities C_{max} and C_{min}. The parameter NTU (number of transfer units) used in the analysis of heat exchanger is specified as

(*a*) $\frac{AU}{C_{min}}$ (*b*) AUC_{min}

(*c*) $\frac{U}{AC_{min}}$ (*d*) $\frac{AC_{min}}{U}$.

272. Which of the following is a *wrong* statement ?

(*a*) Addition of insulation does not always bring about a decrease in the heat transfer rate for geometries with non-constant cross-section.

(*b*) Rubber insulated wires can carry more current than a bare wire for the same rise in temperature.

(*c*) A certain thickness of lagging on a steam pipe may increase the rate of heat flow rather than reduce it.

(*d*) Critical radius of insulation refers to the outer radius of insulation for which there is maximum thermal resistance and consequently maximum heat flow rate.

273. Consider natural convection heat transfer between a vertical tube surface and a fluid surrounding it. For dimensional analysis of the problem, the characteristic length corresponds to

(*a*) length of the tube

(*b*) diameter of the tube

(*c*) perimeter of the tube

(*d*) either length or diameter of the tube.

274. Finned surfaces have improved rate of dissipation due to

(*a*) decrease in ambient temperature

(*b*) increase in the surface area exposed to the surroundings

(*c*) increase in the convective film coefficient

(*d*) all of the above.

275. The relationship, $l_{max}\ T$ = constant, between the temperature of a black body and the wavelength at which maximum value of monochromatic emissive power occurs is known as

(*a*) Planck's law

(*b*) Wien's displacement law

(*c*) Kirchhoff's law

(*d*) Lambert's law.

276. Steady state heat flow implies

(*a*) negligible flow of heat

(*b*) no difference of temperature between the bodies

(*c*) constant heat flow rate, *i.e.*, heat flow rate independent of time

(*d*) uniform rate in temperature rise of a body.

277. The Nusselt number in natural heat transfer is a function of fluid Prandtl number and

(*a*) Stanton number (*b*) Biot number

(*c*) Grashoff number (*d*) Reynolds number.

278. Pick the odd one out :

(*a*) Open feed water heaters

(*b*) Jet condensers

(*c*) De-super heater

(*d*) Surface condenser.

279. Which of the following forms of water will have the highest value of thermal conductivity ?

(*a*) Boiling water (*b*) Steam

(*c*) Solid ice (*d*) Melting ice.

280. Most metals are good conductor of heat because of

(*a*) energy transport due to molecular vibration

(*b*) migration of neutrons from hot end to cold end

(*c*) lattice defects such as dislocations

(*d*) presence of many free electrons and frequent collision of atoms

(*e*) capacity to absorb free energy of electrons.

281. The metal walls of same wall thickness and cross-sectional area have thermal conductivities k, $2k$ and $3k$ respectively. For the same heat transfer, the temperature drops across the wall will be in the ratio

(*a*) 1 : 2 : 3

(*b*) 3 : 2 : 1

(*c*) 1 : 1 : 3

(*d*) temperature drops ratios cannot be worked out as the given data is insufficient.

282. 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 (NTU), the effectiveness of such an exchanger would be

(a) $\frac{NTU}{1 + NTU}$

(b) $1 - \exp(-NTU)$

(c) $\frac{1 - \exp(-2\,NTU)}{2}$

(d) cannot be worked out as the heat capacities are not known.

283. Mark the matter with least value of thermal conductivity :

(a) Air (b) Water

(c) Ash (d) Window glass.

284. Choose the correct statement with respect to a counter flow heat exchanger :

(a) Both the fluids at inlet are in their coldest state.

(b) Both the fluids at exit are in their hottest state.

(c) Both the fluids at inlet are in their hottest state.

(d) One fluid is hottest and the other is coldest at inlet.

285. In a double pipe parallel flow heat exchanger, there occurs condensation of saturated steam over the inner tube. Subsequently, the entrance and exit connections of the cooling medium are interchanged. The ratio of steam condensation

(a) will increase

(b) will decrease

(c) will remain unchanged

(d) may increase or decrease depending upon saturated temperature of steam and inlet temperature of cooling medium.

286. For an ideal reflector, the energy distribution at higher temperature is at

(a) shorter wavelength

(b) longer wavelength

(c) remains same at all wavelength

(d) depends upon factors other than wavelength.

287. The grey body shape factor for radiant heat exchanger between a small body (emissivity 0.4) in a large enclosure (emissivity 0.5) is

(a) 0.1 (b) 0.2

(c) 0.5 (d) 0.5.

288. Molecular transmission of heat is smallest in case of

(a) gases (b) liquids

(c) solids (d) alloys.

289. Heat transfer by radiation is encountered least in

(a) boiler furnace

(b) insulated steam pipe

(c) electric bulb

(d) nuclear reactor.

290. Heat conduction in gases is due to :

(a) motion of electrons

(b) elastic impact of molecules

(c) mixing motion of the different layers of the gas

(d) electromagnetic waves.

291. A thin shield of emissivity ε_3 (on both sides) is placed between two infinite parallel plates of emissivities ε_1 and ε_2, and temperatures T_1 and T_2 respectively. If $\varepsilon_1 = \varepsilon_2 = \varepsilon_3$ then the fraction radiant energy transfer without shield/with shield takes the value

(a) 0.25 (b) 0.50

(c) 0.75 (d) 0.82.

292. A straight fin of cross-sectional area A for all along its length and made of a material of thermal conductivity k serves to dissipates heat to the surroundings from a surface held at a constant temperature. What additional data is required to workout the rate of heat dissipation ?

(a) The root and tip temperatures

(b) The temperature gradient at the root

(c) The temperature gradient at the tip

(d) The convective heat transfer coefficient and the fin perimeter.

293. The temperature of a radiating surface changes from 400°K to 1200°K. The ratio of total emissive powers at the higher and lower temperatures would be

(a) 3 (b) 9

(c) 27 (d) 81.

294. The steam condenser in a thermal power plant is a heat exchanger of the type

(a) direct contact (b) regenerator

(c) recuperator (d) none of these.

295. What happens when the thickness of insulation on a pipe exceeds the critical value ?

(a) There is decrease in the heat flow rate.

(b) There is increase in the heat flow rate.

(*c*) The heat flow rate remains constant.

(*d*) The temperature at the junction between pipe and insulation rises.

296. For infinite parallel planes with emissivities e_1 and e_2 the interchange factor for radiation from surface 1 to surface 2 is

(*a*) $\varepsilon_1\varepsilon_2$ (*b*) $\varepsilon_1 + \varepsilon_2$

(*c*) $\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2}$ (*d*) $\frac{\varepsilon_1\varepsilon_2}{\varepsilon_1 + \varepsilon_2 - \varepsilon_1\varepsilon_2}$.

297. Dropwise condensation usually occurs on

(*a*) glazed surface (*b*) smooth surface

(*c*) oily surface (*d*) coated surface.

298. A perfectly black body

(*a*) absorbs all the incident radiation

(*b*) allows all the incident radiation to pass through it

(*c*) reflects all the incident radiation

(*d*) has its surface coated with lamp black or graphite.

299. Forced convection in a liquid bath is caused by

(*a*) density difference brought about by temperature gradients

(*b*) molecular energy interaction

(*c*) flow of electrons in a random fashion

(*d*) intense stirring by an external agency.

300. Which of the following is a *wrong* statement with respect to the Fourier's heat conduction equation?

(*a*) Fourier law is valid for all matter regardless of its state.

(*b*) Fourier law is a vector expression indicating heat flow in the direction of decreasing temperature.

(*c*) Fourier law can be derived from first principles.

(*d*) Fourier law helps to define thermal conductivity of the heat conducting medium.

301. Solar radiation is mainly scattered or transmitted but not absorbed by the atmosphere. This characteristic manifests because

(*a*) solar radiation is mainly in the visible spectrum for which the atmosphere has very low absorptivity

(*b*) solar radiation is very intense

(*c*) most of solar radiation is scattered and little remains for absorption

(*d*) atmospheric air has a very small density.

302. Choose the *false* statement :

(*a*) Snow is nearly black to thermal radiation.

(*b*) Absorption of radiation occurs in a very thin layer of material near the surface.

(*c*) Transmissivity varies with wavelength of incident radiation, *i.e.*, a material may be non-transport for a certain wavelength band and transparent for another.

(*d*) Most of the engineering materials have rough surfaces, and these rough surfaces give regular (specular) reflections.

303. The normal automobile radiator is a heat exchanger of the type

(*a*) direct contact (*b*) parallel-flow

(*c*) counter-flow (*d*) cross-flow.

304. Saturated steam is allowed to condense over a vertical flat surface and the condensate film flows down the surface. The local coefficient of heat transfer for condensation

(*a*) remains constant at all heights of the surface

(*b*) decreases with increasing distance from the top of the suface

(*c*) increases with increasing thickness of condensate film

(*d*) increases with increasing temperature differential between the surface and vapour.

305. Which dimensionless number has a significant role in forced convection ?

(*a*) Prandtl number (*b*) Reynolds number

(*c*) Mach number (*d*) Peclet number.

306. Gases have poor

(*a*) absorptivity

(*b*) reflectivity

(*c*) transmissivity

(*d*) absorptivity as well as transmissivity.

307. Identify the very good insulator :

(*a*) Saw dust (*b*) Glass wool

(*c*) Cork (*d*) Asbestos sheet.

308. A fin protrudes from a surface which is held at a temperature higher than that of its environments. The heat transferred away from the fin is

(*a*) heat escaping from the tip of the fin

(*b*) heat conducted along the fin length

(*c*) convective heat transfer from the fin surface

(*d*) sum of heat conducted along the fin length and that convected from the surface.

309. For an absolutely white or specular body.

(*a*) asborptivity $\alpha = 1$, reflectivity $\rho = 0$ and transmissivity $\tau = 0$

(*b*) $\rho = 1$ and $\alpha = \tau = 0$

(*c*) $\tau = 1$ and $\alpha = \rho = 0$

(*d*) $\alpha + \rho = 1$ and $\tau = 0$

310. Cork is a good insulator because

(*a*) it is flexible and can be cast into rolls

(*b*) it can be powdered

(*c*) it is porous

(*d*) its density is low.

311. The free convection heat transfer is significantly affected by

(*a*) Reynolds number

(*b*) Grashoff number

(*c*) Prantdtl number

(*d*) Stanton number.

312. The material medium between the heat source and receiver is not affected during the process of heat transmission by

(*a*) conduction

(*b*) convection

(*c*) radiation

(*d*) conduction as well as convection.

313. Milk spills over when it is boiled in an open vessel. The boiling of milk at this instant is referred to as

(*a*) interface evaporation

(*b*) subcooled boiling

(*c*) film boiling

(*d*) saturated nucleate boiling.

314. Mark the system where in heat transfer is by forced convection :

(*a*) Chilling effect of cold wind on warm body

(*b*) Fluid passing through the tubes of a condenser and other heat exchanger equipment

(*c*) Heat flow from a hot pavement to surrounding atmosphere

(*d*) Heat exchanger on the outside of cold and warm pipes.

315. Notable examples of uniform generation of heat within the conducting medium are :

(*a*) Energy generated in the fuel element of a nuclear reactor.

(*b*) Liberation of energy due to some exothermic chemical reactions.

(*c*) Resistance heating in electrical appliances.

(*d*) All of the above.

316. The thermal conductivity k and the electrical conductivity of a metal at absolute temperature T are related as

(*a*) $\frac{k}{\sigma}$ = constant (*b*) $\frac{k}{\sigma T}$ = constant

(*c*) $\frac{k\sigma}{T}$ = constant (*d*) $\frac{kT}{\sigma}$ = constant.

317. Heat transmission is directly linked with the transport of medium itself, *i.e.*, there is actual motion of heated particles during

(*a*) conduction only

(*b*) convection only

(*c*) radiation only

(*d*) conduction as well as radiation.

318. Lumped parameter analysis of transient heat conduction in solids stipulates

(*a*) infinite thermal conductivity

(*b*) negligible temperature gradient, *i.e.*, practically uniform temperature within the solid

(*c*) small conduction resistance

(*d*) predominance of convective resistance

(*e*) all of the above.

319. For steady state and constant value of thermal conductivity, the temperature distribution associated with radial conduction through a cylinder has a

(*a*) linear

(*b*) logarithmic

(*c*) parabolic

(*d*) exponential variation.

320. The essential condition for the transfer of heat from one body to another is

(*a*) both bodies must be in physical contact

(*b*) heat content of one body must be more than that of the other

(*c*) one of the bodies must have a high value of thermal conductivity

(*d*) there must exist a temperature difference between the bodies.

321. For a perfectly black body

(*a*) absorptivity $\alpha = 1$, reflectivity $\rho = 0$ and transmissivity $\tau = 0$

(*b*) $\tau = 1$ and $\alpha = \tau = 0$

(*c*) $\tau = 1$ and $\alpha = \rho = 0$

(*d*) $\alpha + \tau = 1$ and $\rho = 0$

322. Identify the *wrong* statement :

(*a*) The process of heat transfer is thermodynamically an irreversible process.

(*b*) A material medium is always necessary for heat transmission.

(c) For heat exchange, a temperature gradient must exist.

(d) Heat flow is always from a higher temperature to a lower temperature in accordance with the second law of thermodynamics.

323. The ratio of the emissive power of a body to that of a black body at the same temperature, *i.e.*, emissivity is constant for all wavelengths. Such a body is called

(a) white (b) transparent
(c) grey (d) diathermanous.

324. The roof of a house has been given a coating of shining metallic paint. Consequently the temperature inside the room will

(a) fall
(b) rise
(c) remain unaffected
(d) cannot be decided as it depends on factors other than the type of paint.

325. The emissivity is likely to be higher in case of

(a) rubber (b) paper
(c) carbon (d) iron oxide.

326. A radiation shield should

(a) have high transmissivity
(b) absorb all the radiations
(c) have high reflective power
(d) partly absorb and partly transmit the incident radiation.

327. Thermal conductivity is defined as the heat flow per unit time

(a) when temperature gradient is unity
(b) when a unit temperature difference is maintained across the opposite faces of the wall
(c) through a unit thickness of the wall
(d) across unit area when temperature gradient is unity

328. A surface for which emissivity is constant at all temperatures and throughout the entire range of wavelength is called

(a) opaque (b) grey
(c) specular (d) diathermanous.

329. Indicate the metal with highest value of thermal conductivity

(a) Steel (b) Silver
(c) Copper (d) Aluminium.

330. The direction of heat transfer is in accordance with

(a) first law of thermodynamics
(b) second law of thermodynamics
(c) Faraday's law
(d) Stefan's law.

331. The emissivity of white polished body

(a) is lower than black body
(b) is higher than black body
(c) depends upon area of body
(d) same.

332. Planck's law is true for

(a) all coloured bodies
(b) black bodies only
(c) polished bodies
(d) bodies having equal conductivities.

333. In SI system, the unit of thermal diffusivity is

(a) kcal/m^2-sec^2; (b) kcal/m-sec;
(c) m-sec^2; (d) m^2-sec.

334. In SI system the unit of thermal conductivity is

(a) W/m-°C (b) W/m-hr-°C
(c) W/m^2-hr-°C (d) None of these.

335. Fourier's law of heat transfer is applicable for

(a) conduction only
(b) convection only
(c) both conduction and convection
(d) none of these.

336. Electrical analogy for heat transfer coefficient is

(a) resistance (b) inductance
(c) unit conductance (d) none of these.

337. 'Peclet number' used in laminar flow heat transfer coefficients is the product of

(a) Prandtl number and Grashoff number
(b) Reynolds number and Prandtl number
(c) Reynolds number and Grashoff number
(d) none of these.

338. Fourier number may be expressed as

(a) ratio of buoyancy to viscous force
(b) ratio of internal thermal resistance of a solid to the boundary layer thermal resistance
(c) ratio of gravitational and surface tension forces
(d) ratio of heat conduction rate to the rate of thermal energy storage in solid.

339. In a two-fluid heat exchanger, the inlet and outlet temperatures of the hot fluid are 65°C and 40°C respectively. For the cold fluid, these are 15°C and 42°C. The heat exchanger is a

(a) parallel flow heat exchanger;
(b) counter flow heat exchanger;

(c) heat exchanger device where both parallel flow and counter flow operations are possible;

(d) none of the above.

340. randtl number of a flowing fluid less than unity indicates

(a) thermal boundary layer thickness is greater than hydrodynamic boundary layer thickness

(b) hydrodynamic boundary layer thickness is greater than thermal boundary layer thickness;

(c) hydrodynamic and thermal boundary layer thickness are same;

(d) none of the above.

341. Loss of heat from unlagged steam pipe to the ambient air is by

(a) conduction (b) convection

(c) radiation (d) all (a), (b), (c).

342. Thermal diffusivity is given by

(a) $\frac{k}{\rho c_p}$ (b) $\frac{\rho}{k c_p}$

(c) $\frac{\mu}{k c_p}$ (d) none of these.

343. Which of the following has the highest thermal conductivity ?

(a) Air (b) Water

(c) Silver (d) Brick.

344. Reynolds analogy states that

(a) $St = \frac{f}{2}$ (b) $St = \frac{f}{4}$

(c) $St = 4f$ (d) $St = \sqrt{f}$.

where, S_t = Stanton number, f = friction factor in the Fanning equation.

345. Economy of an evaporator is influenced by

(a) steam pressure

(b) temperature of the feed and number of effects

(c) either of the above

(d) none of the above.

346. Prandtl number is the ratio of

(a) momentum diffusivity to mass diffusivity

(b) momentum diffusivity to thermal diffusivity

(c) none of these.

347. Wavelength corresponding to the maximum energy is inversely proportional to the absolute temperature. This is

(a) Stefan's law (b) Kirchhoff's law

(c) Wien's law (d) none of these.

348. Correction is applied to *LMTD* for

(a) parallel flow (b) counter flow

(c) cross-flow (d) none of these.

349. A body is called grey if the monochromatic emissivity of the body is

(a) 0

(b) 1

(c) same for all wavelengths

(d) different for all wavelengths.

350. Heat transfer coefficient in transition region between laminar and turbulent

(a) can be determined by Colburn factor (J_H) *vs* Reynold's number plot

(b) can be determined by $Nu = 0.023\ Re\ 0.8\ Pr^{1/3}$

(c) cannot be determined by any method

(d) any of the above.

351. The velocity and temperature distribution in a pipe flow are given by $u(r)$ and $T(r)$. If u_m is the mean velocity at any section of the pipe, the bulk-mean temperature at that section is

(a) $\int_0^{r_0} u(r)\, T(r)\, r^2\, dr$

(b) $\int_0^{r_0} \frac{u(r)}{3r} \cdot \frac{T(r)}{2r}\, dr$

(c) $\frac{4 \int_0^{r_0} u(r)\, T(r)\, dr}{2\pi r_0^3}$

(d) $\frac{2}{u_m\, r_0^2} \int_0^{r_0} u(r)\, T(r)\, r\, dr$.

352. The units of thermal resistance are

(a) $\frac{m^2 °C}{W}$ (b) $\frac{m^2}{W}$

(c) $\frac{m °C}{W}$ (d) none of these.

353. The conductivity of glass wool varies from sample to sample because of variation in

(a) composition (b) structure

(c) porosity (d) all of the above.

354. The time constant of a thermocouple is

(a) time taken to attain 50% of initial temp. difference

(b) time taken to attain 99% of initial temp. difference

(c) time taken to attain 36.8% of initial temp. difference

(d) not defined.

355. Thermal diffusivity is

(a) $\frac{\rho c_p}{k}$ (b) $\frac{k}{\rho c_p}$

(c) $\frac{\rho k}{c_p}$ (d) $\frac{c_p}{\rho k}$.

356. For heating of a flat plate the hydrodynamic boundary layer is thinner than thermal boundary layer. The value of Prandtl number is

(a) greater than one
(b) less than one
(c) equal to one
(d) can be less than or greater than one depending upon the value of Reynolds number.

357. Nusselt number is

(a) a dimensionless temperature gradient
(b) the ratio of two temperature gradients
(c) none of the above two
(d) both of the above two, *i.e.*, (a) and (b).

358. Stanton number is equal to

(a) $Re \,.\, Pr$ (b) $Gr \,.\, Pr$

(c) $\frac{Re}{Pr}$ (d) $\frac{Nu}{Re \,.Pr}$.

359. The total emissive power E of a diffuse surface is related to radiation intensity I as, E equal to

(a) $\frac{\pi}{4} I$ (b) π I

(c) $\pi^2 I$ (d) $4\pi I$.

360. The absorptivity of a whitewashed wall is close to

(a) 0.1 (b) 0.3

(c) 0.5 (d) 0.9.

361. The rate of heat transfer is constant if

(a) temperature decreases with time
(b) temperature increases with time
(c) temperature is constant
(d) none of the above.

362. Fourier's law is based on assumption that

(a) heat flow is one-dimensional
(b) heat flow is steady
(c) both (a) and (b)
(d) none of the above.

363. The term $\frac{\Delta x}{kA}$ in the equation

$$Q = kA \frac{t_1 - t_2}{\Delta x}$$ is known as :

(a) thermal resistance
(b) thermal conductance
(c) thermal loading
(d) none of the above.

364. Critical radius of a hollow cylinder is defined as:

(a) inner radius which would give maximum heat flow
(b) outer radius which would give minimum heat flow
(c) outer radius which would give maximum heat flow
(d) none of the above.

365. The average temperature difference between the two fluids in case of counterflow heat exchanger as compared to parallel flow heat exchange is :

(a) more (b) less

(c) same (d) none of the above.

NUMERICAL QUESTIONS

*366. The inner surface of a plane brick wall is at 50°C and the outer surface is at 25°C. Calculate the rate of heat transfer per m^2 of the surface area of the wall, which is 220 mm thick. The thermal conductivity of the bricks is 0.51 W/m K.

(a) 20.65 W/m^2 (b) 32.75 W/m^2

(c) 47.62 W/m^2 (d) 57.95 W/m^2.

*367. A mild steel tank of wall thickness 12 mm contains water at 100°C. Calculate the rate of heat loss per m^2 of tank surface area when the atmospheric temperature is 20°C. The thermal conductivity of mild steel is 50 W/m K, and the heat transfer coefficients for the inside and outside the tank are 2850 and 10 W/m^2 K, respectively. Calculate also the temperature of the outside surface of the tank.

(a) 300.5 W/m^2, 45.5°C
(b) 495.2 W/m^2, 67.6°C
(c) 602.6 W/m^2, 80.6°C
(d) 795.2 W/m^2, 99.52°C.

*368. A spherical shaped vessel of 1.4 m diameter is 90 mm thick. Find the rate of heat leakage, if the temperature difference between the inner and outer surfaces is 220°C. Thermal conductivity of the material of the sphere is 0.083 W/mK.

(a) 0.2 kW (b) 0.5 kW

(c) 1.0886 kW (d) 1.6 kW.

*369. Liquid air at –147°C is stored in the space of two concentric spheres of 0.2 m and 0.3 m diameters. The surface emissivities are 0.028. Assume the outer surface temperature is 25°C. Considering only radiation heat transfer and taking the latent heat of liquid air of 210 kJ/kg, find the rate of evaporation.

Take $\sigma = 204 \times 10^{-4}$ kJ/h-m^2-K^4

(*a*) 16.25 kg/h (*b*) 18.22 hg/h

(*c*) 23.25 kg/h (*d*) 30.65 kg/h.

*370. A body at 1000°C in black surroundings at 500°C has an emissivity of 0.42 at 1000°C and an emissivity of 0.72 at 500°C. Calculate the rate of heat loss by radiation per m^2.

(*i*) When the body is assumed to be grey with $\varepsilon = 0.42$

(*ii*) When the body is not grey.

Assume that the absorptivity is independent of the surface temperature.

(*a*) 20.6 kW, 18.5 kW

(*b*) 32.6 kW, 28.5 kW

(*c*) 54.893 kW, 47.962 kW

(*d*) 68.96 kW, 52.9 kW.

B. MATCH LIST I WITH LIST II AND SELECT CORRECT ANSWER USING THE CODES GIVEN BELOW THE LISTS:

371.

	List I		List II
A.	Non-isotropic thermal conductivity is exhibited in case of	1.	molecular
B.	Conduction is the transmission of heat by ..... collision.	2.	four
C.	The thermal conductivity of ice is nearly ..... times the thermal conductivity of water.	3.	porous
D.	Cork is a good insulator because it is	4.	wood.

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

372.

	List I		List II
A.	The process of heat transfer during entry of satellites and missiles, at very high speeds, into earth's surface is known as	1.	Prevost theory
B.	Radiation heat transfer between two surfaces can be reduced by introducing ..... between the surfaces.	2.	ablation
C.	Gases have poor	3.	radiation shield
D.	All bodies above absolute zero emit radiations. This statement is based on ..... of heat exchange.	4.	reflectivity.

Codes:

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

373.

	List I		List II
A.	A body which absorbs heat radiations of all wavelengths falling on it, is called	1.	emisivity
B.	..... is the ratio of emissive power of a body to the emissive power of a perfectly black body	2.	black body
C.	..... is the ratio of thermal conductivity to the equivalent thickness of the film of fluid	3.	absorptive power
D.	Ratio of energy absorbed by a body to the total energy falling on it is	4.	film coefficient.

Codes:

	A	B	C	D
(*a*)	2	1	4	3
(*b*)	1	2	3	4
(*c*)	3	4	2	1
(*d*)	4	2	3	1.

374.

	List I		List II
A.	Radiation heat transfer	1.	Wien displacement law
B.	Conduction heat transfer	2.	Fourier number
C.	Forced convection	3.	Fourier law
D.	Transient heat flow	4.	Stanton number.

Codes:

	A	B	C	D
(*a*)	4	3	1	2
(*b*)	3	4	2	1
(*c*)	1	3	4	2
(*d*)	4	2	1	3.

375.

	List I		List II
A.	Free convection	1.	$\frac{hd}{k}$
B.	Nusselt number	2.	$\frac{2k}{h_o}$
C.	Thermal diffusivity	3.	$\frac{k}{\rho c_p}$
D.	Critical radius of insulation	4.	Grashoff number.

Codes:

	A	B	C	D
(*a*)	1	2	3	4
(*b*)	4	1	3	2
(*c*)	2	3	4	1
(*d*)	4	2	3	1.

376.

	List I		List II
A.	LMTD correction is applied in case of ..... heat exchanger.	1.	highly polished
B.	Dropwise condensation occurs on ..... surfaces.	2.	cross flow
C.	Grashoff number has significant role in heat transfer by	3.	liquid metals
D.	Least value of Prandtl number can be expected in case of	4.	free convection.

Codes:

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

COMPETITIVE EXAMINATIONS QUESTIONS–U.P.S.C. (WITH SOLUTIONS – COMMENTS)

377. Upto the critical radius of insulation
(*a*) added insulation will increase heat loss (*b*) added insulation will decrease heat loss
(*c*) convection heat loss will be less than conduction heat loss
(*d*) heat flux will decrease.

*378. A designer chooses the values of fluid flow ranges and specific heats in such a manner that the heat capacities of the two fluids are equal. A hot fluid enters the counterflow heat exchanger at 100°C and leaves at 60°C. The cold fluid enters the heat exchanger at 40°C. The mean temperature difference between the two fluids is:
(*a*) (100 + 60 + 40)/3°C
(*b*) 60°C
(*b*) 40°C
(*d*) 20°C.

*379. For infinite parallel planes with emissivities, e_1 and e_2, the interchange factor for radiation from surface 1 to surface 2 is given by

(*a*) $\frac{\varepsilon_1 \varepsilon_2}{\varepsilon_1 + \varepsilon_2 - \varepsilon_1 \varepsilon_2}$ (*b*) $\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2}$
(*c*) $\varepsilon_1 + \varepsilon_2$ (*d*) $\varepsilon_1 \varepsilon_2$.

*380. A furnace is made of a red brick wall of thickness 0.5 m and conductivity 0.7 W/mK. For the same heat loss and temperature drop, this can be replaced by a layer of diatomite earth of conductivity 0.14 W/mK and thickness
(*a*) 0.05 m (*b*) 0.1 m
(*c*) 0.2 m (*d*) 0.5 m.

381. The thicknesses of thermal and hydrodynamic boundary layers are equal if (*Pr* = Prandtl Number, *Nu* = Nusselt Number)
(*a*) $Pr = 1$ (*b*) $Pr > 1$
(*c*) $Pr < 1$ (*d*) $Pr = Nu$.

382. A heat exchanger with heat transfer surface area *A* and overall heat transfer coefficient *U* handles two fluids of heat capacities C_{max} and C_{min}. The parameter NTU (number of transfer units) used in the analysis of heat exchanger is specified as

(*a*) $\frac{A C_{min}}{U}$ (*b*) $\frac{U}{A C_{min}}$
(*c*) AUC_{min} (*d*) $\frac{AU}{C_{min}}$

383. ε-NTU method is particularly useful in thermal design of heat exchangers when
(*a*) the outlet temperature of the fluid streams is not known as a priori
(*b*) outlet temperature of the fluid streams is known as a priori
(*c*) the outlet temperature of the hot fluid streams is known but that of the cold fluid streams is not known as a priori
(*d*) inlet temperatures of the fluid streams are known as a priori.

384. Thermal boundary layer is a region where
(*a*) inertia terms are of the same order of magnitude as convection terms
(*b*) convection terms are of the same order of magnitude as dissipation terms
(*c*) convection terms are of the same order of magnitude as conduction terms
(*d*) dissipation is negligible.

385. For evaporators and condensers, for the given conditions, the logarthmic mean temperature difference (LMTD) for parallel flow is
(*a*) equal to that for counterflow
(*b*) greater than that for counterflow
(*c*) smaller than that for counterflow counterflow.
(*d*) very much smaller than that for

386. A thin flat plate 2 m by 2 m is hanging freely in air. The temperature of the surroundings is 25°C. Solar radiation is falling on one side of the plate at the rate of 500 W/m^2. The temperature of the plate will remain constant at 30°C, if the convective heat transfer coefficient (in W/m^2°C) is
(*a*) 25 (*b*) 50
(*c*) 100 (*d*) 200.

*387. A composite slab has two layers of different materials with thermal conductivity k_1 and k_2. If each layer had the same thickness, the equivalent thermal conductivity of the slab would be
(*a*) $k_1 + k_2$ (*b*) $\dfrac{(k_1 + k_2)}{(k_1 k_2)}$
(*c*) $\dfrac{(2 k_1 k_2)}{(k_1 + k_2)}$ (*d*) $k_1 k_2$.

*388. Which one of the following modes of heat transfer would take place predominantly, from boiler furnace to water wall ?
(*a*) Convection
(*b*) Conduction
(*c*) Radiation
(*d*) Conduction and convection.

*389. Given the following data:
Inside heat transfer coeficient = 25 W/m^{2}K
Outside heat transfer coefficient = 25 W/m^{2}K
Thermal conductivity of bricks (15 cm thick) = 0.15 W/mK,
The overall heat transfer coefficient (in W/m^{2}K) will be closer to the
(*a*) inverse of heat transfer coefficient
(*b*) heat transfer coefficient
(*c*) thermal conductivity of bricks
(*d*) heat transfer coefficient based on the thermal conductivity of the bricks alone.

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

	List I (*Dimensionless quantity*)		**List II** (*Application*)
A.	Stanton number	1.	Natural convection for ideal gases
B.	Grashoff number	2.	Mass transfer
C.	Peclet number	3.	Forced convection
D.	Schmidt number	4.	Forced convection for small Prandtl number.

Codes:

	A	*B*	*C*	*D*
(*a*)	2	4	3	1
(*b*)	3	1	4	2
(*c*)	3	4	1	2
(*d*)	2	1	3	4.

391. The burnout heat flux in the nucleate boiling regime is a function of which of the following properties?

1. Heat of evaporation
2. Temperature difference
3. Density of vapour
4. Density of liquid
5. Vapour-liquid surface tension.

Select the corrct answer using the codes given below:

Codes:

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

*392. Which of the following are the reasons for the volumetric efficiency of reciprocating compressor being less than 100% ?

1. Deviations from isentropic process
2. Pressure drop across the valves
3. Superheating in compressor
4. Cearance volume
5. Deviations from isothermal process
6. Leakages.

Select the correct answer from the codes given below:

Codes:

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

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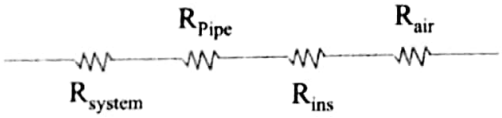
*393. It is desired to increase the heat dissipation rate over the surface of an electronic device of spherical shape of 5 mm radius exposed to convection with $h = 10\ W/m^2K$ by encasing it in a spherical sheath of conductivity 0.04 W/m K. For maximum heat flow, the diameter of the sheath should be

(*a*) 18 mm (*b*) 16 mm
(*c*) 12 mm (*d*) 8 mm.

395. A pipe carrying saturated steam is covered with a layer of insulation and exposed to ambient air. The thermal resistances are as shown in the following figure :



Which one of the following statements is *correct* in this regard ?

(*a*) R_{steam} and R_{pipe} are negligible as compared to R_{ins} and R_{air}
(*b*) R_{pipe} and R_{air} are negligible as compared to R_{ins} and R_{steam}
(*c*) R_{steam} and R_{air} are negligible as compared to R_{pipe} and R_{ins}
(*d*) No quantitative data is provided, therefore no comparison is possible.

395. Which one of the following statements is *correct*?

(*a*) Laminar flow is greater than that for turbulent flow
(*b*) Turbulent flow is greater than that for laminar flow
(*c*) Laminar flow is equal to that for turbulent flow
(*d*) A given flow can be determined only if the Prandtl number is known.

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

List I		List II
A.	Reynolds number	1. Film coefficient, pipe diameter, thermal conductivity
B.	Prandtl number	2. Flow velocity, acoustic velocity
C.	Nusselt number	3. Heat capacity, dynamic viscosity, thermal conductivity
D.	Match number	4. Flow velocity, pipe diameter, kinematic viscosity

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

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

List I	List II
A. Window glass	1. Emissivity independent of wavelength
B. Grey surface	2. Emission and absorption limited of wavelength
C. Carbon dioxide	3. Rate at which radiation leaves a surface
D. Radiosity	4. Transparency to shortwave radiation.

Codes:

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

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

List I	List II
A. Momentum transfer	1. Thermal diffusivity
B. Mass transfer	2. Kinematic viscosity
C. Heat transfer	3. Diffusion coefficient.

Codes:

	A	*B*	*C*
(*a*)	2	3	1
(*b*)	1	3	2
(*c*)	3	2	1
(*d*)	1	2	3.

399. A counterflow heat exchanger is used to heat water from 20°C to 80°C by using hot exhaust gas entering at 140°C and leaving at 80°C. The log mean temperature difference for the heat exchanger is

(*a*) 80°C
(*b*) 60°C
(*c*) 110°C
(*d*) not determinable as zero/zero is involved.

400. A heat exchanger with transfer surface area A and overall heat transfer coefficient U handles two fluids of heat capacities C_1 and C_2 such that $C_1 > C_2$. The NTU of the heat exchanger is given by

(*a*) AU/C_2 (*b*) (*b*) $e^{-\left(\frac{AU}{C_2}\right)}$

(*c*) $e^{-(AU/C_1)}$ (*d*) AU/C_1.

401. Consider the following statements regarding condensation heat transfer :

1. For a single tube, horizontal position is preferred over vertical position for better heat transfer
2. Heat transfer coefficient decreases if the vapour stream moves at high velocity
3. Condensation of steam on an oily surface is dropwise
4. Condensation of pure benzene vapour is always dropwise.

Of these statements
(*a*) 1 and 2 are correct
(*b*) 2 and 4 are correct
(*c*) 1 and 3 are correct
(*d*) 3 and 4 are correct.

402. Consider the following statements pertaining to heat transfer through fins :

1. Fins are equally effective irrespective of whether they are on the hot side or cold side of the fluid.
2. The temperature along the fin is variable and hence the rate of heat transfer varies along the elements of the fin.
3. The fins may be made of materials that have a higher thermal conductivity than the material of the wall.
4. Fins must be arranged at right angles to the direction of flow of the working fluid.

Of these statements :
(*a*) 1 and 2 are correct (*b*) 2 and 4 are correct
(*c*) 1 and 3 are correct (*d*) 2 and 3 are correct.

403. Consider the following statements :

1. Under certain conditions, an increase in thickness of insulation may increase the heat loss from a heated pipe.

2. The heat loss from a insulated pipe reaches a maximum when the outside radius insulation is equal to the ratio of thermal conductivity to the surface coefficient.
3. Small diameter tubes are invariably insulated.
4. Economic insulation is based on minimum heat loss from pipe.

Of these statements :

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

404. Addition of fin to the surface increases the heat transfer if $\sqrt{hA/kP}$ is

(*a*) equal to one
(*b*) greater than one
(*c*) less than one
(*d*) greater than one but less than two.

405. Consider the development of laminar boundary layer for a moving non-reacting fluid in contact with a flat plate of length '1' along the flow direction. The average value of heat transfer coefficient can be obtained by multiplying the local heat transfer coefficient at the trailing edge by the factor

(*a*) 0.75 (*b*) 1.0
(*c*) 1.5 (*d*) 2.0.

406. A solid copper ball of mass 500 grams, when quenched in a water bath at 30°C cools from 530°C to 430°C in 10 seconds. What will be the temperature of the ball after the next 10 seconds?

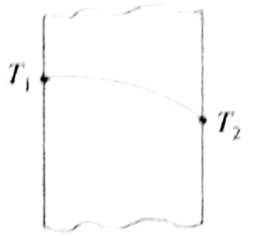
(*a*) 300°C
(*b*) 320°C
(*c*) 350°C
(*d*) Not determinable for want of sufficient data.

407. A steam pipe is covered with two layers of insulating materials, with the better insulating material forming the outer part. If the two layers are interchanged, the heat conducted

(*a*) will decrease
(*b*) will increase
(*c*) will remain unaffected
(*d*) may increase or decrease depending upon the thickness of each layer.

408. In a large plate, the steady temperature distribution is as shown in the given figure. If no heat is generated in the plate, the thermal conductivity '*k*' will vary as (*T* is temperature and is a constant).

(*a*) $k_o(1 + aT)$ (*b*) $k_o(1 - aT)$
(*c*) $k_o + aT$ (*d*) $k_o - aT$



409. The time constant of a thermocouple is the time taken to attain

(*a*) the final value to be measured
(*b*) 50% of the value of the initial temperature difference
(*c*) 63.2% of the value of the initial temperature difference
(*d*) 98.8% of the value of the initial temperature difference.

410. When there is a flow of fluid over a flat plate of length 'L', the average heat transfer coefficient is given by (Nu_x = local Nusselt number; other symbols have the usual meaning).

(*a*) $\int_0^L h_x\,dx$ (*b*) $\frac{d}{dx}(h_x)$
(*c*) $\frac{1}{L}\int_0^L hx\,dx$ (*d*) $\frac{k}{L}\int_0^L Nu_x\,dx$.

411. When all the conditions are identical, in the case of flow through pipes with heat transfer, the velocity profiles will be identical for

(*a*) liquid heating and liquid cooling
(*b*) gas heating and gas cooling
(*c*) liquid heating and gas cooling
(*d*) heating and cooling of any fluid.

412. In the case of turbulent flow through a horizontal isothermal cylinder of diameter '*D*', free convection heat transfer coefficient from the cylinder will

(*a*) be independent of diameter
(*b*) vary as $D^{3/4}$
(*c*) vary as $D^{1/4}$
(*d*) vary as $D^{1/2}$.

***413.** Sun's surface at 5800 K emits radiation at a wavelength of 0.5 m. A furnace at 300°C will emit through a small opening, radiation at a wavelength of nearly

(*a*) 10 μ (*b*) 5 μ
(*c*) 0.25 μ (*d*) 0.025 μ.

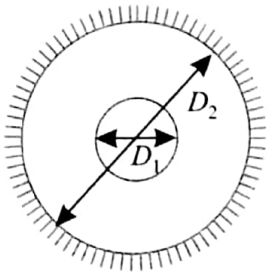
414. Consider the following statements :
If the surface is pock-marked with a number of cavities, then as compared to a smooth surface
1. radiation will increase
2. nucleate boiling will increase
3. conduction will increase
4. covection will increase.

Of these statements :
(*a*) 1, 2 and 3 are correct
(*b*) 1, 2, and 4 are correct
(*c*) 1, 3, and 4 are correct
(*d*) 2, 3, and 4 are correct.

415. Consider two infinitely long blackbody concentric cylinders with a diameter ratio $D_2/D_1 = 3$. The shape for the outer cylinder with itself will be
(*a*) 0 (*b*) 1/3
(*c*) 2/3 (*d*) 1.

416. Consider the following phenomena :
1. Boiling
2. Free convection in air
3. Forced convection
4. Conduction in air.

Their correct sequence in increasing order of heat transfer coefficient is :
(*a*) 4, 2, 3, 1 (*b*) 4, 1, 3, 2
(*c*) 4, 3, 2, 1 (*d*) 3, 4, 1, 2.



417. A thermocouple in a thermowell measures the temperature of hot gas flowing through the pipe. For the most accurate measurement of temperature, the thermowell should be made of
(*a*) steel (*b*) brass (*c*) copper (*d*) aluminium.

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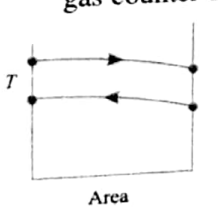
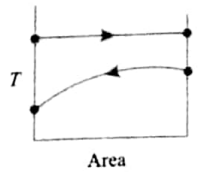
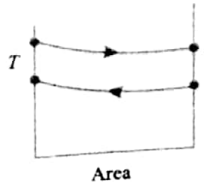
418. Consider the following statements :
The flow configuration in a heat exchanger, whether counterflow or otherwise, will NOT matter if
1. a liquid is evaporating
2. a vapour is condensing
3. mass flow rate of one of the fluids is far greater.

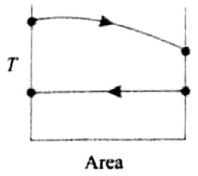
Of these statements :
(*a*) 1 and 2 are correct
(*b*) 1 and 3 are correct
(*c*) 2 and 3 are correct
(*d*) 1, 2 and 3 are correct.

419. Which one of the following diagrams correctly shows the temperature distribution for a gas-to-gas counter-flow heat exchanger ?





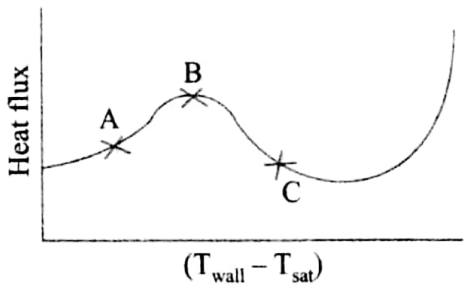




420. Consider the following statements :
The effect of fouling in a water-cooled steam condensers is that it
1. reduces the heat transfer coefficient of water.
2. reduces the overall heat transfer coefficient.
3. reduces the area available for heat transfer.
4. increases the pressure drop of water.

Of these statements :
(*a*) 1, 2 and 4 are correct
(*b*) 2, 3 and 4 are correct
(*c*) 2 and 4 are correct
(*d*) 1 and 3 are correct.

421. The given figure shows a pool-boiling curve. Consider the following statements in this regard:
1. Onset of nucleation causes a marked change in slope.
2. At the point *B*, heat transfer coefficient is the maximum.



3. In an electrically heated wire submerged in the liquid, film heating is difficult to achieve.
4. Beyond the point C, radiation becomes significant.

Of these statements :

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

422. A composite wall consists of two layers of different materials having conductivities k_1 and k_2. For equal thickness of the two layers, the equivalent thermal conductivity of the slab will be

(*a*) $k_1 + k_2$ (*b*) $k_1 k_2$

(*c*) $\frac{2k_1 k_2}{k_1 + k_2}$ (*d*) $\frac{k_1 + k_2}{k_1 k_2}$

ESE-1998

423. Consider the following statements : The Fourier heat conduction equation $Q = -kA\frac{dt}{dx}$ presumes

1. steady-state conditions.
2. constant value of thermal conductivity.
3. uniform temperatures at the wall surfaces.
4. one-dimensional heat flow.

Of these statements :

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

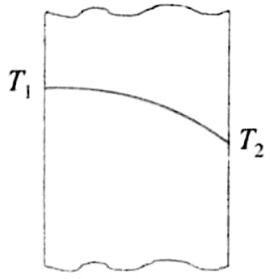
424. The temperature variation in a large plate, as shown in the figure, would correspond to which of the following condition(s)?

1. Unsteady heat.
2. Steady-state with variation of k.
3. Steady-state with heat generation.

Select the correct answer using the codes given below :

Codes :

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



425. In a long cylindrical rod of radius R and a surface heat flux of q_o, the uniform internal heat generation rate is

(*a*) $2q_o/R$ (*b*) $2q_o$
(*c*) q_o/R (*d*) q_o/R^2.

426. Boundary layer is defined as

(*a*) a thin layer at the surface where gradients of both velocity and temperature are small
(*b*) a thin layer at the surface where velocity and velocity gradients are large
(*c*) a thick layer at the surface where velocity and temperature gradients are large
(*d*) a thin layer at the surface where gradients of both velocity and temperature are large.

427. A large spherical enclosure has a small opening. The rate of emission of radiative flux through this opening is 7.35 kW/m^2. The temperature at the inner surface of the sphere will be about (assume Stefan Boltzmann constant, s = 5.67×10^{-8} W/m^2 K^4)

(*a*) 600°C (*b*) 330°C
(*c*) 373 K (*d*) 1000 K.

428. Consider the following statements :

1. For metals, the value of absorptivity is high.
2. For non-conducting materials, reflectivity is low.
3. For polished surfaces, reflectivity is high.
4. For gases, reflectivity is very low.

Of these statements :

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

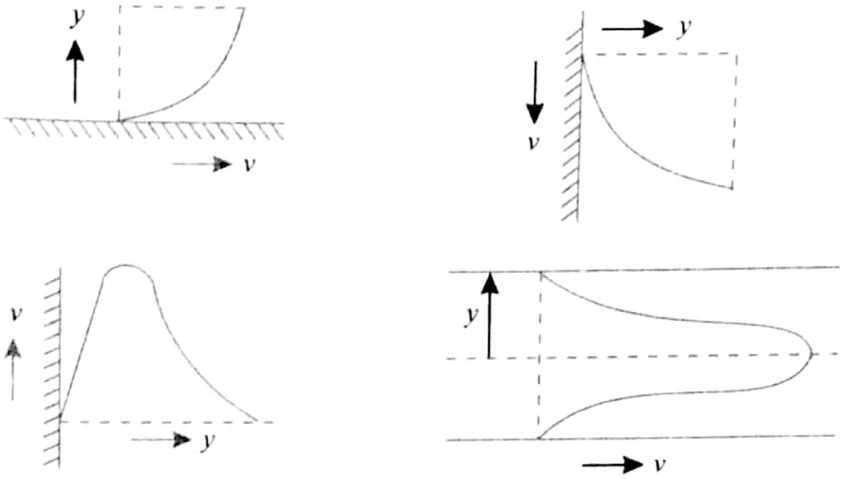
429. On a summer day, a scooter rider feels more comfortable while on the move than while at a stop light because

(*a*) an object in motion captures less solar radiation
(*b*) air is transparent to radiation and hence it is cooler than the body
(*c*) more heat is lost by convection and radiation while in motion
(*d*) air has a low specific heat and hence it is cooler.

430. Match the velocity profiles labelled A, B, C and D with the following situations :

1. Natural convection
2. Condensation

3. Forced convection
4. Bulk viscosity wall viscosity.
5. Flow in pipe entrance.



Select the correct answer using the codes given below :

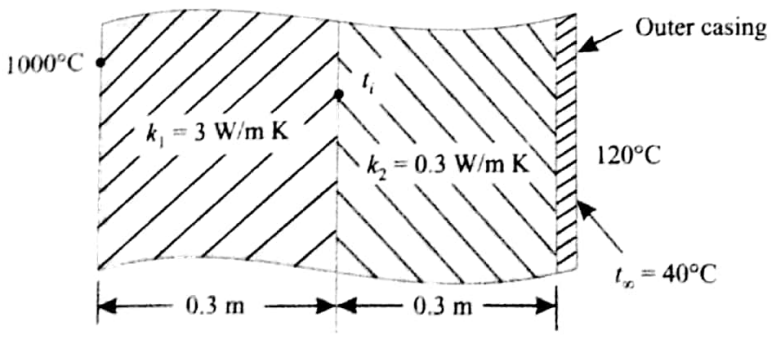
Codes:	A	B	C	D
(*a*)	3	2	1	5
(*b*)	1	4	2	3
(*c*)	3	2	1	4
(*d*)	2	1	5	3.

431. Heat is mainly transferred by conduction, convection and radiation in
(*a*) insulated pipes carrying hot water
(*b*) refrigerator freezer coil
(*c*) boiler furnaces
(*d*) condensation of steam in a condenser.

432. Consider the following statements :
1. If a condensing liquid does not wet a surface dropwise, then condensation will take place on it.
2. Dropwise condensation gives a higher heat transfer rate than film-wise condensation.
3. Reynolds number of condensing liquid is based on its mass flow rate.
4. Suitable coating or vapour additive is used to promote film-wise condensation.

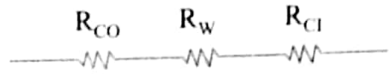
Of these statements :
(*a*) 1 and 2 are correct
(*b*) 2, 3 and 4 are correct
(*c*) 4 alone is correct
(*d*) 1, 2 and 3 are correct.

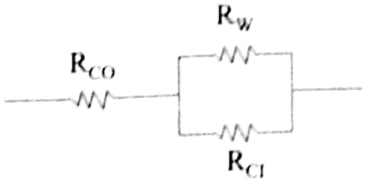
433. A furnace wall is constructed as shown in the figure. The interface temperature t_i will be
(*a*) 5600°C
(*b*) 200°C
(*c*) 920°C
(*d*) 1120°C

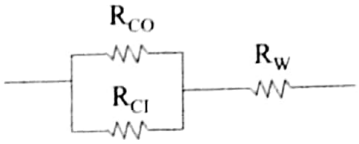


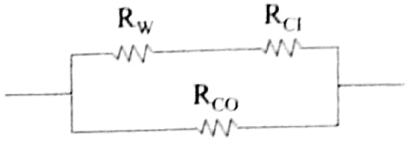
434. Solar energy is absorbed by the wall of a building as shown in the figure. Assuming that the ambient temperature inside and outside are equal and considering steady-state, the equivalent circuit will be as shown in the figure (a, b, c, d).

(symbols : $R_{CO} = R_{convection,\ outside}$, $R_{CI} = R_{convection,\ inside}$ and $R_w = R_{wall}$)

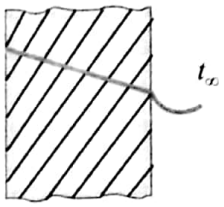
(a) 

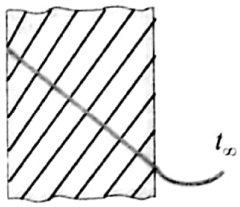
(b) 

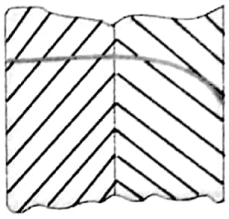
(c) 

(d) 

435. Temperature profiles for four cases are shown in the following figures and are labelled A, B, C and D. Match the above figures with :

(A) 

(B) 

(C) 

(D) 

1. High conductivity fluid.
2. Low conductivity fluid.
3. Insulating body.
4. Guard heater.

Select the correct answer using the codes given below :

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

ESE–1999

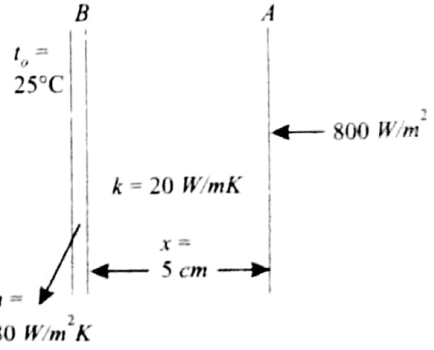
436. The heat flow equation through a cylinder of inner radius 'r_1' and outer radius 'r_2' is desired in the same form as that for heat flow through a plane wall. The equivalent area A_m is given by:

(a) $\dfrac{A_1 + A_2}{\log_e\left(\dfrac{A_2}{A_1}\right)}$ (b) $\dfrac{A_1 + A_2}{2\log_e\left(\dfrac{A_2}{A_1}\right)}$

(c) $\dfrac{A_2 - A_1}{2\log_e\left(\dfrac{A_2}{A_1}\right)}$ (d) $\dfrac{A_2 - A_1}{\log_e\left(\dfrac{A_2}{A_1}\right)}$.

*437. A steel plate of thickness 5 cm and thermal conductivity 20 W/mK is subjected to a uniform heat flux of 800 W/m^2 on one surface 'A' and transfers heat by convection with a heat transfer co-efficient of 80 W/m^{2}K from the other surface 'B' into ambient air t_a of 25°C. The temperature of the surface 'B' transferring heat by convection is

(a) 25°C (b) 35°C
(c) 45°C (d) 55°C



438. The hydrodynamic boundary layer thickness is defined as the distance from the surface where the

(*a*) velocity equals the local external velocity
(*b*) velocity equals the approach velocity
(*c*) momentum equals 99% of the momentum of the free stream
(*d*) velocity equals 99% of the local external velocity.

*439. Heat is lost from a 100 mm diameter steam pipe placed horizontally in ambient at 30°C. If the Nusselt number is 25 and thermal conductivity of air is 0.03 W/mK, then the heat transfer coefficient will be

(*a*) 7.5 W/m^{2}K (*b*) 16.2 W/m^{2}K
(*c*) 25.2 W/m^2 K (*d*) 30 W/m^{2}K.

*440. If the temperature of a solid surface changes from 27°C to 627°C, then its emissive power will increase in the ratio of

(*a*) 3 (*b*) 9
(*c*) 27 (*d*) 81.

*441. A spherical aluminium shell of inside diameter 2 m is evacuated and used as a radiation test chamber. If the inner surface is coated with carbon black and maintained at 600 K, the irradiation on a small test surface placed inside the chamber is (Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4)

(*a*) 1000 W/m^2 (*b*) 3400 W/m^2
(*c*) 5680 W/m^2 (*d*) 7348 W/m^2.

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

List-I

A. Stefan-Boltzmann law
B. Newton's law of cooling
C. Fourier's law
D. Kirchoff's law

List-II

1. $q = hA\,(T_1 - T_2)$
2. $E = \alpha E_b$
3. $q = \dfrac{kA}{L}(T_1 - T_2)$
4. $q = \sigma A\,(T_1^4 - T_2^4)$
5. $q = kA\,(T_1 - T_2)$

Codes :

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

*443. A cross-flow type air-heater has an area of 50 m^2. The overall heat transfer coefficient is 100 W/m^{2}K and heat capacity of both hot and cold stream is 1000 W/K. The value of NTU is

(*a*) 1000 (*b*) 500
(*c*) 5 (*d*) 0.2.

444. Saturated steam is allowed to condense over a vertical flat surface and the condensate film flows down the surface. The local heat transfer coefficient for condensation

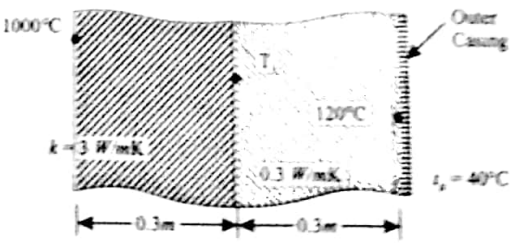
(*a*) remains constant at all locations of the surface
(*b*) decreases with increasing distance from the top of the surface
(*c*) increases with increasing thickness of condensate film
(*d*) increases with decreasing temperature differential between the surface and vapour.

445. A fin of length '*l*' protrudes from a surface held at temperature t_0 greater than the ambient temperature t_a. The heat dissipation from the free end of the fin is assumed to be negligible. The temperature gradient at the fin tip $\left(\dfrac{dt}{dx}\right)_{x=l}$ is

(*a*) zero (*b*) $\dfrac{t_l - t_a}{t_o - t_a}$
(*c*) $h\,(t_o - t_l)$ (*d*) $\dfrac{t_a - t_l}{l}$

*446. A furnace wall is constructed as shown in the given figure. The heat transfer coefficient across the outer casing will be

(*a*) 80 W/m^{2}K (*b*) 40 W/m^{2}K
(*c*) 20 W/m^{2}K (*d*) 10 W/m^{2}K.



*447. For laminar flow over a flat plate, the local heat transfer coefficient 'h_x' varies as $x^{-1/2}$, where x is the distance from the leading edge ($x = 0$) of the plate. The ratio of the average coefficient 'h_a' between the leading edge and some location 'A' at $x = x$ on the plate to the local heat transfer coefficient 'h_x' at A is

(a) 1 (b) 2
(c) 4 (d) 8

*448. A heat pump operating on Carnot cycle pumps heat from a reservior at 300 K to a reservior at 600 K. The coefficient of performance is

(a) 1.5 (b) 0.5
(c) 2 (d) 1

ESE–2000

449. Consider the following statements :

The reheat cycle helps to reduce

1. fuel consumption 2. steam flow
3. the condenser size

Which of these statements are *correct* ?

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

450. The outer surface of a long cylinder is maintained at constant temperature. The cylinder does not have any heat source.

The temperature in the cylinder will

(a) increase linearly with radius
(b) decreases linearly with radius
(c) be independent of radius
(d) vary logarithmically with radius.

451. A composite plane wall is made up of two different materials of the same thickness and having thermal conductivities of k_1 and k_2 respectively. The equivalent thermal conductivity of the slab is

(a) $k_1 + k_2$ (b) $k_1 k_2$
(c) $\dfrac{k_1 + k_2}{k_1 k_2}$ (d) $\dfrac{2k_1 k_2}{k_1 + k_2}$

452. A copper wire of radius 0.5 mm is insulated with a sheathing of thickness 1 mm having a thermal conductivity of 0.5 $W/m - K$. The outside surface convective heat transfer coefficient is 10 $W/m^2 - K$. If the thickness of insulation sheathing is raised by 10 mm, then the electrical current-varrying capacity of the wire will

(a) increase
(b) decrease
(c) remain the same
(d) vary depending upon the electrical conductivity of the wire.

453. For the fully developed laminar flow and heat transfer in a uniformly heated long circular tube, if the flow velocity is doubled and the tube diameter is halved, the heat transfer coefficient will be

(a) double of the original value
(b) half of the original value
(c) same as before
(d) four times of the original value

454. Heat transfer by radiation between two grey bodies of emissivity ε is proportional to (notations have their usual meanings)

(a) $\dfrac{(E_b - J)}{(1 - \varepsilon)}$ (b) $\dfrac{(E_b - J)}{(1 - \varepsilon)/\varepsilon}$
(c) $\dfrac{(E_b - J)}{(1 - \varepsilon)^2}$ (d) $\dfrac{(E_b - J)}{(1 - \varepsilon^2)}$

455. Solar radiation of 1200 W/m^2 falls perpendicularly on a grey opaque surface of emissivity 0.5. If the surface temperature is 50° C and surface emissive power 600 W/m^2, the radiosity of that surface will be

(a) 600 W/m^2 (b) 1000 W/m^2
(c) 1200 W/m^2 (d) 1800 W/m^2.

456. The overall heat transfer coefficient U for a plane composite wall of n layers is given by (the thickness of the ith layer is t_i, thermal conductivity of the ith layer is k_i, convective heat transfer coefficient is h)

(a) $\dfrac{1}{\dfrac{1}{h_1} + \sum_{i=1}^{n} \dfrac{t_i}{k_i} + \dfrac{1}{h_n}}$ (b) $h_1 + \sum_{i=1}^{n} \dfrac{t_i}{k_i} + h_n$

(c) $\dfrac{1}{h_1 + \sum_{i=1}^{n} \dfrac{t_i}{k_i} + h_n}$ (d) $\dfrac{1}{h_1} + \sum_{i=1}^{n} \dfrac{t_i}{k_i} + \dfrac{1}{h_n}$

457. The equation of effectiveness $\varepsilon = 1 - e^{-NTU}$ of a heat exchanger is valid (NTU is number of transfer units) in the case of

(a) boiler and condenser for parallel-flow
(b) boiler and condenser for counter-flow
(c) boiler and condenser for both parallel-flow and counter-flow
(d) gas turbine for both parallel flow and counter-flow.

458. Match List I with List II and select the correct answer using the codes given below the Lists (notations have their usual meanings) :

List I		List II	
A.	Fin	1.	$\frac{UA}{C_{min}}$
B.	Heat exchanger	2.	$\frac{x}{2\sqrt{\alpha\tau}}$
C.	Transient conduction	3.	$\sqrt{\frac{hP}{kA}}$
D.	Heisler chart	4.	hl/k

Codes :

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

459. The Nusselt number is related to Reynolds Number in laminar and turblent flows respectively as

(a) $Re^{-1/2}$ and $Re^{0.8}$ (b) $Re^{1/2}$ and $Re^{0.8}$ (c) $Re^{-1/2}$ and $Re^{-0.8}$ (d) $Re^{1/2}$ and $Re^{-0.8}$.

460. In respect of free convection over a vertical flat plate the Nusselt number varies with Grashoff number '*Gr*' as

(a) *Gr* and $Gr^{1/4}$ for laminar and turblent flows respectively

(b) $Gr^{1/2}$ and $Gr^{1/3}$ for laminar and turbulent flows respectively

(c) $Gr^{1/4}$ and $Gr^{1/3}$ for laminar and turbulent flows respectively

(d) $Gr^{1/3}$ and $Gr^{1/4}$ for laminar and turbulent flows respectively.

461. Consider the following conditions for heat transfer (thickness of thermal boundary layer is δ_t, velocity of boundary layer is d and Prandtl number is *Pr*) :

1. $\delta_t(x) = \delta(x)$ if $Pr = 1$
2. $\delta_t(x) >> \delta(x)$ if $Pr << 1$
3. $\delta_t(x) << \delta(x)$ if $Pr >> 1$

Which of these conditions apply for convective heat transfer?

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

ESE–2001

462. A plane wall of thickness $2L$ has a uniform volumetric heat source q^* (W/m^3). It is exposed to local ambinet temperature T_∞ at both the ends ($x = \pm L$). The surface temperature T_s of the wall under steady-state condition (where h and k have their usual meanings) is given by

(a) $T_s = T_\infty + \frac{q^* L}{h}$ (b) $T_s = T_\infty + \frac{q^* L^2}{2k}$

(c) $T_s = T_\infty + \frac{q^* L^2}{h}$ (d) $T_s = T_\infty + \frac{q^* L^3}{2k}$.

463. A flat plate has thickness 5 cm, thermal conductivity 1 W/(mK), convective heat transfer coefficients on its two flat faces of 10 W/(m^{2}K) and 20 W/(m^{2}K). The overall heat transfer co-efficient for such a flat plate is

(a) 5 W/(m^{2}K) (b) 6.33 W/(m^{2}K)
(c) 20 W/(m^{2}K) (d) 30 W/(m^{2}K).

464. The efficiency of a pin fin with insulated tip is

(a) $\frac{\tan h\, mL}{(hA/kP)^{0.5}}$ (b) $\frac{\tan h\, mL}{mL}$

(c) $\frac{mL}{\tan h\, mL}$ (d) $\frac{(hA/kP)^{0.5}}{\tan h\, mL}$.

465. A cylinder made of a metal of conductivity 40 W/(mK) is to be insulated with a material of conductivity 0.1 W/(mK). If the convective heat transfer coefficient with the ambient atmosphere is 5W/(m^{2}K), the critical radius of insulation is

(a) 2 cm (b) 4 cm
(c) 8 cm (d) 50 cm.

466. Nusselt number for fully developed turbulent flow in a pipe is given by $Nu = CRe^a Pr^b$. The values of *a* and *b* are

(*a*) $a = 0.5$ and $b = 0.33$ for heating and cooling both

(*b*) $a = 0.5$ and $b = 0.4$ for heating and $b = 0.3$ for cooling

(*c*) $a = 0.8$ and $b = 0.4$ for heating and $b = 0.3$ for cooling

(*d*) $a = 0.8$ and $b = 0.3$ for heating and $b = 0.4$ for cooling.

467. For natural convective flow over a vertical flat plate as shown in the given figure, the governing differential equation for momentum is

$$\left(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right) = g\beta\,(T - T_\infty) + \gamma\frac{\partial^2 u}{\partial y^2}$$

If equation is nondimentionalized by $U = \frac{u}{U_\infty}$,

$V = \frac{u}{U_\infty}$, $X = \frac{x}{L}$, $Y = \frac{y}{L}$ and $\theta = \frac{T - T_\infty}{T_s - T_\infty}$

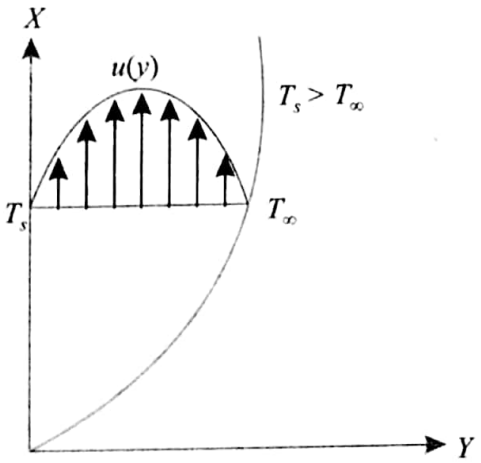
then the term $g\,\beta\,(T - T_\infty)$, is equal to

(*a*) Grashoff number

(*b*) Prandtl number

(*c*) Rayleigh number

(*d*) $\dfrac{\text{Grashof number}}{(\text{Reynolds number})^2}$



468. The shape factor of a hemispherical body placed on a flat surface with respect to itself is

(*a*) zero (*b*) 0.25

(*c*) 0.5 (*d*) 1.0.

469. Which one of the following heat exchangers gives parallel straight line pattern of temperature distribution for both cold and hot fluids ?

(*a*) Parallel-flow with unequal heat capacities

(*b*) Counter-flow with equal heat capacities

(*c*) Parallel-flow with equal heat capacities

(*d*) Counter-flow with unequal heat capacities.

470. In a counter-flow heat exchanger, the hot fluid is cooled from 110° C to 80° C by a cold fluid which gets heated from 30° C to 60° C. LMTD for the heat exchanger is

(*a*) 20° C (*b*) 30° C

(*c*) 50° C (*d*) 80° C.

471. In a counterflow heat exchanger, the product of specific heat and mass flow rate is same for the hot and cold fluids. If NTU is equal to 0.5, then the effectiveness of the heat exchanger is

(*a*) 1.0 (*b*) 0.5

(*c*) 0.33 (*d*) 0.2.

472. For flow over a flat plate the hydrodynamic boundary layer thickness is 0.5 mm. The dynamic viscosity is 25×10^{-6} Pa s, specific heat is 2.0 kJ/(kg K) and thermal conductivity is 0.05 W/(m-K). The thermal boundary layer thickness would be

(*a*) 0.1 mm (*b*) 0.5 mm

(*c*) 1 mm (*d*) 2 mm.

473. An enclosure conists of the four surfaces 1, 2, 3 and 4. The view factors for radiation heat transfer (where the subscripts 1, 2, 3, 4 refer to the respective surfaces) are $F_{11} = 0.1$, $F_{12} = 0.4$ and $F_{13} = 0.25$. The surface areas A_1 and A_4 are 4 m^2 and 2 m^2 respctively. The view factor F_{41} is

(*a*) 0.75 (*b*) 0.50

(*c*) 0.25 (*d*) 0.10.

ESE–2002

*474. A 0.5 m thick plane wall has its two surfaces kept at 300°C and 200°C. Thermal conductivity of the wall varies linearly with temperature and its values at 300°C and 200°C are 25 W/mK and 15 W/mK, respectively. Then the steady heat flux through the wall is

(*a*) 8 kW/m^2 (*b*) 5 kW/m^2

(*c*) 4 kW/m^2 (*d*) 3 kW/m^2.

*475. A 320 cm high vertical pipe at 150°C wall temperature is in a room with still air at 10°C. This pipe supplies heat at the rate of 8 kW into the room air by natural convection. Assuming laminar flow, the height of the pipe needed to supply 1 kW only is

(*a*) 10 cm (*b*) 20 cm

(*c*) 40 cm (*d*) 80 cm.

*476. The average Nusselt number in laminar natural convection from a vertical wall at 180°C with still air at 20°C is found to be 48. If the wall temperature becomes 30°C, all other parameters remaining same, the average Nusselt number will be

(*a*) 8 (*b*) 16

(*c*) 24 (*d*) 32.

*477. A fluid of thermal conductivity 1.0 W/m-K flows in fully developed flow with Reynolds number of 1500 through a pipe of diameter 10 cm. The heat transfer coefficient for uniform heat flux and uniform wall temperature boundary conditions are, respectively,

(*a*) 36.57 and 43.64 $\frac{W}{m^2K}$

(*b*) 43.64 and 36.57 $\frac{W}{m^2K}$

(*c*) 43.64 $\frac{W}{m^2K}$ for both the cases

(*d*) 36.57 $\frac{W}{m^2K}$ for both the cases.

*478. Two large parallel grey plates with a small gap, exchange radiation at the rate of 1000 W/m^2 when their emissivities are 0.5 each. By coating one plate, its emissivity is refuced to 0.25. Temperatures remain unchanged. The new rate of heat exchange shall become

(*a*) 500 W/m^2 (*b*) 600 W/m^2

(*c*) 700 W/m^2 (*d*) 800 W/m^2.

*479. Two long parallel plates of same emissivity 0.5 are maintained at different temperatures and have radiation heat exchange between them. The radiation shield of emissivity 0.25 placed in the middle will reduce radiation heat exchange to

(*a*) $\frac{1}{2}$ (*b*) $\frac{1}{4}$

(*c*) $\frac{3}{10}$ (*d*) $\frac{3}{5}$.

480. Match List-I (Type of radiation) with List-II (Characteristic) and select the correct answer using the codes given below the lists :

List I

(Type of radiation)

A. Black body

B. Grey body

C. Specular

D. Diffuse

List II

(Characteristic)

1. Emissivity does not depend on wavelength
2. Mirror like reflection
3. Zero reflectivity
4. Intensity same in all directions

Codes :

	A	B	C	D
(*a*)	2	1	3	4
(*c*)	2	4	3	1

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

481. Match List-I (Type of heat transfer) with List-II (Governing dimensionless parameter) and select the correct answer using the codes given below the lists :

List I

(Type of heat transfer)

A. Forced convection

B. Natural convection

C. Combined free and forced convection

D. Unsteady conduction with convection at surface

List II

(Governing dimensionless parameter)

1. Reynolds, Grashoff and Prandtl number
2. Reynolds and Prandtl number
3. Fourier modulus and Biot number
4. Prandtl number and Grashoff number

Codes :

	A	B	C	D
(*a*)	2	1	4	3
(*c*)	2	4	1	3

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

*482. The insulated tip temperature of a rectangular longitudinal fin having an excess (over ambient) root temperature of θ_o is

(a) $\theta_o \tanh (ml)$ (b) $\dfrac{\theta_o}{\sinh (ml)}$

(c) $\dfrac{\theta_o \tanh (ml)}{(ml)}$ (d) $\dfrac{\theta_o}{\cosh (ml)}$.

*483. Consider the following statements pertaining to large heat transfer rate using fins :

1. Fins should be used on the side where heat transfer coefficient is small.
2. Long and thick fins should be used.
3. Short and thin fins should be used.
4. Thermal conductivity of fin material should be large.

Which of the above statements are *correct* ?

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

484. Using thermal-electrical analogy in heat transfer, match List-I (Electrical quantities) with List-II (Thermal quantities) and select the correct answer using the codes given below the lists :

List I (*Electrical quantities*)		List II (*Thermal quantities*)	
A.	Voltage	1.	Thermal resistance
B.	Current	2.	Thermal capacity
C.	Resistance	3.	Heat flow
D.	Capacitance	4.	Temperature

Codes :

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

485. Pandtl number of a flowing fluid greater than unity indicates that hydrodynamic boundary layer thickness is

(a) greater than thermal boundary layer thickness
(b) equal to thermal boundary layer thickness
(c) greater than hydrodynamic boundary layer thickness
(d) independent of thermal boundary layer thickness.

ANSWERS

A. CHOOSE THE CORRECT ANSWER :

1. (b)	2. (a)	3. (d)	4. (a)	5. (c)
6. (a)	7. (a)	8. (a)	9. (a)	10. (c)
11. (b)	12. (e)	13. (a)	14. (d)	15. (d)
16. (a)	17. (c)	18. (d)	19. (d)	20. (b)
21. (b)	22. (d)	23. (e)	24. (d)	25. (c)
26. (a)	27. (d)	28. (a)	29. (c)	30. (b)
31. (b)	32. (c)	33. (d)	34. (c)	35. (a)
36. (c)	37. (b)	38. (b)	39. (a)	40. (b)
41. (b)	42. (a)	43. (d)	44. (b)	45. (d)

46. (a)	47. (b)	48. (b)	49. (c)	50. (b)
51. (c)	52. (a)	53. (b)	54. (b)	55. (c)
56. (c)	57. (b)	58. (c)	59. (b)	60. (c)
61. (a)	62. (e)	63. (a)	64. (d)	65. (b)
66. (c)	67. (a)	68. (d)	69. (d)	70. (a)
71. (d)	72. (a)	73. (d)	74. (a)	75. (c)
76. (a)	77. (a)	78. (c)	79. (a)	80. (d)
81. (a)	82. (a)	83. (c)	84. (b)	85. (a)
86. (c)	87. (c)	88. (a)	89. (c)	90. (a)
91. (d)	92. (d)	93. (d)	94. (b)	95. (d)
96. (d)	97. (b)	98. (d)	99. (c)	100. (c)
101. (a)	102. (d)	103. (a)	104. (b)	105. (c)
106. (d)	107. (a)	108. (b)	109. (a)	110. (d)
111. (d)	112. (a)	113. (d)	114. (b)	115. (a)
116. (c)	117. (d)	118. (d)	119. (a)	120. (b)
121. (c)	122. (b)	123. (b)	124. (c)	125. (b)
126. (c)	127. (c)	128. (b)	129. (a)	130. (c)
131. (b)	132. (a)	133. (b)	134. (b)	135. (d)
136. (c)	137. (c)	138. (c)	139. (d)	140. (c)
141. (a)	142. (a)	143. (b)	144. (d)	145. (b)
146. (a)	147. (c)	148. (b)	149. (e)	150. (a)
151. (d)	152. (b)	153. (c)	154. (a)	155. (b)
156. (c)	157. (c)	158. (a)	159. (c)	160. (a)
161. (a)	162. (c)	163. (b)	164. (c)	165. (b)
166. (c)	167. (e)	168. (b)	169. (c)	170. (b)
171. (c)	172. (a)	173. (d)	174. (a)	175. (d)
176. (d)	177. (c)	178. (b)	179. (d)	180. (d)
181. (c)	182. (a)	183. (d)	184. (b)	185. (c)
186. (c)	187. (b)	188. (b)	189. (b)	190. (a)
191. (a)	192. (b)	193. (b)	194. (d)	195. (a)
196. (d)	197. (a)	198. (a)	199. (b)	200. (d)
201. (b)	202. (d)	203. (d)	204. (a)	205. (b)
206. (a)	207. (d)	208. (a)	209. (d)	210. (d)
211. (c)	212. (d)	213. (d)	214. (c)	215. (b)
216. (b)	217. (c)	218. (a)	219. (d)	220. (a)
221. (a)	222. (c)	223. (b)	224. (d)	225. (c)

226. (*b*)	227. (*a*)	228. (*c*)	229. (*c*)	230. (*b*)
231. (*b*)	232. (*b*)	233. (*c*)	234. (*c*)	235. (*b*)
236. (*a*)	237. (*c*)	238. (*d*)	239. (*a*)	240. (*c*)
241. (*d*)	242. (*a*)	243. (*d*)	244. (*b*)	245. (*c*)
246. (*c*)	247. (*c*)	248. (*b*)	249. (*c*)	250. (*d*)
251. (*b*)	252. (*c*)	523. (*d*)	254. (*a*)	255. (*a*)
256. (*d*)	257. (*b*)	258. (*d*)	259. (*d*)	260. (*a*)
261. (*d*)	262. (*a*)	263. (*e*)	264. (*c*)	265. (*b*)
266. (*a*)	267. (*a*)	268. (*c*)	269. (*d*)	270. (*c*)
271. (*a*)	272. (*d*)	273. (*a*)	274. (*b*)	275. (*b*)
276. (*c*)	277. (*c*)	278. (*d*)	279. (*c*)	280. (*d*)
281. (*b*)	282. (*b*)	283. (*a*)	284. (*c*)	285. (*c*)
286. (*a*)	287. (*c*)	288. (*a*)	289. (*b*)	290. (*b*)
291. (*b*)	292. (*b*)	293. (*d*)	294. (*c*)	295. (*b*)
296. (*d*)	297. (*c*)	298. (*a*)	299. (*d*)	300. (*c*)
301. (*c*)	302. (*d*)	303. (*d*)	304. (*b*)	305. (*b*)
306. (*b*)	307. (*b*)	308. (*c*)	309. (*b*)	310. (*c*)
311. (*b*)	312. (*c*)	313. (*c*)	314. (*c*)	315. (*d*)
316. (*b*)	317. (*b*)	318. (*e*)	319. (*b*)	320. (*d*)
321. (*a*)	322. (*b*)	323. (*c*)	324. (*a*)	325. (*b*)
326. (*a*)	327. (*d*)	328. (*b*)	329. (*b*)	330. (*b*)
331. (*a*)	332. (*a*)	333. (*d*)	334. (*a*)	335. (*a*)
336. (*c*)	337. (*b*)	338. (*d*)	339. (*b*)	340. (*a*)
341. (*d*)	342. (*a*)	343. (*c*)	344. (*a*)	345. (*b*)
346. (*b*)	347. (*c*)	348. (*c*)	349. (*c*)	350. (*a*)
351. (*d*)	352. (*a*)	353. (*c*)	354. (*c*)	355. (*b*)
356. (*b*)	357. (*d*)	358. (*d*)	359. (*b*)	360. (*d*)
361. (*d*)	362. (*c*)	363. (*a*)	364. (*c*)	365. (*a*)
366. (*d*)	367. (*d*)	368. (*c*)	369. (*b*)	370. (*c*)

B. MATCH LIST I WITH LIST II

371. (*b*)	372. (*d*)	373. (*a*)	374. (*b*)	375. (*a*)
376. (*a*)				

C. COMPETITIVE EXAMINATIONS QUESTIONS (WITH SOLUTIONS - COMMENTS)

377. (*b*)	378. (*d*)	379. (*a*)	380. (*b*)	381. (*d*)
382. (*d*)	383. (*a*)	384. (*b*)	385. (*c*)	*386. (*a*)

387. (*b*)	388. (*c*)	389. (*d*)	390. (*b*)	391. (*a*)
392. (*d*)	*393. (*a*)	394. (*a*)	395. (*a*)	396. (*b*)
397. (*c*)	398. (*a*)	399. (*b*)	400. (*a*)	401. (*c*)
402. (*b*)	403. (*c*)	404. (*b*)	405. (*d*)	406. (*c*)
407. (*a*)	408. (*a*)	409. (*c*)	410. (*c*)	411. (*d*)
412. (*c*)	*413. (*b*)	414. (*b*)	415. (*a*)	416. (*b*)
417. (*c*)	418. (*d*)	419. (*b*)	420. (*b*)	421. (*a*)
422. (*c*)	423. (*d*)	424. (*a*)	425. (*a*)	426. (*d*)
427. (*a*)	428. (*a*)	429. (*d*)	430. (*a*)	431. (*c*)
432. (*b*)	433. (*c*)	434. (*a*)	435. (*a*)	436. (*d*)
437. (*b*)	438. (*d*)	439. (*a*)	440. (*d*)	441. (*d*)
442. (*c*)	443. (*c*)	444. (*a*)	445. (*a*)	446. (*d*)
447. (*b*)	448. (*c*)	449. (*a*)	450. (*c*)	451. (*c*)
452. (*c*)	453. (*b*)	454. (*b*)	455. (*c*)	456. (*a*)
457. (*d*)	458. (*a*)	459. (*b*)	460. (*a*)	461. (*d*)
462. (*a*)	463. (*a*)	464. (*b*)	465. (*a*)	466. (*d*)
467. (*c*)	468. (*d*)	469. (*b*)	470. (*b*)	471. (*d*)
472. (*d*)	473. (*c*)	474. (*c*)	475. (*b*)	476. (*c*)
477. (*b*)	478. (*b*)	479. (*c*)	480. (*d*)	481. (*c*)
482. (*c*)	483. (*d*)	484. (*a*)	485. (*a*)	

SOLUTIONS–COMMENTS

*366. Temperature of the inner surface of the wall, $t_1 = 50°C$

Temperature of the outer surface of the wall, $t_2 = 25°C$

The thickness of the wall, $x = 220$ mm $= 0.22$ m

Thermal conductivity of the brick, $k = 0.51$ W/m K

The *rate of heat transfer per unit area*,

$$\therefore \quad q = \frac{Q}{A} = \frac{k}{x}(t_1 - t_2)$$

$$= \frac{0.51}{0.22} \times (50 - 25)$$

$$= \mathbf{57.95\ W/m^2.}$$

$$\left[\because Q = \frac{kA}{x}(t_1 - t_2) \text{ and } q = \frac{Q}{A} = \frac{k}{x}(t_1 - t_2)\right]$$

*367. Refer to Fig. 1, Thickness of mild steel tank wall, $x = 12$ mm $= 0.012$ m; Temperature of water, $t_A = 100°C$; Temperature of air, $t_B = 20°C$; Thermal conductivity of mild steel, $k = 50$ W/m K.

Heat transfer coefficients ;

$$\left[\begin{array}{l}\text{Inside, } h_A = 2850\ W/m^2\ K \\ \text{Outside, } h_B = 10\ W/m^2\ K\end{array}\right]$$

(*i*) Rate of heat loss per m^2 of tank surface, q:

$$q = U(t_A - t_B)$$

The overall heat transfer coefficient, U is found from relation:

$$\frac{1}{U} = \frac{1}{h_A} + \frac{x}{k} + \frac{1}{h_B}$$

$$= \frac{1}{2850} + \frac{0.012}{50} + \frac{1}{10}$$

$$= 0.0003508 + 0.00024 + 0.1$$

$$= 0.1006$$

$$\therefore \quad U = \frac{1}{0.1006} = 9.94 \text{ W/m}^2\text{ K}$$

$$\therefore \quad q = 9.94 \times (100 - 20)$$

$$= 795.2 \text{ W/m}^2.$$

i.e., *Rate of heat loss per m^2 of surface area*

= 795.2 W/m².

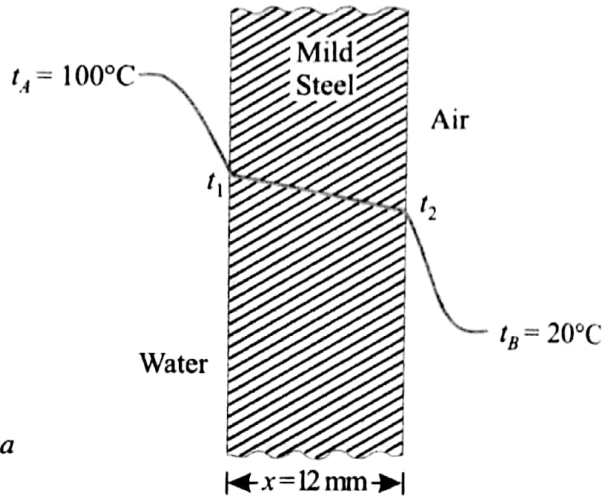


Fig. 1

(*ii*) **Temperature of the outside surface of the tank, t_2 :**

Now, $$q = h_B(t_2 - t_B)$$

$$\therefore \quad 795.2 = 10(t_2 - 20)$$

or, $$t_2 = \frac{795.2}{10} + 20 = 99.52°\text{C}$$

i.e., *Temperature of outside surface of the tank* = **99.52°C.**

*368. $r_2 = 0.7$ m, $r_1 = 0.7 - 0.09 = 0.61$ m

$$t_1 - t_2 = 220°\text{C}, \; k = 0.083 \text{ W/mK}$$

Now, $$Q = \frac{t_1 - t_2}{\left(\frac{r_2 - r_1}{4\pi k r_1 r_2}\right)} = \frac{220}{\left(\frac{0.7 - 0.61}{4\pi \times 0.083 \times 0.61 \times 0.7}\right)}$$

$$= 1088.6 \text{ W or } 1.0886 \text{ kW}$$

i.e., *Rate of heat leakage* = **1.0886 kW.**

*369. Temperature of liquid air, $T_1 = 273 + (-147) = 126$ K

Temperature of outer surface, $T_2 = 273 + 25 = 298$ K

Latent heat of liquid air $= 210$ kJ/kg

Stefan Boltzmann constant, $\sigma = 2.04 \times 10^{-4}$ kJ/h-m² K⁴

Emissivity $\varepsilon_1 = \varepsilon_2 = 0.028$

Rate of evaporation:

The heat transfer through the concentric sphere by radiation is given by

$$Q = \frac{A_c \sigma (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{A_1}{A_2}\left(\frac{1}{\varepsilon_2} - 1\right)}$$

$$= \frac{4\pi \times 0.1^2 \times 2.04 \times 10^{-4}[(126)^4 - (298)^4]}{\left[\frac{1}{0.028} + \left(\frac{0.2}{0.3}\right)^2\left(\frac{1}{0.028} - 1\right)\right]}$$

$$= \frac{-195703.25}{(35.71 + 0.444 \times 34.71)} = 3828.2 \text{ kJ/h}$$

$$\therefore \quad \text{Rate of evaporation} = \frac{3828.2}{210} = \textbf{18.22 kg/h}$$

*370. (*i*) When the body is grey with $\varepsilon = 0.42$:

$$T_1 = 1000 + 273 = 1273 \text{ K}$$
$$T_2 = 500 + 273 = 773 \text{ K}$$
$$\varepsilon \text{ at } 1000°C = 0.42$$
$$\varepsilon \text{ at } 500°C = 0.72$$
$$\sigma = 5.67 \times 10^{-8}$$

Heat loos per m^2 by radiation,

$$q = \varepsilon\sigma (T_1^4 - T_2^4)$$
$$= 0.42 \times 10^{-8} [(1273)^4 - (773)^4] = 54893 \text{ W}$$

i.e., Heat loos per m^2 by radiation = **54.893 kW.**

(*ii*) **When the body is not grey:**

Absorptivity when source is at 500°C = Emissivity when body is at 500°C

i.e., Absorptivity, $\alpha = 0.72$

Then, energy emitted $= \varepsilon\sigma T_1^4 = 0.42 \times 5.67 \times 10^{-8} \times (1273)^4$

and , Energy absorded $= \alpha\sigma T_2^4 = 0.72 \times 5.67 \times 10^{-8} \times (773)^4$

i.e., q = Energy emitted – energy absorbed

$$= 0.42 \times 5.67 \times 10^{-8} \times (1273)^4 - 0.72 \times 5.67 \times 10^8 \times (773)^4$$
$$= 62538 - 14576 = 47962 \text{ W}$$

i.e., Heat loss per m^2 by radiation = **47.962 kW.**

*378. Mean temperature difference = Temperature of hot fluid (at exit) – Temperature of of cold fluid (at entry)

$$= 60 - 40 = 20°C$$

Hence (*d*) is the correct answer.

*379. In case of infinite parallel planes having emissivities ε_1 and ε_2 respectively, the interchange factor (or effective emissivity coefficient)

$$= \frac{1}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = \frac{\varepsilon_1 \varepsilon_2}{\varepsilon_1 + \varepsilon_2 - \varepsilon_1 \varepsilon_2}$$

Hence correct choice is (*a*).

*380. Heat loss for a thick plate homogeneous wall $= kA \cdot \frac{dt}{dx}$

$$\therefore \quad \left(0.7 \times A \times \frac{dt}{0.5}\right)_{red\ bricks} = \left(0.14 \times A \frac{dt}{dx}\right)_{diatomite}$$

or, $$dx = \frac{0.14}{0.7} \times 0.5 = \mathbf{0.1\ m}$$

Hence (*b*) in the correct choice.

*386. Area, $A = 2 \times 2 = 4$ m^2, Rate of solar radiation falling on one side of the plate, $Q = 500$ W/m^2, $dt = 30 - 25 = 5°C$. Convective heat transfer coefficient, h :

Heat transfer by convection, $Q = hA.dt$ (where $Q = 500 \times A$ or $500 \times 4 = 2000$ W)

or, $$2000 = h \times 4 \times 5 \text{ or } h = \frac{2000}{4 \times 5} = \mathbf{100\ W/m^2 °C}$$

*388. The energy from flame, in bolier, is transmitted mainly by *radiation* to water wall and radiant superheater. Hence correct answer is (*c*).

*389. Overall heat transfer coefficient (U) in W/m^2 K is expressed as

$$\frac{1}{U} = \frac{1}{h_i} + \frac{dx}{k} + \frac{1}{h_o},$$

where, $h_i = 25$ W/m^{2}K, $h_o = 25$ W/m^{2}K, and $k = 0.15$ W/mK

or, $$\frac{1}{U} = \frac{1}{25} + \frac{0.15}{0.15} + \frac{1}{25} = \frac{27}{25} \text{ or } U = \frac{25}{27}$$

which is closer to the heat transfer coefficient based on the bricks alone.

Thus (d) is the correct choice.

*392. The volumetric efficiency of reciprocating compressor in less than 100 per cent due to the following reasons: Pressure drop across the valves, superheating in compressor, clearance volume and leakages.

Thus (d) is the correct choice.

*393. For the spherical sheath, critical radius,

$$r_c = \frac{2k_o}{h_o} = \frac{2 \times 0.04}{10} = 0.008 \text{ m} = 8 \text{ mm}$$

$\therefore$ Diameter of the sheath = $2 \times r_c = 2 \times 8 =$ **16 mm.**

*399. In case where the numerator and denominator of *LMTD* expression are equal to zero,

LMTD = Temperature difference at any end which in this case is either

140 – 80 or 80 – 20 = **60°C.**

437. **Ans.** (b) $800 = \frac{t_B - t_o}{1/h} = \frac{t_B - 25}{1/80}$, $10 = t_B - 25$ and $t_B = 35$°C.

439. **Ans.** (a) $\frac{hl}{k} = Nu$, or $h = \frac{25 \times 0.03}{0.1} = 7.5$ W/m^{2}K

440. **Ans.** (d) Emissive power is proportional to T^4 *i.e.* $\alpha \left(\frac{627 + 273}{27 + 273}\right)^4 \alpha\, 3^4\, \alpha\, 81$.

441. **Ans.** (d) Irradiation on a small test surface placed inside a hollow black spherical chamber = σT^4
$= 5.67 \times 10^{-8} \times 600^4 = 7348$ W/m^2.

443. **Ans.** (c) NTU = $\frac{AU}{C_{min}}$, A = area = 50 m^2, U = overall heat transfer coefficient = 100 W/m^{2}K

C_{min} = Heat capacity = 1000 W/K $\quad\therefore$ NTU = $\frac{50 \times 100}{1000} = 5$.

446. **Ans.** (d) For two insulating layers,

$$\frac{Q}{A} = \frac{t_1 - t_2}{\frac{\Delta x_1}{k_1} + \frac{\Delta x_2}{k_2}} = \frac{1000 - 120}{\frac{0.3}{3} + \frac{0.3}{0.3}} = \frac{880}{1.1} = 880$$

For outer casing, $\frac{Q}{A} = \frac{120 - 40}{1/h}$, or $800 \times \frac{1}{h} = 80$, and $h = \frac{800}{80} = 10$ W/m^{2}K

447. **Ans.** (b) Say at $x = 0$, $h_0 = h$, at $x = x$, $h_x = \frac{h}{\sqrt{x}}$

Average = $\frac{1}{x}\int_0^x \frac{h}{\sqrt{x}}\,dx = 2h\sqrt{x}$ $\quad\therefore$ Ratio = $\frac{1}{x} \cdot \frac{2h\sqrt{x}\sqrt{x}}{h} = 2$.

448. **Ans.** (c) C.O.P. of heat pump = $\frac{T_2}{T_2 - T_1} = \frac{600}{600 - 300} = 2$

474. **Ans.** (c) Average thermal conductivity $k_m = \frac{25 + 15}{2} = 20$ W/mK

$$\frac{Q}{A} = \frac{k_m (t_1 - t_2)}{\Delta x} = \frac{20 \times (300 - 200)}{0.5} = 4 \text{ kW/m}^2$$

475. **Ans.** (*b*) $Q \propto h \times l$, and $h \propto \left(\frac{\Delta T}{l}\right)^{1/4}$; $\therefore Q \propto l^{3/4}$; or $\frac{8}{1} = \left(\frac{320}{L}\right)^{3/4}$ and $L = 20$ cm.

476. **Ans.** (*c*) $Nu_{av} \propto Gr^{1/4}$ and $Gr \propto \Delta T$

Thus ratio of Grashoff number in two cases is $\propto \frac{30-20}{180-20} \propto \frac{1}{16}$

$\therefore \quad Nu_{av} \propto \left(\frac{1}{16}\right)^4 \propto \frac{1}{2}, \qquad \therefore \quad Nu_{av}$ for second case $= \frac{48}{2} = 24.$

477. **Ans.** (*b*) For constant heat flux as per Bayley, $h = 4.364\,\frac{k}{D} = 4.364 \times \frac{1.0}{0.1} = 43.64\,\frac{\text{W}}{\text{m}^2\text{K}}$, and for constant wall surface temperature, $h = 3.66\,\frac{k}{D} = 3.66 \times \frac{1.0}{0.1} = 3.66\,\frac{\text{W}}{\text{m}^2\text{K}}$

478. **Ans.** (*b*) $Q = 1000 \times \frac{\frac{2}{\varepsilon_1} - 1}{\left(\frac{1}{\varepsilon_1} - 1\right) + \left(\frac{1}{\varepsilon_2} - 1\right) + 1} = \frac{1000 \times \left(\frac{2}{0.5} - 1\right)}{\frac{1}{0.5} - 1 + \frac{1}{0.25} - 1 + 1} = \frac{3 \times 10^3}{5} = 600\,\frac{\text{W}}{\text{m}^2}$

479. **Ans.** (*c*) Reduction in radiation heat exchange due to introduction of shield

$$\frac{\frac{2}{\varepsilon_1} - 1}{2\left(\frac{1-\varepsilon_1}{\varepsilon_1}\right) + 2\left(\frac{1-\varepsilon_2}{\varepsilon_2}\right) + 2} = \frac{\frac{2}{0.5} - 1}{2 \times \frac{0.5}{0.5} + 2 \times \frac{0.75}{0.25} + 2} = \frac{3}{10}$$

482. **Ans.** (*c*) Insulated tip temperature $= \frac{\theta_0 \tan h\,(ml)}{(ml)}$.

483. **Ans.** (*d*) Only wrong statement is that long and thick fins should be used.

484. **Ans.** (*a*) If $Pr > 1$, then hydrodynamic boundary layer thickness > thermal boundary layer thickness.

ADDITIONAL QUESTIONS (WITH ANSWERS)
AMIE EXAMINATIONS QUESTIONS

A. CHOOSE THE CORRECT ANSWER:

1. This dimensionless number is relevant in transient heat conduction
   (*a*) Fourier number
   (*b*) Grashoff number
   (*c*) Weber number
   (*d*) Archmedes number.

2. Fins are provided on heat transfer surface so as to increase
   (*a*) heat transfer coefficient
   (*b*) mechanical strength to the equipment
   (*c*) heat transfer area
   (*d*) level of turblence.

3. The velocity profile for fully developed laminar flow in a tube is
   (*a*) parabolic (*b*) hyperbolic
   (*c*) linear (*d*) exponential.

4. For steady flow and constant value of conductivity, the temperature distribution for a hollow cylinder of radii r_1 and r_2 is
   (*a*) linear
   (*b*) parabolic
   (*c*) logarithmin function of radii
   (*d*) cubic.

5. The critical radius of insulation for sphere is equal to
   (*a*) $2k \times h$ (*b*) $\frac{2h}{k}$
   (*c*) $\frac{h}{2k}$ (*d*) $\sqrt{2kh}$.

6. In case of heat exchanger, the value of logarithmic mean temperature difference should be
   (*a*) as small as possible (*b*) as large as possible
   (*c*) constant (*d*) none of the above.

7. For a free convection, Nusselt number is a function of
   (*a*) Prandtl and Grashoff number
   (*b*) Reynolds and Grashoff number
   (*c*) Reynolds number only
   (*d*) Reynolds and Prandtl number.

8. If the ratio of emission of a body to that of a black body at a given temperature is constant for all wavelengths, the body is called
   (*a*) black body (*b*) grey body
   (*c*) white body (*d*) opaque body.

9. Kirchhoff's law is applicable to
   (*a*) monochromatic ratiation
   (*b*) total radiation
   (*c*) both (*a*) and (*b*)
   (*d*) neither (*a*) nor (*b*).

10. Stefan and Boltzmann's law is applicable to
    (*a*) grey body (*b*) white body
    (*c*) black body (*d*) all of the above.

11. For an opaque body sum of absorptivity and reflectivity is
    (*a*) 0 (*b*) 1.0
    (*c*) 0.5 (*d*) 0.8.

12. According to Kirchhoff's law the ratio of total radiating power to the absorptivity of the body is dependent on
    (*a*) temperature of the body
    (*b*) nature of the body
    (*c*) wavelength of radiation
    (*d*) none of these.

13. Fins are usually provided to a heat exchanger surface
    (*a*) to augment heat transfer by increasing the heat transfer coefficient
    (*b*) to augment heat transfer by increasing the surface area
    (*c*) to augment heat transfer by increasing the temperature difference
    (*d*) to augment heat transfer by increasing turbulence.

14. A good absorber of thermal radiation is also a good emitter. It is called
    (*a*) Wien's law (*b*) Planck's law
    (*c*) Stefan's law (*d*) Kirchhoff's law.

15. In a concentric double-pipe heat exchanger where one of the fluids undergoes phase change
    (*a*) the two fluids should flow opposite to each other
    (*b*) the two fluids should flow parallel to each other
    (*c*) the two fluids should flow normal to each other
    (*d*) the directions of flow of the two fluids are of no consequence.

16. For natural convection heat transfer, Nusselt number is a function of
    (*a*) Prandtl number and Grashoff number
    (*b*) Reynolds number and Greshoff number
    (*c*) Reynolds number and Prandtl number
    (*d*) Stanton number and Peclet number.

17. A fluid is a substance that
    (*a*) always expands until it fills any container
    (*b*) is incompressible
    (*c*) cannot remain at rest under action of any shear force
    (*d*) cannot be subjected to shear forces.

18. The water pipeline, in cold countries, is laid at a certain depth from the earth surface in order to
    (*a*) supply warm water
    (*b*) prevent water from freezing
    (*c*) reduce frictional losses
    (*d*) none of the above.

19. A cold liquid is stored in spherical vessel in order to
    (*a*) reduce rate of heat transfer
    (*b*) increase rate of heat transfer
    (*c*) prevent the liquid from freezing
    (*d*) none of the above.

20. In a heat exchanger, for a given heat flow rate and also same inlet and outlet temperatures, the heat transfer area will be minimum for
    (*a*) counter-flow type
    (*b*) parallel-flow, type
    (*c*) cross-flow
    (*d*) none of the above.

21. The total average emissivity at a given temperature is given by
    (*a*) $\int_0^\infty \varepsilon_\lambda E_{b\lambda}\, d\lambda \Big/ \int_0^\infty E_{b\lambda}\, d\lambda$
    (*b*) $\int_0^\lambda \varepsilon_\lambda E_{b\lambda}\, d\lambda \Big/ \int_0^\infty E_{b\lambda}\, d\lambda$
    (*c*) $\int_0^\infty \varepsilon_\lambda E_{b\lambda}\, d\lambda \Big/ \int_0^\lambda E_{b\lambda}\, d\lambda$
    (*d*) $\int_0^\lambda \varepsilon_\lambda E_{b\lambda}\, d\lambda \Big/ \int_0^\lambda E_{b\lambda}\, d\lambda$.

22. The heat transfer rate becomes maximum towards the end of
   (*a*) free convection boiling regime
   (*b*) nucleat boiling regime
   (*c*) film boiling regime
   (*d*) none of the above.

23. The thickness of thermal boundary layer is equal to hydrodynamic boundary layer when Pradtl number is equal to
   (*a*) 0 (*b*) 0.1
   (*c*) 0.5 (*d*) 1.0.

24. The heat transfer coefficient, in free convection, is a function of
   (*a*) Reynolds number (*b*) Mach number
   (*c*) Grashoff number (*d*) none of the above.

25. A radiation shlied is used around thermocouples in order to measure more accurately the temperature of
   (*a*) solids (*b*) gases
   (*c*) boiling liquids (*d*) condensing liquids

26. The fouling factor
   (*a*) increases the overall heat transfer coefficient
   (*b*) decreases the overall heat transfer coefficient
   (*c*) is equal to the overall heat transfer coefficient
   (*d*) none of the above.

27. The analogy of conductivity in heat transfer to fluid flow is
   (*a*) velocity of fluid
   (*b*) density of fluid
   (*c*) viscosity of fluid
   (*d*) dielectric constant of fluid.

28. Heat flows from higher temperature to lower temperature in case of
   (*a*) conduction only
   (*b*) convection only
   (*c*) radiation only
   (*d*) all the above cases.

29. High transfer rate is high in
   (*a*) film boiling
   (*b*) nucleate boiling
   (*c*) both in film and nucleate boiling
   (*d*) in simple convection.

30. Radiation heat from a substance
   (*a*) takes place at all temperatures
   (*b*) takes place only above 273°C
   (*c*) takes place only above room temperature
   (*d*) depends on surrounding temperature.

31. In case of a black body
   (*a*) transmittivity is one
   (*b*) absorptivity is zero
   (*b*) reflectivity is one
   (*d*) none of the above.

32. Conventionally, heat transfer area is obtained by
   (*a*) increasing the diameter of the tube
   (*b*) increasing the length of the tube
   (*c*) adding fins to the tube
   (*d*) decreasing the thickness of the tube.

33. In metals heat transfer by conduction happens by
   (*a*) the movements of the atoms
   (*b*) the movements of the free electrons
   (*c*) the bombardment of atoms with each other
   (*d*) none of the above.

34. Radiation heat transfer occurs at a speed of
   (*a*) sound (*b*) light
   (*c*) 60000 km/h (*d*) 3000 m/h.

B. FILL IN THE BLANKS:

1. Dropwise condensation occurs on .....surface.
2. The critical radius of insulation is given to be a ratio of .....and overall heat transfer coefficient.
3. A body, which absorbs all the radiations falling on it, is called ..... .
4. The unit of thermal conductivity in SI units is ..... .
5. Fins are used to ..... the heat flow from the surface.
6. Cold feed should be fed ..... in a multifaced evaporator.
7. The expression for logarithmic mean radius is ..... .
8. For heating air by steam ..... heat exchangers are recommended.
9. Natural convection is caused due to .....
10. In evaporators, to separate liquid droplets from the vapour ..... is used.
11. A gas does not ..... any thermal radiation.
12. The unit of heat transfer coefficient in SI units is ..... .
13. Prandtl number is a ratio of kinematic viscosity and ..... of a fluid.

C. MATCH THE SETS :

1.

Set A	Set B
(*i*) Reciprocity theorem	(*a*) Transient condition
(*ii*) Inertia force/surface tension force	(*b*) Reynolds number
(*iii*) Inertia force/gravitational force	(*c*) Convective heat transfer
(*iv*) Inertia force/viscous force	(*d*) Froude number
(*v*) Biot number	(*e*) Radiant heat exchange.

2.

Set A	Set B
(*i*) Fourier law	(*a*) Forced convection
(*ii*) Fourier number	(*b*) Free convection
(*iii*) Grashoff number	(*c*) Conduction heat transfer
(*iv*) Wien displacement law	(*d*) Transient heat flow.
(*v*) Stanton number	(*e*) Radiation heat transfer.

3.

Set A	Set B
(*i*) Planck's law	(*a*) Turbulent flow
(*ii*) Stanton number	(*b*) Heat exchanger
(*iii*) NTU	(*c*) Radiation heat transfer
(*iv*) Eddy viscosity	(*d*) Capillarity
(*v*) Surface tension	(*e*) Forced convection

ANSWERS

A. CHOOSE THE CORRECT ANSWER :

1. (*a*)	2. (*c*)	3. (*a*)	4. (*c*)	5. (*b*)
6. (*b*)	7. (*a*)	8. (*b*)	9. (*c*)	10. (*c*)
11. (*b*)	12. (*d*)	13. (*b*)	14. (*d*)	15. (*d*)
16. (*a*)	17. (*c*)	18. (*b*)	19. (*a*)	20. (*a*)
21. (*a*)	22. (*b*)	23. (*d*)	24. (*c*)	25. (*b*)
26. (*b*)	27. (*c*)	28. (*d*)	29. (*c*)	30. (*a*)
31. (*d*)	32. (*c*)	33. (*b*)	34. (*b*).	

B. FILL IN THE BLANKS :

1. contaminated	2. thermal conductivity	3. black body
4. W/m°C	5. increase	6. from bottom
7. $\frac{r_2 - r_1}{\ln (r_2 / r_1)}$	8. surface	9. density difference
10. baffle plate	11. reflect	12. W/m^2°C
13. thermal diffusivity.		

C. MATCH THE SETS :

1. (*i*) (*e*)	(*ii*) (*c*)	(*iii*) (*d*)	(*iv*) (*b*)	(*v*) (*a*)
2. (*i*) (*c*)	(*ii*) (*d*)	(*iii*) (*b*)	(*iv*) (*e*)	(*v*) (*a*)
3. (*i*) (*c*)	(*ii*) (*e*)	(*iii*) (*b*)	(*iv*) (*a*)	(*v*) (*d*).