THERMAL PROPERTIES OF MATTER

FACT/DEFINITION TYPE QUESTIONS

1. Heat is associated with
   (a) kinetic energy of random motion of molecules
   (b) kinetic energy of orderly motion of molecules
   (c) total kinetic energy of random and orderly motion of molecules
   (d) None of these

2. Heat content of a body depends on
   (a) mass of the body (b) temperature of the body
   (c) specific heat capacity (d) all of the above

3. Which of the following is not a unit of heat energy ?
   (a) joule (b) kelvin
   (c) calorie (d) None of these

4. Choose the correct equation for interconversion of temperature scales.

   (a) $\frac{T_C - 0}{100} = \frac{T_F - 32}{180}$

   (b) $\frac{T_F - 32}{180} = \frac{T_K + 273.15}{100}$

   (c) $\frac{T_F - 32}{180} = \frac{T_K - 273.15}{180}$

   (d) $\frac{T_C - 0}{180} = \frac{T_F - 32}{100}$

5. Which of the following pairs may give equal numerical values of the temperature of a body?
   (a) Fahrenheit and Celsius
   (b) Celsius and Kelvin
   (c) Kelvin and Reaumur
   (d) None of these

6. Expansion during heating
   (a) occurs only in solids
   (b) increases the weight of a material
   (c) generally decreases the density of a material
   (d) occurs at the same rate for all liquids and solids

7. When water is heated from 0ºC to 4ºC, its volume
   (a) increases
   (b) decreases
   (c) does not change
   (d) first decreases and then increases

8. 4200 J of work is required for
   (a) increasing the temperature of 10 g of water through 10ºC
   (b) increasing the temperature of 100 g of water through 10ºC
   (c) increasing the temperature of 1 kg of water through 10ºC
   (d) increasing the temperature of 10 g of water through 10ºC

9. Triple point of water is
   (a) 273.16ºF (b) 273.16 K
   (c) 273.16ºC (d) 273.16 R

10. The reading of Centigrade thermometer coincides with that of Fahrenheit thermometer in a liquid. The temperature of the liquid is
    (a) –40ºC (b) 313ºC
    (c) 0ºC (d) 100ºC

11. Which of the following will expand the most for same rise in temperature?
    (a) Aluminium (b) Glass
    (c) Wood (d) All will expand same

12. Which of the following is an expression for heat capacity?
    (a) $S = \frac{1}{m}\frac{\Delta Q}{\Delta T}$ (b) $S = \frac{\Delta Q}{\Delta T}$
    (c) $S = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$ (d) All of the above

13. Which of the following is a poor conductor of heat ?
    (a) Copper (b) Concrete
    (c) Mercury (d) Air

14. If α, β and γ are coefficient of linear, area and volume expansion respectively, then
    (a) $\gamma = 3\alpha$ (b) $\alpha = 3\gamma$
    (c) $\beta = 3\alpha$ (d) $\gamma = 3\beta$

15. If two rods A and B of equal length L, and different areas of cross-section A_1 and A_2 have one end each at temperature T_1 and T_2, have equal rates of flow of heat, then

(a) $A_1 = A_2$ (b) $\frac{A_1}{A_2} = \frac{K_1}{K_2}$

(c) $\frac{A_1}{A_2} = \frac{K_2}{K_1}$ (d) $K_1 = K_2$

16. Mass of water which absorbs or emits the same amount of heat as is done by the body for the same rise or fall in temperature is known as
(a) thermal capacity of the body
(b) specific heat capacity of the body
(c) latent heat capacity of the body
(d) water equivalent of the body

17. Which of the following is the unit of specific heat
(a) J kg°C^{-1} (b) J/kg°C
(c) kg°C/J (d) J/kg°C^{-2}

18. The equation $\frac{T_F - 32}{180} = \frac{T_c}{100}$, relates the Fahrenheit and Celsius scale temperature. The T_F versus T_c graph will be a
(a) straight line parallel to x-axis
(b) straight line parallel to y-axis
(c) straight line inclined to x-axis
(d) parabolic curve

19. Which of the following undergo sublimation ?
(a) Dry ice (b) Iodine
(c) Both (a) and (b) (d) None of these

20. The phenomenon of refreezing the water into ice on removing the increased pressure is called
(a) freezing (b) fusion
(c) sublimation (d) regelation

21. The value of molar heat capacity at constant temperature is
(a) zero (b) infinity
(c) unity (d) 4.2

22. The latent heat of vaporization of a substance is always
(a) greater than its latent heat of fusion
(b) greater than its latent heat of sublimation
(c) equal to its latent heat of sublimation
(d) less than its latent heat of fusion

23. A quantity of heat required to change the unit mass of a solid substance, from solid state to liquid state, while the temperature remains constant, is known as
(a) latent heat (b) sublimation
(c) hoar frost (d) latent heat of fusion

24. A bubble of n mole of helium is submerged at a certain depth in water. The temperature of water increases by Δt°C. How much heat is added approximately to helium during expansion?

(a) $nc_v\Delta t$ (b) $\frac{nc_p}{\Delta t}$

(c) $\frac{n^2c_v}{\Delta t}$ (d) $nc_p\Delta t$

25. Which of the following is used as a coolent in automobile radiator as well as a heater in hot water bags?
(a) Ice (b) Sand
(c) Water (d) All of these

26. ... A... and ...B... of heat energy required some material as a transport medium.
Hear, A and B refer to
(a) conduction, radiation
(b) radiation, convection
(c) conduction, convection
(d) radiation, evaporation

27. Which law is obeyed when temperature difference between the body and the surroundings is small?
(a) Stefan's law (b) Newton's law of cooling
(c) Planck's law (d) All of these

28. Heat is transmitted from higher to lower temperature through actual mass motion of the molecules in
(a) conduction (b) convection
(c) radiation (d) None of these

29. Good absorbers of heat are
(a) poor emitters (b) non-emitters
(c) good emitters (d) highly polished

30. Three bodies A, B and C have equal area which are painted red, yellow and black respectively. If they are at same temperature, then
(a) emissive power of A is maximum.
(b) emissive power of B is maximum.
(c) emissive power of C is maximum.
(d) emissive power of A, B and C are equal.

31. Sweet makers do not clean the bottom of cauldron because
(a) emission power of black and bright surface is more.
(b) absorption power of black and bright surface is more.
(c) black and rough surface absorbs more heat.
(d) transmission power of black and rough surface is more.

32. Lamp black absorbs radiant heat which is near about
(a) 90% (b) 98%
(c) 100% (d) 50%

33. At temperature T, the emissive power and absorption power of a body for certain wavelength are e_λ and a_λ respectively, then
(a) $e_\lambda = a_\lambda$
(b) $e_\lambda > a_\lambda$
(c) $e_\lambda < a_\lambda$
(d) there will not be any difinite relation between e_λ and a_λ

34. Newton's law of cooling is applicable for
(a) any excess of temperature over the surrounding.
(b) small excess of temperature over the surrounding.
(c) large excess of temperature over the surrounding.
(d) very large excess of temperature over the surrounding.

35. Newton's law of cooling is also applicable to
(a) convection losses.
(b) natural convection losses.
(c) forced convection losses.
(d) conduction losses.

STATEMENT TYPE QUESTIONS

36. A body *A* is at a temperature T_A and a body *B* is at temperature T_B such that $T_A > T_B$. Bodies *A* and *B* are connected. Which of the following statements is/are true related to two bodies ?
I. Body *A* is hotter than body *B*.
II. Heat flows from *A* to *B*.
III. Heat flows from *B* to *A*.
(a) I and II (b) Only I
(c) II and III (d) I and III

37. Consider the following statements and select the incorrect statements.
I. Water expands on heating between 0°C & 4°C
II. The density of water is minimum at 4°C
III. Density of water increases on heating above 4°C
IV. Water contracts on heating between 0°C & 4°C
(a) I and II only (b) III and IV only
(c) I , II and III (d) I, II, III and IV

38. Which of the following statements regarding specific heat capacity of a substance are correct ? It depends on
I. mass of substance.
II. nature of substance.
III. temperature of substance.
IV. volume of substance.
(a) I and II (b) II and III
(c) III and IV (d) I and IV

39. Consider the following statements and select the correct statement(s).
I. Water and ice have same specific heats
II. Water and ice have different specific heats
III. Specific heat of water is more than that of ice
IV. Specific heat of ice is more than that of water
(a) I only (b) II only
(c) II and III (d) III and IV

40. Consider the following statements and select the correct statement(s).
I. Copper is a better conductor of heat than glass.
II. Silver is the best condutor of heat
III. Thermal conductivity of steel is greater than that of copper.
(a) I only (b) II only
(c) I and II (d) II and III

41. Which of the following statements is/are correct ?
I. Gases are poor thermal conductors.
II. Liquids have conductivities intermediate between solids and gases
III. Heat conduction can be take less from old body to hotter body.
(a) Only I (b) Only II
(c) Only III (d) I and II

42. During vapourisation
I. change of state from liquid to vapour state occurs.
II. temperature remains constant.
III. both liquid and vapour states coexist inequilibrium.
IV. specific heat of substance increases.
Correct statements are
(a) I, II and IV (b) II, III and IV
(c) I, III and IV (d) I , II and III

43. Consider the following statements and select the correct statement(s).
I. Water can never be boiled without heating.
II. Water can be boiled below room temperature by lowering the pressure.
III. On releasing the excess pressure water refreezes into ice.
(a) I only (b) II only
(c) I and II (d) II and III

44. Which of the following statements is/are true ?
I. Steam causes more severe burns than boiling water.
II. Specific heat capacity of water is maximum
(a) I only (b) II only
(c) I and II (d) None of these

45. Which of the following statements is/ are false about mode of heat transfer?
I. In radiation, heat is transfered from one medium to another without affecting the intervening medium
II. Radiation and convection are possible in vaccum while conduction requires material medium.
III. Conduction is possible in solids while convection occurs in liquids and gases.
(a) I only (b) II only
(c) II and III (d) I, II and III

46. Which of the following statements is/are correct ?
I. Convection is a mode of heat transfer by actual motion of matter.
II. Convection is possible only in gases.
III. Convection can be natural or forced process in nature.
(a) Only I (b) I and III
(c) Only II (d) I, II and III

MATCHING TYPE QUESTIONS

47. Match the quantities in column-I with the units in column-II.

Column-I	Column-II
(A) Amount of substance	(1) $J\ kg^{-1}\ K^{-1}$
(B) Coefficient of volume expansion	(2) $J\ s^{-1}\ K^{-1}$
(C) Specific heat	(3) K^{-1}
(D) Thermal conductivity	(4) mol

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

48. **Column-I** **Column-II**

(A) Bimetalic strip (1). Change in length
(B) Steam engine (2) Energy conversion
(C) Linear expansion (3) Change in area
(D) Area expansion (4) Thermal expansion

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

49. Match the column I and column II.

Column I **Column II**

(A) $PV = \mu RT$ (1) Molar specific heat
(B) $\gamma = 3\alpha$ (2) Newton's law of cooling
(C) $C = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$ (3) Ideal gas equation
(D) $\frac{dQ}{dt} = -k(T_2 - T_1)$ (4) Coefficient of expansion

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

50. **Column I** **Column II**

(A) Lowest temperature of water in a lake (1) Less than 4°C
(B) Rate of variation of density (r) is zero (2) Coexistence of three phases of a substance.
(C) Least volume of water (3) Surface tension is zero
(D) Triple point (4) Equal to 4°C

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

51. **Column-I** **Column-II**

(A) Specific heat capacity S (1) $l_1 - l_2$ = constant for $l_1\alpha_1 = l_2\alpha_2$
(B) Two metals (l_1, a_1) and (l_2, a_2) are heated uniformly (2) Y is same
(C) Thermal stress (3) $S = \infty$ for $\Delta T = 0$
(D) Four wires of same material (4) $Y \propto \Delta t$

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

52. Three liquids A, B and C having same specific heat and mass m, 2m and 3m have temperatures 20°C, 40°C and 60°C respectively. Temperature of the mixture when

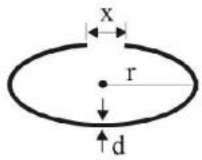
Column-I **Column-II**

(A) A and B are mixed (1). 33.3°C
(B) A and C are mixed (2) 52°C
(C) B and C are mixed (3) 50°C
(D) A, B and C all three are mixed (4) 46.67°C

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

DIAGRAM TYPE QUESTIONS

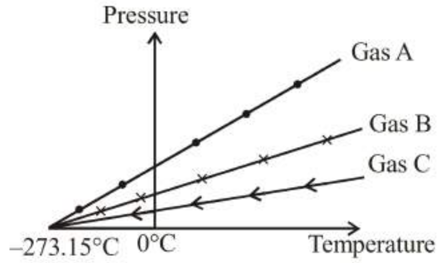
53. A cylindrical metal rod is shaped into a ring with a small gap as shown. On heating the system :



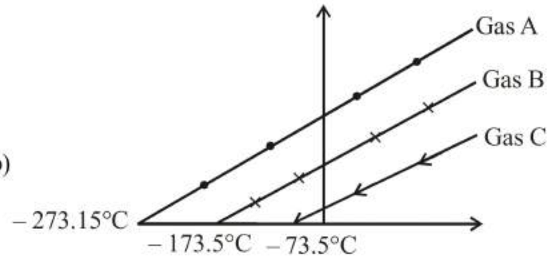
(a) x decreases, r and d increase
(b) x and r increase, d decreases
(c) x, r and d all increase
(d) x and r decreased, d remains constant

54. Which of the following graphs is correct for pressure versus temperature, for low density gases?

(a)



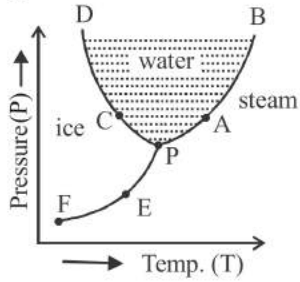
(b)



(c) Both (a) & (b) (d) None of these

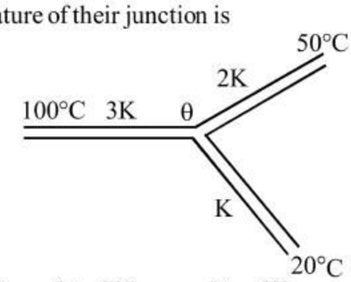
55. In the given pressure-temperature diagram, for water, which point indicates triple point ?

(a) A
(b) C
(c) P
(d) E



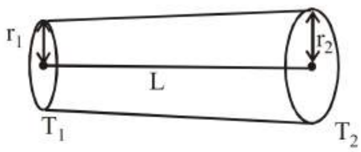
56. In the diagram given above, the CD curve is known as
(a) hoarfrost line (b) steam line
(c) vapourisation line (d) ice line

57. There rods of the same dimensions have thermal conductivities 3K, 2K and K. They are arranged as shown in fig. with their ends at 100°C, 50°C and 20°C. The temperature of their junction is



(a) 60° (b) 70° (c) 50° (d) 35°

58. The rate of heat flow through the cross-section of the rod shown in figure is ($T_2 > T_1$ and thermal conductivity of the material of the rod is K)



(a) $\dfrac{K\pi r_1 r_2 (T_2 - T_1)}{L}$ (b) $\dfrac{K\pi (r_1 + r_2)^2 (T_2 - T_1)}{4L}$

(c) $\dfrac{K\pi (r_1 + r_1)^2 (T_2 - T_1)}{L}$ (d) $\dfrac{K\pi (r_1 + r_1)^2 (T_2 - T_1)}{2L}$

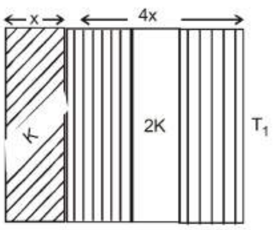
59. The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and $2K$ and thickness x and $4x$, respectively, are T_2 and $T_1 (T_2 > T_1)$. The rate of heat transfer through the slab, in a steady state is $\left(\dfrac{A(T_2 - T_1)K}{x}\right) f$, with f equal to

(a) $\dfrac{2}{3}$

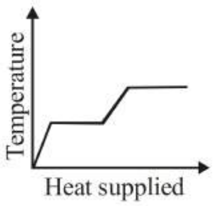
(b) $\dfrac{1}{2}$

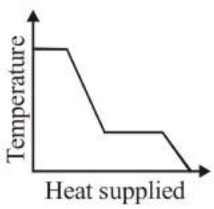
(c) 1

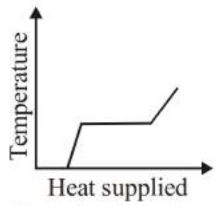
(d) $\dfrac{1}{3}$

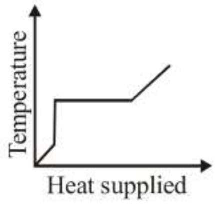


60. A block of ice at – 10°C is slowly heated and converted to steam at 100°C. Which of the following curves represents the phenomenon qualitatively

(a)


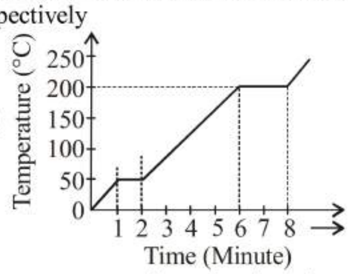
(b)


(c)


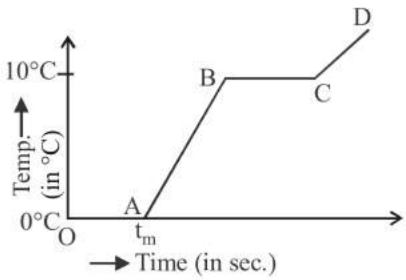
(d)


61. A student takes 50gm wax (specific heat = 0.6 kcal/kg°C) and heats it till it boils. The graph between temperature and time is as follows. Heat supplied to the wax per minute and boiling point are respectively

(a) 500 cal, 50°C
(b) 1000 cal, 100°C
(c) 1500 cal, 200°C
(d) 1000 cal, 200°C



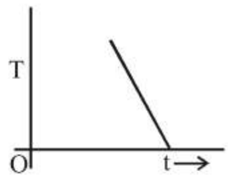
62. In the plot of temperature versus time showing changes in the state of ice on heating, which part represents constant temperature ?

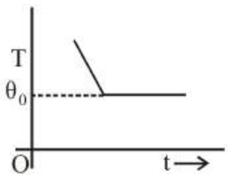


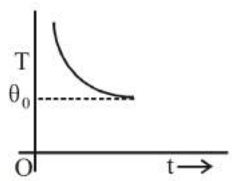
(a) OA (b) AB
(c) CD (d) All of these

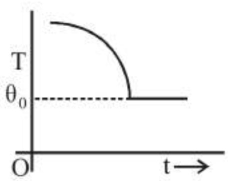
63. Which portion of the graph above indicates that two states co-exist in thermal equilibrium ?
(a) OA (b) BC
(c) Both (a) & (b) (d) None of these

64. If a piece of metal is heated to temperature θ and then allowed to cool in a room which is at temperature θ_0, the graph between the temperature T of the metal and time t will be closest to

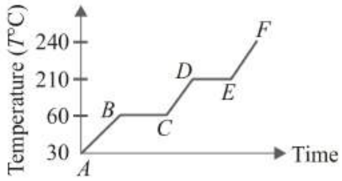
(a)


(b)


(c)


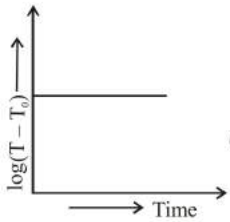
(d)


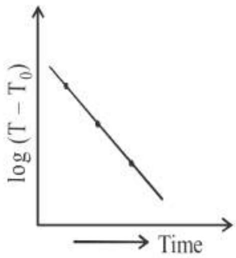
65. A solid substance is at 30°C. To this substance heat energy is supplied at a constant rate. Then temperature versus time graph is as shown in the figure. The substance is in liquid state for the portion (of the graph)

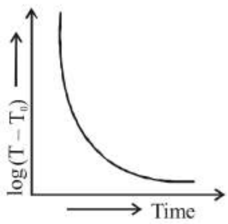


(a) *BC* (b) *CD*
(c) *ED* (d) *EF*

66. Which of the given graphs proves Newton's law of cooling?

(a) 

(b) 

(c) 

(d) None of these

ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

67. **Assertion** : Fahrenheit is the smallest unit measuring temperature.
Reason : Fahrenheit was the first temperature scale used for measuring temperature.

68. **Assertion** : The temperature at which Centigrade and Fahrenheit thermometers read the same is –40°
Reason : There is no relation between Faherenheit and Centigrade temperature.

69. **Assertion** : It is hotter over the top of a fire than at the same distance on the sides.
Reason : Air surrounding the fire conducts more heat upwards.

70. **Assertion:** The triple point of water is a standard fixed point in modern thermometry.
Reason: The triple point of a substance is unique i.e. it occurs at one particular set of values of pressure and temperature.

71. **Assertion:** Copper expands five times more than glass for same rise in temperature.
Reason: Copper is five times far better conductor of heat than glass.

72. **Assertion:** In insulators electrons do not contribute to their conductivity.
Reason: In insulators, no free electrons are present, they cannot conduct heat.

73. **Assertion** : Specific heat capacity is the cause of formation of land and sea breeze.
Reason : The specific heat of water is more than land

74. **Assertion** : Specific heat of a body is always greater than its thermal capacity.
Reason : Specific heat capacity is required for raising temperature of unit mass of the body through unit degree.

75. **Assertion** : Two bodies at different temperature if brought in thermal contact do not necessary settle to the mean temperature.
Reason : The two bodies may have different thermal capacities.

76. **Assertion** : A beaker is completely filled with water at 4°C. It will overflow, both when heated or cooled.
Reason : There is expansion of water below and above 4°C.

77. **Assertion** : Water kept in an open vessel will quickly evaporate onthe surface of the moon.
Reason : The temperature at the surface of the moon is much higher than boiling point of the water.

78. **Assertion** : The melting point of ice decreases with increase of pressure.
Reason : Ice contracts on melting.

79. **Assertion** : The molecules at 0°C ice and 0°C water will have same potential energy.
Reason : Potential energy depens on temperature of the system.

80. **Assertion** : Melting of solid causes no change in internal energy.
Reason : Latent heat is the heat required to melt a unit mass of solid.

81. **Assertion:** The rate of cooling and the rate of loss of heat are same thing.
Reason: In both the cases, the material has to cool down and for a given material, rate of cooling and rate of loss of heat will be same.

CRITICALTHINKING TYPE QUESTIONS

82. A metal sheet with a circular hole is heated. The hole
(a) gets larger
(b) gets smaller
(c) remains of the same size
(d) gets deformed

83. A solid ball of metal has a spherical cavity inside it. The ball is heated. The volume of cavity will
(a) decrease (b) increase
(c) remain unchanged (d) have its shape changed

84. On a linear temperature scale Y, water freezes at $-160°$ Y and boils at $-50°$ Y. On this Y scale, a temperature of 340 K would be read as : (water freezes at 273 K and boils at 373 K)
(a) $-73.7°$ Y (b) $-233.7°$ Y
(c) $-86.3°$ Y (d) $-106.3°$ Y

85. On heating a liquid of coefficient of cubical expansion γ in a container having coefficient of linear expansion $\gamma/3$, the level of liquid in the container will
(a) rise
(b) fall
(c) remain almost stationary
(d) It is difficult to say

86. An iron tyre is to be fitted on to a wooden wheel 1m in diameter. The diameter of tyre is 6 mm smaller than that of wheel. The tyre should be heated so that its temperature increases by a minimum of (the coefficient of cubical expansion of iron is 3.6×10^{-5}/°C)
(a) 167°C (b) 334°C (c) 500°C (d) 1000°C

87. Water of volume 2 litre in a container is heated with a coil of 1 kW at 27°C. The lid of the container is open and energy dissipates at rate of 160 J/s. In how much time temperature will rise from 27°C to 77°C? [Given specific heat of water is 4.2 kJ/kg]
(a) 8 min 20 s (b) 6 min 2 s
(c) 7 min (d) 14 min

88. A beaker is filled with water at 4°C. At one time the temperature is increased by few degrees above 4°C and at another time it is decreased by a few degrees below 4°C. One shall observe that:
(a) the level remains constant in each case
(b) in first case water flows while in second case its level comes down
(c) in second case water over flows while in first case its comes down
(d) water overflows in both the cases

89. Assuming no heat losses, the heat released by the condensation of x g of steam at 100°C can be used to convert y g of ice at 0°C into water at 100°C, the ratio $x : y$ is :
(a) 1 : 1 (b) 1 : 2
(c) 1 : 3 (d) 3 : 1

90. A glass flask is filled up to a mark with 50 cc of mercury at 18°C. If the flask and contents are heated to 38°C, how much mercury will be above the mark? (α for glass is 9×10^{-6}/°C and coefficient of real expansion of mercury is 180×10^{-6}/°C)
(a) 0.85 cc (b) 0.46 cc (c) 0.153 cc (d) 0.05 cc

91. A bar of iron is 10 cm at 20°C. At 19°C it will be (α of iron $= 11 \times 10^{-6}$/°C)
(a) 11×10^{-6} cm longer (b) 11×10^{-6} cm shorter
(c) 11×10^{-5} cm shorter (d) 11×10^{-5} cm longer

92. The coefficient of apparent expansion of mercury in a glass vessel is 153×10^{-6}/°C and in a steel vessel is 144×10^{-6}/°C. If α for steel is 12×10^{-6}/°C, then that of glass is
(a) 9×10^{-6}/°C (b) 6×10^{-6}/°C
(c) 36×10^{-6}/°C (d) 27×10^{-6}/°C

93. A lead bullet strikes against a steel plate with a velocity 200 m s^{-1}. If the impact is perfectly inelastic and the heat produced is equally shared between the bullet and the target, then the rise in temperature of the bullet is (specific heat capacity of lead = 125 J kg^{-1} K^{-1})
(a) 80°C (b) 60°C
(c) 160°C (d) 40°C

94. Certain amount of heat is given to 100 g of copper to increase its temperature by 21° C. If the same amount of heat is given to 50 g of water, then the rise in its temperature is

(Specific heat capacity of copper = 400 J kg^{-1} K^{-1} and that for water = 4200 J kg^{-1} K^{-1})
(a) 4° C (b) 5.25° C
(c) 8° C (d) 6° C

95. A hammer of mass 1 kg having speed of 50 m/s, hit a iron nail of mass 200 gm. If specific heat of iron is 0.105 cal/gm°C and half the energy is converted into heat. the raise in temperature of nail is
(a) 7.1°C (b) 9.2°C
(c) 10.5°C (d) 12.1°C

96. In an energy recycling process, 100 g of steam at 100°C becomes water at 100°C which converts y g of ice at 0°C into water at 100°C. The numeric value of y is
(a) 100 (b) 200 (c) 300 (d) 400

97. In a water-fall the water falls from a height of 100 m. If the entire K.E. of water is converted into heat, the rise in temperature of water will be
(a) 0.23°C (b) 0.46°C
(c) 2.3°C (d) 0.023°C

98. 19 g of water at 30°C and 5 g of ice at -20°C are mixed together in a calorimeter. What is the final temperature of the mixture? Given specific heat of ice = 0.5 cal $g^{-1}(°C)^{-1}$ and latent heat of fusion of ice = 80 cal g^{-1}
(a) 0°C (b) -5°C
(c) 5°C (d) 10°C

99. Steam is passed into 22 g of water at 20°C . The mass of water that will be present when the water acquires a temperature of 90°C is (Latent heat of steam is 540 cal/gm)

(a) 24.8 gm (b) 24 gm (c) 36.6 gm (d) 30 gm

100. A 2 kg copper block is heated to 500°C and then it is placed on a large block of ice at 0°C. If the specific heat capacity of copper is 400 J/kg°C and latent heat of fusion of water is 3.5×10^5 J/kg, the amount of ice that can melt is

(a) (7/8) kg (b) (7/5) kg
(c) (8/7) kg (d) (5/7) kg

101. Two spheres of different materials one with double the radius and one-fourth wall thickness of the other are filled with ice. If the time taken for complete melting of ice in the larger sphere is 25 minute and for smaller one is 16 minute, the ratio of thermal conductivities of the materials of larger spheres to that of smaller sphere is

(a) 4 : 5 (b) 5 : 4 (c) 25 : 8 (d) 8 : 25

102. Ice starts forming in a lake with water at 0°C when the atomspheric temperature is –10°C. If the time taken for the first 1 cm of ice to be formed is 7 hours, then the time taken for the thickness of ice to change from 1 cm to 2 cm is

(a) 7 hours (b) 14 hours
(c) 21 hours (d) 3.5 hours

103. A kettle with 2 litre water at 27°C is heated by operating coil heater of power 1 kW. The heat is lost to the atmosphere at constant rate 160J/sec, when its lid is open. In how much time will water heated to 77°C with the lid open? (specific heat of water = 4.2 kJ/kg)

(a) 8 min 20 sec (b) 6 min 2 sec
(c) 14 min (d) 7 min

104. Steam at 100°C is passed into 20 g of water at 10°C. When water acquires a temperature of 80°C, the mass of water present will be:

[Take specific heat of water = 1 cal g^{-1} $°C^{-1}$ and latent heat of steam = 540 cal g^{-1}]

(a) 24 g (b) 31.5 g
(c) 42.5 g (d) 22.5 g

105. Certain quantity of water cools from 70°C to 60°C in the first 5 minutes and to 54°C in the next 5 minutes. The temperature of the surroundings is:

(a) 45°C (b) 20°C
(c) 42°C (d) 10°C

106. On observing light from three different stars P, Q and R, it was found that intensity of violet colour is maximum in the spectrum of P, the intensity of green colour is maximum in the spectrum of R and the intensity of red colour is maximum in the spectrum of Q. If T_P, T_Q and T_R are the respective absolute temperature of P, Q and R, then it can be concluded from the above observations that

(a) $T_P > T_R > T_Q$ (b) $T_P < T_R < T_Q$
(c) $T_P < T_Q < T_R$ (d) $T_P > T_Q > T_R$

107. The two ends of a metal rod are maintained at temperatures 100°C and 110°C. The rate of heat flow in the rod is found to be 4.0 J/s. If the ends are maintained at temperatures 200°C and 210°C, the rate of heat flow will be

(a) 16.8 J/s (b) 8.0 J/s
(c) 4.0 J/s (d) 44.0 J/s

108. The value of coefficient of volume expansion of glycerine is 5×10^{-4} K^{-1}. The fractional change in the density of glycerine for a rise of 40°C in its temperature, is:

(a) 0.020 (b) 0.025
(c) 0.010 (d) 0.015

109. Four identical rods of same material are joined end to end to form a square. If the temperature difference between the ends of a diagonal is 100°C, then the temperture difference between the ends of other diagonal will be

(a) 0°C (b) $\frac{100}{l}°C$ (c) $\frac{100}{2l}°C$ (d) 100°C

(where l is the length of each rod)

110. Three very large plates of same area are kept parallel and close to each other. They are considered as ideal black surfaces and have very high thermal conductivity. The first and third plates are maintained at temperatures $2T$ and $3T$ respectively. The temperature of the middle (i.e. second) plate under steady state condition is

(a) $\left(\frac{65}{2}\right)^{1/4} T$ (b) $\left(\frac{97}{4}\right)^{1/4} T$

(c) $\left(\frac{97}{2}\right)^{1/4} T$ (d) $(97)^{1/4} T$

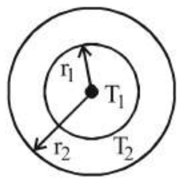
111. The figure shows a system of two concentric spheres of radii r_1 and r_2 are kept at temperatures T_1 and T_2, respectively. The radial rate of flow of heat in a substance between the two concentric spheres is proportional to

(a) $ln\left(\frac{r_2}{r_1}\right)$

(b) $\frac{(r_2 - r_1)}{(r_1 r_2)}$

(c) $(r_2 - r_1)$

(d) $\frac{r_1 r_2}{(r_2 - r_1)}$



112. 300 gm of water at 25°C is added to 100 g of ice at 0°C. The final temperature of the mixture is

(a) $-\frac{5}{3}°C$ (b) $-\frac{5}{2}°C$ (c) 5°C (d) 0°C

113. A slab of stone of area 0.36 m^2 and thickness 0.1 m is exposed on the lower surface to steam at 100°C. A block of ice at 0°C rests on the upper surface of the slab. In one hour 4.8 kg of ice is melted. The thermal conductivity of slab is :

(Given latent heat of fusion of ice = 3.36×10^5 J kg^{-1}.):

(a) 1.24 J/m°C (b) 1.29 J/m°C
(c) 2.05 J/m°C (d) 1.02 J/m°C

114. A partition wall has two layers of different materials A and B in contact with each other. They have the same thickness but the thermal conductivity of layer A is twice that of layer B. At steady state the temperature difference across the layer B is 50 K, then the corresponding difference across the layer A is

(a) 50 K (b) 12.5 K
(c) 25 K (d) 60 K

115. The length of a metallic rod is 5 m at 0°C and becomes 5.01 m, on heating upto 100°C. The linear expansion of the metal will be

(a) 2.33×10^{-5}/°C (b) 6.0×10^{-5}/°C
(c) 4.0×10^{-5}/°C (d) 2.0×10^{-5}/°C

116. A pendulum clock is 5 seconds fast at temperature of 15ºC and 10 seconds slow at a temperature of 30ºC. At what temperature does it give the correct time? (take time interval = 24 hours)

(a) 18ºC (b) 20ºC
(c) 22ºC (d) 25ºC

117. The tempertaure of equal masses of three different liquids A, B and C are 12°C, 19°C and 28°C respectively. The temperature when A and B are mixed is 16°C and when B and C are mixed is 23°C . The temperature when A and C are mixed is

(a) 18.2ºC (b) 22ºC (c) 20.2ºC (d) 25.2ºC

118. A solid copper cube of edges 1 cm each is suspended in an evacuated enclosure. Its temperture is found to fall from 100°C to 99°C in 100 s. Another solid copper cube of edges 2 cm, with similar surface nature, is suspended in a similar manner. The time required for this cube to cool from 100°C to 99°C will be approximately

(a) 25 s (b) 50 s (c) 200 s (d) 400 s

119. A body cools from 50.0°C to 49.9°C in 5s. How long will it take to cool from 40.0°C to 39.9°C? Assume the temperature of surroundings to be 30.0°C and Newton's law of cooling to be valid

(a) 2.5 s (b) 10 s (c) 20 s (d) 5 s

120. In a room where the temperature is 30°C, a body cools from 61°C to 59°C in 4 minutes. The time (in minutes) taken by the body to cool from 51°C to 49°C will be

(a) 8 (b) 5 (c) 6 (d) 4

121. In a surrounding medium of temperature 10°C, a body takes 7 min for a fall of temperature from 60°C to 40°C. In what time the temperature of the body will fall from 40°C to 28°C?

(a) 7 min (b) 11 min
(c) 14 min (d) 21 min

122. A container contains hot water at 100°C. If in time T_1 temperature falls to 80° C and the time T_2 temperature falls to 60°C form 80°C, then

(a) $T_1 = T_2$ (b) $T_1 > T_2$
(c) $T_1 < T_2$ (d) None of these

123. Consider two hot bodies B_1 and B_2 which have temperatures 100°C and 80°C respectively at $t = 0$. The temperature of the surroundings is 40°C. The ratio of the respective rates of cooling R_1 and R_2 of these two bodies at $t = 0$ will be

(a) $R_1 : R_2 = 3 : 2$ (b) $R_1 : R_2 = 5 : 4$
(c) $R_1 : R_2 = 2 : 3$ (d) $R_1 : R_2 = 4 : 5$

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(a)** **2.** **(d)**

3. **(b)** Kelvin is a unit of temperature.

4. **(a)** Temperature on celsius scale (T_C), kelvin scale (T_K) and Fahrenheit scale (T_F) are related as

$$\frac{T_C - 0}{100} = \frac{T_F - 32}{180} = \frac{T_K - 273.15}{100}$$

5. **(a)** The normal temperature of a person is 98.6°F or 37°C.

6. **(c)** Solids, liquids and gases all expand on being heated, as a result density (=mass/volume) decreases.

7. **(d)**

8. **(b)** Work done to raise the temperature of 100 gm water through 10°C is

$W = JQ = 4.2 \times (100 \times 10^{-3} \times 1000 \times 10) = 4200$ J

9. **(b)** Triple point of water is 273.16 K

10. **(a)** Let the readings of two thermometers coincide at $C = F = x$

As $\frac{C}{5} = \frac{F-32}{9}$

$\therefore \frac{x}{5} = \frac{x-32}{9}$

or $9x = 5x - 160$

$4x = -160, x = -40$°C

11. **(a)** Among glass, wood and metals, metals expand more for same rise in temperature.

12. **(b)** Heat capacity is the amount of heat absorbed by a substance for a unit rise in temperature.

$\Delta Q \propto \Delta T$

$$\Delta Q = S\Delta T \Rightarrow S = \frac{\Delta Q}{\Delta T}$$

13. **(d)** Thermal conductivity of air is very-very low 0.024.

14. **(a)** $V + \Delta V = (L + \Delta L)^3 = (L + \alpha L \Delta T)^3$

$= L^3 + (1 + 3\alpha\Delta T + 3\alpha^2\Delta T^2 + \alpha^3\Delta T^3)$

$\Rightarrow$ α^2 and α^3 terms are neglected.

$\therefore$ $V(1 + \gamma\Delta T) = V(1 + 3\alpha\Delta T)$

$1 + \gamma\Delta T = 1 + 3\alpha\Delta T$

$\therefore \gamma = 3\alpha.$

15. **(c)** $\frac{\Delta Q_1}{\Delta t} = \frac{\Delta Q_2}{\Delta t}$

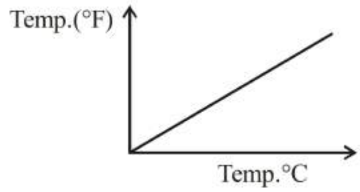
$$K_1 A_1 \frac{T_1 - T_2}{L_1} = K_2 A_2 \frac{T_1 - T_2}{L_2} \qquad (L_1 = L_2)$$

$\therefore \frac{A_1}{A_2} = \frac{K_2}{K_1}$

16. **(d)** Water equivalent is the quantity of water whose thermal capacity is same as the heat capacity of the body.

17. **(b)** $c = \frac{Q}{m\Delta\theta} \rightarrow \frac{J}{kg \times °C}$

18. **(c)**



19. **(c)** Dry ice and iodine pass from solid to vapour state without going into the liquid state.

20. **(d)**

21. **(b)** At constant temperature molar heat capacity

$$C_T = \frac{\Delta Q}{n\Delta T}$$

T is const. $\Rightarrow \Delta T = 0$

$$\therefore \quad C_T = \frac{\Delta Q}{0} = \infty$$

22. (a) The latent heat of vaporization is always greater than latent heat of fusion because in liquid to vapour phase change there is a large increase in volume. Hence more heat is required as compared to solid to liquid phase change

23. **(d)**

24. **(d)** $H = nc_p\Delta t$

25. **(c)** Water has highest specific heat capacity and hence it is used as a coolant in car radiators as well as heater in hot water bags.

26. **(c)** Conduction and convection require some material as a transport medium. These modes of heat transfer cannot operate between bodies separated by distance in vacuum. But the Earth does receive heat from the Sun across a huge distance and we quickly feel the warmth of the fire near by even though air conducts poorly and before convection can set in. We receive heat from Sun by radiation. Radiation can occur in vacuum.

27. **(b)** When the temperature difference between the body and surroundings is small, then Newton's law of cooling is obeyed.

28. (b) 29. (c) 30. (c) 31. (c) 32. (b)
33. (a) 34. (b) 35. (c)

STATEMENT TYPE QUESTIONS

36. (a) If $T_A > T_B$ body 'A' is hotter than body B and heat flows from A to B i.e., from body at higher temperature to body at lower temperature till the temperature becomes same.

37. (c)

38. (b) Specific heat capacity is given by $C = \frac{S}{m} = \frac{1}{m}\frac{\Delta Q}{\Delta T}$

It is defined as the amount of heat per unit mass absorbed or rejected by the substance to change its temperature by one unit. It depends on the nature of the substance and its temperature. It is independent of mass of substance.

39. (b) Water and ice have different specific heats. Specific heat of water is 1 $Jg^{-1}°C^{-1}$ while that of water ice is 0.5 $Jg^{-1}°C^{-1}$.

40. (c) Thermal conductivity of copper is more than that of steel, hence stainless steel cooking pans are provided with extra copper bottoms.

41. (d) Gases are poor thermal conductors while liquids have conductive intermediate between solids and gases. Heat conduction may be described quantitatively as the time rate of heat flow in a material for a given temperature difference.

42. (d) The change of state from liquid to vapour (for gas) is called **vapourisation**. It is observed that when liquid is heated, the temperature remains constant untill the entire amount of the liquid is converted into vapour. The temperature at which the liquid and the vapour states of the substance coexists is called its **boiling point**.

43. (d) Water can be boiled, even at low temperature on releasing the excess pressure, water refreezes into ice called regelation.

44. (c) 45. (b)

46. (b) Convection is mode of heat transfer by actual motion of mater. It is possible only through its. Convection can be natural or forced. In natural convection, gravity plays an important part.

MATCHING TYPE QUESTIONS

47. (b) 48. (b)

49. (c) Ideal gas equation $PV = \mu RT$.

$\gamma = 3\alpha$, relation for coefficient of expansions

$c = \frac{1}{\mu}\frac{\Delta\theta}{\Delta T}$ gives molar specific heat

Newton's law of cooling

$$\frac{d\theta}{dT} = -k\,(T_2 - T_1)$$

50. (c) 51. (a) 52. (a)

DIAGRAM TYPE QUESTIONS

53. (b) Material expands outward and so x, r increases. Due to linear expansion diameter of rod will increase.

54. (a) The graph refers to absolute zero which is same for low density gases.

55. (c) The three curves AB, CD and EF meet at point P which is called the triple point of water. It is the point where all three states solid, liquid and gas of water co-exists.

56. (d) Line CD is the border between ice and water. At every point of line CD, the temperature and pressure values are such that substance co-exist in solid and liquid phase.

57. (b) $\frac{dQ}{dt} = KA\frac{\Delta T}{L}$

For the first rod, $\left(\frac{dQ}{dt}\right)_1 = \frac{3KA}{L}(100-\theta)$

Similarly, $\left(\frac{dQ}{dt}\right)_2 = 2K\frac{A}{L}(\theta - 50)$

$\left(\frac{dQ}{dt}\right)_3 = K\frac{A}{L}(\theta - 20)$

Now, $\left(\frac{dQ}{dt}\right)_1 = \left(\frac{dQ}{dt}\right)_2 + \left(\frac{dQ}{dt}\right)_3$

$\Rightarrow\ 3(100-\theta) = 2(\theta-50) + (\theta - 20)$

$\Rightarrow\ \theta = 70°$

58. (a) $r_{eff} = \sqrt{r_1 r_2}$

$$\frac{dQ}{dt} = \frac{KA(T_2 - T_1)}{L} = \frac{K\pi r_1 r_2 (T_2 - T_1)}{L}$$

59. (d) The thermal resistance is given by

$$\frac{x}{KA} + \frac{4x}{2KA} = \frac{x}{KA} + \frac{2x}{KA} = \frac{3x}{KA}$$

$$\therefore \frac{dQ}{dt} = \frac{\Delta T}{\frac{3x}{KA}} = \frac{(T_2 - T_1)KA}{3x} = \frac{1}{3}\left\{\frac{A(T_2 - T_1)K}{x}\right\}$$

$$\therefore f = \frac{1}{3}$$

60. (a) Initially, on heating temperature rises from – 100°C to 0°C. then ice melts and temperature does not rise. After the whole ice has melted, temperature beigins to rise until it reaches 100°C. then it becomes constant, as at the boiling point will not rise.

61. (c) Since specific heat = 0.6 $kcal/g \times °C = 0.6\ cal/g \times °C$

From graph it is clear that in a minute, the temperature is raised from 0°C to 50°C.

$\Rightarrow$ Heat required for a minute = $50 \times 0.6 \times 50 = 1500\ cal$.

Also from graph, Boiling point of wax is 200°C.

62. (a) OA refers to change of state from ice to water without change of temperature.

63. (c) At OA and BC, there is a change of state from ice to water and water to steam respectively. During this both the state co-exist in thermal equilibrium.

64. (c) According to Newton's law of cooling, the temperature goes on decreasing with time non-linearly.

65. (b) At C, solid completely will convert into liquid.

66. (b) When hot water temperature (T) and surrounding temparature (T_0) readings are noted, and $\log(T - T_0)$ is plotted versus time, we get a straight line having a negative slope; as a proof of Newton's law of cooling.

ASSERTION- REASON TYPE QUESTIONS

67. (c) 68. (c)

69. (c) Heat is carried away from a fire sideways mainly by radiations. Above the fire, heat is carried by both radiation and by convection of air. The latter process carries much more heat.

70. (a)

71. (a) Metals generally have higher coefficient of linear expansion. Since copper has 1.7 K^{-1} and glass has 0.32 K^{-1} coefficient of linear expansion so, copper expands five times more than glass.

72. (a) 73. (a) 74. (d) 75. (a) 76. (a)

77. (c) 78. (a) 79. (d) 80. (d)

81. (d) Rate of cooling a body at a temperature is defined as the fall in temperature per second at that temperature, while rate of loss of heat from a body is the quantity of heat lost per second from the body.

CRITICALTHINKING TYPE QUESTIONS

82. (a) The area of circular hole increases when we heat the metal sheet & expansion of metal sheet will be independent of shape & size of the hole.

83. (b) The volume of cavity inside the solid ball increases when it is heated.

84. (c) $\dfrac{\text{Reading on any scale} - \text{LFP}}{\text{UFP} - \text{LFP}}$ = constant for all scales

$$\frac{340-273}{373-273} = \frac{°y-(-160)}{-50-(-160)}$$

$$\Rightarrow \frac{67}{100} = \frac{y+160}{110}$$

$\therefore$ y = – 86.3° y

85. (c) As coefficient of cubical expansion of liquid equals coefficient of cubical expansion of vessel, the level of liquid will not change on heating.

86. (c) Initial diameter of tyre = $(1000-6)\,mm = 994\,mm$, so initial radius of tyre $R = \frac{994}{2} = 497\,mm$

and change in diameter $\Delta D = 6\,mm$ so $\Delta R = \frac{6}{2} = 3\,mm$

After increasing temperature by $\Delta\theta$ tyre will fit onto wheel

Increment in the length (circumference) of the iron tyre

$$\Delta L = L \times \alpha \times \Delta\theta = L \times \frac{\gamma}{3} \times \Delta\theta \qquad [\text{As } \alpha = \frac{\gamma}{3}]$$

$$2\pi\Delta R = 2\pi R\left(\frac{\gamma}{3}\right)\Delta\theta \Rightarrow \Delta\theta = \frac{3}{\gamma}\frac{\Delta R}{R} = \frac{3\times3}{3.6\times10^{-5}\times497}$$

$\Rightarrow \Delta\theta \simeq 500°C$

87. (a) Heat gained by the water = (Heat supplied by the coil) – (Heat dissipated to environment)

$\Rightarrow mc\,\Delta\theta = P_{Coil}\,t - P_{Loss}\,t$

$\Rightarrow 2\times4.2\times10^3\times(77-27) = 1000\,t - 160\,t$

$\Rightarrow t = \frac{4.2\times10^5}{840} = 500\text{ s} = 8\text{ min }20\text{ s}$

88. (d) water expands on both sides of 4 °C.

89. (c) The heat lost in condensation = $x \times 540$ cal.

$\therefore \quad x\times540 = y\times80 + y\times1\times(100-0)$

or $\quad \frac{x}{y} = \frac{1}{3}$.

90. (c) Due to volume expansion of both mercury and flask, the change in volume of mercury relative to flask is given by $\Delta V = V_0\left[\gamma_L - \gamma_g\right]\Delta\theta = V\left[\gamma_L - 3\alpha_g\right]\Delta\theta$

$= 50[180\times10^{-6} - 3\times9\times10^{-6}](38-18) = 0.153$ cc

91. (c) $L = L_0(1+\alpha\Delta\theta) \Rightarrow \frac{L_1}{L_2} = \frac{1+\alpha(\Delta\theta)_1}{1+\alpha(\Delta\theta)_2}$

$\Rightarrow \frac{10}{L_2} = \frac{1+11\times10^{-6}\times20}{1+11\times10^{-6}\times19} \Rightarrow L_2 = 9.99989$

$\Rightarrow$ Length is shorten by

$10 - 9.99989 = 0.00011 = 11\times10^{-5}$ cm.

92. (a) $\gamma_{real} = \gamma_{app.} + \gamma_{vessel}$

So $(\gamma_{app.} + \gamma_{vessel})_{glass} = (\gamma_{app} + \gamma_{vessel})_{steel}$

$\Rightarrow 153\times10^{-6} + (\gamma_{vessel})_{glass} = 144\times10^{-6} + (\gamma_{vessel})_{steel}$

Further,

$(\gamma_{vessel})_{steel} = 3\alpha = 3\times(12\times10^{-6}) = 36\times10^{-6}/°C$

$\Rightarrow 153\times10^{-6} + (\gamma_{vessel})_{glass} = 144\times10^{-6} + 36\times10^{-6}$

$\Rightarrow (\gamma_{vessel})_{glass} = 3\alpha = 27\times10^{-6}/°C$

$\Rightarrow \alpha = 9\times10^{-6}/°C$

93. (a) Heat produced $= ms\Delta T = \frac{1}{2}\left(\frac{1}{2}mv^2\right)$

$$\Rightarrow \Delta T = \frac{v^2}{4s} = \frac{(200)^2}{4\times125} = \frac{4\times10^4}{4\times125} = 80°C$$

94. (a) The amount of heat required to increase the temperature of copper by 21°C is

$$Q = m_{Cu}s_{Cu}\Delta T = 100\times10^{-3}\times400\times21\ J$$

The amount of heat required to increase the temperature of water by ΔT_1 °C is

$$Q_1 = m_w s_w \Delta T_1 = 50\times10^{-3}\times4200\times\Delta T_1$$

According to question, $Q = Q_1$

$\therefore 100\times10^{-3}\times400\times21 = 50\times10^{-3}\times4200\times\Delta T_1$

$$\Rightarrow \Delta T_1 = \frac{2\times21\times4}{42} = 4°C$$

95. (a) $W = JQ \Rightarrow \frac{1}{2}\left(\frac{1}{2}Mv^2\right) = J(m.c.\Delta\theta)$

$$\Rightarrow \frac{1}{4}\times1\times(50)^2 = 4.2[200\times0.105\times\Delta\theta] \Rightarrow \Delta\theta = 7.1°C$$

96. (c) Specific heat of water = 4200 J/kg-K

Latent heat of fusion $= 3.36\times10^5$ J/kg

Latent heat of vapourisation $= 22.68\times10^5$ J/kg

$x\times10^{-3}\times22.68\times10^5\ J = y\times10^{-3}\times3.36\times10^5\ J + y\times10^{-3}\times4200\times100$

$$\therefore \frac{x}{y} = \frac{7.56}{22.68} = \frac{1}{3}$$

97. (a) $\Delta\theta = 0.0023h = 0.0023\times100 = 0.23°C$

98. (c) Here, specific heat of ice, $S_{ice} = 0.5$ cal $g^{-1}°C^{-1}$

Specific heat of water, $S_{water} = 1$ cal $g^{-1}°C^{-1}$

Latent heat of fusion of ice $L_{f\,ice} = 80$ cal g^{-1}

Here ice will absorb heat while hot water will release it.

Let T be the final temperature of the mixture.

Assuming water equivalent of calorimeter to be neglected.

Heat given by water, $Q_1 = m_{water}S_{water}\Delta T$

$= 19\times1\times(30-T) = 570-19T$ ...(i)

Heat absorbed by ice.

$Q_2 = m_{ice}\times S_{ice}\times[0-(-20)] + m_{ice}\times L_{f\,ice} + m_{ice}\times S_{water}\times(T-0)$

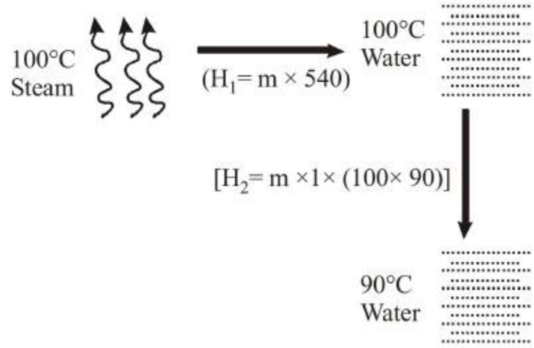
$= 5\times0.5\times20 + 5\times80 + 5\times1\times T$

$= 450 + 5T$

According to principle of calorimetry, $Q_1 = Q_2$

i.e., $570 - 19T = 450 + 5T \Rightarrow T = \frac{120}{24} = 5°C$

99. (a) Let m g of steam get condensed into water (By heat loss). This happens in following two steps.



Heat gained by water (20°C) to raise it's temperature upto 90°C $= 22\times1\times(90-20)$

Hence, in equilibrium, heat lost = Heat gain

$\Rightarrow m\times540 + m\times1\times(100-90) = 22\times1\times(90-20)$

$\Rightarrow m = 2.8$ gm

The net mass of the water present in the mixture $= 22 + 2.8 = 24.8$ gm.

100. (c) Let x kg of ice can melt

Using law of Calorimetry,

Heat lost by copper = Heat gained by ice

$2\times400\times(500-0) = x\times3.5\times10^5$

or $x = \frac{2\times400\times500}{3.5\times10^5} = \frac{8}{7}$ kg

101. (d) Radius of small sphere = r

Thickness of small sphere = t

Radius of bigger sphere = 2r

Thickness of bigger sphere = t/4

Mass of ice melted = (volume of sphere) × (density of ice)

Let K_1 and K_2 be the thermal conductivities of larger and smaller sphere.

For bigger sphere,

$$\frac{K_1 4\pi(2r)^2\times100}{t/4} = \frac{\frac{4}{3}\pi(2r)^3\rho L}{25\times60}$$

For smaller sphere,

$$\frac{K_2\times4\pi r^2\times100}{t} = \frac{\frac{4}{3}\pi r^3\rho L}{16\times60} \quad \therefore \frac{K_1}{K_2} = \frac{8}{25}$$

102. (c)

103. (a) By the law of conservation of energy, energy given by heater must be equal to the sum of energy gained by water and energy lost from the lid.

$Pt = ms\,\Delta\theta$ + energy lost

$1000t = 2\times4.2\times10^3\times50 + 160t$

$840t = 8.4\times10^3\times50 = 500$ sec = 8 min 20 sec

104. (d) According to the principle of calorimetry.

Heat lost = Heat gained

$mL_v + ms_w\Delta\theta = m_w s_w \Delta\theta$

$\Rightarrow\ m \times 540 + m \times 1 \times (100 - 80)$

$= 20 \times 1 \times (80 - 10)$

$\Rightarrow\ m = 2.5\ g$

Therefore total mass of water at 80°C

$= (20 + 2.5)\ g = 22.5\ g$

105. (a) Let the temperature of surroundings be θ_0

By Newton's law of cooling

$$\frac{\theta_1 - \theta_2}{t} = k\left[\frac{\theta_1 + \theta_2}{2} - \theta_0\right]$$

$$\Rightarrow\ \frac{70 - 60}{5} = k\left[\frac{70 + 60}{2} - \theta_0\right]$$

$$\Rightarrow\ 2 = k\,[65 - \theta_0] \quad ...(i)$$

Similarly, $\frac{60 - 54}{5} = k\left[\frac{60 + 54}{2} - \theta_0\right]$

$$\Rightarrow\ \frac{6}{5} = k\,[57 - \theta_0] \quad ...(ii)$$

By dividing (i) by (ii) we have

$$\frac{10}{6} = \frac{65 - \theta_0}{57 - \theta_0} \quad \Rightarrow \quad \theta_0 = 45^\circ$$

106. (a) From Wein's displacement law, $\lambda_m \times T$ = constant

P – max. intensity is at violet $\Rightarrow \lambda_m$ is minimum $\Rightarrow$ temp maximum

R – max. intensity is at green $\Rightarrow \lambda_m$ is moderate $\Rightarrow$ temp moderate

Q – max. intensity is at red $\Rightarrow \lambda_m$ is maximum $\Rightarrow$ temp minimum   i.e., $T_p > T_R > T_Q$

107. (c) As the temperature difference $\Delta T = 10°C$ as well as the thermal resistance is same for both the cases, so thermal current or rate of heat flow will also be same for both the cases.

108. (a) From question,

Rise in temperature $\Delta t = 40°C$

Fractional change in the density $\frac{\Delta\rho}{\rho_0} = ?$

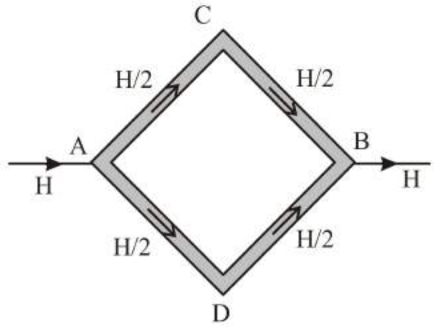
Coefficient of volume expansion

$\gamma = 5 \times 10^{-4} K^{-1}$

$\rho = \rho_0 (1 - \gamma\Delta t)$

$$\Rightarrow\ \frac{\Delta\rho}{\rho_0} = \gamma\Delta T = (5 \times 10^{-4})(40) = 0.02$$

109. (a) Suppose temperature difference between A and B is 100°C and $\theta_A > \theta_B$



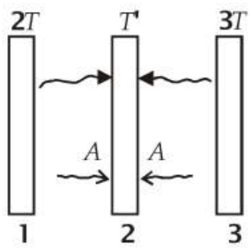
Heat current will flow from A to B via path ACB and ADB. Since all the rod are identical, so, $(\Delta\theta)_{AC} = (\Delta\theta)_{AD}$

(Because heat current $H = \frac{\Delta\theta}{R}$; here R = same for all)

$\Rightarrow \theta_A - \theta_C = \theta_A - \theta_D \Rightarrow \theta_C = \theta_D$

i.e., temperature difference between C and D will be zero.

110. (c) Under steady conditions, the heat gained per second by a plate is equal to the heat released per second by the plate.



$\frac{\text{Heat gained}}{\text{Second}}$ [by (2) from (1)] + $\frac{\text{Heat gained}}{\text{Second}}$

[(by ((2) from (3)] = $\frac{\text{Heat gained}}{\text{Second}}$ (by 2)

$\therefore\ \sigma A(2T)^4 + \sigma A(3T)^4 = \sigma(2A)(T')^4$

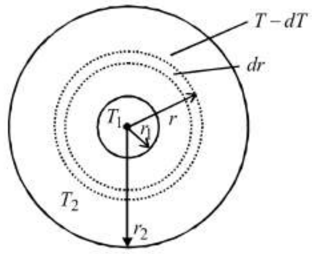
$$\therefore\ T' = \left[\frac{97}{2}\right]^{1/4} T$$

111. (d) Consider a shell of thickness (dr) and of radii (r) and the temperature of inner and outer surfaces of this shell be T, $(T - dT)$

$\frac{dQ}{dt}$ = rate of flow of heat through it

$$= \frac{KA[(T - dT) - T]}{dr} = \frac{-KAdT}{dr}$$

$$= -4\pi Kr^2 \frac{dT}{dr} \quad (\because\ A = 4\pi r^2)$$



To measure the radial rate of heat flow, integration technique is used, since the area of the surface through which heat will flow is not constant.

Then, $\left(\frac{dQ}{dt}\right)\int_{r_1}^{r_2}\frac{1}{r^2}dr = -4\pi K\int_{T_1}^{T_2} dT$

$$\frac{dQ}{dt}\left[\frac{1}{r_1}-\frac{1}{r_2}\right] = -4\pi K\left[T_2 - T_1\right]$$

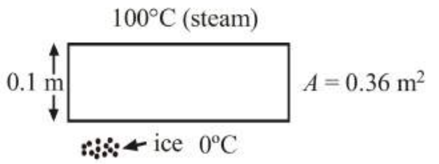
or $\frac{dQ}{dt} = \frac{-4\pi K r_1 r_2 (T_2 - T_1)}{(r_2 - r_1)}$ $\quad\therefore\quad \frac{dQ}{dt} \propto \frac{r_1 r_2}{(r_2 - r_1)}$

112. (d) $\theta_{mix} = \dfrac{m_W\theta_W - \dfrac{m_i L_i}{S_W}}{m_i + m_W}$

$$= \frac{300\times 25 - \dfrac{100\times 80}{1}}{100+300} = -1.25°C$$

Which is not possible. Hence $\theta_{mix} = 0°C$

113. (a)



Rate of heat given by steam = Rate of heat taken by ice

where K = Thermal conductivity of the slab

m = Mass of the ice

L = Latent heat of melting/fusion

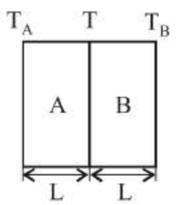
A = Area of the slab

$$\frac{dQ}{dt} = \frac{KA(100-0)}{1} = m\frac{dL}{dt},$$

$$\frac{K\times 100\times 0.36}{0.1} = \frac{4.8\times 3.36\times 10^5}{60\times 60}$$

K=1.24 J/m/s/°C

114. (c)



Let T be temperature of the junction

Here, $K_A = 2K_B$, $T - T_B = 50K$

At the steady state,

$$H_A = H_B$$

$$\therefore \frac{K_A A(T_A - T)}{L} = \frac{K_B A(T - T_B)}{L}$$

$$2K_B(T_A - T) = K_B(T - T_B)$$

$$T_A - T = \frac{T - T_B}{2}$$

$$= \frac{50K}{2} = 25K$$

115. (d) $\ell = 5m \quad t_1 = 0°C$

$\ell_2 = 5.01m \quad t_2 = 100°C$

$$\alpha = \frac{\ell_2 - \ell_1}{\ell_1(t_2 - t_1)} = \frac{5.01-5}{5\times 100} = 2\times 10^{-5}/°C.$$

116. (c) $\Delta t = \frac{1}{2}\alpha\,\Delta T\times t$

$\therefore\ 5 = \frac{1}{2}\alpha(T-15)\times 86400$

and $10 = \frac{1}{2}\alpha(30 - T)\times 86400$

117. (c) Heat gain = heat lost

$$C_A(16-12) = C_B(19-16) \Rightarrow \frac{C_A}{C_B} = \frac{3}{4}$$

and $C_B(23-19) = C_c(28-23) \Rightarrow \frac{C_B}{C_C} = \frac{5}{4}$

$$\Rightarrow \frac{C_A}{C_C} = \frac{15}{16} \qquad ...(i)$$

If θ is the temperature when A and C are mixed then,

$$C_A(\theta - 12) = C_C(28-\theta) \Rightarrow \frac{C_A}{C_C} = \frac{28-\theta}{\theta - 12} \qquad ...(ii)$$

On solving equations (i) and (ii) $\theta = 20.2°C$

118. (c) Rate of cooling $\frac{\Delta\theta}{t} = \frac{A\varepsilon\sigma(T^4 - T_0^4)}{mc}$

$$\Rightarrow t \propto \frac{m}{A}\ [\Delta\theta, t, \sigma, (T^4 - T_0^4) \text{ are constant}]$$

$$\Rightarrow t \propto \frac{m}{A} \propto \frac{\text{Volume}}{\text{Area}} \propto \frac{a^3}{a^2} \Rightarrow t \propto a \Rightarrow \frac{t_1}{t_2} = \frac{a_1}{a_2}$$

$$\Rightarrow \frac{100}{t_2} = \frac{1}{2} \Rightarrow t_2 = 200\,\text{sec}$$

119. (b) $\frac{50-49.9}{5}=K\left(\frac{50+49.9}{2}-30\right)$ ....(i)

$\frac{40-39.9}{t}=K\left[\frac{40+39.9}{2}-30\right]$ ....(ii)

From equations (i) and (ii), we get $t \approx 10$ s.

120. (c) From Newtwon's law of cooling

$\frac{dQ}{dt}=-KA\frac{dT}{dx}$

Area of cross-section A and thickness dx is the same.

Also $dQ = mCd\theta$

Thus in first case

$$\frac{m \times C \times (61° - 59°)}{4}=\frac{-KA}{dx}\left[\left(\frac{61°+51°}{2}\right)-30°\right] \quad (i)$$

In second case,

$$\frac{m \times C \times (51° - 49°)}{t}=\frac{-KA}{dx}\left[\left(\frac{51°+49°}{2}\right)-30°\right] \quad (ii)$$

Dividing equation (i) by equation (ii)

$\frac{t}{4}=\frac{30}{20}$ or $t = 6$ minutes.

121. (a) According to Newton's law of cooling,

$\frac{\theta_1-\theta_2}{t}=K\left[\frac{\theta_1+\theta_2}{2}-\theta_0\right]$

where θ_0 is the surrounding temperature.

$\therefore \frac{60-40}{7}=K\left(\frac{60+40}{2}-10\right)$

$\Rightarrow \frac{20}{7}=40K \Rightarrow K=\frac{1}{14}$

$\therefore \frac{40-28}{t}=K\left[\frac{40+28}{2}-10\right] \Rightarrow \frac{12}{t}=24K$

or $t=\frac{12}{24K}=\frac{12\times 14}{24}=7$ min

122. (c) Rate of colling $=\frac{-d\theta}{dt} \propto \left(\frac{\theta_1+\theta_2}{2}-\theta_0\right)$

In second case average temperature will be less hence rate of colling will be less. Therefore time taken will be more than 4 minutes.

123. (a) Initially at $t=0$

Rate of cooling (R) $\propto$ Fall in temperature of body $(\theta-\theta_0)$

$\Rightarrow \frac{R_1}{R_2}=\frac{\theta_1-\theta_0}{\theta_2-\theta_0}=\frac{100-40}{80-40}=\frac{3}{2}$