UNIT 7

Heat

INTRODUCTION

Heat is a kind of energy that gives us the sensation of hotness or coldness. SI unit of heat is joule (J).

Calorie is a C.G.S unit of heat. One calorie is the amount of heat required to raise the temperature of 1 g of water through 1°C.

One kilocalorie is the amount of heat required to raise the temperature of 1 kg of water through 1°C.

Temperature is the degree of hotness or coldness. It can be measured in °C or °F or K.

The difference between heat and temperature is given below:

	Heat	*Temperature*
1.	Heat is a form of energy.	1. Temperature is the degree of hotness or coldness of a body.
2.	Heat is the cause of temperature.	2. Temperature is the effect of heat.
3.	It does not determine the direction of flow of heat.	3. It does determine the direction of flow of heat.
4.	It is measured in joules.	4. It is measured in °C, °F and K.

Thermometer is a device to measure temperature.

Thermal equilibrium: When two bodies A and B are brought in thermal contact and there is no transfer of heat from A to B or B to A, they are said to be in thermal equilibrium.

Fahrenheit scale: On this scale the lower fixed point is 32°F and the upper fixed point is 212°F. It was given by the scientist named Fahrenheit.

Celsius scale: The lower fixed point on this scale is 0°C and the upper fixed point is 100°C.

Thermometric substance is that substance whose property is utilised for measuring temperature.

Principle of liquid thermometer: Liquids expand on heating and their expansion is generally regular and uniform.

Specific heat: It is the quantity of heat required to raise the temperature of 1 kg of a substance through 1°C. Its SI unit is $J\ kg^{-1}\ K^{-1}$.

Thermal capacity is the amount of heat required to raise the temperature of a body through 1°C. Its SI unit is $J\ K^{-1}$.

Flow of heat takes place from a body at higher temperature to a body at a lower temperature, when placed in thermal contact.

Specific heat depends upon the material of the body.

Heat absorbed or evolved depends upon mass, specific heat and the change in temperature.

Expansion of almost all materials takes place on heating due to the increase in their intermolecular distance.

Linear expansion: When increase in length, breadth or thickness is considered, the expansion is called linear expansion.

Coefficient of linear expansion is the increase in length per unit length per degree rise in temperature. Its unit is per °C and is denoted by α.

Coefficient of cubical (volumetric) expansion is the increase in volume per degree rise in temperature. It is denoted by γ.

Change of solid to liquid or liquid to gas and vice versa without any change in temperature is called change of state.

Latent heat is the hidden heat in the system. It is defined as the quantity of heat required to change its state without any change in its temperature. Its units are cal/g or J/kg or kcal/kg.

Latent heat of fusion of ice is the quantity of heat required to raise the temperature of 1 kg of ice at 0°C completely to 1 kg of water at the same temperature. Its value is 80 kcal/kg or 3.36×10^5 J/kg. **Latent heat of steam** is the quantity of heat required to raise the temperature of 1 kg of water at 100°C to steam at 100°C. Its value is 540 kcal/ kg or 2.27×10^6 J/kg.

Latent heat of solidification is the amount of heat given out by 1 kg of a liquid to fuse into solid state at its freezing point.

Relative humidity: It is the ratio of amount of water vapour actually present in a given volume of air at a certain temperature to the amount of water vapour required to saturate the same volume of air at the same temperature.

Mechanical equivalent of heat is the ratio of mechanical work to the heat produced. It is denoted by J.

Equilibrium temperature is that temperature attained by two bodies when they are brought in thermal contact with each other and a state of thermal equilibrium is attained.

Both evaporation and vaporisation involve a change of state but differ from each other in many ways:

Evaporation	Vaporisation
1. It takes place at all temperatures.	1. It takes place only at some fixed temperature.
2. It is a slow process.	2. It is a fast process.
3. It is almost a silent process.	3. It is mostly a violent process.
4. It only occurs at the surface of the liquid.	4. It occurs over the entire mass of the liquid.
5. The rate of evaporation depends upon the surface area of the liquid, wind speed, humidity and temperature.	5. The rate of boiling does not depend upon the surface area, wind speed, humidity and temperature.

Evaporation is an endothermic process. A liquid absorbs heat during evaporation. This heat is provided either by the liquid or by the surroundings. As the evaporating liquid absorbs heat from the liquid, the liquid itself cools down.

When the relative humidity is 100%, no evaporation is possible. During the rainy season, the RH is generally high. It must be kept in mind that both low and high relative humidities make people uncomfortable.

MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct choice amongst the following:

1. The unit for the coefficient of real expansion is
   (a) cm (b) cm/°C
   (c) cm °C (d) /°C
2. The unit for the coefficient of apparent expansion is
   (a) cm (b) cm/°C
   (c) cm°C (d) /°C
3. With the increase in temperature, the density of a substance, in general,
   (a) increases
   (b) decreases
   (c) first increase then decreases
   (d) first decrease then increases
4. A graph was plotted taking the temperature in °C along the X-axis and the corresponding temperature in Kelvin along the Y-axis. Which of the curves in Fig. 7.1 most correctly represents this behaviour?

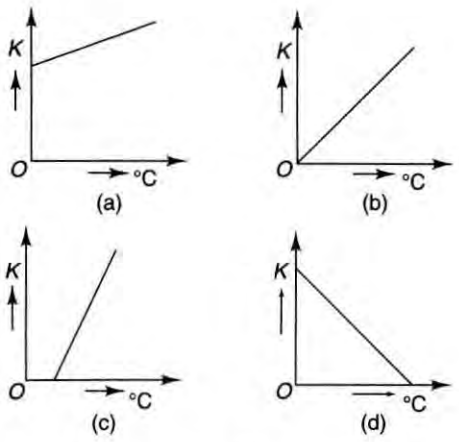

Fig. 7.1

5. If a graph is plotted taking the temperature in Fahrenheit along the Y-axis, and the corresponding temperature in Celsius along the X-axis, then the graph will be a straight line,
   (a) having a positive intercept on the Y-axis
   (b) having a positive intercept on the X-axis
   (c) passing through the origin
   (d) having negative intercepts on the X and Y axes
6. The normal temperature of the human body is
   (a) 37°C (b) 38°C
   (c) 36.8°C (d) none of these
7. Two spheres of the same size are made of the same metal, but one is hollow and the other is solid. They are heated to the same temperature. Then,
   (a) the hollow sphere will expand more
   (b) the solid sphere will expand more
   (c) both spheres will expand almost equally
   (d) only the solid sphere will expand
8. Water evaporates under atmospheric pressure. Without changing the temperature, the same water is placed in partial vacuum. The rate of evaporation will
   (a) increase (b) drop to zero
   (c) decrease (d) remain unaffected
9. A mercury thermometer, with a concave reflector behind the bulb, is placed in front of an electric fire. Which of the following combinations will cause the smallest reading on the thermometer?
   (a) black reflector, black bulb
   (b) black reflector, shiny bulb
   (c) shiny reflector, shiny bulb
   (d) temperature will remain same for any combination.
10. A block of wood is floating on water at 0°C, with a certain volume V above water level. The temperature of water is slowly raised from 0°C. How will the volume V change with the rise of temperature?
    (a) V will be unchanged
    (b) V will decrease from 0°C
    (c) V will decrease till 4°C and then increase
    (d) V will increase till 4°C and then decrease
11. The SI unit for the coefficient of linear expansion is
    (a) °C (b) per°C
    (c) $cm^2/°C$ (d) none of these
12. The SI unit for the coefficient of cubical expansion is
    (a) °C (b) per°C
    (c) cm/°C (d) none of these
13. Coefficient of linear expansion always _____ with the increase in temperature.
    (a) increases (b) decreases
    (c) remains the same (d) doubles itself
14. Choose the correct statement:
    (a) $\alpha:\beta:\gamma :: 1:3:2$ (b) $\alpha:\beta:\gamma :: 3:2:1$
    (c) $\alpha:\beta:\gamma :: 2:3:1$ (d) $\alpha:\beta:\gamma :: 1:2:3$
15. A thermometer is used to measure
    (a) heat (b) thermal capacity
    (c) water equivalent (d) temperature
16. A graph is plotted taking °C along the Y-axis and °F along the X-axis. It is a/an
    (a) parabola (b) straight line
    (c) ellipse (d) circle
17. A circular disc of copper has a symmetrical hole at its centre. The disc is uniformly heated. The diameter of the hole will
    (a) increase
    (b) decrease
    (c) remain the same
    (d) become indeterminate

18. When water is heated from 0°C, its volume
    (a) increases
    (b) decreases till 4°C
    (c) remains the same
    (d) first increases then decreases
19. The most commonly used thermometric substance is
    (a) water (b) alcohol
    (c) mercury (d) none of these
20. In summer, the clocks
    (a) become slow (b) become fast
    (c) gives correct time (d) lose time
21. Therm is the unit of
    (a) heat (b) temperature
    (c) thermometry (d) work
22. Absolute zero corresponds to
    (a) –273 K (b) 273°C
    (c) 273°R (d) none of these
23. If 10 g of ice at 0°C mixes with 10 g of water at 10°C, then the final temperature t is given by
    (a) $(10 \times 80) + 10(t-0) = 10(10-t)$
    (b) $10 \times 80 = 10(10-t) + 10(t-0)$
    (c) $t = 5°C$
    (d) $t = 0°C$
24. The temperature of water at the bottom of a large waterfall is higher than that of the water at the top, because
    (a) the falling water absorbs heat from the sun
    (b) the KE of the falling water is converted into heat
    (c) the water at the bottom has greater PE
    (d) rocks on the bed of the river give out heat
25. When salt is properly mixed with ice, the melting point of ice
    (a) is lowered (b) is raised
    (c) remains the same (d) becomes infinite
26. Steam at 100°C causes more severe burns than water at the same temperature because
    (a) steam is a gas
    (b) steam cannot do work
    (c) steam can provide more heat
    (d) steam is highly combustible
27. When an inflated type bursts, the air escaping out
    (a) will get heated up
    (b) will be cooled
    (c) will not undergo any change in its temperature
    (d) will be liquefied
28. A thermos bottle containing coffee is vigorously shaken. If the coffee is considered as a system, then the temperature of the coffee will
    (a) increase slightly
    (b) fall
    (c) remain the same
    (d) never be determined
29. A container having some gas was kept in a moving train. The temperature of the gas in the container will
    (a) increase slightly (c) remain the same
    (b) decrease (d) become infinite
30. Two glass tumblers have been stuck together (one into the other). They can be separated by
    (a) placing hot water in the inner tumbler
    (b) placing the tumblers in cold water
    (c) placing the outer tumbler in hot water
    (d) hammering them vigorously
31. The quantity of heat required to raise the temperature of 2000 g of water from 10°C to 50°C is
    (a) 80 cal (b) 80,000 cal
    (c) 8000 cal (d) none of these
32. A test tube containing some water is surrounded by melting ice (pure). Then, the water in the test tube will
    (a) not freeze into ice
    (b) freeze into ice
    (c) boil ultimately
    (d) become steam ultimately
33. Glaciers always melt at the _____ first.
    (a) top surface (b) sides
    (c) bottom (d) middle surface
34. Heat flows as a result of difference of
    (a) temperatures (b) weights
    (c) masses (d) none of these
35. The unit of specific heat is
    (a) cal°C (b) cal/g/°C
    (c) cal/g (d) none of these
36. The unit of thermal capacity is
    (a) cal/°C (b) cal/g
    (c) cal/g/°C (d) none of these

37. The unit of latent heat is
    (a) cal-g (b) cal/°C
    (c) cal/g (d) none of these
38. If the thermal capacity of a body is infinity, then
    (a) heat can never be added to it
    (b) heat can never be extracted from it
    (c) the temperature of the body cannot be altered by adding or extracting any amount of heat
    (d) it has infinite amount of heat
39. Calorimeters are generally made of
    (a) copper (b) brass
    (c) aluminium (d) zinc
40. When 1 *g* of water at 100°C gets converted into steam at the same temperature, the change in volume is approximately
    (a) 1 cc (b) 1000 cc
    (c) 1500 cc (d) 1670 cc
41. The amount of heat required for the above operation is
    (a) 380 cal (b) 500 cal
    (c) 4.2 cal (d) none of these
42. One joule is approximately equal to
    (a) 0.28 cal (b) 0.32 cal
    (c) 0.24 cal (d) 4.2 cal
43. *M* g of ice at 0°C is to be converted to water at 0°C. If *L* is the latent heat of fusion of ice, the quantity of heat required for the above operation would be
    (a) *ML* cal (b) $\frac{M}{L}$
    (c) $\frac{L}{M}$ cal (d) none of these
44. Two bodies *A* and *B* are said to be in thermal equilibrium with each other, if
    (a) heat flows from *A* to *B*
    (b) heat flows from *B* to *A*
    (c) both the bodies lose equal amounts of heat to the atmosphere
    (d) heat does not flow from either *A* or *B*
45. 100 g of ice at −15°C was heated. The rise in temperature of ice was plotted against the heat given to ice. Which of the following graphs (Fig. 7.2) correctly depicts this behaviour?

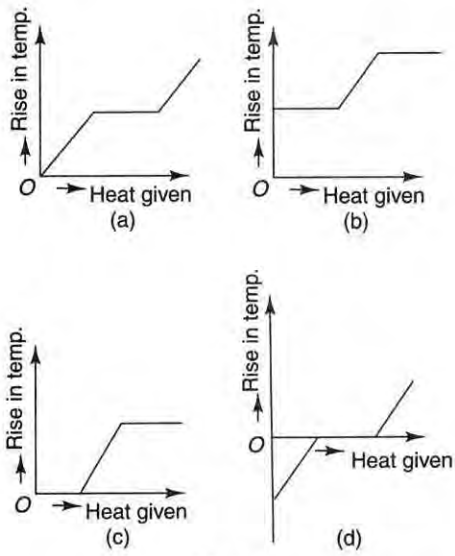

Fig. 7.2

46. If a substance contracts on heating, its coefficient of linear expansion is
    (a) +ve (b) −ve
    (c) zero (d) infinity
47. When air is saturated, it cannot hold
    (a) more water vapour
    (b) more air
    (c) more carbon dioxide
    (d) more oxygen
48. The units of RH are
    (a) kg–m^{-3} (b) kg
    (c) kg–m^2 (d) none of these
49. If RH is high
    (a) we feel sultry
    (b) we perspire less
    (c) clothes do not dry easily
    (d) all the above are correct
50. When it is raining, the dew point is
    (a) 0°C (c) 50°C
    (b) 100°C (d) room temperature
51. At dew point. RH is
    (a) 10% (b) 20%
    (c) 50% (d) 100%
52. The most comfortable value for RH is about
    (a) 10% (b) 30%
    (c) 50% (d) 90%

53. When the temperature of water rises, the rate of evaporation
    (a) increases
    (b) decreases
    (c) remains the same
    (d) first decrease then increases
54. The first thermometer was developed by
    (a) Joule (b) Fahrenheit
    (c) Galileo (d) Watt
55. Burning of a meteorite in the earth's atmosphere is an example of change of
    (a) heat energy into kinetic energy
    (b) kinetic energy into heat energy
    (c) kinetic energy into potential energy
    (d) potential energy into heat energy
56. Heat given (H) to a substance was plotted against rise in temperature (θ). Which of the following parts of the graph (Fig. 7.3), most correctly depicts the latent heat of the substance?

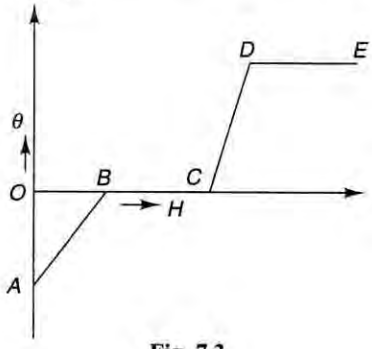

Fig. 7.3

    (a) AB (b) BC only
    (c) CD (d) BC and DE
57. Soda bottles are made of thick glass so that they can withstand the
    (a) pressure in summer
    (b) temperature in summer
    (c) decrease in viscosity
    (d) increase in potential energy
58. The relative humidity is 50%, if air contains about
    (a) 2.55 g of water vapour at 40°C
    (b) 25.5 g of water vapour at 40°C
    (c) 2.55 kg of water vapour at 40°C
    (d) 25.5 kg of water vapour at 40°C
59. Relative humidity is the percentage of the
    (a) absolute humidity value to the amount of humidity actually present
    (b) increase of humidity/absolute humidity
    (c) amount of humidity actually present to the absolute humidity
    (d) none of these
60. Evaporation is the process of changing liquid into vapour
    (a) at any temperature
    (b) above its boiling point
    (c) at its boiling point
    (d) below its boiling point
61. When we cool a gas below its condensation point, the KE of its molecules
    (a) increases
    (b) decreases
    (c) remains the same
    (d) first increases then decreases
62. A piece of ice at 0°C is added to a vessel containing water at 0°C, then
    (a) all of the ice will melt
    (b) some ice will melt
    (c) no ice will melt
    (d) the temperature will decrease further
63. At high temperature, the molecules of a substance
    (a) move more vigorously
    (b) move less vigorously
    (c) become stationary
    (d) are attracted strongly
64. Fahrenheit scale divides two fixed points into
    (a) 180 parts (b) 212 parts
    (c) 100 parts (d) 32 parts
65. Celsius scale divides two fixed points into
    (a) 180 parts (b) 212 parts
    (c) 100 parts (d) 32 parts
66. In hot water bottles, water is used because
    (a) its specific heat is low
    (b) its specific heat is high
    (c) it is cheap
    (d) it is easily available
67. Two rods, one of iron and the other of aluminium, are heated to the same temperature. Then,
    (a) the iron rod will expand less
    (b) the iron rod will expand more
    (c) both rods will expand equally
    (d) the iron rod will not expand at all

68. When steam condenses into water its
(a) temperature remains the same
(b) heat dissipates
(c) temperature increases
(d) temperature decreases

69. Two blocks of steel A and B, A being two times heavier than B, are at 40°C. The ratio of heat content of A to B is
(a) 1 (b) 4
(c) 2 (d) $\frac{1}{2}$

70. When 60 calories of heat are supplied to 15 g of water, the rise in temperature is
(a) 75°C (b) 900°C
(c) 4°C (d) 0.25°C

71. A 10 kg storage battery has an average specific heat of 0.2 kcal/kg°C. When fully charged, the energy content of the battery is 1 kcal. If the entire energy were used to raise the temperature, then the temperature would increase by
(a) 0.2°C (b) 0.5°C
(c) 200°C (d) 20°C

72. Water in a container is heated from 0°C to 10°C. Its volume
(a) increases for the full given range (from 0°C to 10°C)
(b) decreases up to 4°C, then increases
(c) increases up to 4°C, then decreases
(d) decreases for the full range (from 0°C to 10°C)

73. 233 K is equal to
(a) 40°F (b) −40°F
(c) 172°F (d) −172°F

74. The volume of mole of a perfect gas at NTP is
(a) 22.4 litres (b) 2.24 litres
(c) 100 litres (d) none of these

75. −40°F on absolute scale is equal to
(a) 0 K (b) 233 K
(c) 273 K (d) 313 K

76. A temperature difference of 27°C on the Kelvin scale is
(a) 27 K (b) 300 K
(c) −246 K (d) zero

77. A temperature difference of 15°C on the Fahrenheit scale is
(a) 27°F (b) 59°F
(c) −27 °F (d) −59°F

78. At what temperature do the Fahrenheit and Celsius scales give the same reading?
(a) − 40° (b) 0°
(c) 574.25° (d) 273°

79. When 1 g of ice melts at 0°C
(a) 80 cal of heat is liberated
(b) 80 cal of heat is absorbed
(c) no heat is required
(d) none of these

80. A beaker contains 40 g of water at 20°C. Now 50 g of ice is put into the beaker. The resulting temperature will be
(a) −7°C (b) 0°C
(c) 10°C (d) 1.5°C

81. 5 g of ice at 0°C and 20 g of water at 45°C are mixed. The temperature of the mixture will be
(a) 10°C (b) 20°C
(c) 30°C (d) 40°C

82. The amount of heat required to raise the temperature of a body by 1°C is called
(a) latent heat (b) specific heat
(c) thermal capacity (d) none of these

83. If the temperature scale is changed from °C to °F, the numerical value of specific heat will
(a) increase
(b) decrease
(c) remain unchanged
(d) nothing can be said

84. The amount of heat required to convert 1 g of ice (specific 0.5 cal $g^{-1}°C^{-1}$) at −10°C to steam at 100°C is
(a) 721 cal (b) 636 cal
(c) 716 cal (d) none of these

85. How much ice must be added to 100 g water at 30°C in order to reduce its temperature to 20°C?
(a) 10 g (b) 80 g
(c) 400 g (d) None of these

86. Two liquids have the densities in the ratio of 1 : 2 and specific heats in the ratio of 2 : 1. The ratio of thermal capacity of equal volume of those liquids is
(a) 1 : 1 (b) 1 : 4
(c) 4 : 1 (d) 2 : 1

87. Which of the following substances has greatest specific heat?
(a) iron (b) water
(c) copper (d) mercury

88. When temperature is gradually decreased, the specific heat of a substance is
(a) decreased
(b) increased
(c) remain unchanged
(d) nothing can be said

89. 2 kg ice at 0°C is mixed with 8 kg of water at 20°C. The final temperature is
(a) 0°C (b) 20°C
(c) 80°C (d) none of these

90. Two bodies are in thermal equilibrium if they have same
(a) temperature (b) amount of heat
(c) specific heat (d) thermal capacity

91. *A* piece of ice at 0°C is put into a vessel containing water at 0°C. The ice will
(a) melt (b) not melt
(c) slightly melt (d) vanish in no time

92. A fan produces a feeling of comfort during hot weather because
(a) fan supplies cold air
(b) our perspiration evaporates rapidly
(c) our body radiates more heat in air
(d) conductivity of air increases

93. Freezing mixture is a mixture
(a) which solidifies water
(b) freezes at 0°C
(c) which produces very low temperature
(d) which is used in medicine

94. The water can be made to boil even at 0°C if the pressure of surroundings is
(a) 76 cm of Hg (b) 5 cm of Hg
(c) 0.1 cm of Hg (d) 4.6 mm of Hg

95. The saturated vapour pressure of water at 100°C is
(a) 750 mm of Hg (b) 760 mm of Hg
(c) 76 mm of Hg (d) 7.6 mm of Hg

ANSWERS

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