SOLVED EXAMPLE

Ex.1 1 g of steam at 100°C can melt how much ice at 0°C? Latent heat of ice = 80 cal/g and latent heat of steam = 540 cal/g.

Sol. Heat required by ice for melting of m g of ice = mL = m × 80 cal

Heat available with steam for being condensed and then brought to 0°C

= 1 × 540 × 100

= 640 cal

m × 80 = 640

or $m = \frac{640}{80} = 8\,\text{grams}$

Ex. 2 A tap supplies water at 10°C and another tap at 100°C. How much hot water must be taken so that we get 20 kg of water at 35°C ?

Sol. Let mass of hot water = m kg

mass of cold water

= (20 – m) kg

Heat taken by cold water

= (20 – m) × 1 × (35 – 10)

Heat given by hot water

= m × 1 × (100 –35)

Law of mixture gives

Heat given by hot water

= Heat taken by cold water

m × 1 × (100 – 35) = (20 – m) × (35 – 10)

65 m = (20 – m) × 25

65 m = 500 – 25 m

or 90 m = 500

$m = \frac{500}{90} = 5.56$ kg

Ex. 3 5 g of ice at 0°C is dropped in a beaker containing 20 g of water at 40°C. What will be the final temperature ?

Sol. Let final temperature be = θ

Heat taken by ice = $m_1L + m_1c_1\Delta\theta_1$

= 5 × 80 + 5 × 1 (θ – 0)

= 400 + 5θ

Heat given by water at 40°C

= $m_2c_2\Delta\theta_2$ = 20 × 1 × (40 – θ)

= 800 – 20 θ

As Heat given = Heat taken

800 – 20 θ = 400 + 5 θ

20 θ = 400

$\theta = \frac{400}{25} = 16°$ C

Ex. 4 5 g ice of 0°C is mixed with 5 g of steam at 100°C. What is the final temperature ?

Sol. Heat required by ice to raise its temperature to 100°C,

$Q_1 = m_1L_1 + m_1c_1\Delta\theta_1$

= 5 × 80 + 5 × 1 × 100

= 400 + 500 = 900 cal

Heat given by steam when condensed,

$Q_2 = m_2L_2$

= 5 × 536 = 2680 cal

As $Q_2 > Q_1$. This means that whole steam is not even condensed.

Hence temperature of mixture will remain at 100°C.

LEVEL # 1

Questions based on Basic definition

Q.1 The amount of heat required to raise the temperature of 1 kg of water through 1°C is called -
(A) kilocalorie (B) calorie
(C) B.T.U. (D) calorie/°C

Q.2 Two spheres made of same substance have diameters in the ratio 1 : 2. Their thermal capacities are in the ratio of -
(A) 1 : 2 (B) 1: 8 (C) 1: 4 (D) 2 : 1

Q.3 The amount of heat required to change the state of 1 kg of substance at constant temperature is called –
(A) kilo cal (B) calorie
(C) specific heat (D) latent heat

Q.4 The water equivalent of a 400 g copper calorimeter (specific heat = 0.1 cal/g°C) –
(A) 40 g (B) 4000 g
(C) 200 g (D) 4 g

Q.5 The thermal capacity of 40 g of aluminium (specific heat = 0.2 cal/gm°C) –
(A) 40 cal/°C (B) 160 cal/°C
(C) 200 cal/°C (D) 8 cal/°C

Q.6 A ball of mass 20 g and specific heat capacity 0.1 cal/g –ºC. The water equivalent of ball is -
(A) 2g (B) 4g (C) 6g (D) 5g

Q.7 The heat capacity of a metal is 4200 J/k. Its water equivalent is -
(A) 0.5 kg (B) 1 kg
(C) 1.5 kg (D) 2 kg

Q.8 How much heat energy is gained when 5 kg of water at 20ºC is brought to its boiling point ?
(A) 1680 kJ (B) 1700 kJ
(C) 1720 kJ (D) 1740 kJ

Q.9 The amount of heat required to raise the temperature of a body from 20ºC to 60º C is (water equivalent of body is 10 gm).
(A) 200 cal (B) 300 cal
(C) 400 cal (D) 500 cal

Questions based on Specific heat of gas

Q.10 The value of specific heat of an ideal gas, with rise in temperature -
(A) Increases (B) Decreases
(C) Is independent (D) None of these

Q.11 The specific heat of a gas -
(A) Has only two values C_p and C_v
(B) Has only one value at a specific temperature
(C) May have any value between 0 and ∞
(D) Depends on the mass of the gas.

Q.12 Experiments were carried out by the students for determination of values of C_p and C_v in cal/mole K, the following pair is correct -
(A) $C_v = 2, C_p = 1$ (B) $C_v = 4, C_p = 5$
(C) $C_v = 3, C_p = 4$ (D) $C_v = 3, C_p = 5$

Q.13 The ratio of C_p of a mono-atomic gas and C_v of a diatomic gas is -
(A) 3 : 5 (B) 5 : 3 (C) 1 : 1 (D) 7 : 5

Q.14 The approximate value of C_v of 1 gm helium gas is -
(A) 3/4 cal/gmºC (B) 3 cal/gmºC
(C) 3/2 cal/gmºC (D) 2/3 cal/gmºC

Q.15 With the rise in atomicity of a gas the ratio of specific heats of a gas -
(A) Increase
(B) Decrease
(C) Remains unchanged
(D) May increase or decrease

Q.16 The specific heat of gas under constant pressure is 7/2 R, the gas is -
(A) Mono- atomic (B) Diatomic
(C) Tri-atomic (D) Ideal

Q.17 On mixing 1 mole of He and 1 mole of oxygen, the value of molar specific heat at constant volume is-
(A) R (B) 2R (C) 3R (D) 4R

Q.18 In the above question, the value of molar specific heat at constant pressure will be -
(A) R (B) 2R (C) 3R (D) 4R

Questions based on Principle of calorimetry

Q.19 Two liquids A and B are at 32ºC and 24ºC. When mixed in equal masses the temperature of the mixture is found to be 28ºC. Their specific heats are in the ratio of –
(A) 3 : 2 (B) 2 : 3 (C) 1 : 1 (D) 4 : 3

Q.20 A liquid of mass m and specific heat c is heated to a temperature 2T. Another liquid of mass m/2 and specific heat 2c is heated to a temperature T. If these two liquids are mixed, the resulting temperature of the mixture is –
(A) (2/3)T (B) (8/5)T (C) (3/5)T (D) (3/2)T

Q.21 The temperature of equal masses of three different liquids A, B and C are 12ºC, 19ºC and 28ºC respectively. The temperature when A and B are mixed is 16ºC, when B and C are mixed is 23ºC; what is the temperature when A and C are mixed ?
(A) 31ºC (B) 20.26ºC
(C) 19.5ºC (D) 28ºC

Questions based on Latent heat and phase change

Q.22 One kg of ice at 0°C is mixed with 1 kg of water at 10°C. The resulting temperature will be
(A) between 0°C and 10°C
(B) 0°C
(C) less than 0°C
(D) greater than 0°C

Q.23 If 10 g of ice at 0°C is mixed with 10 g of water at 40°C, the final mass of water in the mixture is
(A) 10 g (B) 15 g (C) 18 g (D) 20 g

Q.24 540 g of ice at 0°C is mixed with 540 g of water at 80°C. The final temperature of the mixture is
(A) 0°C (B) 40°C
(C) 80°C (D) less than 0°C

Q.25 Steam at 100°C is passed into 2.0 kg of water contained in a calorimeter of water equivalent 0.02 kg at 15°C till the temperature of the calorimeter and its contents rises to 95°C. The mass of steam condensed in kg is
(A) 0.301 (B) 0.298 (C) 0.60 (D) 2.02

Q.26 10 gm of ice at – 20ºC is added to 10 gm of water at 50ºC. Specific heat of water = 1 cal/g–ºC, specific heat of ice = 0.5 cal/gm-ºC. Latent heat of ice = 80 cal/gm. Then resulting temperature is -
(A) –20ºC (B) 15ºC (C) 0ºC (D) 50ºC

Q.27 5 gm of steam at 100ºC is passed into six gm of ice at 0ºC. If the latent heats of steam and ice in cal per gm are 540 and 80 respectively, then the final temperature is -
(A) 0ºC (B) 100ºC (C) 50ºC (D) 30ºC

Questions based on Heat

Q.28 Heat is –
(A) The amount of internal energy contained in a body
(B) Equal to msθ (where m = mass, s = specific heat and θ = temperature of the body)
(C) The sum of kinetic and potential energy of molecules of the body
(D) The amount of internal energy flowing from a body at higher temperature

Q.29 If C_p and C_v are gram specific heats at constant pressure and constant volume respectively, then it is found that for hydrogen $C_p – C_v$ = a and for oxygen $C_p – C_v$ = b. The relation between a and b is –
(A) a = b (B) a = 4b
(C) a = 16b (D) 16a = b

Q.30 11 grams of carbondioxide are heated at constant pressure from 27ºC to 227ºC. The amount of heat transferred to carbondioxide will be
(A) 110 Calorie (B) 220 Calorie
(C) 450 Calorie (D) 2200 Calorie

Q.31 1 gram of ice at 0ºC is converted to steam at 100ºC. The amount of heat required will be
(A) 756 Calorie (B) 12000 Calorie
(C) 716 Calorie (D) 450 Calorie

Q.32 When the temperature of an iron sphere of mass 1kg. falls from 30ºC to 25º C, then 550 calories of heat are released The heat capacity of iron sphere will be in Cal/ºC
(A) 110 (B) 220 (C) 330 (D) 440

Q.33 In the above problem the specific heat of iron will be -
(A) 0.72 (B) 0.33 (C) 0.11 (D) 0.44

Q.34 The amount of heat required to increase the temperature of 1 mole of an ideal gas through 10K at constant pressure is 207 joule. Keeping the same gas at constant volume, the amount of heat required to increase its temperature through 10K will be -
(A) 124 Joule (B) 215.3 joule
(C) 29 Joule (D) 198.7 Joule

THERMAL EXPANSION

Ex.1 A clock which keeps correct time at 25ºC has a pendulum made of brass whose coefficient of linear expansion is 0.000019. How many seconds a day will it gain if the temperature fall to 0ºC.

Sol. Let L_0 and L_{25} be the length of pendulum at 0ºC and 25ºC respectively.

We know that

$L_{25} = L_0(1 + \alpha T)$

$= L_0(1 + 0.000019 \times 25) = 1.000475\ L_0$

If T_{25} and T_0 be the time periods at 25ºC and 0ºC respectively, then

$$T_{25} = 2\pi\sqrt{\left(\frac{L_{25}}{g}\right)} \text{ and } T_0 = 2\pi\sqrt{\left(\frac{L_0}{g}\right)}$$

$$\therefore \quad \frac{T_{25}}{T_0} = \sqrt{\left(\frac{L_{25}}{L_0}\right)} = \sqrt{\left(\frac{1.000475L_0}{L_0}\right)}$$

$$= \sqrt{(1.000475)} = 1.000237.$$

Now $\dfrac{T_{25} - T_0}{T_0} = 0.000237.$

$\therefore$ Gain in time for one vibration

$= 2 \times 0.000237$ sec.

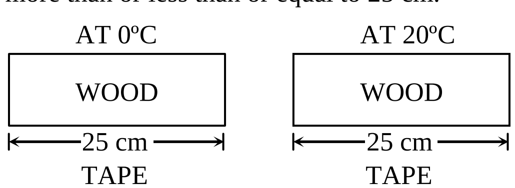
Number of vibration in one day

$$= \frac{24 \times 60 \times 60}{2} \text{ sec. } (\because T = 2 \text{ sec.})$$

Hence, the gain in time in one day

$$= 2 \times 0.000237 \times \frac{24 \times 60 \times 60}{2} = 20.52 \text{ sec.}$$

Ex. 2 A steel tape gives correct reading at 20°C. A piece of wood is being measured with the steel tape at 0°C. The reading is 25 cm on the tape. State whether the real length of the wood is more than or less than or equal to 25 cm.



Sol. The steel expands on heating and contracts on cooling. Given that tape gives correct reading at 20°C. At 0°C. the tape contracts. The situations at 0°C and 20°C are shown in figure. Obviously real length of the wood is less than 25 cm.

Ex.3 A metal disc has a hole in it. What happens to size of hole when disc is heated?

Sol. On heating the size of hole increases.

Ex.4 A circular hole in an aluminium plate is 2.54 cm in diameter at 0°C. What is the diameter when the temperature of the plate is raised to 100°C ? Given

$\alpha_{Al} = 2.3 \times 10^{-5}\ (°C)^{-1}$

Sol. Let D_o and D_t be diameters of hole at 0°C and t°C respectively.

Circumference of hole at 0°C

$\ell = 2\pi r_0 = \pi D_0$

Circumference of hole at t = 100° C

$\ell t = 2\pi r_t = \pi D_t$

From relation $\ell_t = \ell_0\ (1 + \alpha.t)$, we get

$\pi D_t = \pi D_0(1 + 2.3 \times 10^{-5} \times 100)$

$D_t = 2.54\ (1 + 0.0023)$

$= 2.5458$ cm.

Ex.5 A pendulum clock keeps correct time at 0°C. Mean coefficient of linear expansion is α per °C. If the temperature of the room increases by t°C, then show that the clock loses per day by $\frac{1}{2}\alpha t \times 86400$.

Sol. Let L_0 be length at 0°C and L_1 that at t°C. If T_0 and T_1 are time periods at 0°C and t°C respectively, then

$$T_0 = 2\pi\sqrt{\frac{L_0}{g}} \text{ and } T_t = 2\pi\sqrt{\frac{L_t}{g}}$$

$\therefore$ Dividing

$$\frac{T_t}{T_0} = \sqrt{\frac{L_t}{L_0}} = \sqrt{\frac{L_0(1+\alpha t)}{L_0}} = (1+\alpha t)^{1/2} \quad ..(1)$$

[For section pendulum time period is 2 sec i.e. $T_0/2 = 1$ sec.]

If n_0 and n_t are number of seconds in one day, then

$$n_t \frac{T_t}{2} = n_0 \frac{T_0}{2} \Rightarrow \frac{T_t}{T_0} = \frac{n_0}{n_t}$$

From (1)

$$\frac{n_0}{n_t} = (1+\alpha_t)^{1/2} = \left(1-\frac{1}{2}\alpha t\right)$$

or $\frac{n_0}{n_t} - 1 = -\frac{1}{2}\alpha t$

or $\frac{n_t - n_0}{n_0} = -\frac{1}{2}\alpha t$

or $n_t - n_0 = -\frac{1}{2}\alpha t\, n_0$

But $n_0 = 24 \times 60 \times 60 = 86400$

$$nt = -\frac{1}{2}\alpha t \times 86400$$

Negative sign shows that the clock loses time.

Ex.6 If the volume of a block of a metal changes by 0.12% when it is heated through 20°C, what is the coefficient of linear expansion of metal?

Sol. Coefficient of cubical expansion of metal is given by

$$\gamma = \frac{\Delta V}{Vt}$$

$$\frac{\Delta V}{V} = \frac{0.12}{100}, \ t = 20°C$$

$$\therefore \quad \gamma = \frac{0.12}{100 \times 20} = 6.0 \times 10^{-5} \text{ per °C}$$

Coefficient of linear expansion

$$\alpha = \frac{\gamma}{3} = \frac{6.0 \times 10^{-5}}{3} = 2.0 \times 10^{-5} \text{ Per °C}$$

Questions based on Thermal expansion

Q.1 An iron ball is heated. The percentage increase will be the largest in –

(A) diameter (B) surface area

(C) volume (D) density

Q.2 Two holes of unequal diameters d_1 and d_2 $(d_1 > d_2)$ are cut in a metal sheet. If the sheet is heated–

(A) Both d_1 and d_2 will decrease

(B) Both d_1 and d_2 will increase

(C) d_1 will increase, d_2 will decrease

(D) d_1 will decrease, d_2 will increase

Questions based on Differential expansion of two solid

Q.3 Two rods of lengths ℓ_1 and ℓ_2 are made of materials whose coefficient of linear expansions are α_1 and α_2. If the difference between two lengths is independent of temperature–

(A) $\frac{\ell_1}{\ell_2} = \frac{\alpha_1}{\alpha_2}$ (B) $\frac{\ell_1}{\ell_2} = \frac{\alpha_2}{\alpha_1}$

(C) $\ell_2^2\alpha_1 = \ell_1^2\alpha_2$ (D) $\frac{\alpha_1^2}{\ell_1} = \frac{\alpha_2^2}{\ell_2}$

Q.4 The coefficient of linear expansion of steel and brass are 11×10^{-6}/ºC and 19×10^{-6}/ºC respectively. If their difference in lengths at all temperatures has to be kept constant at 30 cm, their lengths at 0ºC should be –

(A) 71.25cm and 41.25cm

(B) 82 cm and 52 cm

(C) 92 cm and 62 cm

(D) 62.25 cm and 32.25 cm

Q.5 A metallic bar is heated from 0ºC to 100ºC. The coefficient of linear expansion is 10^{-6} K^{-1}. What will be the percentage increase in length–

(A) 0.01% (B) 0.1%

(C) 1% (D) 10%

Questions based on Thermal stress

Q. 6 A metal wire of length ℓ and area of cross-section A is fixed between rigid supports at negligible tension. If this is cooled, the tension in the wire will be –

(A) Proportional to ℓ

(B) Inversely proportional to ℓ

(C) Independent of ℓ

(D) Independent of A

Q.7 Two rods of different material having co-efficient of linear expansion α_1 & α_2 and young's modulus γ_1 & γ_2 respectively are fixed between two rigid support . The rods are cooled by same temperature change. If $\alpha_1 : \alpha_2 \Rightarrow 2 : 3$ & thermal stress are equal, then find γ_1 / γ_2 .

(A) 2 : 3 (B) 1 : 1

(C) 3 : 2 (D) 4 : 9

Questions based on Bimettalic strip

Q. 8 If a bimetallic strip is heated, it will

(A) bend towards the metal with lower thermal expansion coefficient

(B) bend towards the metal with higher thermal expansion coefficient

(C) not bend at all

(D) twist itself into a helix

Questions based on Pendulum clock

Q.9 The temperature of a pendulum, the time period of which is t, is raised by ΔT. The change in its time period is :

(A) $\frac{1}{2}\alpha t\ \Delta T$ (B) $2\alpha t\ \Delta T$

(C) $\frac{1}{2}\alpha\ \Delta T$ (D) $2\alpha\Delta T$

Q.10 A pendulum clock is 5 sec fast at temperature of 15ºC and 10 sec slow at a temperature of 30ºC. At what temperature does it give the correct time –

(A) 18ºC (B) 20ºC
(C) 22ºC (D) 25ºC

Q.11 A pendulum clock has an iron pendulum 1m long ($\alpha_{iron} = 10^{-5}$/ºC). If the temperature rises by 10ºC, the clock–
(A) Will lose 8 seconds per day
(B) Will lose 4.32 seconds per day
(C) Will gain 8 seconds per day
(D) Will gain 4.32 seconds per day

Q.12 A second's pendulum clock having steel wire is calibrated at 20ºC. When temperature is increased to 30ºC, then how much time does the clock lose or gain in one week ?
[$\alpha_{steel} = 1.2 \times 10^{-5}$(ºC)$^{-1}$] :
(A) 0.3628 s (B) 3.626 s
(C) 362.8 s (D) 36.28 s

Questions based on **Superficial and volume expansion of solid**

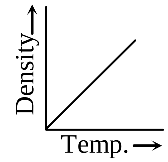
Q.13 If the length of a cylinder on heating increases by 2%, the area of its base will increase by –
(A) 0.5% (B) 2%
(C) 1% (D) 4%

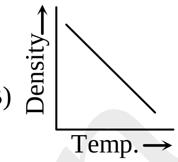
Q.14 A solid ball of metal has a spherical cavity inside it. If the ball is heated, the volume of the cavity will–
(A) Increase
(B) Decrease
(C) Remains unchanged
(D) Have its shape changed

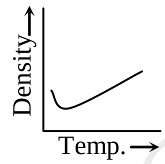
Q.15 If α, β, γ are linear, superficial and cubical expansivity of a solid, then–
(A) α : β : γ = 1 : 2 : 3
(B) α : β : γ = 3 : 2 : 1
(C) α : β : γ = 2 : 3 : 1
(D) α : β : γ = 3 : 1 : 2

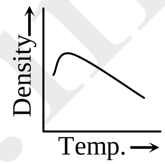
Q.16 The volume of a solid decreases by 0.6% when it is cooled through 50ºC. Its coefficient of linear expansion is –
(A) 4×10^{-6} K (B) 5×10^{-5} K
(C) 6×10^{-4} K (D) 4×10^{-5} K

Q.17 Which of the following curve represent variation of density of water with temperature best –

(A) 

(B) 

(C) 

(D) 

Q.18 Density of substance at 0ºC is 10 gm/cc and at 100ºC, its density is 9.7 gm/cc. The coefficient of linear expansion of the substance will be –
(A) 10^{2} (B) 10^{-2}
(C)10^{-3} (D) 10^{-4}

Q. 19 A rectangular block is heated from 0°C to 100°C. The percentage increase in its length is 0.10%. What will e the percentage increase in it volume?
(A) 0.03% (B) 0.10%
(C) 0.30% (D) None of these

Q. 20 A thin copper wire of length ℓ increases in length by 1% when heated from 0°C to 100°C. If a then cooper plate of area 2l × l is heated from 0°C to 100°C, the percentage increase in its area will be –
(A) 1% (B) 2%
(C) 3% (D) 4%