TOPIC : CALORIMETRY & THERMAL EXPANSION
EXERCISE # 1

SECTION (A)

2. Water equivalent = m × s = 400 × 0.1 = 40g

3. heat required = 1 × 80 + 1 × 1 × 100 + 1 × 540 = 720 cal

4. Thermal capacity = m × s = 40 × 0.2 = 8 cal/°C

5. s = $\frac{\Delta\theta}{m \times \Delta\theta} = \infty$ {Δθ = 0}

6. Resultant temperature is 0°C because entire ice will not melt.

7. Heat required to melt 1 gm ice = 80 cal.
∴ to melt 10 gm
Heat required = 800 cals.
but heat available = 400 calories
So the ice melt = 5gm
Total water = 10 + 5 = 15 gm

8. We know that heat lost = mcθ
For a given quantity of heat, we must need a minimum mass of water for cooling the radiators due to a high value of specific heat.

9. (Water + caloriemetry) From 15°c to 90°c. Heat required to raise temperature of
Heat required
$\Delta Q_1 = 2000 \times 1 \times (90 - 15) + 0.02 \times 1000\,(90 - 15)$
$\Delta Q_2 = m \times 540 + m \times (100 - 90)$
$\Delta Q_1 = \Delta Q_2$
2000 × 75 + 20 × 75 = m[540 + 10]

$$m = \frac{(2000 \times 20) \times 75}{550} = \frac{202 \times 75}{55} \text{ gm}$$
$$= \frac{3030}{11} = 0.280 \text{ kg}$$

10. $mc\theta = m_iL \quad \Rightarrow \quad m_i = \frac{mc\theta}{L}$

11. For minimum value of m, the final temperature of the mixture must be 0°C.
$\therefore 20 \times \frac{1}{2} \times 10 + 20 \times 80 = m\,540 + m.1.\,100$
$\therefore m = \frac{1700}{640} = \frac{85}{32}$ gm.

12. ΔU = ΔQ = 300 cal.
$\Delta U = \frac{300}{50} = 6$ cal.

13. Q = m.s. Δθ = 5 × (1000 × 4.2) × (100 – 20)
= 180 × 10^3 J = 1680 J

14. When two gases are mixed together then Heat lost by the Helium gas = Heat gained by the Nitrogen gas

$\mu_B \times (C_v)_{He} \times \left(\frac{7}{3}T_0 - T_f\right) = \mu_A \times (C_v)_{N2} \times (T_f - T_0)$

Box A: 1 mole N_2, Temperature = T_0

Box B: 1 mole He, Temperature = $\frac{7}{3}T_0$

$$1 \times \frac{3}{2}R \times \left(\frac{7}{3}T_0 - T_f\right) = 1 \times \frac{5}{2}R \times (T_0 - T_f)$$

By solving we get $T_f = \frac{3}{2}T_0$

15. Stem at 100°C contains extra 540 calorie/gm energy as compare to water at 100°C. So it's more dangerous to burn with steam than water.

16. Thermoelectric thermometer has low heat capacity and so is used for finding rapidly varying temperature.

17. Heat required by 1g ice at 0°C to melt into 1g water at 0°C,

$Q_1 = mL$ (L = latent heat of fusion)

$= 1 \times 80 = 80$ cal (L = 80 cal/g)

Heat required by 1g of water at 0°C to boil at 100°C,

$Q_2 = ms\Delta\theta$ (s = specific heat of water)

$= 1 \times 1(100 - 0)$ (s = 1 cal/g°C)

$= 100$ cal

Thus total heat required by 1g of ice to reach a temperature of 100°C,

$Q = Q_1 + Q_2$

$= 80 + 100 = 180$ cal

heat available with 1g of steam to condense into 1g of water at 100°C

$Q' = mL'$ (L' = latent heat of vaporisation)

$= 1 \times 536$ cal (L' = 536 cal/g)

$= 536$ cal

Obviously, the whole steam will not be condensed and ice will attain temperature of 100°C. Thus, the mixture of temperature is 100°C

18. Amount of heat required to convert 1 gm ice → 1 gm steam

= (80 + 100 + 536) = 716 calories.

19. Temperature of mixture = 0°C

ice will not melt completely

20. Heat required to convert 0ºC of ice into water = mL (L = Letent heat)

Now, heat required to rise the temperature of water from 0ºC to 100ºC.

$= ms\,\Delta t$

where s = specific heat, Δt = temperature rise

Total heat $= mL + ms\,\Delta t$

$= 1 \times 80 + 1 \times 1 \times (100 - 0)$

$= 180$ cal

21. Latent heat = 536 cal/g

$= 536 \times 4.2 \times 1000$ J/kg

$= 2.25 \times 10^6$ J/kg

24. Volume expansion coefficient is inversely proportional to temperature

25. According to calorimetery principle,

heat given = heat taken

$m_1s_1(100 - t) = mL + m_2s_2(t - 0)$

$50 \times 1 (100 - t) = 50 \times 80 + 50 \times 1(t - 0)$
$t = 10°C$

26. When the bottle is taken on the moon, then nothing will happen to water, because neither it will emit heat nor absorb, because there is no atmosphere on the moon.

27. Work required = $+(1 \times 0.5 \times 10 + 1 \times 80 + 1 \times 100 + 540) \times 4.2 = 3045$ J

28. Heat capacity

$$H = ms = \frac{4}{3}\pi r^3 \rho s$$

For same material, density ρ and specific heat s are same, so heat capacity

$H \propto r^3$

Hence, the ratio of heat capacities is

$$\frac{H_1}{H_2} = \left(\frac{r_1}{r_2}\right)^3 = \left(\frac{1}{4}\right)^3 = \frac{1}{64}$$

29. As we know that thermal capacity of a substance is defined as the amount of heat required to raise its temperature by 1ºC.

30. According to the mass-energy equivalence, mass and energy remain conserved. So, when water is cooled to from ice, water loses its energy so, change in energy increases the mass of water.

31. The temperature of ice will first increase from – 10°C to 0°C. Heat supplied in this process will be :

$Q_1 = mS_i (10)$ m = mass of ice

S_i = specific heat of ice

Then ice starts melting. Temperature during melting will remain constant (0ºC)

Heat supplied in the process will be

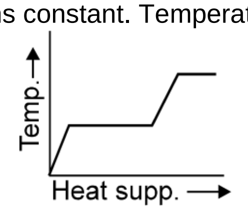
$Q_2 = mL$ L = Latent heat of melting

Now the temperature of water will increase from 0°C to 100°C. Heat supplied will be :

$Q_3 = mS_w (100)$

S_w = Specific heat of water

Finally water at 100°C will be converted into steam t 100°C and during this process temperature again remains constant. Temperature versus heat supplied graph will be as follows :



32. Amount of heat taken by ice at 0°C to melt

$Q_1 = mL = 540 \times 80 = 43200$ cal.

Heat given out by water

$Q_2 = m \times s \times \Delta\theta = 540 \times 1 \times (80 - 0) = 43200$ cal.

Heat given out by water is sufficient for ice to melt completely, so temperature of mixture is 0°C

33. $\Delta Q = ms\,\Delta T$. Thermal capacity $ms = \Delta\theta/\Delta T$

34. Sublimation ⇒ solid to gas so AO
fusion ⇒ solid to liquid so OB
vaparisation ⇒ liquid to vapor so OC

35. Heat evolved due to Joule's heating effect is used up in boiling water
As per key idea

$VIT = ms\Delta t$

$t = \frac{ms\Delta t}{VI}$

Putting given values

I = 4A, V = 220 volt, m = 1kg

Δt = (100 – 20)°C, s = 4200 J/kg°C

$t = \frac{1\times 4200\times 80}{220\times 4} = 6.3\,\text{min}$

36. Let time taken in boiling the water by the heater is t sec. Then

Q = msΔT

$\frac{836}{4.2}\,t = 1 \times 1000 \times 1\,(40^o - 10^o)$

$\frac{836}{4.2}\,t = 1000 \times 30$

$t = \frac{1000\times 30\times 4.2}{836} = 150$ sec

37. Net heat given/sec to water = 1000 – 160

= 840 J/S

if it takes time t then

840 t = 2000 × 4.2 × (77 – 27)

t = 500 sec = 8 min 20 sec.

38. $S = 2100\ \text{J kg}^{-1}\ {}^o\text{C}^{-1}$

$L = 3.36 \times 10^5\ \text{J kg}^{-1}$

$420 = m\,S\,\Delta\theta + (1) \times 10^{-3} \times L$

$420 = m\,S\,(5) + 3.36 \times 10^2$

420 – 336 = m(2100) × 5

$m = \frac{1}{125} \times 1000 = 8$ gm.

SECTION (B)

1. On heating the expansion will take place hence both the distances will increase

2. $6 \times 10^{-5} = 1 \times 12 \times 10^{-6} \times \Delta T$

$\frac{6\times 10^{-5}}{12\times 10^{-6}} = \Delta t \Rightarrow \Delta t = 5^oC.$

3. On heating expansion occurs and volume of substance increases while mass of the substance remains the same. Hence the density will decrease

4. In bimetallic strips the two metals have different thermal expansion coefficient. Hence on heating it bents towards the metal with lower thermal expansion coefficient

7. $\alpha = 10^{-5}$ /K

$\frac{\Delta \ell}{\ell}\times 100 = \alpha\,.\,\Delta T \times 100 = 0.1\%$

9. $\frac{\Delta T}{T_0} = \frac{1}{2}\alpha.\Delta\theta$

in one day the chage in time = $86400 \times \frac{\Delta T}{T_0} = 86,400 \times \frac{1}{2} \times 10^{-5} \times 10 = 4.32$ sec (lose)

10. $\ell_1' = \ell_1\,(1 + \alpha_1\,.\,\Delta\theta)$

$\ell'_2 = \ell_2\,(1 + \alpha_2\,.\,\Delta\theta)$

$\because$ $\ell'_2 - \ell_1' = \ell_2 - \ell_1$
$\Rightarrow$ $\ell_2\alpha_2 - \ell_1\alpha_1 = 0$
or $\ell_2\alpha_2 = \ell_1\alpha_1$

12. $\alpha_s = 11 \times 10^{-6}$ /°C,
$\alpha_B = 19 \times 10^{-6}$ /°C,
$\ell_1 - \ell_2 = 30$ cm and $\ell_1\alpha_1 - \ell_2\alpha_2$

$\ell_1 \times 11 = \ell_2 \times 19$ and $\ell_1 - \ell_2 = 30$ also $\ell_1 - \ell_1 \times \frac{11}{19} = 30$

$\ell_1 = \frac{30\times19}{19-11} = \frac{30\times19}{8} = \frac{15\times19}{4} = \frac{285}{4} = 71.25$ cm
$\ell_2 = 41.25$ cm

14. Length is increased by 2%
$\frac{\Delta A}{A} = K \times \Delta\theta = 2(\alpha \times \Delta\theta)$
Area will increase by 4%

15. $\alpha = 2 \times 10^{-6}$ /°C

percentage change in time period = $\frac{\Delta T}{T} \times 100$
$= \frac{1}{2} \times \alpha \times \Delta\theta \times 100 = \frac{1}{2} \times 2 \times 10^{-6} \times 10 \times 100 = 1 \times 10^{-3}$
Time period will increase

16. $\frac{\Delta V}{V} = \frac{0.6}{100} = \gamma \times \Delta\theta$
$\gamma = \frac{0.6}{100}\times\frac{1}{50}\times\frac{2}{2}$
$3\alpha = \frac{0.6}{100}\times\frac{2}{100} = 1.2 \times 10^{-4}$
$\alpha = 4 \times 10^{-5}$ °/C

18. % increase in volume = 3 × 0.1 = 0.3%

19. % increase in area
$\frac{\Delta A}{A}\times100 = K \times \Delta\theta \times 100 = 2 \times (\alpha \times \Delta\theta) \times 100 = 2 \times 1 = 2\%$

20. $I = MR^2$
$I' = MR^2(1 + 2\alpha\Delta T)$
$\Delta I = I\, 2\alpha\, \Delta T$

21. $V_\ell > V_e$
$\gamma > 3\alpha$.

22. $\ell_1(1 + \alpha_1\Delta t) + \ell_2(1 + \alpha_2 \Delta t) = (\ell_f + \ell_2)(1 + \alpha \Delta t)$
$= (\ell_f + \ell_2)\left[1+\frac{\ell_1+\alpha_1+\ell_2+\alpha_2}{\ell_1+\ell_2}\right] \Rightarrow \alpha_{eff} = \frac{\ell_1\alpha_1+\ell_2\alpha_2}{\ell_1+\ell_2}$.

23. $P\Delta V = nR\Delta T$ $\Delta V = \frac{nR}{P}\Delta T$

$\Delta V = \frac{V}{T}\Delta T$ $\Rightarrow$ $V = \frac{\Delta V}{V \times \Delta T} = \frac{1}{T}$

24. Latent heat is independent of configuration. Ordered energy spent in stretching the spring will not contribute to heat which is disorderd kinetic energy of molecules of substance.

25. Linear expansion coefficient

$= \frac{\text{change in length}}{\text{original length} \times \text{rise in temperature}}$

or $\alpha = \frac{\Delta \ell}{\ell t}$

or $\Delta \ell = \ell \alpha t$

For brass rod, $\Delta \ell_1 = \ell_1 \alpha_1 t$

For steel rod, $\Delta \ell_2 = \ell_2 \alpha_2 t$

since, $\ell_2 - \ell_1 =$ constant

So $\Delta \ell_2 - \Delta \ell_1 = 0$

$\therefore$ $\ell_2 \alpha_2 t = \ell_1 \alpha_1 t$

As $t \neq 0$, hence $\ell_2 \alpha_2 = \ell_1 \alpha_1$

26. From relation

$\gamma_{apparent} = \frac{\text{mass expelled}}{\text{mass remained} \times t} = \frac{\frac{x}{100}}{x \times 80} = \frac{1}{8000} = 1.25 \times 10^{-4}/°C$

27. When force F is applied

$Y = \frac{FL}{A\ell}$, where Y is Young's modulus, A is area

$F = \frac{YA\ell}{L}$ ...(1)

From the formula for linear expansion

$\alpha = \frac{1}{L \times 100}$ ...(2)

According to the condition that bar will not bend or expand

Now from equations (1) and (2)

$F = YA \times 100\alpha$

Hence, force is independent of length L

28. When the sphere of iron is heated than due to volumetric expansion, volume of the sphere will increase.

29. Given $\Delta \ell_1 = \Delta \ell_2$

or $\ell_1 \alpha_a \Delta T = \ell_2 \alpha_s \Delta T$ $\therefore$ $\frac{\ell_1}{\ell_2} = \frac{\alpha_s}{\alpha_a}$

or $\frac{\ell_1}{\ell_1 + \ell_2} = \frac{\alpha_s}{\alpha_a + \alpha_s}$

SECTION (C)

1. $\frac{C-0}{100} = \frac{F-32}{180^o}$

$\frac{\Delta C}{100^o} = \frac{\Delta F}{180^o} \Rightarrow \frac{25}{100^o} \times 180^o = \Delta F \Rightarrow \Delta F = 45^oF.$

2. Let at $x^oF = x^oC$

$\frac{x-32^o}{180} = \frac{x-0}{100}$

$10x - 320$ $x = -40^oC$

So -40^oC or -40^oF

3. $\overline{v^2} \propto T\left(\therefore \overline{v^2} = \frac{3KT}{m}\right)$

4. At absolute zero (i.e.,0K)v_{rms} becomes zero.

5. We know that $P = P_0(1 + \gamma t)$ and $V = V_0(1 + \gamma t)$
and $\gamma = (1/273)/°C$ for $t = -273°C$, we have $P = 0$ and $V = 0$
Hence, at absolute zero, the volume and pressure of the gas become zero

6. $\frac{C}{5} = \frac{F-32}{9} \Rightarrow \frac{25}{5} = \frac{F-32}{9} \Rightarrow F = 77°F$

7. Due to evaporation cooling is caused which lowers the temperature of bulb wrapped in wet hanky.

8. $\frac{\Delta T_C}{100} = \frac{\Delta T_F}{180} = \frac{212-140}{180}$

i.e, $\Delta T_C = 100 \times \frac{72}{180} = 40°C$ $\therefore$ Fall in temperature = 40°C

9. When current is passed through a conductor, electric energy is absorbed by the conductor through collisions between its atomic lattice and the charge carriers causing its temperature to rise.
Energy loss in conductor $Q = i_2Rt$, t = time
Heat developed = $ms\Delta\theta$ $\therefore$ $ms\Delta\theta = i_2Rt$ or $\Delta\theta \propto i_2$

$\frac{\Delta\theta_2}{\Delta\theta_1} = \frac{i_2^2}{i_1^2}$

or $\Delta\theta_2 = \left(\frac{i_2}{i_1}\right)^2 \Delta\theta_1$ ...(i)

Here : $i_2 = 2i_1$, $\Delta\theta_1 = 5°C$ From eq. (i)

$\therefore$ $\Delta\theta_2 = \left(\frac{2i_1}{i_1}\right)^2 \times 5 = 4 \times 5 = 20°C$

10. For -40^o, centrigrade scale and Fahrenheit scales are equal.

11. Relation between centrigrade and Fahrenheit scale.

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

$$\frac{C}{5} = \frac{140-32}{9} \qquad C = 60^o$$

12. According to weins displacement law $\lambda_m T$ = constant or temperature $\propto \frac{1}{\lambda_m}$. It represents that greater the temprature T of an emitted star, smaller is the value of wave length λ. We also know the wave length of light depends upon its colour. Hence, when the temperature of star increases, thewave length of light star decreases, thewave length of star decreases, thewave length increases and star moves towards the red colour. Therefore, the colour of star indicates its temperature.

13. $\frac{F-32}{9} = \frac{K-273}{5}$ But given, x°F = xK $\therefore$ $\frac{x-32}{9} = \frac{x-273}{5}$

5x – 160 = 9x – 2457
4x = 2297
x = 574.25

14. Initial volume V_1 = 47.5 unit temperature of ice cooled water

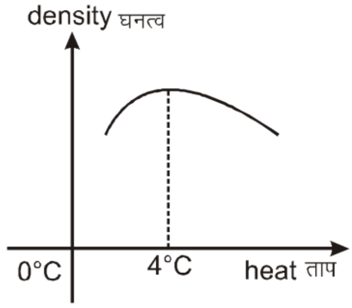
T_1 = 0°C = 273 K

Final volume V_2 = 67 units by Charles law

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (where T_2 is boiling point)

$T_2 = \frac{V_2}{V_1} \times T_1 = \frac{67 \times 273}{47.5}$ = 385 K = 112°C

15. Water density is maximum at 4°C, so whether it is cooled to temperature below 4°C or warmed to temperature above 4°C, in both the cases its density will decrease. In other words it will expand and overflow in both the cases.



16. In general, whenever we are to go from any known scale to any unknown scale, then we follow the equation (Temperature on known scale)

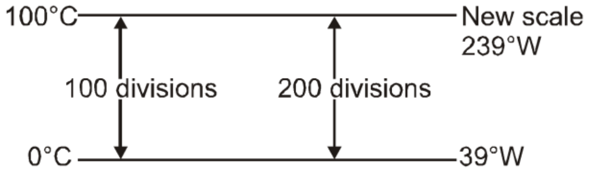
$$\frac{\text{Temperature on known scale} - (\text{LFP for known scale})}{(\text{UFP} - \text{LEP scale})_{\text{known}}}$$

$$= \frac{(\text{Temperature on known scale}) - (\text{LFP for unknown scale})}{(\text{UFP} - \text{LEP scale})_{\text{unknown}}}$$

or $\frac{39-0}{100-0} = \frac{t-39}{239-39}$ or t = 117°W

Note : LFP → Lower fixed point
UFP → Upper fixed point

Alternative :



∴ 39°C = 39 × 2 + 39 = (78 + 39)°W = 117°W

EXERCISE # 2

1. $\frac{m}{1000} \times 3.36 \times 10^5 = \left(\frac{100-m}{1000}\right) 2.1 \times 10^6$

m × 3.36 = 2100 – 21m

$m = \frac{2100}{21+3.36} = 86.2$ g.

2. Heat released by 5 kg of water its temperature falls from 20ºC to 0ºC is,

$Q_1 = mc\Delta\theta = (5)(10^3)(20-0) = 10^5$ cal

when 2 kg ice at –20ºC comes to a temperature of 0ºC, it takes heat

$Q_2 = mc\Delta\theta = (2)(500)(20) = 0.2 \times 10^5$ cal

The remaining heat $Q = Q_1 - Q_2 = 0.8 \times 10^5$ cal will melt a mass m of the ice, where

$m = \frac{0.8\times10^5}{80\times10^3} = 1$ kg

So, the temperature of the mixture will be 0ºC,

mass of water in it is 5 + 1 = 6 kg and mass of ice is 2 – 1 = 1 kg.

3. $\Sigma\Delta Q = 0$

Heat lost by steam to convert into 0ºC water

$H_L = 0.05 \times 540 + 0.05 \times 100 \times 1 = 27 + 5 = 32$ kcal

Heat required by ice to change into 0º C water

$H_g = 0.45 \times \frac{1}{2} \times 20 + 0.45 \times 80 = 4.5 + 36.00 = 40.5$ kcal

Thus, final temperature of mixture is 0ºC = 273 K because entir ice willnot melt

4. Suppose person climbs upto height h, then by using

$W = JQ \Rightarrow mgh = JQ \quad \Rightarrow 60 \times 9.8 \times h = 4.2 \times \left(10^5 \times \frac{28}{100}\right) \Rightarrow h = 200$ m

5. $k_1 = \left(\frac{\rho Fe}{\rho Hg}\right)_{0°C}$ and $k_2 = \left(\frac{\rho Fe}{\rho Hg}\right)_{60°C}$ Here ρ = Density

∴ $\frac{k_1}{k_2} = \frac{(\rho_{Fe})_{0°C}}{(\rho_{Fe})_{0°C}} \frac{(\rho_{Fe})_{60°C}}{(\rho_{Hg})_{0°C}} = \frac{(1+60\gamma_{Fe})}{(1+60\gamma_{Hg})}$

In this problem two concepts are used :

(i) When a solid floats in a liquid then

Fraction of volume submerged (k) = $\frac{\rho_{solid}}{\rho_{liquid}}$ This result comes from the fact that Weight= $U_{pthrust}$

∴ $V \rho_{Solid}\, g = V_{submerged}\, \rho_{liquid}\, g$ ∴ $\frac{V_{submerged}}{V} = \frac{\rho_{solid}}{\rho_{liquid}}$

(ii) $\frac{\rho_{\theta°C}}{\rho_{0°C}} = \frac{1}{1+\gamma.0}$ This is because $\rho \propto \frac{1}{\text{Volume}}$ (mass remaining constant)

∴ $\frac{\rho_{\theta°C}}{\rho_{0°C}} = \frac{V_{0°C}}{V_{\theta°C}} = \frac{V_{0°C}}{V_{0°C}+\Delta V} = \frac{V_{0°C}}{V_{0°C}+V_{0°C}\gamma\theta}$

6. $2.45 \times 10^8 = Y\,\alpha\,\Delta T = 11.8 \times 10^{10} \times 1.6 \times 10^{-5} \times \Delta T$

$\Delta T = \dfrac{2.4\times10^{8}}{11.8\times1.6\times10^{5}} = \dfrac{2450}{11.8\times1.6} = 129.77^{0}C$

so. $T_{Lower} = 20.23^{0}C$

EXERCISE # 3

PART - I

1. Initially liquid oxygen will gain the temp. up to its boiling temprature then it change its state to gas. After this again its temprature will increase, so corresponding graph will be option (1)

2. m(g) steam at 100° → m(g) water at 100°C + 540m .....(1)
m(g) water at 100°C → m(g) water at 80°C + (m)(1) (20) .....(2)
(1) + (2)
m(g) steam at 100°C → m(g) water at 80° + 560m (cal) .....(3)
20 g water at 10°C + (20) (1) 70 → 20 g water at 80°C .....(4)
from (3) and (4)
mix + 1400 cal → (20 + m) g water at 80°C + 560m (cal)
1400 = 560m
2.5 = m
Total mass of water present = (20 + 2.5)g = 22.5g

Alternative

Each gm of steam conerting to 80º water loses heat = 1 × 540 + 1 × 1 × 20 = 560 cal
20 gm water at 10ºC require heat to raise its temperature x from 10ºC t o80ºC = 20 × 1 × 70 = 1400
∴ Amount of steam condersed to 80º water $= \dfrac{1400}{560} = 2.5$gm ∴ water = 20 + 2.5 = 22.5g

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

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

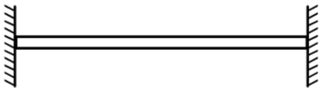
4. $\dfrac{Mgh}{4} = mL \quad \Rightarrow \quad h = \dfrac{4L}{g} = 136$ km

5. $V_i = 0.1\ cm^2$, $V_f = 167.1\ cm^3$
$\Delta V = 167\ cm^3 = 167 \times (10^{-2})^3 = 167 \times 10^{-6}\ m^3$
$W = P\Delta V = (167 \times 10^{-6}) \times (10^5) = 16.7$ J
Q = 54 × 4.2 = 226.8
Q = W + U↑
226.8 = 16.7 + U↑
U↑ = 226.8 – 16.7 = 210 J

PART - II

1. $\dfrac{\Delta\ell}{\ell} = \alpha.\Delta T$ and $Y = \dfrac{F/A}{\Delta\ell/\ell}$

So, $F = AY\alpha t$

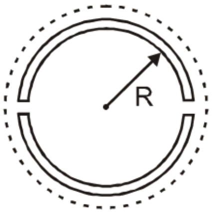


Thermal stress $\left(\dfrac{F}{A}\right) = Y\alpha t$.

2. $\Delta v = v_0(3\alpha)\,\Delta T = \frac{4}{3}\pi(10)^3 \times 3 \times 23 \times 10^{-6} \times 100$

$\Delta v = 28.9$ cc.

3.



$\Delta L = L \propto \Delta T$

$\frac{F}{A} = \frac{\Delta L}{L} Y$

$F = \alpha \Delta T\ YS$

So, $T = 2F$

$T = 2\alpha\Delta T\ YS$

4. $\frac{12}{24 \times 3600} = \frac{1}{2}\alpha(40 - T)$ ...(i)

$\frac{-4}{24 \times 3600} = \frac{1}{2}\alpha(20 - T)$ ...(ii)

from equation (i) and (ii)

$-3 = \frac{40 - T}{20 - T}$

$-60 + 3T = 40 - T$

$4T = 100$

$T = 25$

from equation (ii)

$\frac{-4}{24 \times 3600} = \frac{1}{2}\alpha(20 - 25)$

$\frac{4}{24 \times 3600} = \frac{1}{2} \times \alpha \times 5$

$\alpha = \frac{8}{24 \times 3600 \times 5} = 1.85 \times 10^{-5}/°C$

5. Heat given by cupper ball = Heat taken by water + Heat taken by calorimeter system

$(100)(0.1)(T - 75) = (170)(1)(75 - 30) + (100)(0.1)(75 - 30)$

$10T - 750 = 8100$

$10T = 8850$

$T = 885°C$

6. $\Delta p = -K\frac{\Delta V}{V}$

$\frac{\Delta V}{V} = -\gamma\Delta\theta = -3\alpha\Delta\theta$

$3\alpha\Delta\theta K = p$

$\Delta\theta = \frac{p}{3\alpha K}$

7. Subscript for unknown is ڊ u

Subscript for calorimeter is ڊ c

Subscript for water is ؟ w

$m_v S_u (100 - 21.5) = m_c \times S_c (21.5 - 8.4) + m_w S_w (21.5 - 8.4)$

$\therefore 192 \times S_u \times 78.5 = 128 \times 394 \times 13.1 + 240 \times 4200 \times 13.1$

$\therefore S_u = \dfrac{13.1(128 \times 394 + 240 \times 4200)}{192 \times 78.5}$

$\therefore S_u = 919.94$ J/kg-k

8. Considering the subscript for ball as 'b', for water as 'w' and for container as 'c' and applying principle of calorimetry (assuming final temperature = T°C)

$m_b s_b(500 - T) = m_w s_w (T - 30) + m_c s_c (T - 30)$

$\therefore 0.1 \times 400 (500 - T) = 0.5 \times 4200 (T - 30) + 800 (T - 30)$

$\therefore 20000 - 40T = 2100T - 63000 + 800T - 24000$

$\therefore 2940T = 107000$

$\therefore T = \dfrac{10700}{294} = 36.4$ °C

% rise in temperature = $\dfrac{6.4}{30} \times 100\% \simeq 21\%$

9. Changing in length in both rods are same

$\Delta\ell = \alpha\ell\Delta\theta$

$\therefore \alpha_1\ell_1\Delta\theta_1 = \alpha_2\ell_2\Delta\theta_2$

$4 \times (180 - 30) = (T - 30)3$

$T = 230$

10. Heat lost by water $\Delta Q = ms\Delta T = 50 \times 1 \times 40 = 2000$ cal

Let mass of ice = m

Heat gain by ice ΔQ

$= m \times \dfrac{1}{2} \times 20 + (m - 20) \times 80$

$= 10\ m + 80\ m - 1600$

$= 90\ m - 1600$

Heat gain = Heat lost

$90\ m - 1600 = 2000$

$m = 40$ gm