EXERCISE – V

JEE QUESTIONS

1. $m_v[L_v + S_w\Delta\theta_1] = 100\, S_w\Delta\theta_2$

$m_v[540 + 1(100-90)] = 100(1)(90-24)$

$m_v = 12$ gm

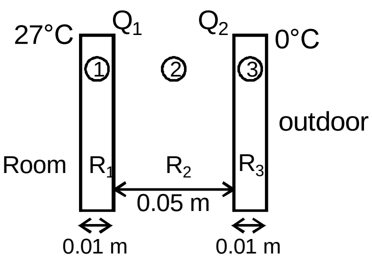
2. $\frac{R_A}{R_B} = \frac{K_B}{K_A} = \frac{200}{300} = \frac{2}{3}$

$\frac{\Delta T_A}{\Delta T_B} = \frac{R_A}{R_B} = \frac{2}{3}$

$\Rightarrow \frac{100-T}{T-0} = \frac{2}{3}$

$T = 60°$ C

3.



$R_1 = R_3 = \frac{0.01}{(0.8)(1)}$

$i = i_1 = i_2 = i_3 \Rightarrow \frac{27 - Q_1}{0.0125} = \frac{Q_1 - Q_2}{0.625}$

$= \frac{Q_2 - 0}{0.0125}$

$\Rightarrow Q_1 = 26.48°$C
$Q_2 = 0.52°$C hence i = 41.6 watt.

4.
D
$P \propto A T^4$

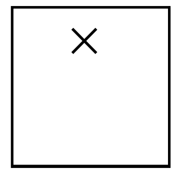
$\frac{P'}{P} = \frac{(A/4)(2T)^4}{AT^4}$

$P' = 450\left(\frac{1}{4}\right)(16) = 1800$ W

5. $\Delta Q_{ice} = (0.28)\,(3.3 \times 10^5$ J/kg$) = 9.24 \times 10^4$
Heat received/second = (1400) (0.2) = 280 J

Time taken $= \frac{9.24\times10^4}{280\times60} = 5.5$ min

6. For $t \le t_1$



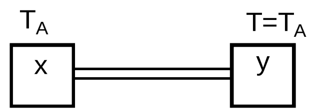
Newton's law of cooling

$-\frac{dT}{dt} = k(T - T_A)$

$\int_{T_0}^{T_1}\frac{dT}{T-T_A} = -k\int_0^{t_1} dt$

$kt_1 = -\ell n\left(\frac{350-300}{400-300}\right) = \ln(2)$

For $t > t_1$ (Radiation + conduction)



Rate of cooling $-\frac{dT}{dt} = k(T - T_A) + \frac{kA}{CL}(T - T_A)$

Let at $t = 3t_1$, temp. of x becomes T_2
then

$\int_{T_1=350}^{T_2}\frac{dT}{T-T_A} = -\left(k + \frac{kA}{LC}\right)\int_{t_1}^{3t_1} dt$

$\Rightarrow \ell n\left(\frac{T_2 - 300}{350-300}\right) = -\left(2kt_1 + \frac{2kA}{LC}t_1\right)$

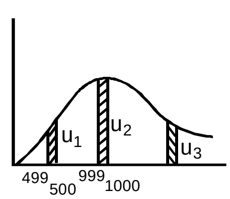
{ $kt_1 = \ln 2$

$T_2 = 300 + 50 \exp\left[-\left(\frac{kA}{L} + \frac{\ln 2}{t_1}\right)2t_1\right]$

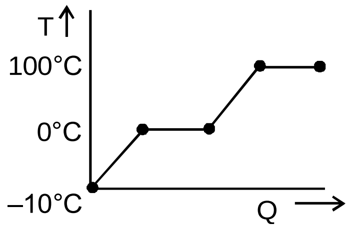
7. **D**
Wien's Displacement law

$\lambda_m T = b \Rightarrow \lambda_m = \frac{b}{T}$

$\Rightarrow \lambda_m = 1000$ nm
from graph
$U_2 > U_1$



8. A



9. B

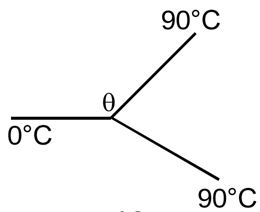
$\lambda_m \propto \frac{1}{T}$

from fig. $(\lambda_m)_1 < (\lambda_m)_3 < (\lambda_m)_2$

$T_1 > T_3 > T_2$

10. B

$\frac{90-\theta}{R} + \frac{90-\theta}{R} = \frac{\theta - 0}{R}$



$\Rightarrow\ \theta = 60°C$

11. D

Initially it willl absorb all the radiant energy so it will be darkest one.

Then radiate maximum energy and it will be brightest of all

12. Heat goined by ice = heat lost by container

$(0.1)\ (8 \times 10^4) + (0.1)\ (10^3)\ (27)$

$$= m\int_{500}^{300}(A + BT)dT$$

$$10700 = -m\left[AT + \frac{BT^2}{2}\right]_{500}^{300}$$

$\Rightarrow\ m = 0.495$ kg

13. A

$Q_{w_{20\to 0}} = 5(10^3)(20-0) = 10^5$ cal

$Q_{ice_{-20\to 0}} = 2(500)(20) = 0.2\times 10^5$ cal

$\Delta Q = 0.8 \times 10^5$ cal will melt a mass m of ice

$m = \frac{Q}{L} = \frac{0.8\times 10^5}{80\times 10^3} = 1$kg

$m_{water} = 5 + 1 = 6$ kg

14. A

$-\frac{dT}{dt} \propto e$

$\left(-\frac{dT}{dt}\right)_x > \left(-\frac{dT}{dt}\right)_y$ from graph

$\therefore\ e_x > e_y$

$e_x > a_y$

15. (a) Rate of heat loss per unit area

$I = e\,\sigma\,(T^4 - T_0^4)$

$= 0.6 \times \frac{17}{3} \times 10^{-8}((400)^4 - (300)^4) = 595$ w/m^2

(b) $\frac{\theta - 127}{(\ell/kA)} = 595\,A$

$\ell = 0.005 \quad k = 0.149$

$\theta = 146.96$ °C $= 419.96$ k

16. B

$Q \propto AT^4$ and $\lambda_m T$ = const.

hence $Q \propto \frac{A}{\lambda_m^4} \propto \frac{r^2}{\lambda_m^4}$

$Q_A : Q_B : Q_C = \frac{2^2}{3^4} : \frac{4^2}{4^4} : \frac{6^2}{5^4}$

17. D

$\frac{dQ}{dt} \propto L\left(\frac{dm}{dt}\right)$ and $\frac{\Delta T}{R} = L\frac{dm}{dt}$

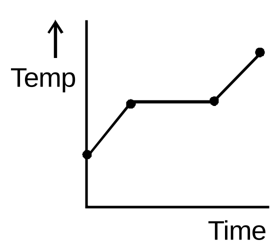
$\Rightarrow\ \frac{dQ}{dt} \propto \frac{1}{R}\ \Rightarrow\ q \propto \frac{1}{R}$

I $\to$ Parallel $R_{eq.} = R/2$

II $\to$ Series $R_{eq} = 2R$

$\frac{q_2}{q_1} = \left[\frac{2R}{(R/2)}\right]^{-1} = 1/4$

18. C



19. $T\uparrow\ V_{cube}\uparrow\ \rho_\ell\ \downarrow$

Depth submerged in liquid remains same

Upthrust = Weight

$v_i \rho_L g = v'_i \rho'_L g$

$(Ah_i)\rho_L g = A(1+2\alpha_s\Delta T)h_i\left(\frac{\rho_L}{1+\gamma_\ell \Delta T}\right)g$

$\Rightarrow\ \gamma_\ell = 2\alpha_s$

20. Rate of heat conduction = Rate of heat lost from right end

$$\frac{kA(T_1 - T_2)}{L} = eA\sigma(T_2^4 - T_5^4)$$

As $T_2^4 = (T_5 + \Delta T)^4 = T_5^4\left(1 + \frac{4\Delta T}{T_s}\right)$

hence $\frac{k(T_1 - T_s - \Delta T)}{L} = 4e\sigma T_5^3 \Delta T$

$\Rightarrow \Delta T = \frac{k(T_1 - T_5)}{(4e\sigma L T_5^3 + K)}$

on comparing proportional const. = $\frac{k}{4e\sigma L T_5^3 + K}$

21. A

λ_m T = const.

from graph $T_3 > T_2 > T_1$

22. C

Glass of bulb heats due to filament by radiation

23. A

Energy goined by water (in 1 s)

= 1000 – 160 = 8405

Time required t = $\frac{ms\Delta\theta}{\text{Rate by which energy}}$

$= \frac{2(4.2\times10^3)(50)}{840}$ = 500 Sec.

24. A

$\frac{dQ}{dt} = e\sigma A T^4$ = 0.6 s A T^4

25. B

LEARN IT

26. A,D

THEORY

27.

0.05 kg steam at (373 k) $\xrightarrow{Q_1 = 50\times540 = 27\text{kcal}}$ 0.05 kg water at 373 k

0.05 kg water $\xrightarrow{Q_2 = 50\times100 = 5\text{kcal}}$ 0.05 kg water at 273 k

0.45 kg ice at $\xrightarrow{Q_3 = 450\times0.5\times20 = 4.5\text{kcal}}$ 0.45 kg water at 273 k

$Q_1 + Q > Q_3$ but $Q_1 + Q_2 < Q_3 + Q_4$

whole ice will not melt

T = 273 k

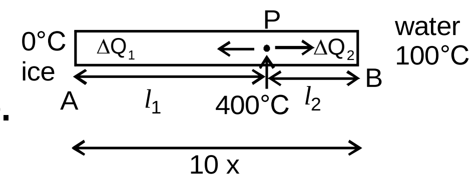
28. (A) → S, Q ; (B) → Q ; (C) → P, Q ; (D) → D, R

or

(A) → S (B) → Q ; (C) → P ; (D) → R

THEORY

29.



Let the mass of water melts or evaporates is m

$\Rightarrow \Delta Q_1 = \frac{kA}{\ell_1}(400 - 0) = m \times 80 \times 42$

$\Delta Q_2 = \frac{kA}{\ell_2}(400 - 100) = m \times 540 \times 42$

$\Rightarrow \frac{\Delta Q_1}{\Delta Q_2} = \frac{\ell_2}{\ell_1} \times \frac{400}{300} = \frac{80}{540}$

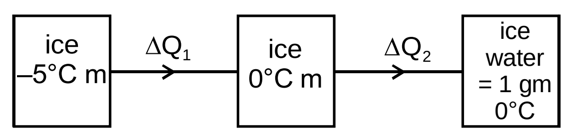
$\Rightarrow \frac{\ell_2}{\ell_1} = \frac{1}{9}$

$\Rightarrow \frac{\ell_2 + \ell_1}{\ell_1} = \frac{10}{9}$

$\Rightarrow \ell_1 = \frac{9}{10} \times 10 = 9$

30.

Total Heat given ΔQ = 420 J



ΔQ_1 = m × 2100 (0 – (–5) = m × 2100 × 5J

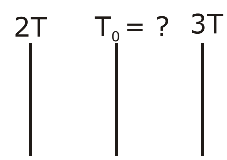
$\Delta Q_2 = 10^{-3} \times 3.36 \times 10^5$ = 336 J

$\Delta Q = \Delta Q_1 + \Delta Q_2$

420 = m × 2100 ×5 + 336

$\Rightarrow$ m = $\frac{84}{2100\times5}$kg = 8 gm

31. C



for middle plate (in unit time)

Heat absorbed/ Area = Heat emitted/Area

$\sigma(2T)^4 + \sigma(3T)^4 = \sigma(T_0)^4\times2$

$T_0 = \left(\frac{97}{2}\right)^{1/4} T$