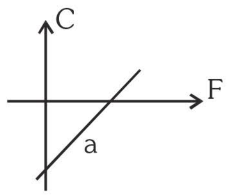
THERMAL PHYSICS

1. Pyrometer is used to measure a temperature of sun by using radiation

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



$y = mx - C$

3. Slope of line AB

$= \frac{\Delta C}{\Delta F} = \frac{100-0}{212-32} = \frac{100}{180} = \frac{5}{9}$

4. For any temperature scale

$\frac{\text{Reading} - \text{ice point}}{\text{Steam point} - \text{ice point}} = \text{constant}$

Solve for the two thermometer.

5. $\frac{x - MP}{BP - MP} = \frac{°C}{100}$

$\Rightarrow \quad \frac{x-39}{239-39} = \frac{39}{100} \Rightarrow x = 117\ °W$

6. $\alpha_{Rod} > \alpha_{Frame}$, then rod may touch ground.

7. TFFT

8. Thermal expansion is like a photographic enlargement.

9. $\Delta\ell = \ell\alpha\Delta T$

$\alpha = \frac{\Delta\ell}{\ell\Delta T}$

$\alpha_1 = \frac{1}{1 \times 100} = 10^{-2}$

$\alpha_2 = \frac{2}{100} = 2 \times 10^{-2}$

$\alpha_3 = \frac{3}{1.5 \times 50} = 4 \times 10^{-2}$

$\alpha_4 = \frac{4}{2.5 \times 20} = 8 \times 10^{-2}$ (maximum)

10. $\Delta\ell_1 = \Delta\ell_2$

$\ell_1\alpha_1\Delta T = \ell_2\alpha_2\Delta T$

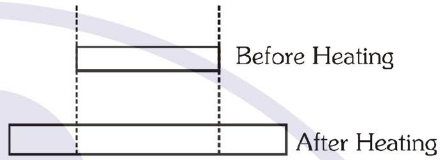
$\ell_1\alpha_1 = \ell_2\alpha_2$

$\Rightarrow \quad \frac{\ell_1}{\ell_1 + \ell_2} = \frac{\ell_1/\ell_2}{\ell_1/\ell_2 + 1} = \frac{\alpha_2/\alpha_1}{\alpha_2/\alpha_1 + 1} = \frac{\alpha_2}{\alpha_1 + \alpha_2}$

11. $Y = \frac{F\ell}{A\Delta\ell} = \frac{F\ell}{A\ell\Delta T\alpha} = \frac{F}{A\alpha\Delta T}$

$F = \frac{10^{11} \times 10^{-3} \times \ell \times 10^{-6} \times 100}{\ell} = 10^4 N$

12. We known that, when rod is freely expand, stress produce = 0



stress α strain

so strain = 0

13. $\gamma_v = \frac{\Delta V}{V\Delta T}$

From PT^4 = constant & $PV = \mu RT$

$\Rightarrow \quad V \propto T^5 \Rightarrow \frac{\Delta V}{V} = 5\frac{\Delta T}{T} \Rightarrow \frac{\Delta V}{V\Delta T} = \frac{5}{T} = \gamma_v$

14. $\frac{1}{2} \times \left(\frac{1}{2}mV^2\right) = msd\theta \Rightarrow d\theta = \frac{V^2}{4s}$

15. KE got converted into heat energy

$\Rightarrow \quad \frac{m}{5}L = mgh \text{ or } h = \frac{L}{5g}$

16. $KE = \frac{1}{2}(10 \times 10^{-3})(20)^2 = 2J$

Now mL = 50% of KE

$\Rightarrow \quad m = \frac{1J}{80 \times 4.2 J/gm} \Rightarrow m = 0.003$ gm

17. $\frac{mgh}{2} = mL$

$\Rightarrow h = \frac{2L}{g} = \frac{2 \times 3.4 \times 10^5}{10} = 68$ km.

18. $Q = mL_f + ms\,\Delta\theta + mL_v$

$= 1 \times 80 + 1 \times 1 \times 100 + 1 \times 536 = 716$ cal

19. Heat required for vapourisation = Rate × time

$= 42 \times 10^3 \times (30-20) = mL = 5 \times L \Rightarrow L = 84$ J/K

20. $Q_1 = ms\Delta T = 10 \times \frac{1}{2} \times 40 = 200 \quad \rightarrow (S)$

$Q_2 = mL = 10 \times 80 \quad \rightarrow (P)$

$Q_3 = ms\Delta T = 10 \times 1 \times 100 = 1000 \quad \rightarrow (Q)$

$Q_4 = mL = 10 \times 540 = 5400 \quad \rightarrow (R)$

21. $P = \frac{Q}{t} \Rightarrow P = \frac{ms\Delta T}{t}$

$P = 2100$ J/s ; $\frac{m}{t} = 20$ g/s

$T_1 = 10$ °C $\qquad T_2 = ?$

$$\left(\frac{2100}{4.2}\right)\frac{\text{cal}}{\text{s}} = 20 \times 1\,(T_2 - 10)$$

$T_2 = 35$ °C

22. Let θ be the final common temperature. Further, let s_c and s_h be the average heat capacities of the cold and hot (initially) bodies respectively (where $s_c < s_h$ given)

From, principle of calorimetry,

heat lost = heat gained

$s_h(100°C - \theta) = s_c\theta$

$$\therefore\ \theta = \frac{s_h}{(s_h + s_c)} \times 100°C = \frac{100°C}{\left(1 + \frac{s_c}{s_h}\right)}$$

$\because\ s_c / s_h < 1 \qquad \therefore\ 1 + s_c / s_h < 2$

$\therefore\ \theta > \frac{100°C}{2}$ or $\theta > 50°C$

OR

Body at 100°C has more heat capacity then body at 0°C so final temperature must be greater than 50°C.

23. Heat lost from steam = Heat gained by water

$m \times 540 + m \times 1 \times 20 = 1400 \times 1\,(80 - 16)$

$$\Rightarrow\ m = \frac{1400 \times 64}{560} = 160\text{gm}$$

24. At 1kg ice at –10°C + 4.4 kg of water at 30°C

Heat gain = Heat loss

$$1000 \times \frac{1}{2} \times 10 + 1000 \times 80 + 1000\ (T - 0)$$

$= 4.4 \times 1000 \times 1 \times (30 - T)$

$\Rightarrow\ 5.4\,T = 4.4 \times 30 - 85$

$\Rightarrow\ T = 8.7°C$

25. 2kg ice at – 20°C + 5 kg water at 20°C

$Q_{gain} = Q_{lost}$

$$2 \times \frac{1}{2} \times 20 + M \times 80 = 5 \times 1 \times 20$$

M = 1 kg

Water = 5 + 1 = 6 kg

26. No. of molecules will be same as PV= nRT (all have same moles)

27. $n = \frac{1}{2}$ So, $PV = \frac{1}{2}RT$

28. According to ideal gas equation

$$P = \frac{\rho RT}{M_w} \Rightarrow M_w = \frac{\rho RT}{P}$$

so $$\frac{M_A}{M_B} = \frac{\rho_A}{\rho_B} \cdot \frac{T_A}{T_B} \cdot \frac{P_B}{P_A} = (1.5)\ (1)\ \left(\frac{1}{2}\right)$$

$$\Rightarrow \frac{M_A}{M_B} = \frac{5}{4}$$

29. $\frac{P}{\rho} = \frac{RT}{M_w}$ (Ideal gas equation)

$$\Rightarrow\ \rho = \frac{PM_w}{RT} = \frac{P \times (mN_A)}{kN_A T} = \frac{Pm}{kT}$$

30. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow V_2 = \frac{P_1}{P_2} \times \frac{T_2}{T_1} \times V_1$

$$V_2 = \frac{1}{0.5} \times \frac{270}{300} \times 500\ m^3 = 900\ m^3$$

31. Closed container $\Rightarrow$ V = constant

$$\frac{\Delta P}{P} = \frac{\Delta T}{T} \quad \Rightarrow \quad T = \frac{P}{\Delta P} \times \Delta T$$

$$T = \frac{100}{0.4} \times 1\ K = 250\ K$$

32. $PV = \frac{M}{M_W}RT$

V, M_W, R are constant

$$\frac{P_1}{M_1T_1} = \frac{P_2}{M_2T_2}$$

$$\frac{M_1}{M_2} = \frac{P_1T_2}{P_2T_1} = \frac{P \times 300}{(P/2) \times 330}$$

$$\frac{M_1}{M_2} = \frac{600}{330} = \frac{20}{11}$$

$$M_2 = \frac{11}{20}M_1 = \frac{11}{20} \times 28 = \frac{77}{5}$$

Leaked amount $= M_1 - M_2 = 28 - \frac{77}{5}$

$$= \frac{140 - 77}{5} = \frac{63}{5}\ g$$

33. V = constant $\Rightarrow \frac{P_1}{M_1T_1} = \frac{P_2}{M_2T_2}$

Final mass $M_2 = \frac{P_2}{T_2} \times \frac{M_1T_1}{P_1}$

$$M_2 = \frac{P/2}{300} \times \frac{6g \times 400}{P} = 4\ g$$

Leak out mass $= M_1 - M_2 = 6 - 4 = 2$ g

34. $n_i = n_f$ (final pressure will be common)

$$\frac{P_0V_0}{RT_0}+\frac{P_0V_0}{RT_0} = \frac{PV_0}{RT_0}+\frac{PV_0}{RT}$$

$$\Rightarrow \quad P = \frac{2P_0T}{(T+T_0)}$$

35. $\mu_i = \mu_f \qquad \mu \to$ moles

36. P^2V = constant

$$\left(\frac{nRT}{V}\right)^2 V = \text{constant} \Rightarrow T^2 \propto V$$

So, $V\uparrow \Rightarrow T\uparrow \Rightarrow dU = \oplus$

37. $PV = \mu RT \quad \Rightarrow \quad P = \frac{\mu RT}{V}$

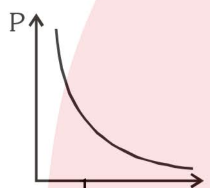
$PV^{2/3} = C \quad \Rightarrow \quad \frac{\mu RT}{V}\times V^{2/3} = C$

$TV^{-1/3} = C \quad \Rightarrow \quad T \propto V^{1/3}$

$T\uparrow \Rightarrow V\uparrow$

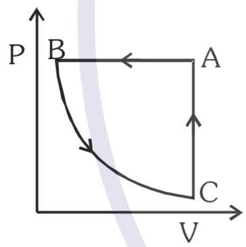
38. $T = \frac{PV}{\mu R}$

$P\left(\frac{PV}{\mu R}\right) = C$



$P^2V = C \quad \Rightarrow \quad P^2 \propto \frac{1}{V}$

39.



$A \to B \Rightarrow P$ constant & $T\downarrow$ So $V\downarrow$

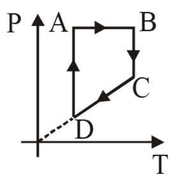
$A \to B \Rightarrow P$ constant & $T\downarrow$ So $V\downarrow$

$B \to C \Rightarrow T$ constant & $P\downarrow$ So $V\uparrow$

$C \to A \Rightarrow V$ constant & $P\uparrow$ So $T\uparrow$

40. $A \to B$ isobaric (P = constant) and $V\uparrow \Rightarrow T\uparrow$

$C \to D$ isochoric ($P \propto T$) and $P\downarrow \Rightarrow T\downarrow$



41. $P = \frac{nRT}{V}$ or $\frac{1}{V} = \left(\frac{1}{nRT}\right)P \Rightarrow$ slope $\propto \frac{1}{T}$

$\Rightarrow T_C > T_B > T_A$

42. $P = \frac{1}{3}\times \rho \times v_{rms}^2$

43. $v_1 = 2u,\ v_2 = 10u,\ v_3 = 11u$ (here, N=3)

Find $v_{rms} = \sqrt{\frac{v_1^2+v_2^2+v_3^2}{N}}$

$$v_{mean} = \frac{v_1+v_2+v_3}{N}$$

by solving rms speed exceeds the mean speed by about u.

44. Even power will not give zero value.

45. $v_{r.m.s} = \sqrt{\frac{v_1^2+v_2^2+v_3^2+v_4^2+v_5^2}{5}}$

$$= \sqrt{\frac{2^2+3^2+4^2+5^2+6^2}{5}} = 4.24 \text{ m/s}$$

46. $v_{rms} \propto \sqrt{\frac{T}{M.W.}}$

$(v_{rms})_H = (v_{rms})_{O_2}$

$\sqrt{\frac{T}{2}} = \sqrt{\frac{273+47}{32}} \Rightarrow T = 20K$

47. $< V > \propto \sqrt{\frac{T}{M_W}}$

$$\frac{< V_H >}{< V_{He} >} = \sqrt{\frac{(M_W)_{He}}{(M_W)_H}} = \sqrt{\frac{4}{1}} = 2$$

48. $v_{rms} \propto \sqrt{\frac{T}{M_w}}$

than $\quad \frac{v'}{v} = \sqrt{\frac{T'}{M_w}\times\frac{M_w}{T}}$

$v' = \sqrt{\frac{2T}{M_w/2}\times\frac{M_w}{T}}\times v$

$v' = 2v$

49. $v \propto \sqrt{T} \Rightarrow \frac{v}{200} = \sqrt{\frac{500}{400}} \Rightarrow v = 200\sqrt{\frac{5}{4}}$ m/s

$$= 100\sqrt{5}$$

50. $v = v_x\hat{i}+v_y\hat{j}+v_z\hat{k}$

$v = \sqrt{\frac{3KT}{m}}$

51. $v_{rms} > v_{avg} > v_{mp}$

53. $U = U_1 + U_2$

$= \mu_1 C_{v_1} T + \mu_2 C_{v_2} T$

$= 2\times\frac{5}{2}RT + 4\times\frac{3}{2}RT$

$= 5RT + 6RT = 11RT$

54. $KE = \frac{f}{2}\ NKT = \text{same}$

$NT = \text{constant} \Rightarrow T\alpha\frac{1}{N}$

and $KE = \frac{f}{2}\ PV = \text{same}$

V = const. then pressure is also constant.
and $T' = T/2$

55. $KE = \frac{3}{2}PV$

So energy density $= \frac{KE}{V} = \frac{3}{2}P$

56. $U_i = U_f$
Let final temperature is T then

$$\frac{3}{2}n_1kT_1 + \frac{3}{2}n_2kT_2 + \frac{3}{2}n_3kT_3 = \frac{3}{2}(n_1+n_2+n_3)kT$$

hence $T = \frac{n_1T_1 + n_2T_2 + n_3T_3}{n_1+n_2+n_3}$

58. Mean free path $\lambda_m = \frac{1}{\sqrt{2}\pi d^2 n}$
where d = diameter of molecule
n = molecular density

$\Rightarrow\ \lambda_m \propto \frac{1}{r^2}$

59. Number of collision $\alpha\ V_{rms}\ \alpha\ \frac{1}{\sqrt{M_W}}$
Number of collision by a molecule of He : O_2

$\frac{1}{\sqrt{4}} : \frac{1}{\sqrt{32}} = 2\sqrt{2} : 1$

60. specific heat of an ideal gas is independent on temperature

61. $\left(P + \frac{aT^2}{V}\right)V^c = RT + b$

$P + \frac{aT^2}{V} = (RT+b)V^{-c}$

$P = (RT + b)V^{-c} - aT^2V^{-1}$ .... (i)
$P = AV^m - BV^n$ (given) ....(ii)
By comparing
$m = -c,\ n = -1$

62. For 1 mole of O_2 gas
$C_P - C_V = 32b = R$
For 1 mole of H_2 gas
$C_P - C_V = 2a = R$
$\Rightarrow\ 2a = 32b \Rightarrow a = 16b$

63. $\frac{R}{C_v} = 0.4 \Rightarrow C_V = \frac{5R}{2}$
So, It is diatomic gas

64. $\gamma = \frac{1+2}{f}$

$f = \frac{\mu_1 f_1 + \mu_2 f_2}{\mu_1 + f_2}$

65. $P = aV^2 \Rightarrow PV^{-2} = \text{constant}$

$C = C_V + \frac{R}{1-x};\ x = -2$

$\Rightarrow C = \frac{5R}{2} + \frac{R}{3} = \frac{17R}{6}$

66. $C_V = f/2\ R$
and f = 3 + 3 {Rotational + Translational}
$\Rightarrow C_V = 3R$

67. $\gamma = \frac{C_P}{C_V} = \frac{C_V + R}{C_V} = \frac{\frac{1}{2}fR + R}{\frac{1}{2}fR} = \frac{f+2}{f}$

$\Rightarrow\quad \gamma f - f = 2 \quad\Rightarrow\quad f = \frac{2}{\gamma - 1}$

68. PV^x = constant (Polytropic process)
Heat capacity in polytropic process is given by

$\left[C = C_V + \frac{R}{1-x}\right]$

Given that PV^5 = constant $\Rightarrow x = 5$ ...(1)

also gas is monoatomic so $C_V = \frac{3}{2}R$ ...(2)

by formula $C = \frac{3}{2}R + \frac{R}{1-5} = \frac{3}{2}R - \frac{R}{4} = \frac{5}{4}R$

70. For polytropic process

$W = \frac{\mu R\Delta T}{1-x}$

Here $x = -2$

$W = \frac{\mu R(T_2 - T_1)}{1-(-2)}$

$= \frac{1}{3}R(T_2 - T_1)$

71. According to FLOT

$Q = W + \Delta U$

Isometric V = Constant $\Delta V = 0$

$Q = \Delta U$

72. $W = \int PdV$ = Area under P-V

$\Rightarrow \quad W = \frac{1}{2} \times (4 + 2) \times (5 - 1) \times 10^{-3}$ J

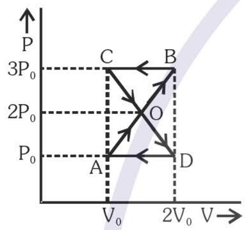
$\{1m^3 = 1000 \text{ L}\}$

$W = 12 \times 10^{-3}$ J

73. W = Area of ellipse = πab

$$= \pi\left(\frac{P_2 - P_1}{2}\right)\left(\frac{V_2 - V_1}{2}\right)$$

74.



Work = ⊕ Area of AOD and ⊖ Area of BCO

$$= \frac{1}{2}P_0V_0 - \frac{1}{2}P_0V_0 = \text{zero}$$

75. $\Delta U = \mu C_V \Delta T = \frac{f}{2}(P_2V_2 - P_1V_1) = \frac{P_2V_2 - P_1V_1}{\gamma - 1}$

76. Change in internal energy is same and

$W_A > W_B$ So, $Q_A > Q_B$

77. $dQ = \mu C_p dT$ {P = constant}

$$Q = \frac{1}{4}\left(\frac{5}{2}R\right)(T_2 - T_1) = \frac{5}{8}K_B N_A (T_2 - T_1)$$

78. $Q_1 = \Delta U_1 + W_1$

$Q_1 = 16 - 20 = -4$ kJ

$Q_2 = \Delta U_2 + W_2$

$W_2 = Q_2 - \Delta U_2 \qquad (\because \Delta U_1 = \Delta U_2)$

$= 9 - (-4) = 13$ kJ

79. AB → Isothermal → P↑ses, V↓ses ⇒ dU = 0, dW = (–)

BC → Isochoric → T↑ses ⇒ dU = (+), dW = 0

CD → Isothermal → P↓ses, V↓ses ⇒ dU = 0, dW = (+)

DA → Isochoric → T↓ses ⇒ dU = (–), dW = 0

80. for iaf $\quad \Delta U = Q - W = 30$ cal

for fi $\quad Q = \Delta U + W$

$Q = (-\Delta U_{iaf}) + W$

$\Rightarrow \quad Q = -30 - 30 = -60$ cal

81. A → B

Q = 200 J, W = 0, ΔU = 200 J

B → C

$Q = 600$ J, $W = P_B(V_C - V_A) = 240$, $\Delta U = 360$J

A → C

$\Delta U = \Delta U_{A\to B} + \Delta U_{B\to C} \Rightarrow \Delta U = 560$ J

82. Path acb

$\Delta U = Q - W = 200 - 80$

$\Delta U = 120$ J

Path adb

$W = Q - \Delta U = 144 - 120$

$= 24$ J

83. P = const.

$$\frac{W}{Q} = \left(\frac{1-1}{\gamma}\right) \times 100\%$$

84. For adiabatic process

$P^{1-\gamma}\,T^{\gamma}$ = constant

$$P \propto T^{\left(\frac{-\gamma}{1-\gamma}\right)} \propto T^{\left(\frac{\gamma}{\gamma-1}\right)}$$

as per question $P^2 \propto T^C$ or $P \propto T^{C/2}$

on comparing

$$\frac{C}{2} = \frac{\gamma}{\gamma - 1} = \frac{5/3}{5/3 - 1} = \frac{5}{2} \Rightarrow C = 5$$

85. $TV^{\gamma-1}$ = constant ⇒ $(300 \text{ K})(V)^{5/3-1} = T_f(8V)^{5/3-1}$

$$\Rightarrow \quad T_f = \frac{300\text{K}}{(8)^{2/3}} = 75\text{K}$$

86. PV^{γ} = constant

$$P^1 = P_0\left(\frac{V_i}{V_f}\right)^{\gamma} = P_0(27)^{4/3} = 81P_0$$

87. $PV^{\gamma} = P^1 (V/2)^{\gamma}$

$P^1 = P(2)^{\gamma} = 2^{1.4}$ P

88. $Q = W + \Delta U\left[W = \frac{Q}{4}\right]$

$Q = \frac{Q}{4} + \Delta U \qquad$ C = Molar specific heat

$\Delta U = \frac{3Q}{4} \qquad \Rightarrow \mu C_v \Delta T = \frac{3}{4}\mu C \Delta T \Rightarrow C_v = \frac{3}{4}C$

$C = \frac{4}{3}C_v = \frac{4}{3}\left(\frac{f}{2}R\right)$ [For diatomic gas f = 5]

$$C = \frac{4}{3} \times \frac{5}{2}R = \frac{10}{3}R$$

89. At constant temperature

PV = constant

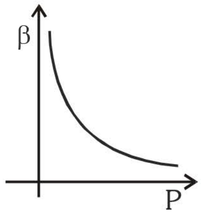
On differentiation

VdP + PdV = 0

$$\frac{dP}{dV} = -\frac{P}{V} \Rightarrow \frac{dV}{dP} = -\frac{V}{P}$$

$$\beta = \frac{-\left(\frac{dV}{dP}\right)}{V} = \frac{1}{P}$$

$$\beta = \frac{1}{P} \text{ Hence } \beta \propto \frac{1}{P}$$



90. $\frac{Q}{W} = \frac{\mu C_P \Delta T}{\mu R \Delta T}$ (as P is constant)

$$= \frac{C_P}{R} = \frac{C_P}{C_P - C_V} = \frac{C_P / C_V}{C_P / C_V} = \frac{\gamma}{\gamma - 1}$$

91. Process $A \rightarrow B$

P = constant, $V\downarrow$, W = –ve ⇒ work done on the gas

and $T \propto V$; $T\downarrow, \Delta U = -ve \Rightarrow$ change in internal energy ↓

$Q = \Delta U + W = -ve$ ie. heat is lost

Process $B \rightarrow C$, V = constant ; W = 0

and $P \propto T$; $P\downarrow, T\downarrow$; change in internal energy ↓

$Q = \Delta U$

Q = –ve → Heat loss

Process $C \rightarrow D$, P = constant

$V\uparrow$, WD = +ve

and $V \propto T$; $\Delta T\uparrow$, ΔU = change in internal energy ↑

$Q = \Delta U + W$

Q = +ve → Heat gained

Process $D \rightarrow A$

T = constant $\Delta U = 0$

$V\downarrow$, W = –ve ; WD on the gas

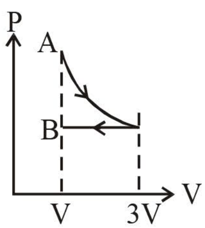
$Q = W + \Delta U$

Q = –ve → Heat loss

92. I → Isothermal expansion from $V \rightarrow 3V$ (T = constant)

II → compressed at constant pressure from

$3V \rightarrow V$



93. Process (1) → volume constant → Isochroic

Process (2) → adiabatic

Process (3) → Temperature constant → Isothermal

Process (4) → Pressure constant → Isobaric

94. $\text{Slope}_{\text{adiabatic}} \propto \gamma$

Slope of 1 < Slope of 2

$\gamma_1 < \gamma_2$ and $\gamma_{mono} > \gamma_{dia}$

So, 2 is monoatomic & 1 is diatomic

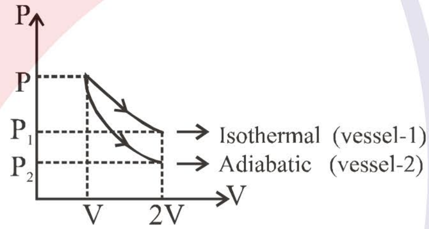
95. $B \rightarrow$ Adiabatic $\rightarrow P \propto \frac{1}{V^{\gamma}}$ $V\uparrow P\downarrow$ (more steep)

No heat exchange during AD process

$A \rightarrow$ Isothermal $\rightarrow P \propto \frac{1}{V}$ $V\uparrow P\downarrow$ (less steep)

(C,D) → positive slope

96.

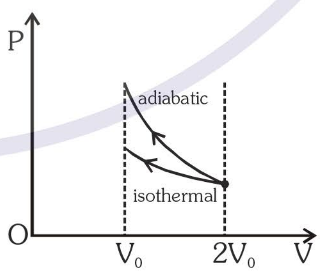


$P_1 > P_2$, final pressure in vessel (1) is more than vessel (2)

$W_1 > W_2$ $W \propto$ Area

so, In first vessel, both pressure and work done are more.

97.



W_{ext} = negative of area with volume-axis

W(adiabatic) > W(isothermal)

98. Free expansion as $P_{ext} = 0 \Rightarrow W = 0$

99. Heat cannot be converted in 100% work, but reverse is true.

100. $\eta = 1 - \frac{T_2}{T_1} = \frac{W}{Q}$

$1 - \frac{300}{900} = \frac{W}{3\times10^6}$

$\frac{2}{3} = \frac{W}{3\times10^6}$

$W = 2\times10^6$ Cal $= 2\times4.2\times10^6$ J $= 8.4\times10^6$ J

101. $W = Q_1 - Q_2 = Q_1\left(1 - \frac{Q_2}{Q_1}\right)$

$\Rightarrow 800\text{ J} = Q_1\left(1 - \frac{T_2}{T_1}\right) = \frac{Q_1}{2} \Rightarrow \boxed{Q_1 = 1600\text{J}}$

102. $\eta = \left(\frac{T_1 - T_2}{T_1}\right) \times 100$

where $T_1 = 373$, $T_2 = 273$

$\Rightarrow \eta = \frac{100}{373} \times 100 = 26.8\%$

103. $0.4 = 1 - \frac{T_2}{T_1}$ ...(1)

and $0.4\left(1 + \frac{50}{100}\right) = 1 - \frac{T_2}{T_1 + \Delta T}$ ...(2)

from (1) & (2)

$\Rightarrow T_1 = \frac{T_2}{0.6} = 500\text{K}$

and $T_1 + \Delta T = \frac{T_2}{0.4} = 750\text{K} \Rightarrow \Delta T = 250$ K

104. $W = Q_1 - Q_2$

$\Rightarrow W = Q_1\left(1 - \frac{Q_2}{Q_1}\right) = Q_1\left(1 - \frac{T_2}{T_1}\right)$

or $W = 3000\left(1 - \frac{300}{900}\right)$Kcal

or $W = 2000\times10^3\times4.2$ J

or $W = 8.4\times10^6$ J

105. $\eta = 1 - \frac{T_1}{T_2} = \frac{1}{2} \Rightarrow T_2 = \frac{T_1}{2}$

$\eta^1 = 1 - \frac{T_2 - 100}{T_1} = \frac{2}{3}$

$\Rightarrow 3(T_2 - 100) = 2T_1 \quad \Rightarrow T_1 = 600$ K

106. $\eta_1 = 50\ \%$ $\Rightarrow$ $T_2 = 500$ K

$\eta_2 = 60\ \%$ $\Rightarrow$ $T'_2 = ?$

$\eta = \left(1 - \frac{T_2}{T_1}\right)\times100\%$

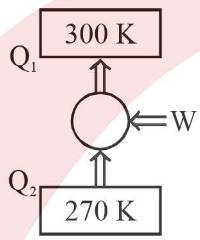
$\Rightarrow \frac{50}{100} = 1 - \frac{500}{T_1}$

$\Rightarrow \quad T_1 = 1000$ K ......(i)

for η=60%

$\frac{60}{100} = 1 - \frac{T_2'}{1000} \Rightarrow T_2' = 400$ K

107.



$W = Q_1 - Q_2$ or $W = Q_2\left(\frac{Q_1}{Q_2} - 1\right)$

or $W = 360\left(\frac{T_1}{T_2} - 1\right) = 360\left(\frac{300}{270} - 1\right) = 40\text{J}$

Power = W per second = 40 W

108. $\text{COP} = \frac{T_C}{T_H - T_C}$

109. $\text{C.O.P} = \frac{T_2}{T_1 - T_2} = \frac{270}{30} = 9$

$\text{Wattage} = \frac{\text{Heat transfer per second}}{\text{C.O.P}} = \frac{180}{9}$

= 20 watt

110. Coefficient of performance of refrigerator

$\text{COP} = \frac{T_L}{T_H - T_L}$

Where $T_L \rightarrow$ lower Temperature

& $T_H \rightarrow$ Higher Temperature

So, $5 = \frac{T_L}{T_H - T_L}$

$\Rightarrow T_H = \frac{6}{5}T_L = \frac{6}{5}(253) = 303.6$ K

111. $\beta = \frac{Q_2}{W} = \frac{T_2}{T_1 - T_2}$ (Where Q_2 is heat removed)

$\Rightarrow \frac{300 \times 4.2}{W} = \frac{277}{303 - 277}$

$\Rightarrow W = 118.25$ joule

$\Rightarrow$ Power $= \frac{W}{t} = \frac{118.25\text{ joule}}{1\text{ sec}} = 118.25$ watt.

112. Heat delivered $= Q_1$

$\text{COP}(\beta) = \frac{Q_2}{W} = \frac{Q_1 - W}{W} = \frac{Q_1}{W} - 1 = \frac{T_2}{T_1 - T_2}$

$\Rightarrow \frac{Q_1}{W} = 1 + \frac{t_2 + 273}{t_1 - t_2} = \frac{t_1 + 273}{t_1 - t_2}$

113. $\beta = \frac{Q_2}{W} = \frac{1 - \eta}{\eta}$

$\Rightarrow \frac{Q_2}{20} = \frac{1 - 0.05}{0.05} = 19$

$\Rightarrow Q_2 = 19 \times 20 = 380$ J

114. $A \to B$; $dW = 0$;

$Q = \Delta U = \frac{3}{2}(2p_0v_0 - p_0v_0) = \frac{3}{2}p_0v_0$

$B \to C$; $W = 2p_0v_0$;

$\Delta U = \frac{3}{2}(4p_0v_0 - 2p_0v_0) = 3p_0v_0$; $Q = 5p_0v_0$

$C \to D$; $W = 0$; $\Delta U = -3p_0v_0$; $Q = -3p_0v_0$

$D \to A$; $W = -p_0v_0$; $\Delta U = -\frac{3}{2}p_0v_0$; $Q = -\frac{5}{2}p_0v_0$

so, $W_{cycle} = p_0v_0$ and

heat from source $= (Q)_+ = 6.5\ p_0v_0$

115. $\eta = \frac{W_{cycle}}{Q_+} \times 100 = \frac{p_0v_0}{6.5p_0v_0} \times 100 \Rightarrow \eta = 15\%$

116. Metal has high thermal conductivity.

117. As $R = \frac{L}{KA} \Rightarrow \frac{L_1}{K_1A} = \frac{L_2}{K_2A} \Rightarrow \frac{L_1}{L_2} = \frac{K_1}{K_2} = \frac{4}{9}$

118. Heat resistance $R = \frac{\ell}{kA} \Rightarrow R \propto \frac{\ell}{A}$

R is minimum for option IV

So conduction of heat will be more.

119. $\frac{\Delta Q}{\Delta t} = \text{same}$

So $\frac{KA(20-10)}{\ell} = \frac{2KA(10-\theta)}{\ell}$

$\Rightarrow 2\theta = 10 \Rightarrow \theta = 5\ ^\circ C$

120. $\frac{T-100}{\frac{L}{3KA}} + \frac{T-0}{\frac{L}{KA}} + \frac{T-50}{\frac{L}{2KA}} = 0$

$\Rightarrow 3(T - 100) + T + 2(T - 50) = 0$

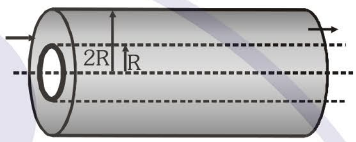
$\Rightarrow T = \frac{400}{6} = \frac{200}{3}\ ^\circ C$

121. $\frac{(9K)(A)(100-\phi)}{18} = \frac{K(A)(\phi - 20)}{6}$

$900 - 9\phi = 3(\phi - 20)$

$\Rightarrow \phi = \frac{900 + 60}{12} = 80^\circ C$

122.



$K_e = \frac{K_1A_1 + K_2A_2}{A_1 + A_2}$ (For parallel combination)

$= \frac{K_1(\pi R^2) + K_2\left[\pi(2R)^2 - \pi R^2\right]}{4\pi R^2}$

$K_e = \frac{K_1 + 3K_2}{4}$

123. $\frac{L_{eq}}{K_{eq}A} = \frac{L_1}{K_1A} + \frac{L_2}{K_2A}$

$\frac{d_1 + d_2}{K_{eq}A} = \frac{d_1}{k_1A} + \frac{d_2}{k_2A} \Rightarrow K_{eq} = \frac{k_1k_2(d_1 + d_2)}{d_1k_2 + d_2k_1}$

124. $R_i = \frac{L}{(200)A} + \frac{L}{(400)A} + \frac{L}{(200A)} = \frac{5L}{(400)A}$

Now they are in parallel

$R_f = \frac{1}{\frac{(200)A}{L} + \frac{(400)A}{L} + \frac{(200)A}{L}} = \frac{L}{(800)A}$

$\Rightarrow \frac{R_f}{R_i} = \frac{1}{10}$ so, $\frac{H_f}{H_i} = 10 \Rightarrow H_f = 400W$

125. In parallel $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{K_{eq}(2A)}{\ell} = \frac{K_1A}{\ell} + \frac{K_2A}{\ell}$

$K_{eq} = \frac{K_1 + K_2}{2}$

126. $Q = \dfrac{K_{eq.}A(\theta_1 - \theta_2)t}{L}$

For fig. (a) ;

Keq = HM of K_1 & K_2

Keq = K

for fig. (b) ; $K_{eq.} = \dfrac{KA + KA}{A + A} = K$

(AM of K_1 & K_2)

$\because \quad Q_1 = Q_2$

$\Rightarrow \dfrac{K(A)}{2L}(\theta_1 - \theta_2)t_1 = \dfrac{K(2A)}{L}(\theta_1 - \theta_2)t_2$

Given t_1 = 4 min.

$\theta_1 - \theta_2 = 100 \quad \Rightarrow \quad t_2 = 1$ min.

127. Convection is due to density difference

128. Convection heat the air molecules which move upward, while high density molecule comes down for low density (pressure)

129. $P = \sigma AT^4 \Rightarrow P \propto T^4$

$\lambda_{m_1}T_1 = \lambda_{m_2}T_2$

$\Rightarrow \quad \lambda_0 T = \dfrac{3}{5}\lambda_0 T_2$

$\Rightarrow \quad T_2 = \dfrac{5}{3}T$

$\therefore\ P_2 = C \times \left(\dfrac{5}{3}T\right)^4 = \dfrac{625}{81} \times P$

$\therefore\ n = \dfrac{625}{81}$

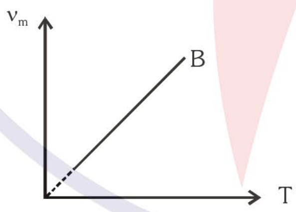
130. $\lambda \uparrow T \downarrow$

wavelength of blue colour is lesser than red so the temperature of blue star is more.

131. $\lambda_m \propto \dfrac{1}{T} \quad \Rightarrow \lambda_m = \dfrac{b}{T}$

$\lambda_m = \dfrac{c}{\nu_m}$

$\nu_m \propto$ temperature



132. $\dfrac{A_1}{A_2} = \dfrac{E_1}{E_2}\left(\dfrac{T_1}{T_2}\right)^4 = \left(\dfrac{\lambda m_2}{\lambda m_1}\right)^4$

Spectural energy distribution curver for (IBB)

133. $\lambda_{m_1}T_1 = \lambda_{m_2}T_2$

$2597\text{ K} \times 12000\text{Å} = 4800\text{Å} \times T_2$

$T_2 = 6492.5\text{ K} = 6219.5\ ^\circ\text{C}$

134. According to wein's law $T\downarrow, \lambda_m\uparrow$

so $\quad \lambda_{Red} > \lambda_{Blue} \Rightarrow T_{Red} < T_{Blue}$

$\boxed{T_b > T_a}$

135. Good absorber is a good emitter, according to Kirchhoff's law.

136. $\lambda_m \propto \dfrac{1}{T}$ (wein's law)

137. $\dfrac{E}{E'} = \dfrac{\sigma(400)^4 \times 8 \times 4}{\sigma(800)^4 \times 4 \times 2}$

$\dfrac{E}{E'} = \left(\dfrac{1}{2}\right)^4 \times 4 \qquad \Rightarrow \qquad E' = 4E$

138. $E \propto T^4$

$E_2 = E_1\left(\dfrac{T_2}{T_1}\right)^4$

$E_2 = 7\left(\dfrac{1000}{500}\right)^4 = 112\text{units}$

139. $P \propto r^2 T^4$

$\Rightarrow \dfrac{P_1}{P_2} = \left(\dfrac{r_1}{r_2}\right)^2\left(\dfrac{T_1}{T_2}\right)^4$

P_2 = 1800 watt

140. $R_1 \propto (600)^4 - (200)^4$

$R_2 \propto (400)^4 - (200)^4$

$\dfrac{R_2}{R_1} = \dfrac{(16+4)(16-4)}{(36+4)(36-4)} = \dfrac{20 \times 12}{40 \times 32}$

$R_2 = \dfrac{3}{16}R$

141. $R_H \propto \text{Area}(A)$, so same for both

142. $R_F = \dfrac{d\theta}{dt} \propto \dfrac{1}{\rho r} \Rightarrow \dfrac{R_{F_1}}{R_{F_2}} = \dfrac{\rho_2 r_2}{\rho_1 r_1} = \dfrac{1 \times 2}{2 \times 1} = 1:1$

143. Newton's law of cooling is used to calculate the specific heat of liquid .

144. In accordance with newton's law of cooling.

145. We know = $\dfrac{d\theta}{dt} = -k(\theta - \theta_0)$

after integration

$\log_e(\theta - \theta_0) = -kt + c$

146. According to newton's law of cooling

$\dfrac{d\theta}{dt} \propto (\theta_{avg} - \theta_0)$

$\dfrac{80 - 60}{10\text{min}} = k\left(\dfrac{80 + 60}{2} - 30\right)$

$\dfrac{60 - T}{10\text{min}} = k\left(\dfrac{60 + T}{2} - 30\right)$

$\Rightarrow \dfrac{60 - T}{20} = \dfrac{T}{80} \Rightarrow T = 48°C$

147. $\frac{90-70}{5}=k\left[\frac{90+70}{2}-20\right]$

$\frac{60-30}{t}=k\left[\frac{60+30}{2}-20\right]$

$\frac{20t}{5\times 30}=\frac{60}{25} \quad \Rightarrow \quad t = 18 \text{ min}$

148. Newton's laws of cooling

$\frac{T_1-T_2}{t}=k\left(\frac{T_1+T_2}{2}-T\right)$

$\frac{3T-2T}{10}=k\left(\frac{5T-2T}{2}\right) \Rightarrow \frac{T}{10}=k\left(\frac{3T}{2}\right) \quad \ldots(i)$

$\frac{2T-T'}{10}=k\left(\frac{2T+T'}{2}-T\right) \Rightarrow \frac{2T-T'}{10}=k\left(\frac{T'}{2}\right) \ldots(ii)$

By solving (i) and (ii) $T'=\frac{3}{2}T$

149. $\frac{\sigma.4\pi r^2T^4}{4\pi R^2}=\frac{\sigma r^2T^4}{R^2}$

150. Kirchhoff's law :-

$\frac{e_\lambda}{a_\lambda}=E_\lambda$