

1. Sol. (a)

Heat taken by ice to melt at 0°C is

$$Q_1 = mL = 540 \times 80 = 43200 \text{ cal}$$

Heat given by water to cool upto 0°C is

$$Q_2 = ms \Delta\theta = 540 \times 1 \times (80 - 0) = 43200 \text{ cal}$$

Hence heat given by water is just sufficient to melt the whole ice and final temperature of mixture is 0°C .

Short trick : For these type of frequently asked questions you can remember the following formula

$$\theta_{\text{mix}} = \frac{m_w \theta_w - \frac{m_i L_i}{c_w}}{m_i + m_w} \quad (\text{See theory for more details})$$

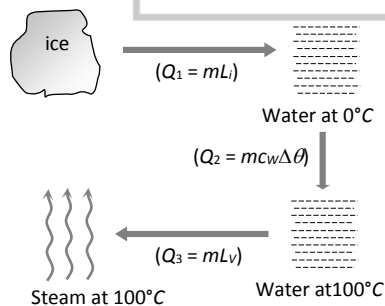
If $m_w = m_i$ then $\theta_{\text{mix}} = \frac{\theta_w - \frac{L_i}{c_w}}{2} = \frac{80 - \frac{80}{1}}{2} = 0^\circ\text{C}$

2. Sol. (a)

$$Q = m.c.\Delta\theta = 5 \times (1000 \times 4.2) \times (100 - 20) = 1680 \times 10^3 \text{ J} = 1680 \text{ kJ}$$

3. Sol. (c)

Conversion of ice (0°C) into steam (100°C) is as follows



Heat required in the given process = $Q_1 + Q_2 + Q_3$
 $= 1 \times 80 + 1 \times 1 \times (100 - 0) + 1 \times 536 = 716 \text{ cal}$

4. Sol. (a)

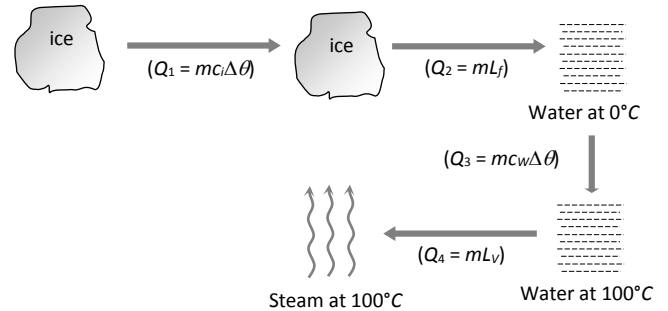
If $m \text{ gm}$ ice melts the Heat lost = Heat gain

$$80 \times 1 \times (30 - 0) = m \times 80 \Rightarrow m = 30 \text{ gm}$$

5. Sol. (a)

Ice (-10°C) converts into steam as follows

(c_i = Specific heat of ice, c_w = Specific heat of water)



Total heat required $Q = Q_1 + Q_2 + Q_3 + Q_4$

$$\Rightarrow Q = 1 \times 0.5(10) + 1 \times 80 + 1 \times 1 \times (100 - 0) + 1 \times 540 = 725 \text{ cal}$$

Hence work done $W = JQ = 4.2 \times 725 = 3045 \text{ J}$

6. Sol. (a)

Same amount of heat is supplied to copper and water so $m_c c_c \Delta\theta_c = m_w c_w \Delta\theta_w$

$$\Rightarrow \Delta\theta_w = \frac{m_c c_c (\Delta\theta)_c}{m_w c_w} = \frac{50 \times 10^{-3} \times 420 \times 10}{10 \times 10^{-3} \times 4200} = 5^\circ\text{C}$$

7. Sol. (b)

Heat lost by hot water = Heat gained by cold water in beaker + Heat absorbed by beaker

$$\Rightarrow 440(92 - \theta) = 200 \times (\theta - 20) + 20 \times (\theta - 20) \Rightarrow \theta = 68^\circ\text{C}$$

8. Sol. (d)

Temperature of mixture

$$\theta_{\text{mix}} = \frac{m_1 c_1 \theta_1 + m_2 c_2 \theta_2}{m_1 c_1 + m_2 c_2} = \frac{m \times c \times 2T + \frac{m}{2} (2c)T}{m.c + \frac{m}{2} (2c)} = \frac{3}{2} T$$

9. Sol. (b)

Firstly the temperature of bullet rises up to melting point, then it melts. Hence according to $W = JQ$.

$$\Rightarrow \frac{1}{2} m v^2 = J.[m.c.\Delta\theta + mL] = J[m S (475 - 25) + mL]$$

$$\Rightarrow m S (475 - 25) + mL = \frac{m v^2}{2J}$$

10. Sol. (a)

$$\text{As } W = JQ \Rightarrow \frac{1}{2}(mgh) = J \times mc \Delta\theta \Rightarrow \Delta\theta = \frac{gh}{2Jc}$$

$$\Delta\theta = \frac{9.8 \times 84}{2 \times 4.2 \times 1000} = 0.098^\circ\text{C} \quad (\because c_{\text{water}} = 1000 \frac{\text{cal}}{\text{kg} \times ^\circ\text{C}})$$

Short trick : Remember the value of $\frac{g}{Jc_w} = 0.0023$,

$$\text{here } \Delta\theta = \frac{1}{2} \times (0.0023)h = \frac{1}{2} \times 0.0023 \times 84 = 0.098^\circ\text{C}$$

11. Sol. (b)

Suppose person climbs upto height h , then by using

$$W = JQ \Rightarrow mgh = JQ$$

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

12. Sol. (a)

Suppose m' kg ice melts out of m kg then by using

$$W = JQ \Rightarrow mgh = J(m'L).$$

Hence fraction of ice melts

$$= \frac{m'}{m} = \frac{gh}{JL} = \frac{9.8 \times 1000}{4.18 \times 80} = \frac{1}{33}$$

13. Sol. (a)

According to energy conservation, change in kinetic energy appears in the form of heat (thermal energy).

$$\Rightarrow \text{i.e. Thermal energy} = \frac{1}{2}m(v_1^2 - v_2^2) \quad \left[\because \begin{matrix} W = Q \\ \text{(Joule)} & \text{(Joule)} \end{matrix} \right]$$

$$= \frac{1}{2}(100 \times 10^{-3})(10^2 - 5^2) = 3.75 \text{ J}$$

14. Sol. (d)

$$\text{Temperature of mixture } \theta = \frac{m_1c_1\theta_1 + m_2c_2\theta_2}{m_1c_1 + m_2c_2}$$

$$\Rightarrow 32 = \frac{m_1 \times 0.2 \times 40 + 100 \times 0.5 \times 20}{m_1 \times 0.2 + 100 \times 0.5} \Rightarrow m_1 = 375 \text{ gm}$$

15. Sol. (a)

$$\theta_{\text{mix}} = \frac{\theta_w - \frac{L_i}{c_w}}{2} = \frac{80 - \frac{80}{1}}{2} = 0$$

16. Sol. (c)

Partial pressure of water vapour $P_W = 0.012 \times 10^5 \text{ Pa}$,

Vapour pressure of water $P_V = 0.016 \times 10^5 \text{ Pa}$.

The relative humidity at a given temperature is

$$\text{given by} = \frac{\text{Partial pressure of water vapour}}{\text{Vapour pressure of water}}$$

$$= \frac{0.012 \times 10^5}{0.016 \times 10^5} = 0.75 = 75\%$$

17. Sol. (b)

Let the final temperature be $T^\circ\text{C}$.

Total heat supplied by the three liquids in coming

$$\text{down to } 0^\circ\text{C} = m_1c_1T_1 + m_2c_2T_2 + m_3c_3T_3 \quad \dots$$

(i)

Total heat used by three liquids in raising temperature from 0°C to $T^\circ\text{C}$

$$= m_1c_1T + m_2c_2T + m_3c_3T \quad \dots\text{(ii)}$$

By equating (i) and (ii) we get

$$(m_1c_1 + m_2c_2 + m_3c_3)T$$

$$= m_1c_1T_1 + m_2c_2T_2 + m_3c_3T_3$$

$$\Rightarrow T = \frac{m_1c_1T_1 + m_2c_2T_2 + m_3c_3T_3}{m_1c_1 + m_2c_2 + m_3c_3}$$

18. Sol. (b)

$$c = \frac{Q}{m \Delta\theta}; \text{ as } \Delta\theta = 0, \text{ hence } c \text{ becomes } \infty.$$

19. Sol. (b)

$$\theta_{\text{mix}} = \frac{m_1c_1\theta_1 + m_2c_2\theta_2}{m_1c_1 + m_2c_2} = \frac{m s (2t) + 1.5 (m s) \times \frac{t}{3}}{m s + 1.5 (m s)} = t$$

20. Sol. (b)

Initially ice will absorb heat to raise its temperature to 0°C then its melting takes place

If m_i = Initial mass of ice, m_i' = Mass of ice that melts and m_w = Initial mass of water

By Law of mixture Heat gained by ice = Heat lost by

$$\text{water} \Rightarrow m_i \times c \times (20) + m_i' \times L = m_w c_w [20]$$

$$\Rightarrow 2 \times 0.5(20) + m_i' \times 80 = 5 \times 1 \times 20 \Rightarrow m_i' = 1 \text{ kg}$$

So final mass of water = Initial mass of water + Mass of ice that melts = $5 + 1 = 6 \text{ kg}$.

21. Sol. (b)

Suppose m kg steam required per hour

Heat released by steam in following three steps

(i) When 150°C steam $\xrightarrow{Q_1}$ 100°C steam

$$Q_1 = mc_{\text{Steam}} \Delta\theta = m \times 1 (150 - 100) = 50 m \text{ cal}$$

(ii) When 150°C steam $\xrightarrow{Q_2}$ 100°C water

$$Q_2 = mL_V = m \times 540 = 540 m \text{ cal}$$

(iii) When 100°C water $\xrightarrow{Q_3}$ 90°C water

$$Q_3 = mc_w \Delta\theta = m \times 1 \times (100 - 90) = 10 m \text{ cal}$$

Hence total heat given by the steam $Q = Q_1 + Q_2 +$

$$Q_3 = 600 m \text{ cal} \quad \dots (i)$$

Heat taken by 10 kg water

$$Q' = mc_w \Delta\theta = 10 \times 10^3 \times 1 \times (80 - 20) = 600 \times 10^3 \text{ cal}$$

$$\text{Hence } Q = Q' \Rightarrow 600 m = 600 \times 10^3$$

$$\Rightarrow m = 10^3 \text{ gm} = 1 \text{ kg.}$$

22. Sol. (c)

Since in the region AB temperature is constant therefore at this temperature phase of the material changes from solid to liquid and $(H_2 - H_1)$ heat will be absorb by the material. This heat is known as the heat of melting of the solid.

Similarly in the region CD temperature is constant therefore at this temperature phase of the material changes from liquid to gas and $(H_4 - H_3)$ heat will be absorb by the material. This heat as known as the heat of vapourisation of the liquid.

23. Sol. (a)

Initially, on heating temperature rises from -10°C to 0°C . Then ice melts and temperature does not rise. After the whole ice has melted, temperature begins to rise until it reaches 100°C . Then it becomes constant, as at the boiling point will not rise.

24. Sol. (c)

Since specific heat $= 0.6 \text{ kcal/gm} \times ^\circ\text{C} = 0.6 \text{ cal/gm} \times ^\circ\text{C}$

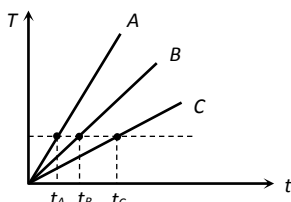
From graph it is clear that in a minute, the temperature is raised from 0°C to 50°C .

$$\Rightarrow \text{Heat required for a minute} = 50 \times 0.6 \times 50 = 1500 \text{ cal.}$$

Also from graph, Boiling point of wax is 200°C .

25. Sol. (c)

Substances having more specific heat take longer time to get heated to a higher temperature and longer time to get cooled.



If we draw a line parallel to the time axis then it cuts the given graphs at three different points.

Corresponding points on the times axis shows that

$$t_C > t_B > t_A \Rightarrow C_C > C_B > C_A$$

26. Sol. (c)

From given curve,

Melting point for $A = 60^\circ\text{C}$ and melting point for $B = 20^\circ\text{C}$

Time taken by A for fusion $= (6 - 2) = 4$ minute

Time taken by B for fusion $= (6.5 - 4) = 2.5$ minute

$$\text{Then } \frac{H_A}{H_B} = \frac{6 \times 4 \times 60}{6 \times 2.5 \times 60} = \frac{8}{5}.$$

27. Sol : (d)

As

$$P = \frac{1}{3} \rho v_{\text{rms}}^2 = \frac{1}{3} (8.99 \times 10^{-2}) \times (3180)^2 = 3.03 \times 10^5 \text{ N/m}^2 = 3.0 \text{ atm}$$

28. Sol. (d)

Kinetic energy $E = 1.5 \times 10^5 \text{ J}$, volume $V = 20 \text{ litre}$

$$= 20 \times 10^{-3} \text{ m}^3$$

$$\text{Pressure} = \frac{2}{3} \frac{E}{V} = \frac{2}{3} \left(\frac{1.5 \times 10^5}{20 \times 10^{-3}} \right) = 5 \times 10^6 \text{ N/m}^2.$$

29. Sol. (a)

$$V = 10^{-3} \text{ m}^3, N = 3.0 \times 10^{22}, m = 5.3 \times 10^{-26} \text{ kg},$$

$$v_{\text{rms}} = 400 \text{ m/s}$$

$$P = \frac{1}{3} \frac{mN}{V} v_{\text{rms}}^2 = \frac{1}{3} \times \frac{5.3 \times 10^{-26} \times 3.0 \times 10^{22}}{10^{-3}} (400)^2 = 8.48 \times 10^4 \text{ N/m}^2$$

30. Sol. (c)

From $PV = \mu RT$ we get

$$\frac{V_2}{V_1} = \left(\frac{T_2}{T_1} \right) \left(\frac{P_1}{P_2} \right) = \left(\frac{270}{300} \right) \left(\frac{1}{0.5} \right) = \frac{9}{5}$$

$$\Rightarrow V_2 = 500 \times \frac{9}{5} = 900 \text{ m}^3$$

31. Sol. (d)

From $PV \propto MT$ or $V \propto \frac{M}{P} T$; Here $\left(\frac{M}{P} \right)$ represents

the slope of curve drawn on volume and temperature axis.

For first condition slope $\left(\frac{M}{P} \right)$ graph is D (given in the problem)

For second condition slope $\frac{2M}{P/2} = 4\left(\frac{M}{P}\right)$ i.e. slope

becomes four times so graph A is correct in this condition.

32. Sol. (a)

Ideal gas equation, in terms of density

$$\frac{P_1}{\rho_1 T_1} = \frac{P_2}{\rho_2 T_2} = \text{constant} \therefore \frac{\rho_1}{\rho_2} = \frac{P_1}{P_2} \times \frac{T_2}{T_1}$$

$$\therefore \frac{\rho_{\text{Top}}}{\rho_{\text{Bottom}}} = \frac{P_{\text{Top}}}{P_{\text{Bottom}}} \times \frac{T_{\text{Bottom}}}{T_{\text{Top}}} = \frac{70}{76} \times \frac{300}{280} = \frac{75}{76}$$

33. Sol. (a)

$$\text{As } v_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\therefore \frac{C_A}{C_B} = \sqrt{\frac{T_A / T_B}{M_A / M_B}} = \sqrt{4} = 2$$

$$\left[\text{As } \frac{T_A}{T_B} = 4 \frac{M_A}{M_B} \text{ given} \right]$$

34. Sol. (d)

$$v_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + v_3^2 + v_4^2 + v_5^2}{5}} = \sqrt{\frac{2^2 + 3^2 + 4^2 + 5^2 + 6^2}{5}}$$

$$= \sqrt{\frac{100}{5}} = \sqrt{20} = 4.24$$

35. Sol. (a)

The rms speed depends upon the molecular mass

$$v_{rms} \propto \frac{1}{\sqrt{M}} \text{ but kinetic energy does not depend on it}$$

$$E \propto M^0$$

In the problem $m_1 > m_2 > m_3$

$$\therefore (v_{rms})_1 < (v_{rms})_2 < (v_{rms})_3 \text{ but } (\bar{K}_1) = (\bar{K}_2) = (\bar{K}_3)$$

36. Sol. (d)

$$E = \frac{3}{2} RT = \frac{3}{2} \times 8.31 \times 273 = 3.4 \times 10^3 \text{ Joule}$$

37. Sol. (d)

If $P_1 = P$ then $P_2 = P + 5\% \text{ of } P = 1.05 P$

From Boyle's law $PV = \text{constant}$

$$\therefore \frac{V_2}{V_1} = \frac{P_1}{P_2} = \frac{P}{1.05 P} = \frac{100}{105}$$

Fractional change in

$$\text{volume} = \frac{\Delta V}{V} = \frac{V_2 - V_1}{V_1} = \frac{100 - 105}{105} = -\frac{5}{105}$$

\therefore Percentage change in volume

$$\frac{\Delta V}{V} \times 100\% = -\frac{5}{105} \times 100\% = -4.76\% \text{ i.e. volume}$$

decrease by 4.76%.

38. Sol. (c)

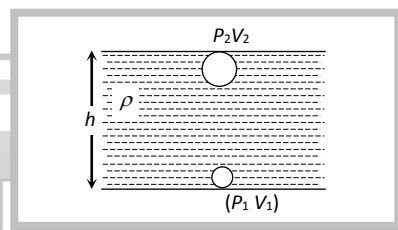
$$P \propto \frac{1}{V} \therefore \frac{V_2}{V_1} = \frac{P_1}{P_2} \Rightarrow V_2 = 10 \times \left(\frac{1}{4}\right) = 2.5 \text{ cc}$$

39. Sol. (d)

According to Boyle's law multiplication of pressure and volume will remain constant at the bottom and top.

If P is the atmospheric pressure at the top of the lake and the volume of bubble is V then

$$\text{from } P_1 V_1 = P_2 V_2$$



$$(P + h\rho g)V_0 = PV$$

$$\Rightarrow V = \left(\frac{P + h\rho g}{P}\right)V_0$$

$$\therefore V = V_0 \left[1 + \frac{\rho gh}{P}\right]$$

40. Sol. (c)

For a given pressure, volume will be more if temperature is more (Charles's law)

From the graph it is clear that $V_2 > V_1$

$$\therefore T_2 > T_1$$

41. Sol. (a)

$$\text{As } V \propto T \therefore \frac{V_2}{V_1} = \frac{T_2}{T_1} \Rightarrow V_2 = \left(\frac{313}{293}\right)V_1$$

Fraction of gas comes out

$$= \frac{V_2 - V_1}{V_1} = \frac{\left(\frac{313}{293}\right)V_1 - V_1}{V_1} = \frac{20}{293} = 0.07$$

42. Sol. (c)

In the given graph line have a positive slop with X axis and negative intercept on Y-axis.

So we can write the equation of line $y = mx - c$
..... (i)

According to Charlie's law $V_t = \frac{V_0}{273}t + V_0$, by

rewriting this equation we get $t = \left(\frac{273}{V_0}\right)V_t - 273$
.....(ii)

By comparing (i) and (ii) we can say that time is represented on Y-axis and volume in X-axis.

43. Sol. (a)

$P_1 = P, T_1 = T, P_2 = P +$

$(0.4\% \text{ of } P) = P + \frac{0.4}{100}P = P + \frac{P}{250} \quad T_2 = T + 1$

From Gay Lussac's law $\frac{P_1}{P_2} = \frac{T_1}{T_2}$

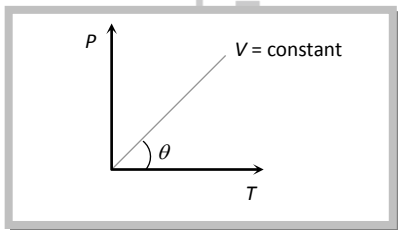
$\Rightarrow \frac{P}{P + \frac{P}{250}} = \frac{T}{T + 1}$

[As $V = \text{constant}$ for closed vessel]

By solving we get $T = 250 \text{ K}$.

44. Sol. (a)

From ideal gas equation $PV = \mu RT \quad \therefore P = \frac{\mu R}{V}T$



Comparing this equation with $y = mx$

Slope of line $\tan \theta = m = \frac{\mu R}{V}$

i.e. $V \propto \frac{1}{\tan \theta}$

It means line of smaller slope represent greater volume of gas.

For the given problem figure

Point 1 and 2 are on the same line so they will represent same volume *i.e.* $V_1 = V_2$

Similarly point 3 and 4 are on the same line so they will represent same volume *i.e.* $V_3 = V_4$

But $V_1 > V_3 (= V_4)$ or $V_2 > V_3 (= V_4)$ as slope of line 1-2 is less than 3-4.

45. Sol. (b)

Energy of 1 mole of gas $= \frac{f}{2}RT = \frac{f}{2}PV$

where $f = \text{Degree of freedom}$

Monoatomic or diatomic both gases posses equal degree of freedom for translational motion and that

is equal to 3 *i.e.* $f = 3 \quad \therefore E = \frac{3}{2}PV$

Although total energy will be different,

For monoatomic gas $E_{\text{total}} = \frac{3}{2}PV$ [As $f = 3$]

For diatomic gas $E_{\text{total}} = \frac{5}{2}PV$ [As $f = 5$]

46. Sol. (c)

Given velocity of sound $v_s = 330 \frac{m}{\text{sec}}$,

Density of gas $\rho = 1.3 \frac{kg}{m^3}$,

Atomic pressure $P = 1.01 \times 10^5 \frac{N}{m^2}$

Substituting these value in $v_{\text{sound}} = \sqrt{\frac{\gamma P}{\rho}}$

we get $\gamma = 1.41$

Now from $\gamma = 1 + \frac{2}{f}$ we get $f = \frac{2}{\gamma - 1} = \frac{2}{1.4 - 1} = 5$.

47. Sol. (a)

At constant pressure $(\Delta Q)_p = \mu C_p \Delta T$

$= 1 \times C_p \times (30 - 20) = 40 \Rightarrow C_p = 4 \frac{\text{calorie}}{\text{mole kelvin}}$

$\therefore C_v = C_p - R = 4 - 2 = 2 \frac{\text{calorie}}{\text{mole} \times \text{kelvin}}$

Now $(\Delta Q)_v = \mu C_v \Delta T = 1 \times 2 \times (30 - 20) = 20 \text{ calorie}$

48. Sol. (d)

Given $c_p - c_v = 4150$ (i) and

$\frac{c_p}{c_v} = 1.4 \Rightarrow c_p = 1.4c_v$ (ii)

By substituting the value of c_p in equation (i) we get

$1.4c_v - c_v = 4150 \Rightarrow 0.4c_v = 4150$

$\therefore c_v = \frac{4150}{0.4} = 10375 \text{ J/kg} - K$.

49. Sol. (d)

When a gas is heated at constant pressure then its one part goes to increase the internal energy and another part for work done against external pressure *i.e.* $(\Delta Q)_p = \Delta U + \Delta W$

$$\Rightarrow \mu C_p \Delta T = \mu C_v \Delta T + P \Delta V$$

So fraction of energy that goes to increase the internal

$$\text{energy } \frac{\Delta U}{(\Delta Q)_p} = \frac{C_v}{C_p} = \frac{1}{\gamma} = \frac{5}{7} \quad [\text{As } \gamma = \frac{7}{5} \text{ for}$$

diatomic gas]

50. Sol. (b)

We know fraction of given energy that goes to

$$\text{increase the internal energy} = \frac{1}{\gamma}$$

So we can say the fraction of given energy that

$$\text{supplied for external work} = 1 - \frac{1}{\gamma}.$$

51. Sol. (d)

Total internal energy of

$$\begin{aligned} \text{system} &= U_{\text{oxygen}} + U_{\text{argon}} = \mu_1 \frac{f_1}{2} RT + \mu_2 \frac{f_2}{2} RT \\ &= 2 \frac{5}{2} RT + 4 \frac{3}{2} RT = 5 RT + 6 RT = 11 RT \end{aligned}$$

[As $f_1 = 5$ (for oxygen) and $f_2 = 3$ (for argon)]

52. Sol. (b)**53. Sol. (d)**

$$\Delta Q = \Delta W + \Delta U \Rightarrow 35 = -15 + \Delta U \Rightarrow \Delta U = 50 J$$

54. Sol. (a)

$$J \Delta Q = \Delta U + \Delta W, \quad \Delta U = J \Delta Q - \Delta W$$

$$\Delta U = 4.18 \times 300 - 600 = 654 \text{ Joule}$$

55. Sol. (c)

$$\Delta Q = \Delta U + \Delta W \quad \because \Delta W = 0 \Rightarrow \Delta Q = \Delta U = \frac{f}{2} \mu R \Delta T$$

$$= \frac{3}{2} \times 2R(373 - 273) = 300R.$$

56. Sol. (b)

$$\Delta Q = \Delta U + \Delta W; \quad \Delta Q = 200 J \text{ and } \Delta W = -100 J$$

$$\Rightarrow \Delta U = \Delta Q - \Delta W = 200 - (-100) = 300 J$$

57. Sol. (b)

From FLOT $\Delta Q = \Delta U + \Delta W$

Work done at constant pressure $(\Delta W)_p = (\Delta Q)_p - \Delta U$

$$(\Delta Q)_p - (\Delta Q)_v \quad (\text{As we know } (\Delta Q)_v = \Delta U)$$

$$\text{Also } (\Delta Q)_p = m c_p \Delta T \text{ and } (\Delta Q)_v = m c_v \Delta T$$

$$\Rightarrow (\Delta W)_p = m(c_p - c_v) \Delta T$$

$$\Rightarrow (\Delta W)_p = 1 \times (3.4 \times 10^3 - 2.4 \times 10^3) \times 10 = 10^4 \text{ cal}$$

58. Sol. (c)

Change in internal energy is always equal to the heat supplied at constant volume.

$$\text{i.e. } \Delta U = (\Delta Q)_v = \mu C_v \Delta T.$$

$$\text{For monoatomic gas } C_v = \frac{3}{2} R$$

$$\Rightarrow \Delta U = \mu \left(\frac{3}{2} R \right) \Delta T = 1 \times \frac{3}{2} \times 8.31 \times (100 - 0)$$

$$= 12.48 \times 10^2 J$$

59. Sol. (c)

$$\Delta U = \mu C_v \Delta T = n \left(\frac{R}{\gamma - 1} \right) \Delta T$$

$$\Rightarrow \Delta U = \frac{P \Delta V}{(\gamma - 1)} = \frac{P(2V - V)}{\gamma - 1} = \frac{PV}{(\gamma - 1)}$$

60. Sol. (c)

According to FLOT

$$\Delta Q = \Delta U + P(\Delta V) \Rightarrow \Delta U = \Delta Q - P(\Delta V)$$

$$= 1500 - (2.1 \times 10^5)(2.5 \times 10^{-3}) = 975 \text{ Joule}$$

61. Sol. (a)

Given $\Delta Q = -20 J$, $\Delta W = -8 J$ and $U_i = 30 J$

$$\Delta Q = \Delta U + \Delta W \Rightarrow \Delta U = (\Delta Q - \Delta W)$$

$$\Rightarrow (U_f - U_i) = (U_f - 30) = -20 - (-8) \Rightarrow U_f = 18 J$$

62. Sol. (a)

In first process using $\Delta Q = \Delta U + \Delta W$

$$\Rightarrow 8 \times 10^5 = \Delta U + 6.5 \times 10^5 \Rightarrow \Delta U = 1.5 \times 10^5 J$$

Since final and initial states are same in both process

So ΔU will be same in both process

For second process using $\Delta Q = \Delta U + \Delta W$

$$\Rightarrow 10^5 = 1.5 \times 10^5 + \Delta W \Rightarrow \Delta W = -0.5 \times 10^5 J$$

63. Sol. (d)

$$W = \mu R T \log_e \frac{V_2}{V_1}$$

$$= \left(\frac{m}{M} \right) R T \log_e \frac{V_2}{V_1} = 2.3 \times \frac{m}{M} R T \log_{10} \frac{V_2}{V_1}$$

$$= 2.3 \times \frac{96}{32} R (273 + 27) \log_{10} \frac{140}{70} = 2.3 \times 900 R \log_{10} 2$$

64. Sol. (b)Differentiate $PV = \text{constant}$ w.r.t V

$$\Rightarrow P\Delta V + V\Delta P = 0 \Rightarrow \frac{\Delta P}{P} = -\frac{\Delta V}{V}$$

65. Sol. (d)

$$W = -\mu RT \log_e \frac{V_2}{V_1} = -1 \times 8.31 \times (273 + 0) \log_e \left(\frac{22.4}{11.2} \right)$$

$$= -8.31 \times 273 \times \log_e 2 = -1572.5 J \quad [\because \log_e 2 = 0.693]$$

66. Sol. (c)

No change in the internal energy of ideal gas but for real gas internal energy increases because work is done against intermolecular forces.

67. Sol. (c)

For isothermal process

$$dU = 0 \text{ and work done } = dW = P(V_2 - V_1)$$

$$\because V_2 = \frac{V_1}{2} = \frac{V}{2} \therefore dW = -\frac{PV}{2}$$

68. Sol. (a)

In isothermal compression, there is always an increase of heat. Which must flow out the gas.

$$\Delta Q = \Delta U + \Delta W \Rightarrow \Delta Q = \Delta W \quad (\because \Delta U = 0)$$

$$\Rightarrow \Delta Q = -1.5 \times 10^4 J = \frac{1.5 \times 10^4}{4.18} \text{ cal} = -3.6 \times 10^3 \text{ cal}$$

69. Sol. (d)For adiabatic process $\frac{T^\gamma}{P^{\gamma-1}} = \text{constant}$

$$\Rightarrow \frac{T_2}{T_1} = \left(\frac{P_1}{P_2} \right)^{\frac{1-\gamma}{\gamma}} \Rightarrow \frac{T_2}{300} = \left(\frac{4}{1} \right)^{\frac{(1-1.4)}{1.4}} \Rightarrow T_2 = 300(4)^{\frac{0.4}{1.4}}$$

70. Sol. (c)

$$PV^\gamma = \text{constant} \Rightarrow \frac{P_2}{P_1} = \left(\frac{V_1}{V_2} \right)^\gamma \Rightarrow \frac{P_2}{1} = \left(\frac{V_1}{V_1/4} \right)^{3/2} = 8$$

$$\Rightarrow P_2 = 8 \text{ atm.}$$

71. Sol. (d)

$$PV^\gamma = \text{constant} \Rightarrow \frac{P_2}{P_1} = \left(\frac{V_1}{V_2} \right)^\gamma \Rightarrow P_2 = (8)^{5/3} P_1 = 32 P_1$$

72. Sol. (c)Volume of the gas $V = \frac{m}{d}$ and using $PV^\gamma = \text{constant}$

$$\text{We get } \frac{P'}{P} = \left(\frac{V}{V'} \right)^\gamma = \left(\frac{d'}{d} \right)^\gamma = (32)^{7/5} = 128$$

73. Sol. (b)

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2} \right)^{\gamma-1} \Rightarrow T_2 = 300 \left(\frac{27}{8} \right)^{\frac{5}{3}-1} = 300 \left(\frac{27}{8} \right)^{\frac{2}{3}}$$

$$= 300 \left\{ \left(\frac{27}{8} \right)^{1/3} \right\}^2 = 800 \left(\frac{3}{2} \right)^2 = 675 K$$

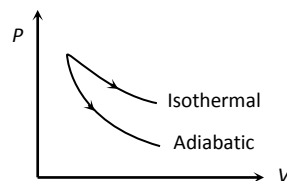
$$\Rightarrow \Delta T = 675 - 300 = 375 K$$

74. Sol. (a)

In thermodynamic processes.

Work done = Area covered by PV diagram with V -axisFrom graph it is clear that $(\text{Area})_{iso} > (\text{Area})_{adi}$

$$\Rightarrow W_{iso} > W_{adi}$$

**75. Sol. (c)**For Isothermal process $PV = \text{constant}$

$$\Rightarrow \left(\frac{dP}{dV} \right) = \frac{-P}{V} = \text{Slope of Isothermal curve}$$

For adiabatic $PV^\gamma = \text{constant}$

$$\Rightarrow \frac{dP}{dV} = \frac{-\gamma P}{V} = \text{Slop of adiabatic curve slope}$$

$$\text{Clearly, } \left(\frac{dP}{dV} \right)_{\text{adiabatic}} = \gamma \left(\frac{dP}{dV} \right)_{\text{Isothermal}}$$

76. Sol. (d)

$$PV^\gamma = \text{constant} \Rightarrow P \left(\frac{RT}{P} \right)^\gamma = \text{constant}$$

$$\Rightarrow P^{1-\gamma} T^\gamma = \text{constant.}$$

77. Sol. (b)Slope of adiabatic curve = $\gamma \times$ (Slope of isothermal curve)**78. Sol. (a)**

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

$$= \frac{8.31 \times \{(273 + 27) - (273 + 127)\}}{1.4 - 1} = -2077.5 \text{ joules}$$

79. Sol. (b)

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2} \right)^\gamma \Rightarrow P_2 = P_1 \left(\frac{V_1}{V_2} \right)^\gamma = P_0 (8)^{4/3} = 16 P_0.$$

80. Sol. (a)

$$\Delta U = \mu C_V \Delta T = 1 \times C_V (T_f - T_i) = -C_V (T_i - T_f)$$

$$\Rightarrow |\Delta U| = C_V (T_i - T_f)$$

81. Sol. (c)

$$T_2 = T_1 \left(\frac{V_1}{V_2} \right)^{\gamma-1} = 273(2)^{0.41} = 273 \times 1.328 = 363K$$

$$W = \frac{R(T_1 - T_2)}{\gamma - 1} = \frac{8.31(273 - 363)}{1.41 - 1} = -1824$$

$$\Rightarrow |W| \approx 1815 J$$

82. Sol. (a)

Given $P \propto T^3$, but we know for an adiabatic process, the pressure $P \propto T^{\gamma/\gamma-1}$

$$\text{So } \frac{\gamma}{\gamma-1} = 3 \Rightarrow \gamma = \frac{3}{2} \Rightarrow \frac{C_p}{C_v} = \frac{3}{2}$$

83. Sol. (d)

$$W = \frac{R(T_i - T_f)}{\gamma - 1} \Rightarrow 6R = \frac{R(T - T_f)}{\left(\frac{5}{3} - 1\right)} \Rightarrow T_f = (T - 4)K.$$

84. Sol. (a)

$$\text{From FLOT } \Delta Q = \Delta U + \Delta W = \Delta U + P\Delta V$$

$$\Rightarrow 100 = \Delta U + 50 \times (4 - 10) \Rightarrow \Delta U = 400 J$$

85. Sol. (a)

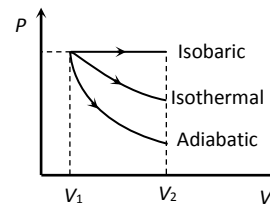
$$W = P \times \Delta V = 2 \times 10^5 (150 - 50) \times 10^{-3} = 2 \times 10^4 J$$

86. Sol. (a)

In thermodynamic process, work done is equal to the area covered by the PV curve with volume axis.

Hence, according to graph shown

$$W_{\text{adiabatic}} < W_{\text{isothermal}} < W_{\text{isobaric}}$$



87. Sol. (d)

$$\text{At constant volume } P \propto T \Rightarrow \frac{P_1}{P_2} = \frac{T_1}{T_2} \Rightarrow \frac{P_1}{P_2} = \frac{300}{400} = \frac{3}{4}$$

88. Sol. (d)

In isothermal process $\Delta Q \neq 0$.

89. Sol. (a)

For isochoric process $\Delta V = 0 \Rightarrow \Delta W = 0$

$$\text{From FLOT } \Delta Q = \Delta U + \Delta W \Rightarrow \Delta Q = \Delta U$$

90. Sol. (d)

$$\eta = \frac{T_1 - T_2}{T_1} - \frac{W}{Q} \Rightarrow Q = \left(\frac{T_1}{T_1 - T_2} \right) W$$
$$= \frac{600}{(600 - 300)} \times 800 = 1600 J$$

