HEAT - II

EXERCISE – I

SINGLE CORRECT

1. B

Law Pr^r and high temperature

2. C

Speed of molecules changes randomly due to collision but average speed remain constant.

3. B

Since net force is zero over the system at rest hence momentum will be zero.

4. A

$$\sqrt{\frac{3R\ T_{o_2}}{M_{o_2}}} = \sqrt{\frac{3R\,T_{N_2}}{M_{N_2}}}$$

$$T_{o_2} = \frac{M_{o_2}}{M_{n_2}}.T_{N_2}$$

$$= \frac{16}{14} \times 373 = 426.3\,K$$

5. C

$$V_{avg} = \frac{V_1 + V_2 + ...V_n}{n}$$

$$V_{rms} = \sqrt{\frac{V_1^{\ 2} + V_2^{\ 2} + ...V_n^{\ 2}}{n}}$$

For one particle n = 1

$V_{avg} = V_{rms} = V_1$

6. C

$$V_{rms_{o_2}} = \sqrt{\frac{3RT_{o_2}}{M_{o_2}}}$$

$$V_{rmso} = \sqrt{\frac{3RT_{o_2} \times 2}{M_{o_2}/2}} = 2\sqrt{\frac{3RT_{o_2}}{M_{o_2}}} = 2\,V$$

7. B

$$V_{avg} \times \frac{1}{\sqrt{M_o}}$$

$$\&\ M_o > M_{H_2}\ \ \therefore V_{avgo} < V_{avg.H_2}$$

8. A

$$V_{rms} = \sqrt{\frac{3RT}{M}} \qquad V_{MP} = \sqrt{\frac{2RT}{M}}$$

$$V_{av} = \sqrt{\frac{8RT}{\pi M}} \qquad V_S = \sqrt{\frac{5RT}{3M}}$$

$$\therefore V_{rms} > V_{av} > V_{MP} > V_S$$

9. B

$$V_{av} = \sqrt{\frac{8RT}{\pi M}}$$

Independent of other gas.

10. C

PV = n RT

$$P = \frac{nRT}{V} = cost.$$

11. A

$$\text{R.M.S. speed} \quad = \sqrt{\frac{\left(2^2 + 10^2 + 11^2\right)}{2}u^2}$$

= 8.66 u

$$\text{Mean speed} \quad = \frac{\left(2 + 10 + 11\right)}{3}u$$

= 7.66 u

12. D

$$V_{avg} = \frac{1 + 2 + 3.........N}{N} = \frac{N\left(N+1\right)}{2\,N}$$

$$= \frac{(N+1)}{2}$$

$$V_{rms} = \sqrt{\frac{1^2 + 2^2 + ...N^2}{N}} = \sqrt{\frac{2N+1}{3}}$$

$$\frac{V_{rms}}{V_{avg}} = \frac{2}{(N+1)}\sqrt{\frac{2N+1}{3}}$$

13. D

Data Insufficient

∵ direction not given

14. C

Isothermally ⇒ internal energy remain constant.

But volume ↓ ⇒ no. of collisions per unit area with walls of container increases.

15. A

Avg rotational $K.\in. = \frac{1}{2}KT \times 2 = KT$

So it will be same for both

16. D

17. D

$$U_1 + U_2 = U_{mixture}$$

$$\frac{3}{2}R\left[n_1 T_1 + n_2 T_2\right] = \frac{3}{2}R\left[n_1 + n_2\right]T_{mix}$$

$$T_{mix} = \left[\frac{n_1 T_1 + n_2 T_2}{n_1 + n_2}\right]\frac{N_A}{N_A}$$

18. B

for L → M

P = const. $\Rightarrow T = \frac{P}{nR}V$

a st. live with +ve slope.

19. D

$$P/T = const. = \frac{nR}{V}$$

but V is different, So slope is different.

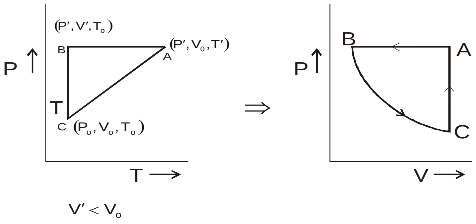
20. C

PT = const.

$$P\left(\frac{PV}{nR}\right) = const.$$

P^2V = const.

21. C



22. A

$$V_{av} \propto \sqrt{T} \propto \sqrt{PV}$$

$$V_{av_1} : V_{av_2} : V_{av_3}$$

$$\sqrt{V_oP_o} : \sqrt{V_o.4P_o} : \sqrt{4V_oP_o}$$

1 : 2 : 2

23. D

PV = nRT

= n N_o KT

$\frac{PV}{KT}$ = n N_o = no. of molecules

24. D

$$\frac{MKT}{PV} = \frac{MKT}{nRT} = \frac{M_o}{N_A}$$

Depend upon Nature of gas

25. A

$$PV = \frac{2}{3}K.E.$$

$$E = \frac{3}{2}nRT$$

(Translational K.E. for all the particle)

26. C

27. A

PV = nRT

$$n = \frac{PV}{RT} = \frac{1.3 \times 10^5 \times \left[7 \times \left(10^{-2}\right)^3 \times 10^3\right]}{8.3 \times 273}$$

So, No of molecules

$$= \frac{1.3 \times 10^5 \times 7 \times 10^{-3}}{8.3 \times 273} \times 6.023 \times 10^{23}$$

$$2.4 \times 10^{23}$$

28. B

$$PV = \frac{4}{M_{Ar}}.RT \quad \_\_\_\_\_\_\_\_ (1)$$

$$\text{Now,} \quad PV = \frac{(4 - .8)}{M_{Ar}} R\ (T + 50) \_ (2)$$

$$(1) \& (2) \Rightarrow (4 - .8)(T + 50) = 4T$$

$$4T - .8T + 200 - .8 \times 50 = 4T$$

$$T = \frac{200 - .8 \times 50}{.8}$$

T = 200 K

29. A

30. C

PV = nRt ____________ (1)

$$P\left(\frac{P_0/2 - P_0}{2V_0 - V_0}\right)V + \frac{3P_0}{2} \quad \_\_\_\_\_\_\_ (2)$$

(1) & (2) $\Rightarrow \left(\frac{3}{2}P_0 - \frac{P_0V}{2V_0}\right)V = nRT$

$$\frac{dT}{dV} = 0 \Rightarrow \frac{3}{2}P_0 - \frac{P_0V}{V_0} = 0$$

$$V = \frac{3}{2}V_0$$

$$T_{max} = \left(\frac{3}{2}P_0 - \frac{P_0}{2V_0}.\frac{3}{2}V_0\right)\frac{3}{2}V_0.\frac{1}{nR}$$

$$= \frac{6}{4}P_0.\frac{3}{2}V_0.\frac{1}{R}$$

$$= \frac{9P_0V_0}{FR}$$

31. B

Initially

$$PV_1 = \frac{12}{M}R\,T_1$$

or

$$P\left(4\times10^{-3}\right) = \frac{12}{M}R\left(273+7\right)$$

$$A = \frac{m}{V_2} = \frac{12}{V_2} = 6\times10^{-4}\ \text{gm/cc}$$

$$P\left(\frac{12}{6\times10^{-4}}\right)\times\left(10^{-2}\right)^3 = \frac{12}{M}R\left(T\right)\_\_\ (2)$$

$$\text{from}\,1\div2$$

$$\frac{4\times10^{-3}}{12\times10^{-6}}\times6\times10^{-4} = \frac{273+7}{T}$$

$$T = 1400\,K$$

32. B

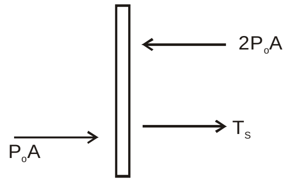
33. A

34. C

V = const.

T = doubled

p = $2P_o$



$$\Rightarrow T_S + P_oA = 2P_oA$$
$$T_S = P_oA$$

35. A

$PV^{2/3}$ = const.

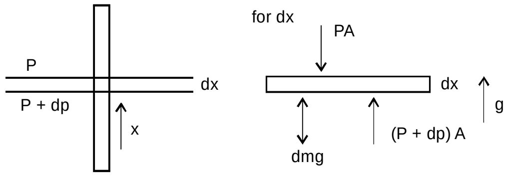
$\frac{nRT}{\upsilon}\upsilon^{2/3}$ = const.

$T\upsilon^{2/3^{-1}}$ = const.

$T.\upsilon^{-1/3}$ = const.

So, $V\uparrow = T\uparrow$

36. C



(p + dp) A - dmg - PA = dmg

Adp = 2dmg

Adp = $2\rho_x$ A dx g

dp = $2\rho_x$ g dx

$$= \frac{PM}{RT}$$

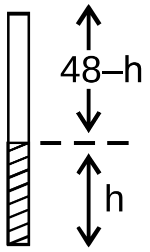
$$dp = \frac{2PM}{RT}.g.dx$$

$$\int_{p_o}^{p_o'} dp/p = \frac{2Mg}{RT}\int_{o}^{x=x/2} dx$$

$$\ln\frac{p_o'}{p_o} = \frac{2Mg}{RT}.\frac{x}{2}$$

$$\frac{p_o'}{p_o} = e^{MgH/RT}$$

37. C



$$P + h = 76$$
$$P_1V_1 = P_2V_2$$
$$76.5 = P(48-h)$$
$$(76-h)(4-h)$$
$$h = 38\,cm$$

$$\text{so, } 48-h = 10\,cm = .1m$$

38. A

P + 50 = 75

P = 25 cm of H_g

$$\frac{10^5}{75}\times25$$

= 33.3 kPa

39. D

Total energy = 100 + 200

= 300 J

40. B

$$W = \int_{V_1}^{V_2} PdV$$

$$= \int_{V_1}^{V_2} aV^2 dV$$

$$= a\left[\frac{V^3}{3}\right]_{V_1}^{V_2} = \frac{a}{3}\left(V_2^3 - V_1^3\right)$$

$$= \frac{1}{3}\left[P_2V_2 - P_1V_1\right]$$

$$= \frac{1}{3}\left[nR\Delta T\right] = \frac{1}{3}R\left(T_2 - T_1\right)$$

41. D

In RS & SP Volume has decreased

42. A

W = Area Under the Curve

43. C

$W = P\Delta V$

$\Delta V_1 = \Delta V_2 \quad \& \quad P_1 < P_2$

$\Rightarrow \; W_1 < W_2$

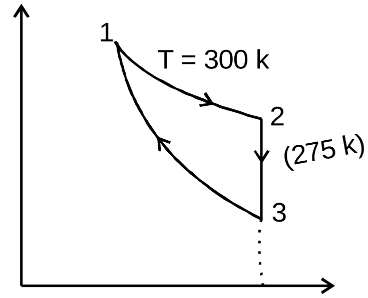
44. A

All the three things for a fixed mass of an ideal gas only depends upon temp.

45. A

W = Area Under the Curve

46. A



$\Delta Q_{1-2} = \Delta W_{1-2}$

$\Delta Q_{2-3} = \Delta U_{2-3} = -40\,J$

$\Rightarrow \quad \Delta W_{2-3} = 0$

$\Delta Q_{3-1} = 0$

$\Delta u_{3-1} = n\,c_v\left(300 - 275\right)$

$\Delta Q_T = \Delta W_T$

$\Delta Q_{3-1} + \Delta Q_{2-3} + \Delta Q_{1-2}$

$= \Delta W_{1-2} + \Delta W_{2-3} + \Delta W_{3-1}$

$\Delta Q_{2-3} - \Delta W_{2-3} = \Delta W_{3-1}$

$\Delta W_{3-1} = -40\,J$

47. B

$\Delta Q = \Delta U + \Delta Q$

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

$Q - P_o \Delta V$

$Q - P_o\left(\frac{1}{\rho_2} - \frac{1}{\rho_1}\right)$

48. D

V = KT

$$\frac{dV}{dT} = K \Rightarrow \frac{d^2V}{dT^2} = 0$$

49. D

$W_{net} = W_{1-2} + W_{2\to3} + W_{3-1}$

$10 = W_{1-2} + 0 - 20$

$W_{1-2} = 30\,J$

$\Delta U_{1-2} = 0$

$\therefore \; \Delta Q_{1-2} = \Delta W_{1-2} + \Delta U_{1\to2}$

$= 30\,J$

50. D

ΔU is a state function

51. D

$\Delta U_{ab} = \Delta Q_{acp} - \Delta W_{acb}$

$= 200 - 80 = 120\,J$

$\Delta W_{adb} = \Delta Q_{adb} - \Delta U_{ab}$

$= 144 - 120 = 24\,J$

52. B

$\Delta Q_{ba} = \Delta W_{ba} + \Delta U_{ba}$

$= -52\,J - 120\,J$

$= 172\,J$

53. D

$\Delta U_{ab} = U_b - U_a$

$U_b = 120 + 40 = 160\,J$

54. B

$\Delta Q_{db} = \Delta U_{db} + \Delta W_{db} \; (v = const.)$

$= U_b - U_d$

$= 160 - 88 = 72\,J$

55. B

For AB

$\Delta U = 0 \qquad (T = const.)$

$$\Delta W = nRT\ \ell n\frac{V_2}{V_1} = nRT\,\ell n\frac{P_1}{P_2}$$

$$= -Ve\ (\because P_1 < P_2)$$

$$\Delta Q = \Delta U + \Delta W = -ve$$

(Heat is rejected)

For BC $\because$ T $\downarrow$ $\therefore$ U $\downarrow$

56. B

for isothermal process
T = const.

$\therefore$ U = const. or $\Delta U = O$

$$\Delta W = \Delta Q$$
$$= +ve$$

57. A, C

ΔU for a cyclic process = 0

58. D

ΔU will be same for both the process

$\Rightarrow$ $\Delta Q - \Delta W$ will be same

59. A

$$\Delta Q = \Delta W + 3\Delta W$$
$$= 4\Delta W$$

$$\because\ n = \frac{\Delta W}{\Delta Q} = \frac{\Delta W}{4\,\Delta W} = 0.25$$

60. A

$$C_v = \frac{f}{2}.R \qquad = \frac{5}{2}R$$

61. B

Work is done during expansion by the gas against external pressure.

62. C

$$C = \frac{fR}{2} + \frac{W_{gas}}{n\Delta T}$$

$$C = CV + \frac{W_{gas}}{n\Delta T} \qquad \therefore C > C_V$$

63. C

$$C_p = C_V + \frac{W_{gas}}{n\Delta T}$$

$C_P - C_V = R$ is for ideal gas

64. B

$f_{translational}$ = 3 (always)

65. A

$$\frac{1}{2}mv^2 = nC_v dT$$

$$\frac{1}{2}mv^2 = \frac{m}{.03}\left(\frac{5}{2}R\right)\Delta T$$

$$\Delta T = \frac{.03\times 100^4}{5R} = \frac{6\times 10^{-3}\times 10^4}{R}$$

$$= \frac{60}{R}$$

66. D

$$\frac{\text{Total Mass}}{\text{Total No. of moles}}$$

$$= \frac{n_1 m_1 + n_2 m_2}{(n_1 + n_2)} = \frac{(5\times 4) + (2\times 2)}{(5+2)}$$

$$= \frac{24}{7}$$

67. A

He - monoatomic H_2 - diatomic
f = 3 f = 5

$$f = \frac{3n_{He} + 5n_{H_2}}{n_{He} + n_{H_2}}$$

$$= \frac{3\times 5 + 5\times 2}{(5+2)}$$

$$= 3.57\ \text{Ans.}$$

68. C

$$y = {C_p}/{C_v} = \left[1 + {2}/{f}\right]$$

$$= \left[1 + {2}/{3.57}\right]$$

$$= 1.56\ \text{Ans.}$$

69. A

V/T = const. P - const.

$$\Delta Q = nC_p\Delta T = n\frac{YR}{Y-1}\Delta T$$

$$\Delta w = nR\Delta R$$

$$\frac{\Delta Q}{\Delta W} = \frac{Y}{Y-1}$$

70. C

$$PV^r = \text{const}$$

$$V^r\frac{dP}{dV} = Y\ PV^{r-1}\frac{dV}{dV} = 0$$

$$\frac{dP}{dV} = \frac{-Y\ PV^{r-1}}{V^r} = \frac{-YP}{V}$$

$$= -1.4 \times \frac{.7 \times 10^5}{.0049}$$

$$= -2 \times 10^7$$

71. A

$$PV^m = \text{constant}\,(K)$$

$$P = \frac{K}{V^m} \Rightarrow \frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^m$$

$$P_2 = (2)^m P_1$$

$Y_{mono} > Y_{di} > Y_{tri}$

72. B

$\Delta U = nC_V \Delta T$

Given

$6300 = \Delta U_i = nC_v\,(150)$

So, $\Delta U = \frac{6300}{150} \times 300$

$\Delta U = 12600$

73. A

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

$$= n\frac{f}{2}R\Delta T + nR\Delta T$$

$$= \left(1 + \frac{f}{2}\right)nR\Delta T$$

$$= \left(1 + \frac{6}{2}\right)nR\Delta T$$

$$= 4\left[P\Delta V\right]$$

$$= 4W = 100\,J$$

74. A

$$\Delta W = \int_{V_1}^{V_2} PdV = \int_{V_1}^{V_2} KVdV \qquad \because \frac{P}{V} = K$$

$$= \frac{KV_2^{\,2} - KV_1^{\,2}}{2} = \frac{P_2V_2 - P_1V_1}{2}$$

$$\Rightarrow \Delta U = \frac{3}{2}R\left(2T_0 - T_0\right) = \frac{3}{2}RT_0$$

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

$$= 2RT_0$$

75. D

$$\Delta Q = \Delta U + \Delta Q$$

$$2C\Delta T = n\frac{f}{2}R\Delta T + PdV$$

$$2C\Delta T = 2 \times \frac{5}{2}R\Delta T + PdV \quad \underline{\qquad}(1)$$

$$\frac{PT^2}{V} = K$$

or $\frac{T^3}{V^2} = \frac{K}{nR} \Rightarrow T^3 = \frac{k}{nR}\,V^2$

$$\Rightarrow 3T^2dT = \frac{K}{nR}2VdV$$

or $\frac{3T^2}{2V}\,dT = \frac{K}{nR}dV$

$$\frac{3}{2}dT = \frac{P}{nR}dV \quad \underline{\qquad}(2)$$

(1) and (2)

$$2C\Delta T = 5R\Delta T + nR\frac{3}{2}dT$$

2C = 5R + 3R

2C = 8R

So, molar heat capacity c = 4R

76. B

As suddenly compressed process is adiabatic

$\therefore P_f = \frac{P_i}{2^r}$ (supposed halfed)

Now heat is released at conctant volume.

PV = nRT

$T \downarrow \quad \therefore P \downarrow$

77. D

The process is adiabatic $\Delta Q = 0$

78. C

$$PV^Y = \text{Constant}$$

$$TV^{Y-1} = \text{Constant}$$

$$\frac{V_B}{V_C} = \left(\frac{T_1}{T_2}\right)^{Y-1} = \frac{V_A}{V_D}$$

79. C

Slope of adiabaic > isothermal

(A) (B)

80. C

Process is sudden so there is no time for heat transfer

$$\Delta U = -\Delta W = nC_V\Delta T$$

$$\Rightarrow \frac{\Delta U}{n} = C_V\Delta T$$

81. A

(P) Isobaric W = PΔ V

$= PV$

(Q) $W = nRT\, ln \dfrac{V_f}{V_i}$

$= PV\, ln\, 2$

(R) Adiabatic

$$W = \frac{PV\left(1-2^{1-y}\right)}{y-1}$$

82. A,D

$\Delta W = -\Delta U$

$\Rightarrow \quad \Delta W + \Delta U = 0 = \Delta R$

$\Rightarrow \quad \Delta Q = 0\,(\text{Adiabatic Process})$

83. D

$PV^Y = K$

$\ln P + Y \ \ln V = \ln K$

Differentiate

$d(\ln P) + Y\ d(\ln V) = 0$

$$\frac{d(\ln P)}{d(\ln V)} = -Y$$

$Y_B > Y_A \Rightarrow$ B is monoatomic

Gas A is diatomic

84. B

$$\Delta U = n\frac{f}{2}R\ \ \Delta T$$

Isobaric $\qquad V_1 \rightarrow T_1 = \dfrac{P_1V_1}{nR}$

$V_2 \rightarrow T_2 = \dfrac{P_1(V_1/2)}{nR} = \dfrac{T_1}{2}$

$\Rightarrow \quad \Delta U_P = \dfrac{nfR}{2}\left[\dfrac{T_1}{2}\right]$ _______(1)

Isothermal $\qquad \Delta U_T = 0$ _______(2)

Adiabatic $\qquad PV^Y = K$

$TV^{y-1} = K$

$$\frac{T_1}{T_2} = \frac{V_2^{\,Y-1}}{V_1^{\,y-1}} = \frac{1}{2^{y-1}}$$

$$T_2 = 2^{y-1}T_1 > \frac{T_1}{2}$$

$$\Delta U_{\text{Adiabatic}} = n\frac{F}{2}R\left[2^{y-1}\right]\frac{T_1}{2}$$

$\Delta U_{\text{adiabatic}} = \Delta U_p\left(2^{y-1}\right)$ ______(3)

85. D

For adiabatic

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

$$\Rightarrow \quad B = \frac{-dP}{(dV/V)} = YP = 1.4\times10^5\ \text{Pa}$$

86. A

Free Expansion

So, $\left.\begin{matrix}\Delta W = 0\\ \Delta Q = 0\end{matrix}\right] \Rightarrow \Delta U = 0 \qquad \Rightarrow \Delta T = 0$

and $\ P_1V_1 = P_2(2V_1)$

$$P_2 = \frac{P_1}{2}$$

87. D

205

I^{st} Process

$\Delta U_1 = \Delta Q_1 - \Delta W_1$

$= 16 - 20 = -4\,KJ$

II^{nd} Process

$\Delta W_2 = \Delta Q_2 - \Delta U_2$

$\Delta U_1 = \Delta U_2 \qquad\qquad (\therefore\ \Delta T = \text{same})$

So, $\ \Delta W_2\,[9 - (-4)] = 13\,KJ$

88. A

$T_1^{\,y}P_1^{\,1-y} = T_2^{\,y}P_2^{\,1-y}$

$$T_2 = T_1\left(\frac{P_1}{P_2}\right)^{1-y/y}$$

$$= 300\left(\frac{1}{4}\right)^{1-\frac{4}{3}/\frac{4}{3}}$$

$$= 300\sqrt{2}$$