EXERCISE – V

JEE QUESTIONS

1. **B**

$V_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow v_{rms} \propto \sqrt{T}$

when T ↑ for 120 to 480 k (4 times)

$v_{rms} = \sqrt{4v^2} = 2v$

2. **D**

$v_{rms} = \sqrt{\frac{3RT}{m}} \propto \sqrt{T}$ T′ = 2T

$v_{rms} = \sqrt{2}(484) = 684\,m/s$

$KE = \frac{3}{2}KT \propto T$ T′ = 2T

KE = $2(6.21 \times 10^{-21}) = 12.42 \times 10^{-21}$ J

3. **C**

Avg. transtational K.E. = $\frac{3}{2}KT$ depends on temperature only hence will be same.

4. **C**

$P \propto T$ { n and V are same

$P' = P\left(\frac{2T}{T}\right) = 2P$

5. **D**

$dQ_A = nC_p dT_A$ { A is free to move

$dQ_B = nC_v\, dT_B$ { B is helf fixed.

$nC_P\, dT_A = nC_v\, dT_B \Rightarrow dT_B = \left(\frac{C_P}{C_V}\right)dT_A$

=(1.4) (30K)

$dT_B = 42$ K {r = 1.4 (diatomic)

6. **C**

Isothermal $P \propto \frac{1}{v}$

In chamber A

$-\Delta P = (P_A)_i - (P_A)_f$

$= \frac{n_A RT}{v} - \frac{n_A RT}{2v} = \frac{n_A RT}{2v}$ ...(i)

In chamber B

$-1.5\,\Delta P = (P_B)_i - (P_B)_f$

$= \frac{n_B RT}{v} - \frac{n_B RT}{2v} = \frac{n_B RT}{2v}$ ....(ii)

from eq. (i) & (ii)

$\frac{n_A}{n_B} = \frac{1}{1.5} = \frac{2}{3}$

$\frac{m_A/m}{m_B/m} = \frac{2}{3} \Rightarrow 3m_A = 2m_B$

7. **A**

$(K.E)_{avg} = \frac{1}{2}KT$

per molecule per dof

{Both the gases are diatomic rot : DOG = 2}

T → same

Both the gases will have same average rotational

K.E. per molecule = $2 \times \frac{1}{2}$ KT

Thus ratio will be 1 : 1

8. **C, D**

$v_{rms} = \sqrt{\frac{3RT}{M}}$ $\bar{v} = \sqrt{\frac{8}{\pi}\frac{RT}{M}} = \sqrt{\frac{2.5RT}{M}}$

$v_P = \sqrt{\frac{2RT}{M}}$

$V_P < \bar{v} < V_{rms}$

$K.E._{average} = \frac{1}{2}\, m\, v_{rms}^2 = \frac{3}{4}mv_p^2$

9. **B**

Bulk modulus B = $-V\left(\frac{\partial P}{\partial V}\right)_T$

For PV = nRT

$\left(\frac{\partial P}{\partial V}\right)_T = -\frac{P}{V}$

Hence B = $-V\left(-\frac{P}{V}\right) = P$

10. **B, C**

Melting of ice → V ↓ w → +ve on ice-water system

ΔQ → +ve ΔU → +ve

11. **C**

$v = \sqrt{\frac{rRT}{M}}$ $v \propto \sqrt{\frac{r}{M}}$

{ T is same for both the gases

$\frac{v_{N_2}}{v_{He}} = \sqrt{\frac{\gamma_{N_2}}{\gamma_{He}}\frac{M_{He}}{M_{N_2}}} = \sqrt{\frac{(7/5)}{(5/3)}\frac{4}{28}} = \frac{\sqrt{3}}{5}$

12. **D**

$U = n\left(\frac{f}{2}RT\right)$

$U = U_{o_2} + U_{Ar} = 2\left(\frac{5}{2}RT\right) + 4\left(\frac{3}{2}RT\right)$ = 11 RT

13. on way back

adia. process

TV^{r-1} = cons

$T_0(4V)^{r-1} = T(v)^{r-1}$ ⇒ $T = 2T_0$

$\Delta U = \frac{f}{2}\, nR\, \Delta T = \frac{f}{2}\, n\, RT_0$

and $r = 1 + \frac{2}{f} = f = 4$

so $\Delta U = 2n\,RT_0 = 2\,P_0V_0$
$= 400$ J

14. A

number of mass n = 2, $T_1 = 300$ K
AB process
pT = costant or p^2V = costant = K

$\therefore\ p = \frac{\sqrt{K}}{\sqrt{V}}$

$$\therefore\ W_{A\to B} = \int_{V_A}^{V_B} p.dV = \int_{V_A}^{V_B} \frac{\sqrt{K}}{\sqrt{V}} dV$$

$= 2\sqrt{K}[\sqrt{V_B} - \sqrt{V_A}]$

$= 2[\sqrt{KV_B} - \sqrt{KV_A}]$

$= 2[\sqrt{(p_B^2V_B)V_B} - \sqrt{(p_A^2V_A)V_A}]$

$= 2[p_BV_B - p_AV_A] = 2[nRT_B - nRT_A]$

$= 2\,nR\,[T_1 - 2T_1] = (2)(2)(R)$

$[300 - 600]$

$= -1200\,R$

B $C_v = \frac{3}{2}R$ or $C_p = \frac{5}{2}R, \gamma = \frac{5}{3}$

$A \to B : \Delta U = nC_1\Delta T$

$= (2)\left(\frac{3}{2}R\right)(T_B - T_A)$

$= (2)\left(\frac{3}{2}R\right)(300 - 600) = -900\,R$

$\therefore\ Q_{A\to B} = W_{A\to B} + \Delta U$
$= (-1200\,R) - (900\,R)$
$Q_{A\to B} = -2100\,R$

$B \to C$

$\therefore\ Q_{B\to C} = nC_p\Delta T$

$= (2)\left(\frac{5}{2}R\right)(T_C - T_B) = 2\left(\frac{5}{2}R\right)(2T_1 - T_1)$
$= (5R)(600 - 300) = 1500\,R$

$C \to A$ $\Delta U = 0$

or $Q_{C\to A} = W_{C\to A} = nRT_C \ln\left(\frac{p_C}{p_A}\right)$

$= nR(2T_1)\ln\left(\frac{2p_1}{p_1}\right)$

$= (2)(R)(600)\ln(2) = 831.6R$

15. B

Slope of P – V graph

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

slope $\propto$ r
$(\text{slope})_2 > (\text{slope})_1 \Rightarrow \gamma_2 > \gamma_1$
$1 \to O_2$ (r = 1.4)

16. A

$\Delta w = 0$ $dQ = dU$
$dQ < 0$ $dU < 0 \Rightarrow U_f < U_i$
Temperature decreases

17. A

$\Delta W_{AB} = P\Delta V = 10\,(2 - 1) = 10$ J

$\Delta W_{BC} = 0$

$\Delta Q = \Delta W + \Delta U$ { $\Delta U = 0$

$= \Delta W_{AB} + \Delta W_{BC} + \Delta W_{CA}$

$\Delta W_{CA} = 5 - (10 + 0) = -5$ J

18. A

$\beta = -\frac{dV/dp}{V}$ = compressibility

$= \frac{1}{\text{coeficietan t}}$

or $\beta = \frac{1}{p}$ isothermal process

19. $V = 1\ m^3$ $P = 100\ N/m^2$
Let T be the temperature of gas then
A Time between two consercutive collision

$= \frac{1}{500}s$ $\frac{2\ell}{v_{rms}} = \frac{1}{500}$

$\Rightarrow v_{rms} = 1000$ m/s { $\ell = 1$ m

$\sqrt{\frac{3RT}{m}} = 1000 \Rightarrow T = \frac{(1000)^2(4\times10^{-3})}{3(25/3)} = 160$ K

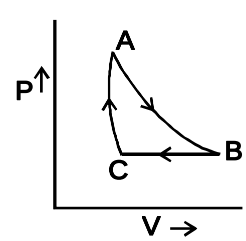
B Avg. Kinetic energy/atom = $\frac{3}{2}kT$
$= 3.312 \times 10^{-21}$ J

C $Pv = nRT = \frac{m}{M}RT$
mass of helium gas m

$= \frac{pVm}{RT}$ $m = \frac{(100)(1)(M)}{(25/3)(160)} = 0.3g$

20. A

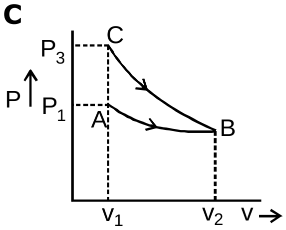
AB is isothermal compression BC is isobaric.



21. $\frac{1}{2}mv_0^2 = nC_v\Delta T = \frac{m}{M}\left(\frac{3}{2}R\right)\Delta T$

$\Delta T = \dfrac{MV_0^2}{3R}$

22. C



$w_{AB} = +ve$; W_{BC} = – ve

$| w_{BC} | > | w_{AB} |$

Hence $W_{AB} + W_{BC} = w < 0$
from graph $P_3 > P_1$

23. At const. Pr. $V \propto T$

$\dfrac{Ah_2}{Ah_1} = \dfrac{T_2}{T_1}$

$h_2 = (100)\left(\dfrac{400}{300}\right) = \dfrac{4}{3} m$

Adibatic $T_f V_f^{\,v-1} = T_i V_i^{\,r-1}$

$T_f = (400)\left(\dfrac{4}{3}\right)^{1.4-1}$ $T_f = (400)\left(\dfrac{4}{3}\right)^{0.4} = 448.8k$

24. C
du = 1 × 1 × 100 × 5 × 60 a= 30000

$= \dfrac{30000}{1000}$ = 30 kJ

25. A

$\beta = \dfrac{\Delta p}{\frac{\Delta v}{v}}$

$= \dfrac{.155 \times 10^5}{\frac{.1v}{v}}$ $= 1.55 \times 10^5$

26. A $\Delta T = \dfrac{\Delta Q}{ms} = \dfrac{20{,}000}{1 \times 400} = 50°C$
$T_f = 20 + 50° = 70°C$

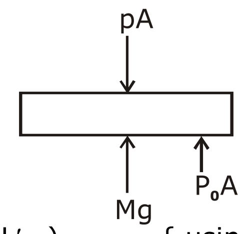
B $\Delta V = r V \Delta T = (9 \times 10^{-5}) \left(\dfrac{1}{9000}\right)(50)$
$= 5 \times 10^{-7}\ m^3$
$w = P\Delta V = (10^5)(5 \times 10^{-7}) = 0.05$ J
C $\Delta U = \Delta Q - W = (2000 - 0.05)$ J
= 19999.95 J

27. Process J → K
A v = const. P ↓ T ↓
w = 0 ΔU = – ve and Q < 0
B Process K → L
P = const. V ↑ T ↑ W > 0
ΔU > 0 and Q > 0
C In process L → M
W = ΔU > 0 and Q > 0
D Process M → J
V ↓ w < 0
$(Pv)_J < (Pv)_M \Rightarrow J_J < T_M$
ΔU < 0 Q < 0

28. A
Since it is open from top pr. will be P_0

29. D
Let P be the pr^r in equilibrium
Then $PA = P_0A - Mg$

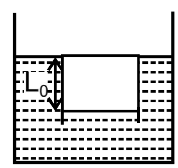
$P = P_0 - \dfrac{M_g}{A}$



$P_0(2AL) = P(AL')$ { using $P_1V_1 = P_2V_2$

$L' = \dfrac{2P_0L}{P} = \left[\dfrac{P_0}{P_0 - \frac{mg}{\pi R^2}}\right](2L)$

30. C



$P_1 = P_2$
$P_0 + \rho g\,(L_0 - H) = P$ ...(i)

Now apply $P_1V_1 = P_2V_2$

$P_0L_0 = P(L_0 - H)$ $P = \dfrac{P_0L_0}{L_0 - H}$

$P_0 + \rho g\,(L_0 - H) = \dfrac{P_0L_0}{L_0 - H}$
$\Rightarrow \rho g\,(L_0 - H)^2 + P_0\,(L_0 - H) - P_0L_0 = 0$

31.B

$PV = \dfrac{1}{3} mN\bar{v}^2$

$PV = \dfrac{2}{3}\{N(1/2\, m\bar{v}^2)\} = \dfrac{2}{3}\{\text{total K.E.}\}$

$\Rightarrow$ K.E. $= \left(\dfrac{3}{2}\right) PV$

Statement 1 is correct
Statement 2 is correct but not the current explanantion of statement - 1

32. C

PT2 = const. $\Rightarrow \dfrac{nRT}{v} T^2 = \text{const.}$
$T^3 v^{-1}$ = const.
on differntiaating

$\frac{3T^2}{v}dT - \frac{T^3}{v^2}dv = 0$

$3T\ dT = \frac{T^2}{v}dv$

we know $r = \frac{dv}{vdT} = \frac{3}{T}$ ans. C

33. A free expansion W = 0, $\Delta U = 0$.
B $PV^2 = c$, PV = nRT, $Q = n\,C\,\Delta T$, for polytropic process, PV^x = constant, $C = C_V + \frac{R}{1-x}$.
C $Q = n\,C\,\Delta T$, for polytropic process, PV^x = constant, $C = C_v + \frac{R}{1-x}$.
D $T = \frac{PV}{nR}$, ΔU = +ve, W = +ve.
A–Q, B–P, R, C – P, S, D– Q,S

34. B, D

$C_p + C_v = \left(\frac{f+2}{2} + \frac{f}{2}\right) R = (f+1)R$

$C_P C_v = \left(\frac{f+2}{2}\right)\left(\frac{f}{2}\right)$

35. B, D
In BCD $\Delta W < 0 \Rightarrow \Delta Q_1 < 0$
$\Delta U < 0$
In ABC, ΔW = Area of semicircular $\neq 0$
For ABCDA, ΔW = Area within curve > 0

36. A–P,Q,S,T, B–Q, C–S, D–S

37. D pressure is low and temperature is high

38. A, B

$U = \frac{f}{2}pv = \frac{f}{2}nRT$ $\qquad U_A = U_B$

$W_{AB} = nRT \ln \frac{V_f}{V_i} = nRT \ln 4 = P_0V_0 \ln 4$

If in BC V × T

so $\frac{T_B}{T_C} = \frac{V_B}{V_C} \Rightarrow \frac{T_0}{T_C} = \frac{4V_0}{V_0}$

$\Rightarrow T_C = \frac{T_0}{4}$ $\qquad$ PV = nRT

at A $\qquad P_0V_0 = nRT_0$

at C $\qquad P_CV_0 = nR\frac{T_0}{4} \Rightarrow P_C = \frac{P_0}{4}$

39. $PV^r = PV^{\frac{7}{5}}$ = cons

$\frac{nRT}{V}.V^{\frac{7}{5}}$ = con

$TV^{\frac{2}{5}}$ = con $\qquad T_1V^{\frac{2}{5}} = aT_1\left(\frac{V}{32}\right)^{\frac{2}{5}}$

$T_1V^{\frac{2}{5}} = \frac{aT_1V^{\frac{2}{5}}}{4}$ $\qquad \boxed{a = 4}$

40. A

$W = \frac{nR(T_1 - T_2)}{r-1}$

TV^{r-1} = cm

$T_1V_1^{2/3} = T_2V_2^{2/3}$

$T_1(5.6)^{\frac{2}{3}} = T_2(0.7)^{\frac{2}{3}}$

$T_2 = T_1(8)^{\frac{2}{3}} = 4T_1$

$W = \frac{nR(T_1 - T_2)}{r-1}$

$= \frac{\frac{5.6}{22.4} \times R(T_1 - 4T_1)}{\frac{2}{3}}$

$= \frac{\frac{1}{4} \times R \times (-3T_1)}{\frac{2}{3}} = \frac{-9}{8}RT_1$

41. A → p,t,r ; B → p,r ; C → q, s ; D → r,t
(A) A → B

Volume and temp. both decrease so internal energy decreases work is done on gas and
$Q = \Delta U + W$ = – ve
hence heat is lost.
(B) W = 0 ; Temp. decreases so internal energy decreases.
W = 0
$Q = \Delta U + W$ = + ve hence heat is gained.
(C) C → D
P = cons. Temp. increases
ΔU = + ve
$Q = nC_p\,\Delta T$ = + ve hence heat is gained.
(D) D → A
$T_D = T_A$
$\Delta U = 0$
W = – ve
$Q = \Delta U + W$ = – ve
hence heat is lost.

42. D

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

$\frac{v_{He}}{v_{Ar}} = \sqrt{\frac{M_{Ar}}{M_{He}}} = \sqrt{\frac{40}{4}} = \sqrt{10} = 3.16$

43. D
$Q = nC_p\Delta T$
= 2 × 5/2 × R × 5
= 208 J