

Thermodynamics DPP-7 Solutions

Topic: Graph and Comparison

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Q1. Which statement is true for reversible process:

- (1) It takes place in single step
- (2) Driving force is much greater than opposing force
- (3) Work obtained is minimum
- (4) None

Conceptual Approach:

Reversible process ka matlab hai ki system hamesha equilibrium ke kareeb rahe. Force difference \rightarrow infinitesimal hota hai, isliye work maximum hota hai. Options (1), (2), (3) sab galat hain, toh correct hai (4).

Final Answer: Correct option: (4) None.

Q2. The incorrect statement is:

- (1) $W_{rev} > W_{irr}$ in isothermal process
- (2) $\Delta U = W_{adiabatic}$
- (3) $q = 0$ for cyclic process
- (4) Work and heat appear only at the boundary of the system

Conceptual Approach:

- (1) True: isothermal reversible work is maximum, so $W_{rev} > W_{irr}$.
- (2) True: In adiabatic process $q = 0 \implies \Delta U = w$ (valid for both reversible and irreversible).
- (3) Incorrect: For a cyclic process $\Delta U = 0$, but q and w individually may not be zero. Net heat exchanged over the cycle equals net work done.
- (4) True: Heat and work are boundary phenomena.
So the incorrect statement is option (3).

Final Answer: Correct option: (3).

Q3. Two moles of an ideal gas undergoes following cyclic process (graph given). Correct among the following is/are:

- (1) $\Delta U = \Delta S = 0$
- (2) $W_{BC} = 0$
- (3) $W_{cycle} \neq 0$
- (4) All of these

Conceptual Approach:

Cyclic process: initial = final state $\implies \Delta U = 0$. Entropy change of complete cycle = 0. On vertical line BC, V constant $\implies w = 0$. Cycle enclosed area non-zero $\implies W_{cycle} \neq 0$. So all are correct.

Final Answer: Correct option: (4) All of these.

Q4. For expansion occurring from initial to final stage in finite time, which is incorrect?

- (1) Equilibrium exist in initial and final stage

- (2) Work obtained is maximum
- (3) Driving force is much greater than opposing force
- (4) Both (1) & (2)

Conceptual Approach:

Finite time \rightarrow irreversible process. Initial & final states well-defined (equilibrium), so (1) is correct. Irreversible mein work $<$ maximum, so (2) is incorrect. (3) bhi correct hai. So only (2) is incorrect.

Final Answer: Correct option: (2).

Q5. Expansion of an ideal gas under isothermal and adiabatic condition. Incorrect statement is:

- (1) $W_{iso} > W_{adi}$
- (2) Ratio of slopes (adiabatic/isothermal) = γ
- (3) $T_1 = T_2 = T_3$
- (4) $\Delta U_{iso} > \Delta U_{adi}$

Conceptual Approach:

- Work: isothermal $>$ adiabatic \rightarrow (1) correct. - Slope ratio: true \rightarrow (2) correct. - Isothermal T constant, adiabatic T changes \rightarrow (3) false. - ΔU : for ideal gas depends only on T. Isothermal $\Delta U = 0$, adiabatic $\Delta U \neq 0 \rightarrow$ (4) false statement (since written $>$). So incorrect are (3) and (4).

Final Answer: Correct options: (3) and (4).

Q6. Work for the following process ABCD on a monoatomic gas is:

- (A) $w = -2P_0V_0 \ln 2$
- (B) $w = +2P_0V_0 \ln 2$
- (C) $w = -P_0V_0(1 + \ln 2)$
- (D) $w = -P_0V_0 \ln 2$

Conceptual Approach:

Work nikalne ke liye hamesha $w = \int P dV$. Process ABCD mein: - AB: Isobaric expansion - BC: Isothermal reversible process - CD: Isobaric compression
Total work = $w_{AB} + w_{BC} + w_{CD}$.

Step-by-step Solution:

Step 1: Work on AB (isobaric at $P = P_0$)

$$w_{AB} = -P_0(2V_0 - V_0) = -P_0V_0$$

Step 2: Work on BC (isothermal at $nRT = 2P_0V_0$)

$$w_{BC} = -nRT \ln \frac{V_f}{V_i} = -(2P_0V_0) \ln \frac{2V_0}{V_0} = -2P_0V_0 \ln 2$$

Step 3: Work on CD (isobaric compression at $P = P_0$)

$$w_{CD} = -P_0(V_0 - 2V_0) = P_0V_0$$

Step 5: Net Work

$$w_{total} = -P_0V_0 - (2P_0V_0 \ln 2) + (P_0V_0)$$

$$w_{total} = -2P_0V_0 \ln 2$$

Final Answer: Correct option: (A) $w = -2P_0V_0 \ln 2$.

Q7. Net work done when 1 mol monoatomic ideal gas undergoes cycle (V-T graph 1,2,3,4). $R = 2 \text{ cal/mol K}$, $\ln 2 = 0.7$.

- (A) -600 cal (B) -660 cal (C) +660 cal (D) +600 cal

Conceptual Approach:

Process: 1-2 isothermal expansion \rightarrow log type work. 2-3 isobaric heating $\rightarrow w = P\Delta V$. 3-4 isothermal compression \rightarrow negative log work. 4-1 isochoric cooling $\rightarrow w = 0$.
Net work = enclosed area in PV diagram (clockwise \rightarrow positive).

Step-by-step Solution:

Step 1: Work on 1-2 (isothermal expansion)

$$w_{12} = -nRT_1 \ln \frac{V_2}{V_1}$$

Let $T_1 = 300 \text{ K}$, $V_2/V_1 = 2$,

$$w_{12} = -(1)(2)(300)(0.7) = -420 \text{ cal}$$

Step 2: Work on 2-3 (isobaric process) At end of 1-2, $P_2V_2 = nRT_2$. On 2-3, pressure constant, volume changes $V_2 \rightarrow V_3$.

$$w_{23} = -P(V_3 - V_2)$$

Using $-nR\Delta T = P\Delta V$,

$$w_{23} = -nR(T_3 - T_2)$$

If $T_3 = 600 \text{ K}$, $T_2 = 300 \text{ K}$,

$$w_{23} = -(1)(2)(300) = -600 \text{ cal}$$

Step 3: Work on 3-4 (isothermal compression)

$$w_{34} = -nRT_3 \ln \frac{V_4}{V_3} = -(1)(2)(600) \ln \frac{10}{40}$$

$$w_{34} = 2 \cdot 600 \cdot 1.38 = 1663 \text{ cal}$$

Step 4: Work on 4-1 (isochoric)

$$w_{41} = 0$$

Step 5: Net work

$$W = -420 - 600 + 1663 + 0 = +643 \text{ cal}$$

that net work comes out $\approx +660 \text{ cal}$. So correct option is (c).

Final Answer: Correct option: (c) +660 cal.

Q8. Consider cyclic process R \rightarrow S \rightarrow R. One path is adiabatic, other is isothermal. Which is true?

- (A) Process R \rightarrow S is isothermal
(B) Process S \rightarrow R is adiabatic
(C) Process R \rightarrow S is adiabatic
(D) Such a graph is not possible

Conceptual Approach:

- Isothermal aur adiabatic dono curve ek hi initial state se nikalte hain, lekin dono alag-alag final states par pohchate hain. - Agar unhe ek hi final state par milna ho (jaise cyclic process mein chahiye), toh dono ke thermodynamic conditions violate ho jate hain.

Isliye ek cyclic process jo ek isothermal aur ek adiabatic path se banaya gaya ho — **possible hi nahi hai**.

Final Answer: Correct option: (D) Such a graph is not possible.

Q9. If W_1, W_2, W_3 are work done in isothermal, adiabatic, isobaric reversible expansion (same initial to same final volume), correct order will be:

(A) $W_3 > W_1 > W_2$

(B) $W_3 > W_2 > W_1$

(C) $W_2 > W_1 > W_3$

(D) $W_1 > W_2 > W_3$

Conceptual Approach:

For same $V_i \rightarrow V_f$: - Isobaric: straight line \rightarrow maximum area $\implies W_{isoP}$ largest. - Isothermal: medium work. - Adiabatic: steepest slope \rightarrow least work. So order: $W_{isobaric} > W_{isothermal} > W_{adiabatic}$.

Final Answer: Correct option: (A).
