

Thermodynamics – Exam 2 (JEE)

System, Properties, Process, FLOT, Heat Capacity

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Q1. Three moles of an ideal gas at 300 K expand isothermally from 30 dm³ to 45 dm³ against a constant pressure of 80 kPa. Heat transferred = ?

Conceptual Approach

Isothermal $\rightarrow \Delta U = 0$. So $q = w$. Work = $P\Delta V$. Bas external pressure aur ΔV ko multiply karo.

Solution

$$\Delta V = (45 - 30) \text{ dm}^3 = 15 \text{ L} = 0.015 \text{ m}^3$$

$$w = P\Delta V = 80 \times 10^3 \times 0.015 = 1200 \text{ J}$$

Final Answer: 1200 J (Option a).

Q2. A 60 W heater runs for 100 s in a const volume adiabatic container. Temp rises by 5°C. Heat capacity = ?

Conceptual Approach

Power \times time = total heat given. Const V \rightarrow all goes to internal energy. $C = q/\Delta T$.

Solution

$$q = 60 \times 100 = 6000 \text{ J}$$

$$C = \frac{q}{\Delta T} = \frac{6000}{5} = 1200 \text{ J/K}$$

Final Answer: 1200 J K⁻¹ (Option d).

Q3. One mole of ideal gas goes from A \rightarrow B (graph shows const V). Process?

Conceptual Approach

Const V \rightarrow no change in volume \rightarrow Isochoric.

Final Answer: Isochoric (Option c).

Q4. Which statement is false? (a) Work is a state function (b) T is state function (c) State change defined by initial + final states (d) Work appears at boundary

Conceptual Approach

Work path function hai, not state function.

Final Answer: (a) False.

Q5. Gas compressed from 377 mL to 177 mL, P=1520 torr, q= -124 J. Find ΔU .

Conceptual Approach

First law: $\Delta U = q - w$. Work = $P\Delta V$. Convert units carefully.

Solution

$$\Delta V = (177 - 377) \text{ mL} = -200 \text{ mL} = -0.200 \text{ L}$$

$$1 \text{ torr} = 133.3 \text{ Pa} \rightarrow P = 1520 \times 133.3 = 202600 \text{ Pa.}$$

$$w = P\Delta V = 202600 \times (-2 \times 10^{-4}) = -40.5 \text{ J}$$

$$\Delta U = -124 - (-40.5) = -83.5 \approx -84 \text{ J}$$

Final Answer: -84 J (Option b).

Q6. Gas compressed isothermally $5 \rightarrow 1 \text{ m}^3$, $P_{ext} = 4 \text{ N/m}^2$. Heat released warms 1 mol Al ($C_m = 24$). Find ΔT .

Conceptual Approach

Isothermal $\rightarrow \Delta U = 0$, so $q = -w$. Work = $P\Delta V$. Released heat warms Al $\rightarrow q = nC\Delta T$.

Solution

$$\Delta V = (1 - 5) = -4 \text{ m}^3$$

$$w = P\Delta V = 4 \times (-4) = -16 \text{ J}$$

$$\text{So } q = -w = 16 \text{ J.}$$

$$q = nC\Delta T = 1 \times 24 \times \Delta T$$

$$\Delta T = 16/24 \approx 0.67 \text{ K} \approx \frac{2}{3} \text{ K}$$

Final Answer: $\frac{2}{3} \text{ K}$ (Option a).

Q7. ΔH for 3 mol Ag when T: $300 \rightarrow 1000 \text{ K}$, $C_p = 23 + 0.01T$.

Conceptual Approach

$$\Delta H = n \int_{T_1}^{T_2} C_p dT = n \int (23 + 0.01T) dT.$$

Solution

$$\Delta H = 3 \left[23(T_2 - T_1) + 0.01 \frac{(T_2^2 - T_1^2)}{2} \right]$$

$$= 3[23(700) + 0.005(1000^2 - 300^2)]$$

$$= 3[16100 + 0.005(1000000 - 90000)]$$

$$= 3[16100 + 4550] = 3 \times 20650 = 61950 \text{ J} \approx 62 \text{ kJ}$$

Final Answer: 62 kJ (Option c).

Q8. Temperature of an ideal gas increases in:

Conceptual Approach

Adiabatic compression \rightarrow work on gas $\rightarrow T \uparrow$.

Final Answer: (a).

Q9. System goes (i) $P_1, V \rightarrow 2P_1, V$, (ii) $P, V_1 \rightarrow P, 2V_1$. Work?

Conceptual Approach

Case i: V const $\rightarrow w=0$. Case ii: P const, V doubles $\rightarrow w=-P(V_2 - V_1) = -PV_1$.

Final Answer: (b) 0, $-PV_1$.

Q10. First law form? Options: (a) $\Delta U = q - W$ (b) $\Delta U = q + W$ (c) $\Delta U = \Delta q + \Delta W$ (d) $\Delta U = q + \Delta W$

Conceptual Approach

Correct sign: $\Delta U = q - w$.

Final Answer: (a).

Q11. 2 L ideal gas expands isothermally into vacuum to 6 L. Find ΔU .

Conceptual Approach

Isothermal ideal gas: $\Delta U = 0$.

Final Answer: 0 J.

Q12. System does 200 J work and absorbs 150 J heat. Find $|\Delta U|$.

Conceptual Approach

$\Delta U = q - w = 150 - 200 = -50$. Magnitude = 50 J.

Final Answer: 50 J.

Q13. 5 mol gas at 293 K expanded isothermally from 2.1 MPa to 1.3 MPa vs $P_{ext} = 4.3$ MPa. Heat transferred?

Conceptual Approach

Isothermal: $\Delta U = 0$, so $q = w$. Work = $P_{ext}(V_f - V_i)$. Use ideal gas law to find V_i, V_f .

Solution

$$\begin{aligned} V_i &= \frac{nRT}{P_i} = \frac{5 \times 8.314 \times 293}{2.1 \times 10^6} \\ &= \frac{12172}{2.1 \times 10^6} = 0.0058 \text{ m}^3 \\ V_f &= \frac{nRT}{P_f} = \frac{12172}{1.3 \times 10^6} = 0.00936 \text{ m}^3 \end{aligned}$$

$$\Delta V = 0.00936 - 0.0058 = 0.00356 \text{ m}^3$$

$$w = -P_{ext}\Delta V = -4.3 \times 10^6 \times 0.00356 = -15300 \text{ J}$$

$$q = w = -15.3 \text{ kJ} \Rightarrow -3.06 \text{ kJ/mol}$$

Final Answer: $\approx -3 \text{ kJ mol}^{-1}$.
