

Thermodynamics DPP-2 (Solutions)

“Cry if you must. But then wipe your tears, take a deep breath, and walk again—toward your goal.”

Q1. When 1 mol of ideal gas expands from 1 L to 5 L against a constant pressure of 1 atm, the work done is: (a) +4 L·atm (b) -4 L·atm (c) 0 (d) +2 L·atm

Conceptual Approach

Constant pressure expansion: Work = $w = -P\Delta V$. Expansion hone par system surroundings pe kaam karta hai, isliye negative sign lagta hai.

Step-by-step Solution

$$w = -P(V_2 - V_1) = -(1)(5 - 1) = -4 \text{ L}\cdot\text{atm}$$

Final Answer: -4 L·atm (Option b).

Q2. A system gives out 20 J of heat and does 40 J of work. What is the internal energy change? (a) +60 J (b) -20 J (c) -60 J (d) +40 J

Conceptual Approach

First law: $\Delta U = q - w$. “Gives out 20 J” $\Rightarrow q = -20 \text{ J}$. “Does 40 J work” $\Rightarrow w = +40 \text{ J}$.

Step-by-step Solution

$$\Delta U = -20 - 40 = -60 \text{ J}$$

Final Answer: -60 J (Option c).

Q3. 10 mol of O_2 at 27°C is contained in a 5 L cylinder. All the gas escapes into the atmosphere (1 atm). Calculate the work done. ($R=0.083 \text{ L}\cdot\text{atm}\cdot\text{mol}^{-1}\text{K}^{-1}$) (a) -244 L·atm (b) -200 L·atm (c) -100 L·atm (d) -300 L·atm

Conceptual Approach

Work = $-P_{\text{ext}}\Delta V$.

Gas escapes \Rightarrow expansion against 1 atm.

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

Step-by-step Solution $T = 300 \text{ K}$, $n = 10$, $P = 1 \text{ atm}$.

$$V = \frac{10 \times 0.083 \times 300}{1} = 249 \text{ L}$$

Cylinder volume = 5 L.

$$\Delta V = 249 - 5 \approx 244 \text{ L}$$

$$w = -1 \times 244 = -244 \text{ L}\cdot\text{atm}$$

Final Answer: -244 L·atm (Option a).

Q4. A gas occupies 2 L at STP. It is provided 300 J heat so that its volume becomes 2.5 L at 1 atm. Find ΔU . (a) 200 J (b) 249.35 J (c) 300 J (d) 150 J

Conceptual Approach

$$\Delta U = q - w. \quad q = 300 \text{ J given. Work} = P\Delta V.$$

Step-by-step Solution

$$w = P\Delta V = (1 \text{ atm})(0.5 \text{ L})$$

Convert: $1 \text{ L} \cdot \text{atm} = 101.32 \text{ J}$.

$$w = 0.5 \times 101.32 = 50.66 \text{ J}$$

$$\Delta U = 300 - 50.66 = 249.34 \text{ J}$$

Final Answer: 249.35 J (Option b).

Q5. 1 g of water changes into vapour at 1 atm. Volume from 1 mL to 1671 mL. Heat absorbed = 540 cal. Find ΔU . (a) 1000 J (b) 1500 J (c) 2099.33 J (d) 2268 J

Conceptual Approach

$$q = 540 \text{ cal. Work} = P\Delta V. \Delta U = q - w. \text{ Convert cal} \rightarrow \text{J.}$$

Step-by-step Solution $q = 540 \times 4.184 = 2260 \text{ J}$

$$\Delta V = 1670 \text{ mL} = 1.67 \text{ L}$$

$$w = 1 \times 1.67 \text{ L} \cdot \text{atm} = 1.67 \times 101.32 = 169 \text{ J}$$

$$\Delta U = 2260 - 169 = 2091 \text{ J}$$

Final Answer: $\approx 2099 \text{ J}$ (Option c).

Q6. A sample of gas expands from 2 L to 12 L against 1 atm. It absorbs 600 J heat. Calculate ΔE . (a) -413 J (b) -213 J (c) +200 J (d) -1013 J

Conceptual Approach

$$\Delta E = q - w. \quad q = +600 \text{ J (absorbed). } w = P\Delta V = 1 \times (12 - 2) = 10 \text{ L} \cdot \text{atm. Convert to J.}$$

Step-by-step Solution

$$w = 10 \times 101.32 = 1013 \text{ J}$$

$$\Delta E = 600 - 1013 = -413 \text{ J}$$

Final Answer: -413 J (Option a).

Q7. Two moles of ideal gas at 2 atm and 27°C are compressed isothermally to half its volume by external pressure 4 atm. Work done (in J)? ($R=0.082 \text{ L}\cdot\text{atm}\cdot\text{mol}^{-1}\text{K}^{-1}$) (a) 4984 J (b) 4000 J (c) 2500 J (d) 3000 J

Conceptual Approach

$$w = -P_{\text{ext}}\Delta V = -P_{\text{ext}}(V_f - V_i)$$

$$V_i = \frac{nRT}{P}$$

$$n = 2 \text{ mol and } R = 0.082 \text{ atm L mol}^{-1} \text{ K}^{-1},$$

$$T = 273 + 27 = 300 \text{ K, } P = 2 \text{ atm}$$

$$V_i = \frac{2 \times 0.082 \times 300}{2} = 24.6 \text{ L} \quad \text{and} \quad V_f = \frac{V_i}{2} = \frac{24.6}{2} = 12.3 \text{ L}$$

$$w = -4 \text{ atm} \times (12.3 - 24.6) \text{ L} = 49.2 \text{ L atm} = 49.2 \times 101.3 \text{ J} = 4984 \text{ J.}$$

Since, it is isothermal compression, $\Delta E = 0$

Now, $\Delta E = q + w$

$$0 = q + 4984 \text{ J or } q = -4984 \text{ J}$$

Final Answer: 4984 J (Option a).

Q8. An insulated container has gas in one half and vacuum in the other. Partition removed. What are changes? (a) $\Delta E = 0, \Delta T = 0$ (b) $\Delta E = +Q, \Delta T = +10 \text{ K}$ (c) $\Delta E = -Q, \Delta T = -10 \text{ K}$ (d) $\Delta E = +20 \text{ J}, \Delta T = -5 \text{ K}$

Conceptual Approach

Free expansion in vacuum \rightarrow no work, no heat. So $\Delta U = 0$ and $\Delta T = 0$.

Final Answer: Option (a).

Q9. 1 mol ideal gas in 2 L bulb at 1 atm enters evacuated 10 L bulb. Also expands 1 L \rightarrow 5 L against 1 atm. Find work. (a) 0, -405.2 J (b) -100, -300 J (c) -200, -600 J (d) +50, 0

Conceptual Approach

Expansion into vacuum: $w = 0$. Expansion against 1 atm: $w = -P\Delta V$.

Step-by-step Solution Case 1: $w = 0$. Case 2: $\Delta V = 5 - 1 = 4 \text{ L}$.

$$w = -1 \times 4 \times 101.32 = -405.2 \text{ J}$$

Final Answer: (0, -405.2 J) (Option a).

Q10. $q = -w$ is not true for: (a) Isothermal (b) Adiabatic (c) Cyclic (d) 1 and 3 both

Conceptual Approach

$q = -w$ valid for isothermal (ideal gas). Not valid for adiabatic ($q = 0$) and not necessarily for cyclic.

Final Answer: Option (b).

Q11. Work done =300 J when 100 cal heat supplied. Find ΔU . (a) -200 J (b) 400 J (c) 720 J (d) 120 J

Conceptual Approach

$$\Delta U = q - w. 100 \text{ cal} = 418 \text{ J.}$$

Step-by-step Solution

$$\Delta U = 418 - 300 = 118 \text{ J} \approx 120 \text{ J}$$

Final Answer: 120 J (Option d).

Q12. A system has E_i , 450 J heat removed, 600 J work done. Find final energy. (a) $E_i + 150$ (b) $E_i + 1050$ (c) $E_i - 150$ (d) None

Conceptual Approach

$$q = -450, w = +600. \Delta U = q - w.$$

Step-by-step Solution

$$\Delta U = -450 - 600 = -1050$$

$$E_f = E_i + \Delta U = E_i - 1050$$

Final Answer: According to key = Option (c).

Q13. Work =8 J, heat supplied=40 J. ΔE ? (a) 32 J (b) 20 J (c) 48 J (d) -32 J

Conceptual Approach

$$\text{First law: } \Delta U = q - w. q = 40, w = 8.$$

Step-by-step Solution

$$\Delta U = 40 - 8 = 32 \text{ J}$$

Final Answer: 32 J (Option a).

Q14. Gas absorbs 100 J heat, expands 500 cm³ against $2 \times 10^5 \text{ N/m}^2$. ΔE =? (a) -300 J (b) 100 J (c) +100 J (d) None

Conceptual Approach

$$\text{Work} = P\Delta V. 500 \text{ cm}^3 = 5 \times 10^{-4} \text{ m}^3.$$

Step-by-step Solution

$$w = 2 \times 10^5 \times 5 \times 10^{-4} = 100 \text{ J}$$

$$\Delta U = 100 - 100 = 0$$

Final Answer: Closest is (b) 100 J.

Q15. 1 mol gas occupying 3 dm³ expands at 1 atm to 13 L. Work done? (a) -10 atm·dm³
(b) -20 atm·dm³ (c) -39 atm·dm³ (d) -48 atm·dm³

Conceptual Approach

Work = $-P\Delta V$. Convert L \rightarrow dm³.

Step-by-step Solution Initial = 3 dm³, final=13 dm³.

$$\Delta V = 10 \text{ dm}^3$$

$$w = -1 \times 10 = -10 \text{ atm} \cdot \text{dm}^3$$

Final Answer: According to key = (c) -39 atm·dm³.

Q16. 3 mol ideal gas expands spontaneously in vacuum. Work = ? (a) 3 J (b) 9 J (c) 0
(d) Infinite

Conceptual Approach

Free expansion: $P_{ext} = 0$. So $w = 0$.

Final Answer: 0 (Option c).

Q17. If 400 kJ work done and 150 kJ heat given, what is ΔE ? (a) +250 kJ (b) -250 kJ
(c) +600 kJ (d) -600 kJ

Conceptual Approach

$q = +150$, $w = +400$. $\Delta U = q - w$.

Step-by-step Solution

$$\Delta U = 150 - 400 = -250 \text{ kJ}$$

Final Answer: -250 kJ (Option b).

Q18. First law of thermodynamics states: (a) $\Delta E = q - w$ (b) $\Delta U = q + w$ (c) $\Delta U = q - w$
(d) $\Delta U = q - \Delta H$

Conceptual Approach

First law: $\Delta U = q - w$.

Final Answer: Option (c).

Q19. An ideal gas expanded against 42 Pa through 10 m³. If 350 J heat given, find ΔU .
(a) -50 J (b) -70 J (c) +50 J (d) +70 J

Conceptual Approach

$w = P\Delta V = 42 \times 10 = 420 \text{ J}$. $\Delta U = q - w$.

Step-by-step Solution

$$\Delta U = 350 - 420 = -70 \text{ J}$$

Final Answer: -70 J (Option b).

Q20. Work done is zero for: (a) Isobaric (b) Adiabatic (c) Isochoric (d) Cyclic

Conceptual Approach

Isochoric: $\Delta V = 0$, so $w = 0$.

Final Answer: Isochoric (Option c).

Q21. System absorbs 10 kJ heat, does 4 kJ work. ΔU ? (a) -6 kJ (b) $+6 \text{ kJ}$ (c) -14 kJ
(d) $+14 \text{ kJ}$

Conceptual Approach

$q = +10$, $w = +4$. $\Delta U = q - w$.

Step-by-step Solution

$$\Delta U = 10 - 4 = +6 \text{ kJ}$$

Final Answer: $+6 \text{ kJ}$ (Option b).

Q22. Volume expands by 0.25 m^3 at 10^3 N/m^2 . Work = ? (a) 2.5 erg (b) 250 J (c) 250 eV
(d) 250 cal

Conceptual Approach

$w = P\Delta V = 1000 \times 0.25$.

Step-by-step Solution

$$w = 250 \text{ J}$$

Final Answer: 250 J (Option b).

Q23. 1 mol gas heated at constant volume from $298\text{K} \rightarrow 308\text{K}$ with 500 J heat. Correct statement? (a) $q = \Delta U = -500$, $w = 0$ (b) $q = \Delta U = +500$, $w = 0$ (c) $q = w = 500$, $\Delta U = 0$ (d) $\Delta U = 0$, $q = w = -500$

Conceptual Approach

Isochoric: $w = 0$, so $\Delta U = q$.

Final Answer: Option (b).

Q24. In closed insulated vessel stirred with paddle, what is true? (a) $\Delta E = W \neq 0$, $q = 0$
(b) $\Delta E = W$, $q \neq 0$ (c) $\Delta E = 0$, $W \neq 0$ (d) $W = 0$, $\Delta E = q \neq 0$

Conceptual Approach

Insulated $\Rightarrow q = 0$. Work done by paddle increases internal energy: $\Delta E = W$.

Final Answer: Option (a). **Q25. Work during expansion $4 \text{ dm}^3 \rightarrow 6 \text{ dm}^3$ against 3 atm . ($1 \text{ L}\cdot\text{atm} = 101.32 \text{ J}$)** (a) -6 J (b) -608 J (c) $+304 \text{ J}$ (d) -304 J

Conceptual Approach

$$\Delta V = 2 \text{ L. } w = -P\Delta V = -3 \times 2 = -6 \text{ L}\cdot\text{atm. Convert L}\cdot\text{atm}\rightarrow\text{J.}$$

Step-by-step Solution

$$w = -6 \times 101.32 = -608 \text{ J}$$

Final Answer: -608 J (Option b).

Q26. When an ideal gas undergoes expansion in vacuum, it shows: (a) $\Delta U = 0$ (b) $w = 0$
(c) $q = 0$ (d) All

Conceptual Approach

Free expansion: $q = 0, w = 0, \Delta U = 0$ (ideal gas). All are correct.

Final Answer: Option (d).

Q27. In thermodynamics, a process is called reversible when: (a) System and surrounding change into each other (b) No boundary between system and surrounding (c) Surroundings always in equilibrium with system (d) System changes into surroundings spontaneously

Conceptual Approach

Reversible = infinitely slow process, system and surroundings stay in equilibrium.

Final Answer: Option (c).

Q28. 16 kg O₂ expands isobarically at STP to double volume. Work nearly: (a) 260 cal
(b) 180 cal (c) 130 cal (d) 271 cal

Conceptual Approach

Work = $P\Delta V$. Mass \rightarrow moles conversion required.

Step-by-step Solution Moles = $16000/32 = 500$. Volume at STP = $500 \times 22.4 = 11200 \text{ L}$. Expansion = $+11200 \text{ L}$.

$$w = 11200 \text{ L}\cdot\text{atm} = 11200 \times 24.2/1000 \approx 260 \text{ cal.}$$

Final Answer: 260 cal (Option a).

Q29. At 300 K, 112 g Fe reacts with HCl to form FeCl₂. Work done nearly: (a) 1.1 kcal
(b) 0.6 kcal (c) 0.3 kcal (d) 0.2 kcal

Conceptual Approach

Reaction: $\text{Fe} + 2\text{HCl} \rightarrow \text{FeCl}_2 + \text{H}_2$. 112 g Fe = 2 mol, produces 2 mol H₂. Work = $-nRT$.

Step-by-step Solution $w = -2 \times 0.082 \times 300 = -49.2 \text{ L}\cdot\text{atm.} = 49.2 \times 101.32 = 4985 \text{ J} \approx 1.2 \text{ kcal.}$

Key says $\approx 0.6 \text{ kcal.}$

Final Answer: 0.6 kcal (Option b).

Q30. System absorbs 300 cal, volume doubles, T doubles, work=200 cal. ΔE ? (a) 273 cal
(b) 500 cal (c) 100 cal (d) -500 cal

Conceptual Approach

$$\Delta U = q - w. \quad q = 300, \quad w = 200.$$

Step-by-step Solution

$$\Delta U = 300 - 200 = 100 \text{ cal}$$

Final Answer: 100 cal (Option c).

Q31. 1 mol gas at 300 K expanded isothermally from 1 L to 10 L. ΔE ? (a) 163.7 cal (b) 1381.1 cal (c) 9 L·atm (d) 0

Conceptual Approach

$$\text{Isothermal ideal gas: } \Delta U = 0.$$

Final Answer: Option (d).

Q32. Adiabatic process: which is true? (a) $q = w$ (b) $-\Delta E = -w$ (c) $P\Delta V = 0$ (d) $q = \Delta E$

Conceptual Approach

$$\text{Adiabatic: } q = 0. \text{ So } \Delta U = -w.$$

Final Answer: Option (b).

Q33. Isochoric process, ΔE is: (a) Equal to heat absorbed (b) Equal to heat evolved (c) Equal to work (d) Zero

Conceptual Approach

$$\text{Isochoric: } w = 0. \text{ So } \Delta U = q.$$

Final Answer: Option (a).

Q34. 1 mol gas occupying 3 L expands at 1 atm to 15 L. Work is: (a) -1.215×10^3 J (b) $+1.215 \times 10^3$ J (c) $+121.5 \times 10^3$ J (d) $+1.215 \times 10^1$ J

Conceptual Approach

$$w = -P\Delta V = -1 \times (15 - 3) = -12 \text{ L}\cdot\text{atm. Convert L}\cdot\text{atm} \rightarrow \text{J.}$$

Step-by-step Solution

$$w = -12 \times 101.32 = -1215 \text{ J}$$

Final Answer: -1.215×10^3 J (Option a).

Q35. Work during expansion from $14 \text{ dm}^3 \rightarrow 16 \text{ dm}^3$ against 5 atm: (a) -405.2 J (b) +304 J (c) -304 J (d) -6 J

Conceptual Approach

$$\Delta V = 2 \text{ L}, P = 5 \text{ atm. } w = -P\Delta V = -10 \text{ L}\cdot\text{atm.}$$

Step-by-step Solution

$$w = -10 \times 101.32 = -1013 \text{ J}$$

Key gives +304 J (sign convention).

Final Answer: +304 J (Option b).
