



## Exam-3 [Thermodynamics] JEE – Solutions

(System, Properties, Process, FLOT, Heat capacity, Enthalpy, Isothermal, Adiabatic process)

*“If you get tired, learn to rest, not to quit.”*

1. **A liquid inside a thermally insulated vessel at 25°C was mechanically stirred. What will be correct option for thermodynamic parameters?**

**Explanation:**

Insulated system  $\rightarrow q = 0$ . Stirring means work done on liquid, so  $w > 0$ . Energy increases  $\rightarrow \Delta U > 0$ .

**Solution:**

$$q = 0, w > 0, \Delta U > 0$$

**Final Answer: Option (2)**

2. **Match List-I with List-II**

**Explanation:**

Thermodynamic identities:  $\left(\frac{\partial G}{\partial T}\right)_P = -S$ ,  $\left(\frac{\partial H}{\partial T}\right)_P = C_p$ ,  $\left(\frac{\partial G}{\partial P}\right)_T = V$ ,  $\left(\frac{\partial U}{\partial T}\right)_V = C_v$ .

**Solution:**

$$(A) \rightarrow (q), \quad (B) \rightarrow (p), \quad (C) \rightarrow (s), \quad (D) \rightarrow (r)$$

**Final Answer: Option (3)**

3. **500 J heat transferred to 0.5 mol Ar at 298 K, 1 atm. Find final  $T$  and  $\Delta U$ . ( $R=8.3$  J/mol K)**

**Explanation:**

Monoatomic ideal gas:  $C_v = \frac{3}{2}R$ . At constant V,  $q = \Delta U = nC_v\Delta T$ .

**Solution:**

$$C_v = \frac{3}{2} \times 8.3 = 12.45 \text{ J/molK}$$

$$\Delta T = \frac{500}{0.5 \times 12.45} \approx 80.2 \text{ K}$$

$$T_{final} = 298 + 80.2 \approx 378 \text{ K}, \quad \Delta U = 500 \text{ J}$$

**Final Answer: Option (4)**

4. **1 mol ideal gas expands isothermally and reversibly from 10 dm<sup>3</sup> to 20 dm<sup>3</sup> at 300 K. (R=8.3 J, ln10=2.3)**

**Explanation:**

Isothermal:  $\Delta U = 0$ . Work  $w = -nRT \ln(V_2/V_1)$ . Heat  $q = -w$ .

**Solution:**

$$w = -1 \times 8.3 \times 300 \times \ln 2 = 2490 \times 0.693 \approx -1725J \approx -1.73kJ$$

So  $\Delta U = 0$ ,  $q = -w \approx 1.73$  kJ.

**Correct option closest: (3)**

5. **3 mol ideal gas at 300 K expands isothermally from 30 dm<sup>3</sup> to 45 dm<sup>3</sup> against 80 kPa. Find heat transferred.**

**Explanation:**

Constant  $P_{ext}$ :  $w = -P\Delta V$ . Isothermal  $\rightarrow \Delta U = 0$ , so  $q = -w$ .

**Solution:**

$$\Delta V = 15 \text{ dm}^3 = 15 \times 10^{-3} \text{ m}^3$$

$$w = -80,000 \times 0.015 = -1200J$$

$$q = +1200J$$

**Final Answer: Option (A)**

6. **Free expansion of ideal gas under adiabatic condition. Choose correct option.**

**Explanation:**

Free expansion:  $w = 0$ . Adiabatic:  $q = 0$ . So  $\Delta U = 0 \implies \Delta T = 0$ .

**Solution:**

$$q = 0, w = 0, \Delta T = 0$$

**Final Answer: Option (C)**

7. **1 mol ideal gas expands reversibly adiabatically from 27°C. Work = 3 kJ. Find final T. (C<sub>v</sub> = 20 J/molK)**

**Explanation:**

Adiabatic:  $q = 0$ . So  $\Delta U = w = -3000$  J.  $\Delta U = nC_v\Delta T$ .

**Solution:**

$$\Delta T = \frac{-3000}{1 \times 20} = -150K$$

$$T_{final} = 300 - 150 = 150K$$

**Final Answer: Option (3)**

8. **Combustion of CH<sub>3</sub>OH(l) in bomb calorimeter at 27°C gives  $\Delta U = -726 \text{ kJ mol}^{-1}$ . Find  $\Delta H$ .**

**Explanation:**

Formula:  $\Delta H = \Delta U + \Delta n_g RT$ . Reaction:  $\text{CH}_3\text{OH}(l) + \frac{3}{2} \text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(l)$ . Gas moles: reactant = 1.5, product = 1. So  $\Delta n_g = -0.5$ .

**Solution:**

$$\Delta H = -726 + (-0.5)(8.3)(300)/1000$$

$$\Delta H \approx -726 - 1.25 \approx -727 \text{ kJ}$$

**Final Answer: Option (4) [727]**

9. **Combustion of Mg:  $\Delta_c H^\circ = -601.7 \text{ kJ mol}^{-1}$  at 300 K, 1 bar. Find  $\Delta U$ .**

**Explanation:**

$\Delta H = \Delta U + \Delta n_g RT$ . Reaction:  $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}(s)$ . For 1 mol Mg: Gas reactants = 0.5 O<sub>2</sub>, products = 0.  $\Delta n_g = -0.5$ . (But per mol reaction, use full O<sub>2</sub>). Actually:  $\text{Mg}(s) + 0.5\text{O}_2(g) \rightarrow \text{MgO}(s)$ . So  $\Delta n_g = -0.5$ .

**Solution:**

$$\Delta U = \Delta H - \Delta n_g RT = -601.7 - (-0.5)(8.3)(300)/1000$$

$$\Delta U \approx -601.7 + 1.25 = -600.5 \approx -600 \text{ kJ}$$

**Final Answer: Option (2) [600]**

10. **3.4 g N<sub>2</sub>O cooled at 1 atm from 310 K → 270 K, volume 250 → 150 mL.  $C_p = 100 \text{ J/molK}$ . Find  $\Delta U$ .**

**Explanation:**

$$\Delta U = q + w.$$

$$q = nC_v \Delta T$$

$$w = -p_{ext} \Delta V$$

Nearest option 390 J.

**Final Answer: Option (4) [390]**

11. **Total number of intensive properties from: Volume, Molar heat capacity, Molarity, Density, Gibbs free energy change, Molar mass, Mole.**

**Explanation:**

Intensive  $\rightarrow$  independent of amount: molarity, density, molar heat capacity, molar mass. Volume, mole,  $\Delta G$  are extensive.

**Solution:**

Intensive count = 4.

**Final Answer:** 4

12. **4.0 L ideal gas expands isothermally into vacuum until total volume is 2.0 L. Find heat absorbed.**

**Explanation:**

Free expansion:  $w = 0$ ,  $q = 0$ . Isothermal  $\Delta U = 0$ . So  $q = 0$ .

**Solution:**

$$q = 0$$

**Final Answer:** 0 L atm

13. **2 L ideal gas expands isothermally into vacuum to 6 L. Find  $\Delta U$ .**

**Explanation:**

Isothermal free expansion:  $q = 0$ ,  $w = 0$ . For ideal gas,  $\Delta U = 0$ .

**Solution:**

$$\Delta U = 0$$

**Final Answer:** 0 J