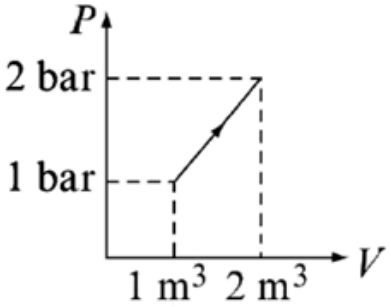
MIX TEST-2 [JEE] – SOLUTIONS

Chapter : Thermodynamics + Some Basic Concepts of Chemistry

Stand up again and fight — winners are just those who never gave up.

Q1. A system absorbs 100 kJ heat in the process shown in the figure. What is ΔU for the system?



Explanation / Approach:

First Law: $\Delta U = q + w$. System absorbs heat ($q = +100$ kJ). Work is given by area under PV curve.

Solution:
From graph, work done by system = -150 kJ (area). So,

$$\Delta U = q + w = 100 + (-150) = -50 \text{ kJ}$$

Correct Option: (1)

Q2. Isothermal expansion from (10 atm, 1 L) to (1 atm, 10 L) – find $\frac{q_{pathI}}{q_{pathII}}$.

Explanation / Approach:

Isothermal $\Rightarrow \Delta U = 0$, so $q = w$. Path I: reversible expansion. Path II: stepwise against 5 atm then 1 atm. Compare works done.

Solution:
Path I:

$$w = -2.303\, nRT \log\left(\frac{V_f}{V_i}\right) = -2.303\, nRT \log 10 = -2.303 P_1 V_1 = -2.303 \times 10$$

Path II: Step 1: 1 L $\rightarrow$ 2 L against 5 atm: $w_1 = -5 \times 1 = -5$ L·atm Step 2: 2 L $\rightarrow$ 10 L against 1 atm: $w_2 = -1 \times 8 = -8$ L·atm Total = –13 L·atm So, ratio:

$$\frac{q_{pathI}}{q_{pathII}} = \frac{2.303}{1.3}$$

Correct Option: (1)

Q3. Two moles of an ideal gas ($C_{V,m} = \frac{5}{2}R$) was compressed adiabatically against constant external pressure of 2 atm, initially at 350 K and 1 atm. The work done on the gas is?

Explanation / Approach:

Yeh process **irreversible adiabatic** hai (constant P_{ext}). Rules: - $q = 0$ (adiabatic). - $\Delta U = w$. - Work by system: $W = -P_{ext}(V_f - V_i)$. - Also $\Delta U = nC_v(T_f - T_i)$. Dono relation se T_f nikal kar phir work compute karna hai.

Solution:

Initial data: $n = 2$, $T_i = 350$ K, $C_v = \frac{5}{2}R$, $P_i = 1$ atm.

Initial volume:

$$V_i = \frac{nRT_i}{P_i} = \frac{2R \times 350}{1} = 700R$$

Final volume at $P_{ext} = 2$:

$$V_f = \frac{nRT_f}{2} = \frac{2RT_f}{2} = RT_f$$

First law:

$$nC_v(T_f - T_i) = -P_{ext}(V_f - V_i)$$

Substitute values:

$$2 \cdot \frac{5}{2}R(T_f - 350) = -2(RT_f - 700R)$$

$$5R(T_f - 350) = -2RT_f + 1400R$$

$$5RT_f - 1750R = -2RT_f + 1400R$$

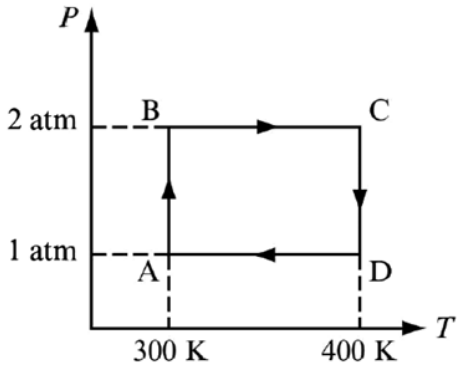
$$7RT_f = 3150R \quad \Rightarrow \quad T_f = 450\,K$$

Now,

$$W = nC_v(T_f - T_i) = 2 \cdot \frac{5}{2}R(450 - 350) = 500R$$

Correct Option: (2)

Q4. Two moles of He gas undergo cyclic process (diagram). Net work done?



Explanation / Approach:

Yeh diagram **P–T graph** ka hai (not PV). Toh directly "area enclosed = work" use nahi kar sakte. Kaise karenge? Step by step har process (AB, BC, CD, DA) ka work nikalenge using ideal gas law $PV = nRT$. Then net work = sum of all 4.

Solution:
Step AB (isothermal at 300 K, $P : 1 \to 2$ atm):

$$W_{AB} = -nRT \ln \frac{V_B}{V_A}$$

At 300 K: $V_A = \frac{2R \times 300}{1} = 600R$, $V_B = \frac{600R}{2} = 300R$

$$W_{AB} = -600R \ln \frac{300}{600} = +600R \ln 2$$

Step BC (isobaric at 2 atm, $T : 300 \to 400$ K):

$$W_{BC} = nR\Delta T = 2R(400 - 300) = 200R$$

Step CD (isothermal at 400 K, $P : 2 \to 1$ atm):

$$W_{CD} = -nRT \ln \frac{V_D}{V_C}$$

At 400 K: $V_C = \frac{800R}{2} = 400R$, $V_D = \frac{800R}{1} = 800R$

$$W_{CD} = -800R \ln \frac{800}{400} = -800R \ln 2$$

Step DA (isobaric at 1 atm, $T : 400 \to 300$ K):

$$W_{DA} = nR\Delta T = 2R(300 - 400) = -200R$$

Net Work:

$$W_{net} = (+600R \ln 2) + (200R) + (-800R \ln 2) + (-200R)$$
$$= -200R \ln 2$$

Correct Answer: $-200R \ln 2$
Correct Option: (3)

Q5. Which of the following statement is incorrect?
Explanation / Approach:

Let's check each option carefully: 1. State functions (like U, H, S) depend only on initial and final states. So difference can be expressed for them $\to$ Correct. 2. A process cannot be fully defined by only initial and final states, because same states can be connected by many different paths (isothermal, adiabatic, irreversible, etc.) $\to$ Correct. 3. In a cyclic process, $\Delta U = 0$ at the end, but during the cycle U may change. So saying it "remains constant throughout" is wrong. 4. For ideal gas, $PV = nRT$ is always true (reversible or irreversible) $\to$ Correct.

Solution:
- **Option (1):** True. Example: $\Delta U = U_{final} - U_{initial}$. - **Option (2):** True. Process = path + states. Same (P, V) can be reached by many ways (isothermal, adiabatic). Hence only initial/final states do not define a process. - **Option (3):** False. In cyclic process, U returns to initial value, but is not constant during the process. - **Option (4):** True. Ideal gas law always valid.

$$\therefore \text{Incorrect statement is Option (3).}$$

Correct Option: (3)

Q6. An aqueous solution of glucose is 10% (w/v). The volume in which 1 mole of glucose is dissolved, will be?
Explanation / Approach:

10% (w/v) ka matlab = 10 g solute / 100 mL solution. Ab 1 mol glucose (180 g) ke liye proportionality use karenge.

Solution:
10 g $\rightarrow$ 100 mL solution
180 g $\rightarrow 100 \times \frac{180}{10} = 1800$ mL = 1.8 L
So approx = 1.81 L.
Correct Option: (4)

Q7. Dopamine $C_8H_{11}O_2N$. How many moles in 1 g?
Explanation / Approach:

Pehle molar mass nikalna hai. Phir moles = $\frac{\text{mass}}{\text{molar mass}}$.

Solution:
Molar mass $= 8 \times 12 + 11 \times 1 + 2 \times 16 + 14$
$= 96 + 11 + 32 + 14 = 153$ g/mol
So, moles in 1 g = $\frac{1}{153} = 0.00654$ mol
Correct Option: (1)

Q8. An organic compound has 40% C and 6.67% H. Find empirical formula.
Explanation / Approach:

Step 1: Mass percent ko convert to moles. Step 2: Divide by smallest to get ratio.

Solution:
Assume 100 g compound: C = 40 g, H = 6.67 g, O = 53.33 g
Moles C = 40/12 = 3.33
Moles H = 6.67/1 = 6.67
Moles O = 53.33/16 $\approx$ 3.33
Ratio C : H : O = 1 : 2 : 1
Empirical formula = CH_2O
Correct Option: (2)

Q9. Burning octane C_8H_{18} gives 7.04 g CO_2. Find mass of H_2O formed.
Explanation / Approach:

Balanced reaction: $C_8H_{18} + 12.5\ O_2 \rightarrow 8\ CO_2 + 9\ H_2O$. $CO_2 : H_2O$ ratio = 8 : 9.

Solution:
Moles CO_2 formed = 7.04/44 = 0.16 mol

By ratio, moles $H_2O = 0.16 \times \frac{9}{8} = 0.18$ mol
Mass $= 0.18 \times 18 = 3.24$ g
Correct Option: (3)

Q10. 0.3 mol $SrCl_2$ + 0.2 mol K_3PO_4. Max KCl formed?
Explanation / Approach:

Reaction: 3 $SrCl_2$ + 2 K_3PO_4 → $Sr_3(PO_4)_2$ + 6 KCl. Use limiting reagent.

Solution:
From reaction: 3 mol $SrCl_2$ → 6 mol KCl. So 0.3 mol $SrCl_2$ → 0.6 mol KCl.
For K_3PO_4: 2 mol → 6 mol KCl. So 0.2 mol → 0.6 mol KCl.
Both give 0.6 mol → no limiting, exactly 0.6 mol formed.
Correct Option: (1)

Q11. The mass of 3.2×10^5 atoms of an element is 8.0×10^{-18} g. Find atomic mass. ($N_A = 6 \times 10^{23}$)
Explanation / Approach:

Atomic mass nikalne ka tareeka: 1 atom ka mass given → usko N_A se multiply kar do.

Solution:
Mass of one atom $= \dfrac{8.0 \times 10^{-18}}{3.2 \times 10^5}$
$= 2.5 \times 10^{-23}$ g
Atomic mass $= 2.5 \times 10^{-23} \times 6 \times 10^{23} = 15$ g/mol
Final Answer: 15

Q12. Twenty molecules of SO_3 will weigh as much as ..... molecules of O_2.
Explanation / Approach:

Weight ratio method: 20 SO_3 molecules ke mass = ? Phir O_2 ke molecular mass se divide karke number nikal lo.

Solution:
Mass of 1 SO_3 molecule 32 (S) + 48 (O) = 8o u
Mass of 20 molecules $= 20 \times 80 = 1600$ u
Mass of 1 O_2 molecule = 32 u
No. of O_2 molecules $= 1600/32 = 50$
Final Answer: 50

Q13. One mole of an ideal gas at 300 K expands isothermally from 1 L to 10 L. Find ΔU.

Explanation / Approach:

> Isothermal process (T constant) ke liye: Internal energy ΔU sirf temperature pe depend karta hai. T constant $\Rightarrow \Delta U = 0$.

Solution:

$$\Delta U = 0$$

Final Answer: 0