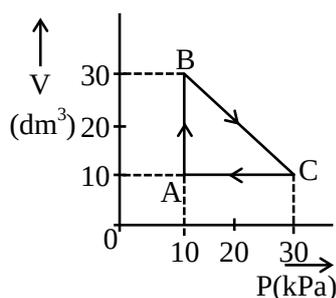


THERMODYNAMICS-1

- If three moles of an ideal gas at 300 K expand isothermally from 30 dm³ to 45 dm³ against a constant opposing pressure of 80 kPa, then the amount of heat transferred is _____ J.
- For a certain thermochemical reaction $M \rightarrow N$ at $T = 400$ K, $\Delta H^\ominus = 77.2$ kJ mol⁻¹, $\Delta S = 122$ JK⁻¹, log equilibrium constant (logK) is $-___ \times 10^{-1}$.
- Which of the following is **not** correct?
 - ΔG is negative for a spontaneous reaction
 - ΔG is positive for a spontaneous reaction
 - ΔG is zero for a reversible reaction
 - ΔG is positive for a non-spontaneous reaction
- Standard enthalpy of vapourisation for CCl₄ is 30.5 kJ mol⁻¹. Heat required for vapourisation of 284g of CCl₄ at constant temperature is _____ kJ.
(Given molar mass in g mol⁻¹; C = 12, Cl = 35.5)



An ideal gas undergoes a cyclic transformation starting from the point A and coming back to the same point by tracing the path $A \rightarrow B \rightarrow C \rightarrow A$ as shown in the diagram.
The total work done in the process is _____ J.

- Two reactions are given below :

$$2\text{Fe}_{(s)} + \frac{3}{2}\text{O}_{2(g)} \rightarrow \text{Fe}_2\text{O}_{3(s)}, \Delta H^\ominus = -822 \text{ kJ / mol}$$

$$\text{C}_{(s)} + \frac{1}{2}\text{O}_{2(g)} \rightarrow \text{CO}_{(g)}, \Delta H^\ominus = -110 \text{ kJ / mol}$$
 Then enthalpy change for following reaction

$$3\text{C}_{(s)} + \text{Fe}_2\text{O}_{3(s)} \rightarrow 2\text{Fe}_{(s)} + 3\text{CO}_{(g)}$$
- Consider the following reaction at 298 K.

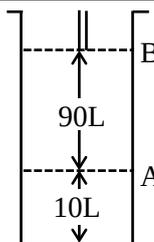
$$\frac{3}{2}\text{O}_{2(g)} \rightleftharpoons \text{O}_{3(g)}, K_p = 2.47 \cdot 10^{-29}.$$
 $\Delta_r G^\ominus$ for the reaction is _____ kJ.
(Given $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$)
- If 5 moles of an ideal gas expands from 10 L to a volume of 100 L at 300 K under isothermal and reversible condition then work w , is $-x$ J. The value of x is _____.
(Given : $R = 8.314 \text{ J K mol}^{-1}$)
- Choose the correct option for free expansion of an ideal gas under adiabatic condition from the following :
 - $q = 0, \Delta T \neq 0, w = 0$
 - $q = 0, \Delta T < 0, w \neq 0$
 - $q \neq 0, \Delta T = 0, w = 0$
 - $q = 0, \Delta T = 0, w = 0$
- For a certain reaction at 300K, $K = 10$, then ΔG^\ominus for the same reaction is $-___ \times 10^1$ kJ mol⁻¹.
(Given $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$)
- Three moles of an ideal gas are compressed isothermally from 60 L to 20 L using constant pressure of 5 atm. Heat exchange Q for the compression is $-______ \text{ Lit. atm.}$

THERMODYNAMICS-1

12. An ideal gas, $\bar{C}_v = \frac{5}{2}R$, is expanded adiabatically against a constant pressure of 1 atm until it doubles in volume. If the initial temperature and pressure is 298 K and 5 atm, respectively then the final temperature is _____ K (nearest integer).

[\bar{C}_v is the molar heat capacity at constant volume]

13.



Consider the figure provided.

1 mol of an ideal gas is kept in a cylinder, fitted with a piston, at the position A, at 18°C. If the piston is moved to position B, keeping the temperature unchanged, then 'x' L atm work is done in this reversible process.

x = _____ L atm. (nearest integer)

[Given: Absolute temperature = °C + 273.15, R = 0.08206 L atm mol⁻¹ K⁻¹]

SOLUTIONS
1. Ans. (1200)

Sol. Using, first law of thermodynamics,

$$\Delta U = Q + W,$$

$$\Delta U = 0 : \text{Process is isothermal}$$

$$Q = -W$$

$$W = -P_{\text{ext}}\Delta V : \text{Irreversible}$$

$$= -80 \times 10^3 (45 - 30) \times 10^{-3}$$

$$= -1200 \text{ J}$$

2. Ans. (37)

Sol. $\Delta G = \Delta H - T\Delta S^\circ$

$$= 77.2 \cdot 10^3 - 400 \cdot 122 = 28400 \text{ J}$$

$$\Delta G = -2.303RT \log K$$

$$\Rightarrow 28400 = -2.303 \cdot 8.314 \cdot 400 \log K$$

$$\Rightarrow \log K = -3.708 = -37.08 \cdot 10^{-1}$$

3. Ans. (2)

Sol. $(\Delta G)_{p,T} = (+)$ ve for non-spontaneous process

4. Ans. (56)

Sol. $\Delta H_{\text{vap}}^\circ \text{ CCl}_4 = 30.5 \text{ kJ/mol}$

$$\text{Mass of CCl}_4 = 284 \text{ gm}$$

$$\text{Molar mass of CCl}_4 = 154 \text{ g/mol}$$

$$\text{Moles of CCl}_4 = \frac{284}{154} = 1.844 \text{ mol}$$

$$\Delta H_{\text{vap}}^\circ \text{ for 1 mole} = 30.5 \text{ kJ/mol}$$

$$\Delta H_{\text{vap}}^\circ \text{ for 1.844 mol} = 30.5 \times 1.844$$

$$= 56.242 \text{ kJ}$$

5. Ans. (200)

Sol. Work done is given by area enclosed in the P vs V cyclic graph or V vs P cyclic graph.

Sign of work is positive for clockwise cyclic process for V vs P graph.

$$W = \frac{1}{2} \times (30 - 10) \times (30 - 10) = 200 \text{ kPa} - \text{dm}^3$$

$$= 200 \times 1000 \text{ Pa} - \text{L} = 2 \text{ L-bar} = 200 \text{ J}$$

6. Ans. (492)

Sol. $2\text{Fe}_{(s)} + \frac{3}{2}\text{O}_{2(g)} \rightarrow \text{Fe}_2\text{O}_{3(s)}, \Delta H^\circ = -822 \text{ kJ/mol}$

.....(1)

$\text{C}_{(s)} + \frac{1}{2}\text{O}_{2(g)} \rightarrow \text{CO}_{(g)}, \Delta H^\circ = -110 \text{ kJ/mol}$

.....(2)

$3\text{C}_{(s)} + \text{Fe}_2\text{O}_{3(s)} \rightarrow 2\text{Fe}_{(s)} + 3\text{CO}_{(g)}, \Delta H_3 = ?$

$$(3) = 3 \times (2) - (1)$$

$$\Delta H_3 = 3 \times \Delta H_2 - \Delta H_1$$

$$= 3(-110) + 822$$

$$= 492 \text{ kJ/mole}$$

7. Ans. (163)

Sol. $\frac{3}{2}\text{O}_{2(g)} \rightleftharpoons \text{O}_{3(g)}, K_p = 2.47 \cdot 10^{-29}$

$$\Delta_r G^\ominus = -RT \ln K_p$$

$$= -8.314 \times 10^{-3} \times 298 \times \ln (2.47 \times 10^{-29})$$

$$= -8.314 \times 10^{-3} \times 298 \times (-65.87)$$

$$= 163.19 \text{ kJ}$$

8. Ans. (28721)

Sol. It is isothermal reversible expansion, so work done negative

$$W = -2.303 nRT \log \left(\frac{V_2}{V_1} \right)$$

$$= -2.303 \cdot 5 \cdot 8.314 \cdot 300 \log \left(\frac{100}{10} \right)$$

$$= -28720.713 \text{ J}$$

$$\equiv -28721 \text{ J}$$

THERMODYNAMICS-1
9. Ans. (4)

Sol. During free expansion of an ideal gas under adiabatic condition $q = 0, \Delta T = 0, w = 0$.

10. Ans. (57)

Sol. $\Delta G^\circ = -RT \ln K$
 $= -8.314 \times 300 \ln (10)$
 $= 5744.14 \text{ J/mole}$
 $= 57.44 \times 10^{-1} \text{ kJ/mole}$

11. Ans. (200)

Sol. As isothermal $\Delta U = 0$
 and process is irreversible
 $Q = -W = -[-P_{\text{ext}}(V_2 - V_1)]$
 $Q = 5(20 - 60) = -200 \text{ atm-L}$

12. Ans. (274)

Sol. $\Delta U = q + w$ ($q = 0$)
 $nC_V \Delta T = -P_{\text{ext}}(V_2 - V_1)$
 $V_2 = 2V_1$
 $\frac{nRT_2}{P_2} = \frac{2nRT_1}{P_1}$
 $P_1 = 5, T_1 = 298$
 $P_2 = \frac{5T_2}{2 \cdot 298}$
 $n \frac{5}{2} R(T_2 - T_1) = -1 \left(\frac{nRT_2}{P_1} - \frac{nRT_1}{P_1} \right)$
 Put $T_1 = 298$
 and $P_2 = \frac{5T_2}{2 \cdot 298}$
 Solve and we get $T_2 = 274.16 \text{ K}$
 $T_2 \approx 274 \text{ K}$

13. Ans. (55)

Sol. $w = -nRT \ln \left(\frac{V_2}{V_1} \right)$
 $= -1 \times 8.206 \times 291.15 \ln \left(\frac{100}{10} \right)$
 $= -55.0128$
 Work done by system $\approx 55 \text{ atm lit.}$