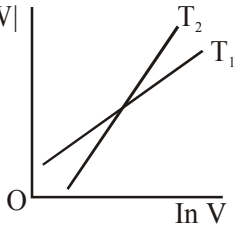
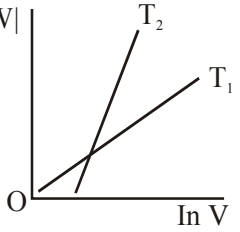
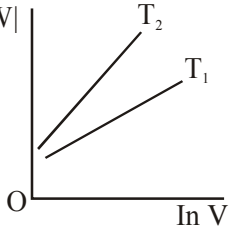
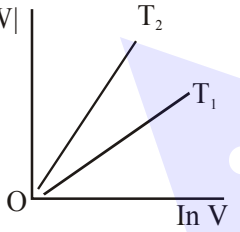
THERMODYNAMICS-01

1. Consider the reversible isothermal expansion of an ideal gas in a closed system at two different temperatures T_1 and T_2 ($T_1 < T_2$). The correct graphical depiction of the dependence of work done (w) on the final volume (V) is:

(1)


(2)


(3)


(4)


2. An ideal gas undergoes isothermal compression from 5 m^3 to 1 m^3 against a constant external pressure of 4 Nm^{-2}. Heat released in this process is used to increase the temperature of 1 mole of Al. If molar heat capacity of Al is 24 J mol^{-1} K^{-1}, the temperature of Al increases by :

(1) $\frac{3}{2}$K (2) $\frac{2}{3}$K

(3) 1 K (4) 2 K

3. Which one of the following equations does not correctly represent the first law of thermodynamics for the given processes involving an ideal gas ? (Assume non-expansion work is zero)

(1) Cyclic process : $q = -w$

(2) Isothermal process : $q = -w$

(3) Adiabatic process : $\Delta U = -w$

(4) Isochoric process : $\Delta U = q$

4. For silver, $C_p(JK^{-1}mol^{-1}) = 23 + 0.01T$. If the temperature (T) of 3 moles of silver is raised from 300K to 1000 K at 1 atm pressure, the value of ΔH will be close to

(1) 21 kJ (2) 16 kJ

(3) 13 kJ (4) 62 kJ

5. 5 moles of an ideal gas at 100 K are allowed to undergo reversible compression till its temperature becomes 200 K.

If $C_V = 28\ JK^{-1}mol^{-1}$, calculate ΔU and ΔpV for this process. ($R = 8.0\ JK^{-1}\ mol^{-1}$]

(1) $\Delta U = 14$ kJ; $\Delta(pV) = 4$ kJ

(2) $\Delta U = 14$ kJ; $\Delta(pV) = 18$ kJ

(3) $\Delta U = 2.8$ kJ; $\Delta(pV) = 0.8$ kJ

(4) $\Delta U = 14$ kJ; $\Delta(pV) = 0.8$ kJ

6. Among the following, the set of parameters that represents path function, is :

(A) q + w (B) q

(C) w (D) H–TS

(1) (A) and (D) (2) (B), (C) and (D)

(3) (B) and (C) (4) (A), (B) and (C)

7. During compression of a spring the work done is 10kJ and 2kJ escaped to the surroundings as heat. The change in internal energy, ΔU(inkJ) is:

(1) 8 (2) 12

(3) – 12 (4) –8

8. An ideal gas is allowed to expand from 1 L to 10 L against a constant external pressure of 1bar. The work done in kJ is :

(1) –9.0 (2) +10.0

(3) –0.9 (4) –2.0

SOLUTION

1. Ans.(2)

$$w = -nRT\ln\frac{V_2}{V_1}$$

$$w = -nRT\ln\frac{V_b}{V_i}$$

$$|w| = nRT\ln\frac{V_b}{V_i}$$

$$|w| = nRT\,(\ln V_b - \ln V_i)$$

$$|w| = nRT\ln V_b - nRT\ln V_i$$

$Y = m\,x - C$

So, slope of curve 2 is more than curve 1 and intercept of curve 2 is more negative then curve 1.

2. Ans. (2)

Work done on isothermal irreversible for ideal gas

$= -P_{ext}\,(V_2 - V_1)$

$= -4\ N/m^2\ (1m^3 - 5m^3)$

$= 16$ Nm

Isothermal process for ideal gas

$\Delta U = 0$

$q = -w$

$= -16$ Nm

$= -16$ J

Heat used to increase temperature of Aℓ

$q = n\,C_m\,\Delta T$

$$16\ J = 1 \times 24\ \frac{J}{mol.K} \times \Delta T$$

$$\Delta T = \frac{2}{3}K$$

3. Ans.(3)

For cyclic process : $\Delta U = 0 \Rightarrow q = -w$

For isothermal process : $\Delta U = 0 \Rightarrow q = -w$

For adiabatic process : $q = 0 \Rightarrow \mathbf{\Delta U = W}$

For isochoric process : $w = 0 \Rightarrow \Delta U = q$

Correct option : (3)

4. Ans.(4)

Sol. $$\Delta H = n\int_{T_1}^{T_2} C_{p,m}dT = 3\times\int_{300}^{1000}(23+0.01T)dT$$

$$= 3\ [\ 23(1000-300) + \frac{0.01}{2}(1000^2 - 300^2)]$$

$= 61950\ J \approx 62$ kJ

Correct option : (4)

5. Ans.(1)

Sol. $n = 5$; $T_i = 100$ K; $T_f = 200$ K;

$C_V = 28$ J/mol K; Ideal gas

$\Delta U = nC_V\Delta T$

$= 5$ mol $\times$ 28 J/mol K $\times$ (200 – 100) K

$= 14{,}000$ J $= 14$ kJ

$\Rightarrow C_p = C_v + R = (28 + 8)$ J/mol K

$= 36$ J/mol K

$\Rightarrow \Delta H = nC_p\Delta T = 5$ mol $\times$ 36 J/mol K $\times$ 100 K

$= 18000$ J $= 18$ kJ

$\Delta H = \Delta U + \Delta(PV)$

$\Rightarrow \Delta(PV) = \Delta H - \Delta U = (18 - 14)$ kJ $= 4$ kJ

6. Ans.(3)

Sol. (A) $q + w = \Delta U \leftarrow$ definite quantity

(B) $q \rightarrow$ Path function

(C) $w \rightarrow$ Path function

(D) $H - TS = G \rightarrow$ state function

$\therefore$ Ans.(3)

7. Ans.(1)

$\Delta U = q + w$

$q = -2$kJ, $W = 10$kJ

$\Delta U = 8$kJ

8. Ans.(3)

$W = -P_{ext}\,(V_2 - V_1)$

$= -1$bar $\times$ (10–1)lit

$= -9$ bar–lit

$= -900$ J

$= -0.9$ kJ