

1. Select the correct statement(s).

- (A) In a reversible process ΔG is always zero in a closed system. F
- (B) In a reversible process $\underline{\Delta S_{\text{univ}}}$ is always zero in a closed system. T
- (C) In a reversible process ΔS_{sys} is always zero in a closed system. F
- (D) In a reversible process ΔS_{sys} is always zero in an isolated system. T

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2. At 500 K for an isobaric process,

$$\Delta S_{\text{system}} = -10 \frac{\text{kJ}}{\text{molK}}$$

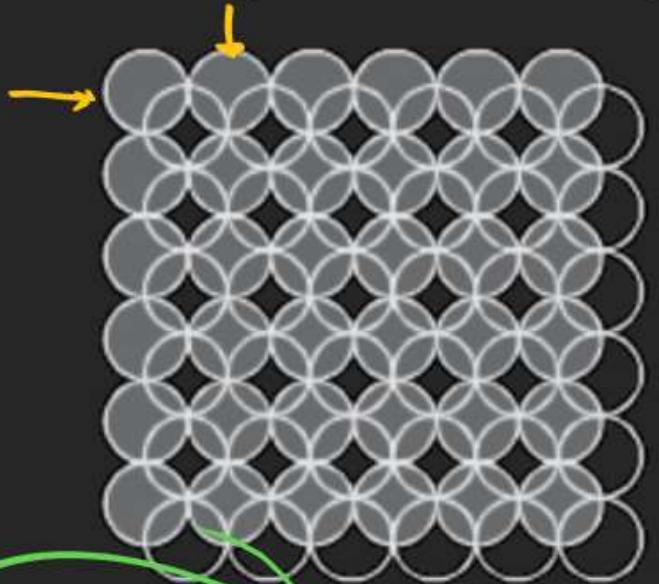
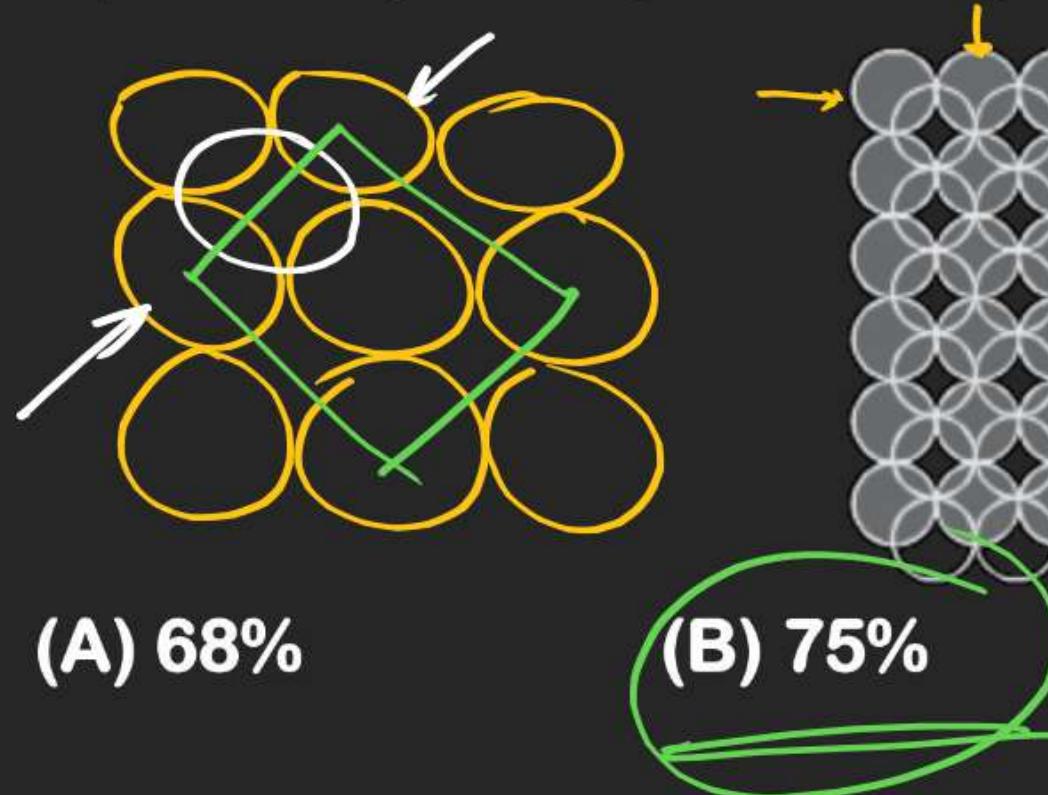
$$\text{and } \Delta S_{\text{surr}} = 12 \frac{\text{kJ}}{\text{molK}}$$

Therefore, DG for the entire process is-

- (A) -500 kJ/mol (B) -1000 kJ/mol (C) -600 kJ/mol (D) -1100 kJ/mol

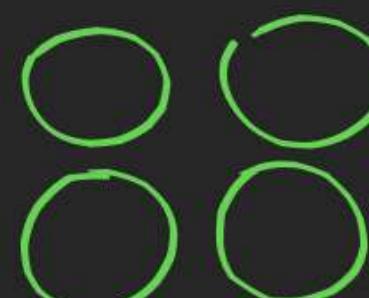
$$\Delta G = -T (\Delta S_{\text{univ}})$$

3. The crystal of a solid is square packing of identical spheres in each layer and spheres of one layer are placed just above the voids made by spheres in previous layer. The packing efficiency of such crystal is. ($\rho = 3.15$, $\sqrt{2} = 1.4$)



(C) 82%

(D) 84%

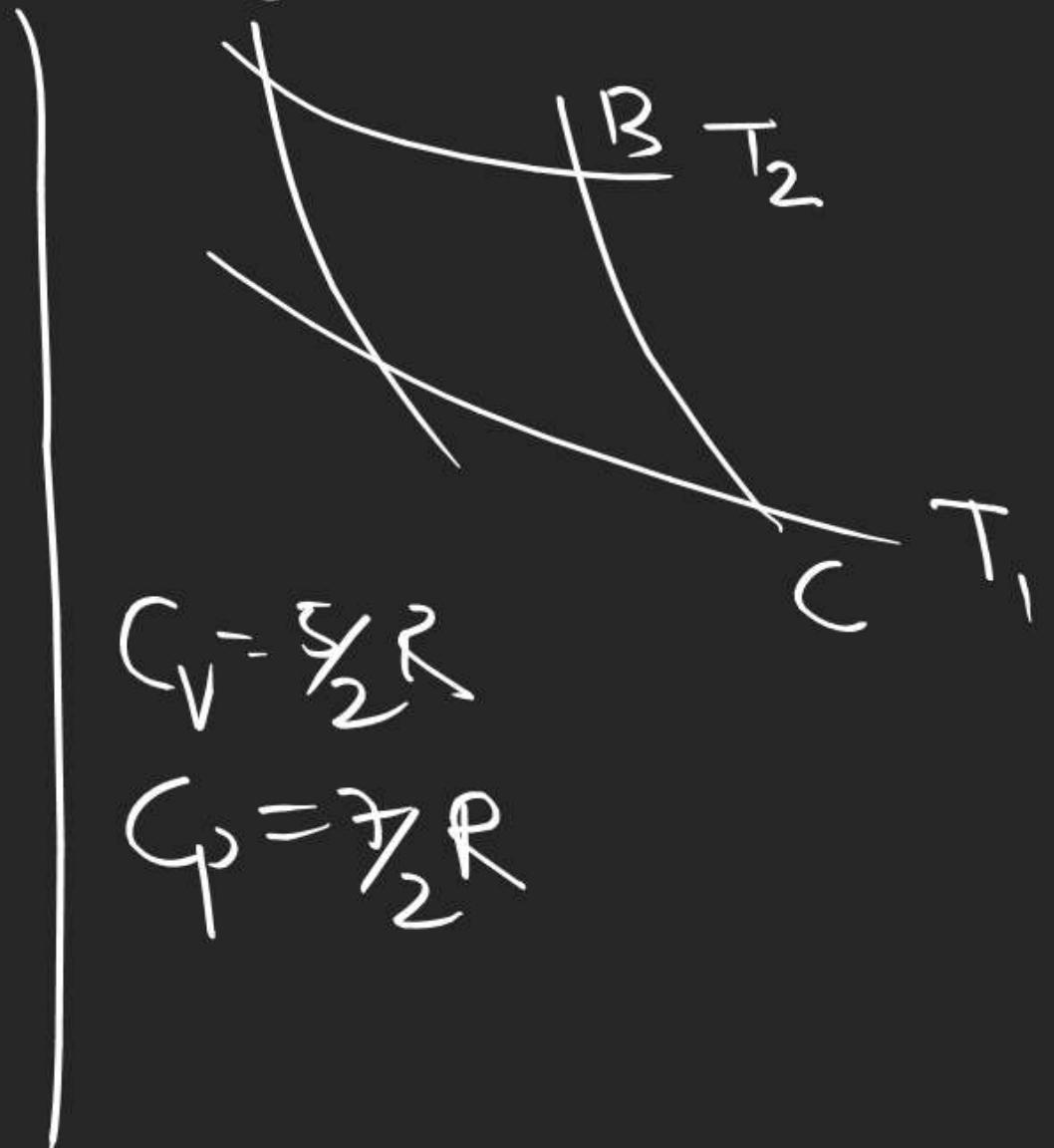


4. A diatomic gas is used in a Carnot engine as a working substance. In an adiabatic expansion, volume of gas increases two times then what is the percentage efficiency of Carnot engine?

$$= \frac{T_2 - T_1}{T_2}$$

$$= 1 - \frac{T_1}{T_2}$$

$$= 1 - \frac{1}{2^{2/5}}$$



$$T_2 V_B^{\gamma-1} = T_1 V_C^{\gamma-1}$$

$$\frac{T_2}{T_1} = \left(\frac{V_C}{V_B} \right)^{\gamma-1}$$

$$\frac{T_2}{T_1} = (2)^{7/5-1} = 2^{2/5}$$

5. 0.50 mol of an ideal gas initially at a temperature of 300 K and at a pressure of 2 atm in expanded isothermally in three steps. In each step, the pressure is dropped suddenly and held constant until equilibrium is reestablished. The pressure at each of the three stages of expansion are 1.6, 1.2 and 1 atm.

Calculate the work done ($|W|$) (in atm - litre) in this process. [Use $R = 0.08 \text{ atm-litre/mole.K}$]

$$W = -P_{\text{ext}} \left(\frac{1}{P_f} - \frac{1}{P_i} \right) nRT$$

$$W_1 = \left[-1.6 \left(\frac{1}{1.6} - \frac{1}{2} \right) - 1.2 \left(\frac{1}{1.2} - \frac{1}{1.6} \right) - 1 \left(\frac{1}{1} - \frac{1}{1.2} \right) \right] nRT$$

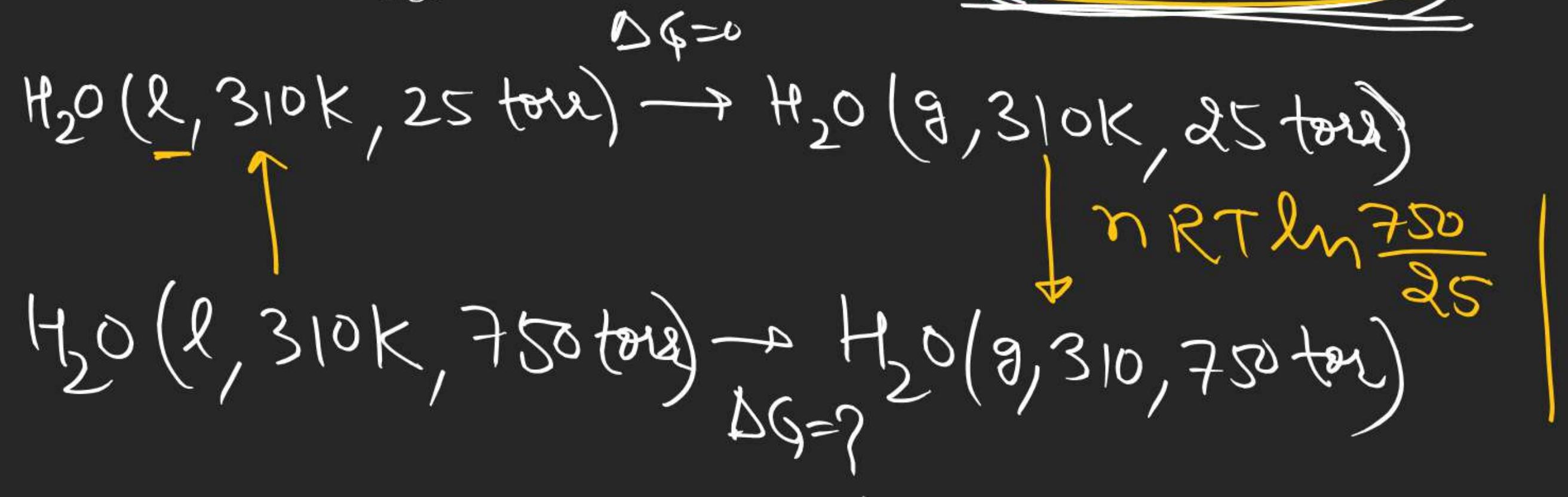
6. The vapour pressure of water at 310 K is 25 torr. If the standard state pressure is defined as (750 torr) estimate the ΔG° [in kJ/mol] for the process.



(Neglect variation of DH and DS with pressure for liquid)

Use [$R = 8.3 \text{ JK}^{-1} \text{ mol}^{-1}$; $\frac{\ln X}{\log X} = 2.3$, $\log 3 = 0.48$]

8758.492



1. Calculate ΔG for the reaction at T K,



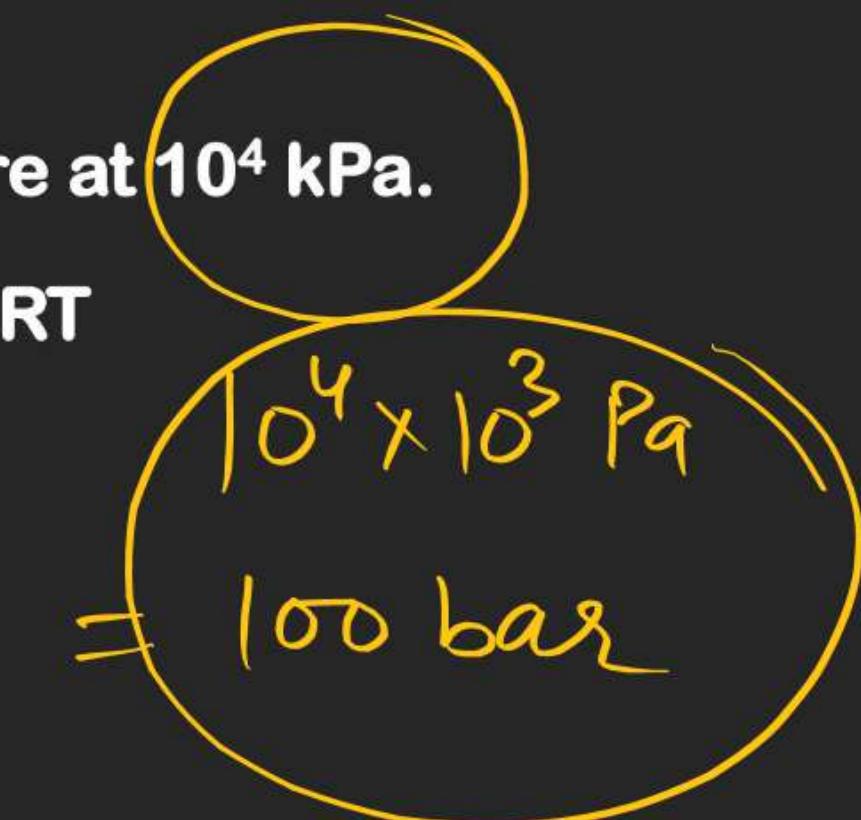
- (A) $-2.303 RT$ (B) $2.303 RT$ (C) $-4.606 RT$ (D) $4.606 RT$



$$\Delta G = -RT \ln K_p + RT \ln Q$$

$$= RT \ln \frac{Q}{K_p}$$

$$= RT \ln \frac{100}{10^3}$$



$$Q = \frac{(100)^3}{(100)^2}$$

5. For the chemical and phase change carried out at equilibrium

(A) ΔH_r is zero

(B) ΔS_r is zero

(C) ΔG_r is zero

(D) $\Delta G_r < 0$

1 atm 373 K



$$K_p = \frac{P_B^2}{P_A}$$

$$Q = \frac{P_B^2}{P_A}$$

8. If for the reaction at 27°C,



$\Delta U_r = 25.6$ kcal and entropy of A, B, C are 200, 100, 500 cal/mole respectively,

then calculate magnitude of ΔG (in Kcal) of reaction.

[$R = 2$ cal/mole-K]

Fill your answer as sum of digits (excluding decimal places) till you get the single digit answer.

$$\Delta G = \Delta H - T\Delta S$$

11. 5 moles of an ideal monatomic gas undergo adiabatic free expansion from $10L, (e^4)$ atm to (e) atm. The change in entropy (in Cal/K) of the system is

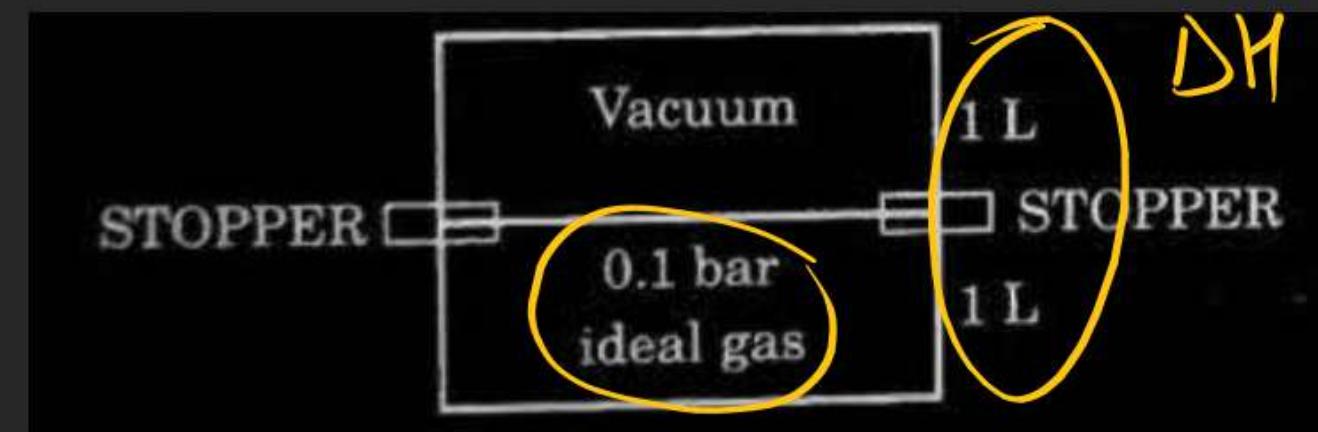
$$\Delta T = 0$$

$$\begin{aligned}\Delta S_{sys} &= 0 + nR \ln \frac{P_1}{P_2} \\ &= 0 + nR \ln e^4/e \\ &= 3nR \\ &= 3 \times 5 \times 2\end{aligned}$$

13. A container is separated into two 1 litre compartments by a piston of negligible mass as shown below. In lower compartment 0.1 mole of an ideal monoatomic gas is filled at 0.1 bar pressure & the other compartment is empty. Now the stoppers are removed so that the gas expands to 2 litre. Heat is supplied to the gas so that finally pressure of gas equals to 0.1 bar. Calculate DH of the process in joule.

[1 bar. litre = 100 J]

$$C_V = \frac{R}{\gamma - 1}$$



$$\frac{\gamma}{\gamma-1} \times 0.1x$$

$$\frac{\gamma}{\gamma-1} PV$$

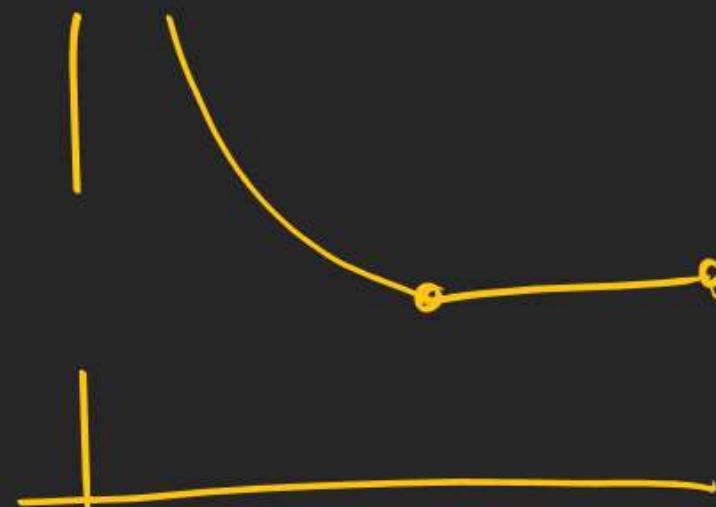
$$\begin{aligned}
 DH &= nC_p(T_2 - T_1) \\
 &= nC_p(2T - T) \\
 &= nC_p T \\
 &= n \frac{\gamma R T}{\gamma - 1}
 \end{aligned}$$

Paragraph for Q.14 to Q.15

1 mole of ideal monoatomic gas was subjected to following processes.

- (i) The gas was isothermally and reversibly expanded to double volume at 300K.
- (ii) The final pressure after first step is 1 atm, and the gas is isobarically heated to double the volume.

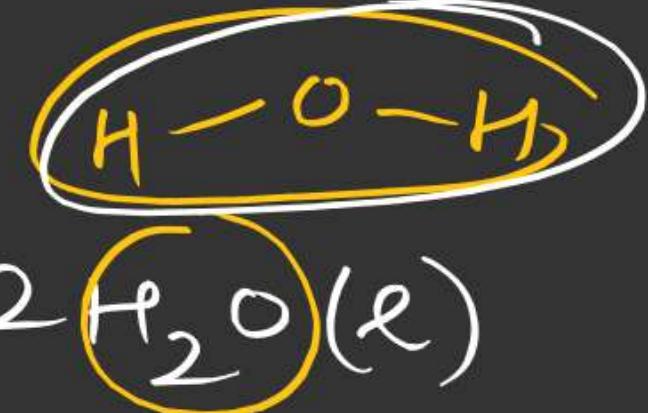
14. What is total heat absorbed by the gas in overall process (take $\ln 2 = 0.7$)
- (A) 960 R (B) 860 R (C) 760 R (D) 520 R



15. The magnitude of work done by the system in overall process is:

- (A) 510 R
- (B) 520 R
- (C) 500 R
- (D) 490 R

Thermochemistry



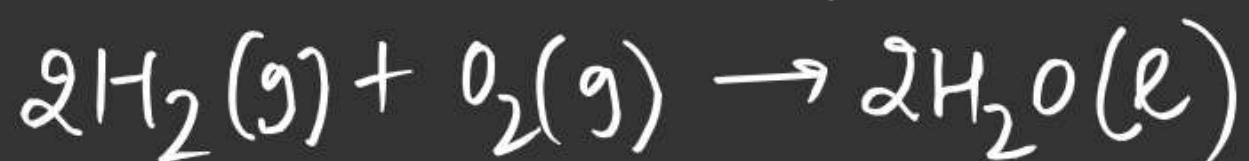
$$2x + y - 4z - 2w$$

$$\Delta H = ?$$

| | | | |
|------|---------------------|---------------------|---------------------|
| Bond | $\text{H}-\text{H}$ | $\text{O}=\text{O}$ | $\text{O}-\text{H}$ |
| BE. | x | y | z |

$$\Delta H_{\text{vap}}[\text{H}_2\text{O}(\ell)] = w$$

$$2x + y - 4z - w$$



$$2x + y - 4z = \Delta H + 2w$$

Q. find C-H bond enthalpy using

$$\begin{aligned} \Delta H_{\text{comb}}[\text{CH}_4(\text{g})] &= -1000 \text{ kJ/mol} \\ \rightarrow \Delta H_f^\circ[\text{H}_2\text{O}(\ell)] &= -285 \text{ "} \\ \rightarrow \Delta H_f^\circ[\text{CO}_2(\text{g})] &= -398 \text{ "} \\ \rightarrow \Delta H_{\text{atomisation}}(\text{graphite}) &= 700 \\ BE_{\text{H-H}} &= 300 \end{aligned}$$

$$\begin{aligned} \Delta H_f^\circ[\text{CH}_4(\text{g})] &=? \\ \text{CH}_4(\text{g}) + \text{O}_2(\text{g}) &\rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\ell) \\ -1000 = \Delta H_r &= \Delta H_f^\circ(\text{P}_r) - \Delta H_f^\circ(\text{R}) \\ &= -398 - 700 - \Delta H_f^\circ(\text{CH}_4) \\ \Delta H_f^\circ[\text{CH}_4(\text{g})] &= -100 \end{aligned}$$



$$-100 = \Delta H_r = 700 + \underline{\underline{600}} - 4 \text{ BE}_{\text{C-H}}$$

$$4 \text{ BE}_{\text{C-H}} = 1400$$

Calculate enthalpy change when 3 mol $P(g)$ atom is converted into $P_4(g)$. Given $BE_{P-P} = 300 \text{ kJ/mol}$

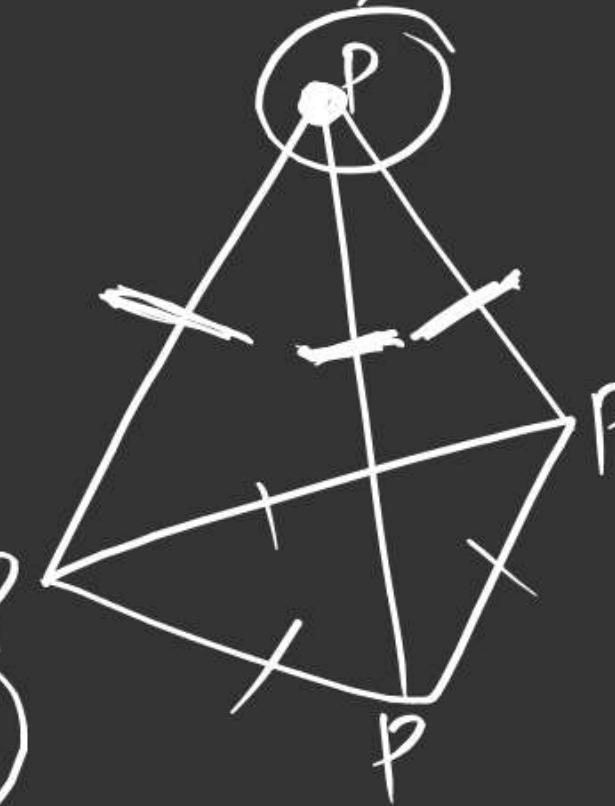


$$\Delta H_f = 0 - 6 \times 300 \\ = -1800$$

$$- 1.5 \times 3 \times 300$$

Aaaa

$$-\frac{3}{4} \times 1800$$

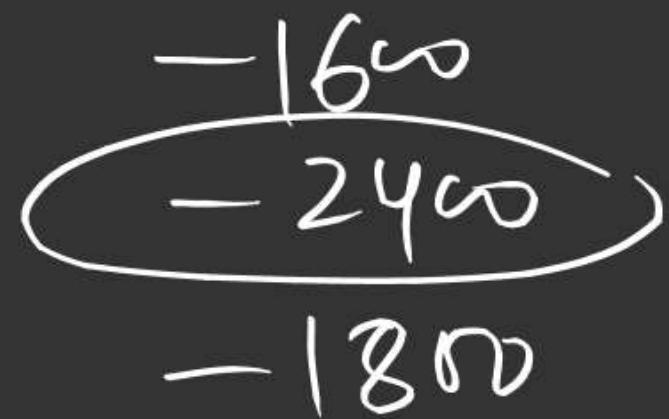


$$-900 \\ -5400 \\ -1350$$

3 mol C(g) is converted into gaseous diamond

Given

$$\text{BE}_{\text{C-C}} = 400 \text{ kJ/mol}$$



-1600

-2400

$$= -2 \times 3 \times 400$$

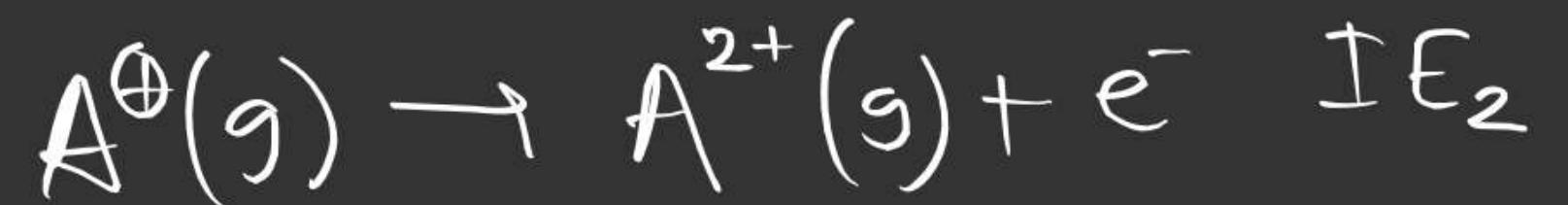
$$= \underline{-2400}$$

Ionisation enthalpy \rightarrow It is the enthalpy change when an e^- is removed from each of 1mol of gaseous atom.

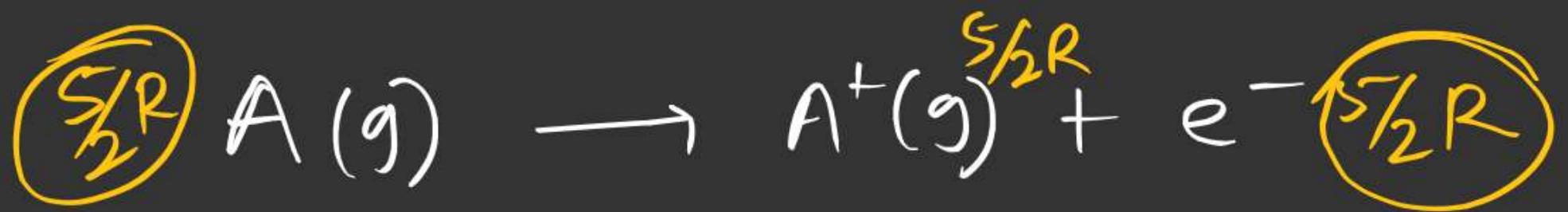
IE



$$\text{IE}_1 < \text{IE}_2 < \text{IE}_3$$



Ionisation energy = $(\text{Ionisation enthalpy})_{\text{OK}}$



$$(\Delta H_{IE})_T - (\Delta H_{IE})_{OK} = (\Delta G_p)_r(T=0)$$

$$(\Delta H_{IE})_T - \begin{matrix} \uparrow \\ \text{ionisation} \\ \text{energy} \end{matrix} = S/2R(T=0)$$

