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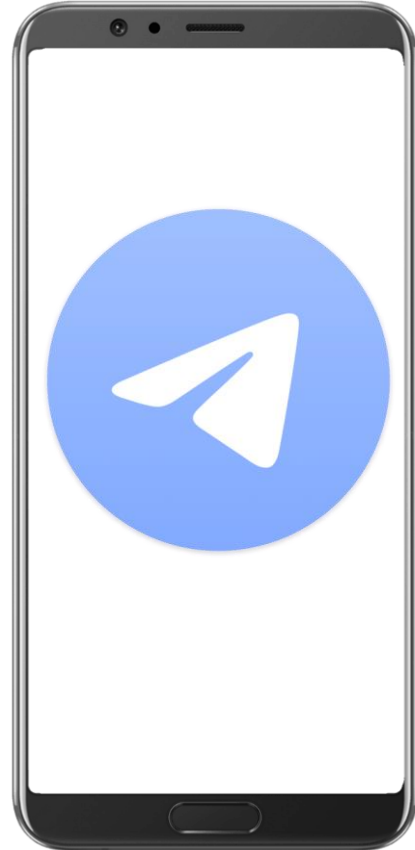
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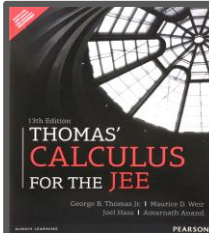
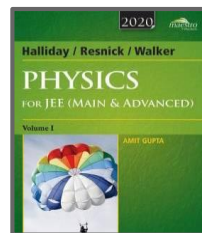
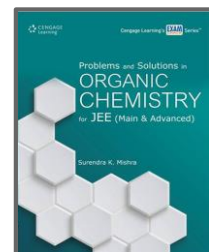
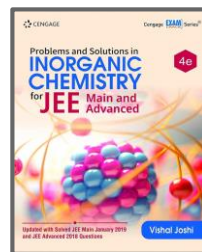
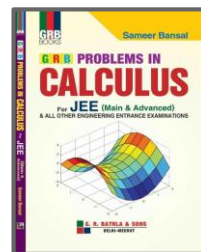
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Course of 12th syllabus Physics for JEE Aspirants 2022: Part - I

Lesson 1 • Apr 2, 2021 12:30 PM

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Ajit Lulla
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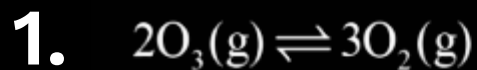
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Questions



At 300 K, ozone is fifty percent dissociated. The standard free energy change at this

temperature and 1 atm pressure is $(-)$ ___ J mol^{-1}
(Nearest integer)

[Given: $\ln 1.35 = 0.3$ and $R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$]

2. The standard entropy change for the reaction $4\text{Fe(s)} + 3\text{O}_2\text{(g)} \rightarrow 2\text{Fe}_2\text{O}_3\text{(s)}$ is -550 JK^{-1} at 298 K.

[Given : The standard enthalpy change for the reaction is -165 kJ mol^{-1}]. The temperature in K at which the reaction attains equilibrium is _____. (Nearest Integer)

3. At 25°C and 1 atm pressure, the enthalpy of combustion of benzene (l) and acetylene (g) are $-3268 \text{ kJ mol}^{-1}$ and $-1300 \text{ kJ mol}^{-1}$, respectively.

The change in enthalpy for the reaction $3 \text{ C}_2\text{H}_2(\text{g}) \rightarrow \text{C}_6\text{H}_6(\text{l})$, is

(A) $+324 \text{ kJ mol}^{-1}$

(B) $+632 \text{ kJ mol}^{-1}$

(C) -632 kJ mol^{-1}

(D) -732 kJ mol^{-1}

jee main 2022

25°C

1 atm

$$\Delta H_{\text{comb}} \text{C}_6\text{H}_6(\text{l}) = -3268 \text{ kJ mol}^{-1}$$

$$\Delta H_{\text{comb}} \text{C}_2\text{H}_2(\text{g}) = -1300 \text{ kJ mol}^{-1}$$

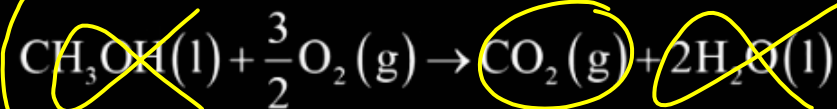
$$\Delta H_{\text{rxn}} = 3\Delta H_{\text{comb}} \text{C}_2\text{H}_2 - \Delta H_{\text{comb}} \text{C}_6\text{H}_6$$

$$= 3(-1300) - (-3268)$$

$$= -3900 + 3268$$

4.

For complete combustion of methanol



the amount of heat produced as measured by bomb calorimeter is 726 kJ mol^{-1} at 27°C . The enthalpy of combustion for the reaction is $-x \text{ kJ mol}^{-1}$, where x is 727. (Nearest integer)

(Given : $R = 8.3 \text{ JK}^{-1} \text{ mol}^{-1}$)

$$T = 300 \text{ K}$$

$$q_v = -726 \text{ kJ mol}^{-1} = \Delta U_r$$

$$\Delta H = ?$$

$$\Delta H = \Delta U + \Delta n_g RT$$

$$\Delta H = -726 + \left[-\frac{1}{2}\right] \left[\frac{8.314}{1000}\right] 300$$

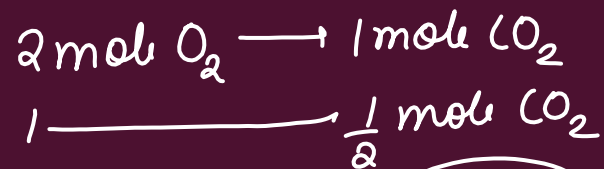
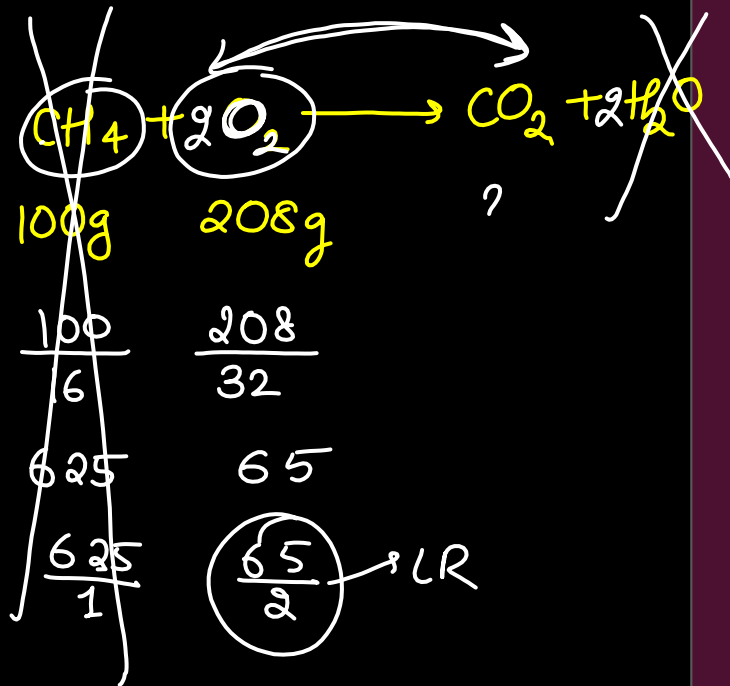
$$\left(1 - \frac{3}{2}\right) \boxed{\text{see P.Y.Q}} \star$$

CH₄

5. CNG is an important transportation fuel. When 100 g CNG is mixed with 208 oxygen in vehicles, it leads to the formation of CO₂ and H₂O and produces large quantity of heat during this combustion, then the amount of carbon dioxide, produced in grams is _____. [nearest integer]

[Assume CNG to be methane]

jee main 2022



$$\begin{array}{l}
 6.5 \text{ mol} \rightarrow \frac{6.5 \times 44}{2} \\
 \underline{\underline{143\text{g}}}
 \end{array}$$

\uparrow 44g/mol
 $\eta \times \text{mm}$

6.

A fish swimming in water body when taken out from the water body is covered with a film of water of weight 36 g. When it is subjected to cooking at 100°C , then the internal energy for vaporization in kJ mol^{-1} is $_$. [nearest integer]

[Assume steam to be an ideal gas. Given $\Delta_{\text{vap}}H^{\ominus}$ for water at 373 K and 1 bar is 41.1 kJ mol^{-1} ; $R = 8.31 \text{ JK}^{-1}\text{mol}^{-1}$]

jel

7. 40° of HI undergoes decomposition to H₂ and I₂ at 300 K. ΔG^\ominus for this decomposition reaction at one atmosphere pressure is _____ J mol⁻¹. [nearest integer]

(Use $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$; $\log 2 = 0.3010$. $\ln 10 = 2.3$, $\log 3 = 0.477$)

8.

lg

	List-I	List-II
(A)	<u>Spontaneous process</u>	(I) $\Delta H < 0$
(B)	<u>Process with $\Delta P = 0$, $\Delta T = 0$</u>	(II) $\Delta G_{T,P} < 0$
(C)	$\Delta H_{\text{reaction}}$?	(III) <u>Isothermal and isobaric process</u>
(D)	<u>Exothermic process</u>	(IV) [Bond energies of molecules in reactants] - [Bond energies of product molecules]

Choose the correct answer from the options given below:

~~(A)~~ (A) - (III), (B) - (II), (C) - (IV), (D) - (I)

(B) (A) - (II), (B) - (III), (C) - (IV), (D) - (I)

(C) (A) - (II), (B) - (III), (C) - (I), (D) - (IV)

~~(D)~~ (A) - (II), (B) - (I), (C) - (III), (D) - (IV)

jee main 2022
Repeat Ques
Same in 2020
&
Similar in 2021

9.

When 5 moles of He gas expand isothermally and reversibly at 300 K from 10 litre to 20 litre, the magnitude of the maximum work obtained is ____

J. [nearest integer] (Given: $R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$ and $\log 2 = 0.3010$)

jee main 2022

He (ideal) $n = 5 \text{ mole}$

isothermal exp

Rev

$$T = 300 \text{ K}$$

$$V_1 = 10 \text{ l}$$

$$V_2 = 20 \text{ l}$$

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

$$= -5 \times 8.3 \times 300 \times \ln \frac{20}{10}$$

2303 $\log 2$

$$= -8630 \text{ J}$$

$$= -5 \times 8.3 \times 300 \times 0.3010$$

$$\times 2303$$

10

4.0 L of an ideal gas is allowed to expand
isothermally into vacuum until the total volume is
20 L. The amount of heat absorbed in this
expansion is _____ L atm. $q = ?$

Ideal Gas $V_1 = 4\text{ l}$
 expansion $p_{\text{ext}} = 0$ \rightarrow const
 Isothermal $V_2 = 20\text{ l}$

$$\begin{aligned} w &= -p_{\text{ext}}(V_2 - V_1) \\ &= -0(V_2 - V_1) \\ &= 0 \end{aligned}$$

1st law

ideal
 $U = f(T)$

$$\Delta U = 0$$

$$dU = dq + dw$$

$$\Delta U = q + w$$

$$q = \cancel{\Delta U} - \cancel{w} = 0$$

$$q = 0$$

11.

For combustion of one mole of magnesium in an open container at 300 K and 1 bar pressure, $\Delta_c H^\circ = -601.70 \text{ kJ mol}^{-1}$, the magnitude of change in internal energy for the reaction is _____ kJ. (Nearest integer)

jel main 2022

(Given : $R = 8.3 \text{ J K}^{-1} \text{ mol}^{-1}$)



open container

1 mole Mg

300K

1 bar

$$\Delta n_g = 0 - \frac{1}{2} = -\frac{1}{2}$$

$$\boxed{\Delta H = \Delta U + \Delta n_g RT}$$

$$\underbrace{-601.70 \text{ KJ}}_{\times 1000} = \Delta U + \underbrace{\left(-\frac{1}{2}\right)(8.314)}_{\text{J}} 300$$

12. 17.0 g of NH_3 completely vapourises at -33.42°C and 1 bar pressure and the enthalpy change in the process is 23.4 kJ mol^{-1} . The enthalpy change for the vapourisation of 85 g of NH_3 under the same conditions is _____ kJ.

hw

13.

2.2 g of nitrous oxide (N_2O) gas is cooled at a constant pressure of 1 atm from 310 K to 270 K causing the compression of the gas from 217.1 mL to 167.75 mL. The change in internal energy of the process, ΔU is '-x' J. The value of 'x' is ____.

[nearest integer]

jee main

(Given: atomic mass of N = 14 g mol^{-1} and of O = 16 g mol^{-1} .)

Molar heat capacity of N_2O is $100 \text{ JK}^{-1} \text{ mol}^{-1}$)

C_m $100 \text{ JK}^{-1} \text{ mol}^{-1}$



2.2 g

const press = 1 atm

$$\left. \begin{array}{l} T_1 = 310 \text{ K} \\ T_2 = 270 \text{ K} \end{array} \right\} \text{cool}$$

compression

$$V_1 = 217.1 \text{ mL}$$

$$V_2 = 167.75 \text{ mL}$$

$$q_p = \Delta H = n C_{p,m} dT$$

1st law

$$\int dU = \int dq + \int dw$$

$$\star \boxed{\Delta U = q + w}$$

$$\int dw = - \int p_{ext} dV$$

$$\star w = -1 \text{ atm} \int dV$$
$$= -1 \text{ atm} (\Delta V)$$

$$\boxed{1 \text{ atm l} = 100 \text{ J}}$$

14. The enthalpy of combustion of propane, graphite and dihydrogen at 298 K are: $-2220.0 \text{ kJ mol}^{-1}$, $-393.5 \text{ kJ mol}^{-1}$ and $-285.8 \text{ kJ mol}^{-1}$ respectively. The magnitude enthalpy of formation of propane (C_3H_8) is..... kJ mol^{-1} . (Nearest integer)

15.

While performing a thermodynamics experiment, a student made the following observations,



$$\Delta H = -55.3 \text{ kJ mol}^{-1}.$$

The enthalpy of ionization of CH_3COOH as calculated by the student is _____ kJ mol^{-1} .

16.

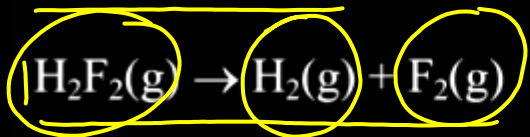
2.4 g coal is burnt in a bomb calorimeter in excess of oxygen at 298 K and 1 atm pressure.

The temperature of the calorimeter rises from 298 K to 300 K. The enthalpy change during the combustion of coal is $-x \text{ kJ mol}^{-1}$. The value of x is _____. (Nearest Integer)

(Given : Heat capacity of bomb calorimeter 20.0 kJ K^{-1} . Assume coal to be pure carbon)

17.

For the reaction

jee main
2022

$$\Delta U = -59.6 \text{ kJ mol}^{-1} \text{ at } 27^\circ\text{C}.$$

The enthalpy change for the above reaction is (-)

57 kJ mol^{-1} [nearest integer] Given : $R = 8.314$

$\text{JK}^{-1} \text{ mol}^{-1}$.

$$\Delta H = \Delta U + \Delta n_g RT$$

$$= -59.6 \text{ kJ mol}^{-1} + \frac{[2 - 1] \times 8.314 \times 300}{1000}$$

18.

The molar heat capacity for an ideal gas at constant pressure is $20.785 \text{ J K}^{-1}\text{mol}^{-1}$. The change in internal energy is 5000 J upon heating it from 300K to 500K . The number of moles of the gas at constant volume is ____ [Nearest integer]

(Given: $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$)

jee main

ideal gas

$$C_{pm} = 20.785 \text{ J/K/mol}$$

$$\Delta U = 5000 \text{ J}$$

$$T_1 = 300 \text{ K}$$



$$T_2 = 500 \text{ K}$$

$$\hat{n} = ?$$

$$C_{pm} - C_{vm} = R$$

$$C_{pm} - R = C_{vm}$$

$$20.785 - 8.314 = C_{vm}$$

ideal

$$\int dU = \int n C_{vm} dT$$

$$\Delta U = n C_{vm} \Delta T$$

19. A gas (Molar mass = 280 g mol^{-1}) was burnt in excess O_2 in a constant volume calorimeter and during combustion the temperature of calorimeter increased from 298.0 K to 298.45 K . If the heat capacity of calorimeter is 2.5 kJ K^{-1} and enthalpy of combustion of gas is 9 kJ mol^{-1} then amount of gas burnt is _____g. (Nearest Integer)

hw

20. Which of the following relation is not correct ?

~~(A)~~ $\Delta H = \Delta U - P\Delta V$ (B) $\Delta U = q + W$ correct

(C) $\Delta S_{\text{sys}} + \Delta S_{\text{surr}} \geq 0$ (D) $\Delta G = \Delta H - T\Delta S$

$$dH = dU + d(PV)$$

$$\Delta H = \Delta U + P\Delta V$$

ju main 2022.

21.

Among the following the number of state variable is 3.

Internal energy (U) ✓

Volume (V) ✓

Heat (q) ✗

Enthalpy (H) ✓

JEE Main 2022

22. When 600 mL of 0.2 M HNO_3 is mixed with 400 mL of 0.1M NaOH solution in a flask, the rise in temperature of the flask is _____ $\times 10^{-2} ^\circ\text{C}$.

(Enthalpy of neutralisation = 57 kJ mol^{-1} and

Specific heat of water = $4.2 \text{ JK}^{-1} \text{ g}^{-1}$)

(Neglect heat capacity of flask)

- 23.** Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R
Assertion A : The reduction of a metal oxide is easier if the metal formed is in liquid state than solid state.
Reason R : The value of ΔG° becomes more on negative side as entropy is higher in liquid state than solid state.
In the light of the above statements. Choose the most appropriate answer from the options given below
- A. Both A and R are correct and R is the correct explanation of A
 - B. Both A and R are correct but R is not the correct explanation of A
 - C. A is correct but R is not correct
 - D. A is not correct but R is correct

24. In thermodynamics, the $P - V$ work done is given by

$$w = - \int dV P_{\text{ext}} .$$

For a system undergoing a particular process, the work done is,

$$w = - \int dV \left(\frac{RT}{V - b} - \frac{a}{V^2} \right)$$

This equation is applicable to a

- (A) system that satisfies the van der Waals equation of state.
- (B) process that is reversible and isothermal.
- (C) process that is reversible and adiabatic.
- (D) process that is irreversible and at constant pressure.

25. Tin is obtained from cassiterite by reduction with coke. Use the data given below to determine the minimum temperature (in K) at which the reduction of cassiterite by coke would take place.

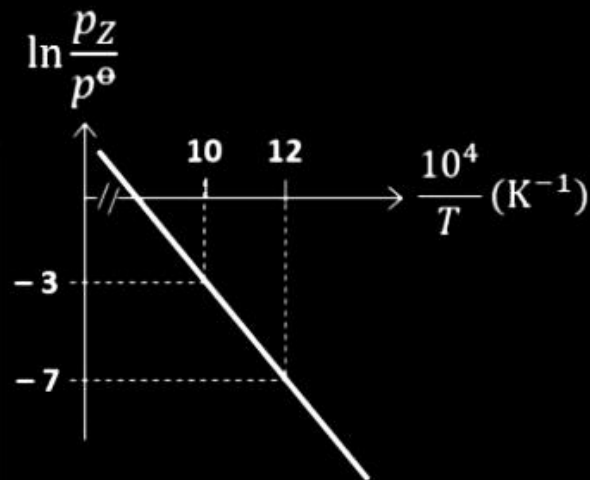
At 298 K: $\Delta_f H^\circ(\text{SnO}_2(s)) = -581.0 \text{ kJ mol}^{-1}$, $\Delta_f H^\circ(\text{CO}_2(g)) = -394.0 \text{ kJ mol}^{-1}$,

$S^\circ(\text{SnO}_2(s)) = 56.0 \text{ J K}^{-1}\text{mol}^{-1}$, $S^\circ(\text{Sn}(s)) = 52.0 \text{ J K}^{-1}\text{mol}^{-1}$,

$S^\circ(\text{C}(s)) = 6.0 \text{ J K}^{-1}\text{mol}^{-1}$, $S^\circ(\text{CO}_2(g)) = 210.0 \text{ J K}^{-1}\text{mol}^{-1}$.

Assume that the enthalpies and the entropies are temperature independent.

- 26.** For the reaction, $X(s) \rightleftharpoons Y(s) + Z(g)$, the plot of $\ln \frac{p_Z}{p^\ominus}$ versus $\frac{10^4}{T}$ is given below (in solid line), where p_Z is the pressure (in bar) of the gas Z at temperature T and $p^\ominus = 1$ bar.



(Given, $\frac{d(\ln K)}{d\left(\frac{1}{T}\right)} = -\frac{\Delta H^\ominus}{R}$, where the equilibrium constant, $K = \frac{p_Z}{p^\ominus}$ and the gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$)

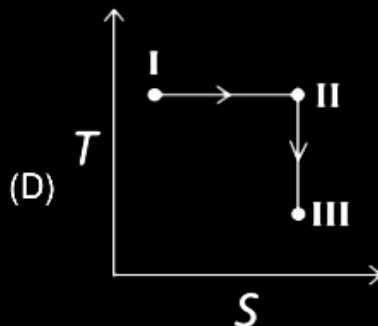
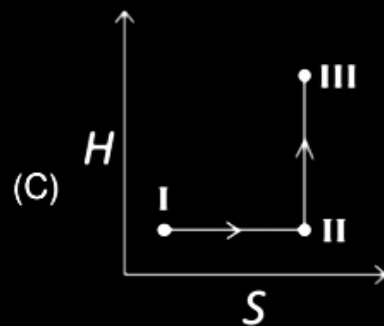
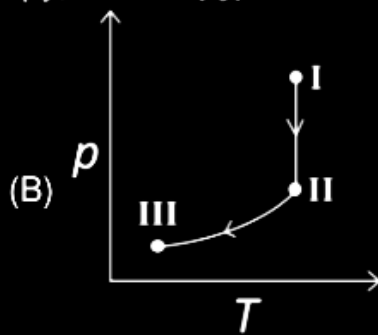
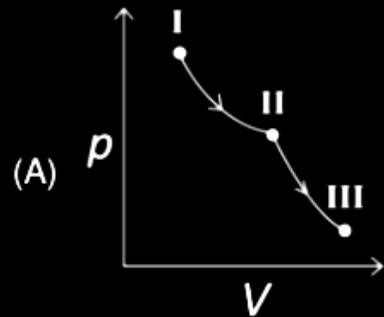
The value of standard enthalpy, ΔH^\ominus (in kJ mol^{-1}) for the given reaction is ____.

27. The value of ΔS^\ominus (in $\text{J K}^{-1} \text{mol}^{-1}$) for the given reaction, at 1000 K is ____.

28.

An ideal gas undergoes a reversible isothermal expansion from state I to state II followed by a reversible adiabatic expansion from state II to state III. The correct plot(s) representing the changes from state I to state III is(are)

(p : pressure, V : volume, T : temperature, H : enthalpy, S : entropy)



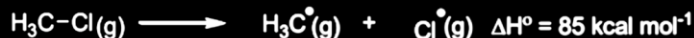
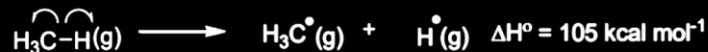
29. For the following reaction



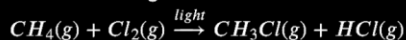
the correct statement is

- (A) Initiation step is exothermic with $\Delta H^\circ = -58 \text{ kcal mol}^{-1}$.
- (B) Propagation step involving CH_3 formation is exothermic with $\Delta H^\circ = -2 \text{ kcal mol}^{-1}$
- (C) Propagation step involving CH_3Cl formation is endothermic with $\Delta H^\circ = +27 \text{ kcal mol}^{-1}$
- (D) the reaction is exothermic with $\Delta H^\circ = -25 \text{ kcal mol}^{-1}$.

The amount of energy required to break a bond is same as the amount of energy released when the same bond is formed. In gaseous state, the energy required for homolytic cleavage of a bond is called Bond Dissociation Energy(BDE) or Bond Strength. BDE is affected by s-character of the bond and the stability of the radicals formed. Shorter bonds typically stronger bonds. BDEs for some bonds are given below:



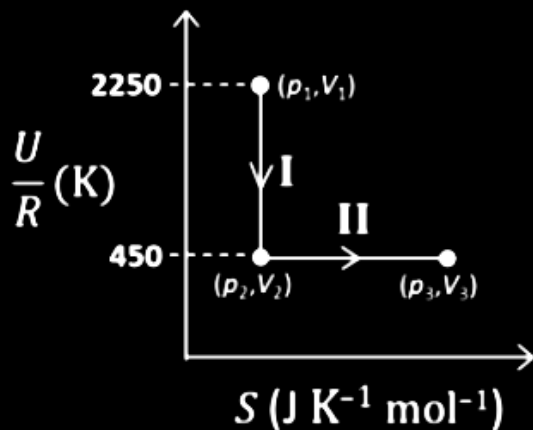
For the following reaction



the correct statement is

30.

One mole of an ideal gas at 900 K, undergoes two reversible processes, I followed by II, as shown below. If the work done by the gas in the two processes are same, the value of $\ln \frac{V_3}{V_2}$ is ____.



(U : internal energy, S : entropy, p : pressure, V : volume, R : gas constant)

(Given: molar heat capacity at constant volume, $C_{V,m}$ of the gas is $\frac{5}{2} R$)

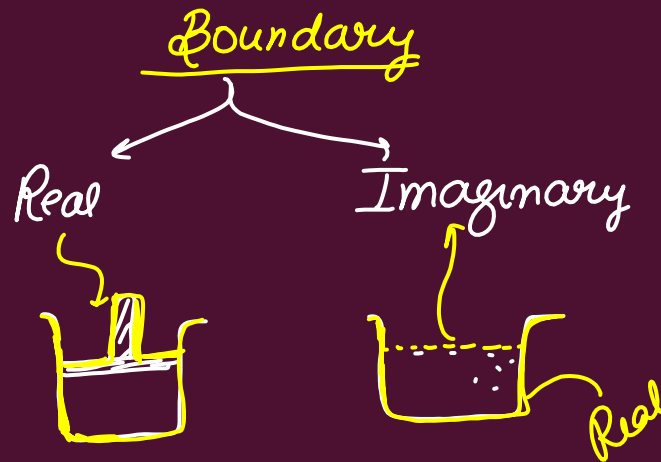
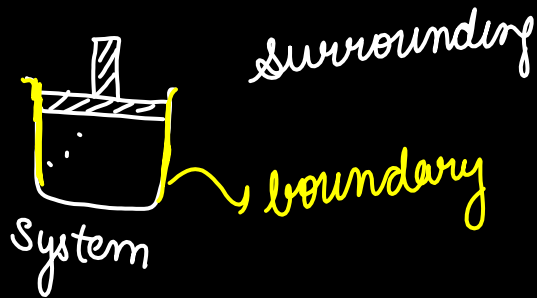
31. 2 mole of Hg(g) is combusted in a fixed volume bomb calorimeter with excess of O_2 at 298 K and 1 atm into HgO(s) . During the reaction, temperature increases from 298.0 K to 312.8 K. If heat capacity of the bomb calorimeter and enthalpy of formation of Hg(g) are 20.00 kJ K^{-1} and $61.32 \text{ kJ mol}^{-1}$ at 298 K, respectively, the calculated standard molar enthalpy of formation of HgO(s) at 298 K is $X \text{ kJ mol}^{-1}$. The value of $|X|$ is _____.
- [Given: Gas constant $R = 8.3 \text{ J K}^{-1}\text{mol}^{-1}$]

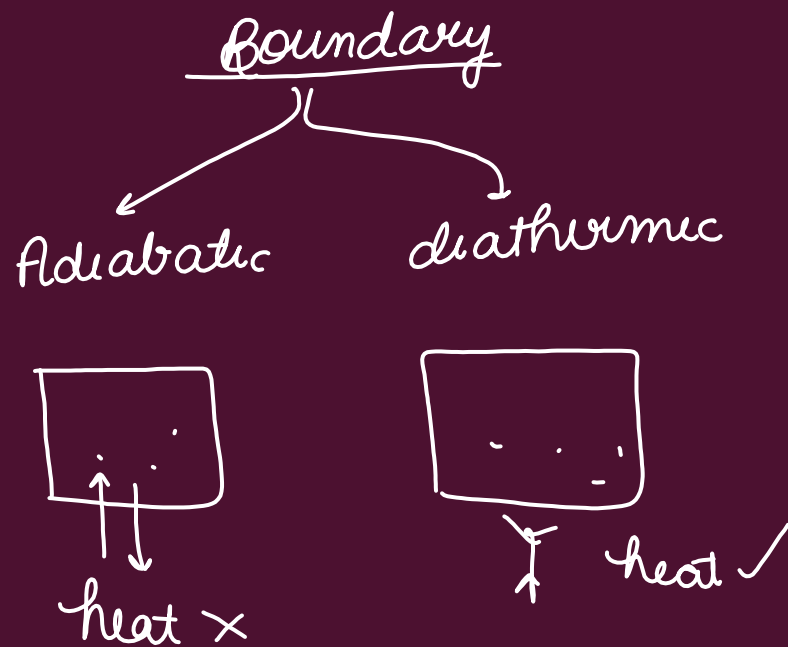
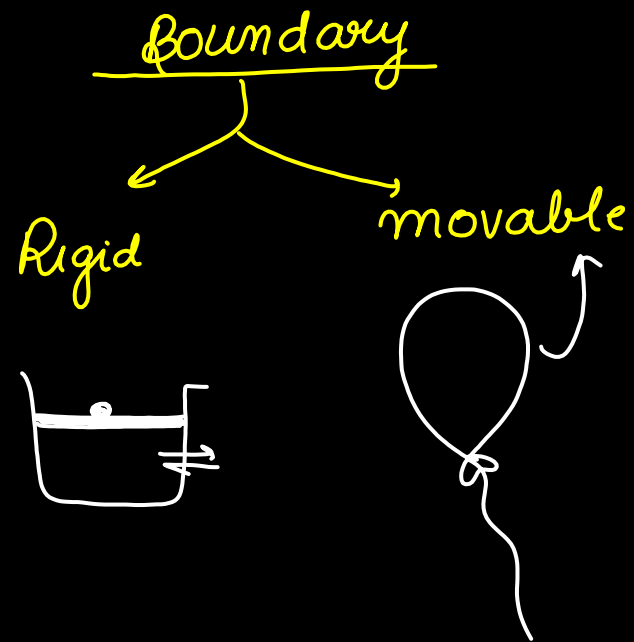
A blurred background of a railway track receding into a forest. The tracks are made of metal rails and gravel, leading towards a dense line of green trees in the distance. The lighting is soft, suggesting a sunny day with dappled light.

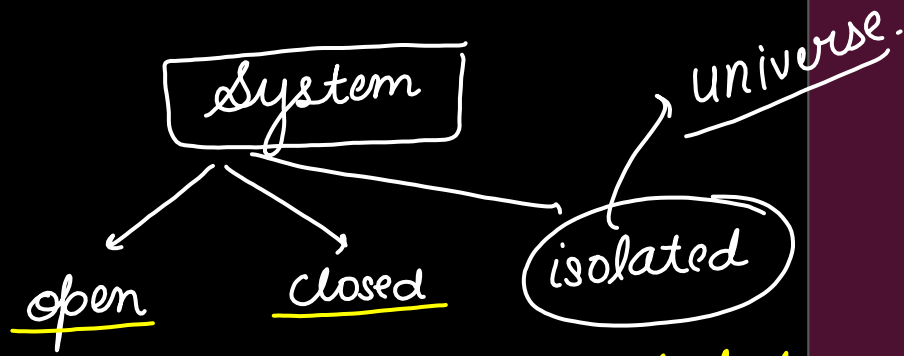
START

Thermodynamics

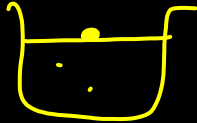
system | surrounding
boundary



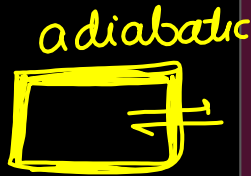




matter ✓
energy ✓



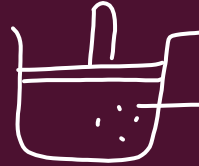
matter x
energy ✓



matter x
energy x

State function
State variables

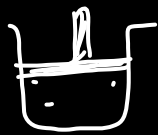
Extensive



Temp ✓
Pressure ✓
Volume ✓
mass ✓
moles ✓

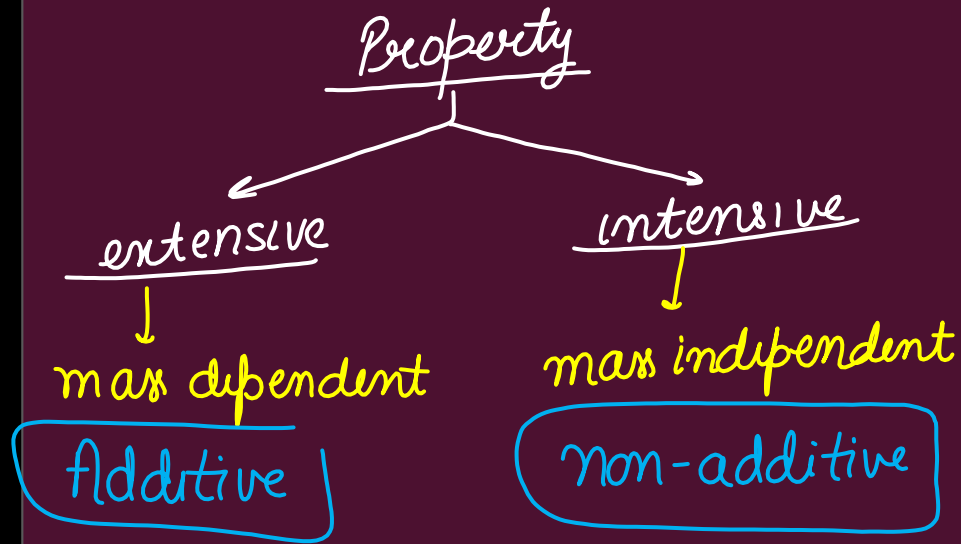
density ✓
surf index ✓
Internal energy
Enthalpy
Gibbs free energy

Path function

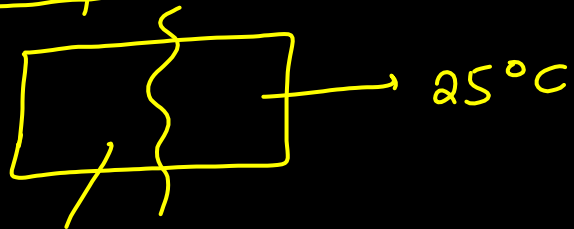


heat (q)

work (w)

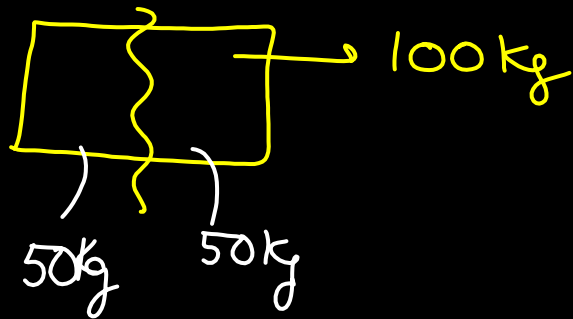


Temp: ————— intensive



$T = 25^{\circ}\text{C}$

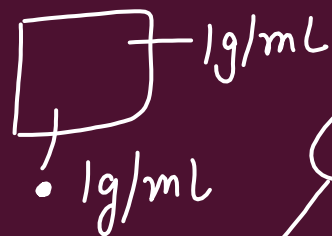
mass - ext



Pressure intensive.



density — intensive



$d = \frac{m}{V}$

intensive

ext

ext

molar mass
mass per molar
mass $\xrightarrow{\text{ext}}$
 n $\xrightarrow{\text{ext}}$

int
Molar property

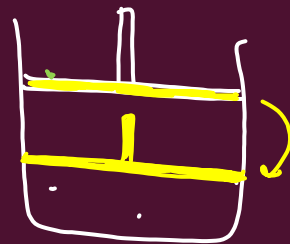
$\xrightarrow{\text{intensive}}$
Q. B. Pt $\rightarrow 100^\circ\text{C}$
 $\xrightarrow{\text{Intens}}$

Process

Reversible

\checkmark ∞ steps
 \checkmark slow

\checkmark hypothetical



Irreversible

\checkmark finite no. of steps
 \checkmark fast/sudden

\checkmark practical



isothermal process

same temp

@ const temperature

$$\begin{cases} dT = 0 \\ \int dT = \Delta T = 0 \end{cases}$$

isobaric process

@ constant pressure

$$dp = 0$$

$$\int dp = \Delta p = 0$$

isochoric process @ const volume

$$dV = 0$$

$$\int dV = \Delta V = 0$$

☆ ☆ state fn → Δ ✓
Path fn → ~~✗~~

$$\int dT = \Delta T \checkmark$$

$$\int dp = \Delta p \checkmark$$

$$\int dV = \Delta V \checkmark$$

$$\int dq = \cancel{\Delta q}$$

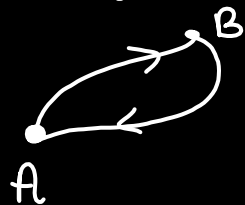
$$\int dw \neq \cancel{\Delta w}$$

adiabatic process

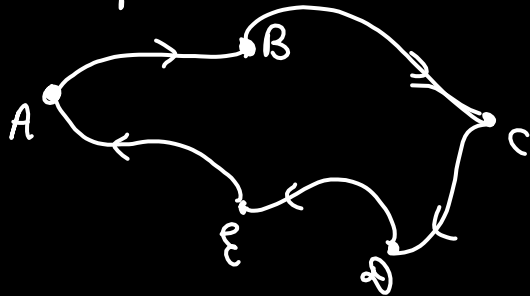
no heat exchange

$$dq = 0$$

cyclic process



initial & final state \rightarrow same

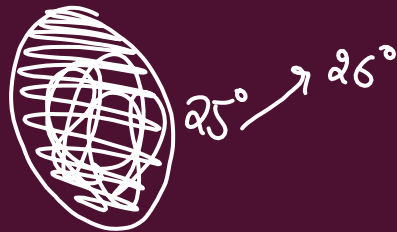


heat capacity
 $C \rightarrow$ extensive

The amt of heat required/released
to change the temp of a sub
by 1°C or by 1K



$$C = \frac{dq}{dT} \rightarrow \begin{matrix} \text{J/K} \\ \text{J/}^\circ\text{C} \end{matrix}$$



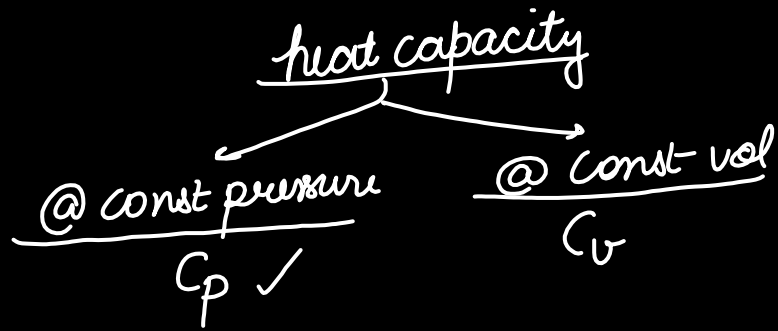
C_s
specific heat capacity \rightarrow intensive \rightarrow molar heat capacity C_m

The amt of heat sup/released to
change the temp of 1g of a
Substance by 1°C or by 1K

$$\begin{aligned} C_s &= \frac{C}{\text{mass}} \\ &= \frac{1}{m} \frac{dq}{dT} \quad \text{②} \\ &= \text{J/K/g} \\ &= \text{J/}^\circ\text{C/g} \end{aligned}$$

1 mole of a substance

$$\begin{aligned} C_m &= \frac{C}{\text{no of moles}} \\ &= \frac{1}{n} \cdot \frac{dq}{dT} \quad \text{③} \\ &= \text{J/K/mole} \\ &= \text{J/}^\circ\text{C/mol} \end{aligned}$$



molar heat cap @ const p $\rightarrow C_{pm} \checkmark$

molar heat cap @ const v $\rightarrow C_{vm}$

Ideal gas

$C_{pm} > C_{vm}$

★

$C_{pm} - C_{vm} = R$

⊗

1 $c = \frac{dq}{dT}$

2 $C_m = \frac{1}{n} \frac{dq}{dT}$

3 $C_s = \frac{1}{m} \frac{dq}{dT}$

4 $C_{pm} - C_{vm} = R$

$8.314 \text{ JK}^{-1} \text{ mol}^{-1}$
 $2 \text{ cal K}^{-1} \text{ mol}^{-1}$

Universal gas const

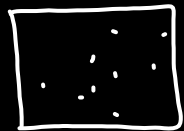
$n = \text{no of moles}$

5 $\frac{C_{pm}}{C_{vm}} = \gamma$

$\frac{C_p}{n} - \frac{C_v}{n} = R$

6 $\Rightarrow C_p - C_v = nR$

Internal Energy (U) or (E) आत्म शक्ति



$$U = \textcircled{KE} + PE + \text{Rot energy} + \text{vib KE} \\ + \text{nuclear energy} + \text{grav energy} + \dots$$

exact value of U ~~is~~

State 1 $U_1 = KE_1 + PE_1 + \text{vibr.}$

State 2 $U_2 = KE_2 + PE_2 + \text{vibr.}$

ΔU exact value of change in I.E.

$\left\{ \begin{array}{l} U \text{ State function} \\ U: \text{extensive property} \end{array} \right\}$

1 $\overbrace{U = f(T, V)}^{\text{solid/li/real gas}}$



ideal gas

particles — don't interact

ideal gas — ~~PK~~

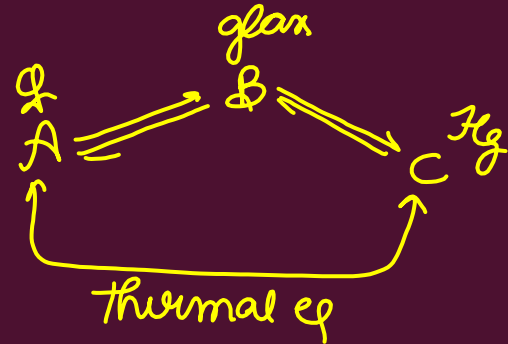
2

$U = f(T) \text{ only}$

Zeroth law of thermodynamics



Body Q



first law of thermo

↓
Conservation of energy

Process

$$9 \quad dU = dq + dw \quad \checkmark$$

$$\int dU = \int dw + \int dq$$

$$10 \quad \Delta U = w + q \quad \checkmark$$

total
change in
I.E

total
work done

total heat
exchanged

IUPAC convention

heat given to the system = \oplus

heat given by the system = \ominus

work done on the system = \oplus

work done by the system = \ominus

compression work : \oplus

expansion work \ominus

118.

During compression of a spring,
the work done is 10 KJ & 2 KJ
heat escaped to the surr
 Cal (ΔU) in KJ

a) 12

b) -8

~~c) 8~~

d) -12

$$W = +10 \text{ KJ}$$

$$Q = -2 \text{ KJ}$$

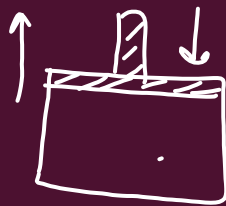
$$\Delta U = Q + W$$

$$= -2 + 10$$

Jee main 2019

work done
 method (रीति) of energy exchange

PV work

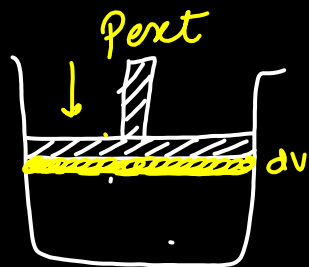


non P.V work

electrical
 mech

Work done calculation

P-V work



general formula

$$dW = -P_{ext} dv$$

Irreversible

$$P_{ext} \approx \text{const}$$

Rev

$$P_{ext} \neq \text{constant}$$

Irr work

$$\int_{irr} dw = - \int P_{ext} dV$$

$$\int dw_{irr} = - \int \underbrace{P_{ext}}_{const} dV$$

$$W_{irr} = - P_{ext} \int_{V_1}^{V_2} dV$$

$$W_{irr} = - P_{ext} (V_2 - V_1)$$

Rev work

$$dw = - P_{ext} dV$$

$$P_{ext} \neq const$$

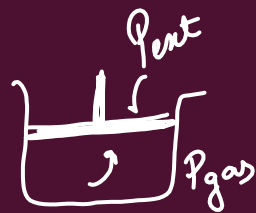
$$P_{ext} = P_{gas} \pm dp$$

$$\int dw_{rev} = - \int (P_{gas} \pm dp) dV$$

$$\int dw_{rev} = - \int P_{gas} dV \mp \int dp dV$$

$$W_{rev} = - \int P_{gas} dV \pm \cancel{\Delta p \Delta V}$$

$$W_{rev} = - \int P_{gas} dV$$



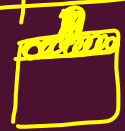
Work done

irr $w = - \int p_{\text{ext}} dv$

rev $w = - \int p_{\text{gas}} dv$

Work done · Calculation


① isobaric process

ideal gas 

$$\int dw = - \int p_{\text{ext}} dv$$

$$w = - p_{\text{ext}} \Delta v$$

$$w = - p_{\text{ext}} (v_2 - v_1)$$

② ideal gas — work done 

isochoric

$$dw = - p_{\text{ext}} \cancel{dv} \rightarrow 0$$

$$w = 0$$

③

ideal gas - isothermal
expansion - irreversible

$$\int dw = -p_{\text{ext}} dV$$

$$W_{\text{irr}} = -p_{\text{ext}} \int dV$$

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

$$= -p_{\text{ext}} (V_2 - V_1)$$

$$W_{\text{irr}} = -p_{\text{ext}} \left[\frac{nRT}{P_2} - \frac{nRT}{P_1} \right]$$

$$= -p_{\text{ext}} nRT \left[\frac{1}{P_2} - \frac{1}{P_1} \right]$$

④

ideal gas - isothermal expansion/
compression - Reversible

$$\int dw = -p_{\text{gas}} dV$$

$$w = - \int \frac{nRT}{V} dV$$

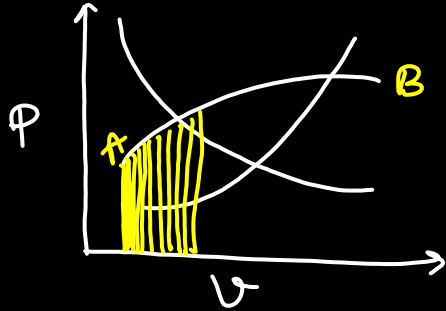
$$w = -nRT \int \frac{1}{V} dV$$

$$w = -nRT \ln V \Big|_{V_1}^{V_2}$$

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

⑬ ☆

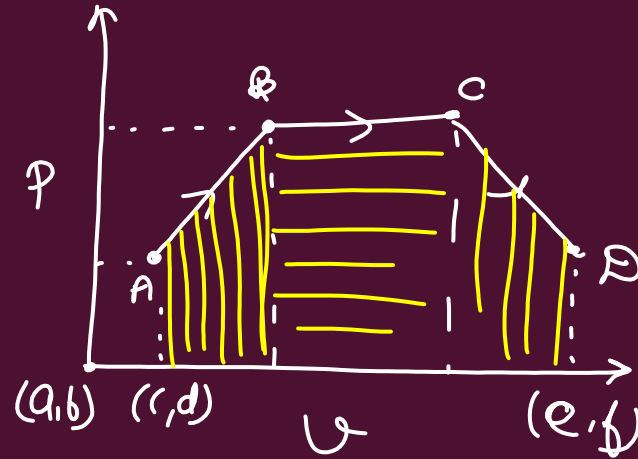
Work done graphically



$$dw = -p dv$$

area under PV curve

je main 2021



heat

method (ratio) of energy exchange

heat/cool → temp change //

$$c = \frac{dq}{dT}$$

$$\Rightarrow \boxed{dq = c dT} \star$$

$$dq = n C_m dT$$

$$dq = m C_s dT$$

isothermal process

heat $q = ?$

~~$dq = c dT \rightarrow 0$~~
 ~~$dq = 0$~~
 ~~$q = 0$~~

1st law $dU = dq + dw //$

$$\boxed{dq = dU - dw}$$

Calculate ΔU for a
chemical reaction

↓
@ const volume



1st $dU = dq + dw$

$$dU = dq - p dV$$

@ const vol

$$dV = 0$$

$$\int dU = \int dq_v$$

④

←

$$\Delta U = q_v$$

heat exchange taking place at const
volume

$$q_v = \Delta U$$

Enthalpy (H)

* state fn

* extensive property

15
$$H = U + PV$$

$$U = f(T, V) \checkmark$$

16
$$H = f(T, P) \checkmark$$

Ideal $U = f(T)$ only \checkmark

17. Ideal. $H = f(T)$ only \checkmark

18
$$\begin{aligned} \Delta U &= q_v \\ \Delta H &= q_p \end{aligned}$$

→ first concept

Question Approach

Ideal Gas:

$$PV = nRT$$

$$C_{pm} - C_{vm} = R$$

19,
$$dU = n C_{vm} dT$$

20,
$$dH = n C_{pm} dT$$

Relation b/w H & U

$$H = U + PV$$

$$dH = dU + d(PV)$$

① if $P = \text{const}$

$$\int dH = \int dU + \int P dV$$

$$\Delta H = \Delta U + P \Delta V$$

② if V is const

$$\int dH = \int dU + \int V dP$$

$$\Delta H = \Delta U + V \Delta P$$

Relation b/w ΔH & ΔU for a CHEMICAL Reaction

@ const temp ideal gas

$$H = U + PV$$

$$dH = dU + d(PV)$$

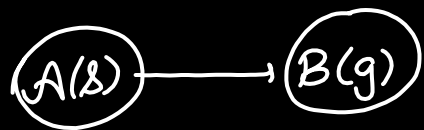
$$dH = dU + d(nRT)$$

$$\int dH = \int dU + \int RT dn$$

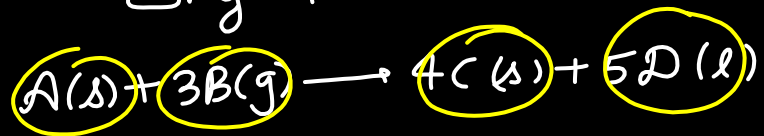
21.

$$\Delta H = \Delta U + \Delta n_g RT$$

$$22 \quad \Delta n_g = n_{p,g} - n_{r,g}$$



$$\Delta n_g = 1 - 0 = 1$$



$$\Delta n_g = 0 - 3 = -3$$

Adiabatic expansion/compression
of an ideal gas

adiabatic

$$dq=0$$

1st law: $dU = dq + dw$

$$dU = dw$$

Ideal gas $dU = nC_{vm}dT$
 $dU = dw$

$$dw = nC_{vm}dT$$

$$W = nC_{vm}\Delta T \rightarrow \underline{\underline{23}}$$

Work done
adiabatic

$$\frac{C_{pm}}{C_{vm}} = \gamma //$$

$$W = \frac{nR}{\gamma - 1} (T_2 - T_1) \rightarrow 24$$

Ideal Gas

Reversible Adiabatic process

25 $TV^{\gamma-1} = k$

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

26 $PV^{\gamma} = k$

27 $T^{\gamma} P^{1-\gamma} = k$

adiabatic process
irreversible ideal gas

1st law

$$dU = \cancel{dq} + dw //$$

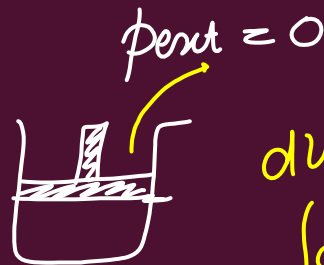
$$\boxed{dU = dw}$$

$$\boxed{dU = -p_{ext} dV}$$

ideal. $dU = nC_{v,m}dT$

$$\boxed{nC_{v,m}dT = -p_{ext} dV}$$

Free expansion



$$dw = -\cancel{p_{ext}} dV$$

$$\int dw = 0$$

$$w = 0$$

Isothermal free expansion of an ideal gas

Ideal: $PV = nRT$

$$dU = nC_{vm}dT$$

$$dH = nC_{pm}dT$$

$$C_{pm} - C_{vm} = R$$

isothermal $\rightarrow T \text{ const}$

$$dT = 0$$

$$\Rightarrow dU = 0 \Rightarrow \boxed{\Delta U = 0}$$

~~$$dH = nC_{pm}dT$$~~

$$\boxed{\Delta H = 0}$$

~~$$dU = dq + dw$$~~

$$dw = 0$$

$$\boxed{w = 0}$$

$$dq = 0$$

$$\boxed{q = 0}$$

adiabatic

Polytropic Process

Ideal gas \rightarrow Reversible process

$$28 \quad PV^x = k$$

$x = \text{real no.}$

$$x=0 \quad PV^0 = k$$
$$P = k \quad (\text{Rev isobaric})$$

$$x=1 \quad PV^1 = k$$

isothermal Rev

$$\left. \begin{array}{l} x=\infty \\ \text{Rev isochoric} \end{array} \right\}$$

$$P \cdot V^x = k$$

$$P_1 V_1^x = P_2 V_2^x$$

$$\frac{P_1}{P_2} = \left(\frac{V_2}{V_1} \right)^x$$

$$\left(\frac{P_1}{P_2} \right)^{\frac{1}{x}} = \left(\frac{V_2}{V_1} \right)^1 \rightarrow 1$$

$$\left(\right)^{\frac{1}{\infty}} = 1$$

$$\left(\right)^0 = 1$$

Polytropic Process

$$\left[\begin{array}{l} PV^\alpha = k \\ \alpha = 0 \quad \alpha = 1 \quad \alpha = \infty \quad \alpha = \gamma \\ \quad ? \quad ? \quad ? \quad = ? \end{array} \right]$$

molar heat capacity for a
polytropic process

$$^{29} \quad C_m = C_{vm} + \frac{R}{1-\alpha}$$

$$\text{if } PV^\alpha = k$$

Entropy (S)

* State fn

* extensive property

* Randomness of the system

disturbance \uparrow $S \uparrow$

H_f° } exact value \times
 U

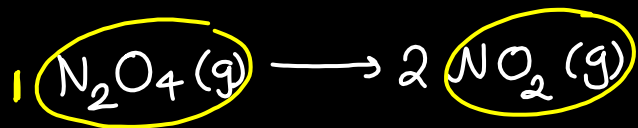
S° } exact value \checkmark 3rd

$$\textcircled{1} (S)_{\text{solid}} < (S)_{\text{liq}} < < < (S)_{\text{gas}}$$

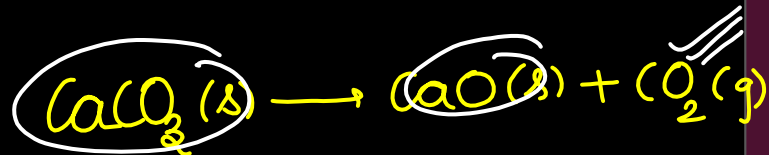
$$\textcircled{2} S_{\text{pure}} < S_{\text{mixture}}$$

$$\textcircled{3} \text{O}_2(\text{g}) < \text{O}_3(\text{g}) \quad \text{entropy}$$

$$\textcircled{4} \text{H}_2\text{O}(\text{l}) < \text{H}_2\text{O}_2(\text{l}) \quad \text{entropy}$$



$$\Delta S = \oplus$$



$$\Delta S = \oplus$$

Spontaneous Process

{ खुद हो जाता है
own its own
no external help req

Spon IRR

2nd law of thermodynamics

* complete conversion of heat \rightarrow work isn't possible

{ * During a spontaneous process, the entropy of the universe increases, and at equilibrium, the entropy remains constant }

spont

$$(\Delta S)_{\text{univ}} \geq 0$$

30

$$\Delta S_{\text{univ}} > 0 \text{ spon}$$

$$= 0 \text{ eq}$$

$$< 0 \text{ non-spon}$$

Calculation of ΔS ✓

★
3/11

$$dS = \frac{dq_{rev}}{T}$$

J/K
cal/K
J/°C
cal/°C

$$\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr}$$

$$\Delta S_{sys} = \int \frac{(dq_{rev})_{sys}}{T_{sys}} \checkmark$$

$$\Delta S_{surr} = \int \frac{(dq_{surr})_{surr}}{T_{surr}} \checkmark$$

ΔS_{sys}
heating/cooling of the substance

temp \rightarrow change

$$dq = c dT$$

$$dS = \frac{dq_{\text{rev}}}{T} = \int_{T_1}^{T_2} \frac{c dT}{T}$$

@ const $p \rightarrow c = c_p \checkmark$

@ const $V \rightarrow c = c_v \checkmark$

isothermal $X \rightarrow$ 1st law.

ΔS_{sys}
Phase transition 

@ constant T & P

$$dq \rightarrow dq_p$$

$$\int dS = \int \frac{dq}{T}$$

$$\Delta S = \frac{1}{T} \int dq_p = \frac{q_p}{T}$$

32

$$\Delta S_{\text{phase Trans}} = \frac{(\Delta H)_{\text{phase trans}}}{T}$$

ΔS_{system}
Ideal Gas

heat/cool/expand/compress

$$dS = \frac{dq_{\text{rev}}}{T}$$

1st $dU = dq + dw$

$$dq = dU - dw$$

$$dS = \frac{dU - dw_r}{T}$$

Ideal:

$$dU = n C_{vm} dT$$

Rev

$$dw = -p_{\text{gas}} dV$$

$$dS = \frac{n C_{vm} dT + p dV}{T}$$

$$dS = n C_{vm} \frac{1}{T} dT + \frac{p}{T} dV$$

$$PV = nRT$$

$$\Rightarrow \frac{p}{T} = \frac{nR}{V}$$

$$dS = \int nC_{vm} \frac{1}{T} dT + \int \frac{nR}{V} dV$$

$$\Delta S = nC_{vm} \ln \frac{T_2}{T_1} + nR \ln \frac{V_2}{V_1}$$

33

$$\Delta S = nC_{pm} \ln \frac{T_2}{T_1} + nR \ln \frac{P_1}{P_2}$$

34

$$\Delta S_{\text{surr}}$$

Reversible

$$\Delta S_{\text{sys}} + \Delta S_{\text{surr}} = 0$$

$$\Delta S_{\text{surr}} = -\Delta S_{\text{sys}}$$

Irreversible

$$\Delta S_{\text{surr}} = \frac{-q_{\text{irr}}}{T_{\text{surr}}}$$

$$\Delta S_{\text{univ}}$$

isothermal — ideal gas —
expansion — Reversible

$$\text{Rev } \textcircled{\text{eq}} \Delta S_{\text{univ}} = 0$$

$$\Delta S_{\text{univ}}$$

isothermal process — ideal gas —
expansion — IRREVERSIBLE

$$\Delta S_{\text{univ}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}}$$

$$\Delta S_{\text{sys}} = nC_{\text{vm}} \ln \frac{T_2}{T_1} + nR \ln \frac{V_2}{V_1}$$

$$\Delta S_{\text{surr}} = ?$$

$$\text{1st law } dU = dq + dw$$

$$\text{Ideal} \rightarrow U = f(T)$$

$$\text{isothermal } dU = 0$$

$$\int dq = - \int dw$$

$$q_{\text{irr}} = + p_{\text{ext}} \int dV$$

$$\Delta S_{\text{surr}} = - \frac{q_{\text{irr}}}{T}$$

$$= - \frac{p_{\text{ext}} \Delta V}{T}$$

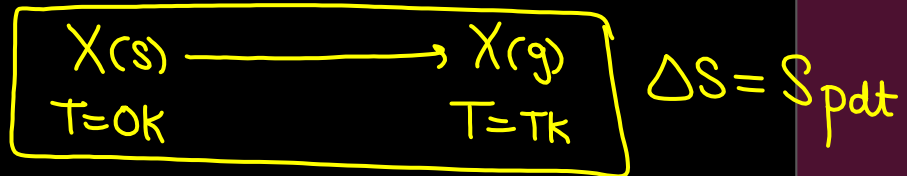
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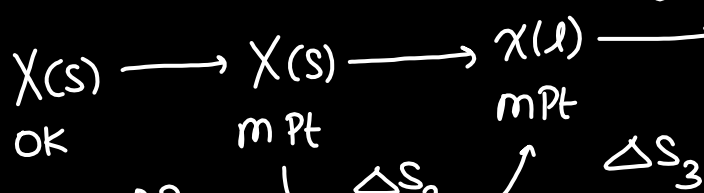
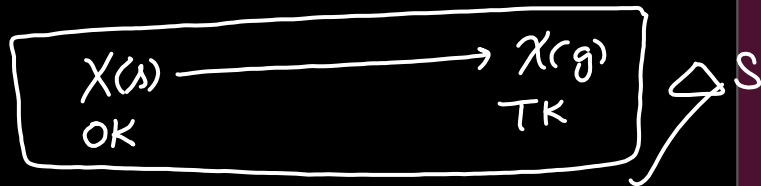
Third law of thermodynamics

absolute zero \longrightarrow 0 K

Perfectly crystalline solid
at entropy = 0

$X(g)$ at T K \longrightarrow Entropy = ?

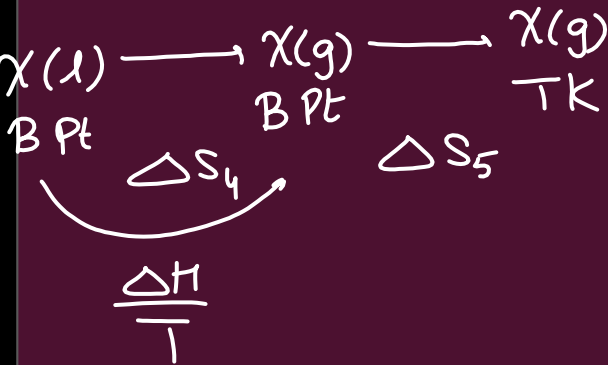




$$\int \frac{dq}{T}$$

$$\frac{\Delta H}{T}$$

$$\int \frac{C dT}{T}$$



Gibbs free energy

G

* state fn

* extensive prop

35

$$G = H - TS$$

$$dG = dH - d(TS)$$

@ Const Temp

$$dG = dH - Tds$$

36

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

$$S = \frac{q}{T}$$

$$ST = q$$

@
const
T, P

$$\Delta G < 0 \quad \text{spont}$$

$$\Delta G = 0 \quad \text{eq}$$

$$\Delta G > 0 \quad \text{non-spont}$$

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

exothermic } $\Delta S = +$ \rightarrow किस temp

$$-T(+)$$

$$\Delta G = - \text{high } T$$

endothermic
 $\Delta S = \ominus$

when the process will be spon

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

$$= + - T(-)$$

$$= ++$$

$$= \oplus$$

Will Never be spon

$$\underbrace{+60 - 300K(-60)}$$

Physical significance of ΔG

system \rightarrow { P-V work
 (non P-V work) }

1st law

$$dU = dq + dw$$

$$dU = dq + dw_{P-V} + dw_{non-PV}$$

@ const pressure

$$dU = dq_p - P dv + dw_{non-PV}$$

$$\underbrace{dU + Pdv} = dq_p + dw_{non-PV}$$

$$dH = dq_p + dW_{\text{non-pv}}$$

@ const temp

$$dS = \frac{dq}{T}$$

$$dq = T dS$$

$$dH = T dS + dW_{\text{non-pv}}$$

$$\underbrace{dH - T dS} = dW_{\text{non-pv}}$$

$$\int dG = \int dW_{\text{non-pv}}$$

$$\Delta G = \textcircled{W_{\text{non-pv}}}$$

$$(\Delta G)_{T,p} = \text{useful work} = W_{\text{non-pv}}$$

Thermochemistry

chemical reaction

if heat absorb $q = \oplus$

if heat release $q = \ominus$

$$q_v = \Delta U_r = \Delta_r U$$

$$q_p = \Delta H_r = \Delta_r H \quad \checkmark$$



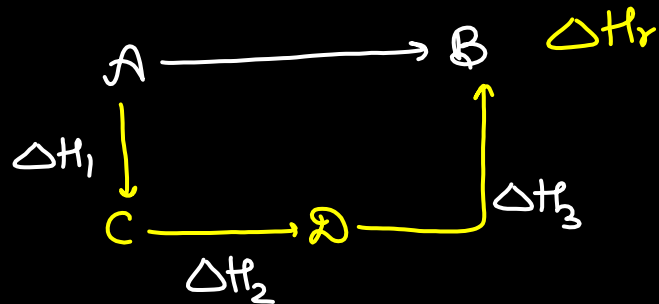
Enthalpy of the reaction

$$\Delta_r H$$

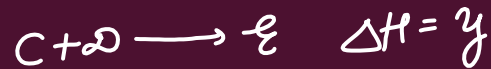


$$\Delta_r H = \checkmark$$

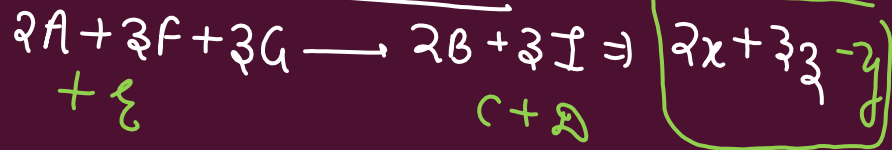
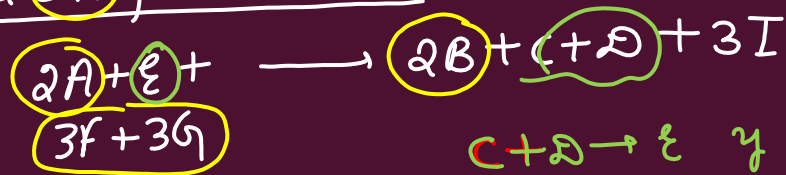
Hess' law of constant heat summation

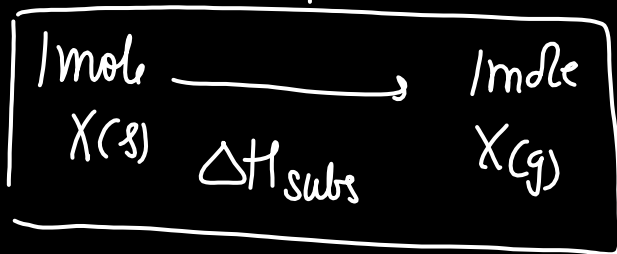
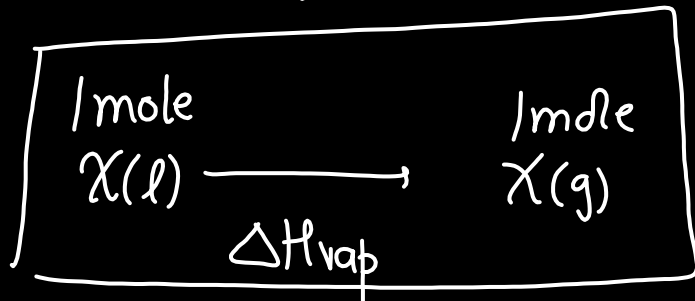
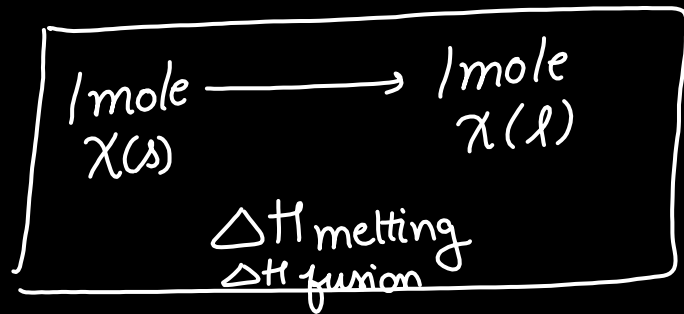


$$\Delta H_r = \Delta H_1 + \Delta H_2 + \Delta H_3$$

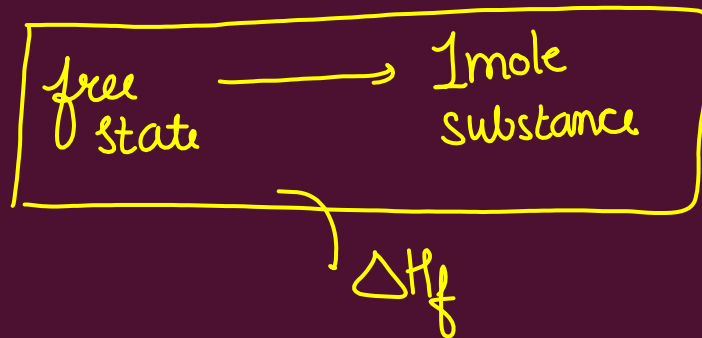


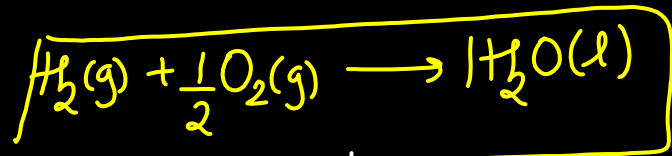
find ΔH for the rxn state fn / ext



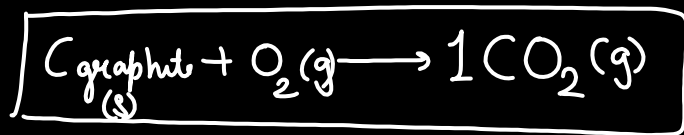


Enthalpy of formation
 ΔH_f or $\Delta_f H$





$$\Delta H_{\text{rx}} = \Delta H_{\text{f}}$$



$$\Delta H_{\text{r}} = \Delta H_{\text{f}} \text{CO}_2$$

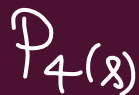
$$\text{free state } \Delta H_{\text{f}} = 0$$

$$\Delta H_{\text{f}} \text{H}_2(\text{g}) = 0 \quad \dots$$

$$\Delta H_{\text{f}} \text{O}_2(\text{g}) = 0$$

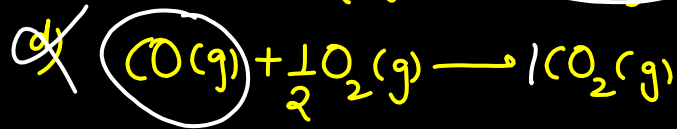
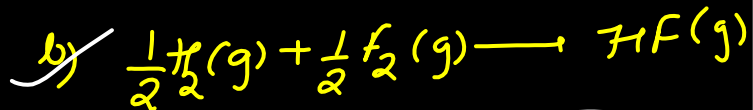
$$\Delta H_{\text{f}}(\text{s}) \text{graphite} = 0$$

free state



see p 48

Q which of the following defines ΔH_f



$$\Delta H_r = \Delta H_f P - \Delta H_f R$$



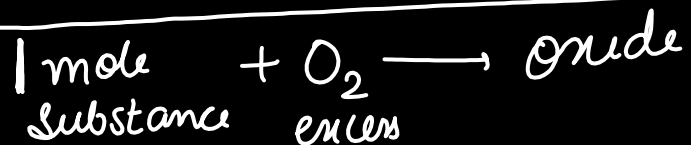
$$\Delta H_r = [\Delta H_f \text{CO}_2 + 2\Delta H_f \text{H}_2\text{O}(\text{l})] -$$

$$[\Delta H_f \text{CH}_4 + 2\cancel{\Delta H_f \text{O}_2}]$$

$$= \Delta H_f \text{CO}_2 + 2\Delta H_f \text{H}_2\text{O} - \Delta H_f \text{CH}_4$$

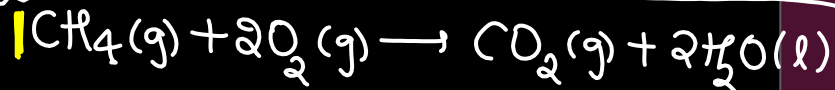
Enthalpy of Combustion

$$\Delta H_{\text{comb}}$$



$$\Delta H_r = \Delta H_{\text{comb}}$$

1 mole



$$\Delta H_r = \Delta H_{\text{comb CH}_4}$$

$$\Delta H_r = \Delta H_{\text{comb}}^{\text{R}} - \Delta H_{\text{comb}}^{\text{P}}$$

Lattice enthalpy

$$\Delta H_{LE}$$

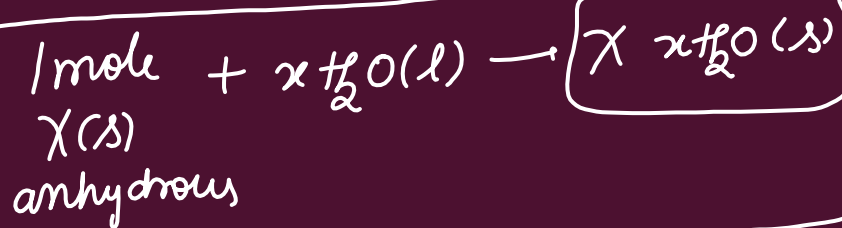
1 mole
ionic solid

→ gaseous ions

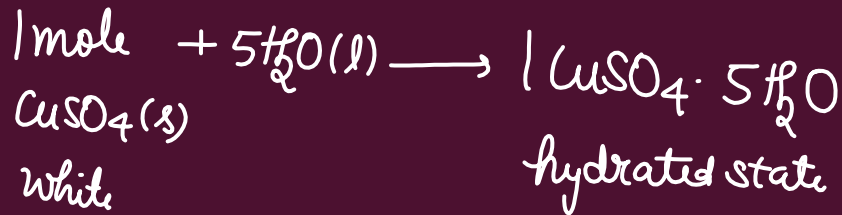
$$\Delta H_{LE} = \Delta H_{lattice}$$

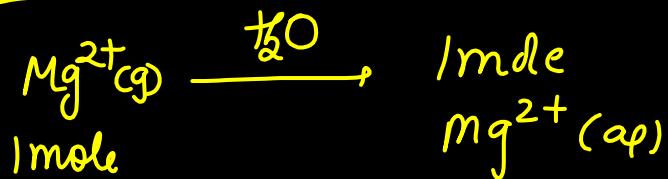
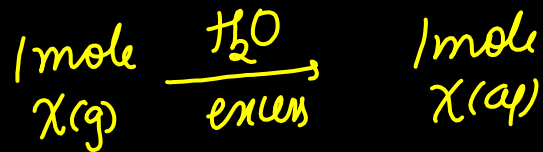


Hydration enthalpy



$$\Delta H = \Delta H_{hydr \text{ energy}}$$





$$\Delta H_r = \Delta H_{HE}$$

Enthalpy of neutralization

1 g eq of an acid

+

1 g eq of a base

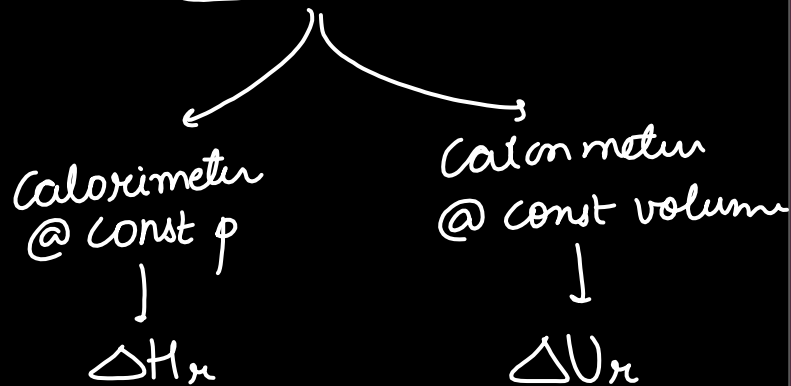
↓

neutralize

$$\Delta H_r = \Delta H_n$$

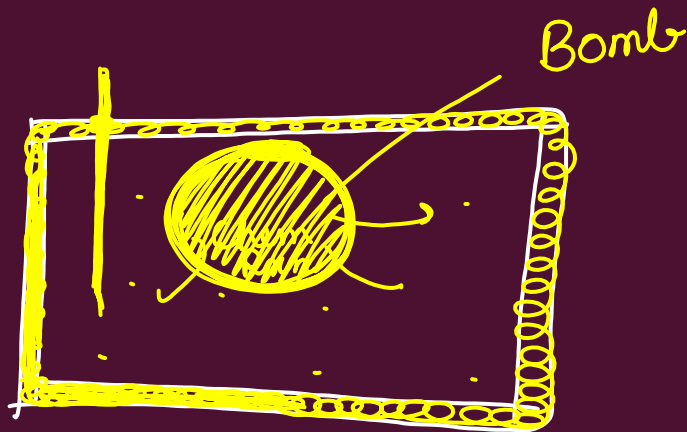
(in equilibrium)

Calorimetry



Bomb Calorimeter

↳ Constant vol calorimeter

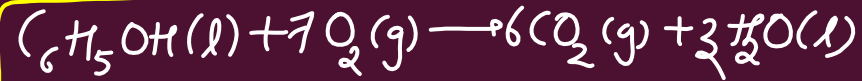


$$-q_{\text{rxn}} = +q_{\text{calorimeter}}$$

$$= \boxed{C\Delta T}_{\text{calorim}} + \boxed{C\Delta T}_{\text{water}}$$

$$\boxed{\Delta U_{\text{rxn}}}$$

Q. 2g sample of phenol was burnt
in bomb calorimeter
whose heat cap is 12 kJ/°C
The temp of the sys inc by 0.5°C
 ΔU for



$$\boxed{\Delta U = q_v}$$

$$q_{\text{released}} = q_{\text{absorbed by cal}}$$

$$= C\Delta T$$

$$= \underline{\underline{12 \times 1000 \times 0.5}}$$

$$12 \times 1000 \times \frac{5}{10}$$

$$\Rightarrow 6000$$

$$= 6 \text{ kJ}$$

$$q_{\text{released}} = -6 \text{ kJ}$$



$$n = \frac{2}{94} \text{ moles} \longrightarrow -6 \text{ kJ}$$

1 mol

$$\frac{-6 \text{ kJ mol}^{-1}}{\frac{2}{94}}$$

ΔU_r

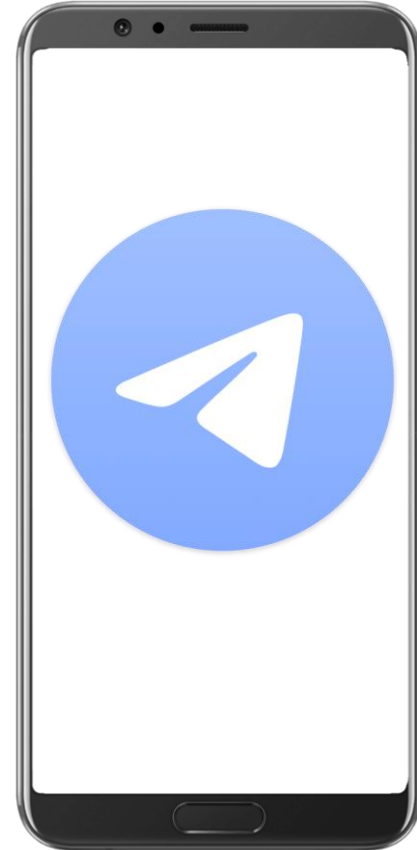
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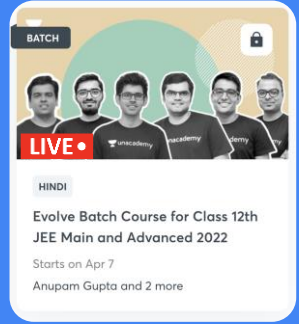
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Started on Jul 7

Nishant Vora and 1 more



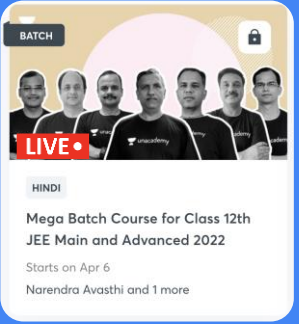
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Starts on Apr 7

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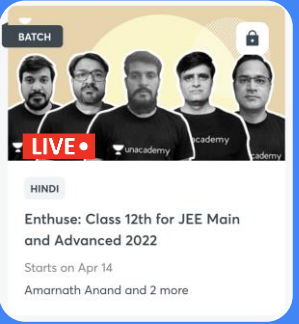
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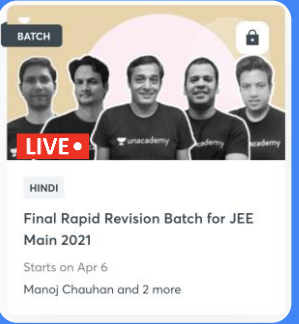
BATCH

HINDI

Enthuse: Class 12th for JEE Main and Advanced 2022

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BATCH

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LIVE

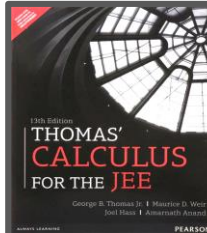
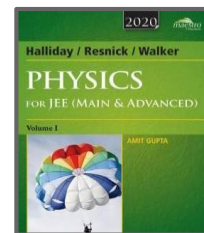
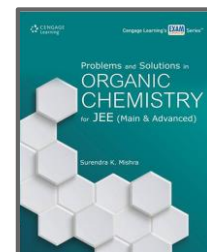
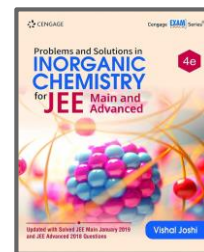
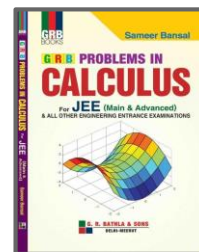
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Prashant Jain
Mathematics



Amarnath Anand
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- Systematically designed courses
- Strengthen JEE problem-solving ability



Prashant Jain
Mathematics Maestro



Nishant Vora
Mathematics Maestro



Ajit Lulla
Physics Maestro



Abhilash Sharma
Physics Maestro



Sakshi Vora
Chemistry Maestro



Megha Khandelwal
Chemistry Maestro



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for Class 12th JEE Main and Advanced 2023

Code: SAKSHI

USPs of the Batch

- Top Educators from Unacademy Atoms
- Complete preparation for class 12th syllabus of JEE Main & Advanced
- Quick revision, tips & tricks



Nishant Vora
Mathematic Maestro



Ajit Lulla
Physics Maestro



Sakshi Ganotra
Organic & Inorganic
Chemistry Maestro



Megha Khandelwal
Chemistry Maestros



Prashant Jain
Mathematics Maestro



Abhilash Sharma
Physics Maestro



Achiever Batch 2.0

for IIT JEE Main and Advanced 2023 Droppers

Code: SAKSHI

Batch highlights:

- Learn from India's Top Educators
- Coverage of Class 11 & 12 syllabus of JEE
- Deep dive at a conceptual level for JEE Main and JEE Advanced
- Systematic course flow of subjects and related topics
- Strengthening the problem-solving ability of JEE level problems

For more details, contact **8585858585**



Nishant Vora
Mathematics Maestros



Prashant Jain
Mathematics Maestros



Ajit Lulla
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