

Here is the lecture today. It is a summary of chapter 3, entropy. I am writing this as I feel the book should have written the summary this way.

First, a brief review of logs. It seems you are a bit weak with this.

The definition of logarithm is: $\ln x = y$ implies $e^y = x$.

Let $x_1 = x^n$. We then have: $\ln x_1 = y_1$.

Therefore, $e^{y_1} = x^n$. Rewriting : $x = \left(e^{y_1}\right)^{\frac{1}{n}} = e^{\frac{y_1}{n}}$

Since $\frac{y_1}{n} = y$, or $y_1 = ny$, $\therefore \ln x^n = n \ln x$

If $n = -1$, then $\ln \frac{1}{x} = -\ln x$.

You should have known this from high school. Just because you should have known it does not mean you actually know it. Ask if it is not clear. "The shy student is a poor student."

The definition of entropy is $\Delta S = \frac{\delta q_{rev}}{T}$

Consider a process that runs in a complete cycle. The end point is the same as the starting point. Since the internal energy U is state variable, it is independent of the path, and so $\Delta U = 0$. U is the sum of heat and work:

$$\Delta U = \delta q_{rev} + \delta w_{rev}$$

Since U is path independent:

$$\delta q_{rev} + \delta w_{rev} = \delta q_{irrev} + \delta w_{irrev}$$

Since $w_{irrev} > w_{rev}$, $\delta q_{irrev} < \delta q_{rev}$

Dividing by T :

$$S = \frac{\delta q_{rev}}{T} > \frac{\delta q_{irrev}}{T}$$

E.g., if there is an irreversible process with no heat exchange (adiabatic), $\Delta S > 0$. This is because in the above inequality, $\delta q_{irrev} = 0$.

Going back to the definition of entropy, at constant T and P we can write

$$\Delta S = \frac{\delta q_{rev}}{T} = \frac{\Delta H}{T}$$

We can use tabulated values of the enthalpy H to calculate entropy changes for phase transitions, like melting ice. For changes in entropy due to temperature changes at a single phase, we use

$\delta q = CdT$, where C is the heat capacity.

For a process where the temperature and phase change, e.g., from T_1 to T_3 , with a phase change at T_2 , we have

$$\Delta S = \int_{T_1}^{T_2} \frac{C}{T} dT + \Delta H_{T_2} + \int_{T_2}^{T_3} \frac{C}{T} dT$$

Consider the above example with $T_3 = T_1$. Does this make sense, to use three steps to end up with the same temperature as the starting temperature?

I asked the class. No one knew.

The answer is for the case of liquid water at -10°C , which spontaneously freezes. We find the entropy change by considering the process as a sequence of reversible processes: Raising T to 0°C , freezing, then cooling to -10°C .

The point is that when reviewing the material, look at the ideas from different angles.

For a reversible isothermal expansion of an ideal gas, to get the entropy change. Since U depends only on T for an ideal gas, U is constant:

$$\cancel{dq} + \cancel{dw} = 0, \text{ or}$$

$$\cancel{dq} = \cancel{dw} = PdV = dS$$

$$\Delta S = \int \frac{P}{T} dV = nR \int_{V_1}^{V_2} \frac{1}{V} dV, \text{ using } PV = nRT$$

$$\therefore \Delta S = nR \ln \frac{V_2}{V_1}.$$

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