热力学与统计物理-课堂作业1

吴远清-2018300001031

2020 年 3 月 10 日

一.概念题

1.什么是孤立系统?

Answer:

Isolated system means that a system doesn't have any energy of materials exchange with outside.

2.什么是平衡态?

Answer:

Equilibrium state is the state that a isolated system's macroscopic properties doesn't change.

3.什么是相空间?

Answer:

Phase space descripe all the possible state of system. Every state of system has a coreesponding point in the phase space

4.什么是弛豫时间?

Answer:

Relaxation time means that the time a non-equilibrium system take to achieve the thermal equilibrium

5.试述等概率原理及你对其的理解。

Answer:

等概率原理:对于一个处于平衡态的热力学系统,其能量E,体积V,粒子数N确定,其处于各微观态的概率相等.

理解:等概率原理是热力学的基本假设. 所有物理性质的变化都受力学定律制约, 但对于处于平衡态的体系, 没有定律能指出系统更容易从某个微观态转化向另一个微观态, 也就是说, 如果不对微观态进行直接测量, 而是只通过

力学定律和对于系统在微观态之间转化的行为进行观测, 我们将完全无法区分各微观态. 因此,我们也没有理由认为某一微观态出现的概率比其他微观态更高.

6.试述热力学第一定律及其物理意义。

Answer:

The first law of thermaldynamics said: The change of a system's inner energy, equal to the sum of the heat absorbed by the system and the work done on it.

$$\Delta U = Q + W$$

Indeed, the first law of thermaldynamics is the energy conservation law.

7.试述热力学第零定律及其物理意义。

Answer:

The zeroth law of thermaldynamics said: If system A and system B is in thermal equilibrium, A and C are also in thermal equilibrium, then B and C must be in thermal equilbrium too.

The zeroth law of thermaldynamics provided the fundamental theory for temperature.

二.推导题

8.对于1维格子上的随机行走，格子步长为l，向右的概率为p，向左的概率为q，N步随机行走后，试推导距离原点为x的概率P（x）dx。这里p+q=1，$N >> 1$，且$0 < p \sim q < 1$。

Answer:

Since $N >> 1$, we can use the Gaussian approximation:

$$W(n_1) = (2\pi Npq)^{-\frac{1}{2}} exp[-\frac{(n_1 - Np)^2}{2Npq}] \tag{1.1}$$

and we have:

$$x = |n_1 - n_2| = |2n_1 - N| \tag{1.2}$$

Then for a specific x, we have:

$$P(x) = W(\frac{N+x}{2}) + W(\frac{N-x}{2})$$

$$= (2\pi Npq)^{-\frac{1}{2}} \{exp[-\frac{(\frac{N+x}{2} - Np)^2}{2Npq}] + exp[-\frac{(\frac{N-x}{2} - Np)^2}{2Npq}]\} \tag{1.3}$$

Finally:

$$P(x)dx \approx (2\pi Npq)^{-\frac{1}{2}}\{exp[-\frac{(\frac{N+x}{2}-Np)^2}{2Npq}]+exp[-\frac{(\frac{N-x}{2}-Np)^2}{2Npq}]\}dx \tag{1.4}$$

9.试推导一平衡态单原子理想气体孤立系统状态数Ω与体系体积V和内能E的关系表达式。

Answer:

For a phase space denote by particles' coordinates and momentum, we have:

$$\Omega \propto \int_E^{E+\delta E} d^3r_1....d^2r_N d^3p_1...d^3p_N \tag{2.1}$$

And obviously:

$$\int d^3r_i = V \tag{2.2}$$

Then:

$$\Omega \propto V^N \int_E^{E+\delta E} d^3p_1...d^3p_N \tag{2.3}$$

Let's dim $\chi(E)$:

$$\chi(E) \propto \int_E^{E+\delta E} d^3p_1...d^3p_N \tag{2.4}$$

Finally:

$$\Omega \propto V^N\chi(E) \tag{2.5}$$