章十一. $\boxed{\text{热力学基础}}$

平衡态: 无做功/热传递而交换热量.

$pV = nRT = \frac{m}{M}RT.$

$Q = \Delta E + A.$ $Q>0$: 吸热. $A>0$: 对外界做正功.

不消耗气体的内能而对外做功: 第一类机

除爆炸外的过程均可视为准静态

计算A: $A = \int_{V_1}^{V_2} p\,dV.$

$\Rightarrow Q = (E_2 - E_1) + \int_{V_1}^{V_2} p\,dV.$

热容: $C = \frac{\Delta Q}{\Delta T}$ $Q = m\int_{T_1}^{T_2} c\,dT.$

比热容: $c = \frac{\Delta Q}{\Delta T \cdot m}.$

自由膨胀: $E_1 = E_2$. $Q=0$. $A=0$.

1mol气体、等体过程: $C_{V,m} = \frac{Q}{\Delta T} = \frac{\Delta E}{\Delta T} = \frac{dE}{dT}.$

$\therefore E(T) = E(T_0) + \int_{T_0}^{T} C_{V,m}\,dT.$

定压热容: $C_{p,m} = C_{V,m} + R.$ $pV = nRT.$

单原子分子: He. Ne. Ar: $C_{V,m} = \frac{3}{2}R$ $\gamma = 1.67$

双 O_2、H_2: $C_{V,m} = \frac{5}{2}R$. $\gamma = 1.40$.

等体: $dQ = dE.$

$\Rightarrow Q = E_2 - E_1 = nC_{V,m}(T_2 - T_1) = \frac{V}{R}\cdot C_{V,m}\cdot(p_2 - p_1)$

等压: $A = p(V_2 - V_1) = nR(T_2 - T_1).$

$Q = (E_2 - E_1) + nR(T_2 - T_1) = n\cdot C_{p,m}\cdot(T_2 - T_1).$

等温: $\Delta E = 0$. $Q = A = \int_{V_1}^{V_2} p\,dV = \int_{V_1}^{V_2} nRT\frac{dV}{V}.$

$\therefore Q_T = nRT\ln\frac{V_2}{V_1}$ $p_1V_1 = p_2V_2 \Rightarrow Q_T = nRT\cdot\ln\frac{p_1}{p_2}.$

绝热过程.

$Q = 0 = (E_2 - E_1) + A \Rightarrow A = -(E_2 - E_1) = -nC_{V,m}(T_2 - T_1).$

$\therefore p\cdot dV = -n\cdot C_{V,m}\cdot dT.$

由 $pV = nRT$ 求导: $p\,dV + V\,dp = nR\,dT.$

$\therefore \frac{dp}{p} + \gamma\cdot\frac{dV}{V} = 0.$ 积: $\ln p + \gamma\ln V = C.$

☆ $pV^{\gamma} = C_1 \Rightarrow$ 绝热过程的p-V线更陡.

$TV^{\gamma-1} = C_2$

$p^{\gamma-1}T^{-\gamma} = C_3$ P31.

$A = \int_{V_1}^{V_2} p\,dV = \int_{V_1}^{V_2} p_1V_1^{\gamma}\frac{dV}{V^{\gamma}} = \frac{1}{\gamma-1}\cdot(p_1V_1 - p_2V_2) = -\frac{nR}{\gamma-1}\cdot(T_2 - T_1)$

热机循环效率: $\eta = \frac{A}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$

制冷中: $w = \frac{Q_2}{A} = \frac{Q_1 - A}{A} = \frac{Q_2}{Q_1 - Q_2}.$

卡诺循环: $\eta = 1 - \frac{T_2}{T_1}$

T_1

T_2.

$\Delta T\uparrow: \eta\uparrow.$

逆(制冷). $w = \frac{Q_2}{A} = \frac{Q_2}{Q_1 - Q_2} = \frac{T_2}{T_1 - T_2}.$

章十二. 气体动理论

n: 单位体积中的分子数.

$$p=\frac{1}{3}nm_0\overline{v^2}=\frac{2}{3}n\cdot\left(\frac{1}{2}m_0\overline{v^2}\right)=\frac{2}{3}n\bar{\varepsilon}$$

λ. c. R

跃迁线系

$$\frac{dN}{N}=f(v)\cdot dv. \qquad f(v)=\frac{dN}{N}\cdot\frac{1}{dv}.$$

$$f(v)=4\pi\cdot\left(\frac{m_0}{2\pi kT}\right)^{\frac{3}{2}}v^2 e^{-m_0v^2/2kT}. \qquad k=\frac{R}{N_A}$$

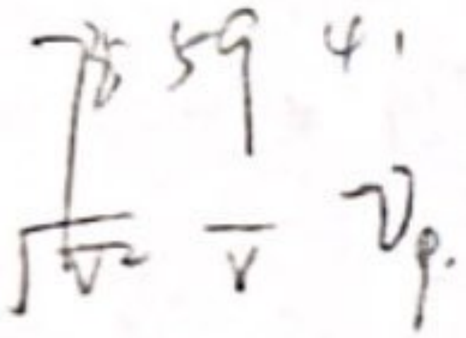
$$\int_0^\infty f(v)dv=1.$$

$$\bar{v}=\sqrt{\frac{8kT}{\pi m_0}}=1.59\sqrt{\frac{RT}{M}}.$$

$$\overline{v^2}=\frac{3kT}{m_0} \qquad \sqrt{\overline{v^2}}=\sqrt{\frac{3kT}{m_0}}=1.73\sqrt{\frac{RT}{M}}.$$

$$v_p=\sqrt{\frac{2kT}{m_0}}=1.41\sqrt{\frac{RT}{M}}.$$

2个都记



$$\bar{\varepsilon}=\frac{3}{2}kT. \qquad p=\frac{2}{3}n\bar{\varepsilon}=nkT.$$

平均平动动能.

内能总量: $n\cdot i\cdot\frac{RT}{2}$. $\because(N_A\cdot k=R)$.

$$=n\cdot\frac{i}{2}RT.$$

$$\therefore C_{v,m}=\frac{i}{2}R. \qquad C_{p,m}=\frac{i+2}{2}R \qquad \gamma=\frac{i+2}{i}.$$

设 $h=0$ 处分子数密度为 n_0. 则 h 处: $n=n_0\cdot e^{-m_0gh/kT}$.

$$p=nkT=p_0\cdot e^{-m_0gh/kT}.$$

平均碰撞频率: $\bar{Z}=\sqrt{2}\pi d^2\cdot\bar{v}\cdot n$.

平均自由程: $\bar{\lambda}=\frac{\bar{v}}{\bar{Z}}=\frac{1}{\sqrt{2}\pi d^2 n}=\frac{kT}{\sqrt{2}\pi d^2 p}$.

$T\uparrow\to d\downarrow\to\bar{\lambda}\uparrow$

理想气体:

$$f(v)dv=\frac{dN}{N}.$$

$$f(v)=4\pi\left(\frac{m_0}{2\pi kT}\right)^{3/2}v^2\cdot e^{-\frac{m_0v^2}{2kT}}.$$

mc^2.

·弦振方程(积和).

章十三. 机械波

$$y(x,t)=A\cdot\cos\left[\omega\left(t-\frac{x}{v}\right)+\varphi_0\right]$$

$$=A\cdot\cos\left[2\pi\cdot\left(ft-\frac{x}{\lambda}\right)+\varphi_0\right]$$

$$=A\cos\left[2\pi\left(\frac{t}{T}-\frac{x}{\lambda}\right)+\varphi_0\right]$$

$$=A\cdot\cos\left[\frac{2\pi}{\lambda}\cdot(vt-x)+\varphi_0\right].$$

$\frac{2\pi}{T}$

$$\frac{\partial^2 y}{\partial x^2}=\frac{1}{v^2}\cdot\frac{\partial^2 y}{\partial t^2}$$

能量密度: $w=\rho A^2\omega^2\sin^2\left[\omega\left(t-\frac{x}{u}\right)+\varphi_0\right]$.

$$\bar{w}=\frac{1}{2}\rho A^2\omega^2.$$

势能、动能同大同小.

能流密度: $I=\frac{1}{2}\rho A^2\omega^2\cdot u$ v.

球面波: $E_1=E_2=I_1S_1=I_2S_2\Rightarrow y(r,t)=\frac{A_0}{r}\cdot\cos\left[\omega\left(t-\frac{x}{u}\right)+\varphi_0\right]$

波的合成: $A^2=A_1^2+A_2^2+2A_1A_2\cdot\cos\Delta\varphi$.

$$I=I_1+I_2+2\sqrt{I_1I_2}\cdot\cos\Delta\varphi.$$

$y_1=A\cos 2\pi\left(ft-\frac{x}{\lambda}\right)$

$y_2=A\cos 2\pi\left(ft+\frac{x}{\lambda}\right)$

$$y_1+y_2=2A\cos 2\pi\frac{x}{\lambda}\cdot\cos 2\pi ft$$

多普勒:

- 观察者动: $f=\frac{u\pm v_0}{u}\cdot f_0$.
- 波源动: $f=\frac{u}{u\mp u_s}\cdot f_0$.
- 都动: $f=\frac{u\pm v_0}{u\mp u_s}\cdot f_0$.

量子[illegible]的[illegible]

单色辐出度：一定的T下，单位S在单位t内发射的、波长在$\lambda \to \lambda+d\lambda$内的辐射能与$d\lambda$之比：$M_\lambda = \frac{dM_\lambda}{d\lambda}$. W/m^3

$M(T) = \int_0^\infty M_\lambda \cdot d\lambda$. W/m^2.

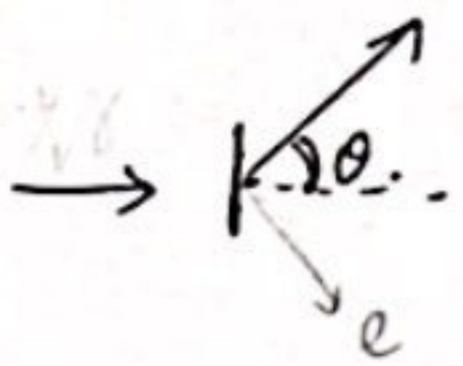
黑体的单色辐出度仅与λ与T有关.

$$\begin{cases} M_B(T) = \int_0^\infty M_{B\lambda}(T)\, d\lambda = \sigma T^4. \\ T \cdot \lambda_m = b. \end{cases}$$

$eU_a = \frac{1}{2} m v_m^2$. $h\nu = A + \frac{1}{2} m v_m^2 = eU_a + A \Rightarrow U_a = \frac{h}{e}\nu - \frac{A}{e}$.

$m_\varphi = \frac{E}{c^2} = \frac{h\nu}{c^2} = \frac{h}{c\lambda}$.

$p = m_\varphi c = \frac{h\nu}{c} = \frac{h}{\lambda}$.



康普顿散射：$\Delta\lambda = \lambda - \lambda_0 = \frac{h}{m_0 c} \cdot (1 - \cos\theta)$.

$$= \frac{2h}{m_0 c} \cdot \sin^2\frac{\theta}{2} = 2\lambda_c \cdot \sin^2\frac{\theta}{2}.$$

$\lambda_c = \frac{h}{m_0 c} = 0.0024\,nm$. 为$\theta = 90^\circ$上测得的$\Delta\lambda$. $0.0024\,nm$

$\sigma = \frac{1}{\lambda} = R_H \cdot \left(\frac{1}{k^2} - \frac{1}{n^2}\right)$.

$$\begin{cases} L = mvr = n \cdot \frac{h}{2\pi} \\ m\frac{v^2}{r} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r^2} \end{cases} \Rightarrow r_n = n^2 \left(\frac{\varepsilon_0 h^2}{\pi m e^2}\right) = n^2 r_1$$

$r_1 = \frac{\varepsilon_0 h^2}{\pi m e^2} = 0.529 \times 10^{-10}\, m$. H原子.

$E_n = -\frac{1}{8\pi\varepsilon_0} \cdot \frac{e^2}{r_n} = -\frac{1}{n^2} \cdot \left(\frac{m e^4}{8\varepsilon_0^2 h^2}\right)$. $E_1 = -\frac{m e^4}{8\varepsilon_0^2 h^2} = -13.6\,eV$.

$L = \sqrt{l(l+1)} \cdot \hbar = \sqrt{l(l+1)} \cdot \frac{h}{2\pi}$. $l = 0, 1, 2 \cdots n-1$.

$L_z = m_l \hbar = m_l \cdot \frac{h}{2\pi}$ $m_l = 0, \pm 1, \pm 2 \cdots \pm l$.

$\mu_z = -\frac{e}{2m_e} \cdot L_z = -\frac{e}{2m_e} \cdot m_l \hbar = -m_l \cdot \mu_B$

$\mu_B = \frac{e\hbar}{2m_e}$ $\Delta E = -\mu B = -\mu_z B = m_l \mu_B \cdot B$.

$\Delta x \cdot \Delta p_x \geq \frac{\hbar}{2}$ $\Delta E \cdot \Delta t \geq \frac{\hbar}{2}$.

章十四、$\boxed{\text{波动光学}}$

$\sqrt{\varepsilon}E=\sqrt{\mu}H$.

$\varepsilon=\varepsilon_0\varepsilon_r$　　$\mu=\mu_0\mu_r$.

$u=\sqrt{\frac{1}{\varepsilon\mu}}$.　真空中 $\varepsilon_r=1$　$\mu_r=1$.　$\therefore C_0=\sqrt{\frac{1}{\varepsilon_0\mu_0}}\approx 3\times10^8 m/s$.

$n=\frac{c}{u}=\sqrt{\varepsilon_r\mu_r}$. 非铁磁质中: $\mu_r\approx 1$.　$\therefore n=\sqrt{\varepsilon_r}$.

$w_e=\frac{1}{2}\varepsilon E^2$　$w_m=\frac{1}{2}\mu H^2$.　$w_{总}=\frac{1}{2}(\varepsilon E^2+\mu H^2)$.

能流密度: $S=wu=\frac{1}{2}(\varepsilon E^2+\mu H^2)\cdot\sqrt{\frac{1}{\varepsilon\mu}}=EH$.

$S=E_0\times H_0\cdot\cos^2[\omega(t-\frac{r}{u})]$.

平均能流密度I:(光强)$=\frac{1}{2}E_0H_0=\frac{1}{2}\sqrt{\frac{\varepsilon}{\mu}}\cdot E_0^2$　相对大小: $I=\frac{1}{2}E_0^2$.

非相干叠加:

光矢量垂直. f不同, 初相差不恒定: $I_p=I_1+I_2$.

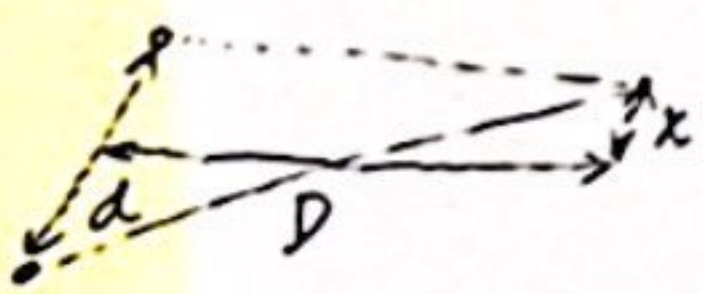
相干时: 频率相同, 相位差恒定、振动方向平行.

$I_p=I_1+I_2+2\sqrt{I_1I_2}\cdot\cos\Delta\varphi$.

$\Delta\varphi=\pm2k\pi$ 时: $(I_p)_{max}=(\sqrt{I_1}+\sqrt{I_2})^2$.　　$I_1=I_2$时 $(I_p)_{max}=4I_1$

$=\pm(2k+1)\pi$ 时: $(I_p)_{min}=(\sqrt{I_1}-\sqrt{I_2})^2$.　　$min=0$.

$\eta=\frac{I_{max}-I_{min}}{I_{max}+I_{min}}$.



光程差 $\delta=r_1-r_2=\frac{xd}{D}$.

$\delta_1=2k\cdot\frac{\lambda}{2}$: 明　　相邻明条纹间距:

$\delta_2=(2k+1)\cdot\frac{\lambda}{2}$: 暗.　　$\Delta x=\frac{D\lambda}{d}$.

光程: is a 折合量 → $x=nr$.

将在介质中传播的距离转为真空中距离.

$\Delta\varphi=2\pi\cdot\frac{(n_2r_2-n_1r_1)}{\lambda_0}=2\pi\cdot\frac{\delta}{\lambda_0}$.