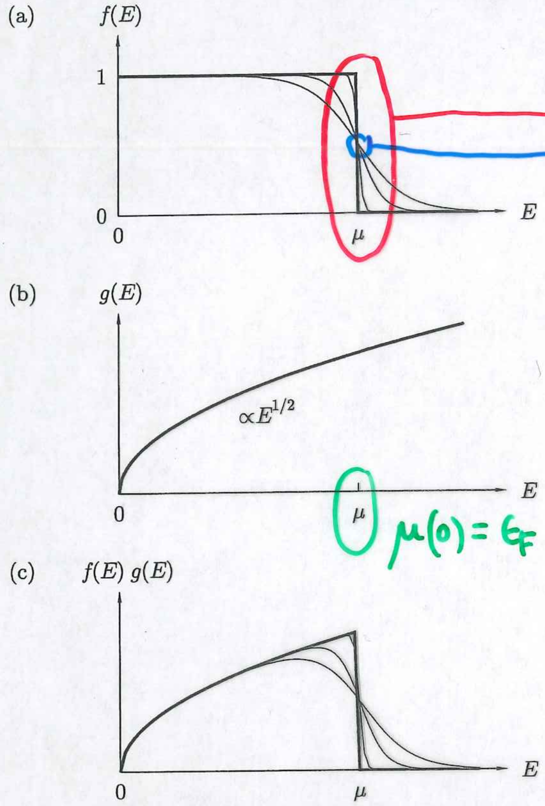
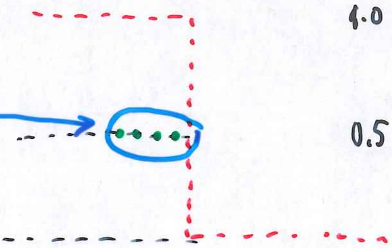


$\mu(0) = \epsilon_F$



$\mu = \mu(T)$ 30.40

$\mu(T) = \mu(0)\left[1 - \frac{1}{3}\frac{\pi^2}{4}\left(\frac{k_BT}{\mu(0)}\right)^2 + \dots\right]$

Fig. 30.2 (a) The Fermi function $f(E)$ defined by eqn 29.26. The thick line is for $T = 0$. The step function is smoothed out as the temperature is increased (shown as thinner lines). The temperatures shown are $T = 0$, $T = 0.01\mu/k_B$, $T = 0.05\mu/k_B$ and $T = 0.1\mu/k_B$. (b) The density of states $g(E)$ for a non-interacting fermion gas in three dimensions is proportional to $E^{1/2}$. (c) $f(E)g(E)$ for the same temperatures as in (a).

$\mu(0) \equiv \epsilon_F$

$\mu(T) = \epsilon_F\left[1 - \frac{1}{3}\left(\frac{\pi^2}{4}\right)\left(\frac{k_BT}{\epsilon_F}\right)^2 + \dots\right]$

$\epsilon_F = 100\cdot(k_BT) \Rightarrow \frac{k_BT}{\epsilon} = 10^{-2}$

$\Downarrow$

$\mu(T) = \epsilon_F \Rightarrow \mu \neq \mu(T)$

At $T = 0$, the distribution function $f(E)$ is a Heaviside step function, taking the value 1 for $E < \mu$ and 0 for $E > \mu$. This step is smoothed out as the temperature T increases, as shown in Fig. 30.2(a). The density of states $g(E)$ for a non-interacting fermion gas in three dimensions is proportional to $E^{1/2}$ (as shown in eqn 30.4) and this is plotted in Fig. 30.2(b). The product of $f(E)g(E)$ gives the actual number distribution of fermions, and this is shown in Fig. 30.2(c). The sharp cutoff you would expect at $T = 0$ is smoothed over an energy scale k_BT around the chemical potential μ. APLIKAZIOA adibidea

The electrons in a metal can be treated as a non-interacting gas of fermions. Using the number density n of electrons in a metal, one can calculate the Fermi energy using eqn 30.29, and some example results are shown in Table 30.1. The Fermi energies are all several eV; converting each number into a temperature, the so-called **Fermi temperature** $T_F = E_F/k_B$, yields values of several tens of thousands of Kelvin. Thus the Fermi energy is a large energy scale, and hence for most metals the Fermi function is close to a step function, at pretty much all temperatures below their melting temperature. In this case, the electrons in a metal are said to be in the **degenerate limit**.

The pressure of these electrons is given (by using eqns 22.49 and 30.17) as

$$p = \frac{2U}{3V}, \tag{30.30}$$