$$\Delta U = \int_0^\infty d\epsilon\ \epsilon\, g(\epsilon) f(\epsilon) \boxed{- \int_0^{\epsilon_F} d\epsilon \cdot \epsilon_F g(\epsilon) + \int_0^{\epsilon_F} d\epsilon\, \epsilon_F g(\epsilon)} - \int_0^{\epsilon_F} d\epsilon\, \epsilon\, g(\epsilon)$$

$$\int_0^{\epsilon_F} d\epsilon\, (\epsilon_F - \epsilon)\, g(\epsilon)$$

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$$- \left\{ \int_0^{\epsilon_F} d\epsilon\ \epsilon_F\, g(\epsilon) \cdot f(\epsilon) + \int_{\epsilon_F}^\infty d\epsilon\, \epsilon_F\, g(\epsilon) f(\epsilon) \right\}$$

$$\int_0^{\epsilon_F} d\epsilon\, \epsilon\, g(\epsilon) f(\epsilon) + \int_{\epsilon_F}^\infty d\epsilon \cdot \epsilon\, g(\epsilon) f(\epsilon)$$

$$\int_0^{\epsilon_F} d\epsilon\, (\epsilon - \epsilon_F)\, g(\epsilon) f(\epsilon) + \int_{\epsilon_F}^\infty d\epsilon\, (\epsilon - \epsilon_F)\, g(\epsilon) f(\epsilon) + \int_0^{\epsilon_F} d\epsilon\, (\epsilon_F - \epsilon)\, g(\epsilon)$$

$$\int_{\epsilon_F}^\infty d\epsilon\, (\epsilon - \epsilon_F)\, g(\epsilon) f(\epsilon) + \int_0^{\epsilon_F} d\epsilon\, (\epsilon_F - \epsilon)\, g(\epsilon)\, (1 - f(\epsilon))$$