4-59

解　(1) 插入前：

$$E_0 = \frac{Q^2}{2C_0} = \frac{Q^2 d}{2\varepsilon_0 S}$$

插入后：

$$E = \frac{Q^2}{2C} = \frac{Q^2 d}{2\varepsilon\varepsilon_0 S}$$

故

$$\Delta E = E - E_0 = \frac{Q^2 d}{2\varepsilon_0 S}(\frac{1}{\varepsilon} - 1)$$

(2) 设介质板面积为 $S = ab$ 插入深度为 x 则

$$C = C_1 + C_2 = \frac{\varepsilon\varepsilon_0 bx}{d} + \frac{\varepsilon_0 b(a-x)}{d} = \frac{\varepsilon_0 b}{d}[a + (\varepsilon - 1)x]$$

$$W = \frac{Q^2}{2C} = \frac{Q^2 d}{2b\varepsilon_0[a + (\varepsilon - 1)x]}$$

$$F = -\frac{\mathrm{d}W}{\mathrm{d}x} = \frac{Q^2 d(\varepsilon - 1)}{2b\varepsilon_0[a + (\varepsilon - 1)x]^2}$$

故做功为

$$A = \int_0^a F\,\mathrm{d}x = \frac{Q^2 d}{2\varepsilon_0 S}(1 - \frac{1}{\varepsilon})$$

4-60

解　(1) 插入前：

$$E_0 = \frac{C_0 U^2}{2} = \frac{\varepsilon_0 S U^2}{2d}$$

插入后：

$$E = \frac{C_0 U^2}{2} = \frac{\varepsilon\varepsilon_0 S U^2}{2d}$$

故

$$\Delta E = E - E_0 = \frac{\varepsilon_0 S U^2}{2d}(\varepsilon - 1)$$

(2)

$$\Delta Q = CU - C_0 U = \frac{\varepsilon_0 S U}{\varepsilon - 1}$$

故电源移动电荷做功为

$$W = \Delta Q U = \frac{\varepsilon_0 S U^2}{\varepsilon - 1}$$

(3) 与上题分析类似可得

$$A = \frac{\varepsilon_0 S U^2(\varepsilon - 1)}{2d}$$

4-61

解

$$C = C_1 + C_2 = \frac{\varepsilon\varepsilon_0 ax}{d} + \frac{\varepsilon_0 a(a-x)}{d} = \frac{\varepsilon_0 a}{d}[a + (\varepsilon - 1)x]$$

$$W = \frac{Q^2}{2C} = \frac{Q^2 d}{2a\varepsilon_0[a + (\varepsilon - 1)x]}$$

$$F = -\frac{\mathrm{d}W}{\mathrm{d}x} = \frac{Q^2 d(\varepsilon - 1)}{2a\varepsilon_0[a + (\varepsilon - 1)x]^2}$$

令 $x = \dfrac{a}{2}$ 得 $F = \dfrac{2(\varepsilon - 1)Q^2 d}{\varepsilon_0(\varepsilon + 1)^2 a^3}$

4-62

解　并联总电容 $C = C_1 + C_2 = \dfrac{\varepsilon_0 S}{d} + \dfrac{\varepsilon\varepsilon_0 S}{d} = \dfrac{\varepsilon_0 S}{d}(\varepsilon + 1)$ 则总能量为

$$W = \frac{CU^2}{2} = 5.4 \times 10^{-5}\mathrm{J}$$

中间是空气的电容器两端电荷为 $Q_1 = C_1 U = \dfrac{\varepsilon_0 SU}{d}$, 中间插入酒精的极板两端电荷为 $Q_2 = C_2 U = \dfrac{\varepsilon\varepsilon_0 SU}{d}$ 则用导线连接后总电荷为 $Q = Q_2 - Q_1$, 总能量为

$$E = \frac{Q^2}{2C} = 4.6 \times 10^{-5}\mathrm{J}$$

$$\Delta E = W - E = 7.8 \times 10^{-6}\mathrm{J}$$

损失的能量部分转换为导线产生的焦耳热，部分转换为电磁波辐射到了外界

$$\mathbb{V}, \mathbf{V}, \mathrm{V}, V, \mathcal{V}, \nu, \mathsf{V}, \mathrm{V}, V$$