8. The electric field inside a dielectric material is reduced by a factor ε_r, the dielectric constant, from the vacuum value. For helium and water at *s.t.p.*, $\varepsilon_r = 1.000068$ and $\varepsilon_r = 80$ respectively.

(a) Discuss briefly the mechanism responsible for the response of helium. [3]

(b) Discuss briefly the mechanism responsible for the response of water. [3]

Consider the coaxial cable of Figure 2. There are equal but opposite charges per unit length $+\lambda$ and $-\lambda$ on the two conducting elements of the cable, which acts as a capacitor.

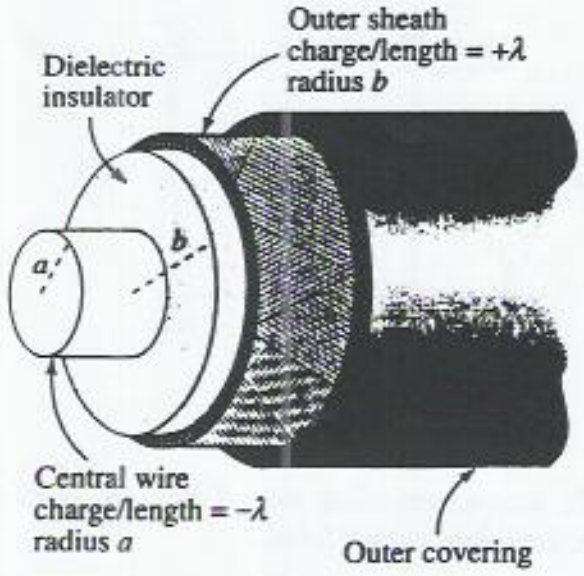

Figure 2

(c) Show that the potential difference between the conductors in the coaxial cable is given by

$$\phi = \frac{\lambda}{2\pi\varepsilon_0\varepsilon_r}\ln\left(\frac{b}{a}\right)$$

where ε_r is the dielectric constant of the insulator inserted between the inner wire and the thin outer sheath, and calculate the capacitance per unit length and potential energy per unit length of the cable. [7]

The coaxial cable shown in Figure 2 is discharged, then used to carry a current $+I$, with uniform current density, along the inner wire and $-I$ along the thin outer sheath.

(d) Assuming that the dielectric material does not affect the magnetic field, use Ampère's law to determine the magnetic field at a distance r from the centre of the wire:
(i) for $r < a$; [4]
(ii) for $a < r < b$; and, [2]
(iii) for $r > b$ [1]