a) $J_{(bound)} = \frac{\partial P}{\partial t} = \frac{\partial}{\partial t}\left(\varepsilon_0 \chi E\right) = \varepsilon_0 \chi j \times 1000\pi \times 3.5 e^{j\omega t}$

(In this case $\omega = 2\pi \times 500$ s$^{-1}$ , 500 Hz oscillation.)

$\varepsilon^* = \varepsilon' - j\varepsilon'' = 1 + \chi$ , $\chi = \varepsilon^* - 1 = 6.94 - 2.51j$

The amplitude of the current density is then:

$\left|\varepsilon_0 \times \left(6.94 - 2.51j\right) \times 1000\pi \times 3.5\right| = 8.85 \times 10^{-12} \times 7.38 \times 1000\pi \times 3.5 = \underline{\underline{7.18 \times 10^{-7}}}$ Am$^{-2}$ **[2 marks]**

b) The current amplitude is 7.18 x $10^{-7}$ x area =7.18 x $10^{-7}$ x 25 x $10^{-4}$ =$\underline{1.80 \times 10^{-9}}$ A **[2 marks]**

c) $$R = \frac{1}{\omega\varepsilon'' C_0} = \frac{d}{\omega\varepsilon''\varepsilon_0 A} = \frac{2 \times 10^{-3}}{1000\pi \times 2.51 \times 8.85 \times 10^{-12} \times 25 \times 10^{-4}}$$
$$= \underline{\underline{1.15 \times 10^{7}\Omega}}$$ **[2 marks]**

d) By definition, the loss tangent is just $\tan\delta = \frac{\varepsilon''}{\varepsilon'} = \frac{2.51}{7.94} = \underline{\underline{0.316}}$ **[2 marks]**

e) The power dissipation is given by either $W = \frac{1}{2}\mathrm{Re}\left[I^* V\right]$ (longer approach), or,

$$W = \frac{V_0^2}{2R}$$

where $V_0$ is the amplitude of the voltage across the slab, $V_0 = E_0 d$ where $E_0 = 3.5$ Vm$^{-1}$

$\therefore V_0 = 3.5 \times 2 \times 10^{-3}$ V.

Thus $W = \frac{\left(3.5 \times 2 \times 10^{-3}\right)^2}{2 \times 1.146 \times 10^7} = \underline{\underline{2.14 \times 10^{-12}}}$ W **[2 marks]**