part of the exam. However, the following were important. (i) The microwaves enter the oven's "cavity" and it obviously must have metal walls to contain the radiation. Plastic, i.e., non-conducting, walls would allow it to leak out, reducing the oven's efficiency and making the radiation a safety hazard. (ii) The window in the oven's door contains a metal mesh that can be seen though but which prevents the microwaves from passing through. (iii) the holes in the mesh are roughly 1 mm in size, which is much less that the ~10 cm wavelength of the radiation. The mesh is seen as a solid metal sheet. Light waves can easily penetrate, though, since their wavelengths are much less than ~ 1mm. (iv) With its radiation confined to a metal cavity, without much loss, it must be undesirable to operate a microwave oven empty. Often the instructions for the ovens include a warning about this use. (v) Pointed, or sharp-edged, metal objects will have voltages induced in them that might lead to sparking at the points and edges, causing them to become a fire-hazard. (vi) Although the oven's cavity is not necessarily a resonant cavity its em fields will have some form of standing wave pattern. Thus the oven may not heat uniformly. We can guess that the spacing between the hot spots will be about half a wavelength (two peaks of electric field per wavelength), or around 5 cm. This is why the ovens often have a rotating plate on the bottom (and in some cases there is a metal "paddle" rotating where the microwaves come in, to help disperse them). (5 points)

(3) How do you think the microwaves heat food?

It is common knowledge that the microwave heating involves the water molecules in the food but from this point the process becomes murky. Students thought the microwaves might resonate with the molecules and/or cause them to rotate vigorously. Some thought the microwaves would heat the food from the inside! We investigated these possibilities after the water molecule was described as being dipolar with a dipole moment (negative on the oxygen end and positive on the end where the two hydrogen atoms are bound). The students were also told that although it is possible to set up internal resonances in individual water molecules the frequencies involved are outside the microwave range. With this information we decided: (i) that the water molecules would first rotate in one direction to line up with the electric field of the wave and then rotate in the opposite direction as the electric field oscillated. There would be no net rotation and the molecule would feed energy into the water and its surroundings by oscillating backwards and forwards and interacting with the surrounding molecules as it did so, i.e., heating by collisions. (ii) we dismissed the concept of the microwaves heating food from the inside out, since they would have to penetrate into the food from the outside, heating it and losing intensity as they penetrated. Nevertheless, (iii) because food is unlikely to be a good conductor, the skin depth at microwave frequencies could well be on the order of a wavelength and the food should be heated relatively uniformly. (3 points)