Question 1:
a) Explain why residual thermal stresses are introduced into a glass piece when it is cooled?
When a glass piece is cooled from an elevated temperature, internal stresses, called thermal stresses, are introduced as a result of the difference in cooling rate and thermal contraction between the surface and the interior regions. These thermal stresses are important, since they may lead to fracture such as thermal shock.

b) Are thermal stresses introduced upon heating as well? Why or why not?
Yes, thermal stresses are introduced upon heating because of the thermal expansion.

c) What can be done to avoid thermal stresses?
   - The glass piece can be cooled at a sufficiently slow rate.
   - Once such stresses have been introduced, elimination, or at least a reduction in their magnitude is possible by annealing heat treatment in which the glassware is heated to the annealing point, then slowly cooled to room temperature.
   - Change the composition to minimize the thermal expansion coefficient of the material

d) How does the thickness of a glass ware affect the magnitude of the thermal stresses? Why?
The thinner the glassware, the lower the thermal stresses that are introduced when it is either heated or cooled. The reason for this is that the difference in temperature across the cross-section of the ware, and thus, the difference in the degree of expansion or contraction will decrease with a decrease in thickness.

Question 2:
What are the advantages of glass ceramics over conventional ceramics and glass?

Glass ceramics vs. ceramics
- Production of pore-free samples:
  glass ceramics are processed via a melting step, whereas conventional ceramics are sintered. During the crystallization process, the glass can flow and accommodate the changes in volume (whereas ceramics always show a rest porosity).
- Production of complex shapes:
  It is much easier to cast complex shapes from a melt than machine them from a sintered sample.
- Wide tailoring of the thermal expansion coefficient
  From -20 to 200.10^{-7}K^{-1}. This is especially important, when joining different materials. Near 0 K^{-1}, the material is thermo-shock resistant \(\rightarrow\) cooking ware, telescope mirrors.
- Transparent (to infrared)
  This fact, combined with the low thermal expansion coefficient and the low heat conductivity of glass ceramics led to the development of glass ceramics as cook tops: the heat source heats only the cook top above, but not the adjacent surface.

Glass ceramics vs. glass
- Higher deformation temperature due to the crystalline phase
  \(T_g,\) glass \(\sim 400\) to \(600^\circ C\), \(T_{deformation,\) glass ceramic} \(\sim 1000\) to \(1200^\circ C\)
- Higher strength and toughness
  The crystallites limit the flaw size and the interlocking grains limit the crack propagation.