

## QUESTION 4

- (a) Sketch the fundamental building block of the silicate ceramics. Explain why silicates can be considered to be both ionically and covalently bonded.
- (b)  $\alpha$ -cristobalite is a polymorph of silica ( $\text{SiO}_2$ ), with tetragonal crystal symmetry, a density of  $2.32 \text{ g/cm}^3$ , and a melting point of around  $1700 \text{ }^\circ\text{C}$ . Explain why the density is low and the melting point is high. Draw the shape of the unit cell (there's no need to draw the individual atoms). Label the angles and indicate which edges are the same length.
- (c) When a powdered sample of cristobalite is placed in an x-ray diffractometer, a series of sharp peaks appear when the diffraction angle is scanned. Explain how you could determine the size of the cristobalite unit cell from a knowledge of the peak positions.
- (d) The sample of cristobalite is heated until it melts, and then cooled rapidly to form a solid. The sharp peaks in the diffraction pattern disappear. Explain why. Draw a schematic graph of the volume of the sample as a function of temperature. Explain the form of your graph.
- (e) What is the common name of your new material? How might we tailor its properties for specific applications?

- (f) Although Bragg's Law is not valid for solids without bulk periodicity, we can obtain the *radial distribution function* from analysis of the x-ray diffraction spectrum. The radial distribution function is defined to be the number of atoms between distance  $r$  and  $r+dr$  from an atom at the origin. In a crystalline sample, the RDF is a periodic array of sharp spikes.

The RDF of our final sample of cristobalite is sketched below. The first peak is fairly sharp, and at a distance corresponding to the Si-O bond length from the origin. The second peak is broader and less well-defined. Additional peaks are hard to resolve. Explain.

