Week 9

Amorphous structures I: Pair distribution function and glasses

Exercise 1

Answer these questions by true or false:

1. If order in a material is more pronounced, the correlation length will be longer
   True/false

2. Short-range order spans over a few atomic distances only
   True/false

3. Amorphous liquids melt over a range of temperatures
   True/false

4. A glass is always transparent
   True/false

Exercise 2:

Select the correct answer(s) (more than one answer can be correct)

1. The structure factor in scattering/diffraction…
   a. Describes the scattering of the interaction of all atoms in a unit cell in crystallography
   b. Describes the interaction between atoms in glasses
   c. Only exists for crystalline material

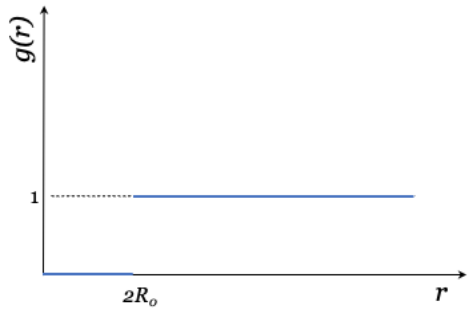
2. What happens if you add a network modifier to a silica glass?
   a. The correlation distance decreases
   b. The correlation distance remains the same
   c. The correlation distance increases
   d. The viscosity at the same temperature increases
   e. The glass transition temperature is unchanged
   Glass transition temperature decreases

3. What happens if you add a network modifier to a borate glass?
   a. The correlation distance decreases
   b. The correlation distance remains the same
   c. The correlation distance increases
   d. The viscosity at the same temperature increases
   e. The glass transition temperature is unchanged
   Glass transition temperature increases

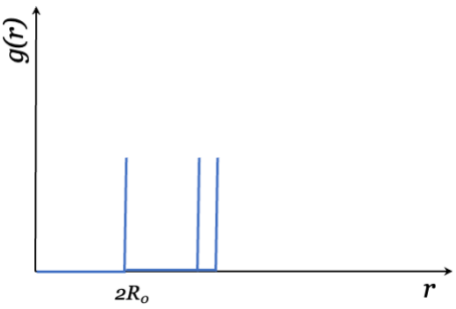
Exercise 3: Pair distribution function

Sketch a typical pair distribution function for

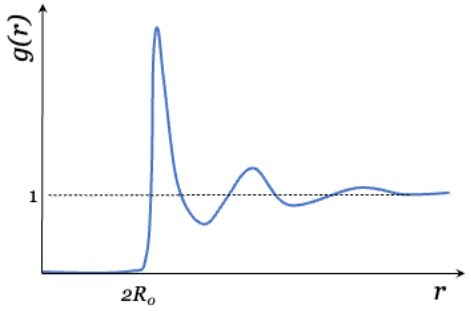
a) A gas



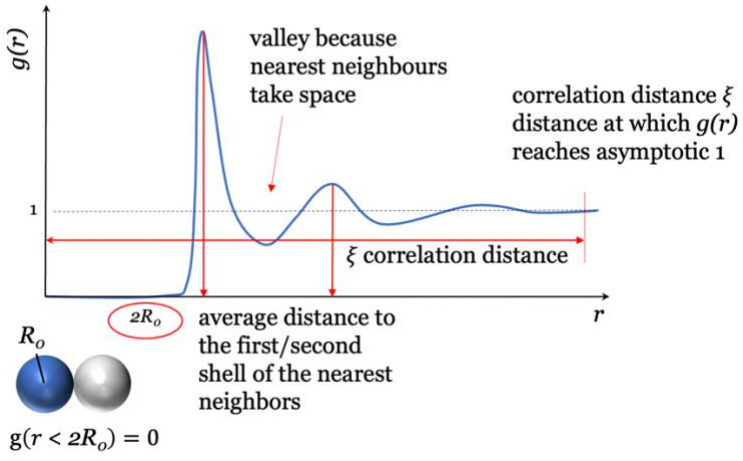
b) A crystalline material



c) A glass



d) Label the relevant points and axes (including units) in the PDF of a glass



The unit of r is Å (or nm, m), g(r) is unitless

e) How does the PDF in c) change if you heat or cool the material?
With lowering temperature material densifies, in particular if it solidifies, the neighboring atoms/molecules will move closer, with higher temperature there is more thermal energy, thus Brownian movement, the peaks will get broader. If there is a melting temperature crossed and a crystalline to liquid transition happens, the PDF will accordingly change drastically.

Exercise 4: Give two examples of application of amorphous materials, and describe the relevant property.

type of amorphous solid	**representative material**	**application**	**special properties**
oxide glass	$(SiO_2)_{0.8}(Na_2O)_{0.2}$ $(SiO_2)_{0.9}(GeO_2)_{0.1}$	window glass fibre-optic	transparency formable purity, ultratransparency, formable
organic polymer	polystyrene, PMMA	structural materials, plastics shatter proof glass	light weight, ease of processing shock resistance
chalcogenide glass	Se, As_2Se_3 Ge-Sb-Te	copiers and laser printers memories	photoconductivity phase change
amorphous semiconductor	$Si_{0.9}H_{0.1}$	solar cells, copiers, flat-panel displays	photovoltaic optical properties, large-area thin films, semiconducting properties
metallic glass	$Fe_{0.8}B_{0.2}$ $Mg_{60}Zn_{35}Ca_5$ $Zr_{58}Cu_{15.6}Ni_{12.8}Al_{10.3}Nb_{2.8}$	transformer cores Bone implants Sports, anti-wear	ferromagnetism, low power loss dissolves in body elasticity, resistance, corrosion
ionic glasses (salts)	Esomeprazole	Pharmaceuticals	Bioavailability (soluble)

Exercise 5: What influences the glass transition temperature of amorphous materials?
The cooling rate, network modifiers (for mineral glasses), plasticizers → example of water in case of pasta or chewing gum