Ceramic Materials Engineering

A.Y. 2019-2020

Homework n. 1

Some data and universal constants are not given and shall be found elsewhere (handbooks, textbooks, internet) or hypothesized.

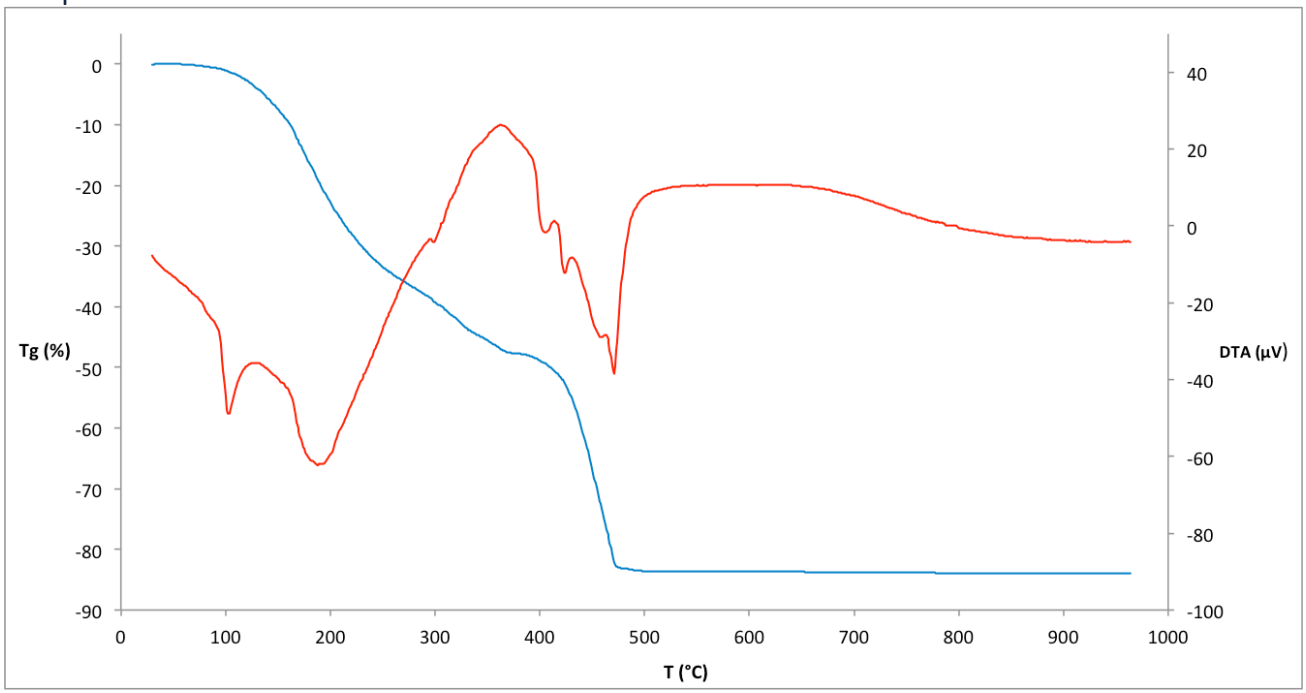
1. Estimate the hydration cloud extension and mass for dissolving KCl (lattice energy = 700 kJ/mol), NaCl (lattice energy = 760 kJ/mol) and MgF_2 (lattice energy = 2900 kJ/mol) if the hydrogen bond has an energy of 51 kJ/mol. Determine the rank of the three compounds in terms of solubility. *The lattice energy refers to the minimum energy of an ionic compound.*

2. In calcite ($CaCO_3$) the Ca^{2+} ion has a CN 6. Using the appropriate Pauling rule, determine the ion environment around each O^{2-} ion.

3. Use the Pauling' s rules to define the structure of calcium titanate.

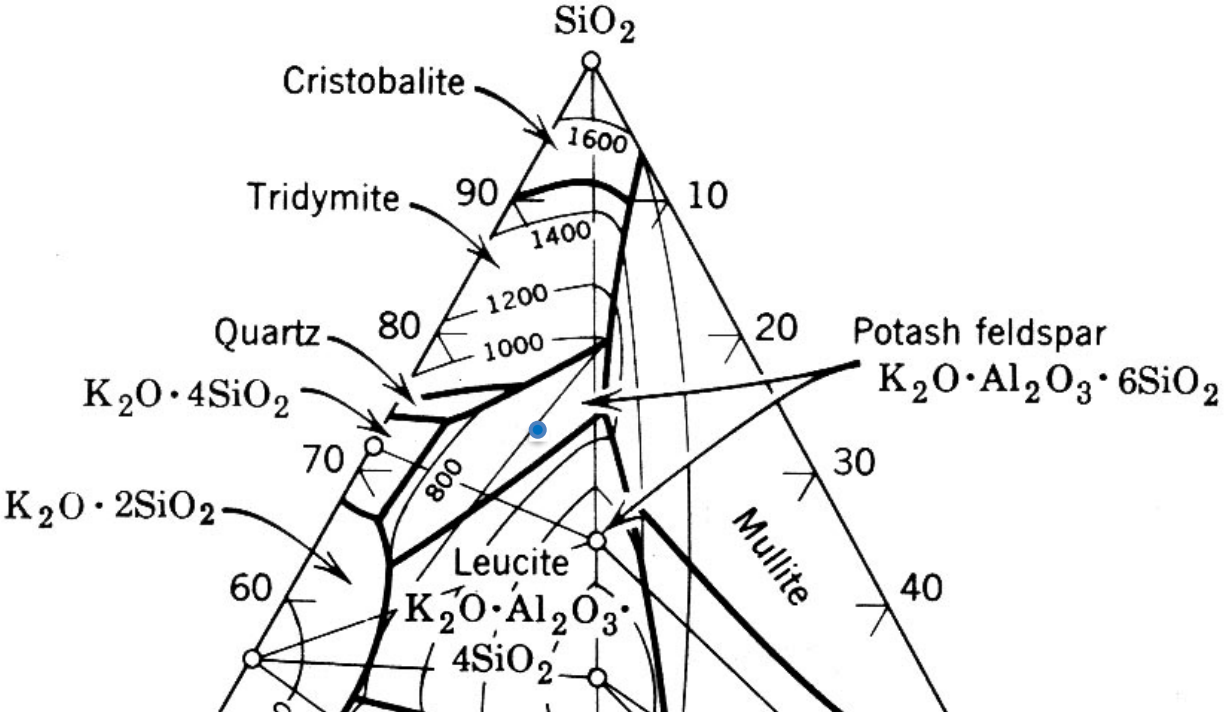
4. Draw in detail the TG, DTA e DTG diagrams for a one-to-two (in weight) mixture of calcite e kaolinite ($Al(Si_2O_5)_2(OH)_4$) from 25°C to 1200°C at fixed heating rate; the first decomposes at 900°C and the second decomposes at 600°C and the residual recrystallize at 1100°C. Draw the diagrams also for higher and lower heating rate.

5. The TGA/DTA diagram for magnesium nitrate hexahydrate is shown. Identify (quantitatively) possible evolution reactions.

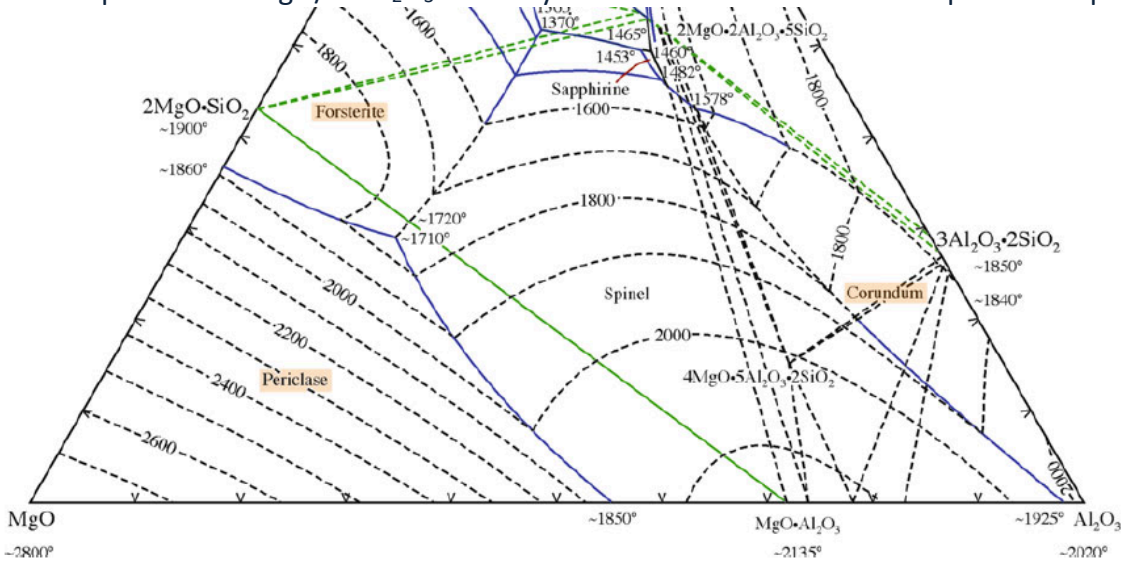


6. Determine the linear and volume shrinkage that occurs during the drying and sintering of a gel containing 5 vol% solids if the dried gel and the sintered one have a solid content (relative density) of 50% and 100%, respectively.

7. Describe the behaviour of a liquid with the composition indicated by the blue circle when it is cooled down to room temperature.



8. Calculate the composition of the phases obtained by cooling a liquid down to room temperature with composition 70 MgO/20 Al_2O_3. Identify also all transformations with specific temperatures.



9. In a nitrogen adsorption experiment at the boiling point of liquid nitrogen, the volume V of gas adsorbed at a pressure p was determined as follows:

p (mm Hg):	80	100	125	140	200
V (cm^3/g):	0.420	0.439	0.464	0.476	0.534

Determine the surface area of the powder (area of the adsorbed N_2 molecule = 16.2 x 10^{-20} m^2).

10. The following data were obtained in a liquid pycnometry experiment at 20°C: mass of the pycnometer = 35.827 g, mass of the pycnometer + powder = 46.402 g, mass of the pycnometer and water = 81.364 g, mass of the pycnometer + powder + water = 89.894 g. If the theoretical density of the solid is 5.605 g/cm^3, determine the amount of closed porosity in the powder.

11. Compare the settling times for alumina particles of 0.1 µm diameter for a settling height of 1 cm under gravitational conditions and in a 3600 rpm centrifuge with an initial radial position of 10 cm.

12. The mass of a fragment of ceramic material is 19.65 g. By Hg intrusion porosimetry a bulk volume equal to 10 cm^3 and an open porosity of 2 cm^3 are calculated. After careful milling (with final particle size lower than 100 nm), a density equal 2.62 g/cm^3 is measure by picnometry. Determine the absolute and relative closed porosity, the apparent and bulk density of the ceramic material.