Department of Materials Science and Engineering
Norwegian University of Science and Technology

TMT4320 Nanomaterials, fall 2015

EXERCISE 5

Guidance: Wednesday 23rd September, 18:15-20:00, H3
Due date: Friday 25th September, 14:00, boxes outside R7 or on It's learning

PROBLEM 1

a) What is a supercritical fluid? Give a short description of the following properties and explain how the first three of these change with temperature and pressure: Solubility, viscosity, diffusion, and thermal conductivity.

b) Name some application areas of supercritical fluids.

c) How can a supercritical fluid be used in the synthesis of inorganic nanoparticles?

d) Supercritical fluids can be used in both physical and chemical procedures. Explain the difference between these two.

e) What is the advantage of using supercritical fluids in combination with reverse micelles compared to using an oily phase as the dispersing solvent?

PROBLEM 2

In hydrothermal synthesis water is used as solvent in a closed vessel. The vessels (called bombs or autoclaves) can contain a volume of liquid up to typically 2/3 of the total volume. In a typical procedure 50 mL of water is used for synthesis in a 125 mL autoclave.

a) Calculate the volume (at 1 atm and 25 °C) that 50 mL water will occupy if all the water is evaporated from the liquid state into the gas state.

b) Calculate the pressure in bar inside the 125 mL autoclave at 180 °C if all the water (50 mL in liquid state) is assumed to be in the gas state. Use the ideal gas law. (This law will not give an exactly correct answer, but we will not go into details of more correct gas laws.)

c) In actual synthesis at 180 °C with 50 mL water in a 125 mL autoclave, the autogenerated pressure will be approximately 14 bar. Why is the pressure lower than calculated in b)?

d) Give some general guidelines for controlling the synthesis in hydrothermal/solvothermal processes (i.e. how can particle size, particle size distribution, crystal structure, and phase purity be controlled?).

e) For hydrothermal/solvothermal synthesis, is it possible to monitor particle growth in situ? If so, explain briefly how.

Volume of 1 mol ideal gas at 1 atm, 25 °C: V_m = 24.46554 L mol^{-1}
Density of water: δ = 1.0 g mL^{-1}
Molar mass, hydrogen: 1.008 g mol^{-1}
Molar mass, oxygen: 16.00 g mol^{-1}
Gas constant: R = 8.314510 J K^{-1} mol^{-1}
Faraday constant: F = 96485.309 C mol^{-1}
Ideal gas law: $PV = nRT$