PhD Qualifying Exam
Nuclear Engineering Program

Part 2 – Specialty Part
Nuclear Fuel Cycle and Radioactive Waste Management

9:00 am – 12:00 pm, Nov. 2, 2018

Specialty - Nuclear Fuel Cycle and Radioactive Waste Management

Problem #1 (40 points)

Differential scanning calorimetry (DSC) is a powerful tool to measure thermodynamic properties for nuclear fuel materials, for example, the enthalpy for a phase transition from solid to liquid. Given a salt such as NaCl, explain how to measure the **melting point** of the salt and **enthalpy of fusion** of the salt.

Problem #2 (30 point)

U-Mo and U-Zr are two common metallic fuels for a sodium-cooled fast reactor. Mo and Zr have different functions in the fuel. If a new metallic fuel U-Mo-Zr is proposed, **explain the potential benefits** of the new U-Mo-Zr fuel over U-Mo and U-Zr fuels.

Problem #3 (30 point)

In the electrochemical separation for actinides using a molten salt, Pu can be co-separated with other actinides such as U by using a solid or liquid cathodic electrode. In one operation, if Pu and U are co-deposited on a solid electrode, deduce the ratio of concentration (in the salt) of Pu at the salt/electrode interface to that of U.

Note: 1) The concentration has a unit of mole fraction; 2) U^{3+} and Pu^{3+} are the stable ions in the salt and the deposition is a one-step reaction, for example, $U^{3+} + 3e \rightarrow U$; 3) the apparent potentials of U^{3+} and Pu^{3+} are given $E^{ap}_{U^{3+}}$ and $E^{ap}_{Pu^{3+}}$; 4) the activities of U and Pu in the electrode at the surface are 1.