

Second Hour Exam
NEEP-423
Nov. 22, 1999

Points **Question**

- 25 pts. 1.) After a short term irradiation (before restructuring) a metallurgical examination revealed that a fuel element had melted to 30% of its radius. Given a linear power rating of 800 W/cm, and a bulk coolant temperature of 500°C, what is the heat transfer coefficient across the gap (h_{gap})? Use the following:

$$\frac{k_{\text{clad}}}{t_{\text{clad}}} = 8 \frac{W}{\text{cm}^2 \cdot ^\circ\text{C}}$$
$$h_{\text{coolant}} = 10 \frac{W}{\text{cm}^2 \cdot ^\circ\text{C}}$$

O.D. of cladding = 7 mm

Use Conductivity graph attached

- 20 pts. 2.) What is the physical state (i. e., metallic or a compound) of Rb in $(U_{0.8}Pu_{0.2})O_{2.08}$ fuel at the outer edge (750°K) and at the inner hole surface (1500 °K)? Use the information in the accompanying diagrams.
- 20 pts. 3.) Calculate the partial pressure of molecular oxygen in equilibrium with the mixed oxide $(U_{0.6}Pu_{0.4})_{2.15}$ at 1100 °C. Use Rand-Markin thermodynamics.

- 20 pts. 4.) a.) Demonstrate that when two bubbles of equal size coalesce, that there is a conservation of bubble surface area
- b.) Is the above conservation equation true when the bubbles coalesce in a solid under hydrostatic pressure P_e ?
- 15 pts. 5.) a) Contrast the causes of fuel failure rates in PWR's and BWR's in the 1970's with those in the 1990's.
- b.) What is the order of magnitude of fuel failure rates in the 1990's?

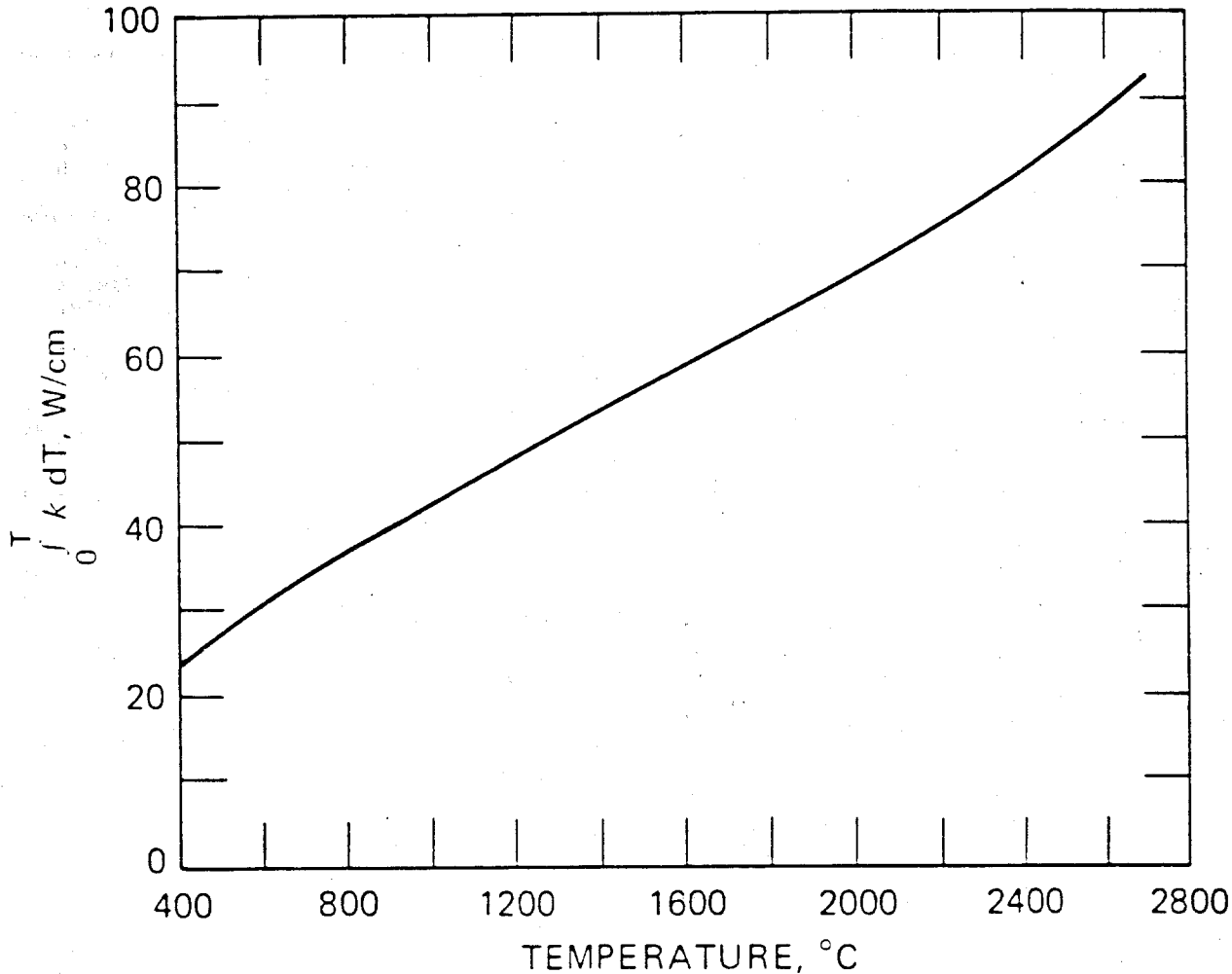


Fig. 10.20 Recommended minimum thermal conductivity integral for $(U_{0.8}Pu_{0.2})O_2$. [From M. J. McNelly, Liquid Metal Fast Breeder Reactor Design Study (1000-MWe UO_2 - PuO_2 Fueled Plant), 2 vols., USAEC Report GEAP-4418, General Electric Company, January 1963.]

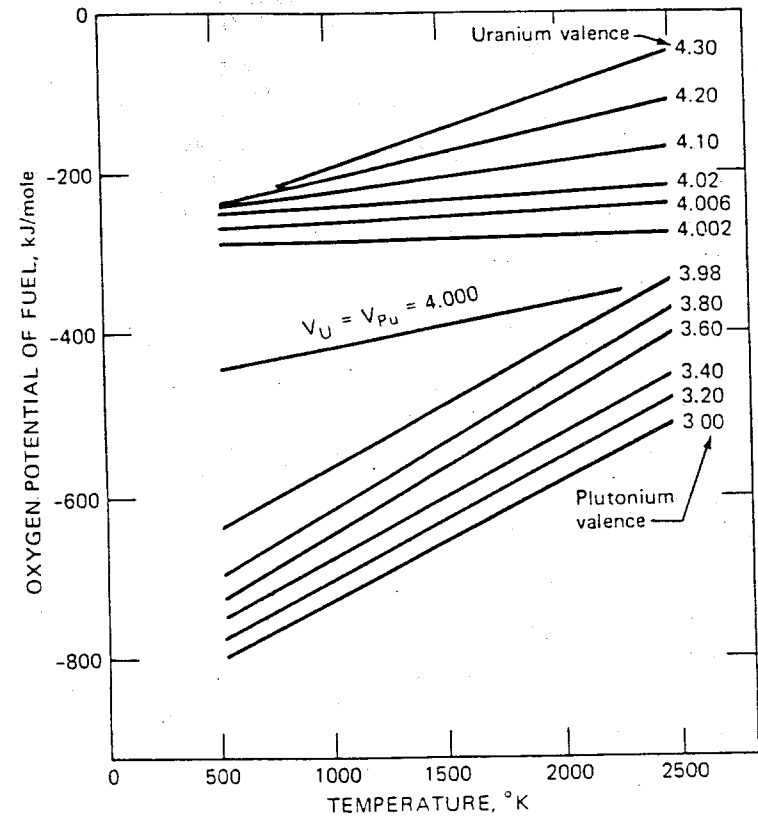


Fig. 12.6 Oxygen potentials of mixed-oxide fuels (taken from Figs. 11.13 and 11.14 and Eq 11.14).

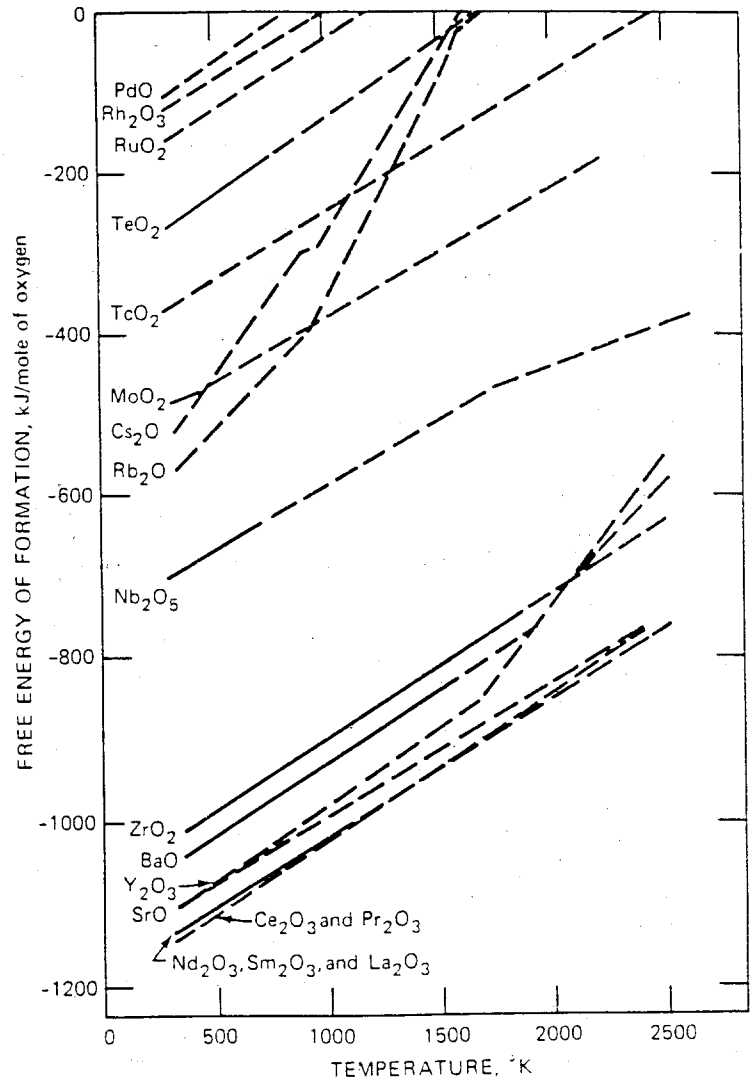


Fig. 12.7 Standard free energies of formation of high-yield fission products. ---, extrapolations of data. [From D. R. O'Boyle et al., *J. Nucl. Mater.*, 29: 27 (1969).]

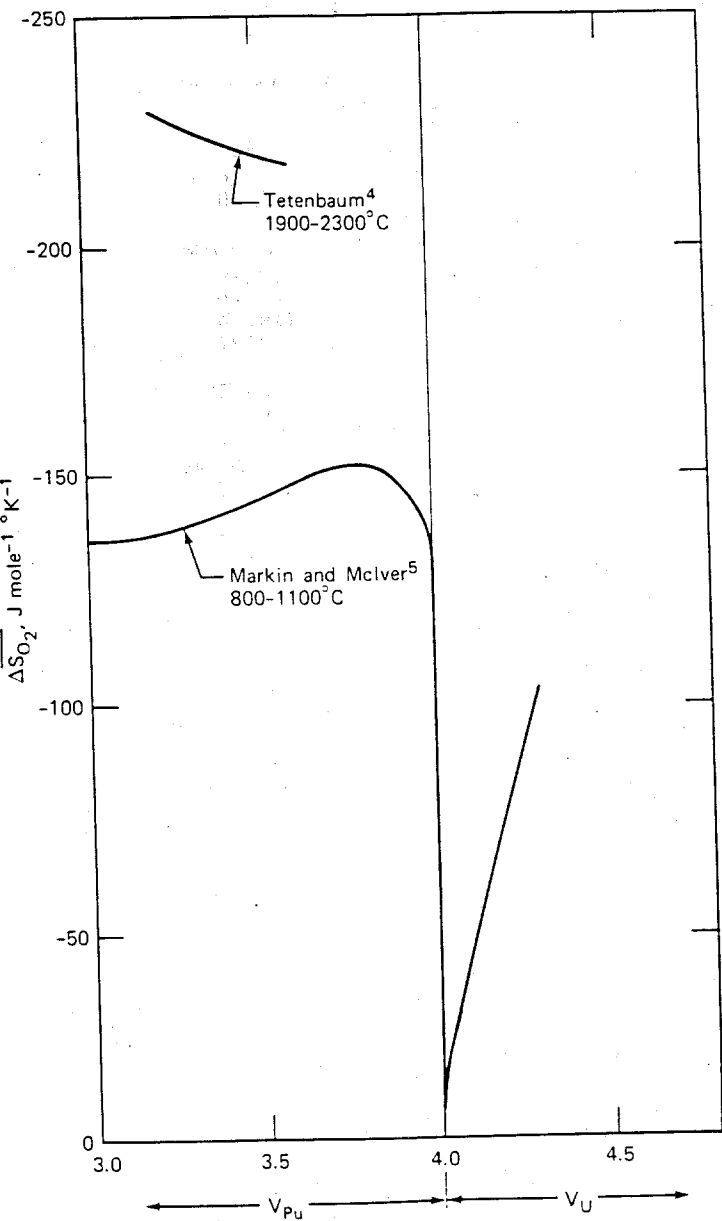


Fig. 11.13 Partial molar entropy of oxygen in mixed uranium-plutonium oxides.

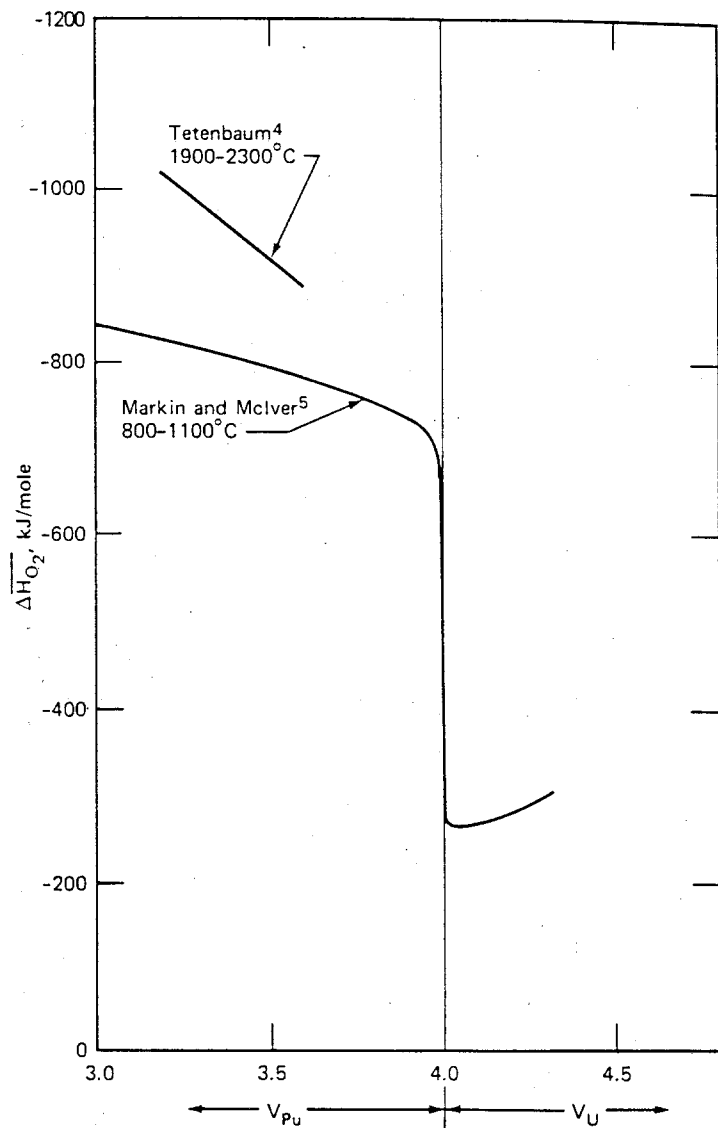


Fig. 11.14 Partial molar enthalpy of oxygen in mixed uranium-plutonium oxides.