RDCH 702
Quiz 5
Assigned 5 December 18
1st Due 13 December 18
2nd Due 15 December 18

Last Name:_____

First Name:_____

Quiz Topics
Lecture 9 Separations
Lecture 10 In reactor chemistry
Lecture 11 Application of Nuclear Material Lecture 12 Nuclear Forensics

Use the lecture notes, chart of the nuclides, table of the isotopes, and web links to answer the following questions.

1. (20 Points) The separation of Pu from U in PUREX is achieved by reduction.

   1.1. What is the reduced Pu metal ion that is backextracted from the organic phase to the aqueous phase? _____

   1.2. Select the reductants that have been used in the PUREX process.

❒ H_2 ❒ $[Fe(CN)_6]^{4-}$ ❒ $NH_3OH^+NO_3^-$ ❒ Na ❒ U^{4+} ❒ $Fe(H_2NO_3S)_2$

   1.3. What are suitable nitric acid concentrations for the initial extraction of U and Pu into the organic phase?
❒ 1.0 M ❒ 2.0 M ❒ 3.0 M ❒ 4.0 M ❒ 5.0 M ❒ 6.0 M ❒ 7.0 M

   1.4. What is the organic ligand in the PUREX process? _____

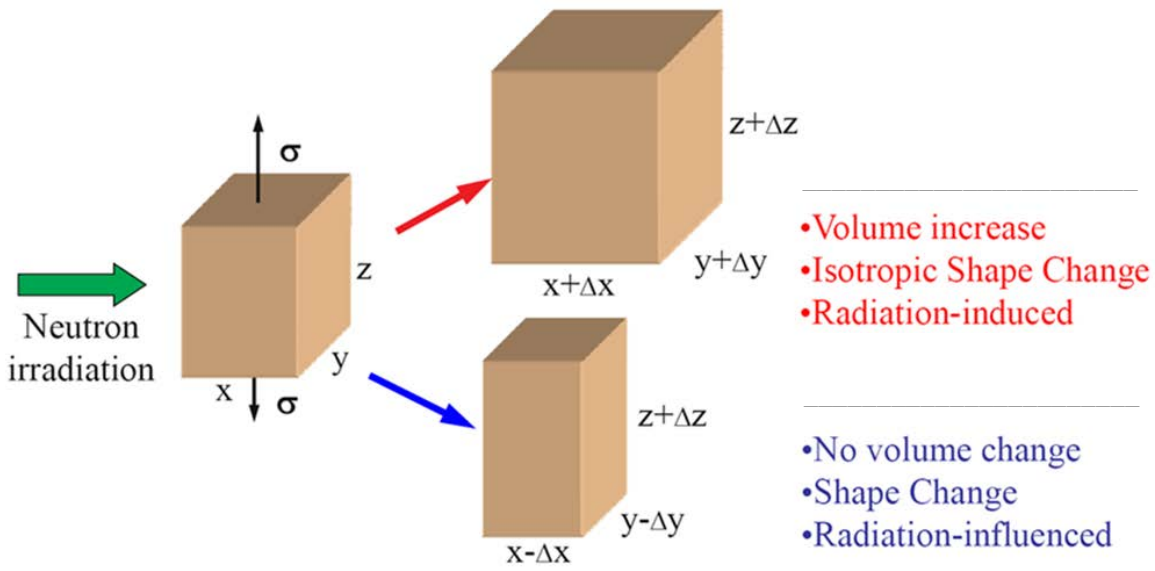
   1.5. What is the oxidation state of the initially extracted uranium in the PUREX process? _____

2. (30 Points) Where is one likely to find a higher Pu concentration in used nuclear fuel?

   2.1. What is reason for the higher Pu concentration in the used nuclear fuel? _____

   2.2. Identify the fission products which have distributions in nuclear influenced by thermal processes?
❒ Mo ❒ Cs ❒ Xe ❒ Sr ❒ Kr ❒ Zr

2.3. Swelling and creep are physical changes in materials that can be induced by radiation. Identify swelling and creep from the figure below?



2.4. Perovskite phases (ABO_3) can form in nuclear fuel. What is reason this phase can form in fuel?

❒ High noble gas fission product formation ❒ Fuel-cladding chemical interactions

❒ Concentration of fission elements Sr, Zr, and lanthanides exceed UO_2 solubility limit

❒ Role of coolant in fuel chemistry ❒ Formation of fission element solids-solutions with UO_2

3. (20 Points) Consider the following question on isotopes

3.1. What is the role of ^{241}Am in smoke detectors?

_____

3.2. The isotope ^{223}Ra is used in the radiopharmaceutical Xofigo.

3.2.1. Is this a diagnostic or therapeutic radiopharmaceutical? _____

3.2.2. How is the isotope ^{223}Ra produced for this application?

❒ $^{223}Fr(p,n)^{223}Ra$ ❒ $^{232}Th(p,^{10}Li)^{223}Ra$ ❒ $^{226}Ra(n,\gamma)^{227}Ra$, followed by decay to form ^{223}Ra

3.3. The isotope ^{238}Pu is used as a power source for space exploration.

3.3.1. Identify methods used to produce ^{238}Pu for this application?

❒ $^{237}Np(n,\gamma)^{238}Np$, followed by ^{238}Np beta decay ❒ Alpha decay of ^{242}Cm ❒ $^{239}Pu(n,2n)^{238}Pu$

3.4. A 100 g sample of PuO_2, at 83.5 % ^{238}Pu, has what power? _____ W

4. (10 points) One has a mixture of metal ions as chloride salts from a pyroprocessing separation route. The metal chlorides can be separated by volatility if a species vapor pressure above 1.0 Bar can be achieved. Select those species that will be separated from the salt at 550 °C using the figure below.

❒ CsCl ❒ $PuCl_4$ ❒ $MoCl_5$ ❒ UCl_4 ❒ UCl_3 ❒ $ZrCl_4$ ❒ $TeCl_4$

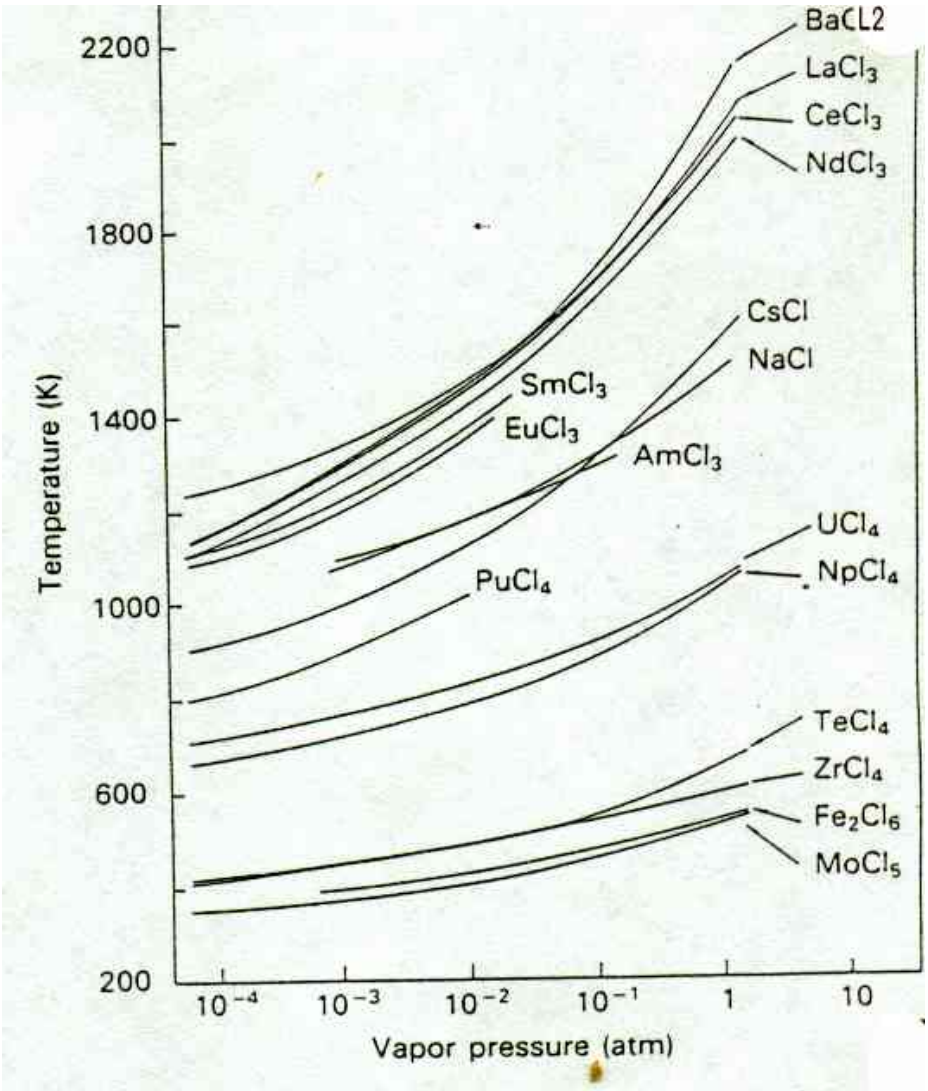


Fig. 4. Vapor pressure of chlorides as a function of temperature.[15,22,23]

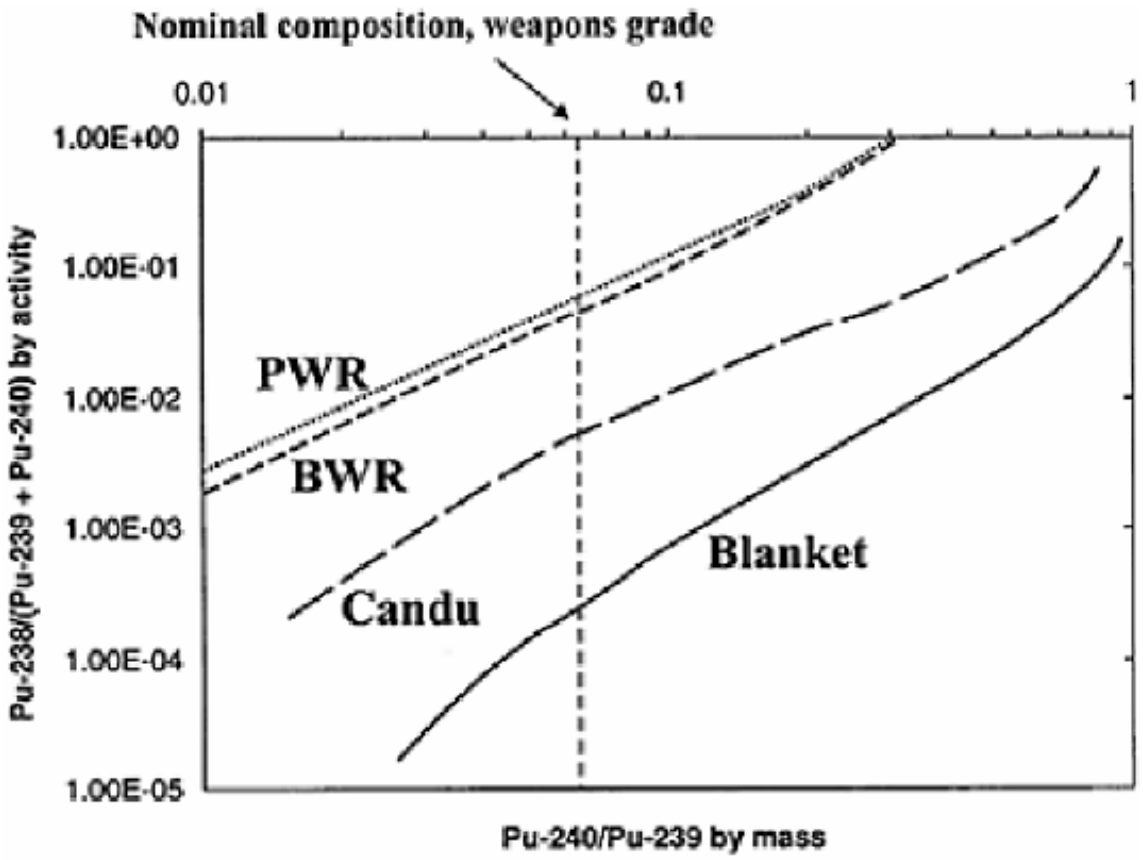
5. (10 Points) A sample of interdicted Pu is evaluated. The resulting data is below.

Isotope	^{238}Pu	^{239}Pu	^{240}Pu
Activity (Bq)	978	7.16E4	2.62E4
Mass (g)		3.12E-5	3.12E-6

5.1. What was used to produce the Pu? _____

5.2. The interdicted Pu sample is an alloy. What alloying element would be a signature for device material?

❒ Al ❒ Ga ❒ Nb ❒ Zr ❒ Mo ❒ Hf



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