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

TMT4320 Nanomaterials, fall 2015

EXERCISE 6

Guidance: Wednesday 30th September, 18:15-20:00, H3
Due date: Monday 5th October, 14:00, boxes outside R7 or on It's learning

PROBLEM 1

Given the reduction reactions and reduction potentials below (aqueous solution, 25 °C), which of the reducing agents H_2, $NaBH_4$ and $N_2H_4 \cdot H_2O$ can theoretically be used to reduce cobalt ions (Co^{2+}) and gold ions (Au^+) to the respective metals?

$Co^{2+} + 2e^- \leftrightarrow Co\ (s)$ $\quad E° = -0.28$ V
$Au^+ + e^- \leftrightarrow Au\ (s)$ $\quad E° = 1.69$ V

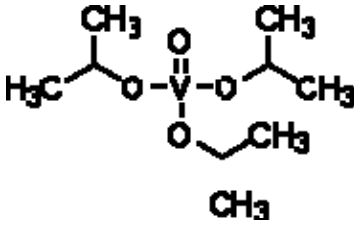
$2H^+ + 2e^- \leftrightarrow H_2$ $\quad E° = 0.00$ V
$B(OH)_3 + 7H^+ + 8e^- \leftrightarrow BH_4^- + 3H_2O$ $\quad E° = -0.481$ V

$N_2H_4 \cdot H_2O \leftrightarrow N_2H_5^+ + OH^-$
$N_2 + 5H^+ + 4e^- \leftrightarrow N_2H_5^+$ $\quad E° = -0.23$ V

PROBLEM 2

Sol-gel synthesis can be used to produce different types of metal oxides.

a) V_2O_5 can be synthesized using a sol-gel process. This process involves two basic steps. The first step is the hydrolysis of the precursor. Given the precursor vanadium tri-isopropoxide oxide ($VO[O(CH_3)_2CH]_3$) (see molecular structure below) write down the hydrolysis reaction that occurs when water is added and explain the reaction briefly in a couple of sentences.



b) The second step in the sol-gel synthesis is the condensation/polymerization reaction. Condensation can occur by two different reactions; oxolation (water condensation) and alkoxolation (alcohol condensation). Both reactions are condensation reactions in which oxobridges (-O-) are formed. Describe the two reactions and write out the reaction equations using the precursor given above.

c) In a sol-gel process used to produce V_2O_5, there is also a third component present, which is acetone. What is the purpose of acetone in this case and how does a lower or higher concentration of this component affect the synthesis?

d) When a sol-gel is heat treated and dried, the chemical composition generally is not changed. However, the product can be defined by its morphology. The three different possible products are ambigels, xerogels and aerogels. Describe these different products in terms of morphology and explain how these can be obtained in terms of different production methods used (f.ex. why do you obtain an ambigel instead of a xerogel?).

e) What is the Pechini method and what are the main differences compared to the standard sol-gel method for synthesizing for example SiO_2? Below is a list of ingredients used to form $BaTiO_3$ by the Pechini method. Classify the ingredients in terms of purpose in the reaction and describe briefly what they do?

$BaCO_3$
$Ti(O^iPr)_4$
Citric acid
Ethylene glycol