Examination

"Chemical Material Technology – Syntheses Techniques"

Date: February 08th, 2019 **Max. 50 Points**

Name, Given name: **Enrolment number**

Please only use these sheets (you might also use the reverse)!

Task 1) (6 Points)

Solid State Reactions

a) Describe the fundamental physical mechanism of a solid state reaction, e.g. for the formation of $MgAl_2O_4$ from MgO and Al_2O_3! (2 Points)

b) Sketch the concentration of defects in a solid state material as function of temperature between 0 K and its melting point! (2 Points)

c) Name two external factors to enhance the speed of a solid state reaction! (2 Points)

Task 2) (6 Points)

Nanoscale Materials

a) Calculate the specific surface area of an Y_2O_3 sample (density = 5.0 g/cm^3), which comprises out of monodisperse spherical particles (particle diameter = 100 nm)! (3 Points)

c) Please calculate the percentage of atoms, which are located at the surface of a Au_{147} cluster. The coordination number of the Au atoms is 12 (cubic close packaging) and the cluster comprises a central atom and three shells. The amount of atoms in shell number n of a cubic close packaged crystal is $10 \cdot n^2 + 2$! (3 Points)

Task 3) (4 Points)

Reductive Nitridation

$CaAlSiN_3$ can be synthesized by reductive nitridation, e.g. carbothermal, at high temperatures by using AlN, $CaCO_3$ and Si_3N_4 or SiO_2 as starting materials. Carbon or Hydrogen is a suitable reducing agent.
Please complete the four following reaction equations and balance them. (1 Point each)

a) $CaCO_3 + AlN + Si_3N_4 + N_2 + C \rightarrow$

b) $CaCO_3 + AlN + Si_3N_4 + N_2 + H_2 \rightarrow$

c) $CaCO_3 + AlN + SiO_2 + N_2 + C \rightarrow$

d) $CaCO_3 + AlN + SiO_2 + N_2 + H_2 \rightarrow$

Task 4) (8 Points)

Chemical Transport Reactions

Halogen lamps comprise Iodine to enhance lifetime and energy efficiency with respect to conventional incandescent lamps.

a) Which chemical transport reaction is the basis of this performance improvement? (2 Points)

b) Explain by using the van't Hoff equation and a simple graph in which way the temperature determines the chemical equilibrium! Why takes a back transport from the glass bulb to the tungsten wire place? (4 Points)

c) Please mention two other technical application areas of Chemical Transport reactions! (2 Points)

Task 5) (8 Points)

Luminescent Pigments

An inorganic luminescent pigment consists of a host lattice comprising activator ions, impurity ions, and lattice defects.

a) Explain the role of the three components, i.e. the activator Eu^{2+}, the impurity Cr^{3+}, and Oxygen vacancies for the optical properties of $BaMgAl_{10}O_{17}:Eu^{2+}$! (3 Points)

b) Loss mechanisms occur in the three steps of the energy flow in a luminescent material: Absorption process, energy transfer process, and emission process.
Give an example for a relevant physical loss mechanism during all three steps of the energy flow! (3 Points)

c) By which technical measures one can improve the long-term stability of a luminescent pigment, e.g. in low-pressure Hg discharge lamps? (2 Points)

Task 6) **(10 Points)**

Inorganic Luminescent Pigments

a) Name a reaction pathway for the synthesis of the following inorganic luminescent pigments! (1 Point each)

$CaS:Eu^{2+}$

$YVO_4:Eu^{3+}$

$Y_3Al_5O_{12}:Ce^{3+}$

$YPO_4:Bi^{3+}$

$Y_2SiO_5:Tb^{3+}$

b) Please mention for each of the aforementioned pigments a potential degradation mechanism! (1 Point each)

Task 7) (4 Points)

Nanoscale Inorganic Pigments

Please name two chemical methods

a) to synthesis nanoscale pigments (2 Points)

b) to stabilise nanoscale pigments in aqueous solution! (2 Points)

Task 8) (4 Points)

Solid State Reactions

Please mention suitable starting materials for the synthesis of the following functional materials and balance the reaction equations! (1 Point each)

a) $\rightarrow$ $BaMgAl_{10}O_{17}$

b) $\rightarrow$ Ba_2GdTaO_6

c) $\rightarrow$ $Ba_2Y_2Si_4O_{13}$

d) $\rightarrow$ $YBa_2Cu_3O_7$