Examination

“Chemical Material Technology – Syntheses Techniques”

Date: **Max. 50 Points**

Name, Given name: **Matrikel number:**

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

Task 1) (6 Points)

Solid State Reactions

a) Give two extrinsic factors, which determine the speed of solid state reactions?

b) Describe the fundamental steps of a solid state reaction, e.g. for the formation of $MgAl_2O_4$ from MgO and Al_2O_3!

c) Name two measures concerning the starting materials to enhance the speed of a solid state reaction!

Task 2) (6 Points)

Co-precipitation Reactions

a) Please name two advantages of the co-precipitation route for the synthesis of solid state materials!

b) Describe the synthesis of the luminescent pigment $(Y_{0.95}Eu_{0.05})_2O_3$ by using a co-precipitation process (starting materials shall be Y_2O_3 and Eu_2O_3)!

c) Give an example for a homogeneous precipitation process!

Task 3) (4 Points)

Carbothermal Nitridation

Eu^{2+} doped nitrides are applied as red emitting luminescent materials in phosphor converted LEDs. For the synthesis of nitride hosts the carbothermal nitridiation is an established synthesis route. Balance the reaction equations for the synthesis of the following nitride hosts!

a) $CaCO_3 + Si_3N_4 + N_2 + C \rightarrow Ca_2Si_5N_8$

b) $CaCO_3 + SiO_2 + N_2 + C \rightarrow Ca_2Si_5N_8$

c) $CaCO_3 + Al_2O_3 + Si_3N_4 + N_2 + C \rightarrow CaAlSiN_3$

d) $SrCO_3 + SiO_2 + N_2 + C \rightarrow SrSiN_2$

Task 4) (8 Points)

Chemical Transport Reactions

a) The purification of transition metals is often done by the Mond process. Give an example and explain the role of the temperature profile under the assumption that the purification reaction is endothermic!

b) Explain by using the van't Hoff equation and a simple graph in which way the temperature determines the chemical equilibrium!

$$\ln K = -\frac{\Delta H}{RT} + \text{const.}$$

c) Which kind of chemical transport reaction is used to enhance the lifetime of incandescent lamps?

Task 5) **(8 Points)**

Nanoscale Inorganic Pigments

a) Describe two chemical or physical methods to synthesize nano scale inorganic oxides!

b) Give two chemical or physical properties, which makes a difference between nano and micro scale materials! Explain the cause for these differences!

Task 6) (10 Points)

Luminescent Pigments

a) An inorganic luminescent pigment consists of a host lattice doped by activator ions, impurity ions, and defects. Explain the role of each component for the optical properties of a luminescent pigment, e.g. for $BaMgAl_{10}O_{17}:Eu^{2+}$, impurity Cr^{3+}, defects: Oxygen vacancies)!

b) Loss mechanisms occur in all steps of the energy flow in a luminescent material: The reduction of the quantum efficiency of a luminescent material is observed either if the absorbed energy does not reach the activator ion, or if the absorbed energy reaches the activator ion, but non-radiative channels exists at the cost of radiative return to the ground state, or if the emitted radiation is re-absorbed by the luminescent material.
Give an example for a relevant physical loss mechanism during all three steps of the energy flow!

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

d) Describe the role of a halide flux, e.g. SrI_2, during the synthesis of SrS:Eu from SrS and EuS!

Task 7) (8 Points)

Ion Conductors

a) Sketch a graph showing the dependence of the conductivity σ on the temperature for a solid state material (x-axis: 1/T, y-axis log σ). Please also assign the area of intrinsic and extrinsic contributions to the conductivity!

b) Give an example for a cation and for an anion conductor and mention the technical application area!

c) How can you enhance the ion conductivity of NaCl and of TiO_2 by doping these solid state compounds? Please give also a simple defect equation for both examples!