Examination

"Chemical Material Technology – Syntheses Techniques"

Date: February 09th, 2018   **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 steps of a solid state reaction, e.g. for the formation of $MgAl_2O_4$ from MgO and Al_2O_3! (2 Points)

b) Name three main factors that determines the speed of a solid state reaction! (2 Points)

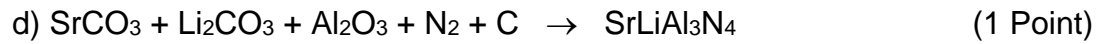c) Name two measures to enhance the speed of a solid state reaction! (2 Points)
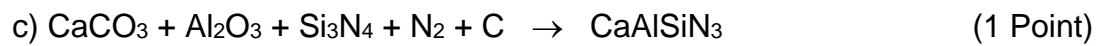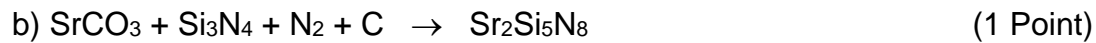
Task 2) **(6 Points)**

Co-precipitation Reactions

a) Please name two advantages of the co-precipitation route for the synthesis of solid state materials! (2 Points)

b) Describe the synthesis of the fluorescent lamp phosphor $(Y_{0.95}Eu_{0.05})_2O_3$ by using a co-precipitation process (starting materials shall be Y_2O_3 and Eu_2O_3)! (2 Points)

c) Give an example for a homogeneous precipitation process! (2 Points)

Carbothermal Nitridation

Eu^{2+} doped silico nitrides are applied as red and green 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) $CaCO_3 + SiO_2 + N_2 + C \rightarrow Ca_2Si_5N_8$ (1 Point)

b) $SrCO_3 + Si_3N_4 + N_2 + C \rightarrow Sr_2Si_5N_8$ (1 Point)

c) $CaCO_3 + Al_2O_3 + Si_3N_4 + N_2 + C \rightarrow CaAlSiN_3$ (1 Point)

d) $SrCO_3 + Li_2CO_3 + Al_2O_3 + N_2 + C \rightarrow SrLiAl_3N_4$ (1 Point)

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? (4 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)

Task 5) **(8 Points)**

Hydrothermal Synthesis

a) Sketch a reactor system for the hydrothermal growth of Quartz crystals (4 Points)

b) By which chemical measure one can enhance the speed of the hydrothermal growth of Quartz and Ruby crystals? (2 Points)

c) Please mention two other gemstones, which evolve in nature due to a hydrothermal process! (2 Points)

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 $Lu_3Al_5O_{12}:Ce^{3+}$, impurity Fe^{3+}, defects: Oxygen vacancies)! (3 Points)

b) Name the most important degradation mechanisms for the following luminescent pigments! (1 Point each)

$BaSi_2O_5:Pb^{2+}$

$BaMgAl_{10}O_{17}:Eu^{2+}$

$Zn_2SiO_4:Mn^{2+}$

$Sr_2SiO_4:Eu^{2+}$

$CaAlSiN_3:Eu^{2+}$
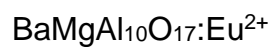
c) Show the role of a halide flux, e.g. ZnI_2, during the synthesis of the orange emitting phosphor ZnS:Mn from ZnS and MnS by the use of a simple sketch! (2 Points)

Task 7)   **(8 Points)**

Colour Pigments

a) Name three important physical properties relevant for the quality of a microscale colour pigment (4 Points)

b) Explain the physical mechanisms for the absorption process in the following colour pigments! (1 Point each)

$Na_8Al_6Si_6O_{24}S_2$ (blue)

$ZnCo_2O_4$ (green)

$BiVO_4$ (yellow)

Pb_3O_4 (red)