Examination

“Chemical Material Technology – Syntheses Techniques”

Date: July 10th, 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 $LaAlO_3$ from La_2O_3 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 key factors to enhance the speed of a solid state reaction! (2 Points)

Task 2) (6 Points)

Co-precipitation Reactions

Describe by the use of reaction equations the syntheses of the following functional materials by the co-precipitation method! (3 Points each)

a) $ZnFe_2O_4$ Starting materials: ZnO, Fe_2O_3

b) $(Y_{1-x}Eu_x)_2O_3$ Starting materials: Y_2O_3, Eu_2O_3

Task 3) (4 Points)

Carbothermal Nitridation

$Ca_2Si_5N_8$ can be synthesized by reductive nitridation, e.g. carbothermal, at high temperatures by using $CaCO_3$ 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) $CaCO_3 + Si_3N_4 + N_2 + C \rightarrow$

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

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

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

Task 4) (8 Points)

Chemical Transport Reactions

Halogen lamps comprise Iodine or Bromine 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 $CaAlSiN_3:Eu^{2+}$! (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 towards humidity of a luminescent pigment, e.g. for application in phosphor converted LEDs? (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 methods

a) to synthesis nanoscale pigments (2 Points)

b) to determine the particle size of nanoscale pigments! (2 Points)

Task 8) (4 Points)

Particle Coatings

a) Please mention a requirement on a suitable coating material for the protection of optical pigments! (1 Point)

b) A 100 g sample of $BaMgAl_{10}O_{17}$:Eu ($\rho(BaMgAl_{10}O_{17})$ = 3.8 g/cm^3), which consists of monodisperse spherical particles with a diameter of 5 µm shall be coated by MgO. Calculate the required amount of MgO to coat all particles by a dense and 50 nm thick coating layer (ρ(MgO) = 3.58 g/cm^3). How much $Mg(NO_3)_2$ is required as precursor for the $Mg(OH)_2$ precipitation? (3 Points)