

# Examination

## Chemical Technology of Materials

M.Sc. Chemical Engineering / Material Science and Engineering

February 01<sup>st</sup>, 2024

(Part: Prof. Dr. Thomas Jüstel)

Name, Given name: \_\_\_\_\_

Enrolment number: \_\_\_\_\_

Birthday: \_\_\_\_\_

Duration: 180 minutes (for both parts)

Achievable score: 50 Points (this part)

**Please use these sheets only (you might also use the reverse)! Please employ IUPAC units solely. Assign axes of graphs and parts of sketches properly!**

**Success!**

**Task 1)****(10 Points)****Solid State Reactions**

- a) Explain why reaction in the solid state take place only slowly in most cases! What can be done to enhance the reaction rate? (2 Points)
- b) Explain the formation of the cubic spinel  $\text{MgAl}_2\text{O}_4$  from the starting materials  $\text{Al}_2\text{O}_3$  and  $\text{MgO}$  by a simple sketch? (2 Points)
- c) Fluxes are often used in solid state chemistry. Please explain by a simple sketch, why for the synthesis of oxides often fluoride fluxes are involved! (3 Points)
- d) Please name three relevant parameter for the selection of a flux to be used for the synthesis of a solid state compound such as  $\text{Lu}_3\text{Al}_5\text{O}_{12}$ ! (3 Points)

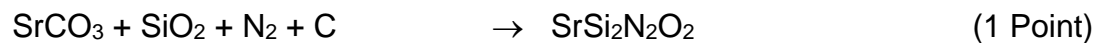
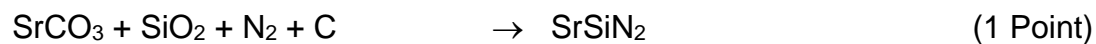
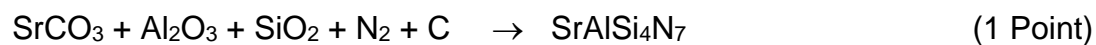
## Task 2)

(10 Points)

### Carbothermal Nitridation

$\text{Eu}^{2+}$  doped silico (oxy) nitrides are applied as red, yellow and green emitting luminescent materials in phosphor converted LEDs. For the synthesis of respective nitride hosts the carbothermal nitridation is widely applied.

a) Balance the reaction equations for the synthesis of the following nitride compounds! (6 Points)



b) Mention two carbon sources, which can easily decompose towards activated carbon and are thus useful starting materials for carbothermal reactions! (2 Points)

c) The mineral Sinoit, which is an impact mineral, has the approximated chemical composition  $\text{Si}_2\text{N}_2\text{O}$ . Speculate about the reaction sequence towards its formation during an meteor impact in quartz! (2 Points)

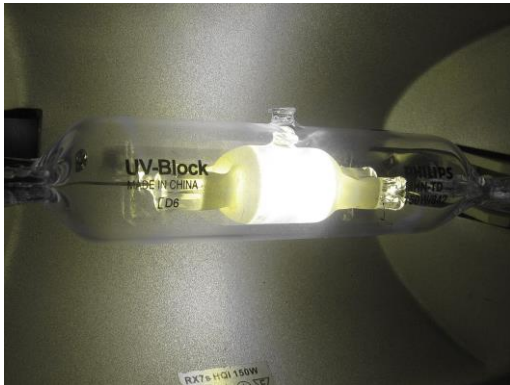
### Task 3)

(10 Points)

#### Chemical Transport Reactions

Halogen (incandescent) lamps comprise Iodine or Bromine to enhance lifetime and energy efficiency with respect to conventional incandescent lamps.

- Which chemical transport reaction is the basis of this performance improvement? (2 Points)
- 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)
- Please mention two other technical application areas of Chemical Transport reactions! (2 Points)
- The light emitting structure of metal halide discharge (MHD) lamps is an internal glowing burner (see image) made from corundum  $\text{Al}_2\text{O}_3$ , which is filled by iodides, such as  $\text{NaI}$ ,  $\text{InI}_3$ ,  $\text{DyI}_3$ , and  $\text{TmI}_3$ . Explain by a simple sketch and respective chemical transport reactions the phenomenon of wall corrosion! (2 Points)



## Task 4)

(10 Points)

### Synthesis of Nanoscale Structures

- a) Describe the polyol method for the preparation of nanoscale particles by using a respective example! (2 Points)
- b) The Pechini method is applied for the synthesis of many nanoscale oxides. Mention reasonable starting compounds and explain the modification of the synthesis by the use of an oxidizing metal salt such as nitrates! (2 Points)
- c) Many 2D nanoscale structures, e.g. semiconductor chips, are epitactically grown by CVD. Please name the reaction equation for the production of an (Al,In,Ga)P layer! (2 Points)
- d) Explain the process of plasma enhanced chemical vapor deposition (PCVD)? (2 Points)
- e) Define the term fluid bed (FB) CVD and name an application area! (2 Points)

**Task 5)****(10 Points)****Production of single crystals**

- 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) Single crystals for laser gain media are often grown by the Czochralski technology. Sketch the process and explain advantages and disadvantages of this technique w.r.t. the cost and quality of laser crystals! (4 Points)