Exercises: Stoichiometry in Solid State Chemistry

1) Calculate the elemental composition in mass percent, i.e. the theoretical elemental analysis of the blue pigment $KFe[Fe(CN)_6]$ as well as of the blue emitting phosphor $Sr_5(PO_4)_3Cl:10\%Eu^{2+}$!

2) How many moles of La, Ce, Tb, P and O comprise 100 kg of $LaPO_4:Ce^{3+}(10\%)Tb^{3+}(30\%)$?

3) Establish the following (redox)reaction equations!
a) $La_2O_2CO_3 + MgCO_3 + Al_2O_3 \rightarrow LaMgAl_{11}O_{19} + CO_2$
b) $SrCO_3 + H_3BO_3 \rightarrow SrB_4O_7 + H_2O + CO_2$
c) $CaH_2 + AlN + Si_3N_4 + N_2 \rightarrow CaAlSiN_3 + NH_3$
d) $NH_4H_2PO_4 + CeO_2 + H_2 \rightarrow CePO_4 + H_2O + NH_3$
e) $Pr_6O_{11} + NH_4Cl + CO \rightarrow PrOCl + H_2O + NH_3 + CO_2$
f) $MgO + MgF_2 + GeO_2 \rightarrow Mg_8Ge_2O_{11}F_2$

4) Calculate the amount of educts to be weighed for the synthesis of 10 g of the following PDP phosphors! Use oxides as educts, only (Ln_2O_3, V_2O_5, P_2O_5)!
a) $(Y_{0.8}Gd_{0.2})VO_4$
b) $(Y_{0.92}Eu_{0.08})VO_4$
c) $(Y_{0.72}Gd_{0.2}Eu_{0.08})VO_4$
d) $(Y_{0.72}Gd_{0.2}Eu_{0.08})(V_{0.8}P_{0.2})O_4$

Comment: No redox reaction takes place for these reactions!

5) Calculate the amount of educts to be weighed for the synthesis of 5 g of the following compounds! Use the following educts, only: MgO, Ln_2O_3, CeO_2, Pr_6O_{11}, Tb_4O_7, H_3BO_3, $MnCO_3$! Take into account the charge and size of the dopants when substituting cations in the host structure!
a) YBO_3:2%Pr
b) $GdBO_3$:5%Tb
c) $GdBO_3$:10%Ce
d) $GdBO_3$:5%Ce,20%Tb
e) $GdMgB_5O_{10}$:10%Ce,30%Tb
f) $GdMgB_5O_{10}$:10%Ce,30%Tb,10%Mn

Comment: During these reactions redox processes take place, with CO acting as a reducing agents!

6) Establish the reaction equation for the synthesis of $Y_3Al_5O_{12}$ (YAG) doped with 2% Ce^{3+}, 20% Gd^{3+} and 0.1% Pr^{3+} and calculate the amount of educts needed to prepare 100 g of this LED phosphor! The synthesis consumes H_2 in order to establish a reducing atmosphere!