Question 1 – Ion-adsorption – Pt/TiO_2 [max. 30 points]

We consider the preparation of Pt/TiO_2 catalyst via ion-adsorption from an aqueous solution of a Pt-ions. For the used TiO_2 support the PZC=5 and the specific surface area is 50 m^2/g.

a) Describe an experiment for adsorption of a Pt-ion on TiO_2. In the description include which Pt-ion you want to use and provide other key parameters of the experiment. [10 points]
b) What is the difference between an 'outer sphere' complex and an 'inner sphere' complex after Pt-ion adsorption? Give an example of both including a simple drawing of both structures. [10 points]
c) For a Pt-ion it has been established that the effective surface area for adsorption on titania is 1 $nm^2 \cdot ion^{-1}$. We want to arrive at about 3 wt.% Pt loading on titania applying ion adsorption with this Pt-ion. Calculate the maximum Pt loading (wt% Pt on total mass of Pt/TiO_2) that can be achieved by Pt-ion adsorption for this titania support. Describe in 2-3 sentences how you would carry out the synthesis of 3 wt.% Pt/TiO_2. [10 points]
   [Pt atomic weight = 195 g/mol; $N_{av}=6.0*10^{23}$ atoms$\cdot mol^{-1}$]

Question 2 – Deposition precipitation – Ni/SiO_2 [max. 30 points]

We consider deposition precipitation (DP) for the synthesis of a silica-supported nickel catalyst (Ni/SiO_2). We start from an aqueous solution of nickel nitrate at pH=2 and urea is used as the precipitating agent. The silica support is suspended as a powder in the solution . The slurry of support and dissolved metal salt is heated to bring about the hydrolysis of urea and thereby the precipitation of nickel compounds that takes place largely at pH=6.

a) Provide the two main chemical reaction equations that occur during the DP described above. [10 points]
b) Sketch the pH as a function of time (0-6 hours) for this DP. [10 points]
c) Explain in 2-3 sentences the overshoot in the pH curve that is observed after about 0.5-1.0 hours. [10 points]

Question 3 – Impregnation and drying – Co/SiO_2 (make use of the article) [max. 40 points]

Please consider the article that has been provided to you for this exam. Answer the following questions typically in 2-3 sentences per question.

a) What scientific question(s) do the authors want to answer with this study? [10 points]
b) What approach do they follow to answer these questions? Describe briefly the most relevant materials and techniques used. [10 points]
c) Figure 2 contains key results on which the main conclusions of the paper are based. Describe the differences between Fig 2-a and Fig 2-b. Also describe how these differences are interpreted by the authors and which conclusions they draw from these. [10 points]
d) Based on what you learned in this course, what criticism could you provide on this study? How would you propose to prove or disprove your criticism by extra experiments? [10 points]