

Typical Questions for ChE 430 Oral Exam:

MODULE 1

- 1.1 Can you explain the difference between top-down and bottom up approaches to the synthesis of nanomaterials ?
- 1.2 Can you list top-down approaches to the synthesis and describe one or two of them more in details ?
- 1.3 Can you list bottom-up approaches to the synthesis and describe one or two of them (excluding colloidal synthesis) more in details ?

MODULE 2

- 2.1 Can you define colloidal nanocrystals ?
- 2.2 Can you discuss quantum confinement ?
- 2.3 If you decrease the size of QDs, which change do you expect in the absorption and emission peaks? Why ?
- 2.4 Can you discuss surface plasmon resonance absorption ?
- 2.4 How does the spectrum of gold nanorods compare to that of gold nanospheres ? why ?
- 2.5 Can you mention the most common techniques to characterize the nanocrystal inorganic core ? What about the organic shell ?
- 2.6 What happens to the xrd peaks when we change the nanocrystal size ? what happens when we change the shape ?

MODULE 3

- 3.1 Can you define homogeneous nucleation ?
- 3.2 Can you define heterogeneous nucleation ?
- 3.3 Can you discuss the classical nucleation theory and the La Mer diagram ?
- 3.4 Within the framework of the classical nucleation theory, can you explain what happens to the size distribution in diffusion-limited regime ? What about the reaction-limited regime ?
- 3.4 Can you explain the difference between classical and non classical nucleation theory ? Which techniques have been used so far to study nucleation and growth pathways ?

MODULE 4

- 4.1 Can you discuss the methods to control size monodispersity ?
- 4.2 Can you discuss the methods to control the nanocrystals size ?
- 4.3 Can you comment on how you can use ligands to control nanocrystal size ?
- 4.4 How does temperature influence nanocrystal size ?
- 4.5 When is the reaction under kinetic control ? When is the reaction under thermodynamic control ?
- 4.6 What is the Wulff construction ?
- 4.7 Can you discuss about the different reaction parameters which allow you to modulate the nanocrystal shape ?
- 4.8 Can you comment on how ligands control nanocrystal shape?

MODULE 5

- 5.1 Can you make some examples which illustrate the advantage of building nanocrystalline heterostructures ?
- 5.2 Can you describe the seeded-growth approach to nanocrystalline heterostructures?
- 5.3 Can you comment on the relationship between the free energy of homogeneous and heterogeneous nucleation ?
- 5.4 What is the lattice mismatch and how does it govern the formation of nanocrystalline heterostructures ?
- 5.5 Which properties can you modify by doping ?

MODULE 6

- 6.1 Can you comment on how ligands can impact nanocrystal properties ?
- 6.2 Can you list different deposition techniques and describe more in details one of your choice ?
- 6.3 When and why nanocrystal self-assemble ? (single component, binary, aerogels)

MODULE 7

- 7.1 What is a n-type semiconductor ? Please comment on Fermi level and its majority carriers
- 7.2 What is a p-type semiconductor ? Please comment on Fermi level and its majority carriers
- 7.3 What is a p-n junction and how does it work in the context of a diode?
- 7.4 What is a p-n junction and how does it work in the context of a solar cell ?
- 7.5 Can you describe the performance metrics of a solar cell ?
- 7.6 What are the first, second, third generation solar cells ?
- 7.7. Can you list some of the third generation solar cells and discuss in more details one of them?
- 7.8 What did you learn about perovskite solar cells ?
- 7.9 How many types of QD solar cell geometry can you name ? Can you describe any in more details ?(CQD-sensitized solar cells, Schottky junction, heterojunction)

MODULE 8

- 8.1 What are the two main reactions we refer to when discussion energy storage in chemical bonds ?
- 8.2 Can you name the figures of merit for electrocatalysts ?
- 8.3 Can you describe and draw the main components of a water electrolyzer?
- 8.4 How many different type of water electrolyzers do we have ? Can you describe them ?
- 8.5 Can you write the water oxidation and reduction reaction in an acid and basic electrolyte ?
- 8.6. Which class of HER catalysts has been investigated by colloidal chemistry ?
- 8.7 What is the best catalyst so far among earth abundant materials for OER ?
- 8.8 What is a fuel cell ?
- 8.9 What are the main components of a fuel cell ?
- 8.10 How many types of fuel cells exist ?

8.11 Which class of ORR has been widely investigated by colloidal chemistry ? Do you remember some of the main conclusions ?

MODULE 9

9.1 Is there a difference between photoelectrochemistry and photocatalysis ? If yes, discuss.

9.2 When was the first PEC cell and which were the main components at the time ?

9.2 Can you describe and draw the main components of a photoelectrochemical cell nowadays?

9.3 What are the requirements of a light absorber to drive water splitting?

9.4. Is it better one light absorber or two to perform water splitting? why ?

9.5 Can you describe the different reactor design for solar-driven water splitting? (baggie type vs panel-type)

9.6 Why nanostructuring might be beneficial in a PEC panel-type device ?

9.7 Can you mention common photocathode materials in a PEC device ? What about the common photoanodes ?

9.8 What are the challenges with photoanodes in PEC ?

9.9 Can you describe the different types of particle—based photocatalytic reactors ? (one step, two steps with redox shuttle, two steps with solid mediator)

9.10 What are the main performance metrics in solar-driven water splitting?