

University of Canterbury

## End of Year Examinations 2009

Prescription Number(s):	CHEM 410
Paper Title:	Nanotechnology

Time Allowed: TWO HOURS

Number of pages: SIX

This paper is divided into **TWO** sections of equal of value.

Section A: Answer **ONE** question from this section.

Section B: Answer question 3 and **TWO** questions from 4-6.



**SECTION A**

(Answer **ONE** question from this section.)

1. Immobilisation of molecular species on surfaces is an important aspect of many nanosensors and nanosensing strategies. A common approach is to self-assemble thiols or disulfides on metals such as gold and silver.

(a) Write brief descriptions of the following with respect to the reaction of thiols and disulfides with gold or silver:

- (i) The chemistry involved;
- (ii) Typical reaction conditions;
- (iii) Methods for forming layers containing more than one modifier;
- (iv) Properties of the resultant layers and factors that determine their stability and order;
- (v) Advantages and limitations of the immobilization method for the construction of sensing elements.

(b) For **ONE** of the following:

*sensing of antigens based on the conductance of gramicidin ion-channels in an immobilized lipid membrane*

**OR**

*sensing of streptavidin based on localized surface plasmon resonance spectroscopy of triangular silver nanoparticles*

- (i) describe the composition of the immobilized layer(s);
- (ii) explain how the sensing strategy works;
- (iii) explain features of the immobilized layer(s) which are essential for optimized sensing performance.

**TURN OVER**

2. (a) Define the terms *sensor* and *nanosensor*. Very briefly describe a specific nanosensor, explaining how it meets your definition of the term.
- (b) Detection of specific sequences of single-stranded DNA (ss-DNA) has been demonstrated using many different nanosensing strategies. Discuss how *two* of the nanosensors or nanosensing strategies listed below could be used to detect, with high sensitivity, specific ss-DNA sequences. Your answer should include a description of the construction of the sensing element or sensing components and the transduction method. Indicate particular advantages and limitations of the sensors/sensing strategies you describe.
- silicon nanowire field-effect transistor
  - distance-dependent optical properties of gold nanoparticles
  - gold-nanoparticle amplified microgravimetric sensor
  - localized surface plasmon resonance spectroscopy of triangular silver nanoparticles

**SECTION B**

(Answer question 3 and **TWO** questions from 4-6.)

3. (a) Compare and contrast properties of metal colloids and clusters
- (b) Why are metal nanoparticles much better catalysts than bulk metals?
- (c) What important roles do surfactants play during synthesis of colloids?

Answer **TWO** questions (4 - 6):

4. (a) Explain, using zeolites as an example, the concepts that underpin the bottom-up approach towards fabrication of nanostructured materials.
  - (b) Name a famous graduate of the University of Canterbury who made a significant contribution to the field of zeolite chemistry.
  - (c) Give an example of the top-down approach towards fabrication of porous materials (membranes) and explain one disadvantage of this approach compared with alternative bottom-up approaches.
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5. Development of adequate characterization methods is of paramount importance for progress in materials chemistry and nanotechnology.

Give an account of transmission electron microscopy (TEM) as a tool for characterization of heterogeneous catalysts. Your answer should contain:

- (a) an overview of principles;
- (b) discussion of advantages and disadvantages/limitations of this technique.

6. (a) Explain the structural differences between the following forms of 1-D carbon (drawing corresponding structures schematically):
- (i) armchair, zig-zag and chiral single-walled carbon nanotubes (SWNTs);
  - (ii) carbon nanofibre, multi-walled carbon nanotube and a bundle of SWNTs.
- (b) Compare and contrast arc discharge, laser ablation and thermal chemical vapour deposition methods for carbon nanotube growth.

**END OF PAPER**