

University of Canterbury

## End-of-year Examinations 2009

Prescription Number(s): CHEM 343

Paper Title: Applied Physical Chemistry

Time Allowed: Two hours

Number of pages: Five

Answer **ALL** questions.

Total marks: 120

*TURN OVER*



1. (60 marks)

Answer **THREE** of the following (a) – (d):

- (a) (i) Define the term **single-site heterogeneous** catalyst.
- (ii) Contrast single-site heterogeneous catalysts with model catalyst systems based on ideal flat (single crystal) metal surfaces.
- (iii) Discuss in detail two modern approaches towards fabrication of single-site heterogeneous catalysts.
- (b) (i) Explain the difference between activity and selectivity of a catalyst.
- (ii) Define the term **turnover frequency**.
- (iii) Define the term **turnover number**.
- (iv) Explain in detail why precise understanding of the nature of the active site of the catalyst is required in order to accurately define turnover frequency.
- (c) (i) Give a definition of a catalyst and provide an appropriate graphical illustration of the role of a catalyst in enabling the reaction to proceed.
- (ii) Name two major advantages and two major disadvantages of heterogeneous catalysts.
- (iii) Discuss the roles of physisorption and chemisorption in heterogeneous catalysis and provide an appropriate sketch of an energy plot as part of your answer.
- (d) (i) Give an account of transmission electron microscopy (TEM) as a tool for characterization of heterogeneous catalysts based on support immobilized metal nanoparticles. Contrast HRTEM vs. STEM and BF vs. DF modes.
- (ii) Explain what is meant by the **size effect** in catalytic activity of metal nanoparticles and give three reasons why such an effect could take place.

*TURN OVER*

2. (12 marks)

Answer **ONE** of the following (a) – (c):

- (a) Discuss the factors responsible for determining the melting point of an ionic liquid.
- (b) Liquids can be classified according to bond type. What are these classifications and what are the general properties of each of these classes?
- (c) (i) The equation below applies to what type of intermolecular force?

$$U = -(Ze\mu\cos\theta)/(4\pi\epsilon_0r^2)$$

- (ii) Define each of the symbols in the equation.

3. (24 marks)

Given below are data for five liquids.

Liquid	$\alpha$	$\beta$	$\pi^*$	$E_T^N$
<b>A</b>	0.98	0.66	0.60	0.762
<b>B</b>	0.00	0.00	-0.04	0.009
<b>C</b>	0.00	0.10	0.59	0.111
<b>D</b>	0.00	0.76	1.00	0.444
<b>E</b>	1.17	0.47	1.09	1.000

- (a) Define the parameters  $\alpha$ ,  $\beta$ ,  $\pi^*$  and  $E_T^N$  and explain how they are determined.
- (b) The five liquids, in random order, are:
- (1) n-hexane
  - (2) methanol
  - (3) benzene
  - (4) water
  - (5) dimethylsulfoxide (Me<sub>2</sub>SO).

Assign each of these liquids to one of the sets of data, **A–E**, and provide a rationale for each of your assignments.

4. (24 marks)
- (a) (i) Distinguish between orientational polarisability and induced polarisability.
- (ii) What combination of methods can be used to determine these properties?
- (b) Indicate fully what is meant by **FOUR** out of FIVE of the following terms:
- (i) Pair additivity
- (ii) Amphiprotic solvents
- (iii) Donor number, DN
- (iv) Local density augmentation
- (v) The Hildebrand solubility parameter,  $\delta$

**END OF PAPER**