

University of Canterbury

End of Year Examinations 2009

Prescription Number(s): CHEM 404

Paper Title: Analytical & Environmental Chemistry

Time Allowed: TWO HOURS

Number of pages: EIGHT

This paper is divided into **THREE** sections.

Answer **TWO** of the **THREE** sections (A – C).

All sections are of equal value (45 marks)

SECTION A

(Answer the one question in this section.)

1. (a) Outline the mechanisms by which cells are protected against toxic chemicals. (15 marks)
- (b) Which of the following compounds (A – C) is/are likely to be carcinogenic and why? (10 marks)

Compound A

Compound B

Compound C

- (c) Explain the theory of endocrine disruption. (10 marks)

TURN OVER

- (d) The natural ligand for the estrogen receptor is 17β -estradiol:

17β -estradiol

Bisphenol-A, the monomer used in polycarbonate plastic manufacture, has approximately 10^{-5} estrogen equivalents activity whereas testosterone, the male hormone, has no estrogen activity. Explain this in terms of structure activity relationships. (5 marks)

Testosterone

Bisphenol-A

- (e) Explain lethal synthesis in the context of cell toxicity. (5 marks)

SECTION B

(Answer question 2 and **either** question 3 **or** 4.)

(Compulsory question) (30 marks)

2. A large spill of a hydrophobic organic contaminant (HOC) has recently occurred at a hazardous waste facility creating a contaminated site.
- (a) Define the term **bioavailability**. As part of your answer explain what three criteria need to be met for a contaminant to be considered bioavailable.
 - (b) Outline the change in bioavailability of the HOC to terrestrial organisms that you would expect to occur with time. As part of your answer describe the sorption processes that would contribute to this change in bioavailability.
 - (c) Describe **TWO** types of chemical methods that could be used to assess the bioavailability of hydrophobic organic contaminants. Provide details of how these methods are carried out.
 - (d) Explain how you could use the chemical extraction methods from part (c) to measure the change in bioavailability with time. Describe the trend in results that you would expect to observe.

Answer **ONE** question: **either 3 or 4** (15 marks)

3. (a) With reference to Table 1, explain the differences in 0.01 M CaCl₂- and 0.05 M EDTA-extractable cadmium concentrations. Describe how these extractions would be carried out.

Table 1: Extractable cadmium content from urban garden soils using different extractants ($\mu\text{g/g}$ dry mass).

<i>Soil sample</i>	<i>Extraction method</i>	
	0.01 M CaCl ₂	0.05 M EDTA
Ilam	0.05	10.6
Sydenham	1.2	11.4
Port Hills	1.0	11.0
New Brighton	0.02	7.6

- (b) The soils will be used for a plant trial measuring cadmium uptake by lettuce. For which soil sample would you expect the lettuce plants to have the highest cadmium content? Explain.
- (c) Describe one other example of a method that could be used to measure the bioavailability of trace elements in soil instead of a bioassay.

4. (a) Describe **THREE** key soil properties that could explain the observed differences in earthworm tissue lead concentration in Table 2. For each soil property, outline the effect on bioavailability of Pb that you would expect to observe.

Table 2: Tissue lead concentrations for earthworms exposed to soils spiked with 2000 mg/kg lead for 28 days.

<i>Soil sample</i>	<i>Earthworm tissue Pb concentration (mg/kg dry weight)</i>
Canisteo	76.4
Pond Creek	566
Dougherty	416
Kirkland	40.6
Hanlon	183

- (b) Describe **THREE** processes that can reduce the bioavailability of trace elements in soil.

SECTION C

(Answer **TWO** of questions 5-7) (45 marks)

5. Show how the measurement of light stable isotope ratios in bone collagen can be used to study the diet of archaeological humans. What use might be made of this information?
6. Show how the chemical analysis of body fabric can be used to indicate the provenance of the ceramics.
7. What is tephrochronology, and what challenges does this pose for the analytical chemist?

END OF PAPER