JAMES COOK UNIVERSITY

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SCHOOL OF PHARMACY AND MOLECULAR SCIENCES
Chemistry Department

This paper must be handed in at the end of the Examination: Yes
Release to Library: No

SECOND SEMESTER EXAMINATIONS 2006

Cairns Campus

STUDENT NAME:
(*block letters*)

STUDENT NUMBER:

SUBJECT CODE: CH1011:03

SUBJECT NAME: CHEMISTRY FOR THE NATURAL SCIENCES

EXAMINER: Dr M. Liddell **PHONE NO:** (07) 4042 1275

DURATION OF EXAMINATION (hours): TWO (2) HOURS

PERUSAL TIME (minutes): FIFTEEN (15) MINUTES

TOTAL NUMBER OF QUESTIONS: 27

INSTRUCTIONS TO STUDENTS:
The exam is composed of two sections:
Section A - Multiple choice - 22 questions - 33%
Section B - Short answer - 5 questions - 67%
Total marks for paper = 100
Answer **ALL** questions. All questions are **not** of equal value.
Timings are indicated to allow approximately 15 minutes of check-over time.

MATERIALS TO BE SUPPLIED BY EXAMINATION SECTION:
Examination Booklets required: Yes
Multiple choice scanner sheets Scanner A- E: Yes

MATERIALS STUDENTS MAY USE:
Scientific calculator with no text storage facilities.
Access to an English Dictionary: Yes

SECTION A

MULTIPLE CHOICE QUESTIONS (EACH QUESTION IS WORTH 1.5 MARKS). ANSWER ALL QUESTIONS – SHADE WITH A PENCIL THE MOST CORRECT ANSWER ON THE MULTICHOICE SCANNER SHEET.
Timing: you should complete the multi-choice section in 30 minutes (≈ 1.5 minutes per question).

SECTION B

SHORT ANSWER QUESTIONS. (MARKS FOR EACH QUESTION ARE AS INDICATED) ANSWER EACH OF THE FIVE (5) QUESTIONS.

Question 1

Timing: you should complete this question in 16 minutes.

(a) (i) Silica (SiO_2) is an example of an amorphous, network covalent solid.
- **Define** an *amorphous solid.*
- **Define** a *network covalent solid* using SiO_2 to illustrate your answer
- What **physical properties** result from SiO_2 being a *network covalent solid* rather than a *molecular covalent solid*.

(ii) Ethanol is highly soluble in water as a result of hydrogen bonding. Using the ethanol / water system illustrate the features of an **intermolecular hydrogen bond** (ie. provide a figure) and clearly define the characteristics of a hydrogen bond.
- Would you expect the boiling point of ethanol to be higher or lower than difluoromethane – justify your answer?

(4 marks)

(b) (i) Provide **systematic names** for the following compounds:
- $SrBr_2$
- P_2O_5

(ii) Provide **formulae** for the following compounds:
- osmium(II) oxide
- hydroiodic acid

(4 marks)

(c) (i) Provide **electronic configurations** for the following ions:
- $Cl^{\ominus}$
- Cr^{+}

(ii) Provide the **atomic number**, **group number**, **mass number**, **number of electrons** and **number of neutrons** for ^{13}C.

(3 marks)

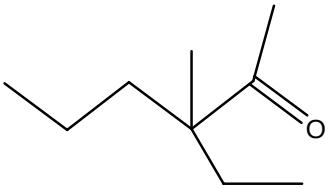
(d) How does **atomic size** vary across Period 2 in the Periodic Table?
- Explain this trend.
- What influence does the variation in size have on the **first ionisation energy** of sodium and chlorine.

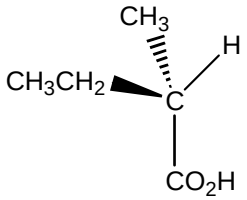
(3 marks)

Question 2

Timing: you should complete this question in 16 minutes.

(a) (i) Provide **IUPAC names** for the following compounds:





(ii) Write down **condensed structures** corresponding to the following systematic names :

- 2,4-hexadiyne
- *N*-methylheptanamine

(5 marks)

(b) Briefly discuss the following topics. [Your answer should consist of a few sentences together with any appropriate chemical structures]

(i) **Globular proteins** have complex 3D shapes which are a result in the first instance of their non-simple **primary structures**.

(ii) DNA is a biopolymer composed of simple **nucleotide monomer units** linked together.

(6 marks)

(c) There are many thousands of enzymes in every cell.

- What is an **enzyme**?
- Provide an **example** of an enzyme system: enzyme, substrate(s), product(s).
- Describe the mechanism (in terms of elementary steps) for the enzyme system you have chosen assuming that it obeys **Michaelis-Menton kinetics**.

(3 marks)

Question 3

Timing: you should complete this question in 14 minutes.

(a) A 2.69 g sample of PCl_5 was placed in a closed 1.00 L flask and heated to 250°C. Under these conditions the PCI_5 completely vaporised and dissociated according to the following equilibrium equation. $PCI_{5(g)} \rightleftharpoons PCI_{3(g)} + CI_{2(g)}$ The total pressure at equilibrium was 1.00 atm. Assume ideal behaviour for the gases. What are the partial pressures and mole fractions of PCI_5, PCI_3 and CI_2 in the reaction mixture?

(4 marks)

(b) A sugar solution is prepared by dissolving 34.2 g of sucrose ($C_{12}H_{22}O_{11}$) in 520 mL of water.

- What is the **water potential** of this solution in atmospheres in an open beaker at sea level, the temperature is 20°C?

(4 marks)

(c) In the atmosphere the formation of ^{14}C occurs according to the following scheme.

$$^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{14}_{6}C + {}^{1}_{1}H$$

- Demonstrate the principles of **conservation of atomic number** and **mass number** using this scheme.
- Explain the principles behind **radiodating** using ^{14}C to illustrate your answer.
- What is the difference between an **alpha emitter** and a **beta emitter**?

(4 marks)

Question 4

Timing: you should complete this question in 17 minutes.

(a) (i) Determine if the production of $SO_{3(g)}$ from $SO_{2(g)}$ and $O_{(g)}$ is a spontaneous reaction using the following data at 298K:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

	ΔH^o_f (kJ/mol)	ΔS^o(J/mol K)
$SO_2(g)$	-296.9	248.5
$SO_3(g)$	-395.2	256.2
$O_2(g)$	0	205.0

(ii) What is the **First Law of Thermodynamics**?

(5 marks)

(b) The cell voltage (e.m.f.) of the following cell at 298K was found to be 0.8795V.

Data: $E^o_{Fe^{3+}/Fe^{2+}} = +0.7050V$

$Sn_{(s)}$ | $SnSO_{4(aq)}$ c = 0.2M || $Fe_2(SO_4)_{3(aq)}$ c = 0.1M, $FeSO_{4(aq)}$ c = 0.1M | $Pt_{(s)}$

- What is the **cell reaction**?
- Calculate the $E^o_{1/2}$ for $Sn^{2+}_{(aq)}/Sn_{(s)}$.
- Calculate the **standard free energy change** for the cell reaction.

(5 marks)

(c) Calculate the **pH** of the following aqueous solution:

- 0.137 M sodium cyanide $K_A(HCN) = 4.80 \times 10^{-10}$

(5 marks)

Question 5

Timing: you should complete this question in 14 minutes.

(a) The hydrologic cycle has a major influence on rock formation and global climate.

- Make a sketch of the **hydrologic cycle** showing the major reservoirs and major fluxes.
- What is the **major buffer system** that controls the acidity of sea-water. Describe how this buffer system functions to control pH.

(4 marks)

(b) The atmosphere is conveniently divided into a number of regions including the mesosphere, stratosphere, thermosphere and troposphere.

- Provide a sketch indicating the **vertical location** of these regions relative to sea-level and the **temperature profile** in each region.
- What type of chemistry occurs in the **thermosphere**? Illustrate your answer with some illustrative chemical species that may be found in this region of the atmosphere.

(4 marks)

(c) The **drinking water** supply in South-East Queensland has become a major political issue as raw water supplies dwindle as the a result of a prolonged drought.

- In a sketch detail how a **municipal water treatment plant** is able to process raw water and turn it into a supply fit for consummation.
- The disinfection stage will become critically important if "grey water" is to be used to augment reservoir storage of raw water. Highlight the advantages and disadvantages of the various technologies that are available for disinfection.

(4 marks)

EQUATION LIST

$$\left(p + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$$

$$\sqrt{\overline{u^2}} = \sqrt{\frac{3RT}{M}}$$

$$\frac{R_1}{R_2} = \sqrt{\frac{M_2}{M_1}}$$

$p_i = p_i^{O}\, x_i$ $\qquad$ $p_i = p_T\, x_i$

$$z = \sigma\, \bar{u}_{rel}\, N$$

$$\lambda = \frac{\bar{u}}{z}$$

$$\Delta G^o = -RT\ell nK$$

$$K = K_p(p^o)^{-\Delta n}$$

$$\ell nK = \frac{-\Delta H^o}{RT} + \frac{\Delta S^o}{R}$$

$$\ell n\frac{K_2}{K_1} = \frac{-\Delta H^o}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\ell n[A_o] - \ell n[A] = kt$$

$$k = Ae^{-Ea/RT}$$

$$\ell n\frac{k_2}{k_1} = \frac{-Ea}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$t_{m\text{-}1/m} = ln(m) / k$$

For the cell reaction $aA + bB \rightarrow cC + dD$

$$E_{cell} = E^o_{cell} - \frac{RT}{nF} ln\left(\frac{[C]^c[D]^d}{[A]^a[B]^b}\right)$$

$$E^o_{cell} = E^o_{cathode} - E^o_{anode}$$

$$\Delta G = -nFE_{cell}$$

$$p_{Total} = \Sigma\, p_i$$

$$[i] = K_H\, p_i$$

$$p_i = (\%_i / 100)\, p_{atm}$$

$$\%_i = ppmv_i \times 10^{-4}$$

$$R.H. = \frac{p(H_2O)}{p(H_2O)sat.} \times 100\,\%$$

$$Flux = A / \tau$$

$$K_{sp} = [cation]^c[anion]^d$$

$$\pi = c_i RT$$

$$\Delta p = x_i\, p^o_{solvent}$$

$$\Delta T = K\, m_i$$

$$\delta = \left(\frac{R_{sample} - R_{standard}}{R_{standard}}\right) \times 10^3\ \text{‰}$$

$$10^3 \ln\alpha \approx \frac{A}{T^2} + B = \delta_A - \delta_B$$

$R = 8.314$ J mol^{-1} K^{-1} $= 8.314$ Pa m^3 mol^{-1} K^{-1}

1 atm. $= 1.013 \times 10^5$ Pa $= 760$ torr

$T(K) = T(^oC) + 273.15$

$F = 9.65 \times 10^4$ C mol^{-1}

1 mole of an ideal gas occupies 22.41 dm^3 at STP

$$\psi = \psi_\pi + \psi_p$$

TABLE 1

$CaCO_3 + 2H^+$	$\rightarrow Ca^{2+} + CO_2 + H_2O$
$CaCO_3 + H_2SO_4 + H_2O$	$\rightarrow CaSO_4.2H_2O + CO_2$
$4FeS_2 + 15O_2 + 14H_2O$	$\rightarrow 4Fe(OH)_3 + 8H_2SO_4$
$2SO_2 + 2H_2O + O_2$	$\rightarrow 2H_2SO_4$ (Mn cat.)

TABLE 2

Physical Quantity	**Name of Unit**	**Symbol for Unit**
Length	metre	m
Mass	kilogramme	kg
Time	second	s
Electric Current	ampere	a
Thermodynamic Temperature	kelvin	K
Amount of Substance	mole	mol
Volume	cubic metre	m^3
Frequency	hertz	Hz
Velocity	metre per second	ms^{-1}
Acceleration	metre per second squared	ms^{-2}
Density	kilogramme per cubic metre	$kg\ m^{-3}$
Molar Mass	kilogramme per mole	$kg\ mol^{-1}$
Concentration	mole per cubic metre	$mol\ m^{-3}$
Molality	mole per kilogramme	$mol\ kg^{-1}$
Force	newton	N
Pressure	pascal	Pa
Energy	joule	J
Electric Charge	coulomb	C
Electron Potential Difference	volt	V

PERIODIC TABLE
CH1011:03