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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 2005

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).

This section has been deleted it is just multi-choice of the same calibre as the modules.

SECTION B

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

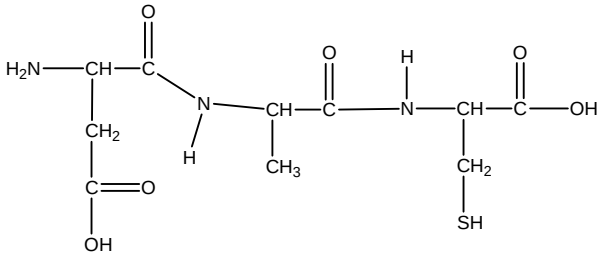
Question 1

Timing: you should complete this question in 16 minutes.

(a) (i) Solid materials have different bonding characteristics and physical properties.
- Provide an **example** of and **define** a *covalent molecular solid.*
- Will this material **conduct electricity** in the solid state? Explain your decision.

(ii) Clearly define an **intramolecular hydrogen bond** using the following tripeptide to illustrate your answer.
- Is this molecule likely to be **water soluble**?
  Explain your answer with respect to the hydrogen bonding ability of water.

(4 marks)



(b) (i) Provide **systematic names** for the following compounds:
- $TiBr_3$
- H_3PO_4

(ii) Provide **formulae** for the following compounds:
- ferric iodide
- potassium chloride

(4 marks)

(c) (i) Provide **electronic configurations** for the following elements:
- a period 4 metal which is commonly used in electrical wires.
- an alkaline earth metal which is a common constituent of limestone.

(ii) What is a pure **isotope**? Provide an example to support your answer.

(3 marks)

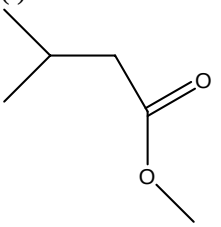
(d) Define the term **first ionisation energy**?
- How does this property vary across and down the periodic table? Explain these trends.

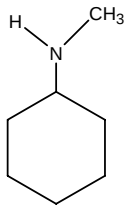
(3 marks)

Question 2

Timing: you should complete this question in 16 minutes.

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





(ii) Draw **skeletal *structures*** corresponding to the following systematic names :

- 3-methyl-2-butanol
- (*E*)-3-heptene

(6 marks)

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

(i) The **Haworth projection** of a monosaccharide indicates the cyclic hemiacetal structure that is the dominant form in solution.

(ii) Four **bases** are important in determining the primary structure of **DNA**.

(iii) **Lipids** are organic molecules found in plants and animals often as simple triglycerides.

(5 marks)

(c) The enzyme **nitrogenase** converts gaseous nitrogen to the ammonium ion at room temperature and pressure.

- How does the **lock-and-key model** for enzymatic catalysis apply in this situation?
- Which organisms use nitrogenase and why have they bothered developing such a complex metalloenzyme?

(3 marks)

Question 3

Timing: you should complete this question in 14 minutes.

(a) At what temperature will the **root-mean-square speed** of the nitrogen molecule be 4.000×10^4 cm sec^{-1}?

- What is the **mean free path** of a gas molecule?

(4 marks)

(b) A solid organic compound contains 18.3% C, 0.51% H and 81.2% Br by weight. A solution of 0.793 g of the compound in 0.01480 dm^3 chloroform (with a density of 1.485 kg dm^{-3}, a boiling point of 60.30°C, and a molal boiling point constant of 3.63 K / mol solute / kg solvent) boils at 60.63°C. Find the **molecular formula** of the compound.

(4 marks)

(c) The chemically inert gas **radon** is formed in granitic rocks according to the following scheme. $^{226}Ra \rightarrow {}^{222}Rn$

- What is the name of the element ^{226}Ra and where does this element come from (ie. what decay path is this element on)?
- The process above involves **α-decay**. Complete the scheme above to illustrate the process of α-decay making sure that conservation of mass number and atomic number are clearly demonstrated.

(4 marks)

Question 4

Timing: you should complete this question in 17 minutes.

(a) (i) Calculate the **NH bond energy** in ammonia using the following data :

Data: ΔH^o_f: $NH_3(aq)$ -80.3 kJ mol^{-1}; $NH_3(g)$ -45.9 kJ mol^{-1}
$N_2(g)$ 0 kJ mol^{-1} $H_2(g)$ 0 kJ mol^{-1}
N(g) 473.0 kJ mol^{-1}; H(g) 218.0 kJ mol^{-1}

(ii) Predict whether **entropy** increases or decreases in the following reactions and explain why.

$$NaBr_{(s)} \xrightarrow{H_2O_{(l)}} Na^+_{(aq)} + Br^-_{(aq)}$$

$$Cl_{2(g)} + O_{2(g)} \rightarrow Cl_2O_{2(s)}$$

(5 marks)

(b) The cell voltage (emf) of the following voltaic cell at 298K is +0.030V.

$Cu_{(s)} \mid CuSO_{4(aq)} \,\|\, KCl_{(aq)}$ (0.100M) $\mid AgCl_{(s)} \mid Ag_{(s)}$

- What is the **cell reaction**?
- Calculate the **standard free energy change ΔG^o** for the cell reaction.
- Calculate the **concentration of $CuSO_{4(aq)}$** in the cell using the data provided.

Data:

$AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$ $E^o = +0.223V$
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ $E^o = +0.340V$

(5 marks)

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

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

(5 marks)

Question 5

Timing: you should complete this question in 14 minutes.

(a) Sketch a profile for the atmosphere up to 100km illustrating changes in temperature and pressure for each region. Indicate clearly the names of each region and the names of the transition regions.

- What are the **major gases** (include % composition) in the atmosphere at sea level?
- Why is the **stratosphere** referred to by this name?

(4 marks)

(b) Make a sketch of the **carbon biogeochemical cycle** and on your sketch:

- Indicate the relative ordering of the **main reservoirs**.
- Indicate the **main chemicals** involved (molecular formulae) and the **direction of fluxes**.
- Define the term **flux**.
- What is **methane hydrate** and how may it impact on this cycle in the future.

(4 marks)

(c) In a large city such as Sydney **water treatment** plants have a number of stages that are used to ensure that the water which arrives with the consumer is fit for consumption.

- Sketch the typical features of a **water treatment plant** indicating the various stages and indicate which water quality parameter(s) are modified at each stage.
- What is **reverse-osmosis** and what are the advantages and disadvantages in using this to supply drinking water?

(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 $aA + bB \rightarrow cC + dD$

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

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

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

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

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

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

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

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

$$Flux = A / \tau$$

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

$$\pi = c_i RT$$

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

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

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

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

$R = 8.314\ J\ mol^{-1}\ K^{-1} = 8.314\ Pa\ m^3\ mol^{-1}\ K^{-1}$ $\qquad$ $1\ atm. = 1.013 \times 10^5\ Pa = 760\ torr$

$T(K) = T(^oC) + 273.15$ $\qquad$ $F = 9.65 \times 10^4\ C\ mol^{-1}$

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

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