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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 2004

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) There are many different types of solid material.

- Give an **example** of and **define** an *ionic solid.*
- Will this material behave as an **electrolyte** when placed in solution and what does the term electrolyte mean?

(ii) Which member(s) of the following pair of compounds may form **intermolecular hydrogen bonds**: Illustrate your answer using a sketch showing the presence of hydrogen bonding and the donor and acceptor atoms.

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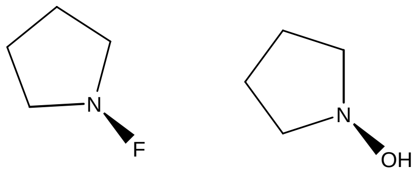


(4 marks)

(b) (i) Provide **systematic names** for the following compounds:

- $PbCO_3$
- P_4S_6

(ii) Provide **formulae** for the following compounds:

- hydrobromic acid
- strontium iodide

(4 marks)

(c) (i) Provide **electronic configurations** for the following:

- Cr
- C^{2+}

(ii) Why is the **atomic mass** of carbon 12.01 not 12.00?

(3 marks)

(d) Provide brief reasoning in your answers to the following questions :

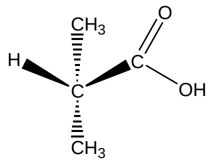
- Which is the **larger ion** in the following pair? F^- and Na^+.
- Provide a definition for the **electron affinity** of Cl (include an equation).

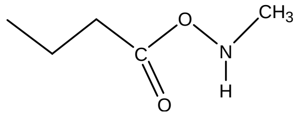
(3 marks)

Question 2

Timing: you should complete this question in 16 minutes.

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





(ii) Draw a **3D *molecular structure*** corresponding to the following systematic name :

- 1-ethylcyclohexene
- (*S*)-2-bromobutane

(6 marks)

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

(i) **D-Glucose** is a monosaccharide. The **Fisher projection** of the molecule indicates the functional groups and chiral centres along the backbone of the carbohydrate.

(ii) Proteins are natural **polymers** where the repeat unit varies in the polymer chain according to the **primary structure**.

(iii) The **structure** of a **soap** relates closely to the **function** of the compound in removing grease/dirt from soiled objects.

(5 marks)

(c) Enzymes function as biological catalysts and there are many thousand in every cell.

- What is an **enzyme**?
- Provide an **example** of an enzyme system.
- Illustrate using equations **Michaelis-Menton kinetics**.

(3 marks)

Question 3

Timing: you should complete this question in 14 minutes.

(a) At 500°C sulphur vapour **effuses** at 0.577 times the rate of SO_2 while at 860°C it effuses at the same rate as SO_2.

- What is the molecular weight and formula of sulphur vapour at 500°C and 860°C?
- What is **diffusion**?

(4 marks)

(b) A sugar mill discharges wastewater containing sucrose ($C_{12}H_{22}O_{11}$) as a major impurity which contributes to water pollution. The wastewater contains on average 34.2g sucrose /L water. The possibility exists to pre-treat the wastewater stream using reverse osmosis to remove the sucrose. What pressure must be used in the **reverse osmosis** (in atmospheres) to remove the sucrose completely at 20^{o}C?.
(R = 0.0821 atm L /mol K)

(4 marks)

(c) Radiocarbon (^{14}C) decays by beta radiation to form ^{14}N. Provide a balanced equation that illustrates this process of beta decay. Demonstrate the principles of **conservation of atomic number** and **conservation of mass number** in your answer.

- How is ^{14}C used in radiodating ancient objects?

(4 marks)

Question 4

Timing: you should complete this question in 17 minutes.

(a) (i) Define the term **Gibbs free energy**.

(ii) Calculate $\mathbf{K_p}$ for the following **equilibrium**.

$$2FeSO_4(s) \rightleftharpoons Fe_2O_3(s) + SO_2(g) + SO_3(g)$$

The equilibrium is established by heating solid ferrous sulphate ($FeSO_4$) to 850K in a closed vessel. At equilibrium the total gas pressure is 0.8 atm.

(5 marks)

(b) The cell voltage of the following cell at 298K was found to be +1.059V.

$$Zn_{(s)} \;|\; Zn^{2+}_{(aq)}\ (0.01M) \;||\; \text{sea water } (Cl^-) \;|\; AgCl_{(s)} \;|\; Ag_{(s)}$$

- What is the **cell reaction**?
- Calculate the **standard cell potential $\mathbf{E^o_{cell}}$**.
- Calculate the **standard free energy change $\mathbf{\Delta G^o}$** for the cell reaction.
- Calculate the concentration of chloride ion in the seawater sample.

Data:

$AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$		$E^o = +0.223V$
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$		$E^o = -0.761V$

(5 marks)

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

- 0.025 M NaOH
- 0.50 M formic acid (HCOOH). K_A (HCOOH) = 1.8×10^{-4}

(5 marks)

Question 5

Timing: you should complete this question in 14 minutes.

(a) The **atmosphere** may be divided into the following regions: mesosphere, stratosphere, thermosphere, troposphere.

- Provide a sketch indicating where each of these regions may be found relative to sea-level.
- What type of chemistry occurs in the **thermosphere**? Illustrate your answer with the major classes of reactions and some illustrative molecules that may be found in this region of the atmosphere
- What is the main **non-permanent gas** in the troposphere? Explain why it is called a non-permanent gas.

(4 marks)

(b) Man has managed to disturb significantly one of the smaller reservoirs in the **carbon cycle**. Make a sketch of this biogeochemical cycle and on your sketch:

- Indicate the **main reservoirs, main chemicals** and **direction of fluxes**.
- Which is the reservoir that man has disturbed significantly and **how** has this occurred?
- Why is the **carbonate equilibrium,** which is part of this cycle, important environmentally?

(4 marks)

(c) Modern **water treatment** plants have a number of stages that are used to take raw water that is not fit for human consumption and turn it into potable (drinking) water.

- 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.
- Raw water must be monitored before it is used as a freshwater supply.
  List **2 water quality parameters** and indicate how they would normally be measured.

(4 marks)

EQUATION LIST

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\Delta G = -n\,F\,E_{cell}$$

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

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

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

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

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

$$Flux = A / \tau$$

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

$$\pi = c_i\, RT$$

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

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

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

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

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

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

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

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

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

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

Period	1	2	3	4	5	6	7	8	9	10	11	12	13/III	14/IV	15/V	16/VI	17/VII	18/VIII
								1 H 1.008										2 He 4.003
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98.91	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	La- Lu	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po 210.0	85 At 210.0	86 Rn 222.0
7	87 Fr 223.0	88 Ra 226.0	Ac- Lr	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une	. . . .								

s block	*d* block	*p* block

Lanthanides	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 146.2	61 Pm 144.9	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
Actinide	89 Ac 227.0	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu 239.1	95 Am 241.1	96 Cm 244.1	97 Bk 249.1	98 Cf 252.1	99 Es 252.1	100 Fm 257.1	101 Md 258.1	102 No 259.1	103 Lr 262.1

f block