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: Yes

FIRST SEMESTER EXAMINATIONS 2002

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): THREE (3) HOURS

PERUSAL TIME (minutes): TWENTY (20) MINUTES

TOTAL NUMBER OF QUESTIONS: NINE (9)

INSTRUCTIONS TO STUDENTS:

Answer **ALL** questions.
Total marks for paper = 100
All questions are **not** of equal value.

MATERIALS TO BE SUPPLIED BY EXAMINATION SECTION:
Examination Booklets required: Yes

Equation List
Tables 1 and 2
Periodic Table

MATERIALS STUDENTS MAY USE:

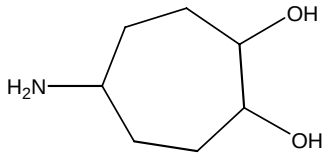
Any type of calculator.
Access to an English Dictionary: Yes

Question 1

(a)
- Define an **ionic solid,** use an example to illustrate your answer.
- Explain, with reasoning, what **physical properties** you would expect for this solid

(3 marks)

(b) Clearly define an **intermolecular hydrogen bond** using water to illustrate your answer.
- Is the following molecule likely to be **water soluble**? Explain your answer by sketching possible hydrogen bonding interactions.



(4 marks)

(c) (i) Provide systematic names for the following compounds:
- CsCl
- P_2O_5

(2 marks)

(ii) Provide formulae for the following compounds:
- nitric acid
- iron(III) oxide

(2 marks)

Question 2

(a) Write down the number of **protons**, **neutrons** and the **electronic configurations** for :
- a main-group element in group 2 of period 3.
- a noble gas with 18 protons.

(3 marks)

(b) Provide brief reasoning in your answers to the following questions :
- Which is the **larger ion** in the following pair? Li^+ and Be^{2+}.
- Define the **electronegativity** of an atom using Cl as an example.
- Sketch a molecule with a high **dipole moment**.

(3 marks)

(c) Provide a "Lewis-dot" structure and use **VSEPR Theory** to predict electronic and molecular geometries for: PF_3
- Is this molecule likely to have resonance structures?

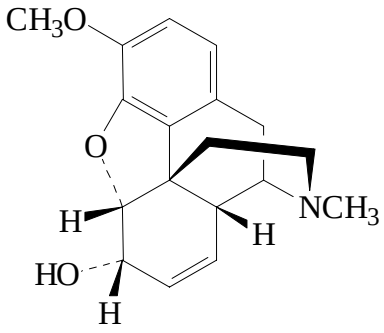
(4 marks)

Question 3

(a) *Codeine* is a common pharmaceutical agent used in many over the counter drugs.

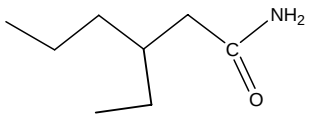
- Copy the structure into your answer book and identify and name all the **functional groups** present in *Codeine*.
- What class of amine is this molecule?

(3 marks)



Codeine

(b) (i) Give an **IUPAC name** for the following compound:



(3 marks)

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

- 2-methylbuta-1,3-diene

(3 marks)

(c) (i) Draw a **Fischer projection** of a pentose sugar.

(3 marks)

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

(a) The relationship between the ***structure* of a soap** and its ***function***.

(b) **Fibrous proteins** have simple, regular 3D shapes which result in the first instance from their ***primary structure***.

(c) **Starch** is a ***polymer*** of D-glucose monomeric units.

(3 marks)

Question 4

(a) (i) Into a gas bulb of 3.10 dm^3 are introduced 0.184 g of H_2 and 1.430 g of N_2. At the temperature of -10°C the gases are assumed to behave ideally.

- What are the **mole-fractions** of each gas.
- What is the **total gas pressure** and what are the **partial pressures** of H_2 and N_2?

(2 marks)

(ii)
- What is meant by the term **mean free path** as applied to gas molecules in the kinetic molecular theory of gases.

(2 marks)

(b) (i) Nitrobenzene freezes at 5.70°C and has a molal freezing point constant of 7.00 K kg solvent / mol solute.

- Calculate the **molecular weight** of an unknown substance from the observation that a solution of 2.05 g of the unknown substance dissolved in 40.0g of nitrobenzene freezes at 1.10°C.

(2 marks)

(ii) Define the terms "**osmosis**" and "**reverse osmosis**" and give an example of each.

(2 marks)

(c) Explain the terms **activation energy**, **elementary step** and **molecularity** with respect to the overall rate of a chemical reaction.

(4 marks)

(d) Nitrogen is converted to the ammonium ion by bacteria at room temperature and pressure using the enzyme **nitrogenase**.

- What is the role of the **active site** in the enzyme?
- Suggest a possible reason for oxygen deactivating the enzyme.

(3 marks)

Question 5

(a) Radiocarbon is formed in the atmosphere according to the following scheme.

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

- Using this scheme demonstrate the principles of **conservation of atomic number** and **conservation of mass number**.
- ^{14}C is used for the dating of carboniferous materials. Explain the principles behind this form of **radiodating**.

(4 marks)

(b) Using the following formula explain how **stable isotope measurements** can be made use of in tracking sulphur pollution in the marine atmosphere. The standard used is the iron sulphide mineral Canyon Diablo Troilite (CDT).

$$\delta\ ^{34}S = \left(\frac{^{34}S/^{32}S_{sample} - {}^{34}S/^{32}S_{standard}}{^{34}S/^{32}S_{standard}} \right) \text{x}1000$$

(4 marks)

Question 6

(a) Calculate the **enthalpy of combustion** of carbon disulphide(l) to form gaseous CO_2 and SO_2 given the data below.

(4 marks)

Compound	ΔH_f^o / kJ mol^{-1}
$CO_2(g)$	-393.5
$CS_2(g)$	117.0
$CS_2(l)$	87.9
$SO_2(g)$	-296.8

(b) Calculate the **pressure of CO_2** that is in equilibrium with a solid mixture of $CaCO_3$-CaO at 298K given the following data :

Compound	ΔG_f^o/kJ mol^{-1}
$CaCO_3$	-1129
CaO	-604
CO_2	-394

(4 marks).

(c) (i) Define the term ***Entropy***.

(2 marks)

(ii) **Balance** the following chemical reaction.

$$N_2(g) + H_2(g) \rightarrow NH_3(g)$$

- predict whether **entropy increases or decreases** and explain why.

(2 marks)

Question 7

(a) Classify the following reactions as either **redox** or **metathesis** reactions.
Identify the **oxidising agent** and **reducing agent** in any redox reactions and the **driving force** in any metathesis reactions.

- $KClO_3(aq) + 6HBr(aq) \rightarrow 3Br_2(l) + 3H_2O(l) + KCl(aq)$
- $K_2CrO_4(aq) + Ba(NO_3)_2(aq) \rightarrow BaCrO_4(s) + 2KNO_3(aq)$

(3 marks)

(b) The cell voltage (e.m.f.) of the following cell at 298K was found to be 0.8795V.
Data: $E^o_{Fe^{3+}/Fe^{2+}} = +0.7050V$

$Sn_{(s)} \mid SnSO_{4(aq)}$ c = 0.200M $\mid\mid Fe_2(SO_4)_{3(aq)}$ c = 0.100M, $FeSO_{4(aq)}$ c = 0.100M $\mid Pt_{(s)}$

- What is the **cell reaction**?
- Calculate $\mathbf{E^o}$ for the $Sn^{2+}/Sn(s)$ couple.
- Calculate the **standard free energy** change of the cell reaction.

(6 marks)

Question 8

(a) The composition of the atmosphere is uniform in the region called the **homosphere**.

- Three distinct **regions** are found in the homosphere, name these regions and provide the criteria for differentiating one region from the next.
- What are the **major gases** (include % composition) in the atmosphere at sea level?

(4 marks)

(b) Catalytic destruction of **ozone** occurs in the ozone layer due to presence of halocarbon compounds such as CFCs.

- Give an example of a **CFC compound** including the chemical formula.
- How are CFCs involved in the catalytic destruction of ozone?

(3 marks)

(c) Sketch a picture of the **geochemical cycle of carbon**. On your sketch:

- Indicate qualitatively the size of the **main reservoirs**.
- Indicate the **main chemicals** involved and the **direction of fluxes**.
- How has man made significant changes to the carbon balance?

(3 marks)

Question 9

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

- 0.035M KOH
- 0.0032M ammonium chloride $K_a[NH_4^+] = 5.62 \times 10^{-10}$

(4 marks)

(b) pH is one the major controlling variables in natural waters.

- List the typical **major acids** in a non-polluted river.
- What is the **major buffer system** that controls the pH in a river. Describe how this buffer system functions.

(3 marks)

(c) Water treatment is a multi-step process that involves a well designed treatment plant.

- Sketch and detail the key features of a modern **water treatment plant** used to treat water raw water so that it becomes suitable for drinking.
- Detail two methods that are used for **disinfecting** the water.

(3 marks)

EQUATION LIST

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$Flux = A / \tau$$

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

$$\pi = i\, c_i\, RT$$

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

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

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

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

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

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

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

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

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

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