CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Autumn 2016

Biological Chemistry 2

Module Code:	CHEM 6009
School:	Science and Informatics
Programme Title:	BSc (Hons) in Biomedical Science BSc (Hons) in Applied Biosciences BSc in Pharmaceutical and Biotechnology BSc (Hons) In Nutritional and Health Science BSc (Hons) in Herbal Science
Programme Code:	**SBISC_8_YR1** **SBIOS_8_YR1** **SNHSC_8_YR1** **SHERB-8_YR1**
External Examiner(s):	Dr Michael Geary
Internal Examiner(s):	Dr William Doherty and Dr Mary Lehane

Instructions: Answer **Three** questions. **Question 1 compulsory (answer any 8 sections). Answer two further questions: one question must be from section B and one question must be from section C.**

Duration: 2 hours

Sitting: Autumn Repeat

Requirements for this examination: Periodic Table of the Elements and Student Logs and Scientific Tables

Note to Candidates: Please check the Programme Title and the Module Title to ensure that you have received the correct examination.
If in doubt please contact an Invigilator.

2016 Autumn Repeat Biological Chemistry Year 1

Section A:

Question 1 (Answer any 8 parts):

i) Distinguish between the equilibrium constant Keqm and the reaction quotient Qc for a chemical reaction (provide appropriate diagrams and equations to support your answer).

ii) Write the equilibrium constant (Keqm) expressions for the following reactions:

a. $CaCO_3\,(s) \rightleftharpoons CaO\,(s) + CO_2\,(g)$
b. $H_2O\,(g) + C\,(s) \rightleftharpoons H_2\,(g) + CO\,(g)$
c. $H_2\,(g) + CO\,(g) \rightleftharpoons H_2O\,(l) + C\,(s)$
d. $N_2O\,(g) + ½\,O_2\,(g) \rightleftharpoons 2NO\,(g)$

iii) For the hydrogenation reaction below,

$$C_2H_4\,(g) + H_2\,(g) \rightleftharpoons C_2H_6\,(g)$$

Calculate the concentration of C_2H_6 at equilibrium if the equilibrium concentrations of the reactants are as follows:
$[C_2H_4] = 0.565$ M
$[H_2] = 0.234$ M
And the Keqm = 0.98

iv) Give the Henderson-Hasselbalch equation, label and explain each of the quantities which it contains.

v) Calculate the change in pH of the following buffer solution, Benzoic acid / Sodium benzoate, each with a concentration of 3.25 $moldm^{-3}$, when 6.70cm^3 of 0.8 moldm-3 HCl is added to the solution.

vi) Calculate the pH of a 0.300 M solution of benzoic acid. Ka = 6.46×10^{-5}

vii) State Markownikoff's rule and provide an appropriate example that illustrates this rule.

viii) Draw the appropriate structures to illustrate the difference between primary, secondary and tertiary alcohols.

ix) Draw three **conformational isomers** of butane which represent highest energy, intermediate energy and lowest energy orientations.

x) Draw the following molecules using the IUPAC rules of nomenclature:

a) 1,1-diethylcyclohexane
b) 5,5-Dimethyl-hex-1-ene
c) 5,5-diethyl-2,2,4,4,-tetramethyloctane

xi) Explain the following terms, giving appropriate examples and/or sketches:

a) Saturated and unsaturated hydrocarbons
b) Carbocation
c) Electrophile
d) (Z) or cis and (E) or trans isomerism in alkenes.#

(8 x5 marks = 40 marks total)

SECTION B:

Question 2:

a) State Le Châtelier's Principle and describe the types of stresses that can impact on the equilibrium of a chemical system.

(4 marks)

b) Use **Le Châtelier's Principle** to predict the effect on the following chemical equilibria:

A. Decreasing the temperature:

i) $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$ $\Delta H = + 49.7$ kJ

ii) $2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$ $\Delta H = +37.2$ kJ

iii) $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$ $\Delta H = -27.6$ kJ

B. Decreasing the volume of the containers in which the following reactions take place from 4.25 L to 1.80 Litres:

i. $2H_2O(g) + N_2(g) \rightleftharpoons 2H_2(g) + 2NO(g)$

ii. $SiO_2(s) + 4HF(g) \rightleftharpoons SiF_4(g) + 2H_2O(g)$

iii. $CO(g) + H_2(g) \rightleftharpoons C(s) + H_2O(g)$

(10 marks)

c) Calculate the **equilibrium concentrations** in M/L of all species in a 3.55L container for the following reaction:

$$H_2(g) + F_2(g) \rightleftharpoons 2HF$$

The initial concentrations are:

$[H_2]_0 = 4.27$ M

$[F_2]_0 = 6.72$ M

and Keqm = 1.15×10^2

(12 marks)

d) Consider the following comparisons of the reaction quotient (Q) with the equilibrium constant (keqm) for a given chemical reaction and predict in each case whether reactants of products are favoured :

i) Q = Keqm

ii) Q < Keqm

iii) Q > Keqm

Provide a reason for your predictions in each case.

(4 marks)

Question 3:

a) Distinguish between a strong acid and a strong base.

(2 marks)

b) Complete the equation for the reaction of each of the following with water. Indicate in each case, the acid, the base and their respective conjugates.

i) $HI(aq) + H_2O(l)$

ii) $HF(aq) + H_2O(l)$

iii) $C_2H_3O_2^-(aq) + H_2O(l)$

iv) $CO_3^{2-}(aq) + H_2O(l)$

v) $O^{2-}(aq) + H_2O(l)$

(10 marks)

c) Sketch the pH graph, labelling each axis and clearly showing the pH values, that represents the typical profile resulting from the titration between a strong acid and a weak base.

(4 marks)

d) Calculate the dissociation constant (K_a) value of a 0.253 M aqueous solution of propionic acid, $CH_3CH_2CO_2H$, with a pH of 4.88.

$$CH_3CH_2CO_2H + H_2O \leftrightharpoons H_3O^+ + CH_3CH_2CO^{-2}$$

(4 marks)

e) Calculate the following:

i) The pH of a 0.042 Ba(OH)2 solution.

ii) The hydrogen ion concentration of an aqueous solution whose pOH is 8.40.

iii) The [H+] of a 0.155M $HClO_2$ solution that is 6.3% ionised.

iv) The Ka and the pKa of a 0.10 M solution of the strong acid HIO_4 whose $[H+] = 3.8 \times 10^{-2}$

(10 marks)

SECTION C:

Question 4:

a) Discuss, briefly, the unique properties of carbon that result in the diversity of organic compounds.

(4 marks)

b) Distinguish between the molecular and empirical formula of an organic compound.

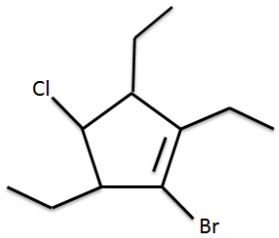
(4 marks)

c) A compound with a known molecular weight (146.99 g/mol) that contains only C, H, and Cl was studied by combustion analysis. When a 0.367 g sample was combusted, 0.659 g of CO_2 and 0.0892 g of H_2O formed. Calculate the empirical and molecular formulae of this compound.

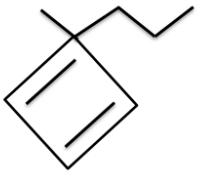
(8 marks)

d) Using the IUPAC rules of nomenclature name the following compounds:

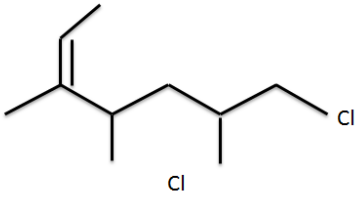
i)



ii)



iii)



(8 marks)

e) n-heptane is a straight chained alkane, draw four other **structural isomers** that have the same molecular formula as n-heptane and give their names.

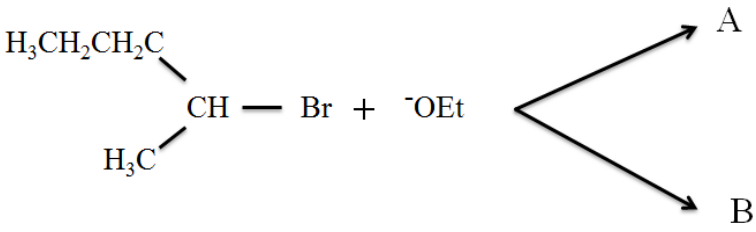
(6 marks)

Question 5:

a) State Zaitsev's Rule.

(4 marks)

b) Predict the A, the major (Zaitsev) and B, the minor (Hoffman) product(s) in the following reaction.



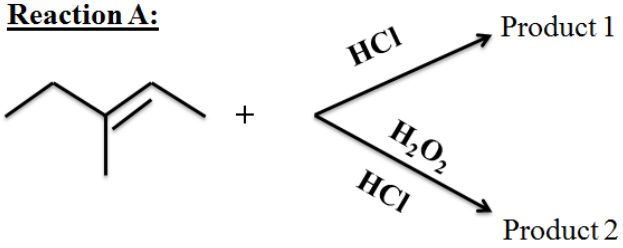
(7 marks)

c) Draw the Newman Projections which illustrate the 'chair' and the' boat' conformations of methyl-cyclohexane and hence discuss the energy differences between these two conformers.

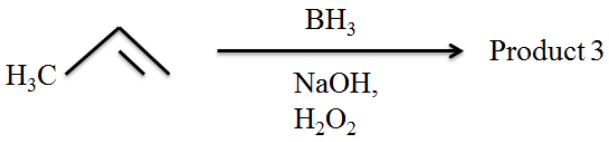
(7 marks)

d) State Markovnikov's Rule and predict the major products of Reactions A and B

Reaction A:



Reaction 2:



(8marks)

f) Draw the following compounds:

i. (2E)-3-methylpent-2-ene
ii. (2Z)-2-chlorobut-2-ene (4 marks)