CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Semester 2 Examinations 2011/12

Module Title: Physical and Organic Chemistry

Module Code: CHEM6003

School: Science

Programme Title:
Bachelor of Science in Applied Biosciences & Biotechnology – Year 1
Bachelor of Science (Honours) in Herbal Science – Year 1
Bachelor of Science (Honours) in Nutritional Health Science – Year 1
Bachelor of Science (Honours) in Pharmaceutical Biotechnology – Year 1
Bachelor of Science in Applied Physics and Instrumentation – Year 1
Bachelor of Science (Honours) in Biomedical Science – Year 1
Bachelor of Science (Honours) in Environmental Science and Sustainable Technology – Year 1

Programme Code: SBISC-8-Y1
SBIOS-7-Y1
SHERB-8-Y1
SNHSC-8-Y1
SPHBI-8-Y1
SPHYS-7-Y1
SHERB_8_Y1
SESST_8_Y1
SBMSC_7_Y1

External Examiner(s): Dr Carmel Roche
Internal Examiner(s): Dr R. Hourihane
Dr M. Lehane
Ms C. Griffin

Instructions:
Attempt four Questions. Question ONE, SECTION A is compulsory. Attempt ONE question each from SECTIONS B and C, and ONE other question. Show all calculations on the examination script.

Duration: 2 Hours

Sitting: Summer 2012

Requirements for this examination: Maths Tables

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

Section A

Q1. Attempt 8 of the following. All carry equal marks.

i) When 25 cm^3 of 1.0 $moldm^{-3}$ H_2SO_4 is added to 50 cm^3 of 1.0 $moldm^{-3}$ NaOH at 25 °C in a calorimeter, the temperature of the aqueous solution increases to 33.9 °C. Assuming that the calorimeter absorbs only a negligible quantity of heat and that the specific heat capacity and density of the solution is the same as water, calculate $\Delta H_{neutralisation}$ (in $kJmol^{-1}$ of H^+), for the reaction

$$H_2SO_4(aq) + 2\ NaOH(aq) \rightarrow Na_2SO_4(aq) + 2\ H_2O(l)$$

Specific Heat Capacity H_2O = 4.18 J/g.K Density H_2O = 1g/cm^3

ii) What is the work done on a gas in Joules when the gas is compressed from an initial volume of 35 dm^3 to a final volume of 19.5 dm^3, under a pressure of 0.995 atm?

iii) Identify the acid, base, conjugate acid and conjugate base in each of the following reactions

(a) $H_2O + H_2S \rightarrow H_30^+ + HS^-$

(b) $O^{2-} + H_2O \rightarrow OH^- + OH^-$

(c) $H_2CO_3 + OH^- \rightarrow HCO_3^- + H_2O$

iv) Calculate the pH of each of the following solutions

(a) 0.25 $moldm^{-3}$ H_2SO_4

(b) 0.15 $moldm^{-3}$ HN_3 Ka = 1.9 x 10^{-5}

(c) 0.35 $moldm^{-3}$ KOH

v) List three properties of an ideal catalyst. Heterogeneous catalysis operates through surface adsorption theory. Explain briefly the stages in surface adsorption theory.

vi) Draw and name the two conformational isomers of cyclohexane

vii) Explain why the boiling point of branched alkanes is usually lower than straight chained alkanes.

viii) Illustrate the reaction of Br_2 with eth**ene**.

ix) Describe using a sketch, a primary (1^o), secondary (2^o) and tertiary (3^o) carbon atom.

x) Give a balanced reaction (including reagents) for the transformation of an alcohol into an alkene.

Section B

Attempt at least **one of the following two** questions

Q2. (i) Write the equilibrium expression for each of the following

(a) Fe_3O_4 (s) + H_2 (g) $\Leftrightarrow$ 3 FeO (s) + H_2O (g)

(b) H_2O (l) $\Leftrightarrow$ H_2O (g)

(c) SO_2 (g) $\Leftrightarrow$ ½ S_2 (g) + O_2 (g) (7 marks)

(ii) For the reaction

½ N_2 (g) + O_2 (g) $\Leftrightarrow$ NO_2 (g) $\Delta H° = 33.8\ kJmol^{-1}$

What would be the effect, if any on the equilibrium of

(a) increasing the total pressure

(a) increasing the temperature (6 marks)

(iii) At 1000 K the value for the equilibrium constant, K, for the process illustrated in the equation below is 4.5×10^{-23}.

$2CO_2$ (g) $\Leftrightarrow$ 2 CO (g) + O_2 (g)

If 1.00 mol of CO_2 is added to a 1.00 dm^3 container at 1000 K, at equilibrium, what are the concentrations of all species? (12 marks)

Q3. (i) Distinguish between average and instantaneous rate, using the data in the table below collected when the rate of disappearance of H^+ was measured for the following reaction

CH_3OH (aq) + HCl (aq) $\rightarrow$ CH_3Cl (aq) + H_2O (l)

Time/ min	$[H^+]$ / M
0.0	1.85
80.0	1.67
160.0	1.52
320.0	1.30
630.0	1.00

(8 marks)

(ii) At elevated temperatures, nitrous oxide decomposes according to the following equation

$$2\ NO_2\ (g) \rightarrow 2\ N_2\ (g) + O_2\ (g)$$

Given the following data

Time / min	0	60	90	120	180
$[N_2O]$	0.250	0.218	0.204	0.190	0.166

(a) Plot the appropriate graph that proves the process obeys 2^{nd} order kinetics.

(b) Write the rate law that describe the process.

(c) Determine a value for the specific rate constant. (12 marks)

(iii) The decomposition of N_2O_5 gas is described by the following reaction.

$$2N_2O_5\ (g) \rightarrow 4NO_2\ (g) + O_2\ (g)$$

(a) Write the relative rate law for the process.

(b) If the rate of decomposition of N_2O_5 in the following reaction is $4.2 \times 10^{-7}\ Ms^{-1}$, what is the rate of appearance of each of the products?

(5marks)

Section C

Q4.

(a)

(i) **<u>Distinguish between</u>** the molecular formula, structural formula and empirical formula of chemical compounds.

Which of these conveys the most information about a given compound? Explain your answer.

(ii) NutraSweet is 57.14% C, 6.16% H, 9.52% N, and 27.18% O. Calculate the empirical formula of NutraSweet and find the molecular formula. (The molar mass of NutraSweet is 294.30 g/mol)

(6 marks)

(b)

Using the IUPAC rules of nomenclature name the following compounds:

(i) 3-ethylhexane
(ii) 2,2-dimethylbutane
(iii) 4,5-diethylnonane
(iv) 1-ethyl-3-methylcyclohexane
(v) 3-bromo-2-methylcyclopentanol

(10 marks)

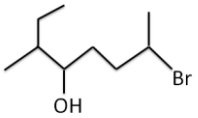
(c)

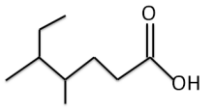
Write out 4 structural (chained, branched or ring) isomers for an alkane with the formula C_6H_{14}

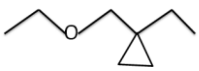
(4 marks)

(d)

Name the following three compounds using the IUPAC rules of nomenclature:







(5 marks)

Q5.

(a)

(i) State Markownikoff's rule and give an example of the rule.

(5 marks)

(b)

(ii) Explain the meaning of each of the following terms and give an example (you may provide a sketch to support your answer:

- cis and trans isomers
- electrophile
- addition reaction
- constitutional isomers.

(8 marks)

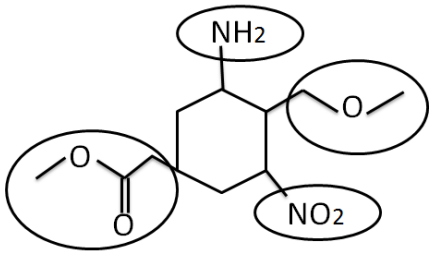
(c)

(i) The long chained alkanes are often subjected to catalytic cracking. Describe catalytic cracking and the purpose of the process.

(8 marks)

(d)

Name the functional groups that are circled in the molecule below:



(4 marks)