CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Autumn Examinations 2012/2013

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 (Honours) in Biomedical Science – Year
Bachelor of Science in Applied Physics and Instrumentation – Year 1

Programme Code: **SBIOS_7_Y1**
SHERB_8_Y1
SNHSC_8_Y1
SPHBI_8_Y1
SBISC_8_Y1
SPHYS_7_Y1

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

Instructions: Answer **four** questions in all. Section A containing **question one is compulsory**. Answer one question from section B and one question from section C, and any other question. All questions carry equal marks.

Duration: 2 Hours

Sitting: Autumn 2013

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. Compulsory Question

Attempt 8 of the following 10 parts (Total: 25 marks).

(i) The water-gas shift reaction used in industry to prepare hydrogen is given in the following equation: $CO_{(g)} + H_2O_{(g)} \leftrightarrow CO_{2(g)} + H_{2(g)}$

At equilibrium the following concentrations were found for this reaction at 500°C; [CO] = 0.180 M, $[H_2O]$ = 0.0411 M, $[CO_2]$ = 0.150 M, and $[H_2]$ = 0.200 M. What is the value of the K_c for this reaction?

(ii) How can we tell that a reaction has reached equilibrium? Illustrate on a plot of concentration versus time.

(iii) Define *specific heat capacity* and state its units.

(iv) Calculate the pH of the following solutions;

(a) 0.25 M H_2SO_4

(b) 0.30 M $Mg(OH)_2$

(c) 0.01M $NaCO_3$, assuming its $K_b = 2.1 \times 10^{-4}$

(v) Identify the conjugate acid-base pairs in the following reaction;

(a) $HSO_4^- + SO_3^{2-} \leftrightarrow HSO_3^- + SO_4^{2-}$

(b) $H_2Se + H_2O \leftrightarrow HSe^- + H_3O^+$

(c) $NH_3 + N_2H_5^+ \leftrightarrow NH_4^+ + N_2H_4$

(vi) Illustrate the pH profile (titration curve) obtained when a weak acid is titrated against a strong base. Show how the end-point is determined from the graph.

(vii) Draw the configurational isomers, *cis* and *trans*, for but-2-ene.

(viii) Draw structures to illustrate the difference between primary, secondary and teritary alcohols.

(ix) Explain why fractional distillation is carried out on crude oil in an oil refinery.

(x) Write a balanced equation for the complete combustion of ethanol (C_2H_5OH).

Section B

Q2.

(a) Define the following terms:

(i) Heat of Formation

(ii) Heat of Combustion

(iii) Heat of Neutralisation

(iv) Hess's Law of heat summation (6 marks)

(b) Given that hydrogen burns in oxygen according to the given equation:

$$H_{2(g)} + \tfrac{1}{2} O_{2(g)} \rightarrow H_2O_{(g)} \qquad \Delta H = -286 \text{ kJ}$$

How much heat is liberated when 12.0 g of hydrogen is burned? (6 marks)

(c) What is the enthalpy of the reaction (ΔH) for the formation of tungsten carbide (WC) from its elements?

$$W_{(s)} + C_{(graphite)} \rightarrow WC_{(s)} \qquad \Delta H = ?$$

Given that:

$$2W_{(s)} + 3O_{2(g)} \rightarrow 2WO_{3(s)} \qquad \Delta H = -1{,}685.8 \text{ kJ}$$

$$C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)} \qquad \Delta H = -393.5 \text{ kJ}$$

$$2WC_{(s)} + 5O_{2(g)} \rightarrow 2WO_{3(s)} + 2CO_{2(g)} \qquad \Delta H = -2{,}391.8 \text{ kJ}$$ (10 marks)

(d) Is the reaction (ΔH) for the formation of tungsten carbide (WC) exothermic or endothermic? (3 marks)

Q3.

(a) State and explain Le Châtelier's Principle. (3 marks)

(b) Predict the effect on the following equilibrium when:

$4NH_{3(g)} + 3O_{2(g)} \leftrightarrow 2N_{2(g)} + 6H_2O_{(g)}$

(i) N_2 is added
(ii) NH_3 is removed
(iii) Water is removed
(iv) Volume is decreased (8 marks)

(c) The rate of a reaction between calcium carbonate ($CaCO_3$) chips and hydrochloric acid (HCl) was monitored by measuring the amount of carbon dioxide produced per unit time:

$CaCO_{3(s)} + 2.HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

Time (seconds)	Mass of CO_2 produced (g)
0	0.00
60	0.66
120	1.20
180	1.60
240	1.90
330	2.10
420	2.18
480	2.20
540	2.20

(i) Plot a graph of mass versus time to show the rate of the reaction.
(ii) Use the graph to estimate the instantaneous rate of the reaction in terms of mass per unit time at 240 seconds
(iii) Using the answer from (ii) above express the instantaneous rate in terms of moles per unit time (10 marks)

(d) State four factors which affect the rate of any chemical reaction. (4 marks)

Section C

Q4.

(a) Draw the following structures using either a molecular or skeletal diagram:

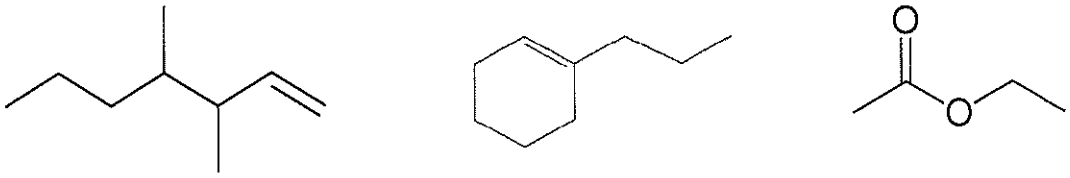
(i) 1,2-dichloro-4,4-dimethyloctane

(ii) 2,2,4-trimethylpentane

(iii) Ethanoic acid (6 marks)

(b) Name the following structures according to IUPAC:

(i) (ii) (iii)



(6 marks)

(c) Using but-1-ene name the major products of the following reactions below and give a brief outline of the reaction mechanism.

(i) Hydration; adding H_2O in the presence of an acid catalyst

(ii) Hydrohalogenation; adding HBr

(8 marks)

(d) Draw and name two conformers of cyclohexane. (5 marks)

Q5.

(a) Describe sp^3 and sp^2 hybridisation as observed in alkanes and alkenes supporting your answer with diagrams. (6 marks)

(b) Using an appropriate example briefly describe how an 'anti-Markovnikov' product can be formed. You should mention the necessary reagents and conditions for the reaction. (9 marks)

(c) Explain the following terms;

(i) Constitutional and configurational isomers

(ii) Primary, secondary and tertiary carbocations

(iii) Saturated and unsaturated hydrocarbons

(iv) Electrophile and nucleophile (6 marks)

(d) Explain why methanol (CH_3OH) has a higher boiling point than propanone (CH_3COCH_3). (4 marks)