CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Semester 2 Examinations 2012/13

Module Title: Physical and Organic Chemistry

Module Code: CHEM6003

School: Science

Programme Title: Bachelor of Science (Honours) in Environmental Science and Sustainable Technology
Bachelor of Science (Honours) in Pharmaceutical Biotechnology
Bachelor of Science (Honours) in Nutrition & Health Science

Programme Code: SESST_8_Y1
SOMNI_8_Y1
SNHSC_8_Y1
SPHBI_8_Y1

External Examiner(s): Dr. Carmel Roche
Internal Examiner(s): Ms. Caroline Griffin

Instructions: Answer **four** questions in all. Section A containing **question one is <u>compulsory</u>**. 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: Summer 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.
If in doubt please contact an Invigilator.

Section A

Q1. Compulsory Question

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

(i) Write the chemical equilibrium expression (K_c) for each of the following reactions;

(a) $CH_3OH_{(g)} + H_{2(g)} \leftrightarrow CH_{4(g)} + H_2O_{(g)}$

(b) $H_{2(g)} + Br_{2(g)} \leftrightarrow 2HBr_{(g)}$ $K_c = 2.0 \times 10^9$

Given the K_c for reaction *(b)* does the mixture contain a greater amount of reactants or products at equilibrium?

(ii) What factors determine whether a collision between two molecules will lead to a chemical reaction?

(iii) Distinguish between the average and the instantaneous rate of reaction.

(iv) Calculate the pH of the following solutions;

(a) 0.300 M HNO_3

(b) 2.0g of NaOH dissolved in 500 cm^3 of water

(c) 0.18 M hydrazoic acid, HN_3, given the $K_a = 1.9 \times 10^{-5}$

(v) Write the formula for the conjugate base of each of the following;
(a) NH_2OH, (b) HSO_3^{1-}, (c) HCN, (d) HNO_2

(vi) 'Water can be classified as amphoteric'. Explain the term *amphoteric* using appropriate equations to justify your answer.

(vii) Distinguish between a constitutional isomer and a conformational isomer using appropriate examples.

(viii) Write the balanced equation for the combustion of natural gas, methane.

(ix) Draw the appropriate structures to illustrate the difference between primary, secondary and tertiary carbocations.

(x) Using the addition of water (H_2O) to propene (C_3H_6) explain Markovnikov's rule.

Section B

Q2.

(a) Define the following terms:

(i) Activation energy

(ii) Exothermic reaction

(iii) Heterogeneous catalyst

(iv) Homogeneous catalyst (6 marks)

(b) Describe, with aid of a graph, how the addition of a catalyst to a reaction mixture affects the activation energy for the reaction. (3 marks)

(c) Given the following reaction

$$2H_2S_{(g)} + 3O_{2(g)} \leftrightarrow 2H_2O_{(g)} + 2SO_{2(g)}$$

State the effect each of the following will have on the equilibrium (if any);

(i) Increasing the concentration of water vapour (H_2O)

(ii) Increasing the pressure of the system

(iii) Increasing the volume of the system

(iv) Increasing the temperature (assuming the forward reaction is exothermic)

(12 marks)

(d) Describe surface adsorption theory for a heterogeneous catalyst. Use a diagram and/or equation to aid your answer. (4 marks)

Q3.

(a) Define the following terms:

(i) Heat of Neutralisation

(ii) Heat of Combustion

(iii) Heat of Formation

(iv) Hess's Law of heat summation (8 marks)

(b) The combustion of cyclohexane may be described by the following balanced equation:

$C_6H_{12(l)} + 9O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)}$ $\Delta H^o = ?$

Given that the heats of formation of cyclohexane, carbon dioxide and water are –156, –394 and –286 kJ mol^{-1}, respectively, calculate the heat of combustion of cyclohexane.

(9 marks)

(c) When 100 cm^3 of a 1.0 M hydrochloric acid (HCl) solution was mixed with 100 cm^3 of a 1.0 M sodium hydroxide (NaOH) solution the temperature increased by 6.2^oC. Assuming that the calorimeter used within the investigation only absorbs a negligable amount of heat and that the specific heat capacity and density of the solution is the same as water, calculate the heat of neutralisation, $\Delta H_{neutralisation}$, for the reaction in terms of kJ mol^{-1}.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

Specific heat capacity of water = 4.18 kJ $kg^{-1o}C^{-1}$

Density of water = 1.0 g cm^{-3} (8 marks)

Section C

Q4.

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

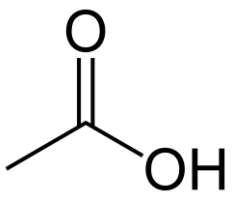
(i) Ethyl ethanoate

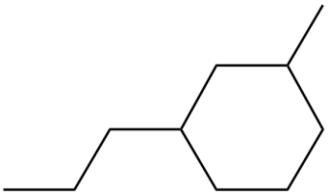
(ii) 2,2-dimethyl-propane

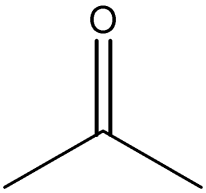
(iii) 3,4-dimethyl-hept-1-ene (6 marks)

(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) Hydroboration; adding (1) BH_3 and (2) H_2O_2 in the presence of NaOH

(ii) Hydrogenation; adding H_2 in the presence of a metal catalyst

(8 marks)

(d) Outline two chemical tests which could be used to distinguish an alkene from an alkane.

(5 marks)

Q5.

(a) (i) Show the mechanism for the free radical substitution of methane, or the halogenation of methane, forming dichloromethane. (9 marks)

(ii) Explain how traces of ethane are produced during the reaction. (5 marks)

(b) Taking ethanol (C_2H_5OH) as an example show how an alcohol can be chemically converted to;

(i) an alkene

(ii) an aldehyde

(iii) a carboxylic acid (6 marks)

(c) Draw Newman projections for ethane (C_2H_6) and indicate which rotamer is most stable. (5 marks)