CORK INSTITUTE OF TECHNOLOGY

INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Semester 2 Examinations 2015/2016

Module Title:	**Biological Chemistry 2**

Module Code:	CHEM6009
School:	Science & Informatics
Programme Title:	Bachelor of Science in Applied Biosciences Bachelor of Science in Pharmaceutical Biotechnology Bachelor of Science in Nutrition and Health Sciences Bachelor of Science in Herbal Science
Programme Code:	SBIOS_7_Y1 SPHBI_8_Y1 SNHSC_8_Y1 SHERB_8_Y1
External Examiners(s):	Dr M. Geary
Internal Examiners(s):	Dr. W. Doherty, Dr. M. Lehane
Instructions:	Attempt THREE questions. Section A is compulsory. Attempt 8 out of 12 parts from Section A. Attempt one question each from sections B and C. Show all calculations and rough work on the answer book.
Duration:	2 Hours
Sitting:	Summer 2016
Requirements for this examination:	Periodic Table of the Elements.

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. Attempt any eight (8) parts in this section.

All parts cary equal marks.

Q 1.

(a) State Le Châtelier's Principle. (5 Marks)

(b) Explain the difference between a reaction equilibrium constant, K, and reaction quotient, Q. (5 Marks)

(c) For the following equilibrium reactions predict whether the products or reactants are favoured: (5 Marks)

(i) $\mathrm{H_2(g) + Cl_2(g) \rightleftharpoons 2\,HCl(g)}$ $\quad K = 4 \times 10^{31}$

(ii) $\mathrm{N_2O_4(g) \rightleftharpoons 2\,NO_2(g)}$ $\quad K = 0.15$

(iii) $\mathrm{2\,BrCl(g) \rightleftharpoons Br_2(g) + Cl_2(g)}$ $\quad K = 5$

(d) For the following equilibrium reaction, (5 Marks)

$$\mathrm{H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)}$$

the partial pressures for $\mathrm{H_2(g)}$, $\mathrm{I_2(g)}$ and $\mathrm{HI(g)}$ were 0.276 bar, 0.064 bar and 0.939 bar, respectively. What is the equilibrium constant, K, for this reaction?

(e) Define and give an example of each of the following: (5 Marks)

(i) Strong acid

(ii) Strong base

(iii) Weak acid

(iv) Weak base

(f) Calculate the pH for the following: (5 Marks)

(i) 0.10 M $\mathrm{NaOH(aq)}$

(ii) 0.05 M $\mathrm{H_2SO_4(aq)}$

(iii) 1.00 M $\mathrm{H_2O_2(aq)}$ $\quad K_a = 2.4 \times 10^{-12}$

(g) What is meant by "unsaturation"?

How many unsaturations are there in cyclohexene? (5 Marks)

 Question 1 continues on next page...

(h) Draw the following molecules: (5 Marks)

(i) 4-ethyl-2,2,3-trimethylheptane

(ii) 4-bromo-3-chloro-4-propylheptane

(iii) 3,4-dimethyl-4-propylheptane

(i) Explain the following difference in boiling points for the three isomers of pentane: (5 Marks)

Isomer	Boiling Point [°C]
n-pentane	36.0
2-methylbutane	27.7
2,2-dimethylpropane	9.5

(j) State Zaitzev's Rule. (5 Marks)

(k) Draw the chair and boat configurations of cyclohexane labelling axial hydrogens, H_a and equitorial hydrogens, H_e. (5 Marks)

(l) List the following in terms of increasing reactivity (i.e. lowest $\rightarrow$ highest): (5 Marks)

1^o alcohols, 2^o alcohols and 3^o alcohols.

Explain your choice of order.

Total for Question 1: 40 Marks

Section B. Attempt 1 question from this section

Q 2.

(a) Explain, with the aid of diagrams, why a system comes to dynamic equilibrium. What is meant by "dynamic equilibrium"? (8 Marks)

(b) Write equilibrium expressions for the following series of reactions:

(i) $2\,BCl\,(g) + 2\,Hg\,(l) \rightleftharpoons B_2Cl_4\,(s) + Hg_2Cl_2\,(s)$

(ii) $P_4\,(s) + 3\,KOH\,(aq) + 3\,H_2O\,(l) \rightleftharpoons PH_3\,(aq) + 3\,KH_2PO_4\,(aq)$

(iii) $CO_2^{2-}\,(aq) + 2\,H_3O^+\,(aq) \rightleftharpoons CO_2\,(g) + 3\,H_2O\,(l)$

(iv) $CH_4\,(g) + Cl_2\,(g) \rightleftharpoons CO_2\,(g) + H_2O\,(g)$

(6 Marks)

(c) A mixture of gases is placed in a vessel and allowed to come to equilibrium. Given the initial concentrations, the equilibrium constant, k_{eqm} and the reaction equation in the table below, calculate the equilibrium concentrations.

$SO_2\,(g) + NO_2\,(g) \rightleftharpoons NO\,(g) + SO_3\,(g)$

$k_{eqm} = 85$

	SO_2	NO_2	NO	SO_3
Initial Conc [M]	0.10	0.20	0.0	0.0

(10 Marks)

(d) Applying Le Châtelier's Principle to the reaction in part (c), predict what effect on the reaction the following will have:

(i) Increase in pressure

(ii) Increase in volume

(iii) Increase in $SO_3\,(g)$ concentration

(iv) Increase in temperature given that $\Delta H^{\ominus} = -42.0\,kJ\,mol^{-1}$

(6 Marks)

Total for Question 2: 30 Marks

Q 3.

(a) Complete the following reactions and identify the conjugate acid-base pairings: (6 Marks)

(i) $NH_3 + H_3O^+ \rightleftharpoons ? + ?$

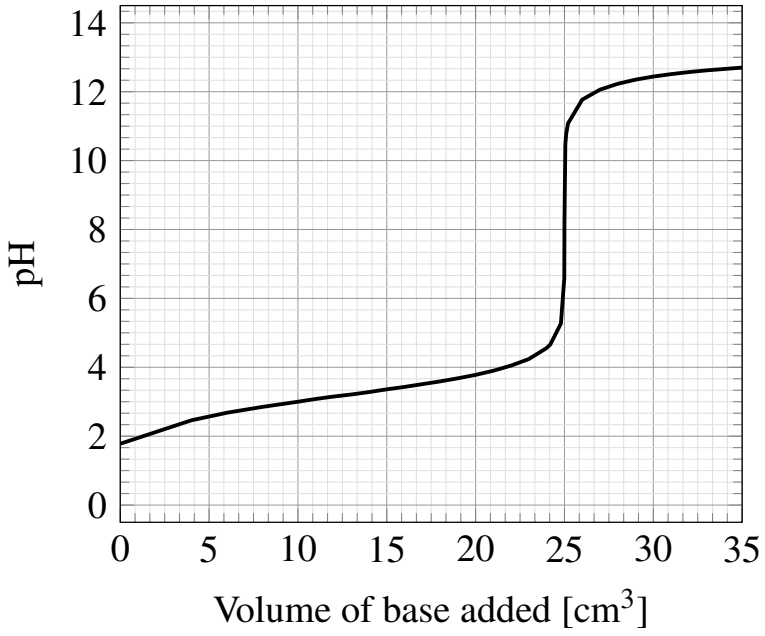
(ii) $HNO_2 + HS^- \rightleftharpoons ? + ?$

(iii) $CH_3COOH + H_2O \rightleftharpoons ? + ?$

(b) (i) What is meant by the K_a of an acid or a base? (2 Marks)

(ii) Why is the pK_a scale used rather than the K_a scale? (2 Marks)

(iii) In an experiment to determine the K_a of a weak acid, the pH was monitored as the volume of base was added. Given that pK_a = pH at half the equivalence point, estimate the pK_a of the weak acid from the following plot. (5 Marks)



(c) (i) Explain what buffers are and how they work. (5 Marks)

(ii) Using the Hendersen–Hasselbalch equation, calculate the pH of a buffer solution made up of 100 cm^3 of 0.1 mol dm^{-3} acetic acid (CH_3COOH) and 150 cm^3 of 0.1 mol dm^{-3} sodium acetate (CH_3COONa). The pK_a of CH_3COOH= 4.74. (5 Marks)

(iii) If 10 cm^3 of 0.1 mol dm^{-3} NaOH is added to 50 cm^3 of the above buffer, what is the new pH? (5 Marks)

Total for Question 3: 30 Marks

Section C. Attempt 1 question from this section

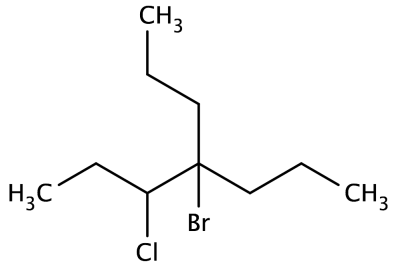
Q 4.

(a) List some of the unique properties of carbon and explain how it can form such a diverse array of compounds. (4 Marks)

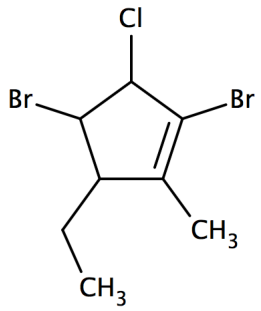
(b) Discuss the Cahn-Ingold-Prelog rules for establishing priority in molecules. (4 Marks)

(c) Name the following molecules: (10 Marks)

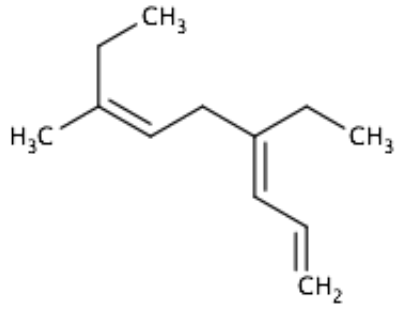
(i)



(ii)



(iii)



(d) There are two distinct 'chair' conformations of methylcyclohexane, one with the methyl group in an axial position, the other with the methyl group in the equitorial position. Using Newman projections, identify which position (equitorial or axial) is the preferred configuration of methyl cyclohexane, giving reasons for your choice.

(12 Marks)

Total for Question 4: 30 Marks

Q 5.

(a) Diethyl maleate is an important additive in the plastics and polymer industry and is comprised of carbon, hydrogen and oxygen only. When 0.86 g of diethyl maleate was combusted in excess oxygen 1.76 g of CO_2 and 0.54 g of H_2O were produced. Given the molar masses of C, H and O are 12.01 $g\,mol^{-1}$, 1.008 $g\,mol^{-1}$ and 16.00 $g\,mol^{-1}$ respectively,

(i) Determine the % weights of C, H and O in diethyl maleate. (7 Marks)

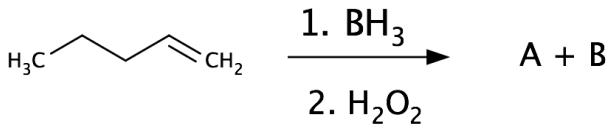
(ii) Determine the empirical formula of diethyl maleate. (3 Marks)

(iii) If the molecular weight of diethyl maleate is 172.18 $g\,mol^{-1}$, what is the molecular formula of diethyl maleate. (3 Marks)

(iv) Write a balanced equation for the combustion of diethyl maleate. (4 Marks)

(b) State Markovnikov's Rule. (5 Marks)

(c) Draw the products of the following reaction (A and B) and clearly identify the Markovnikov product and the anti-Markovnikov product.



(8 Marks)

Total for Question 5: 30 Marks