

CORK INSTITUTE OF TECHNOLOGY

INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Semester 2 Examinations 2016/2017

Module Title:	Biological Chemistry 2
Module Code:	CHEM6009

School: Science & Informatics

Programme Title: Bachelor of Science in Applied Biosciences
Bachelor of Science in Biological Science (Common Entry)
Bachelor of Science in Pharmaceutical Biotechnology
Bachelor of Science in Nutrition and Health Sciences
Bachelor of Science in Herbal Science
Bachelor of Science in Biomedical Science

Programme Code: SBIOS_7_Y1
SCEBS_8_Y1
SPHBI_8_Y1
SNHSC_8_Y1
SHERB_8_Y1
SBISC_8_Y1

External Examiners(s): Dr. Michael Geary

Internal Examiners(s): Dr. M. Lehane, Dr. E. O’Keeffe, Ms. L. Crowe

Instructions: Attempt **THREE** questions. Section A is compulsory.
Attempt 8 out of 12 parts from Section A. Attempt 1
question each from Sections B and C. Show all calculations
and rough work on the answer book.

Duration: 2 Hours

Sitting: Summer 2017

**Requirements for
this examination:** Periodic Table of the Elements.

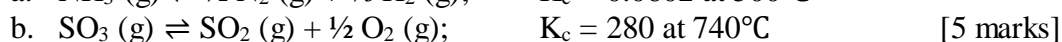
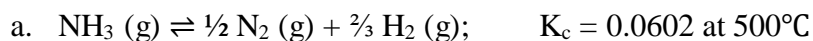
Note to Candidates: Please check the Programme Title and the Module Title to
ensure that you have received the correct examination paper. If
in doubt, please contact an Invigilator.

SECTION A (Answer any 8 parts from Question 1)

Question 1 [40 Marks]

- i) Provide a detailed explanation and a labelled concentration versus time diagram that illustrates the concept of Chemical Equilibrium. [5 marks]

- ii) For the following chemical equations write out the equilibrium constant (K_c) expressions and from the K_c values provided, comment on whether reactants or products will dominate for each reaction:



- iii) The following reaction was studied:



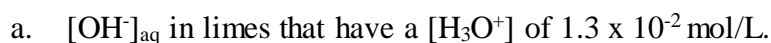
The equilibrium concentrations were found to be:

$[\text{PCl}_5] = 0.032\text{M}$; $[\text{PCl}_3] = 0.185\text{M}$; $[\text{Cl}_2] = 0.62\text{M}$. The reaction was performed in a 1L flask at 540°C .

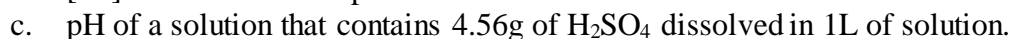
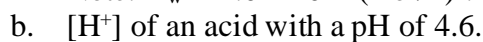
Calculate and comment on the K_c value for this reaction. [5 marks]

- iv) Explain the difference between a strong acid and a weak acid and give examples of both. [5 marks]

- v) Calculate the:



Note: $K_w = 1.0 \times 10^{-14} (\text{mol/L})^2$.



[5 marks]

- vi) Calculate the pK_a of the following:



[5 marks]

- vii) Illustrate (providing a fully labelled diagram) the pH profile that is obtained when a strong acid is titrated against a weak base. [5 marks]

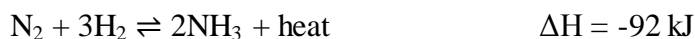
- viii) Describe the following terms providing diagrams and examples where appropriate:
- Saturated and Unsaturated hydrocarbons.
 - Electrophiles and Nucleophiles.
 - Primary (1°), secondary (2°) and tertiary (3°) alcohols. [5 marks]
- ix) Draw the two main conformational isomers observed in cyclohexane and compare their relative energy values. [5 marks]
- x) Draw the following molecules:
- 4-ethyl-2,3-dimethyl-5-propyloctane
 - 2,2,3,3-tetramethylpentane
 - butylcyclopentane [5 marks]
- xi) Draw 5 possible structural isomers of a compound with the formula: C_8H_{18} [5 marks]
- xii) Put these alkanes in order of increased boiling points and explain your reasoning: 2,2-dimethylpropane, n-pentane and 2-methylbutane. [5 marks]

SECTION B (Answer 1 question from this section)

Question 2 [30 marks]

i) Define Le Chatelier's Principle. [5 marks]

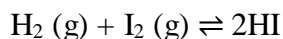
ii) Predict whether the reaction shifts to the right, left or has no change with these set of stresses applied:



- a. Reduce concentration NH_3 gas
- b. Decrease pressure
- c. Increase concentration N_2 gas
- d. Increase temperature
- e. Add Iron catalyst

[5 marks]

iii) Explain what is meant by the reaction quotient (Q_c) for a chemical reaction and calculate Q_c for the following reaction whose equilibrium constant (K_c) value is 51 at 448°C is carried out in a 1L container.



The concentrations of each substance after 1.5 hours are as follows:

$$[\text{HI}] = 2 \times 10^{-2} \text{ M}; [\text{H}_2] = 1 \times 10^{-2} \text{ M}; [\text{I}_2] = 3 \times 10^{-2} \text{ M}.$$

Comment on the direction in which the reaction will proceed. [10 marks]

iv) At 760K, the value of K_c for the reaction:



is 33 mol/L. Calculate the equilibrium concentrations for all species if 10 moles of PCl_5 are placed in a 1L flask at 760K and allowed to reach equilibrium.

[10 marks]

Question 3 [30 marks]

- i) Provide fully labelled diagrams that represent the pH profile arising from a) the titration of a strong acid with a strong base and b) the titration of a weak acid and strong base. Show the equivalence point and, where appropriate, the half-equivalence point. [8 marks]
- ii) Calculate the pH of a 0.100M solution of acetic acid, CH_3COOH . The K_a value is 1.77×10^{-5} . [10 marks]
- iii) Identify the acid, bases and their conjugate pairs in the following reactions:
- a. $\text{HCO}_3^- + \text{OH}^- \rightleftharpoons \text{H}_2\text{O} + \text{CO}_3^{2-}$
 - b. $\text{C}_2\text{O}_4^{2-} + \text{HC}_2\text{H}_3\text{O}_2 \rightleftharpoons \text{HC}_2\text{O}_4^- + \text{C}_2\text{H}_3\text{O}_2^-$
 - c. $\text{PO}_4^{3-} + \text{HNO}_3 \rightleftharpoons \text{NO}_3^- + \text{HPO}_4^-$ [4 marks]
- iv) a. Describe the composition of a typical buffer and explain how the buffer works to maintain an approximately stable pH.
- b. Calculate the pH of a buffer made from 0.32M of HNO_2 and 0.20M of NO_2^- . The K_a for HNO_2 is 4.6×10^{-4} . [8 marks]

SECTION C (Answer 1 question from this section)

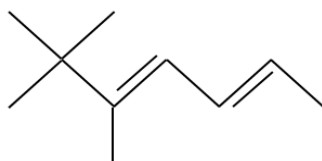
Question 4 [30 marks]

- i) Estradiol is a human steroid consisting of carbon, hydrogen and oxygen only. If 6.81g of estradiol is combusted in excess oxygen, 19.80g of CO_2 and 5.40g of H_2O are produced.

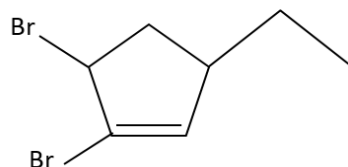
- Calculate the mass of carbon, hydrogen and oxygen in the sample of estradiol. [5 marks]
- Determine the empirical formula of estradiol. [5 marks]
- If the molecular weight is 272.38g/mol^{-1} , what is the molecular formula? [5 marks]
- Write a balanced equation for the combustion of estradiol. [5 marks]

- ii) Name these molecules:

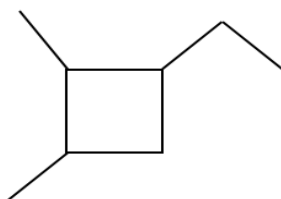
a.



b.



c.



[5 marks]

- iii) Draw these molecules:

- 2-bromo-2-methylbutane
- 5,6-diethyl-7-methyl-3-octene
- 1-ethyl-3-methyl-2-propylcyclopentene

[5 marks]

Question 5 [30 marks]

i) State Markovnikov's rule. [2 marks]

ii) The table below gives the names and structures of three isomeric alkenes.

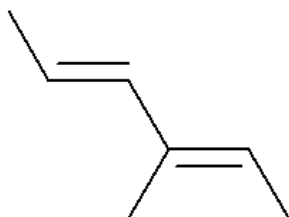
Name	Structure
1-butene	$\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$
2-butene	$\text{CH}_3\text{CH}=\text{CHCH}_3$
methylpropene	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3\text{C}=\text{CH}_2 \end{array}$

a. Give the molecular formula and empirical formula of 2-butene. [2 marks]

b. Draw the structures and give the names of the two geometrical isomers of 2-butene. [4 marks]

c. Outline the mechanism for the reaction between methylpropene and HBr and explain why there are two different products, one major and the other minor. [8 marks]

iii) For the following molecule:



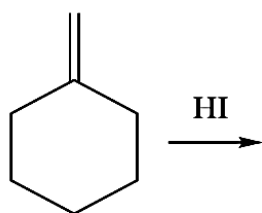
a. Label each double bond as E or Z. [2 marks]

b. Draw all the possible products of complete electrophilic addition with HBr. [4 marks]

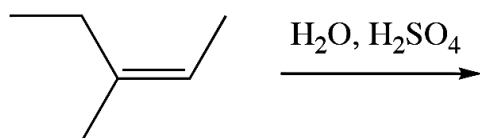
iv) Draw the structure of the alkene that would form 1,2-dibromo-3-methylbutane when reacted with bromine. [2 marks]

v) Draw and name the major product for each of these reactions:

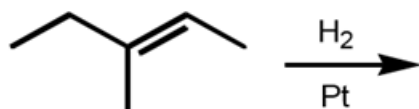
a.



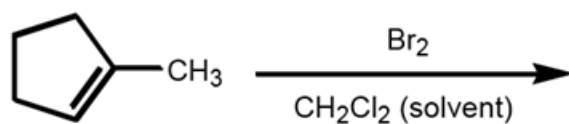
b.



c.



d.



[6 marks]

1																	
1 H 1.008																	2 He 4.0026
3 Li 6.94	4 Be 9.0122																5 B 10.81
11 Na 22.990	12 Mg 24.305																6 C 12.011
		3	4	5	6	7	8	9	10	11	12	13 Al 26.982	14 Si 28.085	15 P 30.974	16 S 32.06	17 Cl 35.45	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.38	31 Ga 69.723	32 Ge 72.630	33 As 74.922	34 Se 78.97	35 Br 79.904	36 Kr 83.798
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.95	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57-71 *	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89-103 #	104 Rf (265)	105 Db (268)	106 Sg (271)	107 Bh (270)	108 Hs (277)	109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (294)	118 Og (294)

* Lanthanide series	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
	# Actinide series														
	89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)