

**CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

Semester 2 Examinations 2013/14

Module Title: Biological Chemistry 2
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Module Code: **CHEM6009**

School: Science and Informatics

Programme Title: BSc in Applied Biosciences Year 1
 BSc (Hons) in Biomedical Science Year 1
 BSc (Hons) in Herbal Science Year 1
 BSc (Hons) in Nutrition & Health Science Year 1
 BSc (Hons) in Pharmaceutical Biotechnology Year 1

Programme Code: SBIOS_7_Y1
 SBISC_8_Y1
 SHERB_8_Y1
 SNHSC_8_Y1
 SPHBI_8_Y1

External Examiner(s): **Dr Carmel Roche**

Internal Examiner(s): **Dr Rosamund Hourihane, Dr Mary Lehane**

Instructions: Attempt **THREE** questions.

Section A is compulsory. Attempt 8 out of 10 questions 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 2014

Requirements for this examination:

<p>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.</p>
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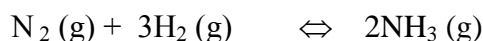
SECTION A

Attempt 8 of the following 10 questions. All questions carry equal marks.

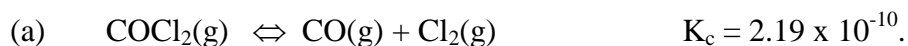
(5 marks each)

Q1.

- (i) For the following equilibrium reaction, illustrate how the concentrations of all species vary in the approach to equilibrium, show too the point where equilibrium is reached.

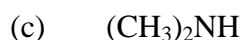


- (ii) When the following reactions come to equilibrium, does the equilibrium mixture contain mostly reactants or mostly products?

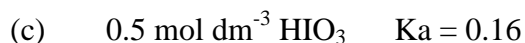
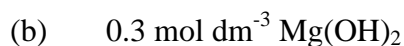


- (iii) (a) How does a reaction quotient differ from an equilibrium constant ?
(b) If $Q_c < K_c$, in which direction will a reaction proceed in order to reach equilibrium.

- (iv) Give the formula for the conjugate acid of each of the following Bronsted-Lowry bases:



- (v) Calculate the pH of each of the following solutions

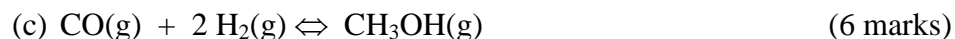
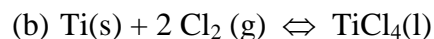
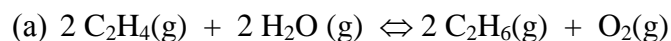


- (vi) Distinguish between a strong acid and a weak acid in words and equation.
(vii) Give an example of a primary, secondary and tertiary alcohol.
(viii) Why do alcohols have higher boiling points than alkanes of comparable molecular mass?
(ix) Mention the evidence which can be used to demonstrate that benzene is not a cyclic alkene.
(x) Draw the following two compounds:
(a) 5,6-diethyl-7-methyl-3-octene
(b) 1,3-butadiene

SECTION B

Attempt 1 of the following 2 questions.

Q2. (i) Write the expression for K_c for the following reactions. In each case indicate whether the reaction is homogeneous or heterogeneous.

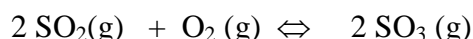


(ii) Methanol (CH_3OH) is produced commercially by the catalysed reaction of carbon monoxide and hydrogen; as described by reaction (c) in (i) above.

An equilibrium mixture in a 2.00-L vessel is found to contain 0.0406 mol CH_3OH , 0.170 mol CO , and 0.302 mol H_2 at 500 K.

Calculate K_c at this temperature. (6 marks)

(iii) Consider the following equilibrium for which $\Delta H < 0$



How will each of the following changes affect the equilibrium position and composition:

(a) $\text{O}_2(\text{g})$ is added to the system;

(b) the reaction mixture is heated;

(c) the volume of the reaction vessel is doubled;

(d) a catalyst is added to the mixture. (8 marks)

(iv) At 2000 °C the equilibrium constant for the reaction



is $K_c = 2.4 \times 10^3$. If the initial concentration of NO is 0.175 M, what are the equilibrium concentrations of NO , N_2 and O_2 ? (10 marks)

Q3.

- (i) Sketch a fully labelled pH profile for a titration of a strong acid with a weak base.
- (a) On the profile indicate the titration end point and the pK_a value. Explain how both are determined.
- (b) Give examples of a typical acid and base combination for this scenario.
- (c) Suggest a suitable indicator for the titration. (10 marks)
- (ii) What effect do buffer solutions have on the pH of a solution? What typically constitutes a buffer solution? Over what pH range are they effective in each case? (5 marks)
- (iii) (a) Derive the Henderson- Hasselbalch equation.
- (b) Use the equation to calculate the pH of a buffer solution that is 0.25 mol dm⁻³ in benzoic acid, (C₆H₅COOH) and 0.50 mol dm⁻³ in sodium benzoate, (C₆H₅COONa). K_a = 6.3 × 10⁻⁵.
- Write an equation for the dissociation of the weak acid.
- (c) If 0.10 mol dm⁻³ of base is added to the buffer solution described in (b) above what will be the effect on pH of the solution? (15 marks)

SECTION C

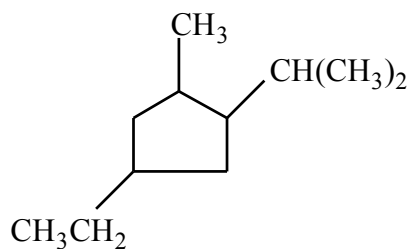
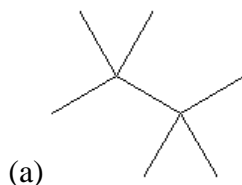
Attempt one of the following two questions

Q 4

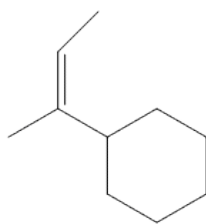
- (i) Discuss how organic compounds differ from inorganic carbon containing compounds. (5 marks)
- (ii) An organic compound, on complete combustion, gave the following elemental analysis: carbon 49.3%, hydrogen 9.6% and nitrogen 19.2%. Its molecular mass was found to be 73. Determine the empirical formula and molecular formula for the compound. (7 marks)
- (iii) Write the reaction mechanism for the reaction of but-1-ene with Bromine, Br₂, in aqueous conditions. (6 marks)
- (iv) Give two chemical tests to distinguish an alkane from an alkene. (4 marks)
- (v) Define the following terms (provide examples and sketches where appropriate):
 - (a) Electrophile
 - (b) Markownikoff's rule
 - (c) 'saturated' and 'unsaturated' hydrocarbons.
 - (d) Conformational isomerism in hexane.(8 marks)

Q5

(i) Name the following compounds:



(b)



(c)

(8 marks)

(ii) Describe two possible reactions of the alkanes, write out the reaction and indicate any reagents used.

(6 marks)

(iii) Draw the following organic compounds: a carboxylic acid, a ketone and ether.

(4 marks)

(iv) Outline a theory for the structure of benzene; provide diagrams to support your answer.

(6 marks)

(v) Draw the structure of Z-but-2-ene and of E-but-2-ene.

(3 marks)

Q5

(vi) n-heptane is a straight chain alkane with a chemical formula of C_7H_{16} .

Draw three structural isomers that possess the same molecular formula and name these compounds. (3 marks)

[illegible]