

CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Semester 2 Examinations 2014/15

Module Title: Biological Chemistry 2
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Module Code: **CHEM 6009**

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 Examiner(s): Dr. C. Roche
Internal Examiner(s): Dr. William Doherty
Dr. Mary Lehane

Instructions: **Attempt THREE questions.**
Section A is compulsory.
Attempt 8 out of 10 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: Semester 2 2014/15

Requirements for this examination: Periodic Table of the Elements

<p>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.</p>
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SECTION A

Q1

- i) Write the equilibrium expression (K_c) for each of the following reactions:
- $\text{H}_2 (\text{g}) + \text{Br}_2 (\text{l}) \leftrightarrow 2\text{HBr} (\text{g})$
 - $\text{CO}_2 (\text{g}) + \text{CaO} (\text{s}) \leftrightarrow \text{CaCO}_3 (\text{s})$
 - $\text{SO}_2 (\text{g}) + \frac{1}{2} \text{O}_2 (\text{g}) \leftrightarrow \text{SO}_3 (\text{g})$
 - $5\text{CO} (\text{g}) + \text{I}_2\text{O}_5 (\text{s}) \leftrightarrow \text{I}_2 (\text{g}) + 5\text{CO}_2 (\text{g})$
- ii) For the following reaction,
- $$2\text{NOCl} (\text{g}) \leftrightarrow 2\text{NO} (\text{g}) + \text{Cl}_2$$
- the equilibrium concentrations were found to be: $[\text{NOCl}] = 0.263\text{M}$, $[\text{NO}] = 0.037\text{M}$, and $[\text{Cl}_2] = 0.092\text{M}$.
- Using this data calculate the equilibrium constant K_c of this reaction.
- iii) Write out the Henderson-Hasselbalch equation and explain what each term in the equation means.
- iv) a. Distinguish between a ***strong and weak*** acid and base.
b. Explain how the value of the acid dissociation constant, K_a , can be used as an index to describe if a given acid is strong or weak.
- v) Calculate the $\text{p}K_a$ values for the following species:
- H_3O^+ ($K_a = -1.5$)
 - NH_3 ($K_a = 36$)
 - H_2PO_4 ($k_a = 7$)

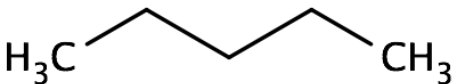
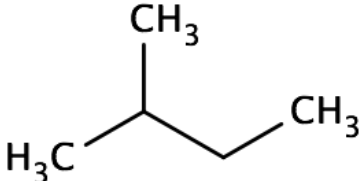
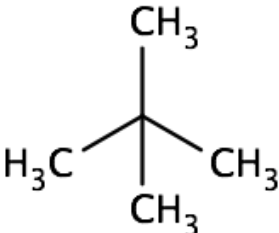
Explain why the $\text{p}K_a$ is often used to describe the strength of an acid rather than the K_a .

- vi) Determine:
- The pH of a $6.50 \times 10^{-3} \text{M}$ solution of KOH
 - The $[\text{H}^+]$ of an acid with a pH of 3.
- The pH and pOH of a 0.05M solution of Carbonic Acid

- vii) Draw the following alkanes:
- 2-bromo-2-methylbutane
 - 1-bromo-3-ethyl-5-methylcyclohexane
 - 2,3,4,5,6-Pentamethyloctane

viii) Draw any four isomers of octane.

ix) Account for the difference in the boiling points of the following isomers of pentane:

Isomer	Boiling point [K]
	309
	301
	282

x) Explain the following terms

- Carbocation
- Electrophile
- Nucleophile
- Substitution Reaction
- Addition Reaction

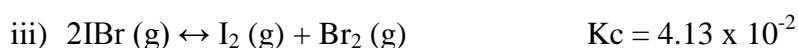
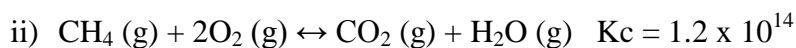
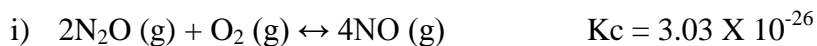
xi) Draw a 1° alcohol, a 2° alcohol and a 3° alcohol. Place them in order of increasing reactivity.

- xii)
- Define saturation and unsaturation
 - Draw the molecule benzene. How many unsaturations are there in benzene?

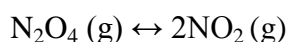
SECTION B

Q2

- a) Predict in the following reactions if products or reactants will predominate at equilibrium at a temperature of 25°C. Justify your answer in each case:

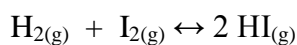


- b) Consider the following endothermic chemical reaction, where $\Delta H = 94\text{KJ}$:



Predict the shift in the direction of the reaction as a consequence of the following stresses:

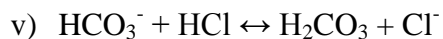
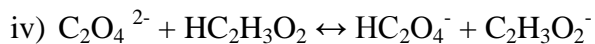
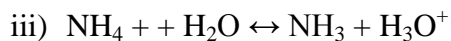
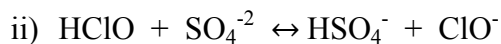
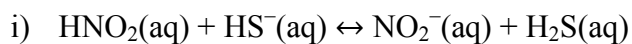
- i) An increase in the concentration of NO_2
 - ii) A decrease in the volume of the reaction container.
 - iii) A decrease in the temperature.
 - iv) A decrease in the concentration of N_2O_4 .
 - v) The addition of a palladium catalyst.
- c) A 7.25 L flask is filled *initially* with 0.215 mol of HI at 698 K. What will be the concentration of H_2 , I_2 and HI at equilibrium? The value of K_{eq} is 0.0184.



- d) Provide a brief explanation and draw an energy graph that shows why all chemical systems strive to attain equilibrium.

Q3

a) In the following reactions identify the acid, the base and their respective conjugate pairs:



b) i) Derive the Henderson- Hasselbalch Equation.

ii) Consider the following dissociation reaction:



The concentration of the acetic acid, CH_3COOH , is 0.255M and the concentration of the CH_3COO^- anion is 0.015M use the Henderson-Hasselbalch equation to determine the pH of the solution.

c) H_2S is a weak acid and it dissociates in the following fashion:



Given that the initial concentration of H_2S is 0.136M, calculate the concentration of all reaction components at equilibrium and hence determine the pH.

d) Draw the pH profile that you may expect if you:

i) titrate a strong acid with a weak base

ii) titrate a strong acid with a strong base

iii) titrate a weak acid with a weak base.

SECTION C

Q4 (a) Equilin is a horse tranquiliser that consists of carbon, hydrogen and oxygen only. If 6.71 g of equilin is combusted in excess oxygen, 19.80 g of CO_2 and 4.50 g of H_2O are produced.

(i) What are the % weights of carbon, hydrogen and oxygen in equilin?

[8 marks]

(ii) What is the empirical formula?

[4 marks]

(iii) If the molecular weight is $268.36 \text{ g mol}^{-1}$ what is the molecular formula?

[4 marks]

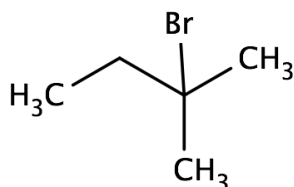
(iv) Write a balanced equation for the combustion of equilin.

[4 marks]

(b) (i) State Zaitsev's Rule

[3 marks]

(ii) For 2-bromo-2-methylbutane (in the figure below) draw the Zaitsev product.



2-bromo-2-methylbutane

[7 marks]

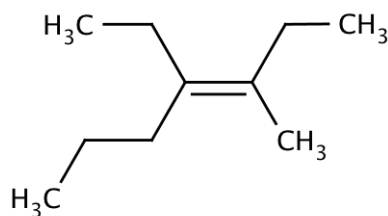
Q5 (a) Draw the following molecules:

(i) (2Z)-5-bromo-6-methylhept-2-ene

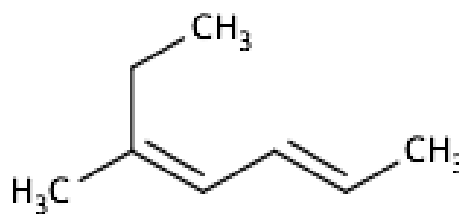
(ii) (3E,6Z)-4-ethyl-7-methylnona-1,3,6-triene

[4 marks]

(b) Name the following molecules:



(i)

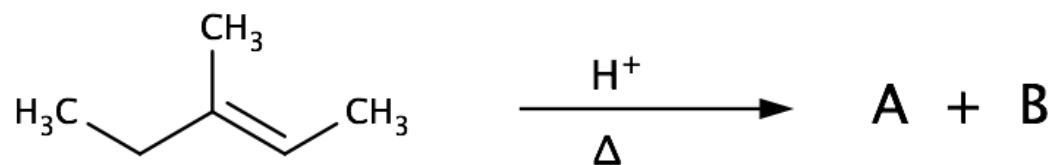


(ii)

[4 marks]

continued overleaf...

- (c) (i) State Markovnikov's rule. [4 marks]
- (ii) For the following reaction, identify products A and B and identify the Markovnikov product.



[8 marks]

- (iii) To produce the “anti-Markovnikov” product exclusively, a different reagent is used. Name and sketch this reagent. Sketch the mechanism of the reaction explaining why the “anti-Markovnikov” is produced. [10 marks]