

**CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

Autumn Examinations 2011/2012

Module Title: Physical and Organic Chemistry

Module Code: **CHEM6003**

School: **Science**

Programme Title:

Bachelor of Science in Applied Biosciences & Biotechnology – Year 1

Bachelor of Science (Honours) in Herbal Science – Year 1

Bachelor of Science (Honours) in Nutritional Health Science – Year 1

Bachelor of Science (Honours) in Pharmaceutical Biotechnology – Year 1

Bachelor of Science (Honours) in Biomedical Science – Year

Bachelor of Science in Applied Physics and Instrumentation – Year 1

Programme Code: **SBIOS_7_Y1**
 SHERB_8_Y1
 SNHSC_8_Y1
 SPHBI_8_Y1
 SBISC_8_Y1
 SPHYS_7_Y1

External Examiner(s): **Dr. C. Roche**
Internal Examiner(s): **Dr. R. Hourihane**
 Dr. M. Lehane
 Ms. C. Griffin

Instructions: Attempt four Questions. Question ONE, SECTION A is compulsory. Attempt ONE question each from SECTIONS B and C, and ONE other question.
Show all calculations on the examination script.

Duration: 2 Hours

Sitting: Autumn 2012

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 paper.
If in doubt please contact an Invigilator.

Section A

Attempt 8 of the following 10 parts

All carry equal marks

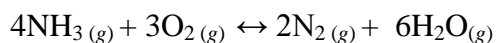
- Q1.** (i) Write equilibrium constant expressions K_c for the following reactions.
Given the K_c for reaction (b) does the mixture contain a greater amount of reactants or products at equilibrium?
- (a) $\text{CS}_2(\text{g}) + 4\text{H}_2(\text{g}) \leftrightarrow \text{CH}_4(\text{g}) + 2\text{H}_2\text{S}(\text{g})$
- (b) $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \leftrightarrow 2\text{NO}_2(\text{g})$ $K_c = 5.0 \times 10^{12}$
- (ii) If the K_c for the reaction $\text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \leftrightarrow \text{SO}_3(\text{g})$ has a value of 20.4 at 700K, calculate the K_c for the reverse reaction at the same temperature.
- (iii) Define pH and calculate the pH of the following solutions:
- (a) $0.3 \text{ mol dm}^{-3} \text{ Mg(OH)}_2$
- (b) 4.0g of sodium hydroxide (NaOH) in water to give a 500 cm^3 solution.
- (iv) Hydrogen Iodide decomposes according to the equation:
- $$2\text{HI}(\text{g}) \leftrightarrow \text{H}_2(\text{g}) + \text{I}_2(\text{g}).$$
- If the rate of decomposition of HI is $5.0 \times 10^{-3} \text{ mol L}^{-1} \text{ s}^{-1}$, what is the rate of formation of hydrogen H_2 and iodine I_2 ?
- (v) Identify the acid, base, conjugate acid and conjugate base in the following reactions:
- (a) $\text{NH}_4^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \leftrightarrow \text{HCO}_3^-(\text{aq}) + \text{NH}_3(\text{aq})$
- (b) $\text{HNO}_3(\text{aq}) + \text{H}_2\text{F}_2(\text{aq}) \leftrightarrow \text{H}_2\text{NO}_3^+(\text{aq}) + \text{HF}_2^-(\text{aq})$
- (vi) In thermodynamics distinguish between state and path functions.
Give appropriate examples.
- (vii) Explain how standard bond enthalpy values may be used to estimate the enthalpy change for a chemical process.
- (viii) Distinguish between a constitutional and conformational isomer using appropriate examples.
- (ix) Draw the appropriate structures to illustrate the difference between primary, secondary and tertiary carbocation.
- (x) Write the balanced equation for the combustion of butane.

(25 marks)

Section B

Q2. (a) State Le Châtelier's Principle. (3 marks)

(b) Predict the effect on the following equilibrium when:



(i) N_2 is added

(ii) NH_3 is removed

(iii) Water is removed

(iv) Volume is decreased (8 marks)

(c) The initial rate for the reaction $\text{A} + \text{B} \rightarrow \text{Product(s)}$ is determined from a series of experiments using different starting concentration of each reactant.

Results are listed in the table.

| Experiment | [A]/mol dm ⁻³ | [B]/mol dm ⁻³ | Initial Rate |
|------------|--------------------------|--------------------------|-----------------------|
| 1 | 0.185 | 0.133 | 3.35×10^{-4} |
| 2 | 0.185 | 0.266 | 1.34×10^{-3} |
| 3 | 0.370 | 0.133 | 6.75×10^{-4} |
| 4 | 0.370 | 0.266 | 2.70×10^{-3} |

(i) What is the order of the reaction with respect to A and to B?

Hence write the rate law.

(ii) Calculate a value for the specific rate constant k .

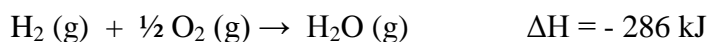
(14 marks)

Q3. (a) Define and give the appropriate symbol for each of the following terms:

- (i) Heat of Formation
- (ii) Heat of Combustion
- (iii) Heat of Neutralisation
- (iv) Hess's Law of heat summation

(8 marks)

(b) Given that hydrogen burns in oxygen according to the given equation:



How much heat is liberated when 12.0 g of hydrogen is burned?

(6 marks)

(c) Calculate the energy change (in kJ) for a system which absorbs 1.48kJ of heat while expanding from 1L to 5L against a pressure of 3 atm (1L.atm ~ 101J).

(5 marks)

(d) How much heat in kJ, does it take to raise the temperature of a 225g sample of water (specific heat capacity $4.184 \text{ Jg}^{-1}\text{K}^{-1}$) from 25°C to boiling point?

(6 marks)

Section C

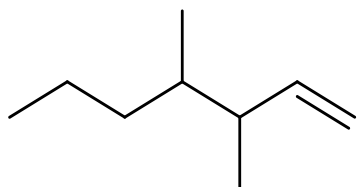
Q4. (a) Draw the following structures using either a molecular or skeletal diagram:

- (i) 1,1-dichloro-4,5-dimethylhexane
- (ii) 3-ethyl-4-methylheptane
- (iii) 3,6-dimethyl-oct-3-ene

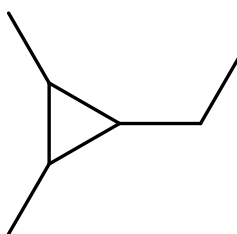
(6 marks)

(b) Name the following structures according to IUPAC:

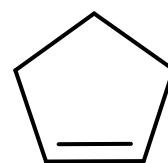
(i)



(ii)



(iii)



(6 marks)

(c) Using but-1-ene as a starting material, predict the major product and give the reaction conditions for the following reactions:

- (i) Addition of water, H_2O
- (ii) Addition of Hydrogen bromide, HBr .

Identify and state the rule that both addition processes are adhering to.

(8 marks)

(d) Give a brief description of the bonding in ethene and how it differs from that of ethane.

(5 marks)

- Q5. (a) 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. Give a possible structural formula for this compound. (8 marks)
- (b) Given an example of the conversion reaction of an alcohol to an alkene, include necessary reagents and/or reaction conditions. (5 marks)
- (c) Explain the following terms and where appropriate sketch structures or provide diagrams:
- (i) Electrophile
 - (ii) Nucleophile
 - (iii) Cracking of long chain alkane (7 marks)
- (d) Write out the configurational structures of the two isomers of but-2-ene and explain which is the cis (Z) isomer and which is the trans (E) isomer. (5 marks)