

**ORK INSTITUTE OF TECHNOLOGY**  
**INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

**Semester 2 Examinations 2009/10**

<b>Module Title:      Physical and Organic Chemistry</b>
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**Module Code:**      **CHEM6003**

**School:**      Science

**Programme Title:**    **Bachelor of Science in Applied Biosciences**  
                             **Bachelor of Science in Herbal Science**  
                             **Bachelor of Science in Nutritional Health Science**  
                             **Bachelor of Science in Pharmaceutical Biotechnology**  
                             **Bachelor of Science in Applied Physics and Instrumentation**

**Programme Code:**   **SBIOS-7-Y1**  
                             **SHERB-8-Y1**  
                             **SNHSC\_8\_Y1**  
                             **SPHBI\_8\_Y1**  
                             **SPHYS\_7\_Y1**

**External Examiner(s):**    **Dr. G. Keaveney**  
**Internal Examiner(s):**    **Dr. R. Hourihane**  
                                     **Mr. D. O'Driscoll**

**Instructions:**      **Attempt four Questions. Question ONE SECTION A is compulsory.**  
                             **Attempt ONE question each from SECTIONS B and C, and ONE other**  
                             **question.**

**Duration:**      2 Hours

**Sitting:**      Summer 2010

**Requirements for this examination:**      Maths Tables

<p><b>Note to Candidates:</b> 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

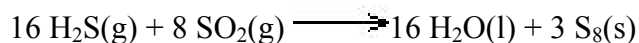
**Q1. Attempt 8 of the following 10 parts. All carry equal marks.**

- (i) Define what is meant by state function in thermodynamics.
- (ii) Solve for internal energy, heat and work using the following data. A process carried out has 3.4 kJ of heat flowing out of the system, while 4.8 kJ of work is done by the system on the surroundings. What is the internal energy?
- (iii) Define what is meant by Le Chatelier's principle.
- (iv) If an acid has an  $\text{H}^+$  concentration of 0.0001 M ( $10^{-4}$ ), find the pH.
- (v) Give the Arrhenius definition of an acid and base. Identify one limitation imposed by this definition.
- (vi) Identify and explain briefly, three differences between organic and inorganic compounds.
- (vii) Define, giving an example, what is meant by term functional group.
- (viii) Draw structures for the following molecules:
  - 2, 2, 3-bromochloronitrohexane
  - 2-methylbut-1-ene
- (ix) Distinguish, giving examples, between addition and substitution reactions.
- (x) Distinguish between a primary, secondary and tertiary alcohol.

(25 marks)

## Section B

- Q2.** (i) Using the following balanced chemical equation and the table of standard enthalpies of formation attached determine the heat of the reaction. Label the process as exothermic or endothermic and explain why. Define the underlined terms.

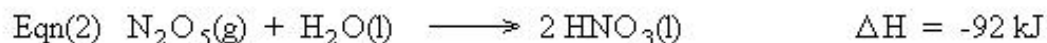
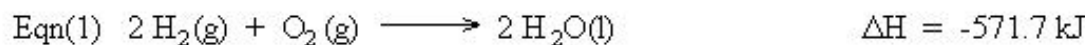


(8 Marks)

- (ii) Determine the enthalpy of reaction for the process outlined in the equation below

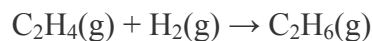


using the following data:



(10 Marks)

- (iii) Using the bond enthalpies provided in the attached table, calculate the heat of reaction,  $\Delta H$ , for the following process:



<i>Chemical formula</i>	<i>Structural Formula</i>
$\text{C}_2\text{H}_4$	<pre>       H   H        \ /         C = C        / \       H   H           </pre>
$\text{C}_2\text{H}_6$	<pre>       H H               H-C-C-H                 H H           </pre>
$\text{H}_2$	<pre>       H — H           </pre>

(7 Marks)

- Q3. (i) From the set of data provided in the table below, determine, (graphically) the order for the decomposition of dinitrogen pentoxide ( $\text{N}_2\text{O}_5$  (g)) at  $65^\circ\text{C}$ . Hence, determine a value for the specific rate constant.

Time/s	$[\text{N}_2\text{O}_5] / \text{mol dm}^{-3}$
0	0.0200
100	0.0169
200	0.0142
300	0.0120
400	0.0101
500	0.0086
600	0.0072
700	0.0061

(15 Marks)

- (ii) (a) State the factors affecting the rate of any chemical reaction. (5 Marks)
- (b) Define and give properties of catalysts. (5 Marks)

## Section C

- Q4. (i) Dianabol is one of the anabolic steroids that has been used by some athletes to increase the size and strength of their muscles. It is similar to the male hormone testosterone. The molecular formula of Dianabol, which consists of carbon, hydrogen, and oxygen, can be determined using the data from two different experiments.
- In the first experiment, 14.765 g of Dianabol is burned, and 43.257 g  $\text{CO}_2$  and 12.395 g  $\text{H}_2\text{O}$  are formed. In the second experiment, the molecular mass of Dianabol is found to be 300.44. Deduce the molecular formula for Dianabol from this data. (8 marks)
- (ii) The halogenation of alkanes is an example of a free radical substitution reaction. Taking the reaction of methane,  $\text{CH}_4$  (g), with chlorine,  $\text{Cl}_2$  (g), as an example, show how this reaction undergoes initiation, then propagation and finally, termination to give mainly chloromethane and traces of ethane as product. (10 marks)

- (iii) Crude Oil is a complex mixture of organic compounds mainly hydrocarbons.

The first step in the refining process is to separate the crude oil into fractions on the basis of boiling point. Lower and higher molecular weight fractions can be converted to more commercially useful ones through reforming or cracking processes.

Explain the underlined terms.

(7 marks)

- Q5. (i) Give two chemical tests to distinguish an alkane from an alkene. (5 marks)

- (ii) Taking propene ( $C_3H_6$ ) as an example, show how an alkene can be chemically converted to:

- (a) an alcohol
- (b) a haloalkane
- (c) an alkane

In each case, give the reagents used for the conversion and write a structure and name the product formed. (9 marks)

- (iii) Define what is meant by constitutional (structural) isomers, illustrate with appropriate examples. (5 Marks)

- (iv) State Markownikoff's Rule.

Taking propene,  $C_3H_6$ , as an example write a chemical equation to illustrate the operation of Markownikoff's Rule, clearly showing the products formed. (6 Marks)

## Standard Enthalpies of Formation

**TABLE 1** Standard Enthalpies of Formation,  $\Delta H_f^\circ$ , at 298 K

Substance	Formula	$\Delta H_f^\circ$ (kJ/mol)	Substance	Formula	$\Delta H_f^\circ$ (kJ/mol)
Acetylene	$C_2H_2(g)$	226.7	Hydrogen chloride	$HCl(g)$	-92.30
Ammonia	$NH_3(g)$	-46.19	Hydrogen fluoride	$HF(g)$	-268.6
Benzene	$C_6H_6(l)$	49.0	Hydrogen iodide	$HI(g)$	25.9
Calcium carbonate	$CaCO_3(s)$	-1207.1	Methane	$CH_4(g)$	-74.8
Calcium oxide	$CaO(s)$	-635.5	Methanol	$CH_3OH(l)$	-238.6
Carbon dioxide	$CO_2(g)$	-393.5	Propane	$C_3H_8(g)$	-103.85
Carbon monoxide	$CO(g)$	-110.5	Silver chloride	$AgCl(s)$	-127.0
Diamond	$C(s)$	1.88	Sodium bicarbonate	$NaHCO_3(s)$	-947.7
Ethane	$C_2H_6(g)$	-84.68	Sodium carbonate	$Na_2CO_3(s)$	-1130.9
Ethanol	$C_2H_5OH(l)$	-277.7	Sodium chloride	$NaCl(s)$	-410.9
Ethylene	$C_2H_4(g)$	52.30	Sucrose	$C_{12}H_{22}O_{11}(s)$	-2221
Glucose	$C_6H_{12}O_6(s)$	-1273	Water	$H_2O(l)$	-285.8
Hydrogen bromide	$HBr(g)$	-36.23	Water vapor	$H_2O(g)$	-241.8

# Average Bond Enthalpies (kJ/mol)

Single Bonds							
C—H	413	N—H	391	O—H	463	F—F	155
C—C	348	N—N	163	O—O	146	Cl—F	253
C—N	293	N—O	201	O—F	190	Cl—Cl	242
C—O	358	N—F	272	O—Cl	203		
C—F	485	N—Cl	200	O—I	234	Br—F	237
C—Cl	328	N—Br	243	S—H	339	Br—Cl	218
C—Br	276			S—F	327	Br—Br	193
C—I	240	H—H	436	S—Cl	253		
C—S	259	H—F	567	S—Br	218	I—Cl	208
		H—Cl	431	S—S	266	I—Br	175
Si—H	323	H—Br	366			I—I	151
Si—Si	226	H—I	299				
Si—C	301						
Si—O	368						
Si—Cl	464						
Multiple Bonds							
C=C	614	N=N	418	O <sub>2</sub>	495		
C≡C	839	N≡N	941	S=O	523		
C=N	615	N=O	607	S=S	418		
C≡N	891						
C=O	799						
C≡O	1072						