

**CORK INSTITUTE OF TECHNOLOGY**  
**INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

**Semester 2 Examinations 2007/08**

**Module Title: Physical and Organic Chemistry**

**Module Code:** CHEM 6003

**School:** Science

**Programme Title:** Bachelor of Science in Biomedical Science – Year 1  
Bachelor of Science in Applied Biosciences – Year 1  
Bachelor of Science (Honours) in Herbal Science – Year 1

**Programme Code:** SBMSC\_7\_Y1  
SBIOS\_7\_Y1  
SHERB\_7\_Y1

**External Examiner(s):** Prof. G. Walsh

**Internal Examiner(s):** Dr. R. Hourihane  
Mr. D. Spicer

**Instructions:** Answer **FOUR** questions.

Answer **Question 1** and at least one question from **Section A** and **Section B**.

**Duration:** 2 hours

**Sitting:** Summer 2008

**Requirements for this examination:** Maths Tables

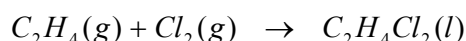
**Note to Candidates:** Please check the Programme Title and the Module Title to ensure that you have received the correct examination paper.

If in doubt please contact an Invigilator.

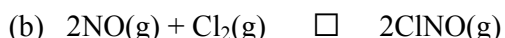
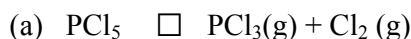
## Section A

**Q1.** Answer **eight** parts, all questions carry equal marks.

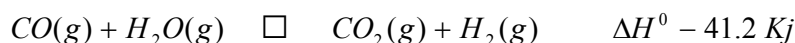
- (i) What is thermal cracking and why is it carried out on hydrocarbons?
- (ii) Draw the Z form of pent-2-ene. Explain your reasoning.
- (iii) Write the equilibrium reaction of ethanoic acid with ethanol and suggest a method by which the equilibrium may be improved.
- (iv) Combustion analysis of an organic compound gives C 81.8%, O 12.1%, and H 6.1%. Its gram molecular mass is 133. Calculate the empirical and molecular formula of the compound.
- (v) Using the attached table of data, calculate the free energy change for the following process, the production of 1,2 dichloroethane, a drycleaning agent.



- (vi) Define what is meant by the standard enthalpy of formation of a material.
- (vii) For each of the following equilibria write the equilibrium constant expression K.

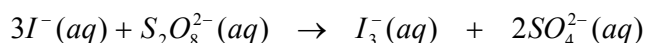


- (viii) For the following reaction:



does the amount of  $H_2$  in the equilibrium mixture increase or decrease when the temperature is increased?

- (ix) The oxidation of iodide ion by peroxydisulfate ion is described by the equation



If the rate of consumption of  $S_2O_8^{2-}$  is  $1.5 \times 10^{-3} \text{ M/s}$ , what is the value of the rate of consumption of  $I^-$  in the same time interval?

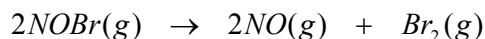
- (x) Define what is meant by a rate law.

How can you tell the order of the reaction from the rate law?

## Section B

**Q2.(a)** List four factors that affect the rates of chemical reactions.

(b) Nitrosyl bromide decomposes at 10°C according to the reaction below:



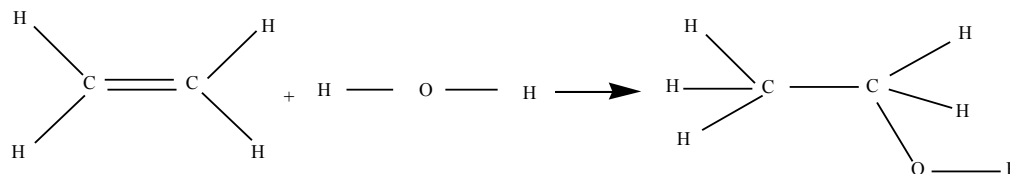
The following kinetic data were obtained.

Time/min	0	10	20	30	40
[NOBr] / M	0.0400	0.0303	0.0244	0.0204	0.0175

- (i) Using the data supplied determine the order of the reaction.  
(ii) Evaluate a value for the specific rate constant.
- (c) (i) What is the difference between ‘adsorption’ and ‘absorption’?  
(ii) Which applies to heterogeneous catalysts?  
(iii) Outline briefly the appropriate mechanism. (25 marks)

**Q3. (a)** (i) State Hess’s Law.

(ii) Using the data in the accompanying table and the chemical equation below, calculate an approximate  $\Delta H^\circ$  (in kilojoules) for the industrial synthesis of ethyl alcohol from



(b) (i) Distinguish between a Bronsted Lowry acid and base. Give one example of each.

(ii) Calculate the pH of each of the following solutions:

- 0.2 mol/dm<sup>3</sup> HNO<sub>3</sub>
- 0.4 mol/dm<sup>3</sup> H<sub>2</sub>SO<sub>4</sub>
- 0.05 mol/dm<sup>3</sup> Nicotinic acid (C<sub>5</sub>H<sub>4</sub>NCOOH) K<sub>a</sub> = 1.4 x 10<sup>-5</sup>
- 3.4 g Ba(OH)<sub>2</sub> in 500mls
- Calculate the [H<sup>+</sup>] for the following – a solution of lactic acid pH 2.46.

(25 marks)

## Section C

- Q4.** (a) Write the reaction mechanism sequence, which shows how dichloromethane may be produced from methane and chlorine. Also explain how minute traces of ethane are produced during the reaction.
- (b) Write the structural formula of the product formed in each of the following reactions:
- (i) But-1-ene +  $\text{HCl(aq)}$
  - (ii) Pent-2-ene +  $\text{H}_2\text{SO}_4\text{(aq)}$
  - (iii) Propene +  $\text{HBr}$ , ether, peroxide
- Give the IUPAC name of each product. (25 marks)

- Q5.** (a) Write the reaction mechanism for the Williamson synthesis of methoxyethane, (methylethylether).
- (b) Drawing structural formulae, distinguish between primary, secondary and tertiary amines or alcohols.
- (c) (i) Explain how amines act as nucleophiles in their reactions with haloalkanes.

OR

- (ii) Explain the process of acid catalysed dehydration of alcohols. Taking 2-methyl-2-butanol as an example, predict the major product and explain your reasoning.

(25 marks)

# Organic Substances

Substance and State	Formula	$\Delta F^\circ_f$ (kJ/mol)	$\Delta G^\circ_f$ (kJ/mol)	$S^\circ$ (J/K · mol)
Acetic acid(l)	<chem>CH3COOH</chem>	-484.5	-390	160
Acetylene(g)	<chem>C2H2</chem>	226.7	209.2	200.8
Benzene(l)	<chem>C6H6</chem>	49.0	124.5	172.8
Butane(g)	<chem>C4H10</chem>	-126	-17	310
Carbon tetrachloride(l)	<chem>CCl4</chem>	-138.4	-65.3	216.4
Dichloroethane(l)	<chem>CH2ClCH2Cl</chem>	-165.2	-79.6	206.5
Ethane(g)	<chem>C2H6</chem>	-84.7	-32.9	229.5
Ethanol(l)	<chem>C2H5OH</chem>	-277.7	-174.9	161
Ethanol(g)	<chem>C2H5OH</chem>	-235.1	-168.6	282.6
Ethylene(g)	<chem>C2H4</chem>	52.3	68.1	219.5
Ethylene oxide(g)	<chem>C2H4O</chem>	-52.6	-33.1	242.4
Formic acid(l)	<chem>HCOOH</chem>	-424.7	-361.4	129.0
Glucose(s)	<chem>C6H12O6</chem>	-1260	-910	212.1
Methane(g)	<chem>CH4</chem>	-74.8	-50.8	196.2
Methanol(l)	<chem>CH3OH</chem>	-238.7	-166.4	127
Methanol(g)	<chem>CH3OH</chem>	-201.2	-161.9	238
Propane(g)	<chem>C3H8</chem>	-106	-25	270
Vinyl chloride(g)	<chem>CH2=CHCl</chem>	35	51.9	263.9

# 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	Br-F	237
C-F	485	N-Cl	200	O-I	234	Br-Cl	218
C-Cl	328	N-Br	243	S-H	339	Br-Br	193
C-Br	276	H-H	436	S-F	327	I-Cl	208
C-I	240	H-F	567	S-Cl	253	I-Br	175
C-S	259	H-Cl	431	S-Br	218	I-I	151
Si-H	323	H-Br	366	S-S	266		
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				