

**CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ**

Semester 2 Examinations 2008/09

Module Title: Physical & Organic Chemistry

Module Code: CHEM 6003

School: Science

Programme Title: B.Sc. in Applied Biosciences – Year 1
B. Sc (Hons) in Herbal Science – Year 1
B. Sc in Biomedical Science – Year 1

Programme Code: SBIOS_7_Y1
SHERB_8_Y1
SBMSC_7_Y1

External Examiner(s): Dr. G. Keaveney

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

Instructions: Attempt FOUR questions. Question 1 Section A is COMPULSORY.
Attempt at least ONE question from each Sections B and C and a
fourth question from either Sections B or C.

Duration: 2 Hours

Sitting: Summer 2009

Requirements for this examination:

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

Section A

Q1. Attempt 8 of the following. All carry equal marks.

- (i) What is meant by specific heat capacity and when is it used? Give the units.
- (ii) Using the following equation and the table of standard enthalpy of formation data attached, calculate the enthalpy of formation of propane, $C_3H_8(g)$
- $$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l) \quad \Delta H^\circ = -2219 \text{ kJ}$$
- (iii) Predict the effect of increasing the pressure at constant temperature on the position of the equilibrium, the equilibrium constant K , and the concentration of each reactant and product in the following reaction:
- $$2SO_3(g) + 2Cl_2(g) \rightleftharpoons 2SO_2Cl_2(g) + O_2(g)$$
- (iv) Calculate the pH of the following solution
- $$0.2 \text{ mol dm}^{-3} \text{ Ca(OH)}_2$$
- (v) Identify the acid, base, conjugate acid and conjugate base in each of the following reactions
- (a) $HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$
- (b) $HSO_4^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + SO_4^{2-}(aq)$
- (vi) Write the structures of two constitutional **and** two configurational isomers of C_5H_{10} .
- (vii) Explain how methylamine can act as a base and as a nucleophile.
- (viii) Quoting suitable examples, explain why cycloalkanes have the general molecular formula C_nH_{2n} , whereas alkanes general molecular formula is $C_nH_{(2n+2)}$.
- (ix) Write the balanced reaction equation for
- (a) an elimination (b) a substitution and (c) an addition reaction.
- (x) Explain the difference between an empirical and a molecular formula of an organic molecule.

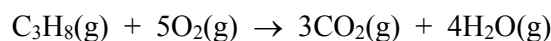
(25 marks)

Section B

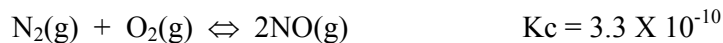
Q2. (i) Using the following data and the combustion equation below

	$\Delta H^\circ \text{ kJ mol}^{-1}$
(a) $3\text{C(s)} + 4\text{H}_2\text{(g)} \rightarrow \text{C}_3\text{H}_8\text{(g)}$	-103.85
(b) $\text{C(s)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$	-393.51
(c) $\text{H}_2\text{(g)} + \frac{1}{2} \text{O}_2\text{(g)} \rightarrow \text{H}_2\text{O(g)}$	-241.82

calculate the enthalpy of combustion of propane, ($\text{C}_3\text{H}_8\text{(g)}$).



(ii) Calculate the equilibrium concentrations of N_2 , O_2 and NO present, when a mixture that was initially $0.100 \text{ mol dm}^{-3}$ in N_2 and $0.090 \text{ mol dm}^{-3}$ in O_2 , comes to equilibrium at 600°C . The following equation illustrates the reaction



(25 marks)

Q3. Butadiene, (C_4H_6), in the gas phase undergoes a reaction to produce the reaction product C_8H_{12} . The following data were collected for the process

Time / min	$[\text{C}_4\text{H}_6] / \text{mol dm}^{-3}$
0	1
100	0.91
500	0.66
1000	0.49
1500	0.39
2000	0.32
2500	0.27

- Determine the order of the reaction by drawing the appropriate graph(s). Hence or otherwise write the rate law for the process.
- Calculate the rate constant for the reaction.
- What is the rate of the reaction when the concentration of butadiene is 0.55 mol dm^{-3} ?

(25 marks)

Section C

- Q4. (a) Write a reaction sequence which explains how a polyester is synthesised.
(5 marks)
- (b) Explain why the product of the reaction of pent-1-ene with HCl (aq) is 2-chloropentane and not 1-chloropentane.
(10 marks)
- (c) Describe three processes which occur during the refining of crude oil. Outline the commercial reason for each process.
(10 marks)
- Q5. (a) Write the mechanism for the dehydration of butan-2-ol in the presence of a strong acid. Account for the formation of a major and a minor product.
(10 marks)
- (b) Account for the chemical reactivity of alkenes towards electrophiles.
(5 marks)
- (c) Explain how an ether can be synthesised for an alcohol and a haloalkane. Write the chemical reaction from the ether formation.
(10 marks)

Table 5.3 Standard Enthalpies of Formation

TABLE 5.3 Standard Enthalpies of Formation, ΔH_f° , at 298 K

Substance	Formula	ΔH_f° (kJ/mol)	Substance	Formula	ΔH_f° (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