

CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Autumn 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_8_Y1

External Examiner(s): Prof. G. Walsh
Internal Examiner(s): Dr. R. Hourihane
Mr. D. Spicer

Instructions: Attempt 4 questions.
Question 1 Section A is compulsory.
Attempt one question from Section B,
one question from section C , and a fourth question
from either section B or C.

Duration: 2 hours

Sitting: Auutmn 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. Attempt eight of the following all carry equal marks.

- (i) How can we tell that a reaction has reached equilibrium? Illustrate on a plot of concentration versus time.
- (ii) Calculate K_c for the following equilibrium reaction at 400K given the following equilibrium concentrations



0.0222 M NO, 0.0111M Cl_2 and 0.978M NOCl

Does the reaction at equilibrium contain mostly reactants or mostly products?

- (iii) Identify the acid, base, conjugate acid and conjugate base in the following reactions
 - (a) $\text{HNO}_3 \text{ (aq)} + \text{NH}_3 \text{ (aq)} \rightarrow \text{NH}_4^+ \text{ (aq)} + \text{NO}_3^- \text{ (aq)}$
 - (b) $\text{HClO}_2 \text{ (aq)} + \text{KOH (aq)} \rightarrow \text{H}_2\text{O (l)} + \text{KClO}_2 \text{ (aq)}$
- (iv) Distinguish graphically between average and instantaneous rate.
- (v) When 1.045g of CaO is added to 50.0 mL of water at 25.0 °C in a calorimeter, the temperature of the water increases to 32.3°C. Assuming that the specific heat capacity of the solution is 4.18J /(g °C) and that the calorimeter absorbs a negligible amount of heat, calculate ΔH (in kilojoules/mol) for the process
$$\text{CaO(s)} + \text{H}_2\text{O (l)} \rightarrow \text{Ca(OH)}_2\text{(aq)}$$
- (vi) Explain why Gibbs free energy is a much more reliable quantity than enthalpy, when predicting reaction spontaneity. What is the sign on ΔG for such a process?
- (vii) Explain why alcohols have higher boiling points than hydrocarbons of a similar molecular masses.
- (viii) Is 2-methylpropan-2-ol a primary, secondary or tertiary alcohol? Explain your answer.
- (ix) Write the configurational (geometric) structures of the two isomers of pent-2-ene and explain which is the E and which is the Z isomer.
- (x) Explain why fractional distillation is carried out on crude oil in an oil refinery.

(25 Marks)

Section B

Q2. (a) State Le Chatelier's Principle.

(b) With reference to the equilibrium illustrated below



Predict the effect of the following changes on the equilibrium position and the equilibrium constant :

- (i) increasing the temperature of the reaction at equilibrium
 - (ii) increasing the pressure on the reaction at equilibrium
 - (iii) removing some oxygen from the system when the reaction is at equilibrium.
- (c) (i) What solutions when mixed together constitute a buffer solution?
- (ii) Which of the following mixtures would make the best buffer?
- (a) HCl and NaCl
 - (b) NaCH₃COO and NH₃
 - (c) CH₃COOH and NH₄Cl
 - (d) NH₃ and NH₄Cl.

Justify your selection.

(25 Marks)

Q3. (a) Using the data in the following table

(i) write the rate law

(ii) determine a value for the specific rate constant

for the reaction between methyl iodide and the OH⁻ ion as described in the reaction below



Initial [CH ₃ I] / M	Initial [OH ⁻] / M	Initial Rate of reaction / MS ⁻¹
1.35	0.10	8.78 x 10 ⁻⁶
1.00	0.10	6.50 x 10 ⁻⁶
0.85	0.10	5.53 x 10 ⁻⁶
0.85	0.15	8.29 x 10 ⁻⁶

- (b) (i) What is the internal energy of a system?
- (ii) Calculate the work done (in kilojoules) during a synthesis of ammonia in which the volume contracts from 8.6L to 4.3L at a constant external pressure of 44 atm. If the system also absorbs 1000J of heat, calculate the change in internal energy for the process.

(c) Internal energy is a state function, what is meant by this statement?

Identify at least two other state functions.

(25 Marks)

Section C

- Q4. (a) Explain why propan-2-ol is the only product obtained when propene is hydrated in the presence of a strong acid. (9 marks)
- (b) Describe how propene can be polymerised. (8 marks)
- (c) Write the structural formula of the product formed in the following reaction:
Propene + HBr, ether, **peroxide**. (8 marks)
- Q5. (a) State one way in which the equilibrium constant in an esterification reaction may be increased. Explain your answer. (8 marks)
- (b) Starting from ethanol write a reaction mechanism for the synthesis of diethylether, $\text{C}_2\text{H}_5\text{OC}_2\text{H}_5$. (9 marks)
- (c) How can ethanoic acid can be synthesised from ethanol? (8 marks)