

Cork Institute of Technology
Bachelor of Science (Honours) in Herbal Science – Stage 1

(NFQ Level 8)

Autumn 2007

Chemistry

(Time: 3 Hours)

Instructions

Answer FIVE questions.

Question ONE is Compulsory Section A.

Answer FOUR questions from Section B.

Examiners: Dr. R. Hourihane

Dr. D. Corrigan

Mr. E. Walsh

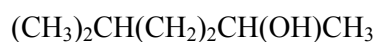
Section A

Q1. **Attempt ten of the following. All question carry equal marks.**

- (i) Distinguish between ionic and covalent bonds.
- (ii) List the steps involved in the formation of a covalent bond.
- (iii) Draw the Lewis structure of each of the following: Mg; NaCl.
- (iv) What is meant by the term 'bond energy'?
- (v) Write the ground state electronic configuration of each of the following: N; Cr.
- (vi) Give the symbol and possible values for the secondary quantum number.
- (vii) Calculate the pH of 0.5 mol dm⁻³ NaOH solution.
- (viii) Identify the acid, base, conjugate acid and conjugate base in the following reaction:



- (ix) What is meant by an isolated system? Give an example.
- (x) What is the change in internal energy of a system that does 7.02 kJ of work and absorbs 888 J of heat?
- (xi) What graph should be plotted to prove that kinetic data obeys first order kinetics?
- (xii) What is the order with respect to each species and the overall reaction order given the following rate law: $\text{Rate} = k[\text{NO}_2][\text{O}_2]$
- (xiii) What is a saturated hydrocarbon? Give an example.
- (xiv) Using the IUPAC rules for naming organic compounds, name the following compound and identify the functional groups:



(20 marks)

Section B

- Q2. (a) The periodic table is a most significant tool that scientists use for organising and remembering chemical facts. It arranges elements in order of increasing atomic number and mass number. Mass numbers are usually non integer values due to the existence of isotopes.

The table consists of a series of **rows** and **columns** about which atomic properties vary periodically.

- (i) Explain the underlined terms.
- (ii) Correctly name the terms in bold.
- (iii) List at least three atomic properties which fit the description in the text.
- (iv) How do the properties vary as one progresses across or down the table?

10 marks)

- (b) The element lead (Pb) consists of four naturally occurring isotopes as outlined in the table below:

Isotope	Abundance / %	Atomic mass / amu
²⁰⁴ Pb	1.4	203.973
²⁰⁶ Pb	24.1	205.974
²⁰⁷ Pb	22.1	206.976
²⁰⁸ Pb	52.4	207.977

From this data calculate the atomic mass of lead correct to two decimal places.

(5 marks)

- (c) For each of the following elements:
- (i) Write the chemical symbol
 - (ii) Name the column of the periodic table to which it belongs
 - (iii) Indicate whether it is metal or non-metal.

Potassium, Iodine, Calcium, Argon, Tin.

(5 marks)

- Q3. (a) Write a comprehensive note, which compares organic and inorganic compounds.

In particular account for the differences in properties such as solubility, melting and boiling points and conductivity. (8 marks)

- (b) Write a note on alcohols which includes the following information:
- (i) General structural formula (1 mark)
 - (ii) The differences between primary, secondary and tertiary alcohols. (3 marks)
 - (iii) Why alcohols possess both acidic and basic properties. (2 marks)
 - (iv) How the melting points, boiling points and solubility of alcohols compare with those of alkanes and alkenes of similar molecular weight. (6 marks)

- Q4. (a) (i) Distinguish between heat capacity and specific heat capacity.
- (ii) When a 9.55 g sample of solid sodium hydroxide dissolved in 100 g of water in a coffee-cup calorimeter, the temperature rises from 23.6°C to 47.4°C.

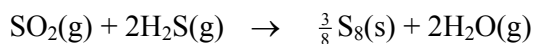
Calculate ΔH (in kJ/mol NaOH) for the following process:



It can be assumed that the specific heat capacity of the solution is the same as that of pure water.

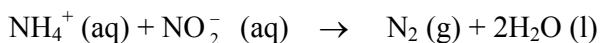
(s.h.c $\text{H}_2\text{O} = 4.18 \text{ J g}^{-1} \text{ K}^{-1}$) (8 marks)

- (b) Distinguish between exothermic and endothermic ΔH values. (4 marks)
- (c) (i) What is meant by the term 'standard enthalpy of formation'?
- (ii) Using the table of standard enthalpy of formation values attached, calculate the enthalpy change for the following process:



- (iii) Is the value endothermic or exothermic? (8 marks)

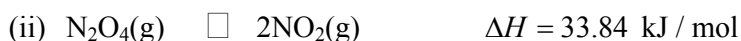
- Q5. (a) (i) What is meant by the term initial rate?
(ii) How may this value be calculated? (5 marks)
- (b) Initial rate data gathered at 25°C for the following process are listed in the table below:



Experiment	$\frac{\text{Initial}[\text{NH}_4^+]}{\text{M}}$	$\frac{\text{Initial}[\text{NO}_2^-]}{\text{M}}$	$\frac{\text{Initial Rate of consumption of } \text{NH}_4^+}{\text{MS}^{-1}}$
1.	0.24	0.10	7.2×10^{-6}
2.	0.12	0.10	3.6×10^{-6}
3.	0.12	0.15	5.4×10^{-6}

- (i) What is the rate law for the process?
(ii) Determine a value for the specific rate constant k.
(iii) What is the reaction rate when the concentrations are:
 $[\text{NH}_4^+] = 0.390 \text{ M}$
 $[\text{NO}_2^-] = 0.052 \text{ M}$
(iv) What is the order of the overall reaction? (12 marks)
- (c) In the reaction shown in (b) above, show how the rate of consumption of the reactants is related to the rate of production of the products. (3 marks)

- Q6. (a) Write the equilibrium expression K_c for each of the following:



- (b) Briefly describe the effects on the equilibrium reaction (ii) part (a) when:

- (i) the temperature is increased
(ii) a catalyst is added
(iii) additional $\text{NO}_2(\text{g})$ is added
(iv) the volume of the reaction vessel is increased (8 marks)

- (c) In relation to reaction (iii) part (a), calculate a value for the equilibrium constant given the following data: $\text{CO}_2 = 0.2 \text{ mol}$, $\text{CO} = 0.3 \text{ mol}$, and $\text{H}_2 = \text{H}_2\text{O} = 0.160 \text{ mol}$
Volume of container is 3.00 L. (6 marks)

Q7. (a) In a laboratory experiment to isolate the solid caffeine from tea leaves, the leaves were first boiled in water for 15 minutes. Lead ethanoate (acetate) solution was then added and the resultant precipitate filtered.

The volume of the filtrate was reduced to about 25 cm^3 , cooled and then extracted twice with 25 cm^3 portions of dichloromethane solvent. The combined dichloromethane extracts were dried with anhydrous sodium sulphate, then filtered and the caffeine collected by distilling off the dichloromethane.

The extracted caffeine was characterised using thin layer chromatography (tlc) and by carrying out melting point and mixed melting point determinations.

- (i) Why were the tea leaves boiled in water for 15 minutes?
- (ii) Explain the purpose in adding the lead ethanoate solution.
- (iii) Why was the volume of filtrate reduced to about 25 cm^3 ?
- (iv) Explain why dichloromethane is a suitable solvent for extracting the caffeine.
- (v) Outline how the dichloromethane extracts were dried and name a desiccant other than anhydrous sodium sulphate. (10 marks)

(b) In the characterisation of caffeine outline:

- (i) How the TLC experiment was carried out and explain the term R_f values, stationary phase and mobile phase as used in TLC.
- (ii) How a melting point and mixed melting point were carried out and comment on the significance of the results obtained. (10 marks)

en. Holley

Standard heats of
formation at 25°C

Substance	ΔH_f° , kJ mol ⁻¹	Substance	ΔH_f° , kJ mol ⁻¹
CH ₄ (g)	-74.8	H ₂ O ₂ (l)	-187.6
CH ₃ OH(l)	-239.0	H ₂ S(g)	-20.6
C ₂ H ₂ (g)	226.8	H ₂ SO ₄ (l)	-814.0
C ₂ H ₄ (g)	52.3	NH ₃ (g)	-46.1
C ₂ H ₆ (g)	-84.6	NH ₄ Cl(s)	-314.4
CO(g)	-110.5	NaCl(s)	-412.1
CO ₂ (g)	-393.5	Na ₂ O(s)	-415.9
HCl(g)	-92.3	O ₃ (g)	143
H ₂ O(g)	-241.8	SO ₂ (g)	-296.8
H ₂ O(l)	-285.8	SO ₃ (g)	-395.7