

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

(NFQ Level 8)

Summer 2007

Chemistry

(Time: 3 Hours)

Instructions

Answer FIVE questions.

Question ONE is Compulsory Section A.

Answer FOUR questions from Section B.

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Section A

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

- (i) List the four quantum numbers. Give the symbol associated with each.
- (ii) Classify the following as ionic, covalent or polar covalent compounds.
NaCl; H₂O; CH₄
- (iii) How many neutrons are in the following elements?
(a) Fe₅₇ (b) Os₁₉₁
- (iv) In each of the following pairs of atoms identify the larger
(a) Na, Na⁺ (b) Br, Br⁻
- (v) Write the equilibrium expression K_c for each of the following reactions:
(a) $2\text{NO (g)} \rightleftharpoons \text{N}_2\text{(g)} + \text{O}_2\text{(g)}$
(b) $\text{Ni (CO)}_4\text{(g)} \rightleftharpoons \text{Ni (s)} + 4\text{CO (g)}$
- (vi) Which of the following equilibrium reactions lie to the right, favouring the formation of products, or to the left favouring formation of reactants?
(a) $\text{COCl}_2\text{(g)} \rightleftharpoons \text{CO (g)} + \text{Cl}_2\text{(g)}$ $K = 2.19 \times 10^{-10}$
(b) $2\text{SO}_2\text{(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{SO}_3\text{(g)}$ $K = 3.0 \times 10^4$
- (vii) At 100°C, $K = 0.078$, for the reaction $\text{SO}_2\text{Cl}_2\text{(g)} \rightleftharpoons \text{SO}_2\text{(g)} + \text{Cl}_2\text{(g)}$
In an equilibrium mixture of the three gases, the concentrations of SO₂Cl₂ and SO₂ are 0.108M and 0.052M, respectively. What is the concentration of Cl₂ in this mixture?

- (viii) Changes in internal energy of a system is given by the expression
 $\Delta E_{\text{system}} = q + w$
 Would the internal energy increase or decrease if heat is absorbed and work is done by the system?
- (ix) What is the standard enthalpy of formation of a material?
 Give the symbol.
- (x) Calculate the standard enthalpy change for the following reactions.
 $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$
 given that ΔH_f° for $\text{SO}_2(\text{g})$ and $\text{SO}_3(\text{g})$, are $-296.9 \text{ kJ mol}^{-1}$ and $-395.2 \text{ kJ mol}^{-1}$ respectively.
- (xi) Name A and draw the structural formula for B.
 A : $(\text{CH}_3)_3\text{CCH}_2\text{OH}$
 B : 2 – Methyl – 3 – Heptene
- (xii) What is an homologous series? Give an example.
- (xiii) List three differences between organic and inorganic compounds.
- (xiv) Using the periodic table, identify a metal and a non-metal.
- (xv) Do atoms get bigger or smaller as we move across a period of the periodic table?
 Give one reason why.

Section B

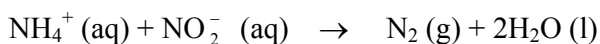
- Q2. (a) Describe the experiment, which led to the discovery of the electron. Include a simple diagram in your answer. (6 marks)
- (b) The periodic table arranges elements in order of increasing atomic number.
 The mass number of elements increases in a similar manner. These values however, are not integer values, due to the existence of isotopes. Atomic properties such as atomic radius, ionisation potential, and electron affinity show trends across periods and down groups of the periodic table.
 Explain the underlined terms in the passage. (10 marks)
- (c) Write the ground state electron configuration for
- (i) Na^+
 - (ii) Cu
 - (iii) O^{2-} (4 marks)

- Q3. (a) Covalent molecules such as organic compounds contain predominantly covalent bonds while inorganic compounds have mainly ionic bonds. The type of bond in a molecular or compound dictates properties such as solubility in water, melting or boiling points, as well as the phase of the materials.
- (i) Distinguish clearly between an ionic and a covalent bond. (4 marks)
 - (ii) Explain why ionic compounds are more soluble in water than covalent compounds. (3 marks)
 - (iii) Which would you expect to have the higher melting points and boiling points? (ionic or covalent) (3 marks)
- (b) Predict the ion generally formed by each of the following atoms:
- (i) Ca (ii) N (iii) Al (3 marks)
- (c) Draw Lewis structures for each of the following:
- (i) Mg (ii) CO₂ (iii) N₂H₄ (7 marks)

- Q4. (a) Distinguish between the Bronsted-Lowry and the Arrhenius theories of acids and bases. (4 marks)
- (b) Identify the Bronsted-Lowry acid, base, conjugate acid and conjugate base in each of the following:
- (i) $\text{HSO}_4^-(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{SO}_4^{2-}(\text{aq}) + \text{HCO}_3^-(\text{aq})$
 - (ii) $\text{H}_3\text{O}^+(\text{aq}) + \text{HPO}_4^{2-}(\text{aq}) \rightarrow \text{H}_2\text{PO}_4^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$
 - (iii) $\text{HCO}_3^-(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{CO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$ (6 marks)
- (c) Determine the pH of each of the following foods.
- (i) SauerKraut, $[\text{H}_3\text{O}^+] = 3 \times 10^{-4} \text{ M}$
 - (ii) Eggs, $[\text{OH}^-] = 6 \times 10^{-7} \text{ M}$ (4 marks)
- (d) Human blood has a pH of 7.40.
Calculate the concentration of H_3O^+ and OH^- (3 marks)
- (e) Calculate the pH of a solution of HNO_2 , 1.5M, $K_a = 4.5 \times 10^{-4}$ (3 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) (i) List two types of reactions that alkenes can undergo. (2 marks)
 (ii) Are alkanes more or less reactive than alkenes? Justify your answer. (3 marks)
 (iii) Write a balanced equation for the combustion of propane. (C_3H_8) (3 marks)
 (iv) Distinguish between addition and substitution reactions. (4 marks)
- (b) In the case of each of the following reactions name and draw the structural formula for all possible product(s).
 (i) $\text{CH}_3\text{CH} = \text{CHCH}_3 + \text{H}_2 \rightarrow \dots\dots\dots$ (2 marks)
 (ii) $(\text{CH}_3)_2\text{C} = \text{CHCH}_3 + \text{HCl} \rightarrow \dots\dots\dots$ (4 marks)
 (iii) $\text{CH}_3\text{CH} = \text{CHCH}_3 + \text{CH}_3\text{CH}_3 \rightarrow \dots\dots\dots$ (2 marks)

- Q7. (a) What is recrystallisation? (2 marks)
- (b) Describe the process in detail. (5 marks)
- (c) List three characteristics of an ideal recrystallisation solvent.
Give an example. (3 marks)
- (d) The purity of a recrystallised material may be determined by its melting point (m.p).
Explain what is meant by melting point and melting point range. (3 marks)
- (e) How would you know from the m.p. value that the sample was contaminated or wet? (2 marks)
- (f) Describe briefly the method of melting point determination. (5 marks)