CORK INSTITUTE OF TECHNOLOGY

INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Autumn 2013

Module Title: Chemical Principles

Module Code: **CHEM6002**

School: Science

Course: BSc in Applied Biosciences & Biotechnology
                BSc (Honours) in Herbal Science
                BSc (Hons) Nutrition & Health Science
                BSc (Hons) in Biomedical Science
                BSc in Applied Physics & Instrumentation
                BSc (Honours) in Instrument Engineering
                BSc in Analytical & Pharmaceutical Chemistry
                BSc (Hons) in Analytical Chemistry with Quality Assurance
                BSc (Hons) in Environmental Science & Sustainable Technology

Programme Code: SBISC-8-Y1 / SBIOS-7-Y1
                SHERB-8-Y1 / SNHSC-8-Y1
                SPHBI-8-Y1 / SPHYS-7-Y1
                SINEN-8-Y1 / SCHEM-7-Y1
                SCHQA-8-Y1 / SESST-8-Y1

External Examiner(s): Dr. C. Roche.

Internal Examiner(s): Dr. M. Lehane

Instructions: Please answer Question 1 (compulsory), attempt **two** other questions.

Duration: 2 Hours

Sitting: Autumn 2013

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.
If in doubt please contact an Invigilator.

Question 1 (answer 10 parts: 40 marks total):

a) Distinguish between ionic and covalent compounds under the following headings:

    1. phase at room temperature,

    2. boiling point and melting point and

    3. solubility in water.

b) State Boyles Law and Charles Law and provide diagrams that help to explain these laws.

c) A quantity of gas under a pressure of 33.3 atm occupies 35 L at $255^{\circ}C$; under standard conditions what will the volume of the gas be?

d) Define the term 'electronegativity' (EN) and illustrate how EN values may be used to determine whether the following molecules are polar or non-polar:

    i. CsF

    ii. CH_4

    iii. HI

    iv. H_2O

e) Explain why H_2O is a liquid at room temperature while H_2S is a gas at room temperature.

f) Balance the following equations:

    i. $C_8H_{16}O + O_2 \rightarrow CO_2 + H_2O$

    ii. $Fe^{2+} + MnO_4^- + H^+ \rightarrow Mn^{2+} + Fe^{3+} + H_2O$

g) Define the following terms:

    i. The Aufbau Principle

    ii. Hund's rule

    iii. Pauli exclusion principle

h) Write out the full electronic configuration of the following:

     i. Na^+

     ii. Ca

     iii. F

     iv. Cr

i) Discuss, with diagrams, why the conductivity of a transition metal decreases with increasing temperature.

j) Explain why a concave ($\cup$) is observed when water is placed in a glass tube, whereas Mercury gives a convex ($\cap$) meniscus.

k) Draw Lewis structures for the following molecules and then use the Valence Shell Electron Pair Repulsion Theory (VSEPRT) to predict their shape:

     i. CCl_4

     ii. H_2O

     iii. $[I_3]^-$

     iv. XeF_4

l) Describe the hybridisation of Carbon in the CH_4 (methane) molecule.

m) A molecule with a molecular weight of 180.18 g/mol is analyzed and found to contain 40.00% carbon, 6.72% hydrogen and 53.28% oxygen. Calculate the empirical and molecular formula of this compound.

Question 2:

A primary standard is made from dissolving 5.10 g of potassium hydrogen phthalate ($C_8H_5O_4K$) in 250 mls of deionised water. *(Potassium Hydrogen Phthalate is also known as KHP).* To standardise a sodium hydroxide (NaOH) solution, a 20 mls aliquot of NaOH solution was titrated against the standard KHP solution with an end-point at 19.5 mls.

$$C_8H_5O_4K \ + \ NaOH \longrightarrow C_8H_4O_4KNa \ + \ H_2O$$
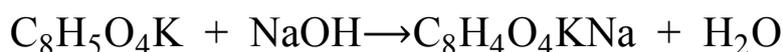
(i)   What is the molar mass of KHP?

(ii)   How many moles of KHP were weighed out?

(iii) What is the concentration in mol/L of KHP?

(iv) Calculate the number of moles of KHP used in the titration.

(v)   Deduce the number of moles of NaOH used in the titration from the reaction equation above.

(vi) Calculate the concentration in mol/L of the NaOH solution.
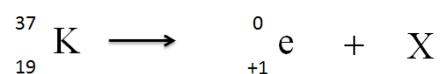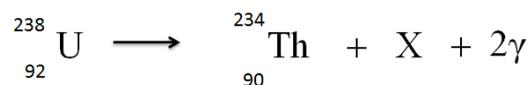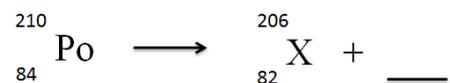
[30 marks]

Question 3:

The ideal gas law is given below:

$$PV = nRT$$

(i) Describe each of the terms in the above equation   [5 marks]

(ii) Name the three individual laws that were combined to give this ideal gas law, and state their relationships (ie give an equation and an explanation for each).

[12 marks]

(iii) What is the density of oxygen gas at 2atm and -73° C?

[7 marks]

(iv) What is the volume of 36 g of oxygen gas at 2 atm and -73° C?

[6 marks]

Question 4:

a) Complete the following Nuclear equations and in each case identify X:

$$^{210}_{84}\text{Po} \longrightarrow {}^{206}_{82}\text{X} + \underline{\quad}$$

$$^{238}_{92}\text{U} \longrightarrow {}^{234}_{90}\text{Th} + \text{X} + 2\gamma$$

$$^{37}_{19}\text{K} \longrightarrow {}^{0}_{+1}\text{e} + \text{X}$$

[12 marks]

b) Explain how to plot the Nuclear Belt of Stability using information from the periodic table, make a sketch of the typical graph and indicate on this sketch where α, β, and γ emissions are located.

[12 marks]

c) Briefly explain the principles of nuclear fission and nuclear fusion.

[6 marks]