Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

AUTUMN EXAMINATIONS 2011

EXAM CODES	**1BPC1, 1BPP1, 1BS1, 1BY1, 1EH1, 1EV1:**
EXAMS	Biopharmaceutical Chemistry,Physics & Applied Physics; Undenominated Science; Biotechnology; Earth and Ocean Sciences; Environmental Science

MODULE CODE	**CH101**
MODULE	**CHEMISTRY**
EXTERNAL EXAMINER	**Professor Richard Taylor**
INTERNAL EXAMINERS	**Dr. F. Aldabbagh**
	Dr. T. Higgins
	Dr. D. Leech

INSTRUCTIONS:	Answer **Five** questions No more than **two from any section** Use a separate answer book for each Section Leave the first page of the Answer Book blank and list on it clearly the numbers of the questions attempted All questions carry 20 marks distributed as shown
DURATION:	**Three Hours**
NUMBER OF PAGES:	**4**
SCHOOL:	**Chemistry**

REQUIREMENTS:

Mathematical tables	**yes**
Graph paper	**yes**

Universal Gas Constant:	R = 8.31 $kPadm^3K^{-1}mol^{-1}$ ($JK^{-1}mol^{-1}$)
Standard Temperature:	273K
Atomic Masses (a.m.u.):	H, 1.0;C, 12.0; N, 14.0; O, 16.0; F, 19.0; Mg, 24.3; S, 32.0; Cl, 35.5; Ar 40.0.
Charge of the electron:	-1.6×10^{-19} C; mass of the electron: 9.109×10^{-31} kg.
Faraday:	96500 C
Avogadro Number:	6.022×10^{23}
Planck Constant:	$h = 6.626 \times 10^{-34}$ Js.; (kgm^2s^{-1})
Velocity of light:	$c = 2.997 \times 10^8$ ms^{-1}

Section A – (Inorganic Chemistry)

1. Answer each of the following: [5 marks each]

(i) Draw diagrams to represent the structure at the atomic level for the ionic lattice of sodium chloride.

(ii) What is the empirical formula of a compound that contains 49.4% K, 20.3% S, and 30.3% O by mass? (Atomic weights; K, 39.098; S, 32.065; O 15.999)

(iii) Sketch an energy level diagram showing the electronic configuration for iron (Fe).

(iv) Briefly outline the main features of the Bohr model of the hydrogen atom and show how this model accounts for the visible emission spectrum of hydrogen. Using Bohr's energy expression, $E = -2.18 \times 10^{-18}$ J $(1/n^2)$, account for the red line (656nm) in the hydrogen emission spectrum.

2. Answer each of the following: [5 marks each]

(i) Draw diagrams to represent the molecular structures of the element nitrogen and of the element fluorine. Clearly show bonding and non-bonding electrons in each case.

(ii) Give the most common oxidation state for each of the elements, magnesium, carbon, and sulphur. Predict molecular formulae for; magnesium carbide, magnesium sulfide, and carbon sulfide.

(iii) Write briefly on the chemistry of chlorine and describe some of its uses.

(iv) Describe the chemistry of 'acid rain' and discuss its significance in health and its impact on the environment.

3. Answer each of the following: [5 marks each]

(i) Write electronic configurations, valence shell electronic configurations, and Lewis (electron dot) pictures for the elements; magnesium, bromine, and phosphorus.

(ii) Write a balanced chemical equation for the reaction of chlorine with sodium hydroxide to form sodium chloride and sodium hypochlorite. Write oxidation and reduction half reactions and clearly identify the chemical species that are oxidised and those that are reduced.

(iii) Describe the chemistry of the lithium battery and account for its advantages over conventional batteries.

(iv) Describe some of the physical and chemical properties of the transition metals.

4. Answer each of the following: [5 marks each]

(i) Assign oxidation states to each of the elements in the following molecules. I_2; KI; KIO_3.

(ii) Write a balanced chemical equation that shows the production of pure silicon from the reaction of hydrogen with silicon tetrachloride.

(iii) Describe the structures and uses of silicon, silicon oxide and silicate minerals.

(iv) Write briefly on soaps in the home and in society and on how hardness of water influences their effectiveness.

Section B – Organic Chemistry and Molecular Structure

5. Answer each of the following:

(i) Using Valence Shell (Domain) Electron Pair Repulsion Theory derive structures for the following molecules:
N_2; NH_4^+; CCl_4; PCl_5 **[12 marks]**

(ii) Describe the chlorate molecule $(ClO_2)^-$ using three possible Lewis structures. Which is the most important structure and why? **[8 marks]**

6. Write an essay on benzene, including its structure, bonding (including hybridization) and reactivity. Give at least one reaction scheme, and describe the electrophilic aromatic substitution mechanism involved. **[20 marks]**

7. Compare and contrast bonding (incl. hybridization) and geometry of ethane, ethene and ethyne molecules. Give a brief mechanism for the addition of HBr onto an alkene. **[20 marks]**

8. Answer *any two* of the following: [10 marks each]

(i) Using resonance structures, discuss the following statement; *phenols are much stronger acids than aliphatic alcohols*. Give the structure of a stronger organic acid than phenol.

(ii) Give a mechanism with conditions for the reaction of cyclohexane with bromine to give bromocyclohexane.

(iii) Explain what is meant by a chiral compound and draw any pair of enantiomers. What interaction would each of these enantiomers have with plane polarised light?

Section C – Physical Chemistry

9. Answer both (i) and (ii):

(i) When a 2.30 g sample of quinone, $C_6H_4O_2$, is burned in a constant-volume bomb calorimeter the temperature of the calorimeter increases from 23.4°C to 30.6°C. In a separate experiment the temperature of the calorimeter rose by 8.8°C when a current of 200 mA was passed through the calorimeter from a power supply of 15 V for 5 minutes.

(a) Write a chemical equation for the combustion of quinone. **[5 marks]**

(b) What is the heat of combustion per gram of quinone? **[3 marks]**

(c) What is the heat of combustion per mole of quinone? **[2 marks]**

(ii) Discuss the phase diagram for water [**10 marks**]

10. Answer both (i) and (ii):

(i) (a) A neon sign is made of glass tubing whose inside diameter is 0.2 m and whose length is 2.0 m. If the sign contains neon at a pressure of 280 Pa at 35°C, how many grams of neon are in the sign, assuming perfect gas behaviour. (The volume of a cylinder is $\pi r^2 h$, and atomic mass of neon is 20.2 a.m.u.). **[5 marks]**

(b) What modifications to the ideal gas law did Van der Waals propose to account for deviations from perfect gas behaviour? **[5marks]**

(ii) (a) List and briefly explain the intermolecular forces of which you are aware. **[8 marks]**

(b) Give an example of a liquid property that can be used as an estimate of the strength of intermolecular forces. **[2 marks]**

11. Answer both (i) and (ii):

(i) Carbon-14 is a radioactive isotope that decays to form Nitrogen-14 with a half-life of 5770 years.

What is the order of the decay process **[2 marks]**

What is the rate constant for the decay? **[3 marks]**

How many years will it take for 90% of the ^{14}C in a sample of naturally occurring carbon (a mixture of carbon isotopes including ^{14}C) to decay? **[5 marks]**

(ii) Glycerol ($C_3H_8O_3$) is a non-volatile water soluble liquid that can be used as radiator antifreeze. A solution of glycerol is made by dissolving 100.0 g of glycerol in enough water to make 0.25 kg of solution at 25°C.

(a) At what temperature would this solution freeze? (K_f for water is 1.86 °C/*m*) **[5 marks]**

(b) What is the solution vapour pressure, in Pa, if the vapour pressure of water at this temperature is 3173 Pa? **[5 marks]**

12. Answer both (i) and (ii):

(i) Describe why ice melts spontaneously at 0^oC even though it is an **endo**thermic process. **[10 marks]**

(ii) Calculate the pH of a 1.0 *M* aqueous solution of HCl at 25°C. Compare this to the pH of a 1.0 *M* aqueous solution of ethanoic acid (CH_3COOH), given that its pK_a is 4.75 at 25°C. **[10 marks]**