Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

Semester I Examinations, 2010/2011

Exam Code(s)	2BS1, 2BY1, 2EH1, 2EV1, 2BPP1, 2BPC1
Exam(s)	
Module Code(s)	CH204 Inorganic Chemistry
Module(s)	
Paper No.	1
Repeat Paper	Special Paper
External Examiner(s)	Professor K. Molloy
Internal Examiner(s)	Dr. A. Erxleben, Dr. T. Higgins

Instructions:

Answer 4 questions.
Answer one question from each section.
All questions carry 25 marks distributed as shown. Leave the first page of the Answer Book blank and list on it clearly the numbers of the questions attempted.

Duration	2 Hr.
No. of Answer books	
Requirements:	
Handout	
MCQ	
Statistical Tables	
Graph Paper	
Log Graph Paper	
Other Material	log tables with periodic table
No. of Pages	5 Following this page
Department(s)	Chemistry

Section A
Answer one question from this section

1. Answer **each** of the following:

(a) What is the origin of temporary and permanent hardness of water? Explain why temporary hardness can be removed by boiling. **[5 marks]**

(b) Outline a gravimetric procedure that you could adopt to determine the nickel content of a solution containing nickel, but no other metal ions. Clearly refer to any precautions that would be necessary within the procedure in order to obtain an accurate analysis.

[6 marks]

(c) With the help of the half-equations and redox potentials provided below, write balanced equations for the following reactions:

(i) $K_2Cr_2O_7 + HCl + Zn$ **[5 marks]**

(ii) $FeCl_3 + KI$

				E° (Volts)
Zn^{2+}	$+ \ 2 e^-$	=	Zn	-0.763
Cr^{3+}	$+ \ e^-$	=	Cr^{2+}	0.41
$1/2 \ I_2$	$+ \ e^-$	=	I^-	0.536
Fe^{3+}	$+ \ e^-$	=	Fe^{2+}	0.77
$Cr_2O_7^{2-} + 14 H^+$	$+ 6 e^-$	=	$2 Cr^{3+} + 7 H_2O$	1.33
$1/2 \ Cl_2$	$+ \ e^-$	=	Cl^-	1.36

(d) Explain the following:

(i) A colour change takes place when a basic aqueous potassium chromate solution is acidified.

(ii) The addition of sodium hydroxide to a copper sulphate solution results in the formation of a bluish precipitate, whereas the addition of excess ammonia solution results in the formation of a deep blue solution that does not contain a precipitate.

(iii) A colour change to green is observed, when NaOH is added to $KMnO_4$ until the solution is alkaline. **[9 marks]**

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2. Answer **each** of the following:

To determine the hardness of tap water, the following experiment has been carried out: To 50 cm^3 of tap water buffer (pH 10) and ErioT indicator were added. The solution was titrated with 1.035×10^{-2} M EDTA-Mg solution. 7.8 cm^3 EDTA solution were required for the titration. Then 250 cm^3 of tap water were boiled for 20 minutes. The solution was cooled, filtered into a 250 cm^3 volumetric flask and diluted to the mark with distilled water. 50 cm^3 of this solution were mixed with buffer (pH 10) and ErioT indicator and titrated with 1.035×10^{-2} M EDTA-Mg solution. 7.1 cm^3 EDTA-Mg solution were used.

(a) Draw the structure of EDTA. **[3 marks]**

(b) Calculate the temporary hardness as mg $CaCO_3$ per dm^3. **[22 marks]**

Atomic weights: Ca: 40
C: 12
O: 16

Section B
Answer one question from this section

3. Answer **each** of the following:

(a) Define the following terms:
- (i) LUMO
- (ii) antibonding molecular orbital
- (iii) van der Waals radius. **[3 marks]**

(b) Construct the MO diagram of B_2. Calculate the bond order and predict whether the molecule is paramagnetic or diamagnetic. **[10 marks]**

(c) Provide an energy *vs*. distance plot for the approach of two hydrogen atoms and explain the form of the plot. **[6 marks]**

(d) Use the Valence Shell Electron Pair Repulsion Theory to derive the geometry of the following: **[6 marks]**
- (i) $SbCl_5$
- (ii) BrF_3
- (iii) $SnCl_3^-$.

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4. Answer **each** of the following:

(a) Define the following terms:
(i) polymorph
(ii) substitutional alloy **[6 marks]**

(b) What is the coordination number of
(i) a sphere in a cubic close-packed structure
(ii) Na^+ in the NaCl lattice **[4 marks]**

(c) Describe the antifluorite lattice in one sentence. **[4 marks]**

(d) Sketch the unit cell of the CsCl lattice. Show that the structure of the unit cell is consistent with the formula CsCl. **[5 marks]**

(e) Calculate the standard enthalpy of formation $\Delta_f H°$ of CaF_2 from the following data:
lattice enthalpy of CaF_2, $\Delta_{lattice}H°(CaF_2) = -2643$ kJ mol^{-1}
enthalpy of atomization of Ca, $\Delta_a H°(Ca,s) = 178$ kJmol^{-1}
first ionization energy of Ca, $IE_1 = 590$ kJ mol^{-1}
second ionization energy of Ca, $IE_2 = 1145$ kJ mol^{-1}
dissociation enthalpy of F_2, $D(F_2,g)= 158$ kJ mol^{-1}
electron affinity of F, $\Delta_{EA}H(F,g) = -328$ kJ mol^{-1} **[6 marks]**

Section C
Answer one question from this section

5. Answer **each** of the following:

(a) Describe the crystal field splitting pattern for octahedral complexes of transition metals. **[5 marks]**

(b) Use crystal field theory to explain why compounds of first row transition metals are coloured and to account for the visible spectrum of the cation, $[Ti(H_2O)_6]^{3+}$. **[6 marks]**

(c) Arrange the following ligands in order of increasing field strength, Br^-, F^-, CN^-, NH_3, H_2O, and account for differences in the visible spectra of the complex ions $[Ti(H_2O)_6]^{3+}$ (λ_{max} = 493nm) and $[TiF_6]^{3-}$ (λ_{max} = 588nm). **[6 marks]**

(d) Predict the spin only magnetic moments of the following compounds.
$[V(H_2O)_6]^{3+}$; $[CoBr_6]^{3-}$; $[Cr(CN)_6]^{4-}$; $[Cu(NH_3)_6]^{2+}$ **[8 marks]**

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6. Answer **five** of the following:

(a) Give the valence shell electronic configuration of iron in the complex ions, $[Fe(H_2O)_6]^{2+}$ and $[FeCl_6]^{3-}$.

(b) Give molecular formulae and draw structures for, (i) a hexa-aqua coordination compound of a transition metal with d^6 electronic configuration and (ii) a hexaamine coordination compound of a transition metal with a d^7 electronic configuration.

(c) Draw structures for all isomers of the complex cations, $[Cr(acac)_2(H_2O)_2]^+$ and $[Cr(acac)_3]$: where acac is the acetylacetonate anion.

(d) Draw structures for the *mer* and *fac* isomers of the coordination compound $[RhCl_3(PMe_3)_3]$.

(e) Draw a structure for the complex ion *trans*-$[ScCl_2(\text{benzo-15-crown-5})]^+$.

(f) Give molecular formulae and draw structures for the products formed when an aqueous solution of ferric chloride is reacted with potassium oxalate.

[5 marks each part]

Section D
Answer one question from this section

7. Answer **each** of the following:

(a) Compare the allotropes of carbon, graphite and diamond, with regard to structure, bonding and properties. **[10 marks]**

(b) Write balanced equations for the following reactions:

(i) SiF_4 with NaF

(ii) PbS with ozone. **[4 marks]**

(c) Describe the various steps of the production of ultrapure silicon starting from SiO_2. **[7 marks]**

(d) Explain why O_2 is a gas at room temperature, while sulfur is a solid. **[4 marks]**

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8. Answer **each** of the following:

(a) Write a brief note on the diagonal relationship shown by the pairs Li/Mg and Be/Al. For each pair, provide **two** examples of the diagonal relationship. **[7 marks]**

(b) Describe the structure of and bonding in $BeCl_2$. **[4 marks]**

(c) What is meant by the thermodynamic 6s inert pair effect? **[4 marks]**

(d) Comment on the following: In contrast to Mg^{2+}, Be^{2+} does not form a stable complex with EDTA. **[4 marks]**

(e) Write balanced equations for the following reactions:

(i) Ca with H_2O

(ii) $Al(OH)_3$ with H_2SO_4

(iii) BeF_2 with an excess of NaF. **[6 marks]**