Write the first 3 letters
Of your surname here

FAMILY NAME: ....

OTHER NAMES:..

STUDENT I.D. : ....

SIGNATURE: ....

THE UNIVERSITY OF NEW SOUTH WALES

SCHOOL OF CHEMISTRY

SEMESTER 1 2014

CHEM1011 Chemistry A

1. TIME ALLOWED – 2 hours.
2. READING TIME – 10 minutes.
3. THIS EXAMINATION PAPER HAS 20 PAGES.
4. TOTAL NUMBER OF QUESTIONS – 10 WRITTEN AND 10 MULTI-CHOICE.
5. ATTEMPT ALL QUESTIONS.
6. TOTAL MARKS AVAILABLE – 60% OF THE COURSE MARK.
7. THE 10 WRITTEN QUESTIONS IN PART A ARE WORTH 10 MARKS EACH, AND THE 10 MULTI-CHOICE QUESTIONS IN PART B ARE WORTH 2 MARKS EACH.
8. ALL ANSWERS TO PART A MUST BE WRITTEN IN INK. EXCEPT WHERE THEY ARE EXPRESSLY REQUIRED, PENCILS MAY BE USED ONLY FOR FILLING IN THE GENERALISED ANSWER SHEET, DRAWING, SKETCHING OR GRAPHICAL WORK.
9. THIS PAPER MAY NOT BE RETAINED BY THE CANDIDATE.
10. PRINT YOUR NAMES AND I.D. NUMBER AT THE TOP OF THIS PAGE, AND WRITE YOUR SIGNATURE.

SPECIAL INSTRUCTIONS

11. PART A: WRITE ANSWERS TO PART A INTO THIS EXAM PAPER, USING BLUE OR BLACK INK. ALL WORKING MUST BE SHOWN. APPROPRIATE UNITS MUST BE GIVEN FOR ALL NUMERICAL ANSWERS. IF MORE SPACE IS NEEDED, USE THE ADDITIONAL WORKING PAGES PROVIDED, AND INDICATE THE NUMBER OF THE ADDITIONAL PAGE USED ON THE QUESTION PAGE.
12. PART B: FOR EACH QUESTION CIRCLE THE LETTER NEXT TO YOUR SELECTED ANSWER, AND FILL IN THE LETTER CORRESPONDING TO THE ANSWER ON THE GENERALISED ANSWER SHEET. MARKS WILL BE AWARDED WHEN THE CORRECT ANSWER, ALONE, IS FILLED IN.
13. ENSURE YOUR PERSONAL DETAILS AND ANSWERS ARE ENTERED ON THE GENERALISED ANSWER SHEET BEFORE THE END OF THE EXAM PERIOD. THE ANSWERS ON THE GENERALISED ANSWER SHEET WILL BE USED TO DETERMINE THE MARKS FOR PART B.
14. CANDIDATES MAY BRING TO THE EXAMINATION: UNSW-APPROVED CALCULATOR.
15. THE FOLLOWING MATERIALS WILL BE PROVIDED: GENERALISED ANSWER SHEET, PERIODIC TABLE AND DATA SHEET.

WORKING PAGE

PART A
WRITTEN QUESTIONS

QUESTION 1

(a) Write balanced ionic equations for the following chemical reactions. Include states of matter, but do not include spectator ions.

(i) Solid sodium sulfite reacts with hydrogen peroxide solution to give sodium sulfate solution and water.

(ii) Hydroiodic acid is added to lead(II) nitrate solution giving an orange precipitate of lead(II) iodide.

(iii) Potassium carbonate solution reacts with dilute sulfuric acid to give gaseous carbon dioxide and other products.

(b) For the chemical species $^{32}S^{2-}$ provide the following information:

(i) Atomic number:

(ii) Mass number:

(iii) Number of protons:

(iv) Number of neutrons:

(v) Number of electrons:

(vi) How many atoms are there in total in 1 g of pure water

(vii) Write the formula for the conjugate base of the acid $H_2AsO_4^-$:

QUESTION 2

(a) (i) Use the Rydberg equation: $\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where $R_H = 1.097 \times 10^7\ m^{-1}$

to calculate the wavelength of light emitted when a hydrogen atom undergoes a transition from the $n = 4$ electronic state to the ground electronic state.

(ii) An emission spectrum from hydrogen atoms excited into the $n = 4$ electronic state displays six lines. Write down the six pairs of values for n_1 and n_2 for these lines.

(iii) Write down the values for n_1 and n_2 for the transition from (ii) above which gives the shortest wavelength of light.

(b) Using '$1s^2$ …' notation, write the complete ground state electronic configurations of the following gaseous atoms and ions.

(i) Zn

(ii) Cu^{2+}

(c) Write down all the species from part (b) which are paramagnetic.

(d) The ions F^-, Mg^{2+}, O^{2-}, N^{3-} and Na^+ are isoelectronic.

(i) What does isoelectronic mean?

(ii) Why do these ions not have identical radii ?

QUESTION 3

(a) In the “Chemical Equilibrium” laboratory experiment that you performed this Semester, you investigated the reactions of calcium hydroxide and its products:

Reaction 1. Carbon dioxide gas was bubbled through a saturated solution of calcium hydroxide. A white precipitate immediately formed.

Reaction 2. The mixture obtained in Reaction 1 was treated by passing more carbon dioxide through it. The white precipitate disappeared.

Reaction 3. The solution obtained in Reaction 2 was heated to boiling. The white precipitate reappeared.

Write net ionic chemical equations for each of the chemical reactions described above.

Reaction 1:
Reaction 2:
Reaction 3:

(b) In the “Chemical Equilibrium” laboratory experiment that you performed this Semester, you investigated the reaction of chromate ions with nitric acid to give dichromate ions. Write a net ionic equation for this reaction.

(c) Barium nitrate solution was added to the solution obtained in part (b). No change was observed. However when sodium hydroxide solution was subsequently added, a precipitate formed. Write a net ionic equation for the precipitation reaction.

QUESTION 4

(a) For each of the following molecules draw a Lewis diagram, describe the shape of the molecule, describe the hybridisation at the central atom, and state whether the molecule is polar.

(i) SiF_3H [2 marks]	(ii) OF_2 [2 marks]
Shape: [1 mark]	Shape: [1 mark]
Hybridisation: [1 mark]	Hybridisation: [1 mark]
Polar (yes or no)? [1 mark]	Polar (yes or no)? [1 mark]

QUESTION 5

(a) For each of the following ions draw a Lewis diagram (with most likely assignments of any formal charges to the appropriate atoms), describe the shape of the ion, and describe the hybridisation at the central atom.

(i) [2 marks] I_3^- Shape: [1 mark] Hybridisation: [1 mark]	(ii) [2 marks] PO_4^{3-} Shape: [1 mark] Hybridisation: [1 mark]

(b) Draw four resonance structures for PO_4^{3-}. [2 marks]

QUESTION 6

(a) Indicate the types of intermolecular forces possible between the two molecules listed as pairs in the table below, by writing the word 'yes' or 'no' in the space provided to indicate if each force is possible or not. [5 marks]

The two molecules	dipole–dipole forces	dispersion forces	hydrogen bonding
(i) H_2O and CH_3OH			
(ii) N_2 and CN			
(iii) CF_3OCH_3 and H_2O			
(iv) CH_2F_2 and CH_2F_2			

(b) For each of the solutes in Column 1 of the table below, choose the solvent from Column 2 in which it will have the greatest solubility, and write the name of the chosen solvent into Column 3. [2 marks]

Column 1: solute	Column 2: solvent choices	Column 3: chosen solvent
sodium acetate	methanol, dichloromethane, carbon tetrachloride	
methane	methanol, dichloromethane, carbon tetrachloride	

(c) For each molecule in Column 1 of the table below, choose the molecule with the highest boiling point and the molecule with the lowest boiling point. Writh your answer in Column 2 (highest boiling point) and Column 3 (lowest boiling point). [3 marks]

Column 1: Molecule choices	Column 2: Highest boiling point	Column 3: Lowest boiling point
Methane, methanol, propanol, propane		
Hexane, butane, octane, dodecane		
HF, HCl, HBr, HI		

QUESTION 7

(a) At 448 °C, K_c for the reaction of dihydrogen and diiodine is 50.5:

$$H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$$

Use a calculation to predict whether a system containing a 2.00 L vessel at 448 °C contains 20.0 mmol of HI, 10.0 mmol of H_2 and 30.0 mmol of I_2, is at equilibrium? If not, what does your calculation tell you about spontaneous direction of the reaction?

(b) Calculate $\Delta H°$ (298 K) for:

$$2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$$

using these enthalpies of formation (at 298K):

$\Delta_f H°$ (ZnS) = –206 kJ mol^{-1}
$\Delta_f H°$ (ZnO) = –350 kJ mol^{-1}
$\Delta_f H°$ (SO_2) = –297 kJ mol^{-1}

(c) Solid copper has a heat capacity of 0.39 J K^{-1} g^{-1}. Calculate the heat required to increase the temperature of 1.00 kg of solid copper by 80 °C.

(d) 2.315 g of glucose ($C_6H_{12}O_6$, molar mass = 180.2 g mol^{-1}) was burned in a bomb calorimeter to produce CO_2(g) and H_2O (l). The bomb had a heat capacity of 1.800×10^3 J K^{-1} and was immersed in 2000 g of water (C_p = 4.184 JK^{-1}g^{-1}). The temperature change of the bomb and surrounding water was +3.52 °C. Calculate the molar internal energy change for the combustion of glucose.

QUESTION 8

(a) Acetic acid can be manufactured by reacting methanol with carbon monoxide:
$CH_3OH(l) + CO(g) \rightarrow CH_3COOH(l)$

Thermodynamic data (at 25 °C, standard state = 1 bar)		
	$\Delta_f H^\circ$ / kJ mol^{-1}	S°/ J K^{-1} mol^{-1}
$CH_3COOH(l)$	–490	160
$CH_3OH(l)$	–240	130
$CO(g)$	–110	200

(*i*) Calculate ΔH° for the above reaction at 25 °C.

(*ii*) Calculate ΔS° for the above reaction at 25 °C.

(*iii*) Calculate ΔG° for the above reaction at 25 °C.

(*iv*) Calculate the equilibrium constant for the above reaction at 25 °C.

(b) Fill in the missing entries in the table below for an aqueous solution at 25 °C.

$[H^+]$ /mol L^{-1}	pH	$[OH^-]$ /mol L^{-1}	pOH
			8.0

(c) Write down the formula and name for the conjugate acid of each of these species:

	Formula of conjugate base	Name of conjugate base
(i) $HClO_2$		
(ii) HSO_3^-		

(d) Use the data in the table to *circle* the correct answer to the following questions.

(*i*) The salt which gives more acidic solution:

$AlCl_3$ or CH_3COONa

(*ii*) The stronger base: NH_3 or CH_3COO^-

	pK_a at 25 °C
Al^{3+}	4.96
CH_3COOH	4.76
NH_4^+	9.24

QUESTION 9

(a) Benzoic acid, a monoprotic acid with the formula C_6H_5COOH, has a pK_a value of 4.20.

(*i*) Calculate the pH of 0.103 M benzoic acid.

(*ii*) Calculate the pH after adding 40.0 mL of 0.206 M NaOH to 80.0 mL of 0.103 M benzoic acid.

(b) What is the oxidation number of the element indicated in each of the following species?

Species	S_8	H_3PO_4	Cl_2O_7	HCO_3^-
Element	S	P	Cl	C
Oxidation Number				

(c) Hydrogen peroxide (H_2O_2) is oxidised by permanganate ion (MnO_4^-). Write balanced half equations and the overall chemical equation for the reaction of aqueous hydrogen peroxide with permanganate ions (MnO_4^-) in acid solution to produce a solution of manganese(II) ions.

QUESTION 10

(a) For the cell represented by this diagram: $Cd(s) \mid Cd^{2+}(aq) \parallel Ag^{+}(aq) \mid Ag(s)$,

(*i*) Write a balanced half-cell equation for the reaction at the anode.

(*ii*) Write a balanced equation showing the overall reaction occuring in the cell.

(*iii*) Given the standard reduction potentials: $E°$ (Cd^{2+} | Cd) = –0.40 V and $E°$ (Ag^{+} | Ag) = +0.80 V, calculate the standard cell potential.

(*iv*) Calculate $\Delta G°$ for the cell.

(b) List two reasons (maximum 3 words each) why lithium metal is often used in batteries for portable electronic devices.

Reason 1: ....

Reason 2: ....

(c) Briefly explain why cracks develop in steel reinforced concrete when measures are not taken to prevent corrosion of the reinforcing rods.

(d) Calculate the mass of zinc produced in 8.00 min by the electrolysis of molten $ZnCl_2$ using a current of 300 A.

PART B
MULTIPLE CHOICE

There are 10 multiple choice questions in this section, each worth 2 marks. Each multiple choice consists of a statement or question followed by 5 possible choices. Select the choice that best answers the statement or question by CIRCLING the appropriate letter.

There is only one correct answer for each question.

- TRANSFER YOUR ANSWERS TO THE GENERALISED ANSWER SHEET WITH PENCIL.
- YOUR MARK FOR THIS PART WILL BE DETERMINED FROM YOUR ENTRIES ON THE GENERALISED ANSWER SHEET.

THIS SECTION OF THE PAPER IS NOT AVAILABLE

DATA SHEET

0 °C = 273 K

1 atm = 760 mmHg = 101.3 kPa = 760 Torr

Ideal Gas Constant R = 8.314 J mol^{-1} K^{-1} = 0.08206 L atm mol^{-1} K^{-1}

Avogadro Number N_A = 6.022×10^{23} mol^{-1}

1 atm = 760 mmHg = 101.3 kPa = 760 Torr = 1.013 bar

Faraday Constant F = 96,485 C mol^{-1}

Nernst Equation $E_{cell} = E°_{cell} - \frac{RT}{nF} \ln Q$

Faraday Equation Q = i × t = amount electrons (mole) × F

Planck Constant h = 6.626 x 10^{-34} J s

Speed of Light c = 2.998 x 10^{8} m s^{-1}

Planck Equation $E = h\nu$

PLEASE SEE OVER

Periodic Group Numbers

The Periodic Table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 ^{99}**Tc** (98.91)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 ^{210}**Po** (210.0)	85 ^{210}**At** (210.0)	86 ^{222}**Rn** (222.0)
87 ^{223}**Fr** (223.0)	88 ^{226}**Ra** (226.0)	89 ^{227}**Ac** (227.0)															

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 ^{145}**Pm** (144.9)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 ^{231}**Pa** (231.0)	92 **U** 238.0	93 ^{237}**Np** (237.0)	94 ^{239}**Pu** (239.1)	95 ^{243}**Am** (243.1)	96 ^{247}**Cm** (247.1)	97 ^{247}**Bk** (247.1)	98 ^{252}**Cf** (252.1)	99 ^{252}**Es** (252.1)	100 ^{257}**Fm** (257.1)	101 ^{256}**Md** (256.1)	102 ^{259}**No** (259.1)	103 ^{260}**Lr** (260.1)

KEY

Atomic N° → 6
Symbol → **C**
Atomic Weight → 12.01

( ) is the relative atomic mass of the most common radioactive isotope, the mass number of which is given as a superscript.

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