UNIVERSITY OF NEW ENGLAND

NAME:_____

STUDENT NUMBER:_____

UNIT NAME: CHEM110

PAPER TITLE: Chemistry I

PAPER NUMBER: First and Only

DATE: **(for examinations to enter)** **TIME:** **(for examinations to enter)**

TIME ALLOWED: Two (2) hours and fifteen (15) minutes

NUMBER OF PAGES IN PAPER: FOURTEEN (14)

NUMBER OF QUESTIONS ON PAPER: FIFTEEN (15)

NUMBER OF QUESTIONS TO BE ANSWERED: FIFTEEN (15)

STATIONERY PER CANDIDATE:					
0	6 LEAF A4 BOOKS	**1**	ROUGH WORK BOOK	**0**	GENERAL PURPOSE ANSWER SHEET
0	12 LEAF A4 BOOKS	**0**	GRAPH PAPER SHEETS	**1**	SEE OTHER 'AIDS REQUIRED' BELOW

OTHER AIDS REQUIRED: **THE PERIODIC TABLE IS ON PAGE 14**

POCKET CALCULATORS PERMITTED: **YES** **(SILENT TYPE)**

TEXTBOOKS OR NOTES PERMITTED: **ONE (A4) PAGE OF STUDENT'S OWN NOTES (MAY BE WRITTEN, TYPED OR PHOTOCOPIED ON BOTH SIDES)**

INSTRUCTIONS FOR CANDIDATES:

- Candidates MAY NOT start writing until instructed to do so by the supervisor
- Please pay attention to the announcements and read all instructions carefully before commencing the paper
- Candidates MUST write their name and student number on the top of this page
- All answers **MUST** be written on the examination paper in the space provided for each question
- The rough work book may be used for rough work, but **ANY WORK IN THE ROUGH WORK BOOK WILL NOT BE ASSESSED**
- The Periodic Table is supplied on page 14
- The maximum marks allocated for each question are shown to the right of the question number. Use these as a guide to how much time you should spend on each question
- This examination question paper **MUST BE HANDED IN** with worked scripts. Failure to do so may result in the cancellation of all marks for this examination

REMEMBER TO WRITE YOUR NAME AND STUDENT NUMBER AT THE TOP OF THIS PAGE

QUESTION 1. [*8 marks]*

For the following reaction, identify the oxidation number of each element indicated in the space provided.

$$2Fe^{2+}(aq) + IO_4^-(aq) + H_2O(aq) \rightarrow 2Fe^{3+}(aq) + IO_3^-(aq) + 2OH^-(aq)$$

(a) For the reaction shown, which reactant is oxidised?

(b) For the reaction shown, which reactant is reduced?

(c) If 63.7 mL of 0.100 M sodium periodate ($NaIO_4$) is required to react with all the iron (II) chloride present in a sample, how many moles of iron (II) chloride were originally present?

(d) How much sodium periodate, in grams, must be dissolved in a 1.000 L volumetric flask to make a 0.100 M solution?

QUESTION 2. *[10 marks]*

Given the following data:

$\Delta_f H^\circ$ naphthalene (s) = +78.53 kJ mol^{-1}
$\Delta_f H^\circ$ water (g) = –241.82 kJ mol^{-1}
$\Delta_f H^\circ$ carbon dioxide (g) = –393.5 kJ mol^{-1}
Heat capacity of water = 4.184 J g^{-1} K^{-1}

(a) Write a balanced equation for the complete combustion of solid naphthalene, $C_{10}H_8$.

(b) How much energy is generated if 50 g of naphthalene is burnt at constant pressure?

(c) If the energy generated by burning 50 g of naphthalene was used to heat 10 kg of water initially at 18°C, what will the final temperature of the water be?

QUESTION 3. *[4 marks]*

(a) The normal melting point of sodium chloride is 801°C and its molar enthalpy of fusion is 2.6 kJ mol^{-1}. What is the change in entropy when a 64 kg pillar of sodium chloride melts at atmospheric pressure?

QUESTION 4. *[8 marks]*

A reaction that could be used to provide emergency oxygen in aircraft is the decomposition of sodium iodate, $NaIO_3$, according to the reaction below:

$$2NaIO_3(s) \rightarrow 2NaI(s) + 3O_2(g)$$

(a) Given the values of $\Delta_f H°$ and S° below, calculate the enthalpy of reaction and entropy of reaction for this process.

	$\Delta_f H°$ (kJ mol^{-1})	**S° (J K^{-1} mol^{-1})**
$NaIO_3(s)$	–440.1	134.2
NaI(s)	–287.8	98.5
$O_2(g)$	0	205.2

(b) From your values of $\Delta H_{rxn}°$ and $\Delta S_{rxn}°$, calculate the temperature at which this reaction will become product-favoured.

QUESTION 5 *[5 marks]*

Extreme ultraviolent light with a wavelength of 13.5 nm is expected to be the basis of the next generation of photolithography for making integrated circuits.

Avogadro's number, $N_A = 6.022 \times 10^{23}$ mol^{-1}
Planck's constant, $h = 6.626 \times 10^{-34}$ J s
Speed of light, $c = 2.998 \times 10^{8}$ m s^{-1}

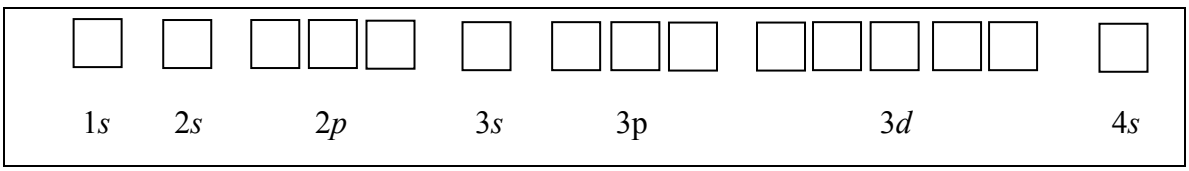
(a) What is the frequency of this 13.5 nm radiation (in s^{-1})?

(b) What is the energy of one photon of this radiation?

(c) If the binding energy of an electron in tantalum is 6.5×10^{-19} J, can it be ejected using 13.5 nm radiation? What will the energy of the ejected electron be?

QUESTION 6 *[4 marks]*

(a) In the space below draw an orbital diagram for the electron configuration of the Cu^{2+} ion.



(b) Write the condensed electron configuration for this ion.

QUESTION 7. *[8 marks]*

(a) Draw Lewis dot structures for both reactants and products illustrating the formation of chemical bonds between (i) a lithium ion and a hydride ion; (ii) a carbon atom and four fluorine atoms; and (iii) a nitrogen atom and two oxygen atoms.

<table>
<tr><td colspan="2">(i)</td><td colspan="2">(ii)</td></tr>
<tr><td>lithium ion</td><td>hydride ion</td><td>carbon atom</td><td>fluorine atom</td></tr>
<tr><td colspan="2">Lithium hydride</td><td colspan="2">Carbon tetrafluoride</td></tr>
<tr><td colspan="4">(iii)</td></tr>
<tr><td colspan="2">nitrogen atom</td><td colspan="2">oxygen atom</td></tr>
<tr><td colspan="4">Nitrogen dioxide</td></tr>
</table>

(b) Explain why you have drawn the number of structures you have for nitrogen dioxide.

QUESTION 8. *[8 marks]*

(a) Fill in the missing quantities in the table. Order the electronegativities of the elements shown from 1 to 5.

Element		Fluorine			
Symbol	^{134}Ba			^{18}O	
#Protons			7		30
#Neutrons		10			34
Mass Number			14		
Electronegativity (1 = highest, 5 = lowest)					

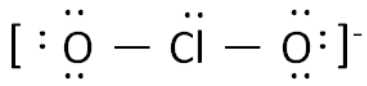
Write balanced equations for the reactions of (b) barium hydroxide and nitric acid, (c) zinc with fluorine, and (d) barium with water. Show the states of matter for all reactants and products.

(b)
(c)
(d)

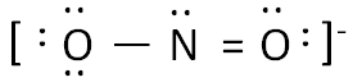
QUESTION 9. *[7 marks]*

(a) Using VSEPR theory and the Lewis structures given, determine the electronic and molecular structure of the following ions.

(i)



(ii)



(b) Predict the bond angle in each case.

(i) (ii)

QUESTION 10. *[7 marks]*

A laboratory-scale method for reducing a metal oxide is to heat it with H_2. The pure metal and H_2O are products. What volume of H_2 at 101.99 kPa and 225°C is needed to form 35.5 g of Cu from copper (II) oxide? Gas constant: R = 8.314 kPa L/K mol = 0.08206 L atm/K mol.

$$CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(g)$$

QUESTION 11. *[3 marks]*

(a) Which of the following has the higher vapour pressure, NH_3 or PH_3? Justify your answer.

(b) Name the phase change in each of these events:

(i) A diamond film forms on a surface from gaseous carbon atoms in a vacuum.

(ii) Mothballs in a bureau drawer disappear over time.

(iii) Molten iron from a blast furnace is cast into ingots.

(i)

(ii)

(iii)

QUESTION 12. *[4 marks]*

An element crystallizes in a face-centered cubic lattice and has a density of 1.45 g/cm^3. The edge of the unit cell is 4.52 x 10^{-8} cm.

(a) How many atoms are there in each unit cell?

(b) What is the volume and mass of a unit cell?

(c) Calculate an approximate atomic mass for the element.

QUESTION 13. *[7 marks]*

(a) A car radiator coolant solution contains 1.00 kg of antifreeze (ethylene glycol, $C_2H_6O_2$) and 4450 g of water. What is the freezing point of this solution?
(K_f = 1.86 $^oC\ m^{-1}$)

(b) The partial pressure of carbon dioxide gas inside a bottle of cola is 4 atm at 25°C. What is the solubility of CO_2? The Henry's Law constant for CO_2 dissolved in water is 3.3 x 10^{-2} mol /L atm at 25°C.

QUESTION 14. *[9 marks]*

The following reaction between ozone (O_3) and atomic oxygen (O), which occurs in the Stratosphere, produces molecular oxygen (O_2).

$$O(g) + O_3(g) \longrightarrow 2\ O_2(g)$$

It has been found that the reaction is first order in ozone and atomic oxygen.

(a) What is the rate law for this reaction?

(b) Given that the rate constant is $k = 4.15\times 10^{-5}\ M^{-1}\ s^{-1}$. What would the rate of ozone destruction be if $[O_3] = 1.2 \times 10^{-8}$ M and $[O] = 1.7 \times 10^{-14}$ M?

(c) The rate law for the decomposition of ammonia

$$2\ NH_3(g) \longrightarrow N_2(g) + 3\ H_2(g)$$

is given by, Rate = $k\ [NH_3]$. Calculate the rate constant, k, for the reaction given the following data.

$[NH_3]$ (M)	**Time (s)**
0.67	0
0.26	19

QUESTION 15. *[8 marks]*

At 2300 K the equilibrium constant for the formation of NO(g) is 1.7×10^{-3}.

$$N_2(g) + O_2(g) \rightleftharpoons 2\ NO(g)$$

(a) If the concentrations of N_2 and O_2 are both 0.25 M, and that of NO is 0.0042 M. Is the system at equilibrium?

(b) If the system is not at equilibrium, in which direction does the reaction proceed?

(c) What is the value for the equilibrium constant, *K*, for the reaction when written as follows?

$$\tfrac{1}{2}\ N_2(g) + \tfrac{1}{2}\ O_2(g) \rightleftharpoons NO(g)$$

The Periodic Table is on page 14

Periodic Table of the Elements

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
1	1 H Hydrogen 1.007 94																	2 He Helium 4.002 60
2	3 Li Lithium 6.941	4 Be Beryllium 9.012 182											5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.998 4032	10 Ne Neon 20.1797
3	11 Na Sodium 22.989 769 28	12 Mg Magnesium 24.3050											13 Al Aluminum 26.981 5386	14 Si Silicon 28.0855	15 P Phosphorus 30.973 762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948
4	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955 912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938 045	26 Fe Iron 55.845	27 Co Cobalt 58.933 195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.409	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.921 60	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798
5	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.905 85	40 Zr Zirconium 91.224	41 Nb Niobium 92.906 38	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.905 50	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.904 47	54 Xe Xenon 131.293
6	55 Cs Cesium 132.905 4519	56 Ba Barium 137.327	57 La Lanthanum 138.905 47	72 Hf Hafnium 178.49	73 Ta Tantalum 180.947 88	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966 569	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.980 40	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (277)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (271)	111 Rg Roentgenium (272)	112 Cn Copernicum (285)		114 Uuq* Ununquadium (289)		116 Uuh* Ununhexium (292)		

- The systematic names and symbols for elements greater than 112 will be used until the approval of trivial names by the IUPAC.

The discoveries of elements with atomic numbers 112, 114, and 116 have been reported but not fully confirmed.

58 Ce Cerium 140.116	59 Pr Praseodymium 140.907 65	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925 35	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930 32	68 Er Erbium 167.259	69 Tm Thulium 168.934 21	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
90 Th Thorium 232.038 06	91 Pa Protactinium 231.035 88	92 U Uranium 238.028 91	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

The atomic masses listed in this table reflect the precision of current measurements. (Each value listed in parentheses is the mass number of that radioactive element's most stable or most common isotope.)