NAME:_____ Student Number:_____

Fall 2018 **Chemistry 1000 Midterm #1A** ____/ 55 marks

INSTRUCTIONS:
1) Please read over the test carefully before beginning. You should have 6 pages of questions and a formula/periodic table sheet.
2) If your work is not legible, it will be given a mark of zero.
3) Marks will be deducted for incorrect information added to an otherwise correct answer.
4) Marks will be deducted for improper use of significant figures and for missing or incorrect units.
5) Show your work for all calculations. Answers without supporting calculations will not be given full credit.
6) You may use a calculator.
7) You have 90 minutes to complete this test.

Confidentiality Agreement:
I agree not to discuss (or in any other way divulge) the contents of this test until after 8:00pm Mountain Time on Tuesday, October 16th, 2018 (i.e. 24 hours **after** you finish writing this test). I understand that breaking this agreement would constitute academic misconduct, a serious offense with serious consequences. The minimum punishment would be a mark of 0/55 on this exam and removal of the "overwrite midterm mark with final exam mark" option for my grade in this course; the maximum punishment would include expulsion from this university.

Signature: _____ Date: _____
Course: CHEM 1000 (General Chemistry I)
Semester: Fall 2018
The University of Lethbridge

Spelling matters!

Fluorine = F Fluorene = $C_{13}H_{10}$

Flourine =



Question Breakdown

Q1	/ 4
Q2	/ 5
Q3	/ 6
Q4	/ 3
Q5	/ 5
Q6	/ 3
Q7	/ 7
Q8	/ 8
Q9	/ 14

Total	/ 55

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1. Write electron configurations for each of the following species. **[4 marks]**
Use the noble gas notation, but always show all electrons in the valence shell explicitly.

(a) N

(b) N^{3-}

(c) Fe

(d) Fe^{3+}

2. Answer the following questions about chlorine (Cl), argon (Ar) and potassium (K). **[5 marks]**

(a) List these three neutral elements in order of increasing atomic radius.

smallest radius _____ _____ _____ largest radius

(b) List these three neutral elements in order of increasing first ionization energy (I_1).

smallest I_1 _____ _____ _____ largest I_1

(c) List these three neutral elements in order of increasing electron affinity (E_{ea}).

smallest E_{ea} _____ _____ _____ largest E_{ea}

(d) In order to be isoelectronic with argon, chlorine must become which ion? _____

(e) In order to be isoelectronic with argon, potassium must become which ion? _____

3. When n = 3, there are three subshells (3s, 3p, and 3*d*). Draw and label **<u>one</u>** orbital from each of these three subshells. Show any radial nodes. **[6 marks]**
Each orbital must be clearly named, drawn on a labeled set of axes and show relative phase. The orbital label must refer to the specific orbital (not just name the subshell).

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4. The table below lists four quantum numbers corresponding to each orbital. There is **one** wrong number in each row. Circle the wrong number. **[3 marks]**

Orbital	***n***	***l***	m_l	m_s
7s	7	0	0	+1
6d	6	2	3	+½
5f	5	4	2	-½

5. Answer the following questions concerning the photoelectric effect. **[5 marks]**

(a) When light is applied to a piece of metal "M" in a photoelectric effect experiment, no electrons are ejected. In order to produce a positive photoelectric effect, which of the following approaches could you take as the next step? *[3 marks]*

Circle **all** the answer(s) that might work. Marks will be deducted for incorrect choices.

a. Increase the intensity of the light.

b. Decrease the intensity of the light.

c. Use light with a longer wavelength.

d. Use light with a shorter wavelength.

e. Use light of higher frequency.

f. Use light of lower frequency.

g. Replace the metal "M" with another metal that has a smaller ϕ (work function/ threshold energy/electron binding energy).

h. Replace the metal "M" with another metal that has a larger ϕ (work function/ threshold energy/electron binding energy).

(b) Use one or two sentences to summarize the contribution made by the photoelectric effect to quantum theory. *[2 marks]*

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6. There are two naturally occurring isotopes of chlorine: ^{35}Cl and ^{37}Cl. **[3 marks]**

(a) How do atoms of ^{35}Cl and ^{37}Cl differ? Be specific. *[1 mark]*

(b) Which of these two isotopes is more abundant in nature? Briefly explain how that can be determined from information provided on this test (including this question and the data sheet). *[2 marks]*

7. ^{192}Ir is often used in radiotherapy to treat certain cancers in the head, as well as some breast cancers. **[7 marks]**

^{192}Ir beta decays, producing an electron with a momentum of 8.376×10^{-22} kg·m·s^{-1}. *(Note: This is a relativistic electron traveling at 95% of the speed of light, so you can't use p = mv here.)*

This decay also produces a gamma ray with a photon energy of 5.0707×10^{-14} J.

(a) Calculate the wavelength of the electron. *[2 marks]*

(b) Calculate the wavelength of the gamma radiation. *[3 marks]*

(c) Calculate the momentum of the gamma-ray photon. *[2 marks]*

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8. Calculate the wavelength of the photon emitted when the electron in a Be^{3+} ion makes a transition from $n = 4$ to $n = 2$. **[8 marks]**

Report your answer in nm.

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9. ^{123}I is often used in Canadian hospitals for kidney and thyroid imaging. It decays to ^{123}Te. **[14 marks]**

(a) Write a balanced nuclear reaction for this decay. *[1 mark]*
If there is more than one possible answer, only one answer is required.

(b) Identify the type of decay described by your answer to part (a). *[1 mark]*

(c) Explain (in a few words) why ^{123}I decays as you indicated. *[2 marks]*

(d) The half-life of ^{123}I is 13.1 h. Because of the short half-life, once produced, ^{123}I must be quickly shipped and used. Data sheets provided to hospitals suggest that the product expires after 30 hours. It is sold in capsules that initially have a radioactivity of 3.7 MBq. What is the radioactivity of a capsule at the time of expiry? *[3 marks]*

...continued on next page…

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9. …*continued*

(e) The amount of radioactivity of a fresh capsule of ^{123}I might sound like a lot, but it only corresponds to about 0.014 pg of ^{123}I. How much energy is released by the decay of this amount of ^{123}I? *[7 marks]*

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Some Useful Constants and Formulae

Fundamental Constants and Conversion Factors

Atomic mass unit (u)	$1.660\,539 \times 10^{-27}$ kg	Planck's constant	$6.626\,070 \times 10^{-34}$ J·Hz^{-1}
Avogadro's number	$6.022\,141 \times 10^{23}$ mol^{-1}	Proton mass	1.007 277 u
Bohr radius (a_0)	$5.291\,772 \times 10^{-11}$ m	Neutron mass	1.008 665 u
Electron charge (e)	$1.602\,177 \times 10^{-19}$ C	Rydberg Constant (R_H)	$2.179\,872 \times 10^{-18}$ J
Electron mass	$5.485\,799 \times 10^{-4}$ u	Speed of light in vacuum	$2.997\,925 \times 10^{8}$ m·s^{-1}

Formulae

$$c = \lambda\upsilon \qquad E = h\upsilon \qquad p = mv \qquad \lambda = \frac{h}{p} \qquad \Delta x \cdot \Delta p > \frac{h}{4\pi}$$

$$r_n = a_0 \frac{n^2}{Z} \qquad E_n = -R_H \frac{Z^2}{n^2} \qquad E_k = \frac{1}{2}mv^2 \qquad \Delta E = \Delta m c^2$$

$$N_2 = N_1 \left(\frac{1}{2}\right)^{\Delta t / t_{1/2}} \qquad A = -\frac{\Delta N}{\Delta t} \qquad A = kN \qquad \ln\left(\frac{N_2}{N_1}\right) = -k(t_2 - t_1) \qquad \ln(2) = k \cdot t_{1/2}$$

Chem 1000 Standard Periodic Table

1												13	14	15	16	17	18
1.0079 **H** 1	2																4.0026 **He** 2
6.941 **Li** 3	9.0122 **Be** 4											10.811 **B** 5	12.011 **C** 6	14.0067 **N** 7	15.9994 **O** 8	18.9984 **F** 9	20.1797 **Ne** 10
22.9898 **Na** 11	24.3050 **Mg** 12	3	4	5	6	7	8	9	10	11	12	26.9815 **Al** 13	28.0855 **Si** 14	30.9738 **P** 15	32.066 **S** 16	35.4527 **Cl** 17	39.948 **Ar** 18
39.0983 **K** 19	40.078 **Ca** 20	44.9559 **Sc** 21	47.88 **Ti** 22	50.9415 **V** 23	51.9961 **Cr** 24	54.9380 **Mn** 25	55.847 **Fe** 26	58.9332 **Co** 27	58.693 **Ni** 28	63.546 **Cu** 29	65.39 **Zn** 30	69.723 **Ga** 31	72.61 **Ge** 32	74.9216 **As** 33	78.96 **Se** 34	79.904 **Br** 35	83.80 **Kr** 36
85.4678 **Rb** 37	87.62 **Sr** 38	88.9059 **Y** 39	91.224 **Zr** 40	92.9064 **Nb** 41	95.94 **Mo** 42	(98) **Tc** 43	101.07 **Ru** 44	102.906 **Rh** 45	106.42 **Pd** 46	107.868 **Ag** 47	112.411 **Cd** 48	114.82 **In** 49	118.710 **Sn** 50	121.757 **Sb** 51	127.60 **Te** 52	126.905 **I** 53	131.29 **Xe** 54
132.905 **Cs** 55	137.327 **Ba** 56	**La-Lu**	178.49 **Hf** 72	180.948 **Ta** 73	183.85 **W** 74	186.207 **Re** 75	190.2 **Os** 76	192.22 **Ir** 77	195.08 **Pt** 78	196.967 **Au** 79	200.59 **Hg** 80	204.383 **Tl** 81	207.19 **Pb** 82	208.980 **Bi** 83	(210) **Po** 84	(210) **At** 85	(222) **Rn** 86
(223) **Fr** 87	226.025 **Ra** 88	**Ac-Lr**	(265) **Rf** 104	(268) **Db** 105	(271) **Sg** 106	(270) **Bh** 107	(277) **Hs** 108	(276) **Mt** 109	(281) **Ds** 110	(280) **Rg** 111	(285) **Cn** 112	(284) **Nh** 113	(289) **Fl** 114	(288) **Mc** 115	(293) **Lv** 116	(294) **Ts** 117	(294) **Og** 118

138.906 **La** 57	140.115 **Ce** 58	140.908 **Pr** 59	144.24 **Nd** 60	(145) **Pm** 61	150.36 **Sm** 62	151.965 **Eu** 63	157.25 **Gd** 64	158.925 **Tb** 65	162.50 **Dy** 66	164.930 **Ho** 67	167.26 **Er** 68	168.934 **Tm** 69	173.04 **Yb** 70	174.967 **Lu** 71
227.028 **Ac** 89	232.038 **Th** 90	231.036 **Pa** 91	238.029 **U** 92	237.048 **Np** 93	(240) **Pu** 94	(243) **Am** 95	(247) **Cm** 96	(247) **Bk** 97	(251) **Cf** 98	(252) **Es** 99	(257) **Fm** 100	(258) **Md** 101	(259) **No** 102	(262) **Lr** 103

Developed by Prof. R. T. Boeré (updated 2016)

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Some Useful Masses

${}^{4}_{2}\alpha$	4.001 506 179 u
${}^{1}_{1}p$	1.007 276 467 u
${}^{1}_{0}n$	1.008 664 916 u
${}^{0}_{+1}\beta$	0.000 548 579 9 u
${}^{0}_{-1}\beta$	0.000 548 579 9 u
${}^{123}I$	122.905 588 5 u
${}^{123}Te$	122.904 269 8 u

Band of Stability Graph

The graph below shows the band of stability. Stable isotopes are in black. Isotopes that exist but are not stable are shown in varying shades of gray with the shades of gray corresponding to different half-lives.

The original version of the graph used a rainbow colour scale.

http://commons.wikimedia.org/wiki/File:Isotopes_and_half-life_eo.svg

