

NAME: _____

Student Number: _____

Spring 2020

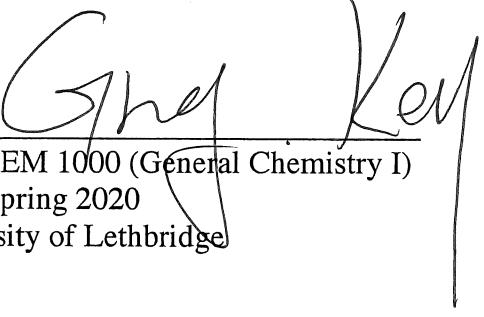
Chemistry 1000 Midterm #1A

____ / 60 marks

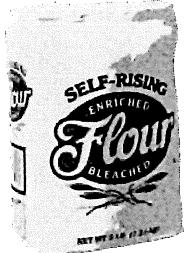
- INSTRUCTIONS:**
- 1) Please read over the test carefully before beginning. This exam consists of 11 questions.
 - 2) If your work is not legible, it will be given a mark of zero.
 - 3) Marks will be deducted for incorrect information added to an otherwise correct answer.
 - 4) Marks will be deducted 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 exam until they have all been marked and returned. I understand that breaking this agreement would constitute academic misconduct, a serious offense with serious consequences. The minimum punishment would be a mark of 0/60 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: Spring 2020
 The University of Lethbridge

Spelling matters!	
Fluorine = F	Fluorene = C ₁₃ H ₁₀
Flourine =	

Question Breakdown

Q1	/ 4
Q2	/ 8
Q3	/ 3
Q4	/ 5
Q5	/ 4
Q6	/ 6
Q7	/ 4
Q8	/ 4
Q9	/ 6
Q10	/ 4
Q11	/ 12

Total	/ 60
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1. Complete the following table.

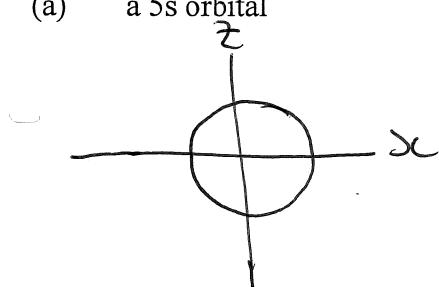
[4 marks]

Symbol	# protons	# neutrons	# electrons
$^{97}_{43}Tc$	43	54	43
$^{129}_{53}I^-$	53	76	54
$^{48}_{22}Ti^{4+}$	22	26	18

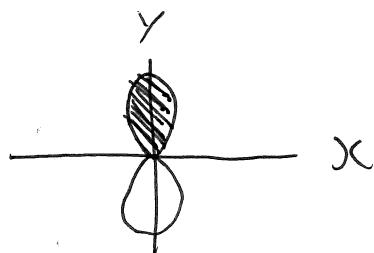
2. Draw and label the following orbitals. Each orbital must be drawn on a labeled set of axes and must show relative phase. You are not required to show any radial nodes.

[8 marks]

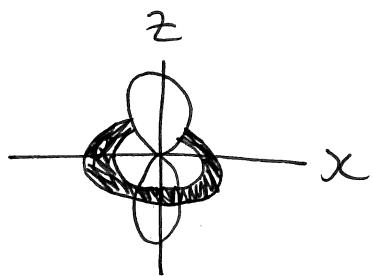
- (a) a 5s orbital



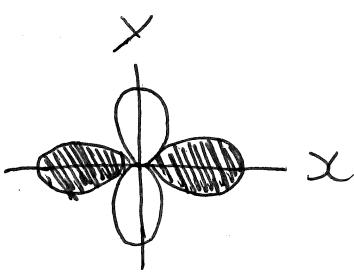
- (b) a 4p
- _y
- orbital



- (c) a 3d
- _{z^2}
- orbital



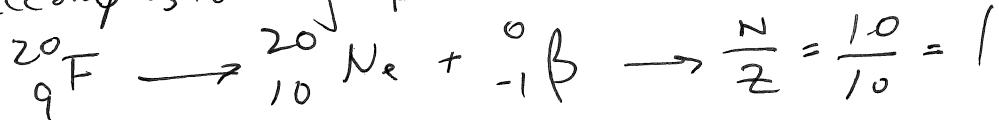
- (d) a 3d
- _{x^2-y^2}
- orbital



3. The
- $^{20}_9F$
- nuclide is unstable and will undergo decay to form a more stable nuclide. What is the most probable mode of decay for
- $^{20}_9F$
- ? Briefly explain your answer. [3 marks]

$$^{20}_9F \quad \frac{N}{Z} = \frac{11}{9} = 1.2 \rightarrow \text{too high for a small nuclide.}$$

$\therefore {}^{20}_9F$ will decay in a fashion that will lower N and/or increase Z to get a better $\frac{N}{Z}$. For small nuclides, this is accomplished by β^- emission.



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4. Thallium has two naturally occurring isotopes. ^{203}Tl has a natural abundance of 29.524% and an atomic mass of 202.9723 u. Calculate the natural abundance and the atomic mass for ^{205}Tl . [5 marks]

$$M_{\text{avg}} = \sum \left(\frac{\% \text{ abundance of isotope}}{100\%} \right) \times M_{\text{isotope}}$$

$$\text{Tl } M_{\text{avg}} = 204.383 \text{ u}$$

$$^{203}\text{Tl} \rightarrow 29.524\% \text{ with } M_{\text{Tl-203}} = 202.9723 \text{ u.}$$

$$^{205}\text{Tl} \rightarrow 100\% - 29.524\% = 70.476\% \quad M_{\text{Tl-205}} = ?$$

$$204.383 \text{ u} = \left(\frac{29.524\%}{100\%} \right) 202.9723 \text{ u} + \left(\frac{70.476\%}{100\%} \right) \times M_{\text{Tl-205}}$$

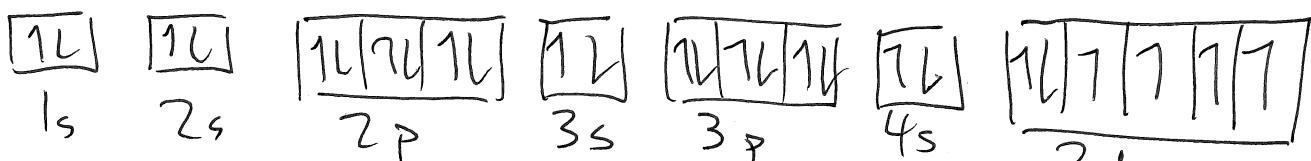
$$204.383 \text{ u} = 59.92554185 \text{ u} + (0.70476) \times M_{\text{Tl-205}}$$

$$\frac{204.383 \text{ u} - 59.92554185 \text{ u}}{0.70476} = M_{\text{Tl-205}}$$

$$M_{\text{Tl-205}} = 204.9739743 \text{ u}$$

^{205}Tl 70.476% abundant with mass
of 204.97 u

5. [4 marks]
- (a) Draw an orbital occupancy diagram ("orbital box diagram") for a neutral ground state iron atom (Fe). Include all electrons and label all subshells.



- (b) How many valence electrons does a neutral ground state iron atom have?

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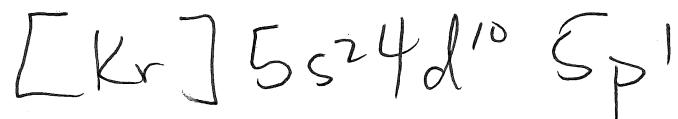
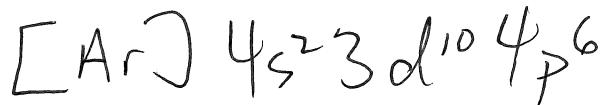
- (c) Is a neutral ground state iron atom paramagnetic or diamagnetic?

Paramagnetic.

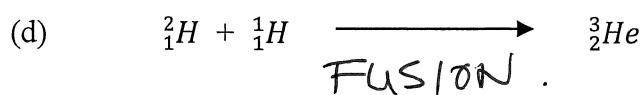
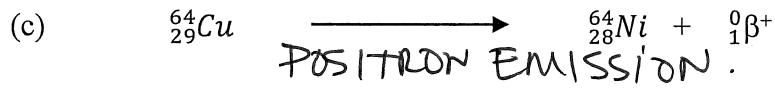
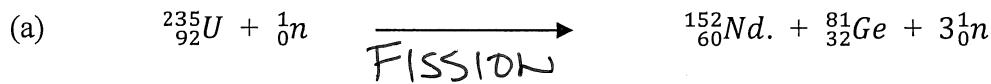
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6. Write electron configurations for each of the following species in the ground state.
Use the noble gas notation, but always show all electrons in the valence shell explicitly.
[6 marks]

(a) Ru^{4+} (b) In (c) As^{3-} 

7. There are seven classes of nuclear reactions. Classify each of the following as one of the seven different types of nuclear reactions. **[4 marks]**



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8. A sample of Radon-222 ($^{222}_{86}Rn$) has an initial activity of 7.0×10^4 Bq. After 6.6 days, its activity is 2.1×10^4 Bq. Calculate the half-life of radon-222. [4 marks]

$$A_2 = 2.1 \times 10^4 \text{ Bq}$$

$$A_1 = 7.0 \times 10^4 \text{ Bq}$$

$$\Delta t = 6.6 \text{ days.}$$

$$\ln\left(\frac{A_2}{A_1}\right) = -k(\Delta t)$$

$$\ln\left(\frac{2.1 \times 10^4 \text{ Bq}}{7.0 \times 10^4 \text{ Bq}}\right) = -k(6.6 \text{ days})$$

$$\ln(0.3) = -k(6.6 \text{ days})$$

$$k = \frac{\ln(0.3)}{-6.6 \text{ days}}$$

$$k = 0.1824201219 \text{ day}^{-1}$$

$$\ln(2) = k \cdot t_{\frac{1}{2}}$$

$$t_{\frac{1}{2}} = \frac{\ln(2)}{k}$$

$$t_{\frac{1}{2}} = 3.79972984 \text{ d}$$

$$\therefore t_{\frac{1}{2}} = 3.8 \text{ days.}$$

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9. Calculate the energy change for the following fission reaction: [6 marks]



(a) Report your answer in J. $\Delta E = \Delta m c^2$

$$\Delta m = m_{\text{products}} - m_{\text{reactants}}$$

$$\Delta m = 151.924692u + 80.978832u + (3 \times 1.008664916u) - (235.043930u + 1.008664916u)$$

$$\Delta m = 235.8795187 - 236.0525949$$

$$\Delta m = -0.173076168u$$

$$\Delta E = (-0.173076168u) \left(\frac{1.660539 \times 10^{-27} \text{ kg}}{1u} \right) \left(2.997925 \times 10^8 \frac{\text{m}}{\text{s}} \right)^2$$

$$\Delta E = -2.5830207 \times 10^{-11} \frac{\text{kg m}^2}{\text{s}^2} \xrightarrow{\text{recall}} 1 \text{J} = \frac{\text{kg m}^2}{\text{s}^2}$$

$$\Delta E = -2.58302 \text{ J}$$

(b) Report your answer in J/mol.

$$\Delta E = \Delta m c^2$$

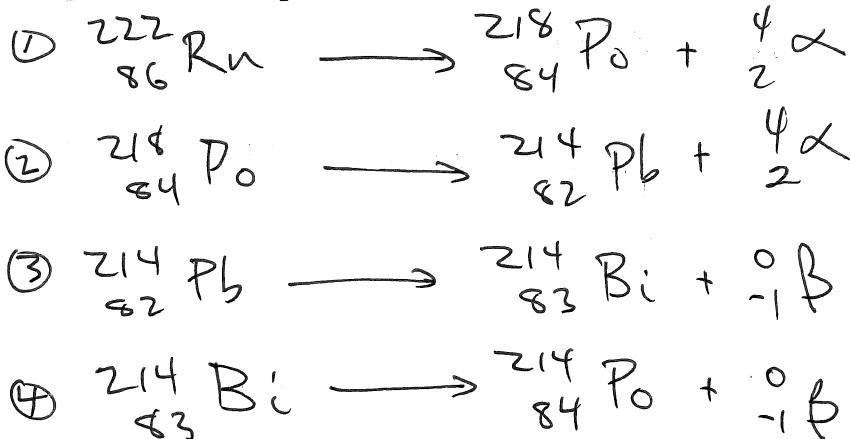
$$\Delta E = \left(-0.173076168 \frac{\text{J}}{\text{mol}} \right) \left(\frac{1 \text{ kg}}{1000 \text{ g}} \right) \left(2.997925 \times 10^8 \frac{\text{m}}{\text{s}} \right)^2$$

$$\Delta E = -1.55553 \times 10^{13} \frac{\text{J}}{\text{mol}}$$

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10. Radon-222 (^{222}Rn) transmutes to a stable nuclide by emitting α and β particles. The first four steps of this decay series are α -decay, α -decay, β -decay, and β -decay. Write this sequence as four separate, balanced nuclear reactions. [4 marks]



11. Fill in each blank with the word or short phrase that best completes the sentence.

[12 marks]

- (a) In the photoelectric effect experiment, whether or not a current will flow depends on the frequency of the incident light.
- (b) A wave with a wavelength of 12 nm has more / higher energy than a wave with a wavelength of 32 nm.
- (c) The Pauli Exclusion Principle states that no two electrons in an atom can have the same set of quantum numbers.
- (d) An electron in a $6f$ orbital has $n = \underline{6}$ and $\ell = \underline{3}$.
- (e) The maximum number of electrons in a single atom that can have $n = 2$, $\ell = 0$ and $m_s = -\frac{1}{2}$ is 1.
- (f) The unit for the equivalent dose of radiation is the Seivert (Sv). The equivalent dose is essentially the absorbed dose multiplied by a radiation weighing factor (W_R).
- (g) A neutral atom of chlorine has 10 core electrons and 7 valence electrons.
- (h) According to the Bohr model of the atom, electrons within an allowed orbital can move without radiating. Bohr calculated the energy of the electron in a hydrogen atom using this equation: $E = -R_H \frac{Z^2}{n^2}$.

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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

$$c = \lambda v$$

$$E = h\nu$$

$$p = mv$$

$$\lambda = \frac{h}{p}$$

$$\Delta x \cdot \Delta p > \frac{h}{4\pi}$$

$$r_n = a_0 \frac{n^2}{Z}$$

$$E_n = -R_H \frac{Z^2}{n^2}$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta E = \Delta mc^2$$

$$N_2 = N_1 \left(\frac{1}{2}\right)^{\Delta t / t_{1/2}}$$

$$A = -\frac{\Delta N}{\Delta t}$$

$$A = kN$$

$$\ln\left(\frac{N_2}{N_1}\right) = -k(t_2 - t_1)$$

$$\ln(2) = k \cdot t_{1/2}$$

1	Chem 1000 Standard Periodic Table												18	
1.0079 H 1	9.0122 Be 4												4.0026 He 2	
6.941 Li 3	22.9898 Na 11	24.3050 Mg 12	3	4	5	6	7	8	9	10	11	12	10.811 B 5	
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
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
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 (210) Bi 83
(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

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Some Useful Masses

${}_2^4\alpha$	4.002 603 254 u
${}_1^1p$	1.007 276 467 u
${}_0^1n$	1.008 664 916 u
${}_{+1}^0\beta$	0.000 548 579 9 u
${}_{-1}^0\beta$	0.000 548 579 9 u
${}^{235}_{92}U$	235.043 930 u
${}^{152}_{60}Nd$	151.924 692 u
${}^{81}_{32}Ge$	80.928 832 u

Band of Stability Graph

The graph below shows the band of stability. The black dots represent all known stable isotopes.

