

NAME: _____

Student Number: _____

Spring 2020

Chemistry 1000 Midterm #2A

____ / 80 marks

INSTRUCTIONS:

- 1) Please read over the test carefully before beginning. This exam consists of 10 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 0/80 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

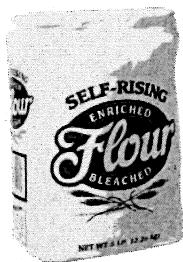
The University of Lethbridge

Spelling matters!

Fluorine = F

Fluorene = C₁₃H₁₀

Flourine =

**Question Breakdown**

Q1	/ 18
Q2	/ 6
Q3	/ 8
Q4	/ 5
Q5	/ 2
Q6	/ 8
Q7	/ 5
Q8	/ 12
Q9	/ 8
Q10	/ 8

Total	/ 80
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1. Fill in each blank with the word or phrase that best completes the sentences. When choices are offered in brackets after the blank, choose one by either circling it or writing it in the blank. *If your answer is an element, you must provide the name and symbol for that element for full credit.* [18 marks]

- (a) The ability of an element to both hold onto its own electrons and attract electrons is referred to as the electro negativity of that element.
- (b) The thin protective oxide layer on a metal's surface is known as the passivation layer.
- (c) The element whose cation gives a green flame is barium (Ba).
- (e) The noble gases refer to the group 18 elements of the periodic table.
- (f) Atomic radius generally _____ (increases/decreases) down a group.
- (g) The gas that is produced when strontium metal reacts with water is hydrogen.
- (h) Energy is _____ (consumed/released) when a covalent bond is formed.
- (i) An ionic compound will have a large lattice energy when the charge of the ions is _____ (large/small) and when the distance of the ions is _____ (large/small).
- (j) A metal lattice whose layers follow the ABCA pattern is referred to as having cubic closest packing.
- (k) Two metals who have a diagonal relationship with each other are lithium (Li)/beryllium (Be) and magnesium (Mg)/aluminium (Al).
- (l) The scientific name for K₂O is potassium oxide.
- (m) The scientific name for TiCl₄ is titanium (IV) chloride.
- (n) The chemical formula for copper (II) sulfide is CuS.
- (o) The group 17 elements are referred to as the halogens.
- (p) During the chlor-alkali process (electrolysis of aqueous sodium chloride) the species that is oxidized is chlorine (Cl⁻) and the species that is reduced is hydrogen (H⁺).

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2. Complete the following table. You may find the partial periodic table (copied from the Data Sheet) helpful. *Misspelled elements will not get full credit.* [6 marks]

Atomic Number (Z)	Symbol	Name
10	Ne	Neon
11	Na	Sodium
20	Ca	Calcium
23	V	Vanadium
33	As	Arsenic
34	Se	Selenium

Chem 1000 Standard Periodic Table

1	2													18		
6.941 Li 3	4 Mg 12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
6.941 Li 3	4 Mg 12	44.9559 Sc 21	47.88 Ti 22	51.9961 Cr 24	59.94 Nb 41	(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 Te 52	126.905 I 54	4.0026 He 2 10
39.0983 K 19	20	88.9059 Sc 21	91.224 Ti 22	92.9064 Cr 24	95.94 Nb 41	(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 Te 52	126.905 I 54	39.948 Ar 18
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 Te 52	126.905 I 54	131.29 Xe 54
132.905 Cs 55	137.327 Ba 56	178.49 La-Lu 72	180.948 Hf 73	183.85 Ta 74	186.207 W 75	190.2 Re 76	192.22 Os 77	195.08 Ir 78	196.967 Pt 79	200.59 Au 80	204.383 Hg 81	207.19 Tl 82	208.980 Pb 83	(210) Bi 84	(210) Po 85	(222) At 86
(223) Fr 87	226.025 Ra 88	Ac-Lr 104	(265) Rf 105	(268) Db 106	(271) Sg 107	(270) Bh 108	(277) Hs 109	(276) Mt 110	(281) Ds 111	(280) Rg 112	(285) Cn 113	(284) Nh 114	(289) Fl 115	(288) Mc 116	(293) Lv 117	(294) Ts 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		

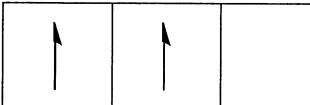
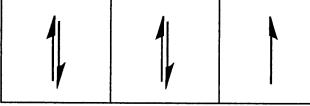
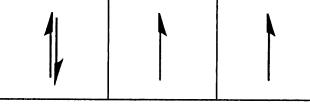
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3.

I just looked for symbol [8 marks]

- (a) Identify the neutral element (name and symbol) corresponding to each valence-shell orbital box diagram. [4 marks]

			Element
A			Si
	3s	3p	
B			F
	2s	2p	
C			Sr
	5s	5p	
D			S
	3s	3p	

- (b) Rank the four neutral elements in part (a) from smallest to largest (use their elemental symbols): [2 marks]

smallest F S Si Sr largest

- (c) Which element is most likely to form a -1 anion? [1 marks]

F if F gains 1 e⁻, it will have a noble gas like electron configuration.

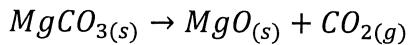
- (d) Which element is most likely to have the highest third ionization energy (E_{i3})? [1 marks]

Sr Sr only has 2 valence e⁻ ∴ losing a 3rd e⁻ would be from a noble gas like configuration.

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4. When magnesium carbonate is thermally decomposed, it produces magnesium oxide and carbon dioxide: [5 marks]



What volume of carbon dioxide gas is produced when 12.622 g of MgCO₃ is thermally decomposed? Assume that the carbon dioxide gas is stored at a temperature of 22.45 °C and a pressure of 1.020 bar (102.0 kPa).

Report your answer in L.

① Molar mass of MgCO₃:

$$24.3050 \text{ g/mol} + 12.011 \text{ g/mol} + (3 \times 15.994 \text{ g/mol}) = \underline{\underline{84.3144 \text{ g/mol}}}$$

② n MgCO₃: $12.622 \text{ g} \times \frac{1 \text{ mol}}{84.3144 \text{ g}} = \underline{\underline{0.1497015931 \text{ mol Mg}}}$

③ n CO₂ = $0.1497015931 \text{ mol Mg} \times \frac{1 \text{ mol CO}_2}{1 \text{ mol Mg}} = \underline{\underline{0.1497015931 \text{ mol CO}_2}}$

④ vol CO₂ = PV = nRT = $V = \frac{nRT}{P}$

$$V = 0.1497015931 \text{ mol} \times \frac{8.314462 \frac{\text{m}^3 \text{Pa}}{\text{mol} \cdot \text{K}}}{\cancel{102.0 \text{ kPa}}} \times 295.6 \text{ K} \times \frac{1 \text{ kPa}}{1000 \text{ Pa}}$$

~~102.0 kPa~~

$$V = \underline{\underline{0.0036071552 \text{ m}^3}} = 3.607 \text{ L}$$

$$1000 \text{ L} = 1 \text{ m}^3$$

5. List 2 ways in which metals and nonmetals differ. 4 sig. figs.

[2 marks]

Metals

- shiny solids
- moderate to high m.p.
- good conductors of heat & electricity
- machined into wires/sheets
- lose electrons to non-metals

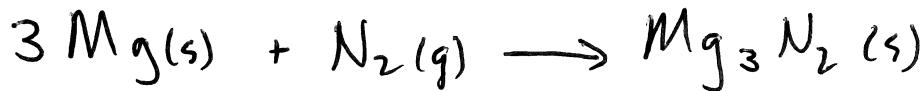
Nonmetals

- typically not shiny
- relatively low m.p.
- poor conductors
- crumbly solids
- gain electrons from metals

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6. Write balanced chemical equations for each of the following reactions. **[8 marks]**
Include states of matter. If no reaction occurs, write "NO REACTION".
- (a) Magnesium metal reacts with nitrogen gas. **[2 marks]**



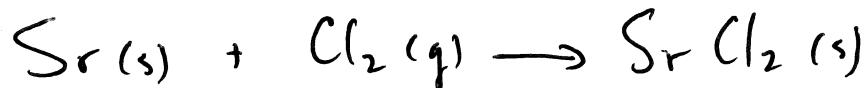
- (b) Barium metal reacts with water. **[2 marks]**



- (c) Calcium carbonate (CaCO_3) is added to a solution of aqueous acid ($\text{H}_{(aq)}^+$). **[2 marks]**

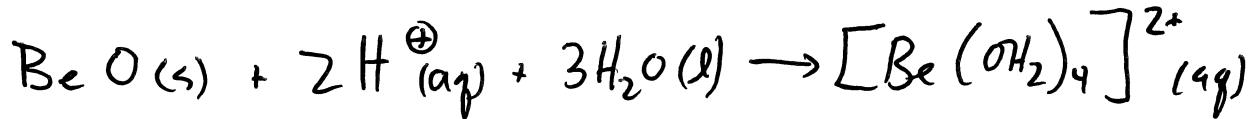


- (d) Strontium metal reacts with chlorine gas. **[2 marks]**

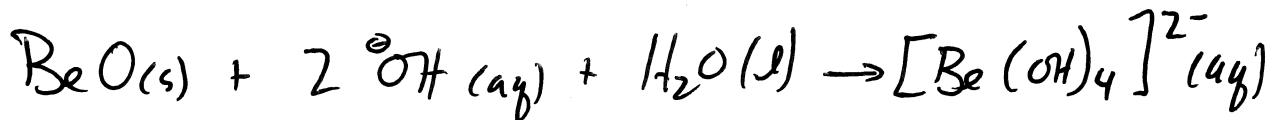


7. Beryllium oxide is amphoteric, that is, it reacts with both acids and bases. **[5 marks]**

- (a) Write a balanced chemical equation for its reaction with aqueous acid ($\text{H}_{(aq)}^+$).
Include states of matter. **[2 marks]**



- (b) Write a balanced chemical equation for its reaction with aqueous base ($\text{OH}_{(aq)}^-$).
Include states of matter. **[2 marks]**



- (c) What element does beryllium share a diagonal relationship with? **[1 marks]**

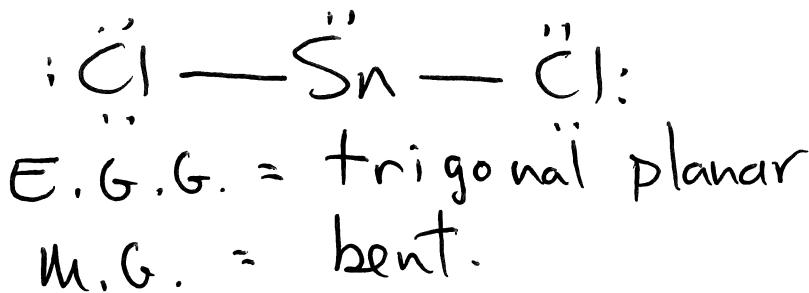
Aluminium (Al)

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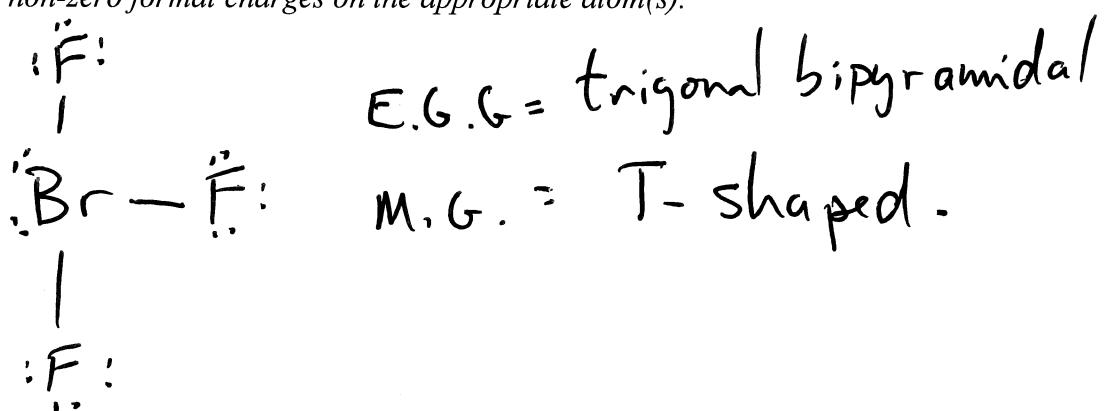
Student Number: _____

8. For each of the following molecules/ions: [12 marks]

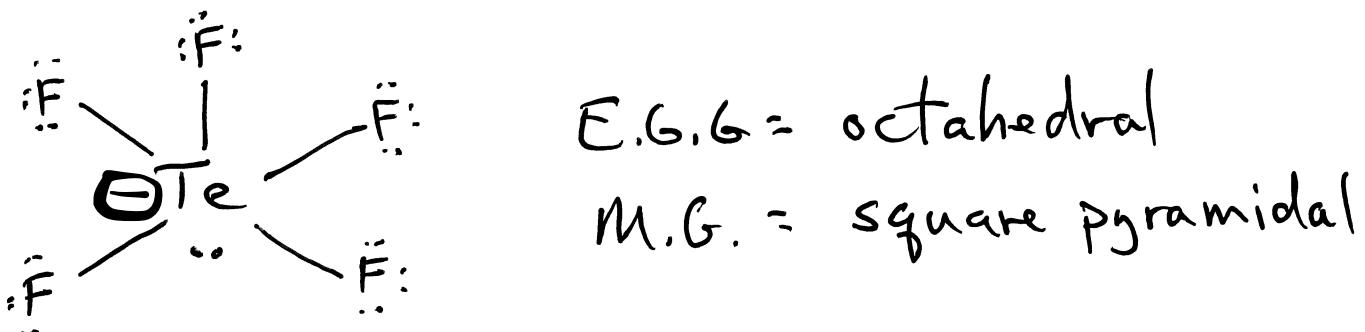
- draw a valid Lewis Diagram
 - Identify its Electron Group Geometry (E.G.G.)
 - Identify its Molecular Geometry (M.G.)
- (a) $\text{SnCl}_2 \cdot 4 + 14 = 18e^-$ [4 marks]
Include any non-zero formal charges on the appropriate atom(s).



(b) $\text{BrF}_3 \cdot 7 + 21 = 28e^-$ [4 mark]
Include any non-zero formal charges on the appropriate atom(s).



(c) $\text{TeF}_5^- \cdot 6 + 35 + 1 = 42e^-$ [4 mark]
Include any non-zero formal charges on the appropriate atom(s).

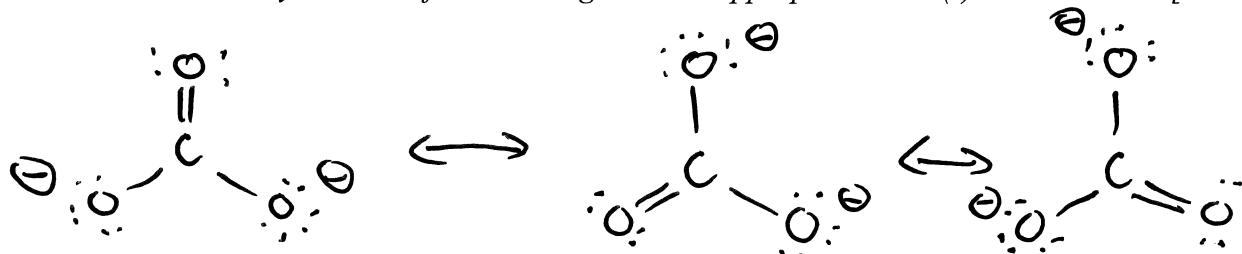


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$$4 + 18 + 2 = 24e^-$$

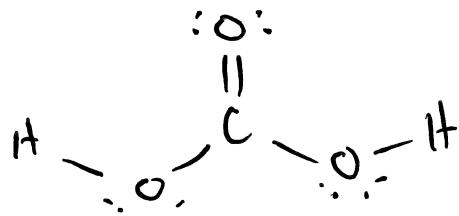
9. The carbonate ion has the chemical formula CO_3^{2-} . [8 marks]
- (a) Draw all three resonance structures of CO_3^{2-} which have minimized formal charge.
Include any non-zero formal charges on the appropriate atom(s). [4 marks]



- (b) What is the average $C - O$ bond order for the carbonate ion? [1 mark]

$$\frac{2+1+1}{3} = \frac{4}{3} = 1\frac{1}{3}$$

- (c) Carbonic acid has the chemical formula H_2CO_3 . Draw a Lewis diagram for H_2CO_3 in which you have minimized formal charge.
Include any non-zero formal charges on the appropriate atom(s). [2 marks]



- (d) Compare the lengths of the $C - O$ bonds in H_2CO_3 . Which $C - O$ bond(s) do you expect to be longer/shorter? [1 mark]

$C = O$ is shorter

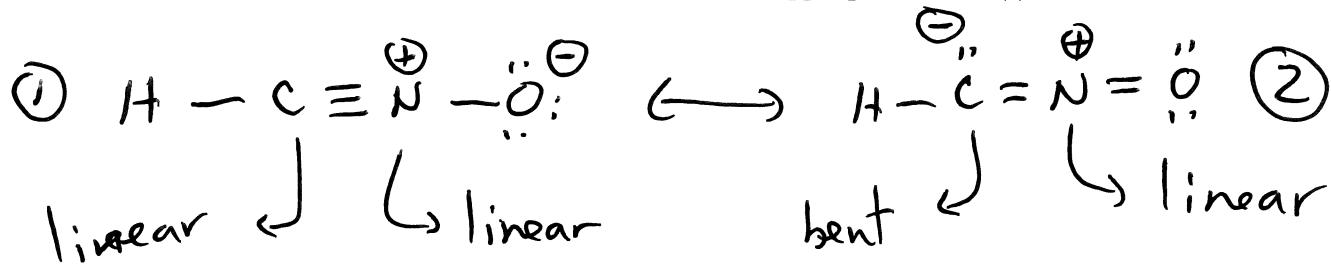
$C - O$ is longer

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10. A nitrile oxide (HCNO) is a simple organic molecule which contains 1 hydrogen, 1 carbon, 1 nitrogen, and 1 oxygen atom. It has two valid resonance structures. [8 marks]

- (a) Draw the two Lewis diagrams for each of its resonance structures given that the connectivity of nitrile oxide is H-C-N-O. [4 mark]
Include any non-zero formal charges on the appropriate atom(s).



NOT A VALID STRUCTURE: $\text{H}-\text{C}=\text{N}=\text{O}$ Ack! N has $10e^-$ around it!
Second row elements can never exceed $8e^-$.

- (b) For both resonance structures, indicate the molecular geometry around each of the central C and N atoms. [2 marks]

See above.

- (c) Of the two resonance structures, which one do you think better represents the overall structure of the molecule? Briefly explain your reasoning. [2 mark]

Resonance structure $\textcircled{1}$ is best. Both structures follow the octet rule. The only difference is the placement of formal charges. In both structures the formal \oplus is on N. The formal \ominus is found on O (structure 1) or C (structure 2). O is more electronegative than C and ∴ would prefer to have the \ominus charge.

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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	Kelvin temperature scale	0 K = -273.15 °C
Avogadro's number	$6.022\ 141 \times 10^{23}$ mol ⁻¹	Planck's constant	$6.626\ 070 \times 10^{-34}$ J·Hz ⁻¹
Bohr radius (a_0)	$5.291\ 772 \times 10^{-11}$ m	Proton mass	1.007 277 u
Electron charge (e)	$1.602\ 177 \times 10^{-19}$ C	Neutron mass	1.008 665 u
Electron mass	$5.485\ 799 \times 10^{-4}$ u	Rydberg Constant (R_H)	2.179 872 x 10^{-18} J
Ideal gas constant (R)	$8.314\ 462\ J \cdot mol^{-1} \cdot K^{-1}$	Speed of light in vacuum	$2.997\ 925 \times 10^8$ m·s ⁻¹
	$8.314\ 462\ m^3 \cdot Pa \cdot mol^{-1} \cdot K^{-1}$	Standard atmospheric pressure	1 bar = 100 kPa
		Volume	1000 L = 1 m ³

Formulae

$$c = \lambda v$$

$$E = h\nu$$

$$p = mv$$

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

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

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

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

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

$$PV = nRT$$

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

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

$$A = kN$$

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

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

$$1$$

Chem 1000 Standard Periodic Table

$$18$$

4.0026 He 2

1	2																		
6.941 Li 3	4																		
24.3050 Mg 12	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17				
39.0983 K 19	20	44.9559 Sc 21	47.88 Ti 22	51.9961 Cr 24	52	58.9332 Co 27	59	63.546 Cu 29	65.39 Zn 30	72.61 Ge 32	10.811 B 5	12.011 C 6	14.0067 N 7	15.9994 O 8	18.9984 F 9	10			
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		
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(223) Fr 87	226.025 Ra 88	Ac-Lr 104	(265) Rf 105	(268) Db 106	(271) Sg 107	(270) Bh 108	(277) Hs 109	(276) Mt 110	(281) Ds 111	(280) Rg 112	(285) Cn 113	(284) Nh 114	(289) Fl 115	(288) Mc 116	(293) Lv 117	(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
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