NAME:__________________________ Section:_____ Student Number:_________________

Fall 2012 **Chemistry 1000 Practice Midterm #2A** ____/ 60 marks

INSTRUCTIONS:

1) Please read over the test carefully before beginning. You should have 6 pages of questions and a double-sided 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 exam until after 8pm Mountain Time on Monday, November 19th, 2012. 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: Fall 2012
The University of Lethbridge

Question Breakdown

Q1	/ 15
Q2	/ 3
Q3	/ 3
Q4	/ 6
Q5	/ 3
Q6	/ 5
Q7	/ 5
Q8	/ 6
Q9	/ 4
Q10	/ 5
Q11	/ 5

Total	/ 60

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1. **[15 marks]**

(a) All ionization energies have a _positive_ sign.

(b) A carbon atom is _larger_ in size than an oxygen atom.

(c) Germanium is _less_ electronegative than selenium.

(d) Sodium metal is produced by electrolysis of _NaCl_ in the _liquid_ state.

(e) Aluminium metal is produced by electrolysis of _Al_2O_3_ in the _liquid_ state.

(f) Sodium hydroxide is produced by electrolysis of _NaCl_ in the _aqueous_ state.

(g) The gas produced when barium carbonate is added to acid is _carbon dioxide_.

(h) Lithium and magnesium have similar chemical properties because of _their diagonal relationship_

(i) Aluminium is less reactive than one might expect because _it is coated in a layer of Al_2O_3_

(j) Two amphoteric oxides are _BeO_ and _Al_2O_3_.

(k) One ion that can make water "hard" is _Ca^{2+} or Mg^{2+}_.

2. Briefly explain why Cu^{2+} has a smaller atomic radius than Cu^{+}. **[3 marks]**

Cu^{2+} and Cu^{+} both have 29 protons in their nuclei; however, Cu^{+} has 28 electrons ([Ar] $3d^{10}$) while Cu^{2+} has 27 electrons ([Ar] $3d^{9}$).

Because Cu^{+} has more electrons, its valence electrons are more shielded from the positive charge of the nucleus and therefore feel a weaker effective nuclear charge. Thus, they are attracted less strongly toward the nucleus, giving Cu^{+} a larger atomic radius than Cu^{2+}.

3. Which element has a larger electron affinity, Ne or F?
Briefly explain your answer. **[3 marks]**

Electron affinity is defined as the energy released when an electron is added to a neutral atom in the gas phase.

F has a larger electron affinity than Ne.

It is much more favourable to add an electron to F (giving F^{-}) than it is to add an electron to Ne (giving Ne^{-}). To add an extra electron to Ne, it would be necessary to begin a new shell that would be strongly shielded from the nuclear charge so the new electron would not be strongly attracted to the nucleus. On the other hand, the extra electron added to F is added to the valence shell, giving a noble gas electron configuration of [He] $2s^2 2p^6$.

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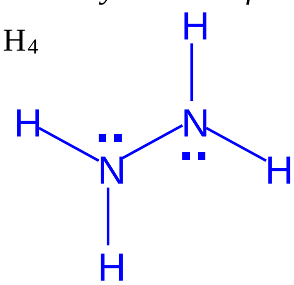
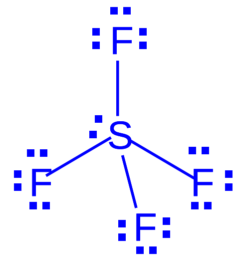
4. Draw one valid Lewis diagram for each of the molecules/ions listed below. **[6 marks]**
Include any non-zero formal charges on the appropriate atoms.

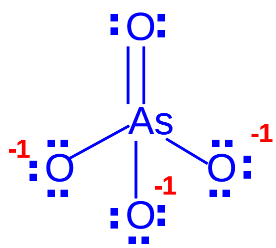
(a) N_2H_4



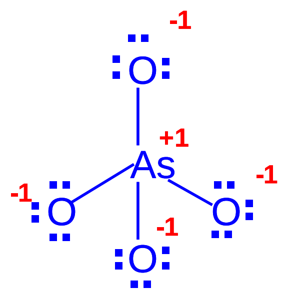
(b) SF_4



(c) AsO_4^{3-}



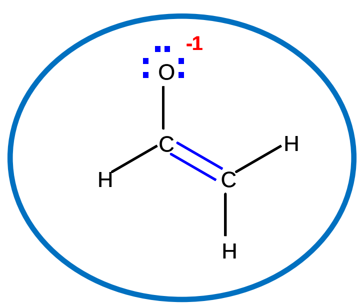
or

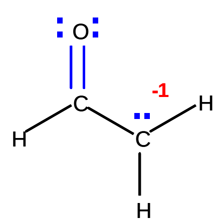


5. Is SF_4 a polar or nonpolar molecule? Why? **[3 marks]**

Polar. The central S atom has a seesaw geometry, and the overall molecule has a net dipole. Molecules with net dipoles are polar.

6. There are two valid resonance structures for an anion with the chemical formula $C_2H_3O^-$. The connectivity for this anion is shown below. **[5 marks]**





(a) On the two skeletons above, draw each of the two valid resonance structures. *[4 marks]*
Include any non-zero formal charges on the appropriate atoms.

(b) Circle the better resonance structure (the resonance structure which more closely resembles the true/averaged structure of this anion). *[1 mark]*
You will only obtain credit for part (b) if your answers to part (a) are correct.

O is more electronegative than C and they are similarly sized atoms, so the resonance structure with the negative charge on O will dominate.

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7. Lithium carbonate (Li_2CO_3, 25.33 g) is heated to 1400 °C and releases carbon dioxide. **[5 marks]**

(a) Write a balanced chemical equation describing this reaction. Include states of matter. *[1 mark]*

$$Li_2CO_{3(s)} \rightarrow Li_2O_{(s)} + CO_{2(g)}$$

(b) The carbon dioxide is collected in a container at 23.7 °C and 0.956 bar ambient pressure. Under these conditions, what volume of carbon dioxide is formed? *[4 marks]*

Step 1: Calculate moles of $Li_2CO_3(s)$

$$n_{BeCO_3} = 25.33g \times \frac{1mol}{73.8912g} = 0.3428mol$$

Step 2: Calculate moles of $CO_2(g)$

$$n_{CO_2} = 0.3428 \text{ mol } Li_2CO_3 \times \frac{1 \text{ mol } CO_2}{1 \text{ mol } BeCO_3} = 0.3428 \text{ mol } CO_2$$

Step 3: Calculate volume of $CO_2(g)$

$$T = (23.7 + 273.15)K = 296.85K$$

$$P = 0.956bar \times \frac{100kPa}{1bar} \times \frac{1000Pa}{1kPa} = 9.56 \times 10^4 Pa$$

$$PV = nRT$$

$$V_{CO_2} = \frac{n_{CO_2}RT}{P_{CO_2}} = \frac{(0.3428mol)(8.3145 \frac{Pa \cdot m^3}{mol \cdot K})(296.85K)}{(9.56 \times 10^4 Pa)} = 0.00885m^3 = 8.85L$$

1 m^3 = 1000 L; answer can be reported in either m^3 or L

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8. Write a balanced chemical equation for each of the following reactions. Include states of matter. If no reaction occurs, write "NO REACTION" instead. **[6 marks]**

Where more than one chemical equation is written, each is a valid alternative.

(a) Barium (Ba) is added to liquid bromine. *[1 mark]*

$$Ba_{(s)} + Br_{2(l)} \rightarrow BaBr_{2(s)}$$

(b) Lithium is added to aqueous HCl. *[1 mark]*

$$2Li_{(s)} + 2HCl_{(aq)} \rightarrow 2LiCl_{(aq)} + H_{2(g)}$$

$$2Li_{(s)} + 2H^{+}_{(aq)} \rightarrow 2Li^{+}_{(aq)} + H_{2(g)}$$

$$2Li_{(s)} + 2H_3O^{+}_{(aq)} \rightarrow 2Li^{+}_{(aq)} + 2H_2O_{(l)} + H_{2(g)}$$

(c) Beryllium is added to water. *[1 mark]*

NO REACTION

(d) Magnesium is reacted with oxygen. *[1 mark]*

$$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$$

(e) Aluminium is added to concentrated aqueous NaOH. *[2 marks]*

$$2Al_{(s)} + 2NaOH_{(aq)} + 6H_2O_{(l)} \rightarrow 2Na\left[Al\left(OH\right)_4\right]_{(aq)} + 3H_{2(g)}$$

$$2Al_{(s)} + 2OH^{-}_{(aq)} + 6H_2O_{(l)} \rightarrow 2\left[Al\left(OH\right)_4\right]^{-}_{(aq)} + 3H_{2(g)}$$

9. Complete the following table. **[4 marks]**

Chemical Formula	**Name**
MnO_2	manganese(IV) oxide
CaF_2	calcium fluoride
Na_2S	sodium sulfide
Mg_3N_2	magnesium nitride

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10. Give the **name** and **symbol** for each of the elements below: **[5 marks]**

		name	**symbol**
i.	$Z = 4$	beryllium	Be
ii.	$Z = 14$	silicon	Si
iii.	$Z = 17$	chlorine	Cl
iv.	$Z = 27$	cobalt	Co
v.	$Z = 31$	gallium	Ga

Partial Periodic Table (copied from data sheet)

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1.0079 **H** 1																	4.0026 **He** 2
6.941 **Li** 3	4											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											13	14	15	16	17	39.948 **Ar** 18
39.0983 **K** 19	20	44.9559 **Sc** 21	22	50.9415 **V** 23	51.9961 **Cr** 24	54.9380 **Mn** 25	55.847 **Fe** 26	27	58.693 **Ni** 28	63.546 **Cu** 29	30	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**	(261) **Rf** 104	(262) **Db** 105	(263) **Sg** 106	(262) **Bh** 107	(265) **Hs** 108	(266) **Mt** 109	(281) **Dt** 110	(283) **Rg** 111							

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11. The ions Br^-, Rb^+, Se^{2-} and Sr^{2+} all have the same electron configuration. Their ionic radii are 132, 166, 182 and 184 pm (not necessarily in that order). **[5 marks]**

(a) Give the electron configuration for these ions. Do not use the noble gas abbreviation. *[1 mark]*

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$

(b) Give the electron configuration for these ions using the noble gas abbreviation. *[1 mark]*

$[Ar]\ 4s^2\ 3d^{10}\ 4p^6$

(c) Assign which ion has which radius. *[1 mark]*

Br^- _182_ pm Rb^+ _166_ pm Se^{2-} _184_ pm Sr^{2+} _132_ pm

(d) **Briefly** explain why you assigned each radius in part (c). *[2 marks]*

The main structural difference between the four ions is the number of protons in the nucleus: Se^{2-} has 34 protons, Br^- has 35 protons, Rb^+ has 37 protons and Sr^{2+} has 38 protons.

In the atoms with more protons in the nucleus, the valence electrons are more strongly attracted to the nucleus (feeling a stronger effective nuclear charge) so the radius is smaller.

Therefore, when ranked from smallest to largest, the ions are $Sr^{2+} < Rb^+ < Br^- < Se^{2-}$.

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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}
Ideal gas constant (R)	8.314 462 J·mol^{-1}·K^{-1} 8.314 462 m^3·Pa·mol^{-1}·K^{-1}	Standard atmospheric pressure	1 bar = 100 kPa

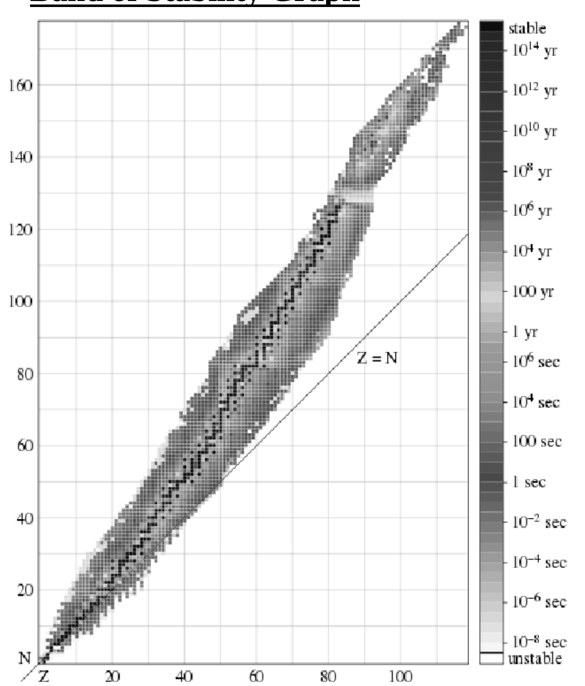
Formulae

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

$$r_n = a_0 \frac{n^2}{Z} \qquad E_n = -R_H \frac{Z^2}{n^2} \qquad E_k = \frac{1}{2}mv^2 \qquad PV = nRT$$

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

Band of Stability Graph



The graph at the right 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

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CHEM 1000 Partial Periodic Table

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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	(260) **Lr** 103

Developed by Prof. R. T. Boeré