NAME:________________________________ Student Number:_________________________

Spring 2013 **Chemistry 1000 Practice Midterm #2C** ____/ 50 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 exam until after 8pm Mountain Time on Wednesday, March 20th, 2013. I understand that breaking this agreement would constitute academic misconduct, a serious offense with serious consequences. The minimum punishment would be a mark of 0/50 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 2013
The University of Lethbridge

Spelling matters!

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

Flourine = 

Question Breakdown

Q1	/ 10
Q2	/ 5
Q3	/ 4
Q4	/ 3
Q5	/ 3
Q6	/ 5
Q7	/ 9
Q8	/ 5
Q9	/ 5
Q10	/ 1

Total	/ 50

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1. For each of the following statements, circle whether they are true **or** false.
If true, briefly explain why.
If false, give an example that proves the statement false. **[10 marks]**

*Note: All marks on this question are for the explanations and/or examples. No credit will be given for a 'true' or 'false' without appropriate support. **This was enforced**. Also, 'explanations' that just rephrased the statement were not credited nor were 'memory tricks' considered good explanations (e.g. 'ionization energy increases left-to-right').*

(a) The ionization energy for every element is larger than for the element below it (assuming that there is an element below it). **TRUE / FALSE**

Within a group, the elements that are lower on the periodic table have more shells of electrons. As such, their valence electrons are farther away from the nucleus (even though the effective nuclear charge is similar).

Since ionization energy is the energy required to remove an electron from a neutral atom and it requires more energy to remove an electron that is close to the nucleus (as long as the effective nuclear charge is similar), the ionization energy of an element will be larger than for the element below it on the periodic table.

(b) The electron affinity for every element is larger than for the element to its left (assuming that there is an element to its left). **TRUE / FALSE**

This statement is false for all noble gases.

Electron affinity is the energy released when an electron is added to a neutral atom. Since it is not favourable to add an electron to a noble gas, the electron affinity of a noble gas is not larger than for the halogen to its left.

(c) Elements in Group 2 form +2 cations but not ions with any other charges. **TRUE / FALSE**

Elements in Group 2 have two valence electrons. Removal of those two electrons gives a +2 cation with the same electron configuration as the nearest noble gas.

(d) The radius of a neutral atom of alkali metal is always larger than the radius of a neutral atom of the alkaline earth metal in the same period as it. **TRUE / FALSE**

An alkaline earth metal has one more proton and one more electron than the alkali metal to its left. Since the extra electron cannot fully shield the positive charge of the extra proton, the effective nuclear charge on the valence electrons of the alkaline earth metal is greater. In other words, the valence electrons of the alkaline earth metal are pulled more closely toward the nucleus. This gives the alkaline earth metal atom a smaller radius (and therefore the alkali metal atom a larger radius).

Partial credit was awarded if it was clear that a student understood the terms 'alkali metal', 'alkaline earth metal' and 'period'.

(e) An atom bonded to three other atoms is always trigonal planar. **TRUE / FALSE**

e.g. NH_3 is trigonal pyramidal because the nitrogen atom has four electron groups: one lone pair in addition to the three bonded atoms

Any molecule containing a trigonal pyramidal or T-shaped atom was a good counterexample.

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2. If 5.0 g lithium metal reacts fully with nitrogen, what mass of lithium nitride is produced? *As part of your answer, you must include a balanced chemical equation.* **[5 marks]**

$$6Li_{(s)} + N_{2(g)} \rightarrow 2Li_3N_{(s)}$$

Step 1: Calculate moles of lithium reacted

$$n_{Li} = 5.0g \times \frac{1mol}{6.941g} = 0.72mol$$

Step 2: Use mole ratio to calculate moles of lithium nitride produced

$$n_{Li_3N} = 0.72molLi \times \frac{2molLi_3N}{6molLi} = 0.24molLi_3N$$

Step 3: Calculate mass of lithium nitride produced

$$m_{Li_3N} = 0.24mol \times \frac{34.8297g}{1mol} = 8.4g$$

2 sig. fig.

When performing calculations, you must carry all digits in your calculator through each step. ***Do not round until the end!*** *While I am showing the correct number of sig. fig. in the answer to each step, I am using all digits in my calculator for the next step.*

3. Air contains a number of different gases. Sometimes, a scientist needs to create an environment in which some of those gases have been removed from the air. The two gases which are most commonly removed are carbon dioxide and water vapour.

One way to remove carbon dioxide from air is to pass the air through a tube containing magnesium oxide. **[4 marks]**

(a) Write a balanced chemical equation for the reaction that occurs between the carbon dioxide and the magnesium oxide. *Include states of matter.* *[2 marks]*

$$MgO_{(s)} + CO_{2(g)} \rightarrow MgCO_{3(s)}$$

(b) How could the magnesium oxide be regenerated so that it could be used to 'clean' more air? *[1 mark]*

Heat the magnesium carbonate to reverse the reaction shown in part (a).

(c) Write a balanced chemical equation to show what happens in your answer to part (b). *Include states of matter.* *[1 mark]*

$$MgCO_{3(s)} \rightarrow MgO_{(s)} + CO_{2(g)}$$

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4. The current procedure used for the industrial production of aluminium was developed in the late 1800s. Before then, aluminium was considered a precious metal. Why was aluminium once so difficult to make, and how was this difficulty overcome? **[3 marks]**

Most naturally occurring aluminium occurs in ionic compounds – primarily oxides and hydroxides (Al_2O_3, AlO(OH) and $Al(OH)_3$). To obtain aluminium metal, the aluminium cations in these ionic compounds must be reduced (from +3 to neutral).

Electrolysis can be used to reduce the aluminium cations; however, since ionic solids can't conduct electricity, the ionic compounds must be melted. *(Dissolving them in water would also allow conduction of electricity, but the water would get reduced instead of the Al^{3+}.)* The melting points of Al_2O_3, etc. are all very very high. Thus, extremely large amounts of energy were required to melt these compounds to permit electrolysis. This made the aluminium metal very very expensive to make.

It was discovered that mixing Al_2O_3 with cryolite lowered its melting point substantially. This reduced the amount of energy necessary to melt the Al_2O_3 for electrolysis and made the process much more affordable.

Also, now that industry has produced a reasonably large amount of aluminium metal, it's much less energy-intensive and therefore much cheaper to recycle it than it is to produce more via the electrolysis method.

I was surprised by how few students mentioned the recycling alternative. While not a complete answer (and you would not get full credit if this was the only point made), it is a significant factor.

5. **[3 marks]**

(a) Why is it essential that the chlorine gas and sodium hydroxide produced when aqueous sodium chloride is electrolyzed are kept separate? Be specific. *[2 marks]*

When chlorine gas and sodium hydroxide are mixed, they react to produce NaOCl (bleach):

$$2NaOH_{(aq)} + Cl_{2(g)} \rightarrow NaOCl_{(aq)} + NaCl_{(aq)} + H_2O_{(l)}$$

or

$$2OH^-_{(aq)} + Cl_{2(g)} \rightarrow ClO^-_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$$

While NaCl is a byproduct of this reaction, this is not the reverse of the electrolysis reaction so it is not correct to say that the process would go backward.

(b) What is the third product in the electrolysis of aqueous sodium chloride? *[1 mark]*

Hydrogen gas (H_2)

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6. Give the <u>name</u> and <u>symbol</u> for each of the elements below: **[5 marks]**

		name	**symbol**
i.	*Z* = 22	titanium	Ti
ii.	*Z* = 25	manganese	Mn
iii.	*Z* = 28	nickel	Ni
iv.	*Z* = 31	gallium	Ga
v.	*Z* = 34	selenium	Se

Half marks were given for names that were misspelled but still recognizable. e.g. "sellenium"

No marks were given for names misspelled to the point of changing the name. e.g. "selium" or "selarium" instead of "selenium".

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	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											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	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	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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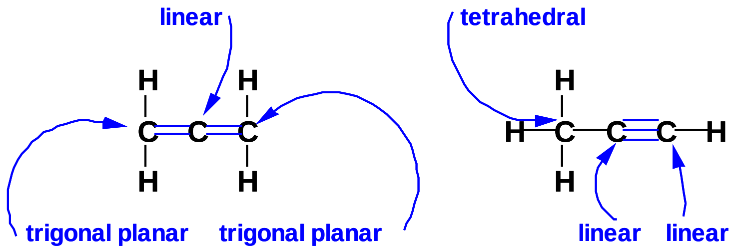
7. **[9 marks]**

(a) Complete the Lewis diagrams for the two molecules whose skeletons are shown below. *[2 marks]*



(b) Rank the bonds in the two molecules above from shortest to longest. *[2 marks]*
You may group together bonds of the same type.

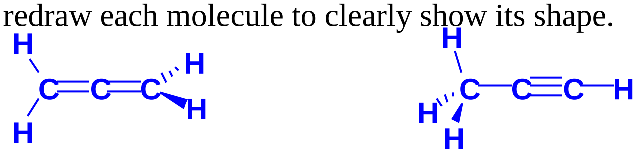
C-H (shortest) C≡C C=C C-C (longest)

Atomic radius is the first consideration. H is much smaller than C.

After that bond order is considered. Triple bonds are shorter than double bonds which are shorter than single bonds.

(c) Identify the molecular geometry of each carbon atom in both molecules. *[3 marks]*
Answer this question by labeling your answers to part (a).

(d) In the space below, redraw each molecule to clearly show its shape. *[2 marks]*



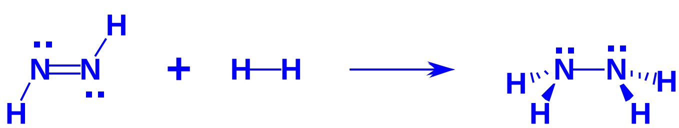
I did not expect you to know that the two trigonal planar carbon atoms aren't in the same plane. Full credit was given for a completely flat picture.

There should be <u>no</u> 90° or 180° angles on the tetrahedral carbon atom.

8. **[5 marks]**

(a) Calculate the approximate enthalpy change for the reaction below: *[4 marks]*

$$N_2H_2 + H_2 \rightarrow N_2H_4$$



$$\Delta_{rxn}H \approx \sum \Delta_{BD}H(bonds broken) - \sum \Delta_{BD}H(bonds formed)$$
$$\Delta_{rxn}H \approx [\Delta_{BD}H(N=N) + \Delta_{BD}H(H-H)] - [\Delta_{BD}H(N-N) + 2\Delta_{BD}H(N-H)]$$
$$\Delta_{rxn}H \approx [(420\,\tfrac{kJ}{mol}) + (435\,\tfrac{kJ}{mol})] - [(160\,\tfrac{kJ}{mol}) + 2(390\,\tfrac{kJ}{mol})]$$
$$\Delta_{rxn}H \approx -85\,\tfrac{kJ}{mol}$$

0 decimal places therefore 2 sig.fig.

(b) Is this process exothermic or endothermic? In ten words or less, justify your answer. *[1 mark]*
Exothermic

The enthalpy change was negative.

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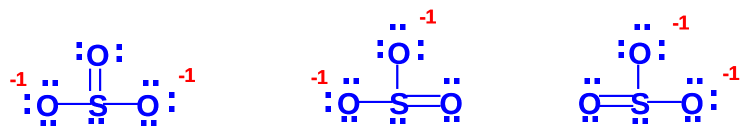
9. **[5 marks]**

(a) Draw **all** valid resonance structures for the sulfite ion (SO_3^{2-}). *[4 marks]*
You must show all non-zero formal charges on the appropriate atoms.



It was also acceptable to add the structure in which the sulfur atom obeys the octet rule (but formal charge was not minimized).

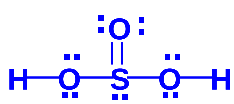
(b) What is the average S-O bond order in SO_3^{2-}? *[1 mark]*

average S-O bond order = ⅓ (2+1+1) = 4/3 = 1⅓

If you also drew the resonance structure in which formal charge is not minimized but S obeys the octet rule, your average S-O bond order calculation should have been ¼(2+1+1+1) = 5/4 = 1¼

Since that extra resonance structure is not degenerate with the other three, your calculation would only give an approximate bond order.

10. Draw a valid Lewis diagram for sulfurous acid (H_2SO_3). *[1 mark]*
You must show all non-zero formal charges on the appropriate atoms.



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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

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

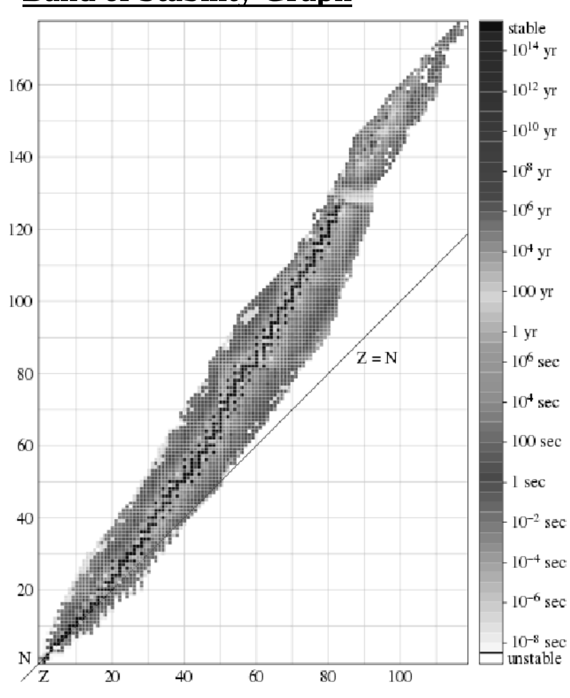
$$r_n = a_0 \frac{n^2}{Z} \qquad E_n = -R_H \frac{Z^2}{n^2} \qquad E_k = \frac{1}{2}mv^2 \qquad PV = nRT$$

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

Bond Dissociation Enthalpy Values

	$\Delta_{BD}H$ (kJ/mol)
H-H	435
C-H	415
N-H	390
O-H	460
C-C	345
C=C	615
C≡C	835
N-N	160
N=N	420
N≡N	945
O-O	145
O=O	495

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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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