NAME:_____ Student Number:_____

Fall 2018 **Chemistry 1000 Midterm #2A** ____/ 57 marks

INSTRUCTIONS:
1) Please read over the test carefully before beginning. You should have 7 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 8:00pm Mountain Time on Tuesday, November 6th, 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 0/57 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	/ 3
Q2	/ 3
Q3	/ 2
Q4	/ 10
Q5	/ 8
Q6	/ 8
Q7	/ 6
Q8	/ 8
Q9	/ 3
Q10	/ 6

Total	/ 57

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1. List three properties of metals that are different from those of nonmetals. **[3 marks]**

(a) good conductor of heat

(b) good conductor of electricity

(c) resistivity increases with temperature *(electrical conductivity decreases as temperature increases)*

(d) reflect light across a wide range of wavelengths *(making them shiny)*

(e) malleability *(can be hammered into sheets, etc.)*

(f) ductility *(can be pulled into wires)*

2. Complete the following table by naming each compound. **[3 marks]**

Chemical Formula	**Name**
NaF	sodium fluoride
$AlCl_3$	aluminium chloride
Li_2O	lithium oxide

3. Sodium phosphate is reasonably soluble in water. (A saturated solution is about 0.7 $\frac{mol}{L}$ at room temperature.) On the other hand, lithium phosphate has a very low solubility (about 0.004 $\frac{mol}{L}$ at room temperature).

Explain why there is such a large difference between the solubilities of these two alkali metal phosphates in water. **[2 marks]**

Li^+ is a significantly smaller cation than Na^+. As such, the ionic bonds between Li^+ and PO_4^{3-} are shorter/stronger than those between Na^+ and PO_4^{3-}. For this reason, the lattice energy for lithium phosphate is larger than that for sodium phosphate.

Ionic compounds with larger lattice energies are less soluble in water than those with smaller lattice energies since it requires more energy to disrupt the lattice.

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4. Write balanced chemical equations for each of the following processes. **[10 marks]**
Include states of matter. Some of these processes can be described using a single reaction equation; others require more than one.

(a) The reaction of potassium metal with water.

$2\,K_{(s)} + 2\,H_2O_{(l)} \rightarrow 2\,KOH_{(aq)} + H_{2(g)}$

or $2\,K_{(s)} + 2\,H_2O_{(l)} \rightarrow 2\,K^+_{(aq)} + 2\,OH^-_{(aq)} + H_{2(g)}$

(b) The reaction of magnesium metal with chlorine.

$Mg_{(s)} + Cl_{2(g)} \rightarrow MgCl_{2(s)}$

(c) The formation of a precipitate when an aqueous solution containing calcium ions and hydrogen carbonate ions (HCO_3^-) is heated.

$2\,HCO^-_{3(aq)} \rightleftharpoons CO^{2-}_{3(aq)} + H_2O_{(l)} + CO_{2(g)}$

and $Ca^{2+}_{(aq)} + CO^{2-}_{3(aq)} \rightarrow CaCO_{3(s)}$

It is also acceptable to write H_2CO_3 as a product of the first reaction instead of H_2O and CO_2 and also include $H_2CO_{3(aq)} \rightleftharpoons H_2O_{(l)} + CO_{2(g)}$ as a second equilibrium.

Heating the solution reduces the solubility of carbon dioxide, thereby driving the first equilibrium forward. (It is also fine to write → instead of ⇌.)

(d) The reaction of aluminium oxide with a non-oxidizing acid.

$Al_2O_{3(s)} + 6\,H^+_{(aq)} \rightarrow 2\,Al^{3+}_{(aq)} + 3\,H_2O_{(l)}$

It is also acceptable to choose a specific non-oxidizing acid (e.g. HCl) and show the reaction between that and aluminium oxide.

5. Fill in the blanks in the following paragraph describing the industrial production of aluminium. *Where the answer is a compound, it is acceptable to give either the name or the chemical formula.* **[8 marks]**

Bauxite is a mixture of aluminium oxides and hydroxides. It is typically contaminated with other minerals such as _iron(III) oxide (Fe_2O_3)_. In order to separate the aluminium compounds from the contaminants, it is necessary to add _aqueous base ($OH^-_{(aq)}$)_. After this addition, the aluminium is found in the _aqueous_ phase while the contaminants are found in the _solid_ phase. The two phases are separated, and the aluminium is recovered as Al_2O_3 by adding _acid (carbon dioxide; CO_2)_ and then _heating_ to remove water.

The pure Al_2O_3 is then melted and subjected to _electrolysis_, giving molten aluminium metal. The other product of this reaction is _carbon dioxide (CO_2)_.

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6. The alkaline earth metals react with nitrogen to form nitrides. **[8 marks]**

(a) Write a balanced chemical equation for the reaction of calcium with nitrogen to form calcium nitride. *Include states of matter.* *[2 marks]*

$3\ Ca_{(s)} + N_{2(g)} \rightarrow Ca_3N_{2(s)}$

(b) What mass of calcium nitride can be made when 6.54 g of calcium reacts with an excess of nitrogen? *[4 marks]*

Step 1: Calculate moles of Ca

$n_{Ca} = 6.54\ g \times \frac{1\ mol}{40.078\ g} = 0.163\ mol$ 3 sig. fig.

Step 2: Calculate moles of Ca_3N_2

$n_{Ca_3N_2} = 0.163\ mol\ Ca \times \frac{1\ mol\ Ca_3N_2}{3\ mol\ Ca} = 0.0544\ mol\ Ca_3N_2$ 3 sig. fig.

Step 3: Calculate mass of Ca_3N_2

$m_{Ca_3N_2} = 0.0544\ mol \times \frac{148.25\ g}{1\ mol} = 8.06\ g$ 3 sig. fig.

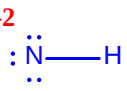
(c) Lithium is the only alkali metal that forms a nitride. This is an example of what principle? *[1 mark]*

diagonal relationship

(d) When calcium nitride reacts with hydrogen gas, calcium imide ($CaNH$) is formed. This reaction has been proposed as a hydrogen storage method. The hydrogen can be released from the imide by heating, reforming the nitride.

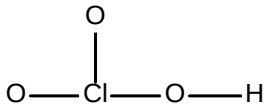
Draw a Lewis diagram for the imide ion (NH^{2-}). *[1 mark]*

Include any non-zero formal charges on the appropriate atom(s).



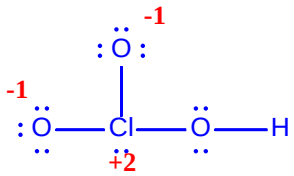
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7. The connectivity for chloric acid ($HClO_3$) is shown below: **[6 marks]**

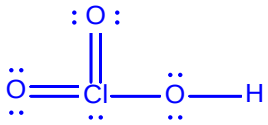


(a) Draw one Lewis diagram for chloric acid where all atoms obey the octet rule. *[2 marks]*

Include any non-zero formal charges on the appropriate atom(s).

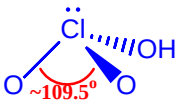


(b) Draw one Lewis diagram for chloric acid where all formal charges have been minimized. *[1 mark]*



(c) Choose one of your Lewis diagrams. Use that Lewis diagram to determine the molecular geometry around the chlorine atom. Your answer should include: *[3 marks]*

- Which of your Lewis diagrams are you using? _____ (the one from (a) or (b)?)
  If your answers to part (a) and (b) were both correct, this part is irrelevant since both correct answers give the same answers for part (c). For some students who made errors in part (a) and/or part (b), however, this allowed us to give partial credit if the answers to part (c) matched the chosen Lewis diagram.
- The name of the molecular geometry around the chlorine atom.
- A drawing of the molecular geometry around the chlorine atom.
- The $O-Cl-O$ bond angle. *Use ~ to indicate an angle that is not exact.*



trigonal pyramidal

It is also acceptable to indicate that the bond angle is <109.5°.

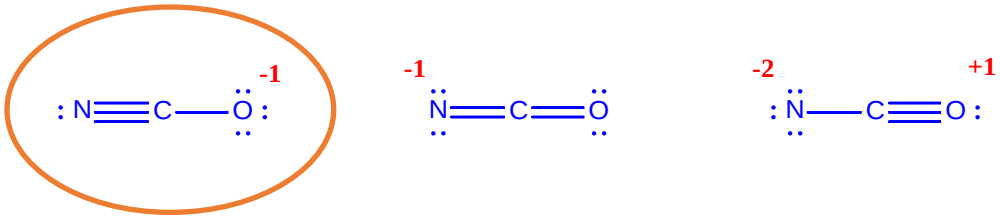
NAME:_____ Student Number:_____

8. The connectivity for the cyanate ion (NCO^-) is shown below: **[8 marks]**

N—C—O

(a) Three resonance structures can be drawn for this anion. Draw all three of them. *[6 marks]*

Include any non-zero formal charges on the appropriate atom(s).



(b) One of these three resonance structures most closely resembles the true structure of the cyanate ion. It can be considered the 'most important' of the three resonance structures.

Circle this 'most important' resonance structure. *[2 marks]*

In 10 words or less, justify your choice.

negative formal charge is placed on most electronegative atom (oxygen).

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9. Use the data provided in the table below to calculate the approximate standard enthalpy change ($\Delta_r H°$) for the reaction between hydrogen selenide and chlorine gas: **[3 marks]**

$$H_2Se_{(g)} + Cl_{2(g)} \rightarrow SeCl_{2(g)} + H_{2(g)}$$

Table of Bond Dissociation Enthalpies

Bond	$\Delta_{BD}H° \left(\frac{kJ}{mol}\right)$
$H - H$	435.7799
$H - Se$	305
$Cl - Cl$	242.85
$Se - Cl$	322



$\Delta_r H° \approx \sum \Delta_{BD}H°(bonds\ broken) - \sum \Delta_{BD}H°(bonds\ formed)$

$\Delta_r H° \approx [2\Delta_{BD}H°(H - Se) + \Delta_{BD}H°(Cl - Cl)] - [2\Delta_{BD}H°(Se - Cl) + \Delta_{BD}H°(H - H)]$

$\Delta_r H° \approx \left[2\left(305\frac{kJ}{mol}\right) + \left(242.85\frac{kJ}{mol}\right)\right] - \left[2\left(322\frac{kJ}{mol}\right) + \left(435.7799\frac{kJ}{mol}\right)\right]$

$\Delta_r H° \approx -227\frac{kJ}{mol}$ 0 decimal places therefore 3 sig. fig.

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10. 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
22	Ti	titanium
24	Cr	chromium
26	Fe	iron
30	Zn	zinc
32	Ge	germanium
34	Se	selenium

CHEM 1000 Partial Periodic Table

1																	18
1.0079 **H** 1	2											13	14	15	16	17	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	**Sc** 21	**Ti** 22	**V** 23	**Cr** 24	**Mn** 25	**Fe** 26	**Co** 27	**Ni** 28	**Cu** 29	**Zn** 30	**Ga** 31	**Ge** 32	**As** 33	**Se** 34	**Br** 35	**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	(260) **Lr** 103

NAME:_____ Student Number:_____

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 x 10^{-18} J
Electron mass	$5.485\,799 \times 10^{-4}$ u	Speed of light in vacuum	2.997 925 x 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

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

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

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

Chem 1000 Standard Periodic Table

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