Name: ________________________ Student Number: ____________________

Chemistry 1000 Practice Final Exam C
Based on Fall 2014 Test (Content Updated to Fall 2017 Curriculum)

INSTRUCTIONS

1) Read the exam carefully before beginning. There are 21 questions on pages 2 to 13 followed by 2 pages of "Data Sheet" (including periodic table) and a blank page for any rough work. **Please ensure that you have a complete exam. If not, let an invigilator know immediately**. All pages must be submitted at the end of the exam.
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) You may use a calculator.
5) Show your work for all calculations. Answers without supporting calculations will not be given full credit.
6) Marks will be deducted for improper use of significant figures and for numerical answers with incorrect/missing units.
7) **Do not open the exam until you are told to begin. Beginning prematurely will result in removal of your exam paper and a mark of 0.**
8) You have **3 hours** to complete this exam. Nobody may leave the exam room during the first hour or the last 15 minutes of the exam.

Q	Mark
1	/ 17
2	/ 8
3	/ 8
4	/ 3
5	/ 6
6	/ 9
7	/ 2
8	/ 7
9	/ 6
10	/ 10
11	/ 14

Q	Mark
12	/ 4
13	/ 5
14	/ 8
15	/ 2
16	/ 4
17	/ 8
18	/ 11
19	/ 10
20	/ 6
21	/ 6
22	/ 1

Total	**/ 145**

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1. Fill in each blank with the word or short phrase that best completes the sentence. **[17 marks]**

(a) The ionic radius of Ca^{2+} is ____________________ than the atomic radius of Ca.

(b) The atomic radius of neon is _____________________ than the atomic radius of nitrogen.

(c) The element with the largest first ionization energy is ____________________________.
Write the name (not the symbol).

(d) Two elements for which a diagonal relationship (to each other) is observed are ____________________ and ____________________. *Write the names (not the symbols).*

(e) An atom that has no lone pairs and is bonded to six other atoms has __________________________________ molecular geometry according to VSEPR theory.

(f) An atom that has one lone pair and is bonded to three other atoms has __________________________________ molecular geometry according to VSEPR theory.

(g) Energy is ____________________ when a bond is broken.

(h) One class of nuclear reaction that is not normally spontaneous is ______________________.

(i) The type of ionizing radiation with the lowest penetrating power is __________________.

(j) The SI unit for measuring effective biological dose (or equivalent dose) is the ___________________________.

(k) The ore from which aluminium is commonly obtained is called ______________________.

(l) A Lewis base is defined as ____.

(m) $HClO_4$ is a __________________________ Brønsted acid than $HClO_3$.

(n) Ti^{3+} is a _________________________ Lewis acid than Ti^{4+}.

(o) If two gases are kept at the same temperature, the particles of the gas with the higher molar mass will have a _______________________________ average speed.

(p) The only intermolecular forces active in a pure sample of a neutral nonpolar substance are ____.

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2. Complete the following table: **[8 marks]**

Z	**Name of Element**	**Charge of Most Commonly Formed Ion**
4		
21		+3
28		+2
34		
35		

3. Complete the following table: **[8 marks]**

Symbol	***Z***	***N***	**Stable? (yes/no)**	**Predicted Type of Decay***
$^{186}_{83}Bi$				
$^{60}_{22}Ti$				

*If you have indicated that an isotope is stable, do not fill in the box for its “predicted type of decay”.

4. Complete the following table. **[3 marks]**

Name	**Formula**
copper(II) chloride	
	$Cr(NO_2)_3$
aluminium oxide	

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5. Write the electron configuration for each of the following atoms/ions.
Please use a noble gas abbreviation. **[6 marks]**

(a) Zn

(b) S^{2-}

(c) Mn^{2+}

6. **[9 marks]**

(a) Write the electron configuration of a ground-state phosphorus atom.
Do not use a noble gas abbreviation. *[2 marks]*

(b) Draw an orbital occupancy diagram (also called "orbital box diagram") for the **valence electrons** of a ground-state phosphorus atom. *Label each subshell.* *[3 marks]*

(c) Use the table below to list a set of quantum numbers describing the **valence electrons** in a ground-state phosphorus atom. *[4 marks]*
Use as many rows as necessary; the correct answer may include one or more empty rows.

Electron	n	l	m_l	m_s
1				
2				
3				
4				
5				
6				
7				
8				

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7. **[2 marks]**

(a) State the Pauli exclusion principle.

(b) In atoms, what is the consequence of the Pauli exclusion principle?

8. **[7 marks]**

(a) Write a balanced chemical equation for the reaction of nitrogen with hydrogen in the presence of a suitable catalyst (Haber process or Haber-Bosch process). *[2 marks]*
You must include states of matter.

(b) In addition to the catalyst, what reaction conditions must be used to generate the product at a reasonable rate and in good yield? Explain briefly why these conditions are necessary. *[3 marks]*

(c) Agrium operates a large Haber-Bosch plant near Carseland, Alberta. The hydrogen required for this process is obtained by steam reforming of natural gas, followed by the water gas-shift reaction. Write balanced equations for both of these reactions. *[2 marks]*

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9. The following reactions studied in class are important to the production and setting of lime mortar. Write a balanced chemical equation for each of these reactions. **[6 marks]**
You must include states of matter.

(a) Calcium carbonate is heated to give calcium oxide.

(b) Calcium oxide is hydrated to give calcium hydroxide.

(c) Calcium hydroxide absorbs carbon dioxide to regenerate calcium carbonate.

10. For each of the following substances, *either* write a balanced chemical equation for its reaction with water at room temperature *or* write "no reaction" if it does not react with water at room temperature. *You must include states of matter.* **[10 marks]**

(a) aluminium metal

(b) calcium metal

(c) potassium metal

(d) SO_3 gas

(e) N_2 gas

(f) HCl gas

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11. **[4 marks]**

(a) Write a balanced chemical equation for the electrolysis of **liquid** sodium chloride in a Down's cell. *[2 marks]*
You must include states of matter.

(b) Write a balanced chemical equation for the reaction that will occur if the products of this electrolysis are not kept separate from each other. *[2 marks]*
You must include states of matter.

12. An alkaline earth metal (1.00 g) is reacted with chlorine gas to produce the resulting chloride salt (1.81 g). A solution of the salt in water gives a red flame test. Identify the alkaline earth metal **and** give the chemical formula for the chloride salt. **[4 marks]**
You must show your work and/or explain your logic. You may find it easiest to refer to the metal as M until you identify it. For full credit, your answer must address the masses.

symbol for alkaline earth metal = _________ formula for chloride salt = _________

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13. The hydride ion (H^-) is a strong base. It reacts with water to give the hydroxide ion and hydrogen gas. Write a reaction equation for this process, drawing Lewis diagrams for all reactants and products. Also, use curly arrows to show the movement of electrons in this reaction. **[5 marks]**

14. Complete the table below. Provide the best Lewis diagram for each compound, or one representative of the best set of Lewis diagrams for molecules with resonance structures. *Include any non-zero formal charges on the appropriate atom(s).* **[8 marks]**
Note that hydrogen atoms are not usually attached to the central atom in oxoacids.

Formula	Name	Lewis diagram	Drawing of Molecule with Bond Angles Labeled
PO_3^{3-}			
HNO_2			

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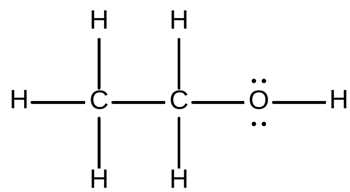
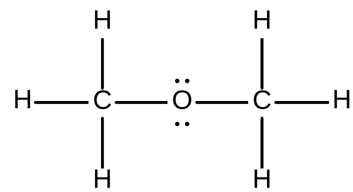
15. Ethanol has a boiling point of 78 ˚C. Dimethyl ether has a boiling point of -24 ˚C. Given that these two compounds have the same molecular formula (C_2H_6O), explain why the boiling point of ethanol is so much higher than the boiling point of dimethyl ether.

[2 marks]



ethanol



dimethyl ether

16. **[6 marks]**

(a) Draw a Lewis diagram for a molecule with the molecular formula $C_2H_2F_2$ which is **polar**. *If the geometry of the molecule is not clear from your Lewis diagram, redraw the molecule to clearly show its geometry.* *[2 marks]*

(b) Draw a Lewis diagram for a molecule with the molecular formula $C_2H_2F_2$ which is **nonpolar**. *If the geometry of the molecule is not clear from your Lewis diagram, redraw the molecule to clearly show its geometry.*
[2 marks]

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17. A 25 L container contains 2.25 kg of water vapour at 375 ^{o}C. **[8 marks]**

(a) What physical factors lead to deviations from the ideal gas law? *[2 marks]*

(b) Calculate the pressure in the container if the water vapour behaved as an ideal gas. *[2 marks]*

(c) Calculate the actual pressure in the container given that the water vapour does not behave ideally. *[4 marks]*

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18. In the 12 Amber Bottles lab, you made a dark red complex ion when you mixed potassium thiocyanate solution (KSCN) with iron(III) nitrate solution. The formula for this complex ion is $[Fe(SCN)(H_2O)_5]^x$ where x is the charge of the ion. **[11 marks]**

(a) What is the chemical formula for iron(III) nitrate? *[1 mark]*

(b) What is the overall charge of the complex ion? (In other words, what is x?) *[1 mark]*

(c) What is the co-ordination number of iron in this complex ion? *[1 mark]*
Thiocyanate is a monodentate ligand.

(d) Write the electron configuration for iron(III). **Please use** a noble gas abbreviation. *[2 marks]*

(e) The complex ions of iron(III) in the reaction you performed are both in the high-spin state. Draw an energy-level diagram for the crystal field splitting of high-spin iron(III). Place the electrons and label the orbitals. *[3 marks]*

(f) **Briefly** explain why these iron complexes are coloured. *[3 marks]*

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19. **[10 marks]**

(a) Why is hydrogen the only neutral atom for which the ionization energy can be readily calculated? *[1 mark]*

(b) Calculate the ionization energy of a neutral ground-state hydrogen atom. *[4 marks]*
Report your answer in J.

(c) Ionization energies are usually reported in kJ/mol. Convert your answer to part (b) into kJ/mol. *[2 marks]*

(d) Calculate the longest wavelength of light that could be used to ionize a hydrogen atom. *Report your answer in nm.* *[3 marks]*

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20. The following measurements were taken from a radioactive sample. **[6 marks]**

Time (minutes)	Activity (Bq)
0	160
5	113
10	80
15	57
20	40

(a) What is the half-life of this radioactive sample? *[1 mark]*

(b) Calculate the decay constant for this radioactive sample. *[2 marks]*

(c) At what time will the activity of the sample be 10 Bq? *[1 mark]*

(d) How many radioactive nuclei were in the initial sample? (In other words, at time = 0) *[2 marks]*

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21. Small stars such as our sun convert hydrogen into helium via a series of reactions called the proton-proton chain reaction. **[6 marks]**

(a) In the first step of the proton-proton chain reaction, two ^{1}H nuclei react to give a positron and one other product. Write a balanced equation for this reaction. *[1 mark]*

(b) What is a positron? *[1 mark]*

(c) Calculate the energy released by this reaction. *[4 marks]*
Report your answer in kJ/mol.

22. What was the most useful and/or interesting thing you learned in CHEM 1000? **[1 mark]**

…AND THAT'S ALL FOR CHEM 1000.
HAPPY HOLIDAYS!

DATA SHEET

Fundamental Constants and Conversion Factors

Atomic mass unit (u)	$1.660\ 539 \times 10^{-27}$ kg	Kelvin temperature scale	0 K = -273.15 ºC
Avogadro's number (N_A)	$6.022\ 141 \times 10^{23}$ 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)	$2.179\ 872 \times 10^{-18}$ J
Ideal gas constant (R)	8.314 462 J·mol^{-1}·K^{-1}	Speed of light in vacuum	$2.997\ 925 \times 10^{8}$ m·s^{-1}
	8.314 462 m^3·Pa·mol^{-1}·K^{-1}	Standard atmospheric pressure	1 bar = 100 kPa
		Volume	1000 L = 1 m^3

Formulae

$c = \lambda \upsilon$ $\quad E = h\upsilon$ $\quad p = mv$ $\quad \lambda = \dfrac{h}{p}$ $\quad \Delta x \cdot \Delta p > \dfrac{h}{4\pi}$ $\quad r_n = a_0 \dfrac{n^2}{Z}$ $\quad E_n = -R_H \dfrac{Z^2}{n^2}$

$\overline{E_k} = \dfrac{1}{2} m\overline{v^2} = \dfrac{3}{2}\dfrac{RT}{N_A}$ $\quad v_{rms} = \sqrt{\overline{v^2}} = \sqrt{\dfrac{3RT}{M}}$ $\quad PV = nRT$ $\quad \left(P + a\dfrac{n^2}{V^2}\right)(V - bn) = nRT$

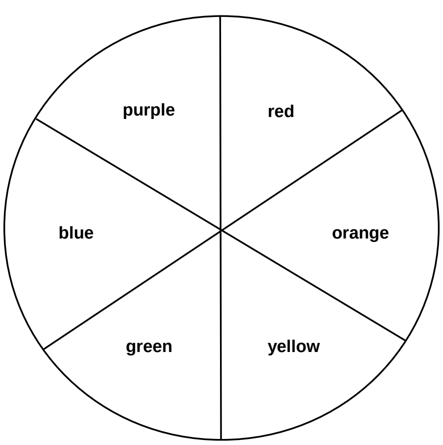
$\Delta E = \Delta mc^2$ $\quad A = -\dfrac{\Delta N}{\Delta t}$ $\quad A = kN$ $\quad \ln\left(\dfrac{N_2}{N_1}\right) = -k(t_2 - t_1)$ $\quad \ln(2) = k \cdot t_{1/2}$

$pK_a \approx 8 - 5p$ for oxoacids $O_pE(OH)_q$

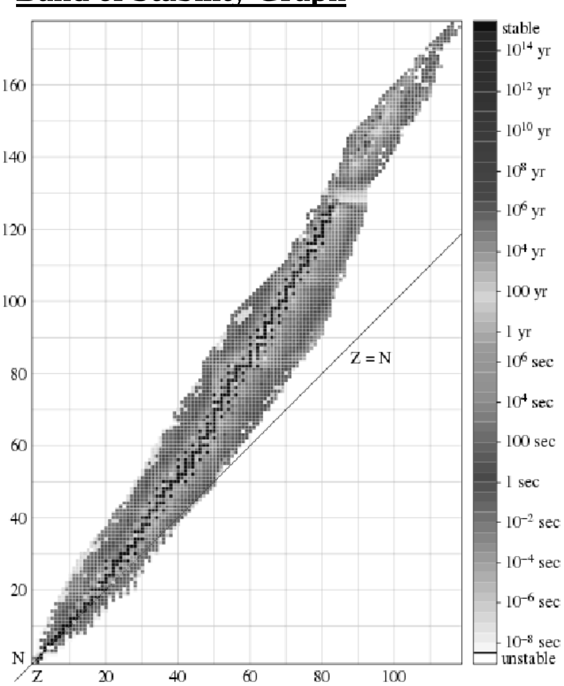
Spectrochemical Series

strong field weak field

CN^- > ethylenediamine > NH_3 > $EDTA^{4-}$ > H_2O > oxalato > OH^- > F^- > Cl^- > Br^- > I^-



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.

DATA SHEET

CHEM 1000 Standard Periodic Table

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 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	44.9559 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 28	63.546 **Cu** 29	65.39 **Zn** 30	69.723 **Ga** 31	72.61 **Ge** 32	74.9216 **As** 33	78.96 34	79.904 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**	(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) **Uut** 113	(289) **Fl** 114	(288) **Uup** 115	(293) **Lv** 116	(294) **Uus** 117	(294) **Uuo** 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

Developed by Prof. R. T. Boeré (updated 2014)

Some Useful Masses

$^{1}_{1}\mathrm{H}$	1.007 825 032 u
$^{2}_{1}\mathrm{H}$	2.014 101 778 u
$^{3}_{2}\mathrm{He}$	3.016 029 319 u
$^{4}_{2}\mathrm{He}$	4.002 603 254 u
$^{4}_{2}\alpha$	4.001 506 179 u
$^{1}_{1}\mathrm{p}$	1.007 276 467 u
$^{1}_{0}\mathrm{n}$	1.008 664 916 u

van der Waals constants for $H_2O_{(g)}$

a = 0.5537 Pa·m^{6}·mol^{-2}

b = 3.05 × 10^{-5} m^{3}·mol^{-1}