Name: ________________________ Student Number: _____________________

Chemistry 1000 Practice Final Exam A
Based on Fall 2009 Test (Content Updated to Fall 2017 Curriculum)

INSTRUCTIONS

1) Read the exam carefully before beginning. There are 19 questions on pages 2 to 12 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	/ 23
2	/ 3
3	/ 5
4	/ 3
5	/ 3
6	/ 2
7	/ 4
8	/ 3
9	/ 12
10	/ 2

Q	Mark
11	/ 7
12	/ 9
13	/ 8
14	/ 3
15	/ 4
16	/ 10
17	/ 6
18	/ 2
19	/ 1

Total	/ 110

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1. Fill in the blank(s). **[23 marks]**

(a) ________________________________ is an atomic property combining ionization energy and electron affinity.

(b) The alkaline earth metal with the smallest atomic radius is __________________________.

(c) The radioactive isotope of hydrogen is _________________.

(d) Phosphorus has three major allotropes. Two of them are ___________ and ____________.

(e) One allotrope of carbon that conducts electricity is _______________.

(f) Aluminium oxide has the chemical formula ____________. When aluminium oxide is reacted with hydroxide, an anion is formed which has the chemical formula ____________.

(g) The only intermolecular force active in a nonpolar liquid is _________________________.

(h) Fluorine has only one isotope. Its mass number is ______.

(i) Which of the following ions give(s) a colourless solution: $[Ti(OH_2)_6]^{4+}$, $[Mo(OH_2)_6]^{4+}$ or $[Mo(OH_2)_6]^{3+}$? ____

(j) The Pauli exclusion principle is a rule stating that _________________________________ ____.

(k) The quantum number describing the shape of an orbital _______________.

(l) The photoelectric effect demonstrated the _____________________ nature of light.

(m) An isotope whose N/Z value is too high will most often undergo ______________ decay.

(n) A neutral atom of ^{3}He has ______ proton(s), ______ electron(s) and _______ neutron(s).

(o) $Cu(NO_3)_2$ is named ____.

(p) A Gray is a unit used to measure ____.

(q) The halogen that is a solid at room temperature is _________________________________.

(r) A molecule which has 'see saw' molecular geometry must have _____________________ electron group geometry.

(s) B_2H_6 is an unusual molecule because ____.

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2. $CoCO_3$ is used in pottery glazes. Dry $CoCO_3$ consists of light red (pink) crystals. **[3 marks]**

(a) What is the IUPAC name for $CoCO_3$? *[1 mark]*

(b) What colour of light is absorbed by dry $CoCO_3$? *[1 mark]*

(c) $CoCO_3$ reacts with acids. Write a balanced chemical equation for the reaction between $CoCO_3$ and $H_3O^+_{(aq)}$. *Include states of matter.* *[1 mark]*

3. H_3PO_4 is a triprotic acid. **[5 marks]**

(a) What is the IUPAC name for H_3PO_4? *[1 mark]*

(b) Draw a valid Lewis diagram for H_3PO_4. *[2 marks]*

Include any non-zero formal charges on the appropriate atoms.

(c) Use your Lewis diagram to calculate an approximate pK_a for H_3PO_4. *[1 mark]*

(d) According to the pK_a you calculated, is H_3PO_4 best classified as a strong acid or a weak acid? *[1 mark]*

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4. Write a balanced chemical equation for each of the following reactions. **[3 marks]**

(a) Sulfur reacts with chlorine to give disulfur dichloride.

(b) Lithium is combusted to give lithium oxide.

(c) Fluorine reacts with water to give hydrofluoric acid and oxygen.

5. Write a balanced chemical equation for each of the following reactions. **[3 marks]**
Include states of matter for all reactants and products.

(a) Barium reacts with oxygen.

(b) Zinc reacts with hydrochloric acid.

(c) Potassium reacts with chlorine.

6. **[2 marks]**

(a) What is hard water? *[1 mark]*

(b) Briefly describe one method of softening water. *[1 mark]*

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7. Lead paint has been prominent in the news lately due to its toxicity. "Lead paint" is not lead metal. "Lead paint" refers to ionic compounds containing lead. **[4 marks]**

(a) What is the electron configuration for a neutral lead atom (Pb)? *[1 mark]*
Use the noble gas abbreviation.

(b) Lead can form two stable ions. What are their charges? Clearly explain your choices. *[3 marks]*

8. Lead has the following isotopic composition: **[3 marks]**

Isotope	Mass (u)	Abundance (%)
$^{204}_{82}Pb$	203.973	1.4
$^{206}_{82}Pb$	205.974	24.1
$^{207}_{82}Pb$	206.976	22.1
$^{208}_{82}Pb$	207.977	52.4

(a) Calculate the average atomic mass for lead. *[2 marks]*

(b) This average atomic mass can be used for calculations involving neutral lead atoms or for calculations involving lead ions. Why? *[1 mark]*

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9. Consider each of the following neutral elements:

- an s-block element of the 6^{th} period with 1 valence electron
- a p-block element of the 3^{rd} period with 5 valence electrons
- a d-block element of the 4^{th} period with 4 valence electrons

In the table below, identify each element, sketch a picture of an orbital in which the highest energy electron could be found and provide a valid set of quantum numbers for that highest energy electron. **[12 marks]**

element description	**element** **symbol <u>and</u> name**	**sketch of orbital containing highest energy electron** **(include labeled axes!)**	***n***	***l***	m_l	m_s
s-block element in 6^{th} period; 1 valence electron						
p-block element in 3^{rd} period; 5 valence electrons						
d-block element in 4^{th} period; 4 valence electrons						

10. The ionic radius of K^+ is 133 pm while the ionic radius of Cu^+ is 96 pm. Explain why the radius of Cu^+ is smaller than that of K^+. **[2 marks]**

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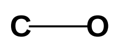
11. The following compounds are a few of the many toxins found in cigarette smoke. **[7 marks]**

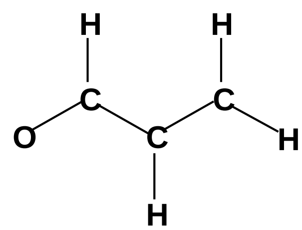
(a) For each of the following compounds, you have been given a skeleton showing all atoms and their connectivity. Turn each skeleton into a valid Lewis diagram by adding the appropriate number of electrons. *[3 marks]*

Include any non-zero formal charges on the appropriate atoms.

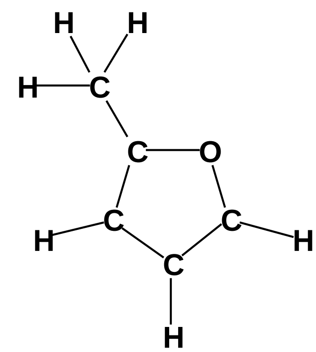
(i)



(ii)



(iii)



(b) For each of the following compounds, you have been given the molecular formula. Draw a valid Lewis diagram for each. *[2 marks]*

Include any non-zero formal charges on the appropriate atoms.

(i) HCN (ii) H_2S

(c) Underneath each of your Lewis diagrams in part (b), identify the molecular geometry and give the corresponding bond angle. *[2 marks]*

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12. Ozone molecules in the upper atmosphere absorb radiation. If the radiation has a wavelength between 240 nm and 310 nm, the ozone molecules will decompose into oxygen molecules and oxygen atoms. The oxygen atoms then recombine with the oxygen molecules to make more ozone, releasing heat. This converts light energy into heat energy and insulates Earth. **[9 marks]**

$$O_{3(g)} \rightarrow O_{2(g)} + O_{(g)}$$ light energy absorbed

$$O_{2(g)} + O_{(g)} \rightarrow O_{3(g)}$$ heat energy released

(a) What kind of electromagnetic radiation has a wavelength between 240 and 310 nm? *[1 mark]*

(b) Which wavelength represents the minimum amount of energy required for this reaction to proceed: 240 nm or 310 nm? *[1 mark]*

(c) Calculate the minimum amount of light energy that must be absorbed to convert 1 mole of ozone into oxygen molecules and atoms. *Report your answer in kJ/mol.* *[4 marks]*

(d) Draw all valid resonance structures for ozone. *[3 marks]*

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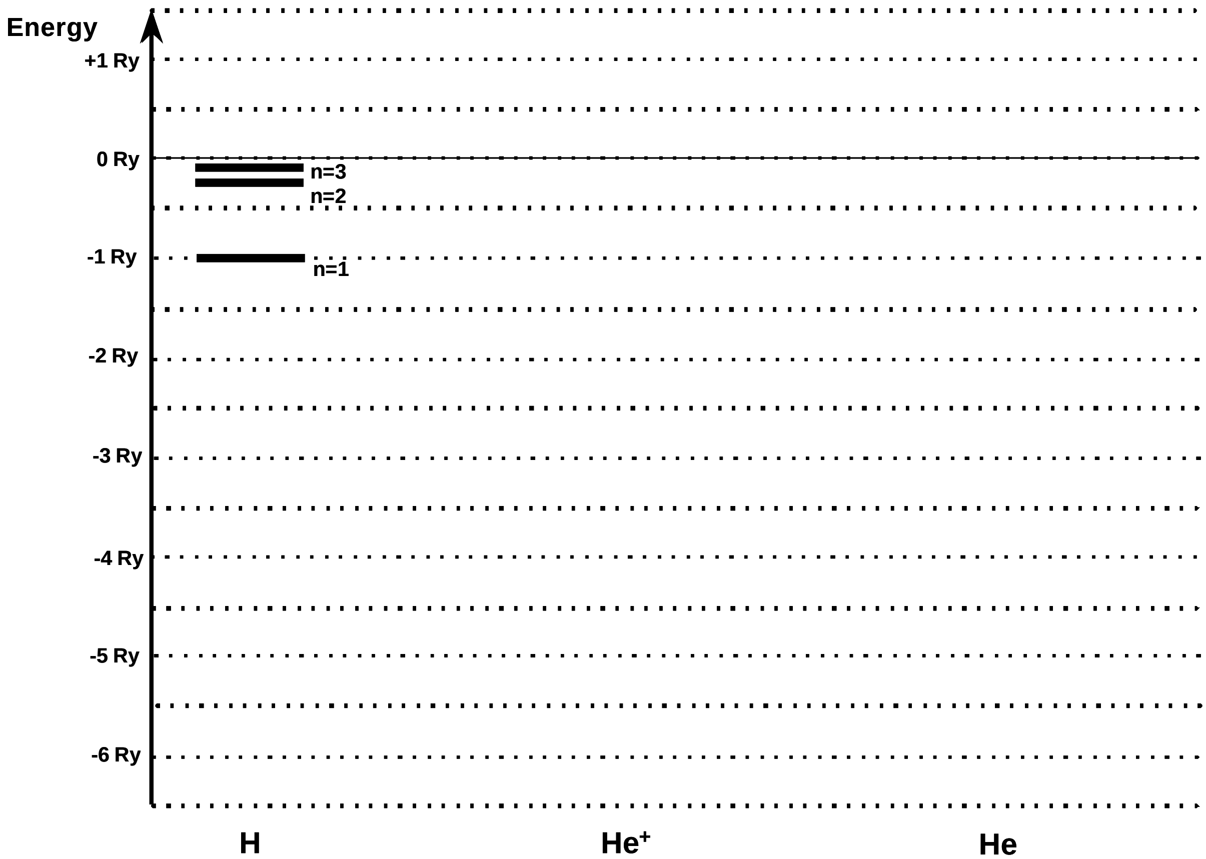
13. The graph below shows the energy levels for three orbitals in a hydrogen atom.
$1\ Ry = R_H = 2.179\ 872 \times 10^{-18}$ J **[8 marks]**



(a) On the graph above, clearly show the ionization energy for a hydrogen atom. *[1 mark]*
Leave the He^+ and He columns clear. You will need them for parts (b) and (c).

(b) In the He^+ column, draw and label lines showing the energies of the $n = 1$, $n = 2$ and $n = 3$ orbitals in He^+. *[3 marks]*

(c) It is not possible to calculate the exact energies of the orbitals in He without the help of a computer; however, they can be estimated. In the He column, draw and label a line showing the approximate energy of the $n = 1$ orbital in He. *[2 marks]*

(d) Why is it not possible to calculate the exact energies of the orbitals in He without the help of a computer? *[2 marks]*

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14. For each of the molecules below, identify the dominant intermolecular force. **[3 marks]**

(a) NH_3

(b) CH_4

(c) CH_2Cl_2

15. **[4 marks]**

(a) Under what conditions does a gas **NOT** behave ideally? Why? *[2 marks]*

(b) Most gases have lower pressures than expected under nonideal conditions. Only a few gases have higher pressures than expected under nonideal conditions. Based on what you know about nonideal gases, suggest one gas that you might expect to have a **higher** pressure than expected, and explain your choice. *[2 marks]*

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16. Tritium (^{3}H) has a half-life of 4.50 $\times 10^3$ days. Its decays product is helium-3 (^{3}He).

[10 marks]

(a) Write a balanced equation for the decay of tritium to helium-3. *[1 mark]*

(b) What mass of tritium would remain in a 1.00 g sample after 1 year of decay? *[3 marks]*

(c) How much energy would be released by the decay described in part (b)? *[6 marks]*

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17. Write a balanced chemical equation for the reaction of each of the following substances with water. Circle whether the resulting solution is acidic or basic. **[6 marks]**

Include states of matter for all products.

(a) $SO_{3(g)}$ + $H_2O_{(l)}$ acid or base?

(b) $Cs_{(s)}$ + $H_2O_{(l)}$ acid or base?

(c) Fe^{3+} + $H_2O_{(l)}$ acid or base?

18. As seen in class, Cs reacts much more violently with water than Na does. Use one of the three main periodic trends discussed in the 'periodic trends' section of the course to explain why this is the case. **[2 marks]**

19. 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)	$2.179\ 872 \text{ x } 10^{-18}$ J
Ideal gas constant (R)	8.314 462 J·mol^{-1}·K^{-1}	Speed of light in vacuum	$2.997\ 925 \text{ x } 10^{8}$ 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

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

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

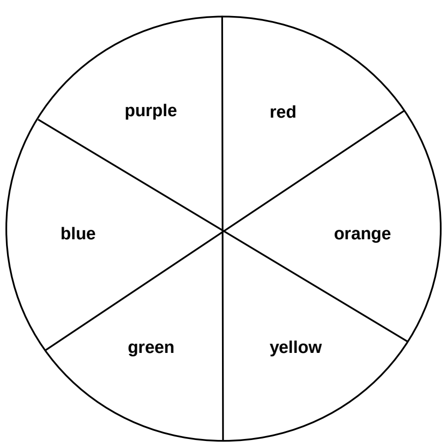
$\Delta E = \Delta mc^2$ $\quad A = -\frac{\Delta N}{\Delta t}$ $\quad A = kN$ $\quad \ln\left(\frac{N_2}{N_1}\right) = -k(t_2 - t_1)$ $\quad \ln(2) = k \cdot t_{1/2}$

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

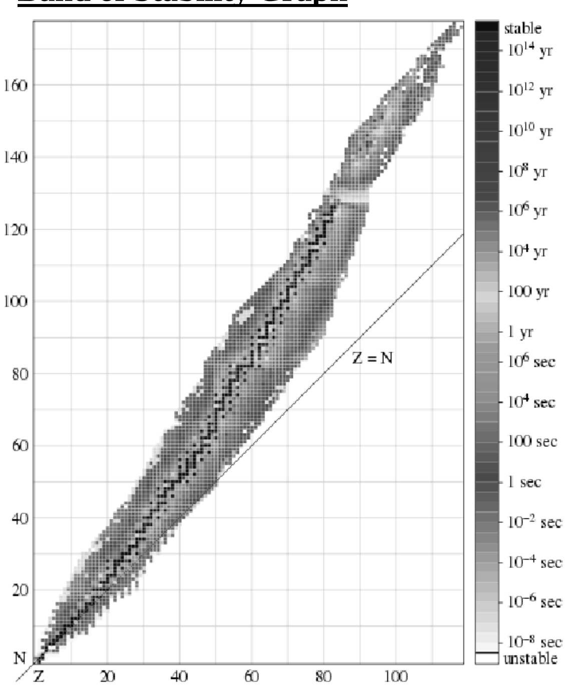
Spectrochemical Series

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

Chemistry 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 **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	44.9559 **Sc** 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 **Ni** 28	63.546 **Cu** 29	65.39 **Zn** 30	69.723 **Ga** 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							

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

Isotope	Mass
^{3}H	3.016 049 278 u
^{3}He	3.016 029 319 u