Name: ________________________ Student Number: ______________________

Chemistry 1000 Practice Final Exam B
Based on Fall 2012 Test (Content Updated to Fall 2017 Curriculum)

INSTRUCTIONS

1) Read the exam carefully before beginning. There are 21 questions on pages 2 to 14 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	/ 4
2	/ 6
3	/ 12
4	/ 4
5	/ 4
6	/ 5
7	/ 10
8	/ 2
9	/ 5
10	/ 3

Q	Mark
11	/ 9
12	/ 12
13	/ 10
14	/ 7
15	/ 18
16	/ 2
17	/ 3
18	/ 5
19	/ 3
20	/ 7
21	/ 1

Total	**/ 132**

Name: ________________________ Student Number: _____________________

1. Complete the table below. **[4 marks]**

Name	**Formula**
copper(II) hydroxide	$Cu(OH)_2$
phosphate ion	PO_4^{3-}
magnesium-24 ion	${}^{24}_{12}Mg^{2+}$
nitric acid	HNO_3

2. Write balanced chemical equations for each of the following processes: **[6 marks]**

(a) ^{133}Ba decays by electron capture

$${}^{133}_{56}Ba + {}^{0}_{-1}e \rightarrow {}^{133}_{55}Cs$$

(b) Nitrogen reacts with magnesium

$$N_{2(g)} + 3Mg_{(s)} \rightarrow Mg_3N_{2(s)}$$

(c) Potassium reacts with water

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

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

(d) Calcium reacts with bromine

$$Ca_{(s)} + Br_{2(l)} \rightarrow CaBr_{2(s)}$$

(e) Aqueous sodium chloride is subjected to electrolysis

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

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

(f) Aluminium oxide is reacted with aqueous sodium hydroxide.

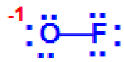
$$Al_2O_{3(s)} + 2NaOH_{(aq)} + 3H_2O_{(l)} \rightarrow 2Na[Al(OH)_4]_{(aq)}$$

or $$Al_2O_{3(s)} + 2OH^-_{(aq)} + 3H_2O_{(l)} \rightarrow 2[Al(OH)_4]^-_{(aq)}$$

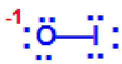
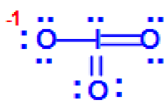
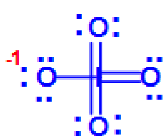
Name: ________________________ Student Number: _____________________

3. Chlorine, bromine and iodine are all capable of forming several different oxoanions. On the other hand, fluorine can only form one oxoanion, and it is not stable. **[12 marks]**

(a) Draw the Lewis structure of the one oxoanion containing fluorine. *[1 mark]*



(b) Complete the table below for any two of the four oxoanions of iodine. *[10 marks]*

Formula	Lewis structure*	Name of Molecular Geometry	Oxidation State of I	Name
IO^-		linear	+1	hypoiodite
IO_2^-		bent	+3	iodite
IO_3^-		trigonal pyramidal	+5	iodate
IO_4^-		tetrahedral	+7	periodate

(c) Explain why fluorine behaves differently from the other halogens (in this context). *[1 mark]*

F is the most electronegative element on the periodic table and is in period 2. In any other oxoanion of F, it would be necessary to have a positive formal charge on F (which is forbidden) or for F to have more electrons than a complete octet (also forbidden).

4. Lithium-6 and lithium-7 are the only two stable isotopes of lithium. **[4 marks]**

(a) Predict the likely modes of decay for isotopes of lithium that are heavier than the stable isotopes. Briefly explain your reasoning. β^- decay *[2 marks]*

Heavier isotopes of an element have more neutrons than the stable isotopes so they will decay in ways that lower N/Z. When a neutron decays to a proton, a β^- particle is released.

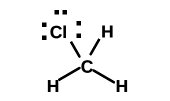
(b) Predict the likely modes of decay for isotopes of lithium that are lighter than the stable isotopes. Briefly explain your reasoning. β^+ decay or electron capture *[2 marks]*

Lighter isotopes of an element have fewer neutrons than the stable isotopes so they will decay in ways that raise N/Z. Electron capture converts a proton to a neutron. Positron (β^+) emission has the same effect.

Name: ________________________ Student Number: _____________________

5. For each pair of species, list the intermolecular force(s) which can act between the two species. Also, circle the strongest intermolecular force acting between those two species. **[4 marks]**

(a) I^- (ion) and chloromethane (polar molecule) (see diagram below)



chloromethane

ion-dipole
ion-induced dipole
dipole-induced dipole
induced dipole-induced dipole (aka London dispersion forces)

(b) H_2O (polar molecule) and NH_3 (polar molecule)

hydrogen bonding
dipole-dipole
dipole-induced dipole
induced dipole-induced dipole (aka London dispersion forces)

6. Which of the gases PF_3 or BF_3 would you expect to have the higher value of *a* in the van der Waals equation and why? **[5 marks]**

The value for *a* increases as the strength of intermolecular forces increases. So, the substance with stronger intermolecular forces should have a higher value for *a*.

To determine which substance has stronger intermolecular forces, we first need to know if either is polar. Begin by drawing a Lewis diagram for each. Then use the Lewis diagram to determine each substance's VSEPR geometry (shown below):

BF_3 is trigonal planar and therefore nonpolar. PF_3 is trigonal pyramidal and therefore polar. Furthermore, PF_3 is slightly larger than BF_3. As such, not only will PF_3 have stronger induced dipole-induced dipole forces than BF_3, it will also have dipole-dipole forces and dipole-induced dipole forces (which nonpolar substances do not). Clearly, PF_3 experiences more and stronger intermolecular forces than BF_3.

For this reason, PF_3 will have a larger value of *a* in the van der Waals equation.

Students who just say that PF_3 is polar while BF_3 is not (with no explanation of why) would only get partial credit for this question.

Name: ________________________ Student Number: _____________________

7. Define each term and give an example of each (a compound or a specific balanced reaction, as appropriate). **[10 marks]**

For (a) and (b), several good examples have been listed. A Lewis diagram in addition to (or instead of) the formula was appreciated.

(a) Lewis acid

an electron pair acceptor

e.g. BF_3, CO_2, SO_3, Fe^{3+}, Cu^{2+}, H^+

(b) Brønsted base

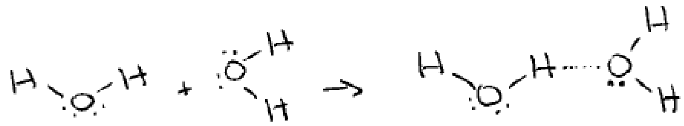
a proton (H^+) acceptor

e.g. NH_3, OH^-, O^{2-}, S^{2-}, CO_3^{2-}

(c) Hydrogen bonding

a strong directional intermolecular force in which a lone pair on an atom of N, O or F is partially donated to an atom of H that is bonded to another atom of N, O or F

e.g.



(d) Ionization energy

the energy required to remove an electron from a neutral atom in the gas phase

e.g. $Na_{(g)} \rightarrow Na^+_{(g)} + e^-$

(e) Electron affinity

the energy released when an electron is added to a neutral atom in the gas phase

e.g. $Cl_{(g)} + e^- \rightarrow Cl^-_{(g)}$

Name: ________________________ Student Number: _____________________

8. Choose an element from group 14, group 15 or group 16 that has more than one allotrope. Give two different allotropes that this element can form. You can use either molecular formulae or names. **[2 marks]**

Possible answers

carbon: diamond, graphite, graphene, fullerenes, nanotubes, etc.

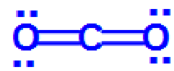
phosphorus: P_4 (white phosphorus), red phosphorus, black phosphorus

oxygen: O_2, O_3 (ozone)

sulfur: S_8, plastic sulfur, S_2, S_3, S_4, S_5, S_6, S_7, etc.

9. **[5 marks]**

(a) Draw the Lewis diagrams for carbon monoxide and carbon dioxide. *Include any nonzero formal charges on the appropriate atoms.* *[2 marks]*



(b) What is unusual about the Lewis diagram for carbon monoxide? *[1 mark]*

It has a negative formal charge on carbon (not a very electronegative element) and a positive formal charge on oxygen (one of the more electronegative elements).

(c) Is carbon dioxide a Lewis acid or a Lewis base? *[1 mark]*

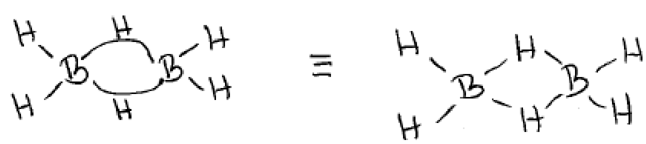
Lewis acid (primarily) *no credit for cutesy answers like "yes"*

(d) Is carbon monoxide a Lewis acid or a Lewis base? *[1 mark]*

Lewis base *no credit for cutesy answers like "yes"*

10. Borane (BH_3) does not exist in nature. Rather, it exists as diborane. **[3 marks]**

(a) Draw the Lewis diagram for diborane. *[1 mark]*



(b) What is unusual about this structure? *[1 mark]*

It has three-center two-electron bonds (i.e. bonds in which the pair of electrons are shared between three atoms instead of the usual two).

This is shown more clearly in the diagram on the left.

(c) Why do you think that diborane exists while borane does not? *[1 mark]*

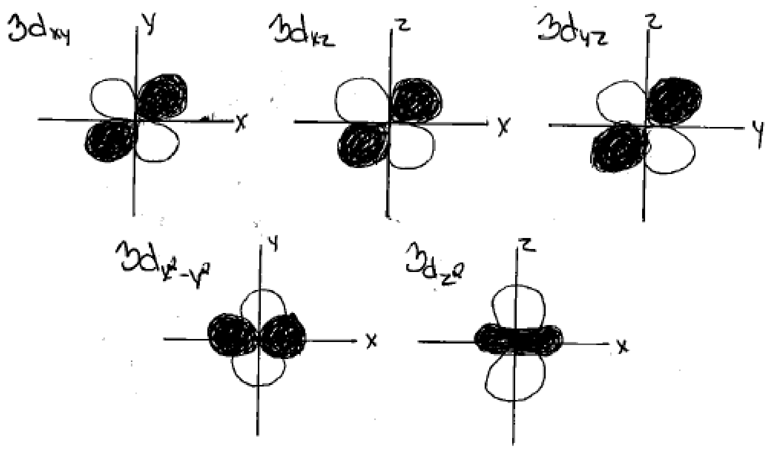
The boron atoms obey the octet rule in diborane but they do not in borane (BH_3).

Name: ________________________ Student Number: _____________________

11. **[9 marks]**

(a) Draw a full set of 3*d* orbitals. *[5 marks]*

Each orbital must be drawn on a properly labeled set of axes

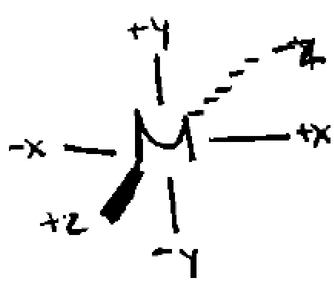


(b) In an octahedral complex, these orbitals split into two sets of different energies. Indicate which orbitals belong to the higher-energy set and which to the lower-energy set. Explain your choices. *[4 marks]*

The higher-energy set is $d_{x^2-y^2}$ and d_{z^2}.

The lower energy set is d_{xy}, d_{xz} and d_{yz} .

In an octahedral complex, a metal is surrounded by six atoms, each donating an electron pair to the metal. The six atoms are located along the three axes:

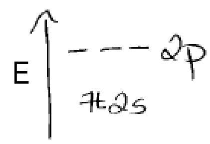


There is repulsion between the electron pairs donated by these atoms and the electrons in the d orbitals of the metal, raising the energy of these d orbitals. This effect is stronger for the two d orbitals pointing directly at the electron-donating atoms (i.e. $d_{x^2-y^2}$ and d_{z^2}).

Name: ________________________ Student Number: ____________________

12. **[12 marks]**

(a) Draw an orbital energy diagram for the valence shell (both occupied and unoccupied orbitals) of a beryllium atom. *[2 marks]*



(b) Give one possible complete set of quantum numbers for an electron in the highest energy occupied orbital of beryllium. *[2 marks]*

$n = 2$, $\ell = 0$, $m_\ell = 0$, $m_s = +\frac{1}{2}$

or $n = 2$, $\ell = 0$, $m_\ell = 0$, $m_s = -\frac{1}{2}$

(c) Explain why we can't measure an electron affinity for beryllium. *[3 marks]*

The next electron added to Be would start a new subshell (2p). The four electrons already in Be would shield enough of the +4 nuclear charge (from the four protons in the nucleus) that the new electrons would feel as much repulsion from the four electrons as it would feel attraction to the nucleus. Thus, Be^- would not form.

(d) What is an emission spectrum? *[1 mark]*

An emission spectrum shows the wavelengths of light emitted when excited state atoms relax to the ground state.

(e) The lowest energy transition in the emission spectrum of a beryllium atom has a wavelength of 455 nm. To what transition does this line correspond? *[1 mark]*

$1s^2 2s^1 2p^1 \rightarrow 1s^2 2s^2$

excited state Be (lowest energy one) → ground state Be

(f) Calculate the energy difference between the two energy levels involved in the transition described in part (e). *[3 marks]*

The energy difference between the two energy levels is equal to the energy of the photon emitted

For light, $E_{photon} = \frac{hc}{\lambda}$

Therefore

$$\Delta E = E_{photon} = \frac{hc}{\lambda} = \frac{\left(6.626070\times10^{-34}\ \frac{J}{Hz}\right)\left(2.997925\times10^{8}\ \frac{m}{s}\right)}{(455nm)} \times \frac{10^9\ nm}{1m} \times \frac{1Hz}{1\frac{1}{s}} = 4.37\times10^{-19}\ J$$

Name: ________________________ Student Number: _____________________

13. Natural nitrogen samples from different sources have different molar masses. Two particular samples of nitrogen have molar masses of 14.00648 g/mol and 14.00711 g/mol respectively. **[10 marks]**

(a) Based on the molar masses given above, what is likely to be the most common isotope of nitrogen? *[1 mark]*

^{14}N (nitrogen-14)

(b) How many protons and how many neutrons would the nucleus contain for the isotope you named in part (a)? *[2 marks]*

7 protons and 7 neutrons

(c) What experimental method could we use to determine the molar mass? Explain briefly what data we get from this experiment and how a molar mass is calculated from that data. *[4 marks]*

We could use mass spectrometry (MS). This would give the exact mass of each isotope present in the sample and the relative amount of each isotope present in the sample (wchich allows calculation of percent abundance for each isotope). From this information, we use the formula below to calculate molar mass:

$$M_{av} = \sum \frac{\%_n}{100\%} M_n$$

where n represents each isotope ($\%_n$ is its percent abundance and M_n is its exact mass)

(d) For the two samples described above and the experiment you described in part (c), what data would be the same (within experimental error) and what data would be different? Can you say (at least qualitatively) how they would differ? In other words, what data would be larger/smaller for what sample? *[3 marks]*

The exact mass of each isotope (M_n) is the same.

The relative amounts of each isotope will differ, so the percent abundances ($\%_n$) will differ.

The heavier sample (14.00711 g/mol) will contain a higher percentage of heavier isotopes in comparison to the lighter sample.

Name: ______________________ Student Number: ____________________

14. In proton therapy, a beam of protons is used to destroy tumors inaccessible to normal surgical procedures. Ions (alpha particles, protons, etc.) progressively slow down as they pass through biological tissues, and they do most of their damage just as they are about to stop. By choosing their energy correctly, it is therefore possible to target a tumor at a very specific depth, causing much less damage to intervening tissues. In one particular operation, protons with a kinetic energy of 3.0×10^{-11} J per proton were used. **[7 marks]**

(a) Calculate the wavelength of these protons. *[3 marks]*

Since protons are particles with mass,

$$E_{kinetic} = \tfrac{1}{2}mv^2$$

$$v = \sqrt{\frac{2E_{kinetic}}{m}} = \sqrt{\frac{2\left(3.0\times10^{-11}\,J\right)}{\left(1.007277u\right)}\times\frac{1u}{1.660539\times10^{-27}\,kg}\times\frac{1\,\frac{kg\cdot m^2}{s^2}}{1J}} = 1.9\times10^{8}\,\tfrac{m}{s}$$

Then use the de Broglie equation to calculate wavelength

$$\lambda = \frac{h}{mv} = \frac{\left(6.626070\times10^{-34}\,\frac{J}{Hz}\right)}{\left(1.007277u\right)\left(1.9\times10^{8}\,\frac{m}{s}\right)}\times\frac{1u}{1.660539\times10^{-27}\,kg}\times\frac{1\,\frac{kg\cdot m^2}{s^2}}{1J} = 2.1\times10^{-15}\,m$$

These protons are traveling at high enough speeds that (if we knew how), we would use relativity theory to answer this problem. As it turns out, the answer is approximately the same using classical physics (as done in the solution above) or using relativity.

(b) At the stage at which tumors are noticed and treated, they typically have dimensions on the order of centimeters. How does the wavelength of the protons compare? What, if anything, would this imply for their use in proton therapy? *[2 marks]*

The wavelength of the proton is substantially smaller than the dimensions of the tumour ($\sim10^{13}$ times smaller) so the protons can be used to precisely target the tumor.

(c) A radiotherapist plans to deliver a proton therapy dose of 3.5 Gy to a tumor with an estimated mass of 32 g.

(i) How much energy would this dose represent? *[1 mark]*

1 Gy = 1 J/kg (absorbed dose)

$$E = 3.5\,\tfrac{J}{kg}\times32g\times\frac{1kg}{1000g} = 0.11J$$

(ii) How many protons would be needed to deliver this dose? *[1 mark]*

Each proton has a kinetic energy of 3.0×10^{-11} J

$$\#\,protons = \frac{E_{total}}{E_{proton}} = \frac{0.11J}{3.0\times10^{-11}\,\frac{J}{proton}} = 3.7\times10^{9}\,protons$$

Name: ________________________ Student Number: _____________________

15. In power plants, the burning of coal produces SO_2 because the coal contains a small amount of sulfur (hence sulfur is also burned). One way to remove SO_2 from the flue gases of power plants is to react it with an aqueous solution of H_2S. One product of this reaction is sulfur and the other is water.
[18 marks]

(a) How many moles of SO_2 will be produced by burning 1.00 ton (1.00×10^3 kg) of coal containing 3.00% sulfur by mass? *[3 marks]*

Step 1: Calculate the mass of sulfur (S_8) that will be burned

$$m_{S_8} = \left(\frac{3.00\%}{100\%}\right)\left(1.00 \times 10^3 kg\right) = 30.0kg$$

Step 2: Calculate the moles of sulfur that will be burned (molar mass of S_8 is 256.528 g/mol)

$$n_{S_8} = 30.0kg \times \frac{1000g}{1kg} \times \frac{1mol}{256.528g} = 117mol$$

Step 3: Calculate the moles of SO_2 that will be produced (every 1 mole of S_8 contains 8 sulfur atoms so will produce 8 moles SO_2)

$$n_{SO_2} = 117molS_8 \times \frac{8molSO_2}{1molS_8} = 936molSO_2$$

Note that you should get the same answer for moles of SO_2 using any allotrope of sulfur (or even a generic "S"). The only part that will give a different answer for each allotrope is step 2.

(b) Write a balanced chemical equation for the reaction between SO_2 and H_2S. *[1 mark]*

$$16H_2S + 8SO_2 \rightarrow 3S_8 + 16H_2O$$

(c) What are the oxidation states of sulfur in SO_2 and H_2S? *[2 marks]*

S in SO_2: ____+4____ S in H_2S: ____-2____

(d) At 25 ˚C (298K) and 100 kPa, how many liters of hydrogen sulfide (H_2S) gas would be needed to remove all the SO_2 formed in (a)? *[3 marks]*

Step 1: Calculate the moles of $H_2S_{(g)}$ required

$$n_{H_2S} = 936molSO_2 \times \frac{16molH_2S}{8molSO_2} = 1.87 \times 10^3 molH_2S$$

Step 2: Calculate the volume of $H_2S_{(g)}$ required

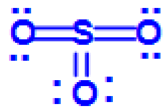
$$PV = nRT$$

$$V = \frac{nRT}{P} = \frac{\left(1.87 \times 10^3 mol\right)\left(8.314462 \frac{m^3 \cdot Pa}{mol \cdot K}\right)\left(298.15K\right)}{\left(100kPa\right)} \times \frac{1kPa}{1000Pa} = 46.4m^3$$

This volume could be converted into L if you like. That would give 4.64×10^4 L.

15. *continued…*

(e) If the untreated flue gases of power plants are released into the environment, SO_2 will react with another pollutant, NO_2, to produce sulfur trioxide and nitrogen monoxide. Draw a formal charge-minimized Lewis diagram for SO_3. *[2 marks]*



(f) Fill in the following table for SO_3. *[4 marks]*

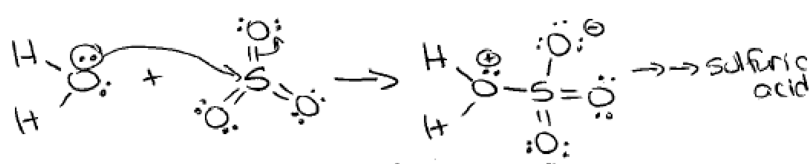
Name of Molecular Geometry	Bond Angles	Average S-O Bond Order	Molecular Polarity? (circle one)
trigonal planar	120°	2	polar / nonpolar

(g) When SO_3 dissolves in atmospheric water, we get acid rain! Write a balanced chemical equation for the reaction of SO_3 with water. *[1 mark]*

$$H_2O + SO_3 \rightarrow H_2SO_4$$

(h) In the Lewis acid-base reaction described in part (g), is SO_3 acting as a Lewis acid or a Lewis base? Support your answer with a reaction equation showing the movement of electrons using curly arrows. *[2 marks]*

Lewis acid



16. **[2 marks]**

(a) On what quantum number(s) does the orbital energy in a hydrogen atom depend? *[1 mark]*

n

Because there is only one electron in hydrogen, n is the only quantum number that affects the energy of the electron.

(b) Would your answer be the same for helium? If not, state the quantum number(s) on which the energy of an orbital in a helium atom depends. *[1 mark]*

n and ℓ

Helium has more than one electron, so both n and ℓ affect the energy of the orbitals.

(e.g. Electrons in 2s and 2p orbitals have different energies in a multi-electron atom.)

Name: ________________________   Student Number: _____________________

17. The Haber-Bosch process is arguably one of the most important industrial reactions. **[3 marks]**

(a) Write a balanced chemical equation for the reaction involved in the Haber-Bosch process. Include all states of matter. *[2 marks]*

$$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$$

(b) What property of nitrogen makes this reaction so challenging? *[1 mark]*

Nitrogen is very unreactive due to the strong N≡N triple bond.

18. Consider the following complex: $[Co(OH)_6]^{4-}$ **[5 marks]**

(a) What is the co-ordination number of cobalt in this complex? *[1 mark]*

6

(b) What is the oxidation state of cobalt in this complex? *[1 mark]*

+2 *six OH^- ligands; overall charge of -4 so Co must be +2*

(c) How many d electrons does cobalt have in this complex? *[1 mark]*

7 *Co^{2+} electron configuration is [Ar] $3d^7$*

(d) Would you expect this complex to absorb light with a longer or shorter wavelength than $[Co(NH_3)_6]^{2+}$? Explain. *[2 marks]*

longer wavelength (i.e. lower energy light)

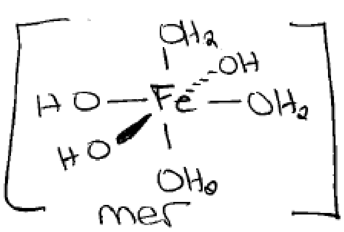
NH_3 is a stronger field ligand than OH^-. *(see spectrochemical series on data sheet)*

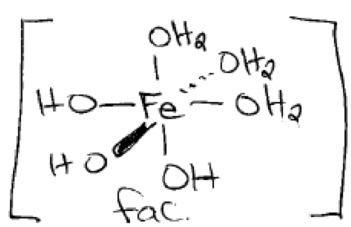
As such, the energy difference between the two sets of 3d orbitals is larger in $[Co(NH_3)_6]^{2+}$. Thus, $[Co(NH_3)_6]^{2+}$ will absorb higher energy light and $[Co(OH)_6]^{4-}$ will absorb lower energy light.

Lower energy light has a longer wavelength.

19. **[3 marks]**

(a) Draw both isomers of $[Fe(H_2O)_3(OH)_3]$. *[2 marks]*
Your pictures must clearly show the correct geometry at Fe.





(b) Clearly label your answers to part (a) as the *fac* isomer and the *mer* isomer. *[1 mark]*

Name: ________________________ Student Number: _____________________

20. The ground-state electron configuration of tantalum (Ta) is [Xe] $6s^2$ $4f^{14}$ $5d^3$. **[7 marks]**

(a) The most common oxidation states of tantalum are III, IV and V (i.e. +3, +4 and +5).
Write the ground-state electron configuration for each of the following ions: *[3 marks]*

Ta^{3+} [Xe] $4f^{14}$ $5d^2$

Ta^{4+} [Xe] $4f^{14}$ $5d^1$

Ta^{5+} [Xe] $4f^{14}$

(b) Which of these ions would you expect to yield coloured complexes? Explain briefly.
Ta^{3+} and Ta^{4+} *[4 marks]*

For us to observe colour, the metal in a complex must have a partially filled d subshell so that there are electrons in the lower-energy d orbitals and at least one vacancy in the higher-energy d-orbitals. This is necessary for visible light to be absorbed and excite one electron from a lower-energy to a higher-energy d orbital. When this absorption occurs, we observe the complex as a combination of the colours of light not absorbed by the complex.

BONUS: In a special chelating solvent called diglyme, the following reaction can be performed

$$TaCl_{5(sol)} + 6Na_{(s)} + 6CO_{(g)} + 12diglyme_{(l)} \rightarrow [Ta(CO)_6]^-_{(sol)} + 5Cl^-_{(sol)} + 6[Na(diglyme)_2]^+_{(sol)}$$

Here, the subscript (sol) indicates a species dissolved in diglyme (the solvent).

What is the oxidation state of the tantalum atom in the product complex? *[1 mark]*

-1 *that's correct! a metal with a negative oxidation state! odd…*

What would the corresponding ground-state electron configuration be? *[1 mark]*

[Xe] $6s^1$ $4f^{14}$ $5d^5$ *would probably be lower energy than [Xe] $6s^2$ $4f^{14}$ $5d^4$ (similar to electron configuration of Cr: [Ar]$4s^1$ $3d^5$)*

21. 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

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

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

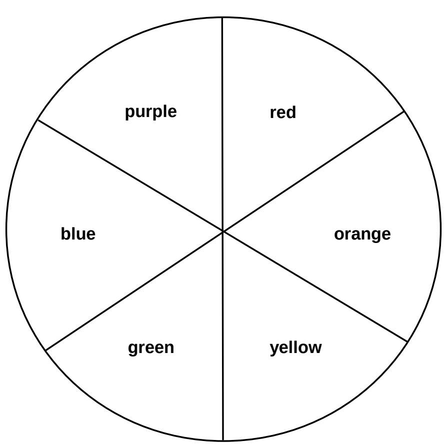
$\Delta E = \Delta mc^2$ $\quad A = -\frac{\Delta N}{\Delta t}$ $\quad A = kN$ $\quad \ln\left(\frac{N_2}{N_1}\right) = -k(t_2 - t_1)$ $\quad \ln(2) = k \cdot t_{1/2}$

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

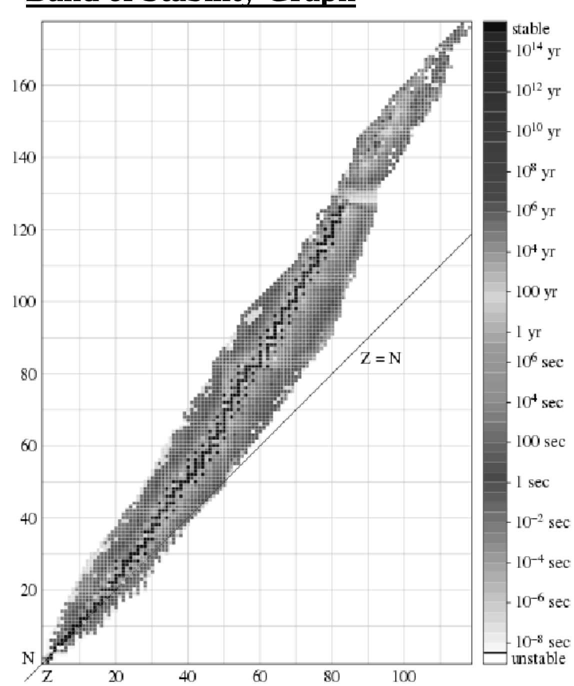
Spectrochemical Series

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