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Last Name: _____

Student Number: _____

First Name: _____

2013 Practice Final Exam: CHM 1311F

Duration: 3 hours

	part A	part B										total
question		1	2	3	4	5	6	7	8	9	10	
marks	20	8	8	8	8	8	8	8	8	8	8	100
score												

INSTRUCTIONS:

- Verify that you have all 19 pages of the exam including 5 appendices.
- There are a total of **100 marks** for the exam.
- Programmable calculators are not permitted.
- Your final answer must have the correct units and the correct number of significant digits.
- This is a **closed book** exam.
- Formulas and the periodic table are in the appendices at the end of the exam. You can detach them.

Part A (20 marks)

Answer all **20 questions** in this part. *Each question is worth 1 mark.* For each question, provide brief answers (i.e.; either one or two words, a picture, or a few numbers). Do not explain your reasoning. If you need space to work in order to determine your final answer, please do this work on the formula sheets and provide only the final answer in the space provided.

(1) Draw a reasonable Lewis structure for ONC^- , including the formal charges (N.B. the N is the central atom).

(2) Draw a reasonable Lewis structure for XeO_3 , including formal charges (N.B. the Xe is the central atom).

(3) Draw a reasonable Lewis structure for O_2^- , including the formal charges.

(4) Draw the three dimensional structure of PF_4^+ (N.B. the P is the central atom).

(5) Draw the three dimensional structure of PF_4^- (N.B. the P is the central atom).

(6) Draw the three dimensional structure of SF_5^- (N.B. the S is the central atom).

(7) What is the oxidation state of S in $\text{S}_2\text{O}_5^{2-}$?

(8) What is the conjugate base of H_2SO_4 ?

(9) How many significant digits are there in the answer for $11.2 + 90.335 + 8.00 - 0.5$?

(10) For the reaction $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(l)$, is the value of ΔS positive, negative, or null?

(11) For the endothermic reaction, $\text{Zn}(s) + 2 \text{HCl}(aq) \rightarrow \text{ZnCl}_2(aq) + \text{H}_2$, is Zn the oxidizing agent or the reducing agent?

(12) Who proposed that energy comes in small quantities known as “quanta”?

(13) HNO_3 is nitric acid. What is the molecular formula for the nitrite anion?

(14) Among Li, Be, B, C, N, O, F, and Ne, which atom possesses the largest absolute value for the difference between “spin up” and “spin down” electrons?

(15) Write the electron configuration for Cr?

(16) For the Zn^{2+} ion (in its ground state), how many electrons have $m = +1$?

(17) For the As atom (in its ground state), how many electrons have $m = 0$?

(18) For the Br^- atom (in its ground state), how many electrons have $m = +2$ and $s = +\frac{1}{2}$?

(19) Between Cu, Zn, Ga, Ge, As, Se, and Ba, which is diamagnetic?

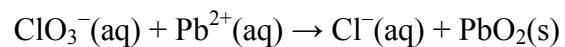
(20) True or False. We can simultaneously know the exact position and momentum of an electron.

Part B (80 marks)

Answer each of the **10 questions** in this part. *Each question is worth 8 marks.* Show your calculations to obtain full marks. You may write your answer on the reverse side of the page if necessary, but indicate this clearly with an arrow at the bottom of the page.

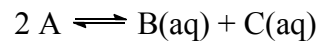
Question 1

Balance the following redox equation under *acidic conditions*:



Question 2

For the reaction



The concentrations of A(aq), B(aq), and C(aq) at equilibrium are 0.422 M, 0.277 M, and 0.188 M. Calculate the value of ΔG° . If the concentrations of B(aq) and C(aq) were each 0.100 M, what concentration of A(aq) would be necessary in order to obtain a value of $\Delta G = -5.00$ kJ. For each part of the question, the temperature is always 25°C.

Question 3

We heat 25.0 kg of water by performing the combustion of propane (N.B. a combustion is the reaction between a substance with $\text{O}_2(\text{g})$ in order to produce $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\text{l})$). At 25.0°C and at a pressure of 1.00 atm, we perform the combustion of 37.7 L of propane (C_3H_8). All of the heat released by this reaction enters the 25.0 kg of water. If the initial temperature of the water was 23.0°C , what will be the final temperature of the water? To answer this question, you need the following data.

$$\Delta H_f^\circ (\text{C}_3\text{H}_8, \text{g}) = -103.9 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ (\text{CO}_2, \text{g}) = -393.5 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ (\text{H}_2\text{O}, \text{l}) = -285.8 \text{ kJ mol}^{-1}$$

$$s (\text{H}_2\text{O}, \text{l}) = 4.184 \text{ J K}^{-1} \text{ mol}^{-1}$$

Question 4

63.3 g of C(s) (graphite) are placed in a 40.0 L stainless steel container, which contains only O₂(g) at a temperature of 25°C. The pressure is 1.00 atm. The C(s) and the O₂(g) react together to form CO₂(g) in the stainless steel container. What mass of CO₂(g) is produced? At the end of the reaction, what are the partial pressure of CO₂(g) if the temperature of the container increases to 75°C over the course of the reaction?

Question 5

(a, 6 marks) The percent mass composition of an unknown salt is 71.41% O, 9.86% Mg, 13.01% S, and 5.73% H. What is the empirical formula of this salt?

(b, 2 marks) For a second compound that contains only Ni (nickel) and O (oxygen), the mass percentage of Ni is 70.98%. What is the empirical formula of this second salt?

Question 6

We dissolve 0.517 mol of a weak acid, HA, and 12.7 g of NaOH in enough water to produce a 1.00 L solution. The pH of this buffer solution is 4.45. What is the value for the ionization constant, K_a , for this weak acid HA? We add 0.050 mol of HCl (make the approximation that the volume remains 1.00 L). What the new buffer solution after the addition of the HCl?



Question 7

What volume of 0.150 M $\text{Ba}(\text{OH})_2$ solution is necessary in order to neutralize 25.0 mL of a 0.276 M acetic acid, CH_3COOH , solution? $\text{Ba}(\text{OH})_2$ is a strong base and acetic acid is a weak acid with a pK_a of 4.74. What is the pH at the equivalence point?

Question 8

(a, 5 marks) The rate of a first order reaction increases by a factor of 10.0 when the temperature of a reaction is increased from 25°C to 45°C. What is the energy of activation for this reaction? If the half-life is 50.0 s at 25°C, what is the half-life at 45°C?

(b, 3 marks) For the reaction



we obtain the following kinetic data:

$[\text{A}]_0$ (M)	$[\text{B}]_0$ (M)	$[\text{C}]_0$ (M)	initial rate, v_0 (M s^{-1})
0.25	0.20	0.20	0.20
0.25	0.40	0.20	0.20
0.25	0.40	0.40	0.20
0.50	0.40	0.40	0.80
0.50	0.80	0.40	0.80
1.00	0.80	1.00	3.20

What is the rate law for this reaction (please calculate the value of k as well)?

Question 9

(a, 4 marks) The solubility product of $\text{Mg}_3(\text{PO}_4)_2$ is 1.0×10^{-24} . Calculate the solubility (in g/L) in pure water.

(b, 4 marks) We add an excess of AgNO_3 to a 577 mL solution of NaCl and we produce 3.73 g of a AgCl(s) precipitate. What was the concentration of $\text{Cl}^{\text{-}}(\text{aq})$ in the original solution?

Question 10

We have an aqueous solution of $\text{C}_3\text{H}_8\text{O}$ with a molarity of 0.200 M. The density of this solution is 0.957 g/mL. Calculate the molality, the percent mass, and mole fraction of $\text{C}_3\text{H}_8\text{O}$ in this solution.

fundamental constants:

$$R = 8.3145 \text{ kPa L K}^{-1} \text{ mol}^{-1} = 8.3145 \text{ J K}^{-1} \text{ mol}^{-1} = 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$$

$$1 \text{ atm} = 101\,325 \text{ Pa} = 760 \text{ mm Hg}$$

$$N_A = 6.022 \times 10^{23}$$

$$1 \text{ mL} = 1 \times 10^{-3} \text{ L} = 1 \times 10^{-6} \text{ m}^3$$

$$\text{atomic mass unit} = 1.661 \times 10^{-24} \text{ g}$$

formulas:

density:

$$\rho = \frac{\text{mass}}{\text{volume}}$$

Boyle's Law (constant n, T):

$$P_1V_1 = P_2V_2$$

Charles' and Gay-Lussac's Law (constant n, P):

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Avogadro's Law (constant P, T):

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

Ideal Gas Law equation:

$$PV = nRT$$

$$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

molar mass of a gas:

$$M = \frac{\rho RT}{P}$$

mole fraction:

$$X_A = \frac{n_A}{n_T}$$

Dalton's Law of Partial Pressures:

$$P_A = X_A P_T$$

root-mean-square speed:

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

first law of thermodynamics

$$\Delta U = Q + W$$

enthalpy:

$$H = E + PV$$

heat capacity and specific heat capacity:

$$Q = C\Delta T = ms\Delta T$$

change in standard enthalpy:

$$\Delta H^\circ = \sum_A^{\text{products}} n_A \Delta H_f^\circ(A) - \sum_B^{\text{reactants}} n_B \Delta H_f^\circ(B)$$

expansion work of a gas (constant external pressure)

$$W = -P_{ex} \Delta V$$

chemical reaction at constant temperature:

$$\Delta H = \Delta U + RT\Delta n_{gas}$$

change in entropy at constant temperature:

$$\Delta S = \frac{Q}{T}$$

second law of thermodynamics:

$$\Delta S_{universe} \geq 0$$

change in standard enthalpy:

$$\Delta S^\circ = \sum_A^{\text{products}} n_A S^\circ(A) - \sum_B^{\text{reactants}} n_B S^\circ(B)$$

free energy:

$$G = H - TS$$

change in free energy, constant temperature:

$$\Delta G = \Delta H - T\Delta S$$

change in standard free energy

$$\Delta G^\circ = \sum_A^{\text{products}} n_A \Delta G_f^\circ(A) - \sum_B^{\text{reactants}} n_B \Delta G_f^\circ(B)$$

change in free energy:

$$\Delta G = \Delta G^\circ + RT \ln Q$$

relationship between free energy and the equilibrium constant:

$$\Delta G^\circ = -RT \ln K \quad \text{or} \quad K = e^{\frac{-\Delta G^\circ}{RT}}$$

the van't Hoff equation:

$$\ln \frac{K_2}{K_1} = \frac{-\Delta H^\circ}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$$

titration (equivalence point, for an acid/base pair with only one proton to donate/accept):

$$C_{\text{standard}} V_{\text{standard}} = C_{\text{unknown}} V_{\text{unknown}}$$

Henderson-Hasselbalch equation:

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

conjugate acid/base pair:

$$K_a K_b = K_{\text{water}} (= 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C})$$

first order reaction:

$$\ln[A] = \ln[A]_0 - kt \quad ; \quad \ln \frac{[A]_0}{[A]} = kt \quad ; \quad [A] = [A]_0 e^{-kt} \quad ; \quad t_{\frac{1}{2}} = \frac{\ln 2}{k}$$

Arrhenius equation:

$$\ln \frac{k_2}{k_1} = -\frac{E_a}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$$

Solubility Rules:

1. All compounds containing alkali metals are soluble.
2. All ammonium (NH_4^+) based compounds are soluble.
3. All nitrates, chlorates, and perchlorates are soluble.
4. Most hydroxides are insoluble with the exception of alkali metal hydroxides and barium hydroxide. Calcium hydroxide is weakly soluble.
5. Most chlorides, bromides, and iodides are soluble with the exception of those formed with Ag^+ , Hg^{2+} , and Pb^{2+} .
6. All carbonates, phosphates, and sulfides are insoluble with the exception of those formed with alkali metal ions and ammonium ions.
7. Most sulfates are soluble. Calcium sulfate and silver sulfate are weakly soluble. Barium sulfate, mercury(II) sulfate, and lead sulfate are insoluble.

Oxidation State Rules:

1. For free elements, each atom has an oxidation state equal to zero.
2. For monoatomic ions, the oxidation state is equal to the charge of the ion. All alkali metals have an oxidation state of +1 and alkaline-earth metals have an oxidation state of +2, for any compound. Aluminum has an oxidation state of +3 in all compounds.
3. The oxidation state of oxygen in most compounds is -2 . In hydrogen peroxide (H_2O_2) and in the peroxide anion (O_2^{2-}), its oxidation state is -1 .
4. The oxidation state of hydrogen is +1. An exception is when it is bonded to a metal in a binary compound; in that case, its oxidation state is -1 .
5. Fluorine has an oxidation state of -1 in all compounds. The other halogens have a negative oxidation state when they appear as metal halides. However, when they combine with oxygen, they have positive oxidation states.
6. In a neutral molecule, the sum of the oxidation states of all atoms must be zero. In a polyatomic ion, the sum of the oxidation states of all atoms must be equal to the net charge of the ion.

1 IA		2 IIA		3 IIIB		4 IVB		5 VB		6 VIB		7 VIIB		8 VIII		9 IIB		10 IB		11 IB		12 IIB		13 IIIA		14 IVA		15 VA		16 VIA		17 VIIA		18 VIIIA																																																																																																																																																																																																																																																																																									
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H 1 1.00794 2.1 Hydrogen	Li 3 6.941 1.0 1.5 Lithium	Na 11 22.989768 0.9 1.2 Sodium	K 19 39.0983 0.8 1.4 Potassium	Rb 37 85.4678 0.8 1.4 Rubidium	Cs 55 132.90543 0.7 1.3 Cesium	Fr 87 223.0197 0.9 1.1 Francium	Be 4 9.012182 1.5 2.0 Beryllium	Mg 12 24.3050 1.2 2.0 Magnesium	Ca 20 40.078 1.3 2.0 Calcium	Sc 21 44.955910 1.3 3.0 Scandium	Y 39 88.90585 1.3 3.0 Yttrium	La 57 138.9055 1.1 3.0 Lanthanum	Ac 89 227.0278 1.1 3.0 Actinium	Ti 22 47.88 1.5 3.0 Titanium	Zr 40 91.224 1.4 3.0 Zirconium	Hf 72 178.49 1.3 3.0 Hafnium	Rf 104 261.11 0.9 3.0 Rutherfordium	V 23 50.9415 1.6 3.0 Vanadium	Nb 41 92.90638 1.6 3.0 Niobium	Ta 73 180.9479 1.5 3.0 Tantalum	Db 105 262.11 0.9 3.0 Dubnium	Cr 24 51.9961 1.6 3.0 Chromium	Mn 25 54.93805 1.5 2.0 Manganese	Fe 26 55.847 1.8 2.0 Iron	Ru 44 101.07 1.9 2.0 Ruthenium	Rh 45 102.9055 2.2 3.0 Rhodium	Pd 46 106.42 2.2 2.0 Palladium	Ag 47 107.8682 1.1 1.0 Silver	Cd 48 112.411 1.7 2.0 Cadmium	Hg 80 200.59 1.9 2.0 Mercury	Cu 29 63.546 1.9 2.0 Copper	Zn 30 65.39 1.6 2.0 Zinc	Ga 31 69.723 1.6 3.0 Gallium	Ge 32 72.61 2.0 3.0 Germanium	As 33 74.92159 2.0 3.0 Arsenic	Se 34 78.96 2.4 2.0 Selenium	Br 35 79.904 2.8 1.0 Bromine	Kr 36 83.80 - - Krypton	Al 13 26.981539 1.5 3.0 Aluminum	Si 14 28.0855 1.8 4.0 Silicon	C 6 12.011 2.5 4.0 Carbon	B 5 10.811 2.0 3.0 Boron	N 7 14.00674 3.0 3.0 Nitrogen	O 8 15.9994 3.5 2.0 Oxygen	F 9 18.9984032 4.0 1.0 Fluorine	Ne 10 20.1797 - - Neon	P 15 30.973762 2.1 3.0 Phosphorus	S 16 32.066 1.8 4.0 Sulfur	Cl 17 35.4527 3.0 1.0 Chlorine	Ar 18 39.948 - - Argon	Sc 21 44.955910 1.3 3.0 Scandium	Ti 22 47.88 1.5 3.0 Titanium	V 23 50.9415 1.6 3.0 Vanadium	Cr 24 51.9961 1.6 3.0 Chromium	Mn 25 54.93805 1.5 2.0 Manganese	Fe 26 55.847 1.8 2.0 Iron	Cu 29 63.546 1.9 2.0 Copper	Zn 30 65.39 1.6 2.0 Zinc	Ga 31 69.723 1.6 3.0 Gallium	Ge 32 72.61 2.0 3.0 Germanium	As 33 74.92159 2.0 3.0 Arsenic	Se 34 78.96 2.4 2.0 Selenium	Br 35 79.904 2.8 1.0 Bromine	Kr 36 83.80 - - Krypton	Al 13 26.981539 1.5 3.0 Aluminum	Si 14 28.0855 1.8 4.0 Silicon	C 6 12.011 2.5 4.0 Carbon	B 5 10.811 2.0 3.0 Boron	N 7 14.00674 3.0 3.0 Nitrogen	O 8 15.9994 3.5 2.0 Oxygen	F 9 18.9984032 4.0 1.0 Fluorine	Ne 10 20.1797 - - Neon	P 15 30.973762 2.1 3.0 Phosphorus	S 16 32.066 1.8 4.0 Sulfur	Cl 17 35.4527 3.0 1.0 Chlorine	Ar 18 39.948 - 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- Argon	Sc 21 44.955910 1.3 3.0 Scandium	Ti 22 47.88 1.5 3.0 Titanium	V 23 50.9415 1.6 3.0 Vanadium	Cr 24 51.9961 1.6 3.0 Chromium	Mn 25 54.93805 1.5 2.0 Manganese	Fe 26 55.847 1.8 2.0 Iron	Cu 29 63.546 1.9 2.0 Copper	Zn 30 65.39 1.6 2.0 Zinc	Ga 31 69.723 1.6 3.0 Gallium	Ge 32 72.61 2.0 3.0 Germanium	As 33 74.92159 2.0 3.0 Arsenic	Se 34 78.96 2.4 2.0 Selenium	Br 35 79.904 2.8 1.0 Bromine	Kr 36 83.80 - - Krypton	Al 13 26.981539 1.5 3.0 Aluminum	Si 14 28.0855 1.8 4.0 Silicon	C 6 12.011 2.5 4.0 Carbon	B 5 10.811 2.0 3.0 Boron	N 7 14.00674 3.0 3.0 Nitrogen	O 8 15.9994 3.5 2.0 Oxygen	F 9 18.9984032 4.0 1.0 Fluorine	Ne 10 20.1797 - - Neon	P 15 30.973762 2.1 3.0 Phosphorus	S 16 32.066 1.8 4.0 Sulfur	Cl 17 35.4527 3.0 1.0 Chlorine	Ar 18 39.948 - - Argon	Sc 21 44.955910 1.3 3.0 Scandium	Ti 22 47.88 1.5 3.0 Titanium	V 23 50.9415 1.6 3.0 Vanadium	Cr 24 51.9961 1.6 3.0 Chromium	Mn 25 54.93805 1.5 2.0 Manganese	Fe 26 55.847 1.8 2.0 Iron	Cu 29 63.546 1.9 2.0 Copper	Zn 30 65.39 1.6 2.0 Zinc	Ga 31 69.723 1.6 3.0 Gallium	Ge 32 72.61 2.0 3.0 Germanium	As 33 74.92159 2.0 3.0 Arsenic	Se 34 78.96 2.4 2.0 Selenium	Br 35 79.904 2.8 1.0 Bromine	Kr 36 83.80 - - Krypton	Al 13 26.981539 1.5 3.0 Aluminum	Si 14 28.0855 1.8 4.0 Silicon	C 6 12.011 2.5 4.0 Carbon	B 5 10.811 2.0 3.0 Boron	N 7 14.00674 3.0 3.0 Nitrogen	O 8 15.9994 3.5 2.0 Oxygen	F 9 18.9984032 4.0 1.0 Fluorine	Ne 10 20.1797 - - Neon	P 15 30.973762 2.1 3.0 Phosphorus	S 16 32.066 1.8 4.0 Sulfur	Cl 17 35.4527 3.0 1.0 Chlorine	Ar 18 39.948 - - Argon	Sc 21 44.955910 1.3 3.0 Scandium	Ti 22 47.88 1.5 3.0 Titanium	V 23 50.9415 1.6 3.0 Vanadium	Cr 24 51.9961 1.6 3.0 Chromium	Mn 25 54.93805 1.5 2.0 Manganese	Fe 26 55.847 1.8 2.0 Iron	Cu 29 63.546 1.9 2.0 Copper	Zn 30 65.39 1.6 2.0 Zinc	Ga 31 69.723 1.6 3.0 Gallium	Ge 32 72.61 2.0 3.0 Germanium	As 33 74.92159 2.0 3.0 Arsenic	Se 34 78.96 2.4 2.0 Selenium	Br 35 79.904 2.8 1.0 Bromine	Kr 36 83.80 - - Krypton	Al 13 26.981539 1.5 3.0 Aluminum	Si 14 28.0855 1.8 4.0 Silicon	C 6 12.011 2.5 4.0 Carbon	B 5 10.811 2.0 3.0 Boron	N 7 14.00674 3.0 3.0 Nitrogen	O 8 15.9994 3.5 2.0 Oxygen	F 9 18.9984032 4.0 1.0 Fluorine	Ne 10 20.1797 - - Neon	P 15 30.973762 2.1 3.0 Phosphorus	S 16 32.066 1.8 4.0 Sulfur	Cl 17 35.4527 3.0 1.0 Chlorine	Ar 18 39.948 - - Argon	Sc 21 44.955910 1.3 3.0 Scandium	Ti 22 47.88 1.5 3.0 Titanium	V 23 50.9415 1.6 3.0 Vanadium	Cr 24 51.9961 1.6 3.0 Chromium	Mn 25 54.93805 1.5 2.0 Manganese	Fe 26 55.847 1.8 2.0 Iron	Cu 29 63.546 1.9 2.0 Copper	Zn 30 65.39 1.6 2.0 Zinc	Ga 31 69.723 1.6 3.0 Gallium	Ge 32 72.61 2.0 3.0 Germanium	As 33 74.92159 2.0 3.0 Arsenic	Se 34 78.96 2.4 2.0 Selenium	Br 35 79.904 2.8 1.0 Bromine	Kr 36 83.80 - - Krypton	Al 13 26.981539 1.5 3.0 Aluminum	Si 14 28.0855 1.8 4.0 Silicon	C 6 12.011 2.5 4.0 Carbon	B 5 10.811 2.0 3.0 Boron	N 7 14.00674 3.0 3.0 Nitrogen	O 8 15.9994 3.5 2.0 Oxygen	F 9 18.9984032 4.0 1.0 Fluorine	Ne 10 20.1797 - - Neon	P 15 30.973762 2.1 3.0 Phosphorus	S 16 32.066 1.8 4.0 Sulfur	Cl 17 35.4527 3.0 1.0 Chlorine	Ar 18 39.948 - - Argon	Sc 21 44.955910 1.3 3.0 Scandium	Ti 22 47.88 1.5 3.0 Titanium	V 23 50.9415 1.6 3.0 Vanadium	Cr 24 51.9961 1.6 3.0 Chromium	Mn 25 54.93805 1.5 2.0 Manganese	Fe 26 55.847 1.8 2.0 Iron	Cu 29 63.546 1.9 2.0 Copper	Zn 30 65.39 1.6 2.0 Zinc	Ga 31 69.723 1.6 3.0 Gallium	Ge 32 72.61 2.0 3.0 Germanium	As 33 74.92159 2.0 3.0 Arsenic	Se 34 78.96 2.4 2.0 Selenium	Br 35 79.904 2.8 1.0 Bromine	Kr 36 83.80 - - Krypton	Al 13 26.981539 1.5 3.0 Aluminum	Si 14 28.0855 1.8 4.0 Silicon	C 6 12.011 2.5 4.0 Carbon	B 5 10.811 2.0 3.0 Boron	N 7 14.00674 3.0 3.0 Nitrogen	O 8 15.9994 3.5 2.0 Oxygen	F 9 18.9984032 4.0 1.0 Fluorine	Ne 10 20.1797 - - Neon	P 15 30.973762 2.1 3.0 Phosphorus	S 16 32.066 1.8 4.0 Sulfur	Cl 17 35.4527 3.0 1.0 Chlorine	Ar 18 39.948 - - Argon	Sc 21 44.955910 1.3 3.0 Scandium	Ti 22 47.88 1.5 3.0 Titanium	V 23 50.9415 1.6 3.0 Vanadium	Cr 24 51.9961 1.6 3.0 Chromium	Mn 25 54.93805 1.5 2.0 Manganese	Fe 26 55.847 1.8 2.0 Iron	Cu 29 63.546 1.9 2.0 Copper	Zn 30 65.39 1.6 2.0 Zinc	Ga 31 69.723 1.6 3.0 Gallium	Ge 32 72.61 2.0 3.0 Germanium	As 33 74.92159 2.0 3.0 Arsenic	Se 34 78.96 2.4 2.0 Selenium	Br 35 79.904 2.8 1.0 Bromine	Kr 36 83.80 - - Krypton	Al 13 26.981539 1.5 3.0 Aluminum	Si 14 28.0855 1.8 4.0 Silicon	C 6 12.011 2.5 4.0 Carbon	B 5 10.811 2.0 3.0 Boron	N 7 14.00674 3.0 3.0 Nitrogen	O 8 15.9994 3.5 2.0 Oxygen	F 9 18.9984032 4.0 1.0 Fluorine	Ne 10 20.1797 - - Neon	P 15 30.973762 2.1 3.0 Phosphorus	S 16 32.066 1.8 4.0 Sulfur	Cl 17 35.4527 3.0 1.0 Chlorine	Ar 18 39.948 - - Argon	Sc 21 44.955910 1.3 3.0 Scandium	Ti 22 47.88 1.5 3.0 Titanium	V 23 50.9415 1.6 3.0 Vanadium	Cr 24 51.9961 1.6 3.0 Chromium	Mn