Scarsdale High School **Name:** _____
Spring 2016
Midterm Cumulative Practice
Time Limit: 100 Minutes

Welcome to the Chemistry Midterm Cumulative Practice! This is a student-written exam designed to review some of the topics we learned during the first semester, and to help you embrace the challenge of problem-solving.

This exam contains 10 pages (including this cover page) and 10 questions, separated into 2 big sections: Multiple choice,Matching & Fill in the blanks, and Long Responses. Some of the questions are not easy, but they're all doable with the stuff we learned in class! Equilibrium & Organic Chemistry is not covered in this test. Also, some of the problems are modified from the regional test of USNCO, and from chemistry tests of the various chemistry teachers.

The total number of points is 150, with 3 bonus points. The test is not easy, and getting around 100-120 points should be considered a high score.

Final tip before you begin: The test is pretty long. Try not to waste your time on a specific question, or you may not get to the later ones. The test is NOT in order of difficulty!

Have fun with the test & have a nice day!

Grade Table

Question	Points	Score
1	8	
2	22	
3	15	
4	17	
5	15	
6	18	
7	10	
8	8	
9	10	
10	27	
Total:	150	

Section 1. Multiple choice & Matching

1. Match the experiment from the following table with the statement about it:

(A) Oil-Drop Experiment	(B) Doppler's Experiment with trains
(C) Cathode Ray Tube Experiment	(D) Rutherford Gold Foil Experiment
(E) Magdeburg Hemispheres Experiment	(F) Synthesis of Noble Gas Compound

(a) _____demonstrated the power of atmospheric pressure. (2)

(b) _____led to the development of a nuclear model of the atom. (2)

(c) _____led to the discovery of the electron. (2)

(d) _____determined that electric charge is quantized. (2)

2. Match the person from the following table with the correct statement about it: (Don't worry - there are not 26 choices for each letter :)

(A) Avogadro	(B) Boyle	(C) Curie	(D) Dalton	(E) Einstein
(F) Bunsen	(G) Thompson	(H) Bohr	(I) Pauli	(J) Mandeleev
(K) Schrödinger	(L) Lavoisier	(M) de Broglie	(N) Szkolar	(O) Nobel

(a) _____explained the concept of wave-particle duality. (2)

(b) _____came to the conclusion that energy has mass. (2)

(c) _____discovered a law concerning the Volume and Pressure of a gas. (2)

(d) _____created the plum-pudding model of the atom. (2)

(e) _____came up with the following principle: In a given atom no two electrons can have the same set of quantum numbers. (2)

(f) _____created the quantum model of the atom. (2)

(g) _____discovered a law concerning the number of atoms of a gas and its pressure. (2)

(h) _____discovered the law of conservation of mass. (2)

(i) _____created a model of the atom where electrons travel in circular orbits around the nucleus. (2)

(j) _____produced the first periodic table that's similar to the ones we use today. (2)

(k) _____is a teacher in Scarsdale High School. (2)

3. Refer to your periodic table for the following multiple choice questions:

(a) Which of the following element exhibits most metallic characteristic? (3)
A. Na B. Fe C. Ga D. Cs E. Ne

(b) Which of the following element has the smallest ionization energy? (3)
A. B B. S C. Ga D. Ge E. As

(c) Which of the following element has the largest atomic radius? (3)
A. W B. Ag C. N D. Er

(d) Which of the following element reacts with water to form a base? (3)
A. Be B. Mg C. Ca D. Ag E. I

(e) Which element has the following table of ionization energy? (3)

n	nth Ionization Energy (kJ/mol)
1	786.5
2	1577.1
3	3231.6
4	4355.5
5	16091

A. Na B. Mg C. Al D. Si E. P

4. Solutions! (No, I'm not giving you solutions to problems.)

(a) An aqueous solution is known to contain Ag^+, Mg^{2+}, and Sr^{2+} ions. Which reagent should be used to selectively precipitate the Ag^+ ? (4)
A. 0.20 M NaCl B. 0.20 M NaOH C. 0.20 M Na_2SO4 D. 0.20 M Na_3PO4

(b) Which of the following compounds is insoluble in water? (3)
A. $C_6H_12O_6$ B. $NaC_2H_3O_2$ C. $PbCl_2$ D. $NaHCO_3$

(c) Solid camphor is insoluble in water but is soluble in vegetable oil. The best explanation for this behavior is that camphor is a(n)... (3)
A. ionic solid B. metallic solid C. molecular solid D. network solid

(d) Magnesium chloride dissolves in water to form... (4)
A. hydrated MgCl2 molecules
B. hydrated Mg^{2+} ions and hydrated Cl^- ions
C. hydrated Mg^{2+} ions and hydrated Cl_2^{2-} ions
D. hydrated Mg atoms and hydrated Cl_2 molecules

(e) Each of the following forms a colored aqueous solution EXCEPT (3)
A. $Cr(NO_3)_3$ B. $Co(NO_3)_2$ C. $Cu(NO_3)_2$ D. AgCl

(f) Each of the following forms a colored aqueous solution EXCEPT (3 (bonus))
A. $Cr(NO_3)_3$ B. $Co(NO_3)_2$ C. $Cu(NO_3)_2$ D. $Zn(NO_3)_2$

5. Translate $\alpha\tau o\mu o$ to English! The following question should give you some hints.

(a) What is the ground state electron configuration of a ^{60}Co atom in the gas phase? (3)
A. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7$
B. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$
C. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^8$
D. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^7$

(b) $^{235}_{92}U$ undergoes an α decay, a β^- decay, and an α decay after that. What's the resulting isotope after the decays? (3)
A. $^{229}_{87}Fr$ B. $^{226}_{89}Ac$ C. $^{229}_{87}Ra$ D. $^{227}_{89}Ac$

(c) Some people are concerned that without proper supervision of a nuclear power plant, it can potentially explode into a giant fireball like a nuclear weapon. Are their concerns valid? Why? (3)

A. Yes. Without proper supervision the nuclear power plant could potentially explode like a nuclear weapon once meltdown begins, because then the moderator can no longer slow down the high energy neutrons from triggering an uncontrolled fission reaction.

B. Yes. Without proper supervision the nuclear power plant could potentially explode if the coolant leaks, because then the core can reach high enough temperature to trigger an uncontrolled fission reaction.

C. No. The Uranium nuclear power plants uses is not concentrated enough to make such an explosion possible.

D. No. A nuclear power plant can never reach a high enough temperature for uncontrolled fission to occur, and therefore cannot explode into a giant fireball.

(d) Which substance can be used as both a moderator and a coolant in a nuclear reactor? (3)

A. liquid sodium B. plutonium C. heavy water D. graphite

(e) A sample of wood was analyzed and found to have only 12.5% the ratio of ^{14}C to ^{12}C as in a living sample. Given that the half life of ^{14}C is 5700 years, the wood is probably about _____years old. (3)

6. Bonds! There's no hardcore hybridizations or molecular orbitals :)

(a) In which choice are the molecules listed in order of increasing bond angle? (3)

A. H_2O, CH_4, NH_3 B. CH_4, NH_3, H_2O C. H_2O, NH_3, CH_4 D. NH_3, CH_4, H_2O

(b) What type of bonds exist in the compound NH_3Cl? (3)

A. Ionic, only

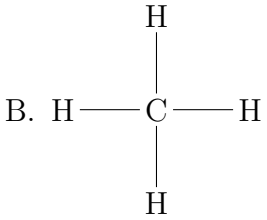
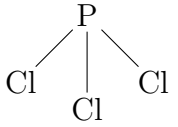
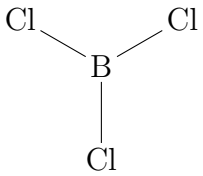
B. Covalent, only

C. Metallic, only

D. Ionic and Covalent

E. Ionic, Covalent, and Coordinate Covalent

(c) Which of the following molecules has dipoles? (Valence electrons not shown) (3)

A.  B.  C.  D. 

(d) Organize the following compounds by increasing boiling points: (3)

CH_4,H_2S, He, NaCl, H_2Te, HF

A. He, HF, H_2S, CH_4, NaCl, H_2Te
B. He, CH_4, H_2S, H_2Te, HF, NaCl
C. He, CH_4,H_2S, NaCl, H_2Te, HF
D. He, H_2S, CH_4, H_2Te, NaCl, HF

(e) Consider the following reactions: (3)

$$X(NO_3)_2 + Y \rightarrow X + Y(NO_3)_2$$

$$X(NO_3)_2 + Z \rightarrow X + Z(NO_3)_2$$

$$Y(NO_3)_2 + Z \rightarrow \text{No reaction}$$

What is the correct order of increasing activity for the metals; X, Y, Z?

A. $X < Y < Z$ B. $X < Z < Y$ C. $Z < Y < X$ D. $Z < X < Y$

(f) Which reaction has the most positive entropy change under standard conditions? (3)

A. $H_2O_{(g)} + CO_{(g)} \rightarrow H_{2(g)} + CO_{2(g)}$
B. $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$
C. $NH_{3(g)} \rightarrow NH_{3(aq)}$
D. $C_8H_{18(l)} \rightarrow C_8H_{18(s)}$

7. Gas laws!

STOP. Before you move on to answer the questions, and yawn thinking about how you have another whole section to go, take a moment and relax!

(a) A sample of gas at 15°C and 1 atm has a volume of 2.58L. What volume will this gas occupy at 30°C and 0.5 atm? (3)

A. 1.36L B. 2.58L C. 5.16L D. 5.42L E. 10.32L

(b) Suppose we have a sample of ammonia gas with a volume of 7.00mL at a pressure of 1.68 atm. The gas is compressed to a volume of 2.70mL at a constant temperature. What's its final pressure? (3)

A. 1.00 atm B. 1.88 atm C. 3.16 atm D. 4.36 atm E. 5.87 atm

(c) What did the Ideal Gas Law not account for compared to the Van der waals equation? (Two of the following choices are correct, and choosing both of them and both of them only is required to get the credit) (4)

A. Gas molecules, when under high pressure, tends to create heat between each other because of friction. Therefore, the temperature of the gas will constantly increase under high pressure.

B. Gas molecules take up space inside the container. Therefore, the space of the molecules must be subtracted from the space of the container to calculate the real volume.

C. Gas molecules have intermolecular force of attraction between one another. As they attract each other, they exhibits less pressure on the walls of the container.

D. Gas molecules will break up into smaller molecules under low pressure to achieve equilibrium. Therefore, the number of molecules inside the container can change depending on the pressure.

E. Gas molecules will lose electrons and become ionized as the temperature increases. As they lose electrons, they behave much more differently, and therefore a different equation is required during high temperatures.

Section 2. Long Responses

8. Use the thermodynamic information: (8)

$$\frac{1}{2}N_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow NO_{(g)}, \Delta H^\circ = 90.4\text{kJ/mol}$$

$$2NO_{2(g)} \rightarrow N_2O_{4(g)}, \Delta H^\circ = -58.0\text{kJ/mol}$$

$$2NO_{2(g)} \rightarrow 2NO_{(g)} + O_{2(g)}, \Delta H^\circ = 114.0\text{kJ/mol}$$

to calculate ΔH° in kJ/mol for the reaction:

$$2NO(g) + O_2(g) \rightarrow N_2O_{4(g)}$$

9. Chlorine is an industrially and biologically important element. (10)

   (a) Give the ground state electron configuration for gas-phase atomic Cl.

   (b) Draw a Lewis structure for molecular chlorine, including all lone pairs and any formal charges.

   (c) Which would have a larger radius, atomic Cl or the chloride ion (Cl^-)? Justify your answer.

   (d) (Bonus) Explain why the oxoanions ClO^- , ClO_2^-, ClO_3^- , and ClO_4^- all form stable salts, but the oxoanion ClO_5^- is unknown. (Hint: Oxidation state, or number of orbitals)

   (e) (Bonus) Which would have a greater first ionization energy, atomic Cl or molecular Cl_2? Justify your answer

10. Mr. Williams, Ms. Wagner and Mr. Szkolar are also asked to make CO2, but they all took different approaches:

    Mr. Williams combusted 50.0 grams of methane with excess oxygen. However, he did the reaction on the top of a mountain during his ski trip, where the temperature is -35° C, and the pressure is 0.8 atm;

    Ms. Wagner added 200. grams of sodium carbonate to some amount of 2.0M HCl, producing a salt and CO2; She did the reaction in front of her chemistry class, at STP (defined as 0°C and 1 atm). She decided to be conservative, and used just the right amount of HCl. Meanwhile, some of the students including Alan & Anna are suggesting to turn off the air conditioning;

    Mr. Szkolar decomposed 400. grams of ferrous carbonate to also produce CO2; He did his reaction in front of his chemistry class, at room temperature. However, the day is rainy and the atmospheric pressure is only 0.95 atm.

    This question does not imply any judgment on the three teachers - they are all awesome and we love all of them.

    (a) On Mr. Williams' reaction:
        i. Identify the type of the reaction, and write out the balanced molecular equation of the reaction. (2)
        ii. Given that ΔH_f for $CO_{2(g)}$ is -393.5 kJ/mol, ΔH_f for $H_2O_{(l)}$ is -285.8 kJ/mol, and the heat of combustion is 882 kJ/mol, calculate the heat of formation of methane in kJ/mol. (3)
        iii. How many liters of CO_2 did he produce? (3)

    (b) On Ms. Wagner's reaction:
        i. Write out the balanced molecular equation of the reaction. (2)
        ii. How should Ms. Wagner dispose the remaining solution, following proper waste disposal rules? (3)
        iii. How many liters of CO_2 did she produce? (3)

    (c) On Mr. Szkolar's reaction:
        i. Identify the type of the reaction, and write out the balanced molecular equation of the reaction. (2)
        ii. The CO_2 triggered the Americium smoke detector inside the room. Explain how the smoke detector functions. Then, given that Am-241 has a half-life of 432.2 years, how much Americium have decayed after 10 years? (Hint: I heard that Math 434 just took a quiz on logarithms...) (3)
        iii. How many liters of CO_2 did he produce? (3)

    (d) Did you enjoy the test? What should we improve on next time? (3)