Science Olympiad

2013 Eastside Invitational

Chemistry Lab

School Name _____

Student Names _____

_____

Please do not write below this line

Part 1: Periodicity Score: _____

15 pts.

Part 2: Equilibrium Score: _____

15 pts

Overall Score: _____

30 pts.

Place: _____

School Name _____/ Part 1: Periodicity

Use your knowledge of periodicity to answer the following multiple choice questions. Place your answer on the line provided. (1 point each)

_____ 1. Atom T has 3 valence electrons and atom S has 6 valence electrons. The formula expected for an ionic compound of T and S is

(A) T_2S_3
(B) T_3S_2
(C) TS_3
(D) T_2S

(E) TS_2

_____ 2. Which statement about the electron configuration in a Cs atom is correct?

(A) The outermost two electrons are paired in the same atomic orbital.
(B) The 4f shell is completely full.
(C) Only one of the 55 electrons is involved in most interactions of Cs with other atoms.
(D) The 4f shell is only partially filled.

(E) Cesium will react to share one electron to fill the 6s sublevel.

_____ 3. Which atom has the lowest second ionization energy?

(A) Mg
(B) Na
(C) K
(D) Ar

(E) Be

_____ 4. Which is the most metallic element in the fifth period?

(A) Y
(B) Cd
(C) Sn
(D) Sb

(E) I

_____ 5. In the lanthanide elements, which orbitals are only partially filled?

(A) 5s and 4d
(B) 5d and 4f
(C) 6s and 5d
(D) 6p and 5f

(E) 4f only

_____ 6. Ions with the electronic structure $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ would ***not*** be present in which aqueous solution?

(A) NaF(aq)
(B) NaCl(aq)

(C) KBr(aq)
(D) CaI_2(aq)

(E) $ScBr_3$

_____ 7. In moving from left to right across a period in the periodic table of the elements

(A) ionization energy decreases due to increases shielding effect.
(B) atomic radius decreases due to an increase in effective nuclear charge.
(C) electronegativity decreases due to an increase in atomic radius.
(D) electron affinity decreases due to an increase in effective nuclear charge.

(E) ionization energy increases due to an increase in atomic radius.

_____ 8. In which pair are the elements most similar in their chemical properties?

(A) B and N
(B) Li and Fr
(C) Mg and Al
(D) S and Cl

(E) H and He

_____ 9. Transition metals typically have all of these characteristics *except*

(A) forming colored components.
(B) showing a variety of oxidation states.
(C) possessing one or more unpaired electrons as individual atoms.
(D) having low melting points in the elemental state.

(E) good conductors of heat and electricity.

_____10. The species F^-, Ne and Na^+ all have the same number of electrons. Which is the correct order when they are arranged in order of *decreasing* size (largest first)?

(A) $F^- > Ne > Na^+$
(B) $Ne > Na^+ > F^-$
(C) $Na^+ > F^- > Ne$
(D) $F^- > Na^+ > Ne$

(E) they will be equal in size.

_____11. Which of the following statements is *true*?

(A) The first ionization potential of H is greater than that of He.
(B) The ionic radius of Fe^+ is larger than that of Fe^{3+}.
(C) The ionization energy of S^{2-} is greater than that of Cl^-.
(D) The first ionization energy of Be is greater than B.
(E) Oxygen has a greater first ionization energy than N.

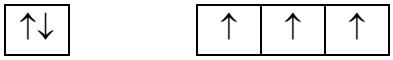
_____12. Which of the following exhibits the correct orders for both atomic radius and ionization energy, respectively?

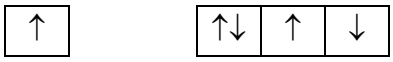
(A) S, O, F, and S, O, F
(B) F, S, O, and O, S, F
(C) S, F, O, and S, F, O
(D) F, O, S, and S, O, F
(E) O, S, F and F, S, O

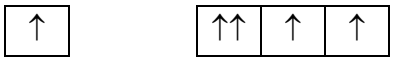
_____13. Select the true statement.

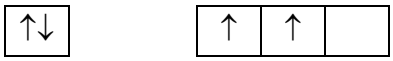
(A) F^{-1} ions have a smaller radius than F atoms because the p sublevel has been filled.
(B) P atoms have a less exothermic electron affinity than silicon atoms due to extra repulsion.
(C) Cl atoms have greater electronegativity than F atoms due to increased atomic radius.
(D) F atoms have a more exothermic electron affinity than Cl atoms due to a smaller atomic radius.
(E) All metals have endothermic electron affinities because they become unstable as the radius increases.

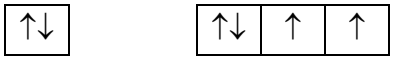
_____14. Consider the following electron arrangements. Which represents the ground state for the C^{-2} ion?

(A) 

(B) 

(C) 

(D) 

(E) 

_____15. Select the correct order for ***increasing*** melting points for the elements silicon, phosphorus, sulfur, chlorine, and argon.

(A) $Si < P_4 < S_8 < Cl_2 < Ar$

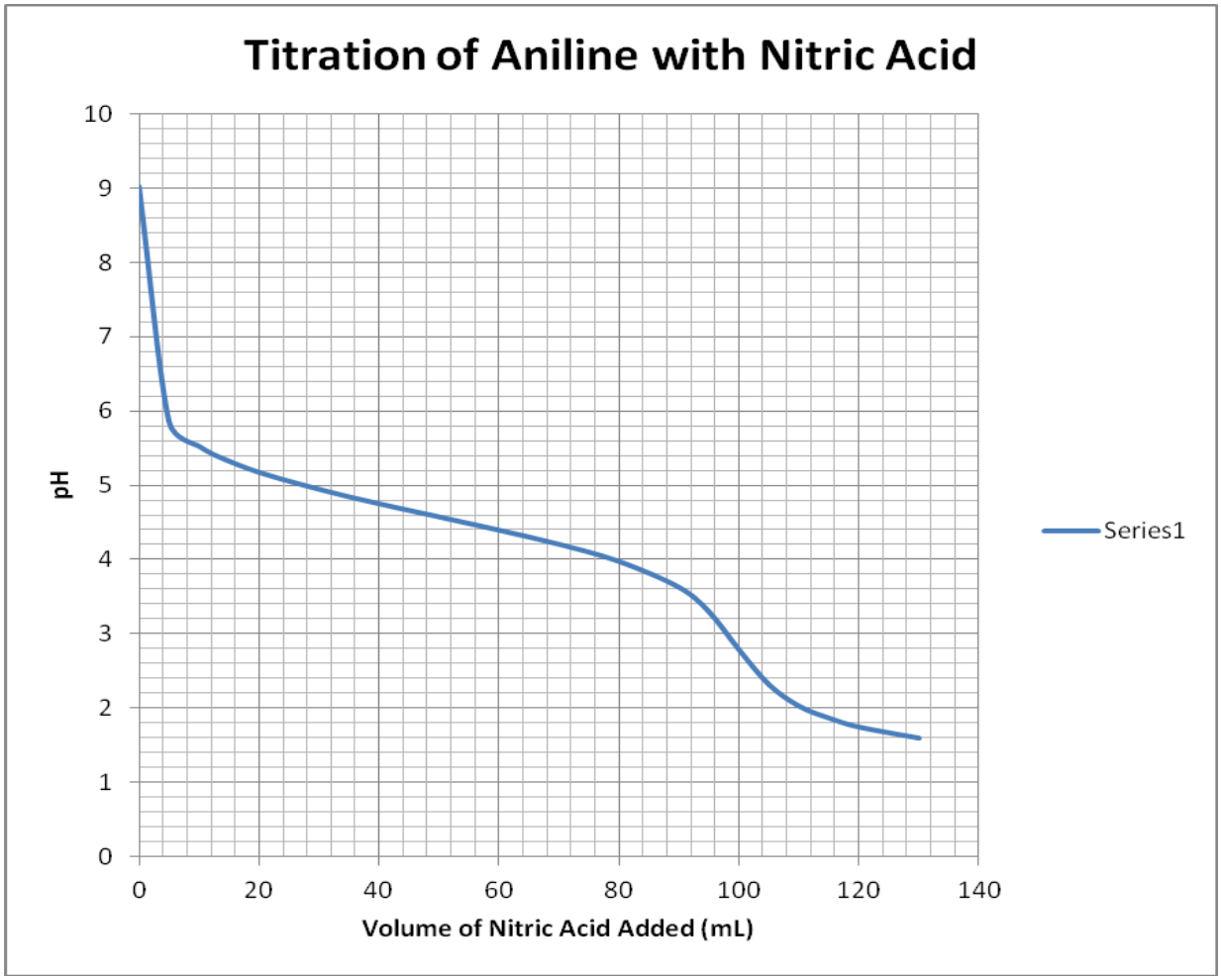
(B) $Ar < Cl_2 < S_8 < P_4 < Si$

(C) $Ar < Cl_2 < P_4 < S_8 < Si$

(D) $Cl_2 < Ar < S_8 < P_4 < Si$

(E) $Ar < Cl_2 < Si < S_8 < P_4$

Vol. HNO_3 added (mL)	pH
0	9.03
5	5.86
10	5.53
15	5.33
22	5.13
35	4.85
50	4.58
60	4.4
70	4.21
80	3.98
90	3.63
95	3.3
100	2.79
105	2.32
110	2.03
115	1.87
120	1.75
130	1.6



School Name _____/ Part 2: Equilibrium

Show your work in the box provided and please circle your answer!

1. The data and graph given here represents the titration of 50.00 mL of a solution of aniline ($C_6H_5NH_2$) with a 0.150 M solution of nitric acid (HNO_3).

(a) Determine the value of the base dissociation constant (K_b) for aniline. (3 Points)

(b) Determine the concentration, in molarity, of the aniline solution. (3 points)

2. For the reaction $NH_4(NH_2CO_2)(s) \longleftrightarrow 2\ NH_3(g) + CO_2(g)$, 25.0 grams of ammonium carbamate ($NH_4(NH_2CO_2)(s)$) are placed in an evacuated 250.-mL reaction vessel and allowed to come to equilibrium at 25 °C.

(a) If it is found that 3.40 grams of $NH_3(g)$ exits at equilibrium, determine the mass of CO_2 present at equilibrium. (2 points)

(b) Determine the value of the equilibrium constant, K_c, for the reaction at this temperature.

(2 points)

(c) Find the moles of CO_2 that would need to be added to the equilibrium mixture in part (b) to give an equilibrium concentration for NH_3 of 0.40 M. Assume the temperature remains constant. (2 points)

(d) Use Le Chatelier's Principle to predict the change in the partial pressure of $CO_2(g)$ that results from the following changes being made to the reaction at equilibrium. *Circle the correct response.* (1 point each)

(i) Additional $NH_4(NH_2CO_2)(s)$ is added. **Decrease** **No Change** **Increase**

(ii) The partial pressure of $NH_3(g)$ is reduced. **Decrease** **No Change** **Increase**

(iii) Lowering the temperature. ($\Delta H° > 0$) **Decrease** **No Change** **Increase**