Chem Lab

Brookwood Invitational

2013

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School

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name

I. For each of the following multiple choice questions, write the letter of the best answer on your answer sheet. Please make each letter clear and obvious what it is. There is no benefit of the doubt here.

1. An atom with _____ electrons in its outer (valence) shell is most stable.
a) 5 b) 4 c) 7 d) 8

2. Group _____ of the periodic table contains the most active metals.
a) IA b) IIA c) VIIA d) VIIIA

3. Metallic ions are _____ their corresponding atoms.
a) smaller than b) the same size as c) larger than

4. An atom having a(n) _____ filled sublevel is likely to be relatively stable.
a) 1/4 b) 1/3 c) 1/2 d) 3/4

5. Atomic radii generally increase in size from _____ in the periodic table.
a) top to bottom and left to right
b) bottom to top and left to right
c) bottom to top and right to left
d) top to bottom and right to left.

6. Members of a _____ have a similar arrangement of outer electrons and thus tend to react similarly.
a) period b) family c) row

7. _____ atoms tend to lose their electrons most easily.
a) Smaller b) Larger

8. The behavior of _____ most closely resembles the behavior of the Mg^{+2} ion.
a) francium b) sodium c) potassium d) lithium

9. Based on its position in the periodic table, what is predicted to be the most stable oxidation state of Ta, #73?
a) +1 b) +2 c) +3 d) +4 e) +5

10. What is the common oxidation state of the lanthanides?

a) +1 b) 0 c) –1 d) +3 e) +5

11. The atomic radius of Pd is 137 pm. What would be a good estimate of the atomic radius of Pt? a) 167 pm b) 107 pm c) 197 pm d) 137 pm e) 77 pm

12. Atoms of an element, X, have the electronic configuration $1s^2\ 2s^2 2p^6\ 3s^2 3p^3$. The compound most likely formed with magnesium, Mg, is

a) MgX b) Mg_2X c) MgX_2 d) MgX_3 e) Mg_3X_2

13. The elements in which of the following have most nearly the same atomic radius?

(A) Be, B, C, N
(B) Ne, Ar, Kr, Xe
(C) Mg, Ca, Sr, Ba
(D) C, P, Se, I
(E) Cr, Mn, Fe, Co

14. Which of the following represents the ground state electron configuration for the Mn^{3+} ion? (Atomic number Mn = 25)

(A) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^4$
(B) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^5\ 4s^2$
(C) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^2\ 4s^2$
(D) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^8\ 4s^2$
(E) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^3\ 4s^1$

15. Ca, V, Co, Zn, As
Gaseous atoms of which of the elements above are paramagnetic?

(A) Ca and As only
(B) Zn and As only
(C) Ca, V, and Co only
(D) V, Co, and As only
(E) V, Co, and Zn only

16. $HgO(s) + 4\ I^- + H_2O \text{ <===> } HgI_4^{2-} + 2\ OH^-;\ \Delta H < 0$
Consider the equilibrium above. Which of the following changes will increase the concentration of HgI_4^{2-}?

(A) Increasing the concentration of OH^-
(B) Adding 6 M HNO_3
(C) Increasing the mass of HgO present
(D) Increasing the temperature
(E) Adding a catalyst

17. In which of the following systems would the number of moles of the substances present at equilibrium NOT be shifted by a change in the volume of the system at constant temperature?

(A) $CO(g) + NO(g) <===> CO_2(g) + 1/2\ N_2(g)$
(B) $N_2(g) + 3\ H_2(g) <===> 2\ NH_3(g)$
(C) $N_2(g) + 2\ O_2(g) <===> 2\ NO_2(g)$
(D) $N_2O_4(g) <===> 2\ NO_2(g)$
(E) $NO(g) + O_3(g) <===> NO_2(g) + O_2(g)$

18. Which of the following characteristics is common to elemental sulfur, chlorine, nitrogen, and carbon?

(A) They are gaseous elements at room temperature.
(B) They have oxides that are acid anhydrides.
(C) They have perceptible color at room temperature.
(D) They form ionic oxides.
(E) They react readily with hydrogen at room temperature.

Questions 19-22

(A) Heisenberg uncertainty principle
(B) Pauli exclusion principle
(C) Hund's rule (principle of maximum multiplicity)
(D) Shielding effect
(E) Wave nature of matter

19. Can be used to predict that a gaseous carbon atom in its ground state is paramagnetic
20. Explains the experimental phenomenon of electron diffraction
21. Indicates that an atomic orbital can hold no more than two electrons
22. Predicts that it is impossible to determine simultaneously the exact position and the exact

23. $PCl_3(g) + Cl_2(g) <===> PCl_5(g) + energy$
Some PCl_3 and Cl_2 are mixed in a container at 200 °C and the system reaches equilibrium according to the equation above. Which of the following causes an increase in the number of moles of PCl_5 present at equilibrium?
I. Decreasing the volume of the container
II. Raising the temperature
III. Adding a mole of He gas at constant volume

(A) I only
(B) II only
(C) I and III only
(D) II and III only
(E) I, II, and III

24. Equal numbers of moles of HCl and O_2 in a closed system are allowed to reach equilibrium as represented by this equation:

$$4\ HCl(g) + O_2(g) \text{ <===> } 2\ Cl_2(g) + 2\ H_2O(g)$$

Which of the following must be true at equilibrium?

I. [HCl] must be less than [Cl_2].
II. [O_2] must be greater than [HCl].
III. [Cl_2] must equal [H_2O].

(A) I only (B) II only (C) I and III only (D) II and III only
(E) I, II, and III

25. Using the periodic table provided, predict which atom in each of the following pairs has the larger atomic radius. Write the answer on your answer sheet.

a. H, Li

b. Na, Be

c. P, S

d. N, S

26. Using the periodic table provided, predict which atom in each of the following pairs has the greater electronegativity. Write the answer on your answer sheet.

a. Al, C

b. O, S

c. Na, Mg

d. S^{2-}, F^-

27. Which of the following species are paramagnetic? List all the paramagnetic species on your answer sheet. (Tie breaker question)

Li, Be, B, F, Ne, Sc, Fe^{2+}, Sc^{3+}, W^{4+}

II. Measuring an Equilibrium Constant

Data has been collected for you to determine the equilibrium constant, K_c, for the reaction:

$$Fe^{3+} + SCN^- \text{ <==> } FeSCN^{2+}$$

Since $FeSCN^{2+}$ is highly colored, we can measure its concentration (in Molarity) spectrophotometrically. Before we can determine the concentration in an unknown solution, we must first produce a standard curve with a various concentrations of $FeSCN^{2+}$ in solution. I've done all that work for you. The table below provides the information you need for the standard curve.

	1	2	3	4	5
$[FeSCN^{2+}]$	0	4.0×10^{-5}	8.0×10^{-5}	1.2×10^{-4}	1.6×10^{-4}
Absorbance	0.015	0.138	0.279	0.414	0.556

Construct a calibration (standard) curve for Absorbance vs $[FeSCN^{2+}]$ on the graph paper provided. Part of your score will be on the quality of this graph.

To make the $FeSCN^{2+}$ we mixed various volumes of 0.002 M NaSCN with 5.00 mL of 0.002 M $Fe(NO_3)_3$ and added enough water to make the total volume 10.0 mL. Calculate the moles of Fe^{+3} and SCN^- added to the solution and record your results in the table below.

	1	2	3	4	5
Volume $Fe(NO_3)_3$	5.00	5.00	5.00	5.00	5.00
Moles Fe^{3+} (initial)					
Volume NaSCN	1.00	2.00	3.00	4.00	5.00
Moles SCN (initial)					
Absorbance	0.123	0.259	0.396	0.508	0.654

Determination of K_c

To find K_c, you will need to complete the following table using your calibration curve and knowledge of stoichiometry.

	1	2	3	4	5
$[FeSCN^{+2}]$ from calibration curve					
Moles $[FeSCN^{+2}]$ at equilibrium					
Moles Fe^{3+} reacted					
Moles Fe3+ unreacted					
$[Fe^{3+}]$ at equilibrium unreacted					
Moles SCN^- reacted					
Moles SCN^- unreacted					
$[SCN^-]$ at equilibrium unreacted					
K_c					

Average K_c _____