**AP Chemistry Final Exam 2015 Updated, April 28th.**



**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Chemistry**

**Section I**

**60 Multiple-choice Questions**

**(Time- 90 minutes)**

**YOU MAY NOT USE YOUR CALCULATOR FOR SECTION I**

**Record ALL answers on the student answer sheet**.

**Note:** For all questions, assume that the temperature is 298 K, the pressure is 1.00 atmosphere, and solutions are aqueous unless otherwise specified.

Base your answers to questions 1-3 on the simulated photoelectron spectrum (PES) of pure element “X” shown above. The energy is measured in megajoules per mole.

1. This diagram best represents the PES of

A) Si B) S C) Ar D) Ne

2. The first ionization energy of this element, in megajoules per mole, is closest to

 A) 300 B) 30 C) 5 D) 1

3. The PES of the element having an atomic number one greater than that of element” X” is plotted on the same axes. The spectrum would contain

 A) The same number of peaks, all placed to the left of the peaks of produced by X

 B) The same number of peaks, all placed to the right of the peaks produced by X

 C) One *additional* peak, located to the right of the 1 megajoule mark

 D) One *additional* peak, located to the left of the 1 megajoule mark.

4. A 1.00 gram sample of which of the following compounds contains the greatest mass of nitrogen? A) NO B) N2O3 C) N2H4 D) N2S

5. Solutions containing the dark purple ion permanganate, MnO4- turn colorless when added

 to a flask containing sulfur dioxide gas, SO2. The balanced equation is

 2 MnO4- (aq) + 5 SO2 (g) + 2 H2O(l) ⭢ 2 Mn2+ + 5 SO42- + 4 H+

 Which element is oxidized in this reaction, and what is its change in oxidation state?

 A) Mn is oxidized from +7 to +2 B) S is oxidized from +4 to + 6

 C) S is oxidized from +4 to + 8 D) Mn is oxidized from +8 to +2

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|  |  |  |
| --- | --- | --- |
|  | Nitrogen | Oxygen |
| First Ionization Energy (kJ/mol) | 1400  | 1300  |
| Covalent Atomic Radius (pm) | 70  | 66  |
| Electronegativity | 3.0 | 3.5 |

Base your answers to questions 6 to 8 on the information in the table above.

6. The lower first ionization energy of oxygen, compared with that of nitrogen is best explained by

A) a greater effective charge acting on the valence electrons in oxygen

 B) repulsions between the electrons in the filled “p” orbital of an oxygen atom

 C) repulsions between 2s and 2p electrons that are greater in oxygen than in nitrogen

 D) a greater effective charge acting on the valence electrons in nitrogen

7. Which description most accurately describes the nitrogen and oxygen atoms in a molecule of nitrogen monoxide, NO?

A) The nitrogen acquires a charge of 2+, while the oxygen acquires a charge of 2- B) The nitrogen acquires a slight + charge, while the oxygen acquires a slight - charge C) The nitrogen acquires a slight - charge, while the oxygen acquires a slight + charge D) Both atoms remain electrically neutral due to nonpolar covalent bonding

8. Compared with the data for these two elements, we would expect the ionization energy, atomic radius, and electronegativity values for fluorine, to be, respectively

 A) larger, smaller, larger C) smaller, larger, smaller

B) larger, larger, larger D) smaller, smaller, larger

Questions 9 -13 refer to the following molecules:

 A) CH2Cl2 B) ICl3 C) CBr4 D) SO3

9. Which molecule is both a dipole and has tetrahedral geometry?

 A) A B) B C) C D) none of these

10. Which molecule(s) have a planar molecular geometry?

A) A and D B) A and B C) B and D D) D only

11. In which molecule are the bond angles closest to 90̊ ?

 A) A B) B C) C D)D

12. In which molecule does the central atom contain non-bonding electron pairs (lone pairs)?

 A) A B) B C) C D) D

13. Which molecule contains both sigma and pi bonds?

A) A B) B C) C D) D

14. A yellow solid melts at 700°C, and does not conduct electricity. However, when melted or when dissolved in water it does conduct electricity. Which of the following could be the

 identity of that solid? A) urea (CO(NH2)2 B) gold C) sodium chromate, Na2CrO4

 D) silicon dioxide, SiO2

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15. When 100 mL of 2.00 M NaOH is added to 50 mL of 3.00 M HCl the pH of the resulting mixture is closest to A) 1.0 B) 7.0 C) 9.5 D) 13.5

Base your answers to questions 16-19 on the following information:

 For the reaction 2 SO2(g) + O2(g) ➞ 2 SO3(g)  at 298 K

 ΔGo = **–** 140. kJ/mol rxn and Δ Ho = **–** 196 kJ/mol rxn

16. The effect of an increase in temperature on this reaction would be to

 A) make ΔGo MORE negative, and increase the value of K

 B) make ΔGo LESS negative, and increase the value of K

 C) make ΔGo MORE negative, and decrease the value of K

 D) make ΔGo LESS negative, and decrease the value of K

17. The reaction reaches equilibrium in a closed system. What would be the effect of adding

 oxygen gas to the equilibrium system? (assume no change in temperatue.

 A) The amount of SO2 would increase, while the Kp would remain the same

 B) The amount of SO2 would decrease while the Kp would remain the same.

 C) The amount of SO2 would increase while the Kp would decrease

 D) The amount of SO2 would decrease while the Kp would increase

18. The system reaches equilibrium in a 2.0 liter vessel. The total pressure in the vessel is 4.0 atm. At constant temperature, the volume of the vessel is increased to 4.0 liters. The NEW total pressure at equilibrium would be

 A) greater than 4.0 atm. B) greater than 2.0 atm, but less than 4.0 atm.

 C) 2.0 atm. D) less than 2.0 atm.

19. If the equilibrium constant of the reaction as written is K, then the equilibrium constant of

 the reaction SO3(g)  ➞ SO2(g) + ½O2(g) is

 A) 1/K B) – K C)  D) 0.5 K

20. The CF4 molecule is nonpolar, while the SF4 molecule is polar. Which statement best accounts for this difference in molecular polarity?

 A) CF4 contains only σ bonds, while SF4 contains both σ and π bonds.

 B) S-F bonds are polar, while C-F bonds are nonpolar

 C) C-F bonds have more ionic character than S-F bonds

 D) CF4 has a symmetrical charge distribution, with no lone pairs on the central atom,

 while SF4 has an asymmetric charge distribution, with a lone pair on the central atom

21. The enthalpy of vaporization of ethane, C2H6 is 14.7 kJ/mol, while that of water is 40.7

 kJ/mol. The best explanation of the higher value for water is that

 A) ethane does not exhibit hydrogen bonding, while water does

 B) the larger ethane molecules are more highly polarizable than the smaller water molecules

 C) ethane has a smaller density than water

 D) the O-H bonds in water have a higher bond energy than to the C-H bonds in ethane

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Base your answers to questions 22-23 on the following reaction:

 4 HBr(g) + O2(g) ➞ 2 H2O(g) +2 Br2(g) (ΔHrx = – 427 kJ)

A suggested three step mechanism for this reaction is:

 1. HBr(g) + O2(g) ➞ HOOBr (g)

 2. HOOBr(g) + HBr(g) ➞ 2 HOBr(g)

 3. 2 HOBr(g) +2 HBr(g) ➞ 2 H2O(g) +2 Br2(g)

22. If the second step is the rate determining step, then the rate law is most likely to be

 A) Rate = k[HBr][O2]

 B) Rate = k[HBr]2[O2]

 C) Rate = k [HOOBr][HBr]2[O2]

 D) Rate = k[HBr]4[O2]

23. An increase in temperature would

A) increase the rate constant and the equilibrium constant for the reaction

B) decrease the rate constant and the equilibrium constant for the reaction

C) increase the rate constant while decreasing the equilibrium constant

D) decrease the rate constant and increase the equilibrium constant.

Base your answers to questions 24-25 on the following reaction:

2 NO (g) + O2(g) ➞ 2 NO2(g) is found to obey the rate law

 Rate = k[NO]2[O2].

At a certain temperature, the rate constant is 7.00 x 103 M–2s–1.

24. What is the initial rate of disappearance of O2(g) (in M/s) when the initial concentration of NO(g) is 0.50 M, and the initial concentration of O2(g) is 2.0 M ?

 A) 3.50 x 103 B) 7.00 x 103 C) 1.40 x 104 D) 2.80 x 104

25. What would be the initial effect on the rate of disappearance of O2 if the volume of the reaction vessel was suddenly halved? The reaction rate would become

 A) 2 times faster B) half as fast C) 4 times faster D) 8 times faster

26. Which ion contains 7 electrons in its 3-d sublevel?

 A) Cu2+ B) Ni+ C) Co2+ D) Ni2+

27. In one of the earliest atomic theories, John Dalton stated that all atoms of the same element are identical. This statement can be most directly **disproved** using

 A) Photoelectron spectroscopy C) IR spectroscopy

B) Mass spectroscopy D) UV spectroscopy

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28. At STP, the volume of 1.00 mole of O2, N2, or He gas is 22.4 liters. However, the volume of 1.00 mole of SO2 gas at STP is 21.9 liters. The best explanation of the smaller volume occupied by the SO2 molecules is

A) the larger SO2 molecules cannot be treated as point sources, and occupy a significant portion of the container.

 B) the larger SO2 molecules move slower than the other gas particles, and therefore exert a smaller pressure on the container walls.

C) there are significant intermolecular attractions between SO2 molecules.

 D) endothermic collisions between SO2 molecules decrease the average molecular velocity.

29. A sample of O2 gas occupies a volume of 20.0 liters. If the number of moles of oxygen, the pressure of the oxygen, and the Kelvin temperature of the oxygen are ALL doubled, the new volume of the oxygen will be

 A) 20.0 liters B) 40.0 liters C) 60.0 liters D) 160. liters

30. Sodium nitrate is very soluble in water. The bonding force most responsible for this large solubility is best described as

A) an interionic attraction C) a dipole-dipole attraction

B) an ion-dipole attraction D) a hydrogen bond

31. For the reaction: HSO4−(aq) + F– (aq) → SO42– (aq)+ HF(aq) , Keq = 18.

It is evident from the information above that the strongest of the following Brønsted-Lowry bases is

A) HSO4– B) F– C) SO42– D) H2SO4

Base your answers to questions 32-33 on the following half reactions and the corresponding standard reduction potentials:

|  |  |
| --- | --- |
| Reaction | Eo (volts) |
| Fe3+(aq) + e- ➞ Fe2+ (aq)  | +0.77 |
| MnO4–(aq)  + 8 H+ (aq) + 5e– ➞ Mn2+(aq) + 4 H2O (*l*)  | +1.51  |

32. When the reaction below is balanced using the smallest possible whole number coefficients, the coefficient before the Fe2+ is

 MnO4– (aq) + Fe2+(aq) + H+(aq) ➞ H2O*(l)* + Fe3+ (aq) + Mn2+(aq)

A) 1 B) 2 C) 5 D) 10

33. What is the standard potential, Eo, for the reaction shown in question 32?

 A) +2.28 volts B) +0.74 volts C) +2.34 volts D) -2.28 volts

Base your answers to questions 34-35 on the following :

CO(g) is added to a reaction vessel until the pressure is 2.0 atmospheres. H2(g) is added until the total pressure reaches 5.0 atmospheres. The reaction CO(g) + 2 H2(g) ➞ CH3OH (g) occurs, and reaches equilibrium at a **total** pressure of 3.0 atm. The temperature is kept constant.

34. What is the initial pressure of the hydrogen gas, before the reaction takes place?

 A) 2.0 atm B) 3.0 atm C) 5.0 atm D) 7.0 atm

35. What is the pressure of the hydrogen gas at equilibrium?

 A) 1.0 atm B) 0.020 atm C) 25atm D) 50atm **GO ON TO THE NEXT PAGE**

36. Hydroxylamine, HONH2, has a Kb of 1.1 x 10-8. The molarity of HONH2 that would provide a [OH–] of 1.0 x 10-5 M is closest to

A) 0.10 M B) 0.010 M C) 0.0010 M D) 1.0 x 10–4- M

37. How many moles of ZnCl2 would be needed to produce a [Cl– ] of

 0.100 molar in a volume of 100. mL ?

 A) 5.00x10-3 B) 1.00 x 10-2 C) 2.00 x 10-2 D) 20.0

38. Which sentence correctly describes and explains the differences in first ionization energy

 between F and Ne?

 A) Fluorine has a higher ionization energy because of its greater electronegativity

 B) Fluorine has a higher ionization energy because of its higher electron affinity

 C) Neon has a higher ionization energy because of its greater nuclear charge

 D) Neon has a higher ionization energy because of its completely filled 2p sublevel

39. The pKa of propionic acid is 4.89. How many milliliters of 0.20 molar NaOH must be added to 20.0 mL of 0.40 molar propionic acid to produce a solution with a pH of 4.89?

 A) 10.0 mL B) 20.0 mL C) 40.0 mL D) 80.0 mL

40. CO32– has a Kb of 1.8 x 10–4. In a 1.0 molar aqueous solution of K2CO3, which of the following ions is present in the greatest concentration?

 A) CO32– B) HCO3– C) OH– D) H3O+

Base your answers to questions 41-43 on the following :

A chemical cell is constructed using the reaction,

 Zn(s) + Cu2+(aq) ➞ Zn2+(aq) + Cu(s) (Eo = +1.10 volts)

A zinc strip immersed in 1.0 M Zn(NO3)2 is connected, by a wire, to a copper strip immersed in 1.0 M Cu(NO3)2 and the two solutions are connected via a salt bridge.

41. The voltage generated by the cell would **increase** if

A) a larger zinc electrode was used

B) the solid copper formed by the reaction was removed as it was formed

C) solid sodium carbonate is added to the zinc nitrate solution, causing a precipitate

 of ZnCO3 to form

 D) solid sodium hydroxide is added to the copper(II) nitrate solution, causing a precipitate of Cu(OH)2 to form.

42. ΔGo for the cell reaction, in kJ/mol is

A) (96.5)(1.1) B) (96.5)(2.2) C) – (96.5)(1.1) D) –( 96.5)(2.2)

43. When the reaction in the cell reaches equilibrium

 A) the concentrations of Cu2+ and Zn2+ are equal B) ΔG for the reaction = 0

 C) Keq for the reaction = 1 D) there are no longer any ions in the salt bridge

44. A student performed an experiment to determine the formula of a hydrated copper (II) sulfate. A sample of the hydrate was heated to drive off the water, and was weighed before and after the heating. The student obtained the formula CuSO4•6H2O, but the actual formula is CuSO4•5H2O. Which error best accounts for the difference in results?

 A) The hydrated sample was not reheated to a constant mass.

 B) Some of the solid hydrate was lost during heating.

 C) The initial sample of hydrate was contaminated with some anhydrous CuSO4.

 D) The balance gave masses that were consistently 0.20 grams too high.

45. What are the signs of ΔHo and ΔSo for a reaction that is spontaneous only at low temperature? A) ΔHo is positive, ΔSo is positive B) ΔHo is negative, ΔSo is positive

 C) ΔHo is positive, ΔSo is negative D) ΔHo is negative, ΔSo is negative

46. The times in the table are recorded at 25̊ C for the reaction below to produce a detectable amount of I2(aq).  S2O82– (aq) + 2 I– (aq) ➞ I2(aq) + 2 SO42– (aq)

|  |  |  |  |
| --- | --- | --- | --- |
| Experiment | Initial [S2O82-] (M) | Initial [I-] (M) | Time to appearance of I2 (sec) |
| 1 | 0.0400 | 0.0800 | 40 |
| 2 | 0.0400 | 0.0400 | 80 |
| 3 | 0.0100 | 0.0800 | 160 |
| 4 | 0.0200 | 0.0200 | **?** |

What is the expected time for experiment 4?

 A) 160 sec B) 240 sec C) 320 sec D) 640 sec

47. According to the equation, N2O3(g) + 6 H2(g) ➞ 2 NH3(g) + 3 H2O(g), how many moles

 of NH3(g) could be formed from the reaction of 0.22 mol of N2O3 with 0.90 moles

 of H2? A) 0.30 B) 0.45 C) 0.60 D) 1.2

48. 50.0 mL of 2.00 molar NaNO3 is mixed with 20.0 mLof 3.00 molar KNO3. The solution is diluted with water to a final volume of 100. mL. What is the concentration of NO3- in the solution? A) 1.60 M B) 0.160 M C) 16.0 M D) 0.150 M

49. Aluminum is extracted from its ore through electrolysis: 2 Al2O3 ➞ 4 Al + 3 O2.

 How many moles of Al are produced from the passage of 1.50 moles of electrons?

 A) 0.500 moles B) 6.00 moles C) 4.50 moles D) 0.125 moles

50. Which of the following properties of liquids **decreases** as the strengths of intermolecular forces **increase** ?

A) boiling point C) vapor pressure

B) viscosity D) heat of vaporization

51. What happens to the pH of a buffer solution when it is diluted with water by a factor of 10?

 A) pH increases by 1 unit B) pH decreases by 1 unit

 C) pH either increases or decreases 1 unit, depending on whether the buffer is an acid range buffer or a base range buffer. D) pH does not change appreciably

52. The O—N—O bond angle in the nitrite ion, NO2– is closest to

 A) 180̊ B) 120̊ C) 90 ̊ D) 109̊

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53. In the diagram above, nitrogen atoms are represented as filled circles and oxygen atoms as open circles. How much NO2 can be prepared from the mixture shown?

 A) 4 molecules B) 5 molecules C) 6 molecules D) 8 molecules.

54. In which species is the **electron** geometry around the central atom tetrahedral?

 A) SF4 B) BF4–  C) XeF4 D) PCl5

55. Which pair of solutions forms a buffer when equal volumes of each are mixed?

 A) 0.20 M HCl and 0.20 M NaCl C) 0.20 M HCl and 0.20 M NH3

 B) 0.40 M HC2H3O2 and 0.20 M NaOH D) 0.40 M HCl and 0.20 M NH3

56. A student is attempting to standardize a NaOH solution with a 0.500 molar solution of oxalic acid, H2C2O4. The net ionic equation for the reaction is:

 H2C2O4(aq) + 2 OH–(aq) ➞ C2O42– (aq) + 2 H2O(*l*)

The student prepares three 20.0 mL samples of the 0.500 molar oxalic acid, adding phenolphthalein to each sample. The burette is thoroughly rinsed with distilled water, the NaOH solution is added to the burette, and then the student titrates each of the three samples, refilling the burette after each trial. The student finds the results are inconsistent. It is most likely that the determined concentration of NaOH would be

A) lower in the first run than in the other two

B) higher in the first run than in the other two.

C) the same in the first two runs, but lower in the third.

D) the same in the first two runs, but higher in the third.

57. The sublevel that is filled between elements 39 and 48 is the

A) 3d B) 4d C) 5d D) 5p

58. The three groups on the periodic table in which **none** of the elements have any unpaired

 electrons in the ground state are groups

A) 2, 8, and 12 B) 2, 16 and 18 C) 2, 12, and 18 D) 12, 16 and 18

59. Which process requires the greatest amount of energy per mole of H2O ?

 A) breaking the O–H bonds C) subliming the solid

 B) evaporating the liquid D) melting the solid

60. Given these reactions: A ➞ 2 B ΔHo = +30 kJ

 B➞C ΔHo = -60 kJ

 2C ➞ D ΔHo = -20 kJ

 Calculate ΔHo for the reaction D + A ➞ 4 C

 A) –70 Kj B) –110 Kj C) –190 kJ D) + 110 Kj



