TUTORIAL QUESTIONS

CHM 131: General Physical Chemistry

MR . KABIR O. OTUN

Topics Covered:

- **Atomic Structure**
- **Periodicity**
- **Chemical Equilibrium**
- **Electrochemistry**

ATTEMPT ALL QUESTIONS

1. How many orbitals make up the 4d subshell? a) 4 b) 10 c) 3 d) 5 e) 7

2. Which one of the following isoelectronic species has the smallest radius?
a) Mg^{2+} b) Na^+ c) Ne d) F^- e) O^{2-}

3. Which of the following distributions of electrons is correct for three electrons in p-subshell?
a) ↑ ↑ ↑
b) ↑↓ ↑ _
c) ↑ ↑ ↓
d) ↑ ↑↓ _
e) ↑↑ ↑ _

4. Which of the following pairs correctly shows the proper relationship between the two atoms/ions in terms of atomic/ionic radii?

 a) $Na < Na^+$

b) $Cl > Cl^-$

c) Ti < Zn

d) $N^{3-} > N$

e) O > S

5. An element having which of the following electronic configurations would have the greatest ionization energy?

a) [He] $2s^2 2p^3$

b) [He] $2s^2 2p^5$

c) [Ne] $3s^2 3p^3$

d) [Ne] $3s^2 3p^5$

6. Sodium is much more apt to exist as a cation than is chlorine. This is because

 a) chlorine is a gas and sodium is a solid

b) chlorine has a greater ionic radius than sodium does

c) chlorine has a greater atomic radius than sodium

d) chlorine has a greater ionization energy than sodium does

e) chlorine is more metallic than sodium

7. Which is not true of nonmetals?

a) Most of their oxides are acidic

b) They are poor conductors of heat

c) They are poor conductors of electricity

d) Many are gases at room temperature

e) Most tend to lose electrons readily

8. Of the following metals, _____ exhibits multiple oxidation states

a) Al b) Cs c) V d) Ca e) Na

9. Calculate the wavelength of the 4th line in the Balmer series (the visible series) of the hydrogen spectrum (n=6 to n=2)

a) 0.12334 nm

 b) 12.334 nm

c) 2.753 × 10^{-7} nm

 d) 4.1029 × 10^{-7} nm

e) 36.559 nm

10. Which of the following sets of quantum numbers is possible for a 3d electron?

a) n = 3, ℓ =3, m_ℓ= -2, m_s= +1/2

b) n = 2, ℓ =1, m_ℓ= +1, m_s= -1/2

c) n=3, ℓ =1, m_ℓ= 0, m_s= -1/2

d) n=3, ℓ =2, m_ℓ= -2, m_s= +1/2

e) n=4, ℓ =1, m_ℓ= +1, m_s= +1/2

11. Using Bohr's equation for the energy levels of the electron in the hydrogen atom, determine the energy (J) of an electron in the n = 4 level.

a) -5.45 x 10^{-19}

b) -1.84 x 10^{-29}

c) -1.36 x 10^{-19}

d) +1.84 x 10^{-29}

e) -7.34 x 10^{18}

12. When the electron in a hydrogen atom moves from n = 6 to n = 2, light with a wavelength of _____ nm is emitted. a) 657 b) 93.8 c) 411 d) 434 e) 487

13. What is the De Broglie wavelength (m) of a 2.0 kg object moving at a speed of 50 m/s? a) 1.5 x 1035 b) 3.8 x 1034 c) 2.6 x 10-35 d) 5.3 x 10-33 e) 6.6 x 10-36

14. Which of the subshells below do not exist due to the constraints upon the azimuthal quantum number? a) 2p b) 2s c) 2d d) all of the above e) none of the above

15. Which one of the following represents an acceptable possible set of quantum numbers (in the order n, l, m_l, m_s) for an electron in an atom?
a) 2, 1, 0, 0 b) 2, 2, 0, 1/2 c) 2, 0, 2, +1/2 d) 2, 0, 1, -1/2 e) 2, 1, -1, 1/2

16. The atomic radius of main-group elements generally increases down a group because
a) effective nuclear charge increases down a group
b) the principal quantum number of the valence orbitals increases
c) effective nuclear charge decreases down a group
d) effective nuclear charge zigzags down a group
e) both effective nuclear charge increases down a group and the principal quantum number of the valence orbitals increases

17. Which one of the following has the smallest radius?
a) P b) Na c) Br d) Cl e) Fe

Consider the following electron configurations to answer the questions that follow:
(i) [Kr] $5s^1$
(ii) [Ne] $3s^2 3p^5$
(iii) [Ar] $4s^2 3d^{10} 4p^4$
(iv) [Ne] $3s^2 3p^6$
(v) [Ar] $4s^1$
18) The electron configuration of the atom that is expected to have the lowest first ionization energy is _____. a) (i) b) (ii) c) (iii) d) (iv) e) (v)
19. The electron configuration of the atom that is expected to have the highest first

ionization energy is _____. a) (i) b) (ii) c) (iii) d) (iv) e) (v)

20. Of the choices below, which gives the order for first ionization energies?

a) $Cl > S > Al > Ar > Si$

b) $S > Si > Cl > Al > Ar$

c) $Al > Si > S > Cl > Ar$

d) $Cl > S > Al > Si > Ar$

e) $Ar > Cl > S > Si > Al$

21. _____ have the lowest first ionization energies of the groups listed.

a) Transition elements

b) Halogens

c) Alkaline earth metals

d) Alkali metals

e) Noble gases

22. Which of the following correctly represents the second ionization of calcium?

a) $Ca^+ (g) \rightarrow Ca^{2+} (g) + e$

b) $Ca (g) \rightarrow Ca^+ (g) + e^-$

c) $Ca^- (g) + e^- \rightarrow Ca^{2-} (g)$

d) $Ca^+ (g) + e^- \rightarrow Ca (g)$

e) $Ca^+ (g) + e^- \rightarrow Ca^{2+} (g)$

23. Which of the following sets contains species that are isoelectronic?

a) Cl, Ar, K b) F^-, Ne, Na^+ c) F, Ne, Na d) Al^{3+}, S^{2-}, Ar e) P^{3-}, S^{2-}, Ar^-

24. Of the following elements, _____ has the most negative electron affinity.

a) Be b) N c) F d) Li e) Na
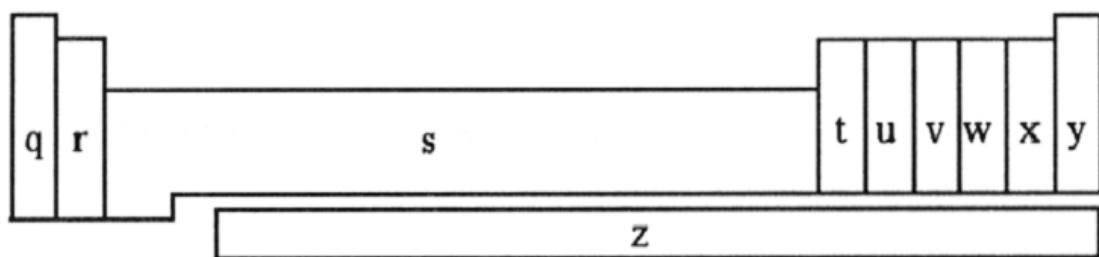
25. Of the elements below, _____ is the most metallic.

a) sodium b) barium c) calcium d) cesium e) magnesium

26. Which ion in the isoelectronic series below has the smallest radius in a crystal?

a) O^{2-} b) N^{3-} c) Na^+ d) Al^{3+} e) F

27. In which set of elements would all members be expected to have very similar chemical properties?

a) S, Se, Si b) O, S, Se c) Ne, Na, Mg d) N, O, F e) Na, Mg, K

28. The electron configuration of the valence electrons of an atom in its ground state is ns^2np^1. This atom is a group _____ element. a) q b) r C) s d) t e) y

29. A nuclear particle that has about the same mass as a proton, but with no electrical charge, is called a) nuclide. b) neutron. c) electron. d) isotope.

30. Whose series of experiments identified the nucleus of the atom?

a) Rutherford b) Dalton c) Chadwick d) Bohr

31. Which of the following is *not* part of Dalton's atomic theory?

a)Atoms cannot be divided, created, or destroyed.

b) The number of protons in an atom is its atomic number.

c) In chemical reactions, atoms are combined, separated, or rearranged.

d) All matter is composed of extremely small particles called atoms.

32. Arrange the following to obtain an acceptable set of quantum numbers for an electron: 4, 5, -2 a) 4, 5, -2 b) -2, 5, 4 c) 5, -2. 4 d) 5, 4, -2

33. All isotopes of hydrogen contain

a) one neutron.b) one proton. c) two electrons. d) two nuclei

34. The atomic sublevel with the next highest energy after $4p$ is

  a) $4d$. b) $5p$. c) $4f$. d) $5s$.

35. The gold foil experiment contributed to the discovery that:

a) atoms contain electrons c) atoms are mostly empty space

b) atoms contain a nucleus d) both "b" and "c"

36. In an operating electrochemical cell the function of a salt bridge is to…

a) allow hydrolysis to occur

b) allow a non-spontaneous reaction to occur

c) permit the migration of ions within the cell

d) transfer electrons from the cathode to the anode

37. A substance that is reduced during a redox reaction…

a) loses mass b) is the anode c) is the reducing agent d) is the oxidizing agent

38. The oxidation number of As in $H_4As_2O_7$ is… a) +4 b) +5 c) +9 d) +10

39. At equilibrium, _____.
a) all chemical reactions have ceased
b) the rate constants of the forward and reverse reactions are equal
c) the rates of the forward and reverse reactions are equal
d) the value of the equilibrium constant is 1
e) the limiting reagent has been consumed

40. The effect of a catalyst on an equilibrium is to _____.
a) slow the reverse reaction only
b) shift the equilibrium to the right
c) increase the equilibrium constant so that products are favored
d) increase the rate of the forward reaction only
e) increase the rate at which equilibrium is achieved without changing the composition of the equilibrium mixture

41. Which statement is true for an electrochemical cell?

A. Oxidation occurs at the anode only.

B. Reduction occurs at the anode only.

C. Oxidation occurs at both the anode and cathode.

D. Reduction occurs at both the anode and cathode

42. Given the equation: $2Cr(s) + 3Pb^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Pb(s)$, which is the correct reduction half reaction?

A. $Cr(s) \rightarrow Cr^{3+}(aq) + 3e^-$ C. $Pb^{2+}(aq) \rightarrow Pb(s) + 2e^-$

B. $Cr(s) + 3e^- \rightarrow Cr^{3+}(aq)$ D. $Pb^{2+}(aq) + 2e- \rightarrow Pb(s)$

43. What is the E° for an electrochemical cell with the following reaction?

$$2Au^{3+} + 3Co \rightarrow 3Co^{2+} + 2Au$$
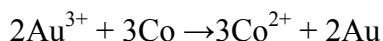
A. -1.22 V   B. 1.78 V   C. 1.22 V   D. 3.84 V

44. Consider the following unbalanced redox equation:

__$CH_3OH(l)$ + __$Cr_2O_7^{2-}(aq)$ + __$H^+(aq) \rightarrow$ __$CH_2O(aq)$ + __ $Cr^{3+}(aq)$ + __$H_2O(l)$
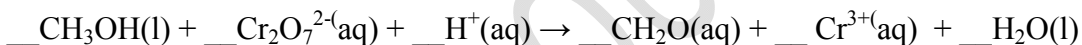
Which of the following sets of numbers will balance the equation?

A. 1, 1, 14, 1, 2, 7   B. 3, 1, 8, 3, 2, 7   C. 3, 1, 8, 3, 2, 8   D. 3, 1, 14, 3, 2, 8

45. What happens to the reducing agent in an oxidation-reduction reaction?

A. It is oxidized as it gains electrons.   C. It is reduced as it gains electrons.

B. It is oxidized as it loses electrons.   D. It is reduced as it loses electrons.

46. The cell potential, E°, for an oxidation-reduction reaction was found to equal 1.10 V. What can be said about this reaction? A. at equilibrium B. endothermic C. non spontaneous D. spontaneous

47. In an electrochemical cell, electrons travel in which direction?

A. from the anode to the cathode through the external circuit

B. from the anode to the cathode through the porous cup

C. from the cathode to the anode through the external circuit

D. from the cathode to the anode through the porous cup.

48. How many coulombs of charge pass through a cell if 2.40 amperes of current are passed through the cell for 85.0 minutes?

a) 2.04×10^2 C   b) 1.33×10^{-1} C   c) 1.22×10^4 C   d) 2.12×10^3 C   e) 3.40 C

49. How many moles of chromium would be electroplated by passing a current of 5.2 amperes through a solution of $Cr_2 (SO4)_3$ for 45.0 minutes?

a. 0.048 mol

b. 2.9 mol

c. 0.15 mol

d. 6.9 mol

e. 0.073 mol

50. Calculate E_{cell} for the reaction below when $[Zn^{2+}] = 1.00$ M, $[H^+] = 1.00 \times 10\text{-}6$ M, and = 1.00 atm. $Zn(s) + 2H^+ \rightarrow Zn^{2+} + H_2(g)$

a. +0.41 V

b. +0.053 V

c. 0.64 V

d. +1.12 V

e. +0.76 V

51. Calculate the cell potential of the following voltaic cell

$Zn|Zn^{2+}(1.0 \times 10^{-4}$ M)||$Cu^{2+}(1.0 \times 10^{-6}$ M)|Cu

a. +0.98 V

b. +1.10 V

c. +1.04 V

d. +1.22 V

e. +1.16 V

52. Calculate the Cd2+ concentration in the following cell if $E_{cell} = 0.23$ V.

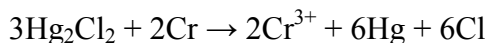$Cd(s)|Cd^{2+}(\times$ M)||$Ni^{2+}($1.00 M)|Ni

a. 0.0019 M

b. 1.4×10^{-5} M

c. 0.0036 M

d. 0.015 M

e. 0.0086 M

53. Calculate $\Delta G0$ for the following reaction from its E value.

F = 96,500 J/V•mole)

$3Hg_2Cl_2 + 2Cr \rightarrow 2Cr^{3+} + 6Hg + 6Cl$

a. -1.12×10^3 kJ

b. -585 kJ

c. -361 kJ

d. 1.62×10^3 kJ

e. -1.78×10^3 kJ

54. Calculate ΔG for the reaction of the cell below under the stated conditions.

F = 96,500 J/V•mol e-)

$Zn|Zn^{2+}(1.0 \times 10^{-8}\ M)\|Cu^{2+}(1.0 \times 10^{-6}\ M)|Cu$

a. -163 kJ

b. -192 kJ

c. 201 kJ

d. -212 kJ

e. -268 kJ

55. Calculate the reduction potential of the Zn^{2+}/Zn electrode when $[Zn^{2+}] = 1.0 \times 10^{-8}\ M$.

a. -0.73 V

b. -0.75 V

c. -0.76 V

d. -0.77 V

e. -1.00 V

56. An aqueous copper (II) sulfate solution is electrolyzed for 45 minutes. A 3.2 ampere current is used. What mass of copper is produced?
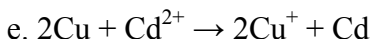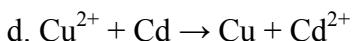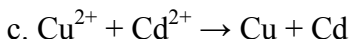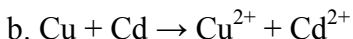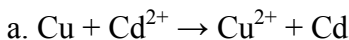
a. 0.95 g

b. 1.9 g

c. 2.8 g

d. 4.6 g

e. 5.5 g

57. Which of the following describes the net reaction that occurs in the cell,

$Cd|Cd^{2+}(1\ M)||Cu^{2+}(1\ M)|Cu$?

a. $Cu + Cd^{2+} \rightarrow Cu^{2+} + Cd$

b. $Cu + Cd \rightarrow Cu^{2+} + Cd^{2+}$

c. $Cu^{2+} + Cd^{2+} \rightarrow Cu + Cd$

d. $Cu^{2+} + Cd \rightarrow Cu + Cd^{2+}$

e. $2Cu + Cd^{2+} \rightarrow 2Cu^{+} + Cd$

58. Which of the following is NOT produced during the electrolysis of water?

   a) Electricity
   b) Acid
   c) Hydrogen
   d) Oxygen

59. At which electrode is H_2 in the electrolysis of water?

   a) The anode
   b) The electrode connected to the negative side of the battery
   c) The cathode
   d) Cannot be determined with the given information

60. Rusting is

   a) A decomposition reaction
   b) A combustion reaction
   c) A redox reaction
   d) A neutralization reaction
   e) A double displacement reaction

61. In both a galvanic cell and an electrolytic cell,

   a) Reduction occurs at the cathode
   b) The cell potential is positive
   c) The overall reaction is spontaneous
   d) An external voltage is required
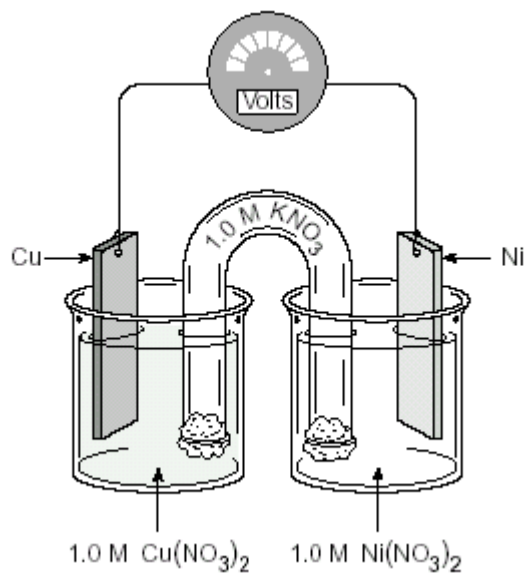   e) Chemical energy is converted to electrical energy

62. Primary batteries contain...

a) Rechargeable cells
b) No cells
c) Fuel cells
d) Electrolytic cells
e) Galvanic cells

63. What is a faraday?

a) A unit of current
b) A unit of energy
c) A unit of charge
d) A mole of electrons

64. Consider the following electrochemical cell:

1.0 M $Cu(NO_3)_2$ 1.0 M $Ni(NO_3)_2$

The half-reaction that occurs at the anode is

A. $Ni \rightarrow Ni^{2+} + 2e^-$

B. $Ni^{2+} + 2e^- \rightarrow Ni$

C. $Cu \rightarrow Cu^{2+} + 2e^-$

D. $Cu^{2+} + 2e^- \rightarrow Cu$

65. In an operating electrochemical cell the function of a salt bridge is to

A. allow hydrolysis to occur.

B. allow a non-spontaneous reaction to occur.

C. permit the migration of ions within the cell.

D. transfer electrons from the cathode to the anode.

66. The process of applying an electric current through a cell to produce a chemical change is called

A. corrosion.

B. ionization.

C. hydrolysis.

D. electrolysis

67. Which of the following is correct for an electrolytic cell?

	E°_{cell}	Type of reaction
A.	positive	spontaneous
B.	positive	non-spontaneous
C.	negative	spontaneous
D.	negative	non-spontaneous

68. Write the appropriate equilibrium constant expression K_c for the following reaction:
$$2\ CO(g) + O_2(g) <==> 2\ CO_2(g)$$

a) $K_c = k[CO]^2[O_2]$

b) $K_c = \dfrac{[CO]^2[O_2]}{[CO_2]^2}$

c) $K_c = \dfrac{[CO_2]}{[CO][O_2]}$

d) $K_c = \dfrac{[CO_2]^2}{[CO]^2[O_2]}$

69. The reaction: $2\ NO_2(g) <==> 2\ NO(g) + O_2(g)$ is endothermic. If additional O_2 is

added to a vessel at equilibrium what will ultimately happen to the NO_2 concentration? It will a) increase b) decrease c) remain the same

70. In the reaction in Problem #69, what will happen to the NO (g) concentration after additional O_2 is added? It will   a) increase   b) decrease c) remain the same

71. Identify the INCORRECT statement below regarding chemical equilibrium:

a) All chemical reactions are, in principle, reversible.

b) Equilibrium is achieved when the forward reaction rate equals the reverse reaction rate.

c) Equilibrium is achieved when the concentration of species become constant.

d) Equilibrium is achieved when the reaction quotient Q equals the equilibrium constant.

e) Equilibrium is achieved when the reactant and product concentrations become equal.

72. When $K_c \gg 1$ for a chemical reaction:

a) the equilibrium would be achieved rapidly.

b) the equilibrium would be achieved slowly.

c) reactants would be much more stable than products.

d) product concentrations would be much greater than reactant concentrations at equilibrium.

e) reactant concentrations would be much greater than product concentrations at equilibrium.

73. What would be the effect of decreasing the pressure by increasing the volume on the following system at equilibrium?

$$2 \, CO(g) + O_2 <==> 2 \, CO_2(g)$$
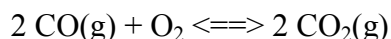
a) The K_p value would get smaller.

b) The K_p value would get larger.

c) The equilibrium would be perturbed and would show a net shift to the left.

d) The equilibrium would be perturbed and would show a net shift to the right.

e) There would be no effect. The system is at equilibrium.

74. Nitrogen reacts with hydrogen to form ammonia in the Haber process:

$$N_2(g) + 3\ H_2(g) <==> 2\ NH_3(g)$$
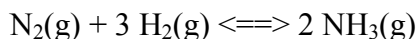
An equilibrium mixture at a given temperature is found to contain 0.31 mol/L N_2, 0.50 mol/L H_2, and 0.14 mol/L NH_3. Calculate the value of K_c at the given temperature.

   a) 1.97   b) 0.903   c) 1.107   d) 0.506

75. In which system does a spontaneous redox reaction produce electrical energy?

a. electrolytic cell
c. electroplating cell
b. electrochemical cell
d. half-cell

76. What standard reduction electrode has a half-cell potential of 0.00 V?

a. Oxygen
c. Lithium
b. Hydrogen
d. Fluorine

77. In 1897 _____ used the Cathode Ray Tube to discover the electron and determined its charge to mass ratio (a) J.J. Thompson, (b) Dalton, (c) Avogadro, (d) Gay-Lussac, (e) Bohr.

78. The actual charge of an electron was discovered using an oil drop experiment by:
(a) Millikan, (b) Dalton, (c) Avogadro, (d) Gay-Lussac, (e) Bohr

79. The planetary model of the atom was stated by:
(a) Millikan, (b) Dalton, (c) Avogadro, (d) Rutherford, (e) Bohr

80. The first person to discover the nucleus: (a) Democritus,
(b) Empedocles, (c) Aristotle, (d) Sennert, (e) Rutherford.

81. Rutherford's gold foil experiment added to our knowledge of atomic structure. How?
(a) Determined the charge on an electron,
(b) Determined the charge to mass ratio of the electron,
(c) Determined that the atom has a central "core" or nucleus,
(d) Discovered the planetary model of the atom.

82. Which subatomic particle contributes the least to the mass of an atom?

a. nucleon   b. electron   c. proton   d. neutron

83. The idea that no two electrons can have exactly the same set of quantum numbers is set forth in the: (a) Heisenberg's probability position, (b) Pauli exclusion principle, (c) Plank's constant, (d) the diagonal rule.

84. The rule that electrons will enter empty orbitals of a sublevel before they pair up (show a maximum number of unpaired electrons in a sublevel!) is: (a) Millikan's rule, (b) Hund's rule, (c) Gay-Lussac's rule

85. The mass and charge of a proton are respectively ___.
(a) 1 and -1   (b) 1 and +1   (c) 0 and +1   (d) 0 and –1

86. How many sublevels are possible in the 4th energy level:
(a) 2, (b) 3, (c) 4, (d) 6, (e) 8.

87. Which quantum number describes the orientation or the space occupied by one pair of electrons in its orbital.

(a) n, the principle quantum number.

(b) l, the second quantum number.

(c) m, the third quantum number.

(d) s, the fourth quantum number.

88. Each electron in an atom can be identified by a unique set of four:

(a) Orbitals, (b) quantum numbers, (c) spectrum numbers, (d) dimensions

89. The letters s, p. d, or f are used to designate a particular_____ within an energy level. (a) sublevel, (b) space, (c) spin, (d) color

90. A system for predicting the order of filling energy sublevels with electrons is the: (a) Heisenberg's probability position, (b) Plank's constant (c) Pauli exclusion principal, (d) the diagonal rule.

91. The radii of the atoms become smaller from sodium to chlorine across period three. This is primarily due to:

a) the shielding effect   b) the increased number of electrons

c) increased nuclear charge   d) decreased metallic character.

92. The largest elements in a period are: (a) metalloids   (b) metals   (c) non-metals   (d) size is not affected.

93. The ability to conduct electricity readily is a property of:

(a) nonmetals (b) semiconductors (c) metals (d) halogens

94. The idea that it is impossible to know both the exact position and momentum of an object at the same time is the uncertainty principle proposed by: (a) Millikan, (b) Schrodinger, (c) Louise de Broglie (d) Heisenberg, (e) Bohr

` 95. The idea of arranging the elements in the periodic table according to their chemical and physical properties is attributed to

a. Mendeleev.   c. Bohr.

b. Moseley.   d. Ramsay.

96. Mendeleev is credited with developing the first successful

a. periodic table.

b. method for determining atomic number.

c. test for radioactivity.

d. use of X rays.

97. Mendeleev predicted that the spaces in his periodic table represented

a. isotopes.   c. permanent gaps.

b. radioactive elements.   d. undiscovered elements.

98. The person whose work led to a periodic table based on increasing atomic number was

a. Moseley.

c. Rutherford.

b. Mendeleev.

d. Cannizzaro.

99. The periodic law states that the physical and chemical properties of elements are periodic functions of their atomic

a. masses.

c. radii.

b. numbers.

d. structures.

100. Krypton, atomic number 36, is the fourth element in Group 18. What is the atomic number of xenon, the fifth element in Group 18?

a. 54

c. 72

b. 68

d. 90

101. Calcium, atomic number 20, has the electron configuration [Ar] $4s^2$. In what period is calcium?

a. Period 2

c. Period 8

b. Period 4

d. Period 20

102. Strontium's highest occupied energy level is $5s^2$. To what group does strontium belong?

a. Group 2

c. Group 6

b. Group 4

d. Group 8

103. When determining the size of an atom by measuring the distance between identical adjacent nuclei, the radius of an atom is

a. equal to the distance between nuclei.

c. twice the distance between nuclei.

b. one-half the distance between nuclei.

d. one-fourth the distance between nuclei.

104. In contrast to elements in the main group, the first ionization energies of *d*-block elements _____ as one proceeds down each group.

a. remain constant   c. are identical

b. Decrease   d. increase

105. If n stands for the highest occupied energy level, the outer configuration for all Group 1 elements is

a. ns^1.   c. $n - s$.

b. $2n$.   d. np^1.

106. The group of 14 elements in the sixth period that have occupied $4f$ orbitals is the

a. actinides.   c. transition elements.

b. lanthanides.   d. metalloids.

107. The most reactive group of the nonmetals are the

a. lanthanides.   c. halogens.

b. transition elements.   d. rare-earth elements.

108. An element with a greater effective nuclear charge has a(n) _____ atomic radius

a. larger b. smaller c. undefined   d. undulating

109. The halogens tend to form anions because….

   a. They have low first ionization energies

   b. They have low electron affinities

   c. They have high electron affinities

   d. They don't; they form cations

110. Which is correct when the ionic or atomic radii are compared?

A. $Ca^{2+} < Ca^+$

B. $Cl^- < Cl$

C. $Na < Na^+$

D. $B <$