DO NOT OPEN

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CHEM 110 – Dr. McCorkle – Exam #4 ***KEY***

While you wait, please complete the following information:

Name: ________________________________

Student ID: ________________________________

Turn off cellphones and stow them away. No headphones, mp3 players, hats, sunglasses, food, drinks, restroom breaks, graphing calculators, programmable calculators, or sharing calculators. Grade corrections for incorrectly marked or incompletely erased answers will not be made.

Periodic Table of the Elements

PERIOD	GROUP 1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H 1.01																	2 He 4.00
2	3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57 La * 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 Ac ** (227)	104 Rf (267)	105 Db (268)	106 Sg (271)	107 Bh (270)	108 Hs (277)	109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Cn (285)	113 Uut (284)	114 Fl (289)	115 Uup (288)	116 Lv (293)	117 Uus (294)	118 Uuo (294)

Lanthanide Series *	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
Actinide Series **	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

Multiple Choice – Choose the answer that best completes the question. Use an 815-E Scantron to record your response. [2 points each]

1. The vertical height of a wave is called
   A) wavelength
   B) amplitude
   C) frequency
   D) energy
   E) de Broglie wavelength

2. When waves of equal amplitude from two sources are out of phase when they interact, it is called
   A) destructive interference
   B) diffraction
   C) amplitude
   D) constructive interference
   E) uncertainty

3. Which of the following quantum numbers describes the shape of an orbital?
   A) principal quantum number
   B) magnetic quantum number
   C) spin quantum number
   D) Schrödinger quantum number
   E) angular momentum quantum number

4. Which of the following quantum numbers describes the orientation of an orbital?
   A) principal quantum number
   B) magnetic quantum number
   C) spin quantum number
   D) Schrödinger quantum number
   E) angular momentum quantum number

5. Electrons filling up the orbitals from low energy to high energy is known as (the)
   A) Pauli exclusion principle
   B) Hund’s rule
   C) Aufbau principle
   D) Heisenberg uncertainty principle
   E) Coulomb’s law

6. How many valence electrons do the halogens possess?

   A) 1 B) 2 C) 5 D) 6 **E) 7**

7. Suppose a metal ejects electrons from its surface when struck by red light. What will happen if the surface is struck by blue light?

   A) No electrons would be ejected.

   B) Electrons would be ejected, and they would have the same kinetic energy as those ejected by red light.

   C) Electrons would be ejected, and they would have greater kinetic energy than those ejected by red light.

   D) Electrons would be ejected, and they would have lower kinetic energy than those ejected by red light.

8. Identify the isoelectronic elements

   A) Cl^{-}, F^{-}, Br^{-}, I^{-}, At^{-}

   B) N^{3-}, S^{2-}, Br^{-}, Cs^{+}, Sr^{2+}

   C) P^{3-}, S^{2-}, Cl^{-}, K^{+}, Ca^{2+}

   D) Zn^{2+}, Co^{2+}, Cu^{2+}, Cr^{2+}, Cd^{2+}

   E) Ne, Ar, Kr, Xe, He

9. What period 3 element has the following ionization energies (all in kJ/mol)?

   $IE_1 = 1012$ $IE_2 = 1900$ $IE_3 = 2910$ $IE_4 = 4960$ $IE_5 = 6270$ $IE_6 = 22{,}200$

   A) Mg B) Si **C) P** D) S E) Cl

10. Arrange the elements in order of increasing IE_1: N, F, As

    A) N < As < F

    B) As < N < F

    C) F < N < As

    D) As < F < N

    E) F < As < N

11. Arrange the elements in order of increasing metallic character: P, As, K

    A) P < As < K

    B) As < P < K

    C) K < P < As

    D) As < K < P

    E) K < As < P

Calculations – Write your initials in the upper-right corner of every page that contains work. For full credit show all work and write neatly; give answers with correct significant figures and units. For calculations, place a box around your final answer.

12. For the following short answer questions, please circle, fill-in, or provide the correct answer. [2 points each]

a. Which transition has a longer wavelength?

$n = 7 \rightarrow n = 5$ $n = 3 \rightarrow n = 1$

b. Which has the lowest energy?

6*s* 5*d* 4*f*

c. A gas phase element gaining an electron is a typically endothermic process.

True **False**

d. How many electrons in an atom could have $n = 4$, $l = 2$, $m_l = +1$? ____**2**______

e. The two most probable ions of titanium are ___**Ti^{2+}**_____ and ___**Ti^{4+}**_____.

13. How many photons are contained in a flash of green light (525 nm) that contains 189 kJ of energy? [4 points]

$$525\ \text{nm} \times \frac{10^{-9}\ \text{m}}{1\ \text{nm}} = 5.25 \times 10^{-7}\ \text{m}$$

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ \text{J} \cdot \text{s})(2.9979 \times 10^{8}\ \text{m/s})}{5.25 \times 10^{-7}\ \text{m}} = 3.78 \times 10^{-19}\ \text{J/photon}$$

$$189\ \text{kJ} \times \frac{10^{3}\ \text{J}}{1\ \text{kJ}} = 1.89 \times 10^{5}\ \text{J}$$

$$\frac{1.89 \times 10^{5}\ \text{J}}{3.78 \times 10^{-19}\ \text{J/photon}} = 5.00 \times 10^{23}\ \text{photons}$$

14. Determine which of the following represents an acceptable set of quantum numbers for an electron in an atom. If the set is acceptable then circle the entire row. If it is not then draw a line through the entire row. [2 points each]

[✓ a. $n = 4$ $l = 2$ $m_l = -1$]

~~b. $n = 3$ $l = 1$ $m_l = +2$~~

[✓ c. $n = 5$ $l = 0$ $m_l = 0$]

15. Complete the following table: [9 points]

Symbol	**Condensed Electron Configuration**	**# of Valence e^-**	**# of Unpaired e^-**
Bi	**$[Xe]6s^2 4f^{14} 5d^{10} 6p^3$**	**5**	**3**
Co^{4+}	**$[Ar]3d^5$**	**5**	**5**
Sr	**$[Kr]5s^2$**	**2**	**0**

16. Fill-in the table below with proper quantum numbers to describe the last electron in each atom. Also, determine if the element is diamagnetic or paramagnetic. [3 points each]

Quantum #	**In**	**Rh**	**Po**	**Mg**
n	**5**	**4**	**6**	**3**
l	**1**	**2**	**1**	**0**
m_l	**−1**	**−1**	**−1**	**0**
m_s	**+½**	**−½**	**−½**	**−½**
dia- or para-	**para-**	**para-**	**para-**	**dia-**

17. Calculate the de Broglie wavelength in meters of a 46 g golf ball with a velocity of 30. m/s. [3 points]

$$\mathbf{m = 46\ g \times \frac{1\ kg}{10^3\ g} = 0.046\ kg}$$

$$\boldsymbol{\lambda} = \mathbf{\frac{h}{mv} = \frac{6.626\times10^{-34}\ J\cdot s}{(0.046\ kg)(30.\ m/s)} = 4.8 \times 10^{-34}\ m}$$

18. Explain the trends in atomic radius across a period (from left to right) and down a group (from top to bottom). [4 points]

Atomic radius decreases across a period because electrons are being added to the same valence shell but the effective nuclear charge increases as protons are added to the nucleus, causing increased attraction with the electrons, pulling them closer, decreasing the radius.

Atomic radius increases down a group because electrons are being added to higher energy shells that are farther away from the nucleus.

19. Consider the electronic transition within a hydrogen atom from *n* = 5 to *n* = 2.

a. Calculate the energy of the photon that is emitted in joules. [2 points]

$$\mathbf{E_{photon} = R_{\mathit{H}}\left[\left(\frac{1}{n^2_{final}}\right) - \left(\frac{1}{n^2_{initial}}\right)\right]}$$

$$\mathbf{E_{photon} = 2.18 \times 10^{-18}\,J\left[\left(\frac{1}{2^2}\right) - \left(\frac{1}{5^2}\right)\right] = 4.58 \times 10^{-19}\,J}$$

b. Calculate the frequency in Hertz. [2 points]

$$\boldsymbol{E = h\nu}$$

$$\boldsymbol{\nu = \frac{E}{h} = \frac{4.58 \times 10^{-19}\,\mathrm{J}}{6.626 \times 10^{-34}\,\mathrm{J} \cdot s} = 6.91 \times 10^{14}\,\mathrm{Hz}}$$

c. Calculate the wavelength in meters. [2 points]

$$\boldsymbol{E_{\mathrm{photon}} = \frac{\mathrm{hc}}{\lambda}}$$

$$\mathbf{\lambda = \frac{hc}{E} = \frac{(6.626 \times 10^{-34}\,J \cdot s)(2.9979 \times 10^{8}\,m/s)}{4.58 \times 10^{-19}\,J} = 4.34 \times 10^{-7}\,m}$$

d. Does this emission occur within the visible region of the electromagnetic spectrum? [2 points]

$$\mathbf{4.34 \times 10^{-7}\,m \times \frac{1\,nm}{10^{-9}\,m} = 434\,nm}$$ **Yes, this is visible (indigo).**

20. Einstein won the Nobel Prize in 1922 for his explanation of the photoelectric effect where it was observed that many metals emit electrons when a light shines on their surface. (This is the basic idea behind solar panels.) It was expected that brighter lights would cause electron emission, while dim lights would not. However, experiments demonstrated that a high-frequency light from a dim source caused electron emission, while a bright low-frequency light did not. How did Einstein explain this unexpected result? (Feel free to include diagrams and equations to support your explanation.) [4 points]

It was thought that the intensity (amplitude) of light was related to its energy. So brighter lights with larger amplitude (larger wave) would have more energy, causing the electrons to be emitted from the metal. However, this was not the case as even very bright lights below a certain threshold frequency were unable to cause electrons to be emitted from the metal. But dim lights above the threshold frequency were able to cause emission of electrons. Einstein proposed the energy of light must therefore be proportional to frequency rather than intensity (amplitude). Rather than light delivering energy as a large or small wave, it is delivered in packets, called quanta or photons. Thus, light is not a wave propagating through space but rather a shower of particles (photons), each with energy equal to hν ($E = h\nu$). Therefore, even a single photon with the minimum frequency (energy) is able to cause an electron to be emitted.

Extra Credit: Of the 29 scientists who attended the 1927 Solvay Conference, 17 won the Nobel Prize. But only one, the lone woman to attend, won the Nobel Prize in two different fields. What was her name? [2 points]

Marie Curie (Madame Curie)

Formulas & Constants
(you may or may not need)

1 inch = 2.54 cm (exact)
1 mile = 5280 ft ≈ 1.609 km
1 kg ≈ 2.205 lb

1 lb = 16 oz ≈ 453.6 g
1 gal = 4 qt = 8 pt ≈ 3.785 L
1 L = 1000 cm^3

K = °C + 273.15
°F = 1.8 x °C + 32
°C = (°F – 32)/1.8

1 cal = 4.184 J
1 Cal = 1000 cal
$q = m \times C \times \Delta T$

Avogadro's # = 6.022×10^{23}
Molar volume = 22.4 L
$R = 0.08206\ \frac{\text{L·atm}}{\text{mol·K}}$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
$u_{\text{rms}} = \sqrt{\frac{3RT}{M}}$
$KE = \frac{1}{2}mv^2 = \frac{3}{2}RT$

1 atm = 760 mmHg
1 mmHg = 1 torr
$P_{\text{Total}} = P_1 + P_2 + \ldots$

$P_A = X_A \cdot P_{\text{Total}}$
$PV = nRT$
$\Delta E = q + w$

$w = -P\Delta V$
$q = C \times \Delta T$
$q = m \times s \times \Delta T$

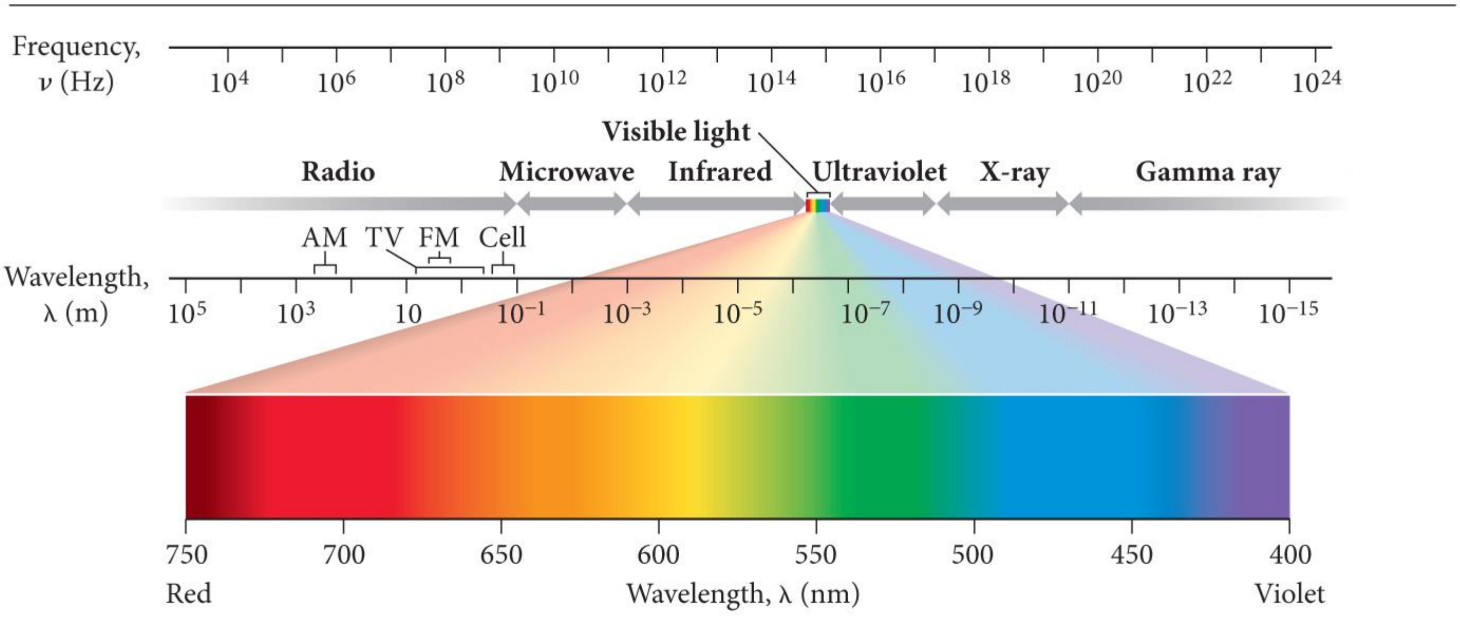
$\Delta H^\circ_{\text{rxn}} = \Sigma[n\ \Delta H_f^\circ(\text{products})] - \Sigma[n\ \Delta H_f^\circ(\text{reactants})]$
R = 8.314 J/mol·K

$h = 6.626 \times 10^{-34}$ J·s
$c = 2.9979 \times 10^{8}$ m/s
$R_H = 2.18 \times 10^{-18}$ J

1 Hz = s^{-1}
$\lambda = \frac{h}{mv}$
$\Delta x \times m\Delta v \geq \frac{h}{4\pi}$

$E_{\text{photon}} = h\nu = \frac{hc}{\lambda}$
$E_{\text{photon}} = R_H\left[\left(\frac{1}{n^2_{\text{final}}}\right) - \left(\frac{1}{n^2_{\text{initial}}}\right)\right]$

The Electromagnetic Spectrum



Scratch Page

(to be handed in)