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CHEM 111 – Dr. McCorkle – Exam #4A

While you wait, please complete the following information:

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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. What is the oxidation state of carbon in $C_2O_4^{2-}$?
   A) +2 B) +3 C) +4 D) +5 E) +6

2. In a voltaic cell, which is true at the cathode?
   A) loses mass B) cations are produced C) source of electrons
   D) cations flow towards it E) oxidation occurs

3. Determine the cell notation for the redox reaction given below.

   $3\ Cl_2(g) + 2\ Fe(s) \rightarrow 6\ Cl^-(aq) + 2\ Fe^{3+}(aq)$

   A) $Cl_2(g)$ | $Cl^-(aq)$ | Pt || Fe(s) | $Fe^{3+}(aq)$
   B) $Cl^-(aq)$ | $Cl_2(g)$ | Pt || $Fe^{3+}(aq)$ | Fe(s)
   C) $Fe^{3+}(aq)$ | Fe(s) || $Cl^-(aq)$ | $Cl_2(g)$ | Pt
   D) Fe(s) | $Cl_2(g)$ || $Fe^{3+}(aq)$ | $Cl^-(aq)$ | Pt
   E) Fe(s) | $Fe^{3+}(aq)$ || $Cl_2(g)$ | $Cl^-(aq)$ | Pt

4. Which of the following is the weakest oxidizing agent?
   A) $H_2O_2(aq)$
   B) $Fe^{3+}(aq)$
   C) $ClO_2(g)$
   D) $F^-(aq)$
   E) Fe(s)

5. Identify the characteristics of a spontaneous reaction.

   A) $\Delta G° < 0$
   B) $\Delta E°_{cell} > 0$
   C) $K > 1$
   D) all of the above
   E) none of the above

6. How many electrons are transferred in the following reaction? (The reaction is unbalanced.)

   $I_2(s) + Fe(s) \rightarrow Fe^{3+}(aq) + I^-(aq)$

   A) 1
   B) 2
   C) 3
   D) 4
   E) 6

7. Which of the following statements is TRUE?
   A) Gamma rays have the lowest ionizing power of any radioactivity.
   B) Alpha radiation has the highest penetrating power of any radioactivity.
   C) Beta emitters will do more damage than alpha emitters within the body.
   D) Beta radiation has the highest ionizing power of any radioactivity.
   E) None of the above are true.

8. Which of the following nuclides are most likely to decay via beta decay?
   A) I-131
   B) Ar-40
   C) F-18
   D) Zr-90
   E) Pb-206

9. Which of the following statements is TRUE?
   A) Positrons are similar in ionizing power and penetrating power to beta particles.
   B) A positron is the antiparticle of the electron.
   C) Beta decay occurs when a neutron changes into a proton while emitting an electron.
   D) An alpha particle is a helium 2+ ion.
   E) All of the above are true.

10. Use the standard half-cell potentials listed below to calculate the standard cell potential for the following reaction occurring in an electrochemical cell at 25°C. (The equation is balanced.)

$$\mathrm{Sn(s) + 2\ Ag^{+}(aq) \rightarrow Sn^{2+}(aq) + 2\ Ag(s)}$$

$\mathrm{Sn^{2+}(aq) + 2\ e^{-} \rightarrow Sn(s)}$ E° = −0.14 V

$\mathrm{Ag^{+}(aq) + e^{-} \rightarrow Ag(s)}$ E° = +0.80 V

   A) +0.66 V
   B) +0.94 V
   C) +1.46 V
   D) −0.94 V
   E) +1.74 V

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. Place a box around your final answer.

11. Balance the following reaction in basic solution using the half-reaction method: [6]

$$Cr(OH)_4^-(aq) + ClO^-(aq) \rightarrow CrO_4^{2-}(aq) + Cl^-(aq)$$

12. A concentration cell is created from zinc metal in 0.500 *M* zinc nitrate solution and iron metal in iron(II) nitrate solution. The potential of the cell is measured to be +0.322 V. What is the equilibrium concentration of Fe^{2+}? [5]

13. Consider a voltaic cell composed of aluminum metal in aluminum nitrate solution and magnesium metal in magnesium nitrate solution.

    a. Sketch the voltaic cell including the location of all metals and solutions. Label the cathode and anode; show the direction of electron flow and the movement of cations. [4]

    b. Calculate $E°_{\text{cell}}$ for the cell. [2]

    c. Calculate the standard free energy of the cell. [2]

    d. Calculate the equilibrium constant of the cell. [2]

14. Write nuclear equations for the following: [3 points each]

    a. Lead-214 undergoes beta decay

    b. Chlorine-36 undergoes electron capture

    c. Fluorine-18 undergoes positron emission

15. Strontium-90 is a byproduct in nuclear reactors fueled by the radioisotope uranium-235. The half-life of strontium-90 is 28.8 yr. What percentage of a strontium-90 sample remains after 75.0 yr? [5]

16. Determine the binding energy per nucleon of an Mg-24 nucleus. The Mg-24 nucleus has a mass of 23.98504 amu. A proton has a mass of 1.00783 amu and a neutron has a mass of 1.00866 amu. [5]

17. A rock contains 0.313 mg of lead-206 for each milligram of uranium-238. The half-life for the decay of uranium-238 to lead-206 is 4.5×10^9 yr. How long ago was the rock formed? [5]

18. How many grams of chromium metal are plated out when a constant current of 8.00 A is passed through an aqueous solution containing Cr^{3+} ions for 320. minutes? [5]

19. Briefly describe two uses of radionuclides in nuclear medicine. Be specific and include the isotope(s) used. [3 points each]

20. Briefly explain the following concepts as they pertain to the neutron-induced fission of uranium-235 in nuclear reactors and weapons: [3 points each]

    a. Why is ^{235}U able to produce a self-sustaining chain reaction?

    b. Why must uranium be enriched before it is suitable for use?

    c. What is meant by the term "critical mass"?

Extra Credit: What famous scientist was in charge of the Manhattan Project? [2 points]

Scratch Page

(to be handed in)

Formulas & Constants

$M = \frac{\text{mol solute}}{\text{liters solution}}$

$m = \frac{\text{mol solute}}{\text{kg solvent}}$

$\chi_A = \frac{\text{mol A}}{\text{total moles}}$

$P_A = \chi_A \cdot P_A^o$

$R = 0.08206 \frac{\text{L·atm}}{\text{mol·K}}$

$R = 8.314 \frac{\text{J}}{\text{mol·K}}$

$\Delta T_f = \underline{m} \cdot K_f$

$\Delta T_b = \underline{m} \cdot K_b$

$\Pi = \underline{M}RT$

$\Delta T_f = i \cdot \underline{m} \cdot K_f$

$\Delta T_b = i \cdot \underline{m} \cdot K_b$

$\Pi = i \cdot \underline{M}RT$

$K = °C + 273.15$

1 atm = 760 torr = 760 mmHg

$S_{gas} = k_H \cdot P_{gas}$

$\Delta H_{sol'n} = \Delta H_{hydration} - \Delta H_{lattice}$

$f = e^{-Ea/RT}$

$k = Ae^{-Ea/RT}$

$\ln \frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

$\ln k = -\frac{E_a}{R}\left(\frac{1}{T}\right) + \ln A$

1 V = 1 J/C

$K_p = K_c(RT)^{\Delta n}$

$K_w = 1.0 \times 10^{-14}$

$K_a \times K_b = K_w$

$K_w = [H_3O^+][OH^-]$

$pH = pK_a + \log \frac{[base]}{[acid]}$

$pH = -\log[H_3O^+]$

$pOH = -\log[OH^-]$

$\Delta G = \Delta G° + RT \ln Q$

$\Delta G° = \Delta H° - T\Delta S°$

$\Delta S°_{rxn} = \sum n(S°_{prod}) - \sum n(S°_{reac})$

$\Delta H°_{rxn} = \sum n(\Delta H°_{prod}) - \sum n(\Delta H°_{reac})$

$K = e^{-\Delta G°/RT}$

$\Delta G° = -nFE°$

$\Delta G°_{rxn} = \sum n(\Delta G°_{prod}) - \sum n(\Delta G°_{reac})$

F = 96,485 J/V·mol

$S = k \ln W$

$k = 1.38 \times 10^{-38}$ J/K

1 A = 1 C/s

$E°_{cell} = E°_{cathode} - E°_{anode}$

$E = E° - (0.0592/n) \log Q$

$E = E° - (RT/nF) \ln Q$

Rate = kN

$t_{1/2} = \frac{0.693}{k}$

$\ln \frac{N_t}{N_0} = -kt$

$\ln \frac{rate_t}{rate_0} = -kt$

$c = 2.99792458 \times 10^8$ m/s

$E = mc^2$

931.5 MeV = 1 amu

1 amu = 1.66054×10^{-27} kg

Order in [A]	Rate Law	Integrated Form, $y = mx + b$	Straight Line Plot	Half-Life $t_{1/2}$
zero-order (n = 0)	rate = $k[A]^0 = k$	$[A]_t = -kt + [A]_0$	$[A]_t$ vs. t	$t_{½} = \frac{[A]_0}{2k}$
first-order (n = 1)	rate = $k[A]^1$	$\ln[A]_t = -kt + \ln[A]_0$	$\ln[A]_t$ vs. t	$t_{½} = \frac{\ln 2}{k} = \frac{0.693}{k}$
second-order (n = 2)	rate = $k[A]^2$	$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$	$\frac{1}{[A]_t}$ vs. t	$t_{½} = \frac{1}{k[A]_0}$

TABLE 18.1 Standard Electrode Potentials at 25 °C

	Reduction Half-Reaction		$E°$ (V)	
Stronger oxidizing agent	$F_2(g) + 2\ e^-$	$\longrightarrow 2\ F^-(aq)$	2.87	Weaker reducing agent
	$H_2O_2(aq) + 2\ H^+(aq) + 2\ e^-$	$\longrightarrow 2\ H_2O(l)$	1.78	
	$PbO_2(s) + 4\ H^+(aq) + SO_4^{2-}(aq) + 2\ e^-$	$\longrightarrow PbSO_4(s) + 2\ H_2O(l)$	1.69	
	$MnO_4^-(aq) + 4\ H^+(aq) + 3\ e^-$	$\longrightarrow MnO_2(s) + 2\ H_2O(l)$	1.68	
	$MnO_4^-(aq) + 8\ H^+(aq) + 5\ e^-$	$\longrightarrow Mn^{2+}(aq) + 4\ H_2O(l)$	1.51	
	$Au^{3+}(aq) + 3\ e^-$	$\longrightarrow Au(s)$	1.50	
	$PbO_2(s) + 4\ H^+(aq) + 2\ e^-$	$\longrightarrow Pb^{2+}(aq) + 2\ H_2O(l)$	1.46	
	$Cl_2(g) + 2\ e^-$	$\longrightarrow 2\ Cl^-(aq)$	1.36	
	$Cr_2O_7^{2-}(aq) + 14\ H^+(aq) + 6\ e^-$	$\longrightarrow 2\ Cr^{3+}(aq) + 7\ H_2O(l)$	1.33	
	$O_2(g) + 4\ H^+(aq) + 4\ e^-$	$\longrightarrow 2\ H_2O(l)$	1.23	
	$MnO_2(s) + 4\ H^+(aq) + 2\ e^-$	$\longrightarrow Mn^{2+}(aq) + 2\ H_2O(l)$	1.21	
	$IO_3^-(aq) + 6\ H^+(aq) + 5\ e^-$	$\longrightarrow \frac{1}{2}I_2(aq) + 3\ H_2O(l)$	1.20	
	$Br_2(l) + 2\ e^-$	$\longrightarrow 2\ Br^-(aq)$	1.09	
	$VO_2^+(aq) + 2\ H^+(aq) + e^-$	$\longrightarrow VO^{2+}(aq) + H_2O(l)$	1.00	
	$NO_3^-(aq) + 4\ H^+(aq) + 3\ e^-$	$\longrightarrow NO(g) + 2\ H_2O(l)$	0.96	
	$ClO_2(g) + e^-$	$\longrightarrow ClO_2^-(aq)$	0.95	
	$Ag^+(aq) + e^-$	$\longrightarrow Ag(s)$	0.80	
	$Fe^{3+}(aq) + e^-$	$\longrightarrow Fe^{2+}(aq)$	0.77	
	$O_2(g) + 2\ H^+(aq) + 2\ e^-$	$\longrightarrow H_2O_2(aq)$	0.70	
	$MnO_4^-(aq) + e^-$	$\longrightarrow MnO_4^{2-}(aq)$	0.56	
	$I_2(s) + 2\ e^-$	$\longrightarrow 2\ I^-(aq)$	0.54	
	$Cu^+(aq) + e^-$	$\longrightarrow Cu(s)$	0.52	
	$O_2(g) + 2\ H_2O(l) + 4\ e^-$	$\longrightarrow 4\ OH^-(aq)$	0.40	
	$Cu^{2+}(aq) + 2\ e^-$	$\longrightarrow Cu(s)$	0.34	
	$SO_4^{2-}(aq) + 4\ H^+(aq) + 2\ e^-$	$\longrightarrow H_2SO_3(aq) + H_2O(l)$	0.20	
	$Cu^{2+}(aq) + e^-$	$\longrightarrow Cu^+(aq)$	0.16	
	$Sn^{4+}(aq) + 2\ e^-$	$\longrightarrow Sn^{2+}(aq)$	0.15	
	$2\ H^+(aq) + 2\ e^-$	$\longrightarrow H_2(g)$	0	
	$Fe^{3+}(aq) + 3\ e^-$	$\longrightarrow Fe(s)$	−0.036	
	$Pb^{2+}(aq) + 2\ e^-$	$\longrightarrow Pb(s)$	−0.13	
	$Sn^{2+}(aq) + 2\ e^-$	$\longrightarrow Sn(s)$	−0.14	
	$Ni^{2+}(aq) + 2\ e^-$	$\longrightarrow Ni(s)$	−0.23	
	$Cd^{2+}(aq) + 2\ e^-$	$\longrightarrow Cd(s)$	−0.40	
	$Fe^{2+}(aq) + 2\ e^-$	$\longrightarrow Fe(s)$	−0.45	
	$Cr^{3+}(aq) + e^-$	$\longrightarrow Cr^{2+}(aq)$	−0.50	
	$Cr^{3+}(aq) + 3\ e^-$	$\longrightarrow Cr(s)$	−0.73	
	$Zn^{2+}(aq) + 2\ e^-$	$\longrightarrow Zn(s)$	−0.76	
	$2\ H_2O(l) + 2\ e^-$	$\longrightarrow H_2(g) + 2\ OH^-(aq)$	−0.83	
	$Mn^{2+}(aq) + 2\ e^-$	$\longrightarrow Mn(s)$	−1.18	
	$Al^{3+}(aq) + 3\ e^-$	$\longrightarrow Al(s)$	−1.66	
	$Mg^{2+}(aq) + 2\ e^-$	$\longrightarrow Mg(s)$	−2.37	
	$Na^+(aq) + e^-$	$\longrightarrow Na(s)$	−2.71	
	$Ca^{2+}(aq) + 2\ e^-$	$\longrightarrow Ca(s)$	−2.76	
	$Ba^{2+}(aq) + 2\ e^-$	$\longrightarrow Ba(s)$	−2.90	
Weaker oxidizing agent	$K^+(aq) + e^-$	$\longrightarrow K(s)$	−2.92	Stronger reducing agent
	$Li^+(aq) + e^-$	$\longrightarrow Li(s)$	−3.04	