Exam 4 Chm 205 (Dr Mattson) 1 May 2019
Academic Integrity Pledge: *In keeping with Creighton University's ideals and with the Academic Integrity Code, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.* ***Signature:***

Name:

Chemistry Student Number: ___________

Instructions: **Show all work whenever a calculation box is provided!** Write legibly. Include units whenever appropriate. You will receive credit for **how** you worked each problem as well as for the correct answer. If you need more space, you may use the back of the data sheet provided — Write: "See data sheet" in the answer box – then write your name on the data sheet. On your desk you are allowed only pencils (but no pencil pouch), an eraser, and a non-programmable calculator without a slipcover. Backpacks, bags, and purse-like items must be stored on the tables in the back of the room. Cell phones must be silent and placed in your backpack/bag/purse – not in your pocket.

1. (5 pts) Assign oxidation numbers to the arsenic atom in each of these compounds.

AsH_3	H_3AsO_3	K_3AsO_4	$AsCl_3$	As_2H_4

2a. (4 pts) Balance this redox reaction in aqueous acidic solution. You will need to add H_2O and/or H^+.

$$MnO_4^- + Br^- \rightarrow Mn^{2+} + BrO_2^-$$

2b. (1 pt) What is the value of n (the LCM)?

3. (5 pts) Multiple Choice. Refer to the table of standard reduction potentials on the data sheet.

3a. Which of these is the best reducing agent?
Zn Ag^+ Ag Zn^{+2}

3b. Which of these is most easily reduced?
Zn Fe^{+3} Ag Pb^{+2}

3c. The cobalt(II) ion will react spontaneously with
Fe Fe^{+2} Cu^{+2} Cu

3d. E^o for the cell Co | (Co^{+2} || (Ni^{+2} | Ni is:
–0.02 v +0.02 v –0.54 v +0.54 v

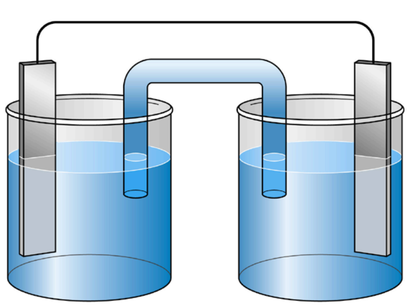
3e. What oxidizing agent can be used to selectively oxidize Ni to Ni^{+2} but will not oxidize the Cu to Cu^{+2}?
(A) Pb (B) Sn (C) Ag^+ (D) Pb^{2+}

4. Consider the galvanic cell for which E^o is given:

$Pb(s)|Pb^{2+}(1\ M)||Fe^{+3}(1\ M)|Fe$ $E^o = +0.094$ v

4a. (3 pts) Label the electrodes and solutions with the following labels: "**Pb**," "**Pb^{+2}**," "**Fe**," and "**Fe^{3+}**." Make the left cell the anode and the right cell the cathode.

4b. (1 pt) Indicate the direction of electron flow in the wire.



Anode **Cathode**

4c. (3 pt) Balance the reaction and **determine n** – you will need it below. (Hint: The coefficients do not include 1.)

4d. (1 pt) In which cell is the concentration of ions increasing? **Circle: Anode or Cathode**

4e. (1 pt) In which cell is the mass of the electrode increasing? **Circle: Anode or Cathode**

4f. (4 pts) Suppose each electrode consisted of 0.100 mol of metal and the solutions were 200 mL of 0.50 M. What is the limiting reagent?

Show work for credit.

Answer: ______________

4g. (4 pts) What is ΔG^o for the reaction?

Show all work for credit.

Answer with units: ______________

4h. (4 pts) What is K_c for the reaction?

Show all work for credit.

Answer: ______________

4i. (4 pts) Calculate a value for E for the system:

$Pb(s)|Pb^{2+}(0.025\ M)||Fe^{3+}(1.00\ M)|Fe$

Show work for credit.

Answer with units: ______________

5. (4 pts) Given E^o = +0.40 for the cell shown, determine the E^o for the $Eu^{+3}(aq) + e^- \rightarrow Eu^{+2}(aq)$ half cell. Use data sheet for Zn(s)|Zn^{+2}.

Zn(s)|Zn^{+2}||Eu^{+3}|Eu^{2+}|Pt(s) E^o = +0.40 V

Show all work for credit.

Answer with units: ______________

6. (3 pts) What **mass** of aluminum can be produced from a molten Al^{3+} salt using a current of 42 amps for 8.0 hrs?

Show all work for credit.

Answer with units: ______________

7. Strontium has five radioactive isotopes, ranging from ^{82}Sr to ^{90}Sr. One of these two isotopes decays by β-emission and the other by electron capture.

7a. (3 pts) Balance the reaction for the β-emission.

7b. (3 pts) Balance the reaction for the electron capture.

7c. (2 pts) Which of these isotopes is most likely stable?

^{83}Sr ^{85}Sr ^{88}Sr ^{89}Sr

7d. (4 pts) Enormous amounts of radioactive strontium-90 was produced in the 1950s during nuclear bomb testing by the US and Soviet Union. The isotope settled out across the globe and entered the food chain as $^{90}Sr^{2+}$ (as would Ca^{2+} - so it ended up in our bones). Sr-90 has a half life of 28.90 years. Determine the decay rate constant for strontium-90.

Show all work for credit.

Answer with units: ______________

7e. (4 pts) What percent of Sr-90 remains after 60 years?

Show all work for credit.

Answer: ______________

8a. (3 pts) The radioactive Fiestaware bowl contains ^{238}U, an α-emitter. Balance that decay process.

Show all work for credit.

8b. (3 pts) As we discussed in class, ^{238}U emits a mixed series of α and β particles, ultimately ending with stable ^{206}Pb. Balance that overall process.

$^{238}U \rightarrow$ _____ $^{4}_{2}\alpha$ + _____ $^{0}_{-1}\beta$ + ^{206}Pb

9. (4 pts) ^{14}C has a half-life of 5715 years, giving it a decay rate constant of 1.21 x 10^{-4} yr^{-1}. Currently living organisms exhibit a decay rate of 15.3 disintegrations per minute per gram carbon. How old is an artifact that shows an activity of 4.4 dpm/gC?

Answer with units: ______________

10. (3 pts) Circle the one member of each pair that is a solid at room temperature. (Three circles)

(a) CCl_4 or KCl (b) Br_2 or I_2 (c) Mn or SO_2

11. (4 pts) Circle the one member of each pair that is a gas at room temperature. (Four circles)

(a) CH_3Cl or $CHCl_3$ (b) BeO or NO_2

(c) CH_3OCH_3 or CH_3CH_2OH (d) CH_4 or C_5H_{10}

12. (4 pts) Check **all** of the forces that are broken when water boils.

- ☐ covalent bonds
- ☐ hydrogen bonds
- ☐ ionic bonds
- ☐ London dispersion forces

13. (5 pts) Circle **all** the molecules that exhibit hydrogen-bonding. Hint: Sketch Lewis dot structure if in doubt.

CH_3NH_2 $HClO_4$ CH_3OH H_2 CH_2O

14. (6 pts) Water that is nearly at the boiling point can be tossed into the air when it is extremely cold (well below water's freezing point) and it will freeze into snow before it hits the ground. In order to calculate the heat released, q, one would need which **six** of the following data? C = molar heat capacity (or molar specific heat)

☐ ΔH_{vap}	☐ ΔH_{fus}	☐ mass of water
☐ $C_{H_2O(s)}$	☐ $C_{H_2O(l)}$	☐ $C_{H_2O(g)}$
☐ $T_{initial}$	☐ T_{final}	☐ $T_{boiling\ point}$

15. (5 pts) A substance has a standard (at 1 atm) melting point of 25.0 ^oC and a boiling point of 113.0 ^oC. It has a triple point of T_t = 19.0 ^oC and P_t = 200 mmHg and its critical point is T_c = +310 ^oC and P_c = 82 atm. What is the state of matter at…

a. T = -10 ^oC, P = 1.0 atm **Circle: Solid Liquid Gas**

b. T = 19 ^oC, P = 100 mmHg **Circle: Solid Liquid Gas**

c. T = +320 ^oC, P = 102 atm **Circle: Solid Liquid Gas**

d. T = 50 ^oC, P = 1 atm **Circle: Solid Liquid Gas**

e. Is the density of the liquid less than that of the solid? Circle: **Yes** or **No**

Table of Standard Reduction Potentials

Useful equations for Electrochemistry:

$E = E^o - \frac{0.05916}{n} \log Q = E^o - \frac{RT}{nF} \log Q$

$E^o = \frac{RT}{nF} \ln K \quad E^o = \frac{0.05916}{n} \log K$

$\Delta G = -nFE \qquad \Delta G^o = -nFE^o$

1 F = 96500 coul = 1 mol e^- = 96500 J/mol V

Charge (coul) = current (amps) x time(s)

Useful equations for Nuclear Chemistry:

$\ln(N_o/N_t) = kt \qquad t_{1/2} = 0.693/k$

Miscellaneous useful values:

$N_A = 6.02 \times 10^{23}$

	E^o (V)
$O_2 + 4 H^+ + 4 e^- \rightarrow 2 H_2O$	1.23
$Ag^+ + e^- \rightarrow Ag$	0.80
$I_2 + 2 e^- \rightarrow 2 I^-$	0.54
$O_2 + 2 H_2O + 4 e^- \rightarrow 4 OH^-$	0.40
$Cu^{2+} + 2 e^- \rightarrow Cu$	0.34
$2H^+ + 2 e^- \rightarrow H_2$	0.00
$Fe^{3+} + 3 e^- \rightarrow Fe$	-0.036
$Pb^{2+} + 2 e^- \rightarrow Pb$	-0.13
$Ni^{2+} + 2 e^- \rightarrow Ni$	-0.26
$Co^{2+} + 2 e^- \rightarrow Co$	-0.28
$Cd^{2+} + 2 e^- \rightarrow Cd$	-0.40
$Fe^{2+} + 2 e^- \rightarrow Fe$	-0.44
$Cr^{3+} + e^- \rightarrow Cr^{2+}$	-0.50
$Cr^{3+} + 3 e^- \rightarrow Cr$	-0.73
$Zn^{2+} + 2 e^- \rightarrow Zn$	-0.76
$2 H_2O + 2 e^- \rightarrow H_2 + 2 OH^-$	-0.83
$Al^{3+} + 3 e^- \rightarrow Al$	-1.66
$Mg^{+2} + 2 e^- \rightarrow Mg$	-1.66
$Na^+ + e^- \rightarrow Na$	-2.71
$Ca^{2+} + 2 e^- \rightarrow Ca$	-2.76
$Ba^{2+} + 2 e^- \rightarrow Ba$	-2.90
$K^+ + e^- \rightarrow K$	-2.92
$Li^+ + e^- \rightarrow Li$	-3.05

1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (97)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	71 Lu 175.0	72 Hf 178.5	73 Ta 181.0	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	103 Lr (262)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (265)	109 Mt (268)	110 Uun (269)	111 Uuu (272)	112 Uub (277)		114 Uuq (289)		116 Uuh (289)		118 Uuo (293)

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
89 Ac (227)	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	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 (260)

Answers:

1.

AsH_3	H_3AsO_3	K_3AsO_4	$AsCl_3$	As_2H_4
-3	+3	+5	+3	-2

2a.

$12\ H^+ + 4\ MnO_4^- + 5\ Br^- \rightarrow 4\ Mn^{2+} + 5\ BrO_2^- + 6\ H_2O$

2b. 20

3a. Zn

3b. Fe^{+3}

3c. Fe

3d. +0.02 v

3e. (D) Pb^{2+}

4a. Anode: "Pb," and "Pb^{+2}," Cathode: "Fe^{3+}" and "Fe"

4b. electron flow is from anode to cathode.

4c. $3\ Pb, + 2\ Fe^{3+} \rightarrow 3\ Pb^{+2} + 2\ Fe$ (n = 6)

4d. Anode

4e. Cathode

4f. Pb

4g. $\Delta G^o = -54.4$ kJ

4h. K_c $3.37 \times 10^{+9}$

4i. 0.141 v

5. -0.36 v

6. 112.7 g

7a. ${}^{90}_{38}Sr \rightarrow {}^{0}_{-1}\beta + {}^{90}_{39}Y$

7b. ${}^{82}_{38}Sr + {}^{0}_{-1}e \rightarrow {}^{82}_{37}Rb$

7c. ${}^{88}Sr$

7d. 0.0240 yr^{-1}

7e. 23.7%

8a. ${}^{238}_{92}U \rightarrow {}^{4}_{2}\alpha + {}^{234}_{90}Th$

8b. ${}^{238}_{92}U \rightarrow 8\ {}^{4}_{2}\alpha + 6\ {}^{0}_{-1}\beta + {}^{206}_{82}Pb$

9. 10,300 yrs

10. (a) KCl (b) I_2 (c) Mn

11. (a) CH_3Cl (b) NO_2 (c) CH_3OCH_3 (d) CH_4

12. hydrogen bonds and London dispersion forces

13. CH_3NH_2 $HClO_4$ CH_3OH

14. ☐ ΔH_{fus} ☐ mass of water ☐ $C_{H_2O(s)}$
☐ $C_{H_2O(l)}$ ☐ $T_{initial}$ ☐ T_{final}

15.
a. **Solid;** b. **Gas**; c. **Gas**; d. **Liquid;** e. **Yes**