version: 235

Exam 2 - S23 - McCord - ch302n

last name ____________ first name ____________ signature ____________

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 65.38	31 Ga 69.72	32 Ge 72.64	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 (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 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	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 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (270)	109 Mt (278)	110 Ds (281)	111 Rg (282)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (290)	116 Lv (293)	117 Ts (294)	118 Og (294)

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 173.04	71 Lu 174.97
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 (266)

constants

$R = 0.08206$ L atm/mol K

$R = 8.314$ J/mol K

$F = 96485$ C/mol e^-

$N_A = 6.022 \times 10^{23}$ /mol

$h = 6.626 \times 10^{-34}$ J·s

$c = 3.00 \times 10^8$ m/s

$g = 9.81$ m/s^2

conversions

1 atm = 760 torr

1 atm = 101325 Pa

1 atm = 1.01325 bar

1 bar = 10^5 Pa

°F = °C(1.8) + 32

K = °C + 273.15

conversions

1 in = 2.54 cm

1 ft = 12 in

1 yd = 3 ft

1 mi = 5280 ft

1 lb = 453.6 g

1 ton = 2000 lbs

1 tonne = 1000 kg

1 gal = 3.785 L

1 gal = 231 in^3

1 gal = 128 fl oz

1 fl oz = 29.57 mL

standard potentials at 25 °C

	$E°$ (V)
$F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$	+2.87 V
$Au^+(aq) + e^- \rightleftharpoons Au(s)$	+1.69 V
$Pd^{2+}(aq) + 2e^- \rightleftharpoons Pd(s)$	+0.915 V
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80 V
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77 V
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34 V
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	**0.00** V
$Fe^{3+}(aq) + 3e^- \rightleftharpoons Fe(s)$	−0.04 V
$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$	−0.13 V
$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	−0.23 V
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	−0.44 V
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	−0.76 V
$Cr^{2+}(aq) + 2e^- \rightleftharpoons Cr(s)$	−0.91 V
$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$	−1.18 V
$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$	−1.66 V
$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	−2.36 V

This exam should have exactly 20 questions. Each question is equally weighted at 5 points each. Bubble in your answer choices on the online bubblehseet provided. Your score is based on what you bubble on the bubblesheet and not what is circled on the exam.

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1. Ammonium ion, NH_4^+ can decompose rapidly to nitrogen gas, N_2. During this process, the N is ______ and the change in oxidation number is equal to ______ .

a. oxidized; +5

b. reduced; −4

c. reduced; −3

● d. oxidized; +3

e. oxidized; +4

f. reduced; +3

Explanation: For NH_4^+, N has ox number of -3. For N_2, N is 0 (zero). The oxidation number goes from -3 to 0 which is a +3 change. Because the oxidation number of N increased, the N is oxidized.

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2. Consider two metals X and Z with corresponding ions X^+ and Z^{3+} and the following electrochemical cell that they are used in:

$$X(s) \mid X^+(aq) \,||\, Z^{3+}(aq) \mid Z(s)$$

If the standard electrical potential for this cell is +0.473 V, how much energy (electrical work) is produced from this redox reaction? Assume the fully balanced reaction (with whole numbers) is run to completion.

a. 45.6 kJ

b. 365 kJ

c. 183 kJ

d. 274 kJ

● e. 137 kJ

f. 91.3 kJ

Explanation: The reaction would be

$$3X(s) + Z^{3+}(aq) \longrightarrow 3X^+(aq) + Z(s)$$

Energy $= -nFE = (3)(96485)(0.473)$

$= 122150$ J $= 137$ kJ

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3. Copper is electroplated from a solution of copper(II) sulfate. What mass of copper is electroplated when 20.0 amps of current is run continuously for 14.0 hours?

a. 308 g

b. 342 g

● c. 332 g

d. 364 g

e. 664 g

Explanation: $\frac{I \cdot t}{n \cdot F}$ = moles of metal

$\frac{20 \cdot 14(3600)}{2 \cdot 96485}$ = moles of Cu = 5.2236...

Copper molar mass is 63.55 g/mol so multiply the 5.2236... moles of solid nickel by 63.55 to get 331.96... grams of solid copper plated.

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4. Balance the following redox reaction in acidic solution:

$$Ru^{2+} + W \longrightarrow Ru + WO_3^{2-}$$

What is the sum of coefficients in the simplest, overall reaction?

a. 18

● b. 15

c. 20

d. 17

e. 11

f. 13

Explanation:

$$3H_2O + 2Ru^{2+} + W \longrightarrow 2Ru + WO_3^{2-} + 6H^+$$

3+2+1+2+1+6 = 15

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5. Consider the cell diagram below:

$$Ag \mid Ag^{+}(aq) \mid\mid Mn^{2+}(aq) \mid Mn$$

What is the cathode and what is the cell type?

a. Ag(s); voltaic cell

●b. Mn(s); electrolytic cell

c. Ag(s); electrolytic cell

d. Mn(s); voltaic cell

Explanation: The left side of a cell diagram is always the anode (oxidation), and the right side of a cell diagram is always the cathode (reduction). Therefore, the cathode is Mn(s). To determine the cell type: E°_{cell} = $E^\circ_{cathode}$ - E°_{anode} = -1.18 - (+0.88) = -1.98 V. As the electrical potential is negative, this is an electrolytic cell.

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6. Consider the following rather planetary and radioactive redox reaction:

$$PuO + NpO_3^{+} \longrightarrow PuO_2 + NpO_2^{2+}$$

Using the smallest possible integer coefficients, balance the reaction in acidic aqueous solution. What is the coefficient for H^+, and which side of the reaction is it on?

a. 4, left

b. 1, left

●c. 2, left

d. 2, right

e. 4, right

f. 1, right

Explanation:

$$2H^{+} + PuO + 2NpO_3^{+} \longrightarrow PuO_2 + 2NpO_2^{2+} + H_2O$$

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7. The following concentration cell has a measured potential of +76.1 mV. What is the unknown chromium(II) ion concentration in this cell?

$$Cr \mid Cr^{2+}\ (1.2 \times 10^{-4}\ M) \mid\mid Cr^{2+}(?M) \mid Cr$$

●a. 0.045 M

b. 0.14 M

c. 2.0×10^{-6} M

d. 0.0023 M

e. 3.2×10^{-8} M

f. 0.075 M

Explanation: Use Nernst equation:

$E = E^\circ - \frac{0.05916}{2} \log Q$

$0.0761 = 0 - (0.02958) \log(\frac{1.2\times10^{-4}}{x})$

$-2.5727 = \log(\frac{1.2\times10^{-4}}{x})$

$0.002675 = \frac{1.2\times10^{-4}}{x}$

$x = 1.2 \times 10^{-4}/0.002914 = 0.045$ M = $[Cr^{2+}]$ in the cathode compartment

---

8. In an electrolytic cell, the positive terminal is the ______ and is the site of the ______ half-reaction.

a. anode; reduction

b. cathode; oxidation

●c. anode; oxidation

d. cathode; reduction

Explanation: In an electrolytic cell (analogous to charging a battery), the cathode is always attributed a negative sign and the anode a positive sign. By definition, the cathode is the site of reduction, and the anode is the site of oxidation.

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9. I put a piece of copper wire into a solution of 1 M Ni^{2+}. What happens?

a. The copper wire begins to oxidize and is eroded away.

●b. Nothing will happen.

c. The two reactants will fuse together to make Zn metal.

d. The copper wire reduces the Ni^{2+} ions to nickel metal.

Explanation: The standard potential for Cu(s) and Ni^{2+}(aq) is -0.57 V. This is very non-spontaneous, so nothing happens.

---

10. Suppose you create a voltaic cell out of nickel and iron with the following half-reactions:

$$Fe^{2+} + 2e^- \longrightarrow Fe$$

$$Ni^{2+} + 2e^- \longrightarrow Ni$$

What is the value of the electrical potential in standard conditions?

a. +0.67 V

b. −0.19 V

c. +0.19 V

d. −0.67 V

●e. +0.21 V

f. −0.21 V

Explanation: For a voltaic cell, the cathode will include the half reaction with the higher standard reduction potential. In this case, it is nickel and to find the electrical potential of the cell with Fe/Fe^{2+} at the anode, we subtract the anode std pot from the std cathode potential.

$E = -0.23 - (-0.44) = +0.21$ V

---

11. Which of the following statements is/are always true for a normal operating voltaic cell?

I. $E^\circ_{\text{cathode}} > E^\circ_{\text{anode}}$
II. The reaction is spontaneous
III. The flow of electrons is from cathode to anode

a. II, & III only

b. II only

c. I & III only

d. III only

e. I, II, & III

●f. I & II only

g. I only

Explanation: none

---

12. Which of the following species listed is the strongest reducing agent?

a. Mg^{2+}(aq)

b. Cu(s)

●c. Cr(s)

d. F_2(g)

e. Ag(s)

Explanation: A good reducing agent needs to push electrons away which means they will be on the right side of a standard potential table and will have the most negative E°. That means that Cr is the best of those listed.

---

13. What is the oxidation number of element M (a metal) in the compound $NaMO_3$?

a. +2

b. +4

●c. +5

d. +1

e. +3

Explanation: The Na is +1 and the O's are all -2. So solve the following for x

$$+1 + x + 3(-2) = 0$$

You get $x = +5$ which is the oxidation number for M

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14. Any regular car (fueled by gasoline) has a battery in it. What are the metal or metals that provide the potential?

a. silver and gold

●b. lead

c. nickel and cadmium

d. lithium

e. chromium

f. manganese and zinc

Explanation: It's a lead storage battery - aka Pb-acid battery. All the active species are lead-based.

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15. Consider the following redox reaction:

$$Sn^{4+}(aq) + Co(s) \longrightarrow Sn^{2+}(aq) + Co^{2+}(aq)$$

What is the oxidizing agent?

●a. Sn^{4+}

b. Co

c. Sn^{2+}

d. Co^{2+}

Explanation: The oxidizing agent is the species being reduced, which is Sn^{4+} being reduced to Sn^{2+}.

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16. Which of the following is true for secondary cells?

I. The battery reaction can only go in the forward direction.

II. This battery can be recharged.

III. A NiMH battery is a popular secondary cell

IV. When power runs out or low, you can add more fuel to it to recharge it.

●a. II and III only

b. I, III, and IV only

c. III and IV only

d. I only

e. I and II only

f. I, II, and IV only

g. III only

Explanation: I. only going forward is a primary cell property, so no. IV. refueling is what you do with fuel cells, not secondary cells. Only II and III are true of secondary cells.

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17. What is the oxidizing agent in an alkaline cell?

a. H_2O (l)

b. Mn_2O_3 (s)

●c. MnO_2 (s)

d. ZnO (s)

e. Zn (s)

Explanation: The overall reaction for an alkaline cell is $2MnO_2 + Zn \longrightarrow Mn_2O_3 + ZnO$ Mn changes its oxidation state from +4 to +3 and is thus reduced and the oxidizing agent is the reactant that itself undergoes reduction. It's the reactant that "takes away" electrons.

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18. Consider the following four half reactions only. Which one should you use to get the maximum voltage for a voltaic cell when paired with the Ag^+/Ag half reaction as the cathode?

$$Pd^{2+} + e^- \longrightarrow Pd$$
$$Mg^{2+} + 2e^- \longrightarrow Mg$$
$$Au^+ + e^- \longrightarrow Au$$
$$Al^{3+} + 3e^- \longrightarrow Al$$

a. Pd^{2+}| Pd

b. Al^{3+}| Al

●c. Mg^{2+}| Mg

d. Au^+| Au

Explanation: The potential will be the Ag^+—Ag cell at +0.80 V MINUS the other half reaction. To get the maximum out, we need to pick the most negative redox couple listed. That would be the Mg^{2+}—Mg electrode at -2.36 V.

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19. What is the cell potential for the following nonstandard cell?

$$\text{Cu} \mid \text{Cu}^{2+}\ (1\text{M}) \mid\mid \text{Ag}^{+}(0.0018\text{M}) \mid \text{Ag}$$

a. 0.332 V

●b. 0.298 V

c. 0.379 V

d. 0.622 V

e. 0.460 V

f. 0.718 V

Explanation: $E° = +0.8 - +0.34 = +0.46$ V. $Q = \frac{1}{0.0018^2}$ and $n = 2$

$E = 0.46 - 0.05916/2 \log(\frac{1}{0.0018^2})$

$E = 0.298$ V

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20. How long will it take to deposit 0.0132 moles of solid promethium (Pm, atomic number 61) by the electrolysis of $Pm(NO_3)_3(aq)$ using a current of 1.59 A?

a. 30 minutes

b. 35 minutes

c. 45 minutes

●d. 40 minutes

e. 25 minutes

Explanation: First note that the oxidation number of promethium is +3 in the aqueous solution given, so when it gets reduced to solid promethium, 3 moles of electrons will be transfered. Now use $t = \frac{mol \cdot n \cdot F}{I} = \frac{0.0132(3)(96485)}{1.59}$ $= 2400$ s $= 40$ minutes

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After you are finished and have all your answers circled, go to the front of the room and then use the QR code show below to pull up the virtual answer page for your exam. Enter the appropriate info plus all your answers - click the SUBMIT button. Double check your choices on the next page. Once your are sure, click the submit button on that page to enter your answers. Make sure you get the confirmation screen (different background color!) and show it to the TA or proctor. After that, turn in your exam and scratch paper. You're free to leave after that.

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