1																	18
1 H 1.008	2											13	14	15	16	17	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	3	4	5	6	7	8	9	10	11	12	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)

$F_2(g) + 2\ e^- \rightleftharpoons 2\ F^-(aq)$	+2.87 V
$Ce^{4+}(aq) + e^- \rightleftharpoons Ce^{3+}(aq)$	+1.61 V
$Cl_2(g) + 2\ e^- \rightleftharpoons 2\ Cl^-(aq)$	+1.36 V
$O_2(g) + 4\ H^+(aq) + 4\ e^- \rightleftharpoons 2\ H_2O(\ell)$	+1.23 V
$Pd^{2+}(aq) + 2\ e^- \rightleftharpoons Pd(s)$	+0.92 V
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80 V
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77 V
$Cu^{2+}(aq) + 2\ e^- \rightleftharpoons Cu(s)$	+0.34 V
$\mathbf{2\ H^+(aq) + 2\ e^- \rightleftharpoons H_2(g)}$	**0.00 V**
$Fe^{3+}(aq) + 3\ e^- \rightleftharpoons Fe(s)$	−0.04 V
$Pb^{2+}(aq) + 2\ e^- \rightleftharpoons Pb(s)$	−0.13 V
$Ni^{2+}(aq) + 2\ e^- \rightleftharpoons Ni(s)$	−0.23 V
$Fe^{2+}(aq) + 2\ e^- \rightleftharpoons Fe(s)$	−0.44 V
$Zn^{2+}(aq) + 2\ e^- \rightleftharpoons Zn(s)$	−0.76 V
$Al^{3+}(aq) + 3\ e^- \rightleftharpoons Al(s)$	−1.66 V
$Li^+(aq) + e^- \rightleftharpoons Li(s)$	−3.05 V
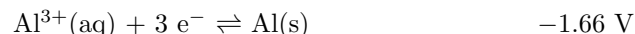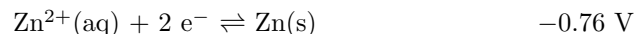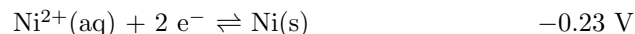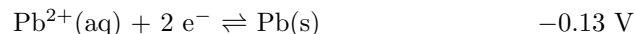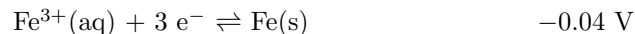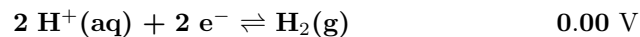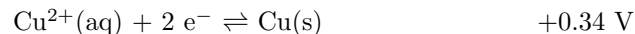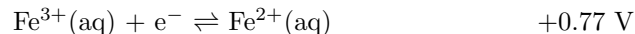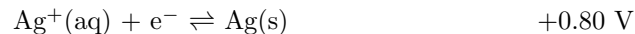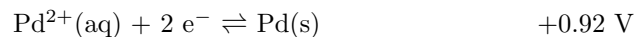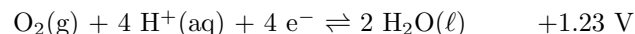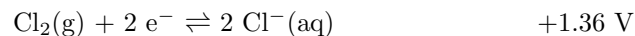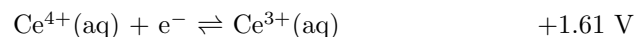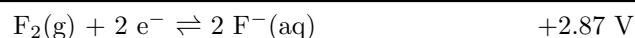
This extra practice set can be used to test your knowledge for the upcoming exam.

1. Conceptually, Faraday's law tells us that the number of moles of metal plated is equal to the charge applied divided by the charge required to plate one mole of metal. How much charge will it take to plate out one mole of cobalt metal from Co^{2+} ions?

●a. 2×96485 C

b. 96485 C

c. $N_a \times 96485$ C

d. 3×96485 C

Explanation: This is asking for the denominator of Coulomb's law, which is the amount of charge required to plate on mole of cobalt. This is simply: nF or 2×96485 C .

---

2. What drives a voltaic cell?

●a. the spontaneity of the redox reaction

b. the push of electrons from cathode to anode

c. the external power source

d. the heat supplied by the chemical reaction

Explanation: A voltaic cell is driven by the spontaneity of the redox reaction.

---

3. Suppose you set up what will be a fully functional electrochemical cell using two beakers with aqueous solutions, electrodes, and a salt bridge. Just before connecting the wires, you think about the cell you created for a bit. Which of the following statements is false?

a. The spontanous reaction will occur when you connect the wires.

b. The cell will run as a voltaic cell if you do not provide any voltage.

c. You can turn this into an electrolytic cell if you provide a sufficient amount of voltage.

●d. You cannot run the nonspontaneous reaction, even if you supply a power source.

Explanation: The cell you made can be run forwards (spontaneous) and backwards (nonspontaneous). However, you must supply a sufficient amount of voltage to run the nonspontaneous reaction.

---

4. The standard cell potential and the number of electrons transferred are matched below for four different electrochemical cells. Which cell will provide the greatest amount of electrical work (energy)?

a. $E° = 3.95$ V, $n = 1$

b. $E° = 0.58$ V, $n = 6$

●c. $E° = 1.38$ V, $n = 4$

d. $E° = 1.55$ V, $n = 3$

Explanation: Electrical work depends on both the standard potential and the number of electrons transferred. Multiply these two values. The highest energy will be provided by $E° = 1.38$ V, $n = 4$. You could also calculate $\Delta G = nFE$ for each cell to get an exact answer.

---

5. What is the balanced redox equation represented by the following shorthand notation:

$$Pt \,|\, H_2 \,|\, H^+ \,||\, Al^{3+} \,|\, Al$$
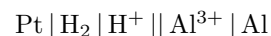
a. $2H^+ + 2Al \rightleftharpoons 3H_2 + 2Al^{3+}$

b. $2H_2 + 3Al^{3+} \rightleftharpoons 2H^+ + 3Al$

c. $H_2 + Al^{3+} \rightleftharpoons H^+ + Al$

●d. $3H_2 + 2Al^{3+} \rightleftharpoons 6H^+ + 2Al$

e. $6H^+ + 2Al \rightleftharpoons 3H_2 + 2Al^{3+}$

Explanation: Write the half-reactions:

$H_2 \rightleftharpoons 2H^+ + 2e^-$

$Al^{3+} + 3e^- \rightleftharpoons Al$
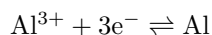
multiply each reaction reach the least common multiple for the number of electrons, which would be 6 in this case:

$3H_2 + 2Al^{3+} \rightleftharpoons 6H^+ + 2Al$
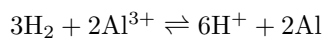
6. What are the oxidation numbers of Na, S, and O in Na_2SO_3?

a. Na = 2, S = 2, O = -2

● b. Na = 1, S = 4, O = -2

c. Na = 1, S = 2, O = -2

d. Na = 2, S = 2, O = -6

e. Na = 2, S = 4, O = -6

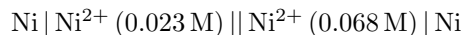**Explanation:** It should be known that the oxidation number on Na is 1 and oxygen is -2. From there, calculate the oxidation number of sulfur:

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

x = 4

---

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

$$Ni \,|\, Ni^{2+}\,(0.023\,M) \,||\, Ni^{2+}\,(0.068\,M) \,|\, Ni$$

a. -202 mV

b. -216 mV

c. 27.9 mV

d. -13.9 mV

● e. 13.9 mV

f. -27.9 mV

Explanation: $E = -\frac{0.05916}{n} \times \log\frac{[Ni^{2+}]_{anode}}{[Ni^{2+}]_{cathode}}$

$0.0139257204\,V = -\frac{0.05916}{(2)} \times \log\frac{0.023}{0.068}$

$= 13.9$ mV

---

8. Looking at two half-reactions on a reduction potential table, how can you determine the roles of each reaction in an electrolytic cell?

a. The cathode is the stronger reduction reaction and the anode is the weaker reduction reaction.

● b. The cathode is the weaker reduction reaction and the anode is the stronger reduction reaction.

c. There is no way to know.

Explanation: For an electrolytic cell, you want to run the nonspontaneous reaction. This means your anode is the reaction that wants to pull electrons (stronger reduction reaction) and the cathode is the species that wants to push electrons (weaker reduction reaction = stronger oxidation reaction for the reverse reaction). Following this logic will always get you a negative cell potential for a standard cell.

---

9. You wish to electroplate 1.00 g of gold on a piece of jewelry from a concentrated solution of Au^{3+} ions. What current is needed to achieve the reaction in 10 hours?

a. 27.2 mA

b. 147 mA

c. 102 mA

d. 1.36 mA

● e. 40.8 mA

Explanation: Use Faraday's law: $\frac{I \cdot t}{n \cdot F} = mol\,metal$

mol Au $= 1.00$ g $\times \frac{mol}{196.97\,g}$

$= .005076915$ mol Au

$n = 3$

$F = 96485$
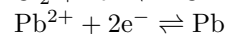
$t = 36000$

Rearrange to solve for current, I:

$I = \frac{(.005076915)(3)(96485)}{36000}$

$I = .0408\,A = 40.8\,mA$

---

10. What is the voltage of a standard voltaic cell made from the following two half reactions:

$$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$$
$$Pb^{2+} + 2e^- \rightleftharpoons Pb$$
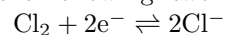
a. -1.26 V

● b. 1.49 V

c. 0.31 V

d. 3.03 V

e. 1.26 V

Explanation: Arrange the half-reactions to give you a positive cell potential:

1.49 V = 1.36 V - (-0.13 V)

11. Which of the following factors is the *main* one that governs the maximum amount of current that a battery can deliver?

a. the salt used in the salt bridge

b. the working voltage of the battery

c. the conductance of the metal electrodes

d. the concentration of the electrolyte

● e. the surface area of the electrodes

Explanation: More electrons can be passed at one time (electric current) when there is more active surface from which to transfer. Increasing surface area will increase the maximum current possible for any battery.

---

12. Elements in their standard state have an oxidation number equal to...

a. the column in the periodic table for metals and eight minus the column in the periodic table for nonmetals

b. the column in the periodic table

● c. 0

d. +1 for monatomics and +2 for diatomics

Explanation: The oxidation number for all elements in their standard state is equal to zero.

---

13. Which type of battery uses the chemistry shown in the following shorthand notation?

$Zn(s) \,|\, ZnOH(s) \,|\, KOH(aq) \,||$

$$KOH(aq) \,|\, Mn_2O_3(s) \,|\, MnO_2(s) \,|C(s)$$
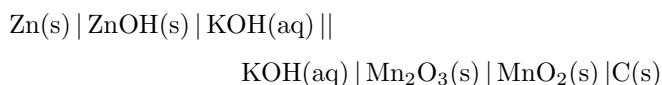
a. NiCd

● b. alkaline cell

c. car battery

d. fuel cell

e. lithium ion

Explanation: This reaction is the chemistry for the alkaline cells.

---

14. What is the maximum amount of electrical work (energy) that can be obtained from the following cell?

$$Fe \,|\, Fe^{3+} \,||\, Pd^{2+} \,|\, Pd$$
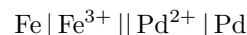
● a. 556 kJ

b. 92.6 kJ

c. 5.76 kJ

d. 278 kJ

e. 185 kJ

Explanation: You need to determine the standard cell potential and the number electrons transferred before plugging into the equation:

$$\Delta G = nFE^\circ = (6)(96485)(0.96)$$

Then convert to kJ to get 556 kJ. '

---

15. Looking at two half-reactions on a reduction potential table, how can you determine the roles of each reaction in a voltaic cell?

a. The cathode is the weaker reduction reaction and the anode is the stronger reduction reaction.

● b. The cathode is the stronger reduction reaction and the anode is the weaker reduction reaction.

c. There is no way to know.

Explanation: For a voltaic cell, you want to run the spontaneous reaction. This means your cathode is the reaction that wants to pull electrons (stronger reduction reaction) and the anode is the species that wants to push electrons (weaker reduction reaction = stronger oxidation reaction for the reverse reaction). Following this logic will always get you a positive cell potential for a standard cell.

**16.** Which of these is NOT a characteristic you would want for the primary cells powering your television remote?

●a. The cell rapidly discharges its full potential.

b. The cell maintains a stable voltage for as long as possible.

c. The cell has a surface area proportional to the amount of current you want to provide to an external circuit.

d. The cell is voltaic.

Explanation: The incorrect statement here is that the cell rapidly discharges. Ideally, the cell will supply a constant current for as long as possible.
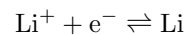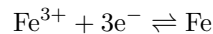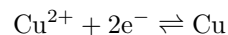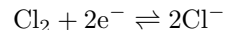
---

17. The lead acid battery (aka car battery) has lead in various oxidation states and compounds. Which of the following species listed is the *active* material at the cathode of a lead acid battery as it is being discharged?

a. $PbSO_4(s)$

●b. $PbO_2(s)$

c. $Pb(s)$

d. $Pb^{2+}(aq)$

e. $Pb_2O_3(s)$

Explanation: The cathode reaction is:

$PbO_2(s) + 3H^+(aq) + HSO_4^-(aq) + 2e^- \rightarrow$
$$PbSO_4(s) + 2H_2O(\ell)$$

---
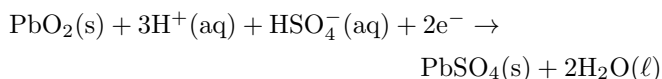
18. What is the standard potential of the strongest voltaic cell you can make using the following half reactions?

$$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$$
$$Cu^{2+} + 2e^- \rightleftharpoons Cu$$
$$Fe^{3+} + 3e^- \rightleftharpoons Fe$$
$$Li^+ + e^- \rightleftharpoons Li$$
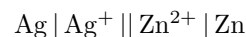
Note: use the standard potentials as your reference for "strongest."

a. 3.05 V

b. 1.36 V

c. 5.40 V

●d. 4.41 V

e. 1.40 V

f. -1.36 V

Explanation: Select the Cl_2 half reaction as your cathode and Li as your anode:

4.41 V= 1.36 V - (-3.05 V)

---

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

$$Ag \,|\, Ag^+ \,||\, Zn^{2+} \,|\, Zn$$

●a. -1.56 V

b. 1.56 V

c. 2.36 V

d. -0.72 V

e. -2.36 V

Explanation: Identify the anode and cathode and solve for the potential. It is worth recognizing from the shorthand notation and half reactions that this is an electrolytic cell.

-1.56 V = -0.76 V -(+0.80 V)

---

20. (part 1 of 2): Consider the electrochemical cell diagram shown below which is running spontaneously with the electron flow direction as shown. Choose the answer the correctly identifies the salt bridge and the flow of cations in cell compartment n.
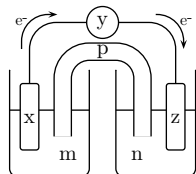
a. y = salt bridge; cations flow towards z

●b. p = salt bridge; cations flow towards z

c. p = salt bridge; cations flow towards p

d. $x + y + z$ = salt bridge; cations do not flow

e. m = salt bridge; cations flow towards x

Explanation: p = salt bridge; cations will flow towards the cathode which has to be the z component due to the fact electrons are flowing towards it in the external circuit

---

21. (part 2 of 2): For the previously shown cell diagram, what is the assigned charge on the component labeled x

●a. negative

b. positive

c. no charge

Explanation: Electrons always travel from anode to cathode. For the diagram given, the electrons travel from x (anode) to z (cathode). For a voltaic cell (it says spontaneous electron flow), the anode is negative (x) and the cathode is positive (z).

---

22. Which of the following half reactions would require an inert electrode?

a. $Li^+(aq) + e^- \rightleftharpoons Li(s)$

b. $Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$

●c. $F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$

d. $Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$

e. $Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$

Explanation: The purpose of an inert electrode is to provide a conductive metal to a reaction that does not inherently involve a conductive solid metal. Out of these choices, this corresponds to:

$F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$

---
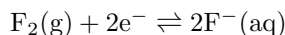
23. In acidic conditions, iron(II) oxide and dichromate will react to form iron(III) ions and chromium ions as shown in the unbalanced redox equation below:

$$FeO + Cr_2O_7^{2-} \rightleftharpoons Fe^{3+} + Cr^{3+}$$
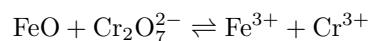
What is the sum of the two coefficients of the product cations (Fe^{3+} and Cr^{3+}) in the properly balanced equation?
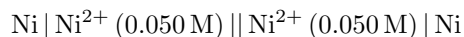
●a. 8

b. 6

c. 2

d. 3

e. 4

Explanation: Start with the half-reactions and follow the steps:

1. Balance the iron and chromium

2. Balance oxygen with water

3. Balance hydrogen with H^+

4. Balance the charges on the left and right of the half-reactions with electrons

5. Balance the half-reactions with the least common multiple of the number of electrons

The balanced equation is:

$26H^+ + 6FeO + Cr_2O_7^{2-} \rightleftharpoons 6Fe^{3+} + 2Cr^{3+} + 13H_2O$
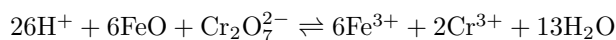
24. Consider the following concentration cells:

$$\text{Pd} \,|\, \text{Pd}^{2+} \,(0.050\,\text{M}) \,||\, \text{Pd}^{2+} \,(0.050\,\text{M}) \,|\, \text{Pd}$$

$$\text{Ni} \,|\, \text{Ni}^{2+} \,(0.050\,\text{M}) \,||\, \text{Ni}^{2+} \,(0.050\,\text{M}) \,|\, \text{Ni}$$
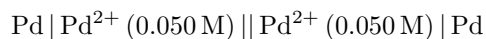
Will the palladium concentration cell have a potential stronger than, weaker than, or equal to the nickel concentration cell?

● a. equal to

b. stronger than

c. weaker than

Explanation: The potential of a concentration cell is strictly concentration-dependent, as long as the charges on compared ions are equal. Both the palladium and nickel cells will have the same potential.

---

25. Identify the change in oxidation number for nitrogen in the conversion of N_2 to NO_2^-. Is this process a reduction or oxidation?

a. +6, reduction

● b. +3, oxidation

c. +4, reduction

d. +4, oxidation

e. -3, reduction

f. +5, oxidation

Explanation: N_2 is a standard state diatomic with an oxidation number equal to 0. Nitrogen has an oxidation state equal to +3 in nitrite (-1 = 3 + 2(-2)). This corresponds to an oxidation reaction.

Remember to bubble in ALL your answers BEFORE time is called. Double check your name, uteid, and version number before you turn in your bubblesheet. You must keep your exam for future reference. Please do not lose it. We will not replace it.