Name _____

Period ___ Date ___/___/___

21 • Electrochemistry

NChO Practice Problems

1985

43. The chemical reaction taking place in a dry cell may be written

$$Zn(s) + 2H^+(aq) + 2MnO_2(s) \rightarrow Zn^{2+}(aq) + 2MnO(OH).$$

The battery is to be discarded after 2.00 g of zinc is converted to $Zn^{2+}(aq)$. If 0.0100 amperes of current is continuously drawn, for how many seconds can the battery operate?

a) [(65.4) (0.0100)] ÷ [(2) (96,500)]
b) [(2) (96,500)] ÷ [(0.0100) (65.4)]
c) [(2) (65.4) (96,500)] ÷ (0.0100)
d) [(2.00) (2) (96,500)] ÷ [(65.4) (0.0100)]

44. In the oxidation-reduction reaction

$Sn^{4+} + 2\ Fe^{2+} \rightarrow 2\ Fe^{3+} + Sn^{2+}$

a) Sn^{4+} is the oxidizing agent and Fe^{2+} is the reducing agent.
b) Sn^{4+} is the reducing agent and Fe^{2+} is the oxidizing agent.
c) Sn^{4+} is the reducing agent and Fe^{3+} is the oxidizing agent.
d) Fe^{3+} is the oxidizing agent and Sn^{2+} is the reducing agent.

45. Given the standard reduction potentials

$Cu^{2+} + 2e^- \rightleftharpoons Cu(s)$ E° = +0.34 Volt

$Al^{3+} + 3e^- \rightleftharpoons Al(s)$ E° = -1.66 Volt

Calculate the standard voltage for the reaction

$2Al(s) + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu(s)$

a) -1.22 Volt b) +2.00 Volt
c) +4.34 Volt d) +5.86 Volt

1986

46. Given the standard electrode (reduction) potentials:

$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s)$ E° = -0.40 v

$Ag^+(aq) + e^- \rightarrow Ag(s)$ E° = +0.80 v

What would be the E° for a cadmium-silver cell?

a) 0.4 v b) 0.5 v
c) 1.2 v d) 2.0 v

48. A current of 10.0 amperes flows for 2.00 hours through an electrolytic cell containing a molten salt of metal x. This results in the decomposition of 0.250 mole of metal x at the cathode. The oxidation state of x in the molten salt is

a) 1+ b) 2+ c) 3+ d) 4+

49. In a voltaic cell, oxidation occurs at the

a) anode
b) cathode
c) salt bridge
d) electrode at which electrons enter from the outside

50. The free energy change for the chemical reaction that occurs in a voltaic cell when it is discharging and producing an electric current must be

a) positive b) negative
c) zero d) unpredictable

1988

34. In the reaction

$$SO_2 + 2\ H_2S \rightarrow 3\ S + 2\ H_2O$$

a) sulfur is oxidized and hydrogen is reduced
b) sulfur is reduced and there is no oxidation
c) sulfur is reduced and hydrogen is oxidized
d) sulfur is both reduced and oxidized

35. Which group among the representative (main-group) elements contains the most powerful oxidizing agent?

a) group I b) group III
c) group VI d) group VII

36. The following standard electrode (reduction) potentials refer to aqueous solution at 25°C.

$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$ E° = - 0.25 V

$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$ E° = + 0.34 V

$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ E° = + 0.77 V

What is the standard potential for the reaction $Cu^{2+}(aq) + Ni(s) \rightleftharpoons Cu(s) + Ni^{2+}(aq)$?

a) 0.09 V b) 0.59 V
c) 0.86 V d) 1.02 V

37. Which ion, in solution, can be oxidized by appropriate chemical means but also can be reduced by a different chemical reaction?

a) Fe^{2+} b) F^-
c) CO_3^{2-} d) NO_3^-

1989

49. Zinc reacts with dilute acid to produce H_2 and Zn^{2+} but silver does not liberate hydrogen from an acid. This information enables one to predict that

a) $H_2(g) + Zn^{2+}(aq) \rightarrow 2H^+(aq) + Zn(s)$
b) $2\ Ag(s) + Zn^{2+}(aq) \rightarrow 2Ag^+(aq) + Zn(s)$
c) $2\ Ag^+(aq) + Zn(s) \rightarrow 2Ag(s) + Zn^{2+}(aq)$
d) $2\ Ag(s) + 2H^+(aq) \rightarrow H_2(g) + 2\ Ag+(aq)$

50. In the electroplating of silver from cyanide solution the cathode reaction is

$Ag(CN)_2^-(aq) + e- \rightarrow Ag(s) + 2CN^-(aq)$

How many grams of silver should be deposited by a current of 4.50 amperes in 28.0 minutes?

a) 0.141 g b) 4.23 g
c) 8.45 g d) 12.53 g

1990

17. For the reaction shown below, which statement is true? $2Fe + 3\ CdCl_2 \rightleftharpoons 2\ FeCl_3 + 3Cd$

a) Fe is the oxidizing agent
b) Cd undergoes oxidation
c) Cd is the reducing agent
d) Fe undergoes oxidation

19. What is the potential in volts for the spontaneous reaction between the Ag/Ag^{2+} and Zn/Zn^{2+} half-cells?

$Zn^{2+} + 2e^- \rightarrow Zn$	E° = -0.763V
$Ag^+ + 1e^- \rightarrow Ag$	E° = 0.799V

a) -2.361 b) -1.562
c) 1.562 d) 2.361

1991

47. Given the standard reduction potentials,

$Cr^{3+} + 3e^- \rightarrow Cr$	-0.74 V
$Pb^{2+} + 2e^- \rightarrow Pb$	-0.13 V

what is the standard potential, E°, for the following reaction?

$2\ Cr + 3\ Pb^{2+} \rightarrow 2\ Cr^{3+} + 3\ Pb$

a) 0.61 V b) 0.87 V
c) 1.09 V d) 1.87 V

Half-cell reaction	E°
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	-0.25 V
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	+0.34 V

65. When two half-cells are connected using a salt bridge,

a) a galvanic cell will result in which Cu is the cathode
b) a galvanic cell will result in which Cu is the anode
c) an electrolytic cell will result in which Ni is the cathode
d) an electrolytic cell will result in which Ni is the anode

1992

58. Corrosion of ships can be minimized by attaching a "sacrificial plate" of zinc to the hull. This plate corrodes instead of the steel of the ship because
    a) the zinc behaves as a cathode, and is oxidized to zinc ions.
    b) the zinc behaves as an anode, and is oxidized to zinc ions.
    c) the steel hull behaves as a cathode, and is reduced to iron ions.
    d) the steel hull behaves as an anode, and is reduced to iron ions.

59. A spoon is made the cathode in an electroplating apparatus containing a $AgNO_3$ solution. How many grams of Ag will be plated on the spoon if a current of 2.00 A is passed through the apparatus for 1.90 min.?
    a) 0.255 g b) 0.150 g
    c) 0.128 g d) 0.0638 g

60. A cell is set up using the following reactions:

$$Zn \mid Zn^{2+}\ (0.5M) \parallel Ni^{2+}\ (0.1\ M) \mid Ni$$

$$Ni^{2+} + 2e^- \rightarrow Ni \quad E° = -0.250\ V$$

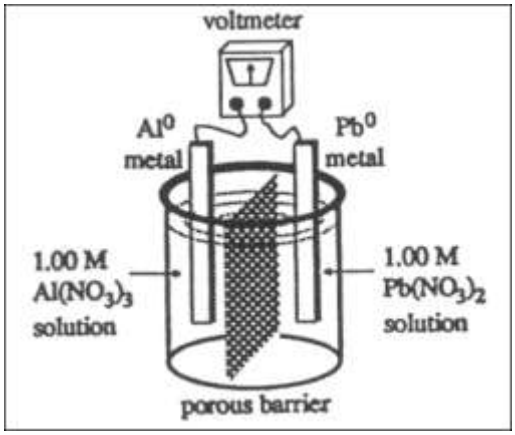
$$Zn^{2+} + 2e^- \rightarrow Zn \quad E° = -0.763\ V$$

What is the voltage of the cell?
    a) -0.513 V b) -1.013 V
    c) 0.492 V d) 0.513 V

1993

67. How many grams of cobalt metal will be deposited when a solution of cobalt(II) chloride is electrolyzed with a current of 10. amperes for 109 minutes?
    a) 0.66 b) 4.0
    c) 20 d) 40

66. What voltage will be produced by the electrochemical cell?



Reduction Potentials

$$Pb^{2+} + 2e^- \rightarrow Pb \quad -0.13\ V$$

$$Al^{3+} + 3e^- \rightarrow Al \quad -1.68\ V$$

    a) 2.97V b) 1.55V
    c) -1.81V d) -2.97V

1994

46. If solid nickel metal were added to separate aqueous solutions each containing 1M concentrations of Ag^+, Cd^{2+}, and Sn^{2+} ions, how many metals would plate out, based on the given standard reaction potentials?

Standard Reduction Potentials

Ag^+/Ag	0.799 V
Sn^{2+}/Sn	-0.141 V
Ni^{2+}/Ni	-0.236 V
Cd^{2+}/Cd	-0.400 V

    a) zero b) one
    c) two d) three

48. Solutions of Ag^+, Cu^{2+}, Fe^{3+} and Ti^{4+} are electrolyzed with a constant current until 0.10 mol of metal is deposited. Which will require the greatest length of time?
    a) Ag^+ b) Cu^{2+}
    c) Fe^{3+} d) Ti^{4+}

1996

43. Use these reduction potentials to determine which one of the reactions below is spontaneous.

Reaction	Reduction Potentials, E°
$Ag^+ + e^- \rightarrow Ag$	0.800 V
$Pb^{2+} + 2e^- \rightarrow Pb$	- 0.126 V
$V^{2+} + 2e^- \rightarrow V$	- 1.18 V

a) $V^{2+} + 2\ Ag \rightarrow V + 2\ Ag^+$
b) $V^{2+} + Pb \rightarrow V + Pb^{2+}$
c) $2\ Ag^+ + Pb^{2+} \rightarrow 2\ Ag + Pb$
d) $2\ Ag^+ + Pb \rightarrow 2\ Ag + Pb^{2+}$

44. It is possible to produce chlorine gas by electrolyzing any of these chlorine-containing compounds under the proper conditions. Which compound will require the smallest number of coulombs to produce one mole of chlorine?

a) $Ca(OCl)_2$ b) $NaClO_2$
c) $KClO_3$ d) $Mg(ClO_4)_2$

1997

43. What is the function of H_2O_2 in this reaction?

$6H^+ + 2MnO_4^- + 5H_2O_2 \rightarrow 2Mn^{2+} + 5O_2 + 8H_2O$

a) catalyst b) reducing agent
c) oxidizing agent d) inhibitor

44. How much hydrogen is produced from the electrolysis of water in the same time that 2.2 L of oxygen is formed?

a) 0.14 L b) 1.1 L
c) 2.2 L d) 4.4 L

45. Which of these changes will cause the value of the potential for this half-reaction to be less negative? (E° = -0.28 V for the reaction.)

$Co^{2+}(aq) + 2\ e^- \rightarrow Co(s)$

a) increasing the amount of solid Co
b) decreasing the amount of solid Co
c) increasing the concentration of $Co^{2+}(aq)$
d) decreasing the concentration of $Co^{2+}(aq)$

1998

40. For this reaction, $E°_{cell} = 0.79$ V.

$6I^-(aq) + Cr_2O_7^{2-}(aq) + 14H^+ \rightarrow 3I_2(aq) + 2Cr^{3+}(aq) + 7H_2O(aq)$

Given that the standard reduction potential for $Cr_2O_7^{2-}(aq) \rightarrow 2Cr^{3+}(aq)$ is 1.33 V, what is $E°_{red}$ for $I_2(aq)$?

a) +0.54 V b) -0.54 V
c) +0.18 V d) -0.18 V

41. What is the product formed at the anode in the electrolysis of 1.0 M $NaNO_3(aq)$?

a) $H_2(g)$ b) $NO_2(g)$
c) $O_2(g)$ d) Na(s)

42. Which of these ions is the best reducing agent?

Standard Reduction Potentials, E°	
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77 V
$Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$	+0.15 V

a) Fe^{3+} b) Fe^{2+}
c) Cu^{2+} d) Cu^+

43. $Zn(s) + Cl_2(g, 1\ atm) \rightleftharpoons Zn^{2+}(aq, 1\ M) + 2Cl^-(aq, 1\ M)$

An electrochemical cell based on this reaction has a cell voltage, E°, of 2.12 V. Which change could make the cell voltage greater than 2.12 V?

a) add more Zn(s)
b) add more $Cl^-(aq)$ ions
c) decrease the concentration of $Zn^{2+}(aq)$ ions
d) decrease the partial pressure of Cl_2

Answers:

1985	43 d, 44 a, 45 b
1986	46 c, 48 c, 49 a 50 b
1988	34 d, 35 d, 36 b, 37 a
1989	49 c, 50 c
1990	17 d, 19 c
1991	47 a, 65 b
1992	58 b, 59 a, 60 c
1993	67 c, 66 b
1994	46 c, 48 d
1996	43 d, 44 a
1997	43 b, 44 d, 45 c
1998	40 a, 41 c, 42 d, 43 c