Unit 3 Multiple Choice Practice

1. According to the balanced equation above, how many moles of the permanganate ion are required to react completely with 25.0 ml of 0.100 M hydrogen peroxide?

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

a. 0.000500 mol
b. 0.00100 mol
c. 0.00500 mol
d. 0.00625 mol

$0.025\ L \times 0.1\ M = 0.0025\ mol\ H_2O_2 \times \frac{2\ MnO_4^-}{5\ H_2O_2} = 0.001\ mol\ MnO_4^-$

2. A chemist wants to plate out 29 g of solid nickel from a solution containing aqueous $Ni(NO_3)_2$. Approximately how many moles of electrons must be transferred to produce that mass of solid nickel?

a. 0.25 mol e^-
b. 1.0 mol e^-
c. 0.50 mol e^-
d. 1.5 mol e^-

Ni^{2+}

$29\ g\ Ni \times \frac{1\ mol\ Ni}{58.69\ g} \times \frac{2\ mol\ e^-}{1\ mol\ Ni} = 0.99\ mol\ e^-$

3. A balanced equation for the reaction of copper metal with nitric acid is shown below. Which of the following represents a true statement about the reaction?

$$3\,Cu(s) + 8\,H^+(aq) + 2\,NO_3^-(aq) \rightarrow 3\,Cu^{2+}(aq) + 4\,H_2O(l) + 2\,NO(g)$$

$\emptyset$ $+1$ $+5, -2$ $+2$ $+1, -2$ $+2, -2$

a. The oxidation state of nitrogen changed from +5 to +2.
b. Hydrogen ions are oxidized to form $H_2O(l)$.
c. The oxidation state of oxygen changes from −1 to −2.
d. Copper metal is reduced to a copper (II) ion.

4. Molten $GaCl_3$ is electrolyzed with a constant current of 1.30 amperes over a period of 2.00 minutes. Which of the following expressions is equal to the maximum mass of Ga(s) that plates out? (1 faraday = 96,500 coulombs)

Ga^{3+}

a. $\frac{(120)(1.30)}{(96{,}500)(3)(69.7)}$ grams
b. $\frac{(120)(1.30)(3)(69.7)}{(96{,}500)}$ grams
c. $\frac{(120)(1.30)(69.7)}{(96{,}500)(3)}$ grams
d. $\frac{(96{,}500)(3)(69.7)}{(120)(1.30)}$ grams

$2.00\ min \times \frac{60\ sec}{1\ min} \times \frac{1.30\ C}{sec} \times \frac{mol\ e^-}{96{,}485\ C} \times \frac{1\ mol\ Ga}{3\ mole^-} \times \frac{69.72\ g}{1\ mol}$

$Cr^{3+}(aq) + 3\,e^- \rightarrow Cr(s)$ $\quad E^\circ_{red} = -0.74\ V$

flip! $Fe^{2+}(aq) + 2\,e^- \rightarrow Fe(s)$ $\quad E^\circ_{red} = -0.44\ V$ $\quad E^\circ_{ox} = +0.44V$

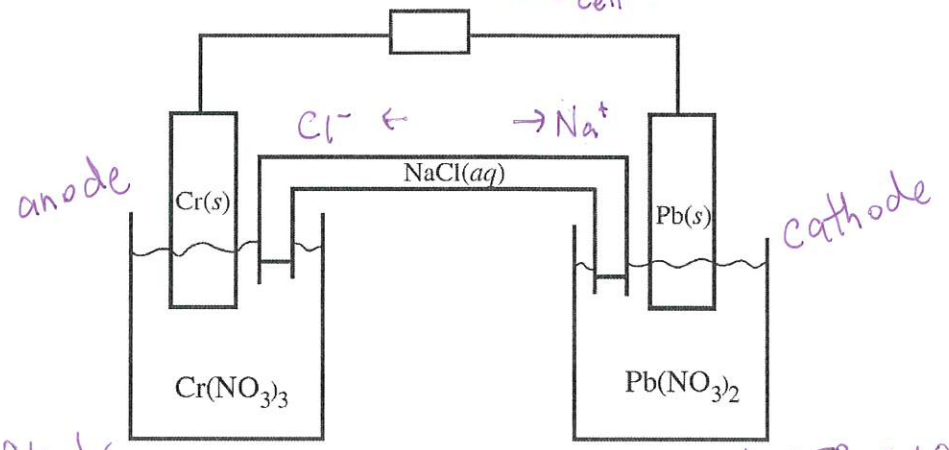
5. Based on the reduction potentials given above, what is the reaction potential for the following reaction?

$$3\,Fe(s) + 2\,Cr^{3+}(aq) \rightarrow 3\,Fe^{2+}(aq) + 2\,Cr(s)$$

a. -0.16 V (b.) -0.30 V c. $+0.16$ V d. $+0.30$ V

$0.44 - 0.74 = -0.30V$

Use the diagram below to answer the questions 6 - 8. A voltaic cell is created using the half-cells shown below. The concentrations of the solutions in each half-cell are 1.0 M. E°_{cell} +



flip! $Cr^{3+} + 3e^- \rightarrow Cr(s)$ $\quad E^\circ = -0.41\ V$ $\Rightarrow E^\circ_{ox} = +0.41$

cathode → $Pb^{2+} + 2e^- \rightarrow Pb(s)$ $\quad E^\circ = -0.12\ V$

6. Which of the following occurs at the cathode? red cat

a. Cr^{3+} is reduced to Cr(s). c. Cr(s) is oxidized to Cr^{3+}.

(b.) Pb^{2+} is reduced to Pb(s). d. Pb(s) is oxidized to Pb^{2+}.

7. Which of the following best describes the activity in the salt bridge as the reaction progresses?

a. Electrons flow through the salt bridge from the Pb/Pb^{2+} half-cell to the Cr/Cr^{3+} half-cell.

b. Pb^{2+} flows to the Cr/Cr^{3+} half-cell, and Cr^{3+} flows to the Pb/Pb^{2+} half-cell.

c. Na^+ flows to the Cr/Cr^{3+} half-cell, and Cl^- flows to the Pb/Pb^{2+} half-cell.

(d.) Na^+ flows to the Pb/Pb^{2+} half-cell, and Cl^- flows to the Cr/Cr^{3+} half-cell.

8. Which of the following statements applies to the change in mass of the electrodes involved in this electrochemical cell?

a. Cr(s) is the cathode and it gains mass since metal ions are being converted to metal atoms which often adhere to the electrode.

(b.) Pb(s) is the cathode and it gains mass since metal ions are being converted to metal atoms which often adhere to the electrode.

c. Cr(s) is the anode and it gains mass since metal ions are being converted to metal atoms which often adhere t the electrode.

d. Pb(s) is the anode and it gains mass since metal ions are being converted to metal atoms which often adhere to the electrode.

$Cu^{2+}(aq) + 2\,e^- \rightarrow Cu(s)$ $\quad E^\circ_{red} = +0.34\ V$

$Zn^{2+}(aq) + 2\,e^- \rightarrow Zn(s)$ $\quad E^\circ_{red} = -0.76\ V$

$Mn^{2+}(aq) + 2\,e^- \rightarrow Mn(s)$ $\quad E^\circ_{red} = -1.18\ V$

9. Based on the reduction potentials given above, which of the following reactions will be thermodynamically favored?

⇒ E°_{cell} +

a. $Mn^{2+}(aq) + Cu(s) \rightarrow Mn(s) + Cu^{2+}(aq)$

b. $Mn^{2+}(aq) + Zn(s) \rightarrow Mn(s) + Zn^{2+}(aq)$

c. $Zn^{2+}(aq) + Cu(s) \rightarrow Zn(s) + Cu^{2+}(aq)$

(d.) $Zn^{2+}(aq) + Mn(s) \rightarrow Zn(s) + Mn^{2+}(aq)$ $\quad E^\circ_{cell} = 1.18 - 0.76 = +$

10. A chemist wants to plate out 98 g of solid titanium from a solution containing Ti_2S_3. Approximately how many moles of electrons must be transferred to produce that much solid titanium?

(Ti_2S_3: Ti^{3+})

a. 2.0 mol e^- c. 4.0 mol e^-

b. 3.0 mol e^- (d.) 6.0 mol e^-

$98\ g\ Ti \times \frac{1\ mol\ Ti}{47.9\ g} \times \frac{3\ mol\ e^-}{1\ mol\ Ti}$

E_{cell} $\quad Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$

11. A galvanic cell based on the reaction represented above was constructed from zinc and copper half-cells. The observed voltage was found to be 0.22 volt instead of the standard cell potential, E°, of 1.25 volts. Which of the following could correctly account for this observation?

$E_{cell} < E^\circ_{cell}$

⇒ ↑ Q

(A.) The cell had been running for a period of time.

B. The standard free energy of the cell, ΔG°, is negative.

(C.) The Cu^{2+} solution was less concentrated than the Zn^{2+} solution.

D. The Zn^{2+} solution was less concentrated than the Cu^{2+} solution.

Oops! Two answers

+1, -2 +7, -2 +3, -2 +4, -2 +7, -2 -2, +1

$2\,H_2O(l) + 4\,MnO_4^-(aq) + 3\,ClO_2^-(aq) \rightarrow 4\,MnO_2(aq) + 3\,ClO_4^-(aq) + 4\,OH^-(aq)$

12. Which species is reduced in the reaction represented above?

a. MnO_2 b. ClO_2^- (c.) MnO_4^- d. ClO_4^-

$3Ni \rightarrow 3Ni^{2+} + 6e^-$

13. In the reaction below, a piece of solid nickel is added to a solution of potassium dichromate.

$14\,H^+(aq) + Cr_2O_7^{2-}(aq) + 3\,Ni(s) \rightarrow 2\,Cr^{3+}(aq) + 3\,Ni^{2+}(aq) + 7\,H_2O(l)$

1 : 3

How many moles of electrons are transferred when 1 mole of potassium dichromate is mixed with 3 mol of nickel?

a. 2 moles of electrons c. 5 moles of electrons

b. 3 moles of electrons (d.) 6 moles of electrons

14. Calculate the standard free energy of the following reaction at 25°C.

$$Fe^{2+}(aq) + Mg(s) \rightarrow Fe(s) + Mg^{2+}(aq) \qquad E°_{cell} = 1.92\ V$$

$\Delta G = -nFE°_{cell}$

$= -(2)(96,485)(1.92)$

a. $3.7 \times 10^5\ J/mol_{rxn}$

(c.) $-3.7 \times 10^5\ J/mol_{rxn}$

b. $1.6 \times 10^3\ J/mol_{rxn}$

d. $-1.6 \times 10^3\ J/mol_{rxn}$

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

15. A thermodynamically favorable cell, utilizing the reaction shown above, ran for 45 minutes. What happens to the measured voltage and why?

(A.) The measured voltage decreases over time because deviations in concentration that bring the cell closer to equilibrium will decrease the magnitude of the cell potential.

B. The measured voltage increases over time because deviations in concentration that bring the cell closer to equilibrium will increase the magnitude of the cell potential.

C. The measured voltage increases over time because $[Mn^{2+}]$ increases as the cell runs.

D. The measured voltage remains constant because $E°_{cell}$ is an intensive property.

16. Given the following half reactions:

flip! $Sn^{4+} + 2e^- \rightarrow Sn^{2+}$ $\quad E° = 0.15\ V$ $\Rightarrow E°_{ox} = -0.15\ V$

$Fe^{3+} + 1e^- \rightarrow Fe^{2+}$ $\quad E° = 0.77\ V$ $= E°_{red}$

Determine the standard cell potential ($E°_{cell}$) for the voltaic cell based on the reaction

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

$E°_{cell} = 0.77 - 0.15$

(a.) +0.62 V

b. +0.92 V

c. −0.62 V

d. −0.92 V

17. A chemist wants to plate out 1.00 g of solid iron from a solution containing aqueous $Fe(NO_3)_3$. Which of the following expressions will equal the amount of time, in seconds, it takes if a current of 2.00 A is applied?

(Fe^{3+})

a. $\frac{(3)(55.85)(2.00)}{(96{,}500)}$ seconds

(b.) $\frac{(3)(96{,}500)}{(55.85)(2.00)}$ seconds

c. $\frac{(55.85)(96{,}500)}{(3)(2.00)}$ seconds

d. $\frac{(3)(55.85)(96{,}500)}{(2.00)}$ seconds

$1.00\ g\ Fe \times \frac{1\ mol\ Fe}{55.85\ g} \times \frac{3\ mol\ e^-}{1\ mol\ Fe} \times \frac{96{,}485\ C}{1\ mol\ e^-} \times \frac{1\ sec}{2\ C}$

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

oxidized

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

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

a. +0.54 V
b. −0.54 V
c. +2.12 V
d. −2.12 V

$E°_{cell} = E°_{ox}(I^-) + E°_{red}(Cr_2O_7^{2-})$

$0.79 = E°_{ox} + 1.33$

$\Rightarrow E°_{ox}(I^-) = 1.33 - 0.79 = +0.54 \Rightarrow E°_{red} = -0.54$ V

19. If 0.060 faraday is passed through an electrolytic cell containing a solution of Ni^{2+} ions, the maximum number of moles of Ni that could be deposited at the cathode is

a. 0.020 mol
b. 0.030 mol
c. 0.060 mol
d. 0.12 mol

$0.060\ \mathcal{F} \Rightarrow 0.060\ mol\ e^- \times \frac{1\ mol\ Ni}{2\ mol\ e^-}$

20. If a gold sample containing some silver impurity is to be purified by electrolysis, the anode and the cathode must be which of the following?

	Anode	Cathode
a.	Pure gold	Pure silver
b.	Pure silver	Pure gold
c.	Pure gold	Impure gold sample
d.	Impure gold sample	Pure gold
e.	Impure gold sample	Pure silver

Cu^{2+}

21. Which expression below should be used to calculate the mass of copper that can be plated out of a 1.0 M $Cu(NO_3)_2$ solution using a current of 0.75 A for 5.0 min?

a. $\frac{(5.0)(60)(0.75)(63.55)}{(96{,}500)(2)}$
b. $\frac{(5.0)(60)(63.55)(2)}{(0.75)(96{,}500)}$
c. $\frac{(5.0)(60)(96{,}500)(0.75)}{(63.55)(2)}$
d. $\frac{(5.0)(60)(96{,}500)(63.55)}{(0.75)(2)}$

$5.0\ min \times \frac{60\ sec}{1\ min} \times \frac{0.75\ C}{sec} \times \frac{1\ mol\ e^-}{96{,}485\ C} \times \frac{1\ mol\ Cu}{2\ mol\ e^-} \times \frac{63.55\ g}{1\ mol}$

22. Which of the following statements is true about the reaction below?

$2\ Ag^+(aq) + Cu(s) \rightleftharpoons 2\ Ag(s) + Cu^{2+}(aq)$ $\quad K_{eq} = 3.7 \times 10^{15}$

$K > 1 \Rightarrow$ fav.

a. $E°$ and $\Delta G°$ are both positive.
c. $E°$ is positive and $\Delta G°$ is negative.
b. $E°$ and $\Delta G°$ are both negative.
d. $E°$ is negative and $\Delta G°$ is positive.

23. In the reaction

$+4,-2 \quad +1,-2 \quad \phi \quad +1,-2$

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

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

24. Which of these ions is most easily oxidized?

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

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

25. What is the oxidation number of manganese in the $KMnO_4$?

$(+1) + x + 4(-2) = \phi$

$x - 7 = \phi$

a. +1
b. +2
c. +5
d. +7

26. When this reaction is balanced, the coefficient on the Sn^{2+} is.

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

a. 1
b. 2
c. 3
d. 4

$(Sn^{4+} + 2e^- \rightarrow Sn^{2+}) \times 3$

$(Cr \rightarrow Cr^{3+} + 3e^-) \times 2$