1. Consider a voltaic cell constructed from the following half cells, linked by an external circuit and by a KCl salt bridge. -an Ag(s) electrode in 1.0 M $AgNO_3$ solution -a Ni(s) electrode in 1.0 M $Ni(NO_3)_2$ solution----- The balanced overall (net) cell reaction is:

- A. $2Ag(s) + Ni^{2+}(aq) \rightarrow Ag^{2+}(aq) + Ni(s)$
- B. $Ag(s) + Ni(s) \rightarrow Ag+(aq) + Ni^{2+}(aq)$
- C. $Ag^{+}(aq) + Ni(s) \rightarrow Ag(s) + Ni^{2+}(aq)$
- D. $2Ag^{+}(aq) + Ni(s) \rightarrow Ni^{2+}(aq) + 2Ag(s)$

---

2. Calculate the $E°_{cell}$ for a cell consisting of -a zinc electrode in 1.0M $ZnSO_4$ -a copper electrode in a 1.0M $CuSO_4$

- A. 1.10 V
- B. -1.10 V
- C. 0.34 V
- D. -0.76 V

---

3. Calculate the standard cell emf for the following cell. $Zn \mid Zn^{2+} \mid\mid Br^{-}(l) \mid Br_2(aq) \mid Pt$

- A. 0.32 V
- B. 1.83 V
- C. -0.32 V
- D. 1.08 V
- E. -1.08 V

---

4. Given the following standard reduction potentials in acid solution:

	E°(V)
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	-1.66
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$	+0.14
$I_2(s) + 2e^- \rightarrow 2I^-(aq)$	+0.53

Which is the most likely to gain electrons?

- A. $Al^{3+}(aq)$
- B. Al(s)
- C. $I^-(aq)$
- D. $I_2(s)$
- E. $Sn^{4+}(aq)$

5. Which one of the following reactions must be carried out in an electrolytic cell, rather than a voltaic cell?

- A. $Zn + Cd^{2+} \rightarrow Cd + Zn^{2+}$
- B. $Al + 3/2\ Br_2 \rightarrow Al^{3+} + 3Br^-$
- C. $2Al^{3+} + 3Fe \rightarrow 2Al + 3Fe^{2+}$
- D. $H_2 + I_2 \rightarrow 2H+ + 2I^-$

---

6. The half-reaction that occurs at the anode during electrolysis of aqueous $CuSO_4$ solution is:

- A. $Cu+ + e- \rightarrow Cu$
- B. $Cu^{2+} + e- \rightarrow Cu$
- C. $2H_2O + 2e- \rightarrow H_2 + OH-$
- D. $2H_2O \rightarrow O_2 + 4H^+ + 4e-$

---

7. Consider the following balanced redox reaction: $3CuO(s) + 2NH_3(aq) \rightarrow N_2(g) + 3H_2O(l) + 3Cu(s)$ Which of the following is true?

- A. CuO(s) is the reducing agent and Cu is oxidized
- B. CuO(s) is the reducing agent and Cu is reduced
- C. CuO(s) is the oxidizing agent and Cu is reduced
- D. CuO(s) is the reducing agent and Cu is oxidized

---

8. Which is most easily reduced?

- A. $KMnO_4$
- B. MnO_2
- C. $MnCl_2$
- D. Mn

---

9. In a cell constructed of Cd^{2+}/Cd and Ni^{2+}/Ni and operating under standard conditions:

- A. the cell voltage is zero
- B. the ΔG for the cell is zero

- C. the ΔG for the cell is positive
- D. the ΔG for the cell is negative

---

10. Given the following notation for an electrochemical cell $Zn|Zn^{2+}$ (1M)$||Fe^{2+}$ (1M), Fe^{3+} (1M)|Pt what is the balanced overall (net) cell reaction?

- A. $Zn + 2Fe^{3+} \text{---> } 2Fe^{2+} + Zn^{2+}$
- B. $Zn^{2+} + 2Fe^{2+} \text{---> } Zn + 2Fe^{3+}$
- C. $Zn + 2Fe^{2+} \text{---> } 2Fe^{3+} + Zn^{2+}$
- D. $Zn + Fe^{3+} \text{---> } Fe^{2+} + Zn^{2+}$

---

11. Examine the following half-reactions and select the strongest oxidizing agent among the substances. $Sr^{2+}(aq) + 2e^- \rightarrow Sr(s) E° = -2.89$ V, $Cr^{2+}(aq) + 2e^- \rightarrow Cr(s) E° = -0.913$ V, $Fe^{2+}(aq) + 2e^- \text{---> } Fe(s) E° = -0.447$ V, $Co^{2+}(aq) + 2e^- \rightarrow Co(s) E° = -0.28$ V

- A. $Cr^{2+}(aq)$
- B. Sr^{2+}
- C. Co^{2+}
- D. Fe^{2+}

---

12. The value of the equilibrium constant for the reaction of nickel(II) ions with cadmium metal is 1.17×10^5. Calculate ΔG for the reaction at 25 °C.

- A. -12.6 kJ
- B. -29.8 kJ
- C. 0 kJ
- D. 29.8 kJ
- E. 12.6 kJ

---

13. A constant current was passed through a solution of $AuCl_4^-$ ions between gold electrodes. After a period of 20 min, the cathode increased in mass by 2.664 g. What was the current, I?

- A. 1.08 A
- B. 3.26 A
- C. 2.17 A

- D. 6.52 A
- E. 3.48 A

---

14. How many grams of the product formed at the cathode in the electrolysis of an aqueous solution of cupric chloride will be produced by a current of 1 A operating for 4 hours?

- A. 2.3 g
- B. 4.7 g
- C. 6.9 g
- D. 8.0 g

---

15. How many Faradays would be required to reduce 1 mole of MnO_4^- to Mn^{+2}?

- A. 1
- B. 2
- C. 3
- D. 5
- E. 7

---

16. A redox reaction that involves the transfer of 3 electrons has a net cell potential of +0.34 V. For this reaction, the value of DG^o is: (F= 96.5 kJ/V)

- A. -98.4 kJ/mol
- B. -32.8 kJ/mol
- C. +98.4 kJ/mol
- D. +32.8 kJ/mol
- E. -8.30 kJ/mol

---

17. Given the following set of half-reactions and reduction potentials, write the net cell reaction for the spontaneous change that will occur and calculate the net cell potential.
$Pb^{+2}(aq) + 2e^-$ º $Pb(s)$ $E^o = -0.13$ V
$Mg^{+2}(aq) + 2e^-$ º $Mg(s)$ $E^o = -2.37$ V

- A. $Pb^{+2}(aq) + Mg(s)$ 6 $Pb(s) + Mg^{+2}(aq)$, $E^o = 2.24$ V
- B. $Pb^{+2}(aq) + Mg(s)$ 6 $Pb(s) + Mg^{+2}(aq)$, $E^o = 2.50$ V

C. $Mg^{+2}(aq) + Pb(s)$ 6 $Mg(s) + Pb^{+2}(aq)$, $E^o = 2.24$ V

D. $Mg^{+2}(aq) + Pb(s)$ 6 $Mg(s) + Pb^{+2}(aq)$, $E^o = 2.50$ V

E. $Mg^{+2}(aq) + Pb^{+2}(aq)$ 6 $Mg(s) + Pb(s)$, $E^o = 2.24$ V

---

18. If the equilibrium constant K is greater than 1 for a given reaction, the value of) G^o will be _____ and ^{o} will be _____.

A.) G^o = positive, E^o = positive

B.) G^o = negative, E^o = negative

C.) G^o = positive, E^o = negative

D.) G^o = negative, E^o = positive

E.) $G^o = 0$, $E^o = 0$

---

19. Sketch a ***voltaic cell*** based on the half-reactions:
$Ni^{+2}(aq) + 2e^-$ º $Ni(s)$ $E^o = -0.25$ V
$Cr^{+3}(aq) + 3e^-$ º $Cr(s)$ $E^o = -0.74$ V
In this voltaic cell,

A. The Cr electrode decreases in mass as the spontaneous reaction occurs.

B. Electrons flow through the external wire from the cathode to the anode.

C. The Ni electrode carries a negative potential.

D. Ni(s) is oxidized as the spontaneous reaction occurs.

E. The cathode carries a negative potential

---

20. How long does it take to plate 0.800 g of silver onto a serving tray from an aqueous solution of $AgNO_3$ at a current of 5.00 A?

A. 48 seconds

B. 1.19 minutes

C. 2.38 min

D. 4.76 min

E. 5.92 min

---

21. A Redox reaction which involves the transfer of 2 electrons has an equilibrium constant $K = 5.40 \times 10^6$. For this reaction, $)G^o = ?$.

- A. $)G^o = +19.2$ kJ/mol
- B. $)G^o = -19.2$ kJ/mol
- C. $)G^o = +38.4$ kJ/mol
- D. $)G^o = -38.4$ kJ/mol
- E. $)G^o = +76.8$ kJ/mol

---

22. A voltaic cell consists of Mn/Mn^{2+} and Cd/Cd^{2+} half-cells with an initial cell potential of +0.768 V. The $[Mn^{2+}]$ concentration is 0.500 M. Use the Nernst equation to calculate the $[Cd^{2+}]$ concentration in the Cd/Cd^{2+} half-cell.
$Cd^{+2}(aq) + 2e^-$ º $Cd(s)$ $E^o = -0.40$ V
$Mn^{+2}(aq) + 2e^-$ º$Mn(s)$ $E^o = -1.18$ V

- A. 0.010 M
- B. 0.050 M
- C. 0.20 M
- D. 0.50 M
- E. 0.25 M

---

23. The value of the equilibrium constant K_{eq} is 1.8×10^{17} for a redox reaction that involves the transfer of 3 electrons. What is the standard cell potential in a voltaic cell involving this redox reaction? (Faraday's constant is 9.65×10^4 J/V)

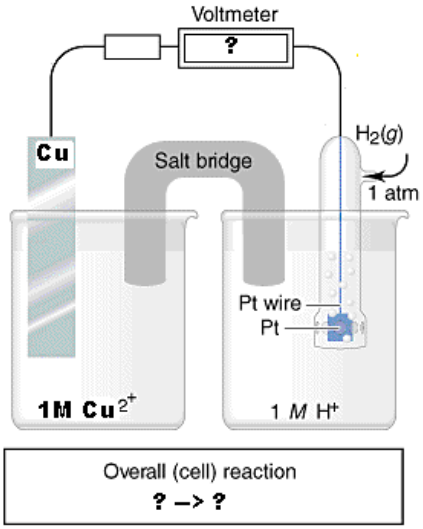
- A. -1.20 V
- B. -0.68 V
- C. +0.12 V
- D. +0.34 V
- E. +1.20 V

---

24. In an electrolytic cell, a current of 3.00 A is passed through an aqueous solution of aluminum chloride for a period of 5.00 min. What volume of chlorine gas would be formed at the anode at 25ºC and 1.00 atm?

- A. 4.61 L
- B. 1.24 L
- C. 456 mL
- D. 228 mL
- E. 114 mL

25. In the voltaic cell below, the hydrogen reference electrode is coupled with a Cu^{2+}/Cu half-cell. If the Cu^{2+}/Cu half-cell is coupled with a Zn^{2+}/Zn half-cell ($E^{o}_{half\text{-}cell}$ = -0.76 V), the net cell potential is 1.10 V. The Cu^{2+}/Cu half-cell has a more positive reduction potential than the Zn^{2+}/Zn half-cell. Based on this information, which of the following statements correctly describes the figure below.



A. The overall cell reaction is $Cu(s) + 2H^{+}(aq)$ Õ $Cu^{2+}(aq) + H_2(g)$ with platinum serving as the cathode in the hydrogen reference electrode.

B. The overall cell reaction is $Cu(s) + 2H^{+}(aq)$ Õ $Cu^{2+}(aq) + H_2(g)$ and the voltmeter reads +1.86 V.

C. The overall cell reaction is $Cu^{2+}(aq) + H_2(g)$ Õ $Cu(s) + 2H^{+}(aq)$ and the voltmeter reads +0.34 V.

D. The copper electrode serves as the anode and carries a negative potential.

E. Electrons travel through the external wire from the copper electrode into the hydrogen reference electrode resulting in a negative potential on the platinum electrode