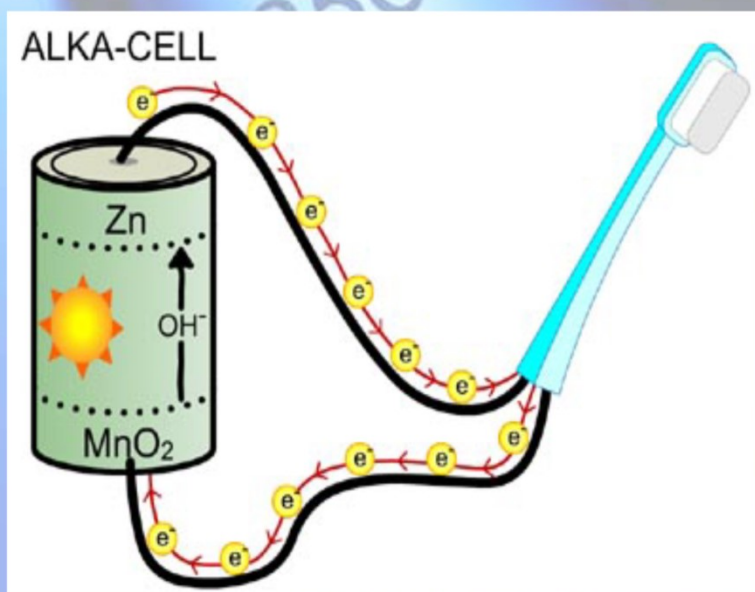# NGSS Regents Chemistry

PRACTICE PACKET

Unit 10: Electrochemistry (Redox)

Assigning Oxidation Numbers   Name_____

Assign oxidation numbers to all of the elements in each of the compounds or ions below.

|	
1. $\overset{+1\ -1}{HCl}$	11. $\overset{+1\ +4\ -2}{H_2SO_3}$
2. $\overset{+1\ +5\ -2}{KNO_3}$ $+1 +5 -6 = 0$	12. $\overset{+1\ +6\ -2}{H_2SO_4}$
3. $\overset{-2\ +1}{OH^-}$ $= -1$ Table E	13. $\overset{+2\ -1}{*MgO_2}$
4. $\overset{+2\ -3}{Mg_3N_2}$ $+6 -6 = 0$	14. $\overset{+1\ +7\ -2}{KMnO_4}$
5. $\overset{+1\ +5\ -2}{KClO_3}$ $+1 +5 -6 = 0$	15. $\overset{+1\ -1}{LiH}$
6. $\overset{+3\ +5\ -2}{Al(NO_3)_3}$ $+15$ $+3 +15 -18 = 0$	16. $\overset{+4\ -2}{MnO_2}$
7. $\overset{0}{S_8}$	17. $\overset{+2\ -1}{OF_2}$
8. $\overset{+1\ -1}{H_2O_2}$	18. $\overset{+6\ -2}{SO_3}$
9. $\overset{+4\ -2}{PbO_2}$	19. $\overset{-3\ +1}{NH_3}$
10. $\overset{+1\ +1\ +6\ -2}{NaHSO_4}$	20. $\overset{0}{Na}$

For each of the following: a) assign oxidation numbers for each element/species; b) indicate the element/species, if any, that are oxidized and reduced..
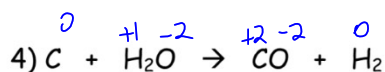
1) $\overset{0}{Zn} + \overset{+2 \; +5 \; -2}{Pb(NO_3)_2} \rightarrow \overset{0}{Pb} + \overset{+2 \; +5 \; -2}{Zn(NO_3)_2}$

$+2 +10 -12 = 0$
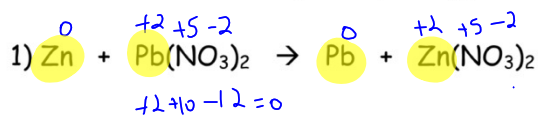
oxidized substance ___Zn^0___

reduced substance ___Pb^{+2}___

2) $\overset{+2 \; +4 \; -2}{Fe(CO_3)} + \overset{+2 \; -2}{CO} \rightarrow \overset{0}{Fe} + 2\overset{+4 \; -2}{CO_2}$

-2
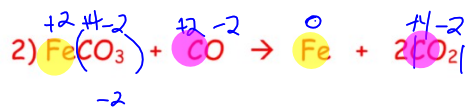
oxidized substance ___C^{+2}___

reduced substance ___Fe^{+2}___

3) $3\overset{0}{H_2} + \overset{0}{N_2} \rightarrow \overset{-3 \; +1}{NH_3}$
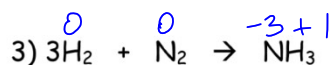
oxidized substance ___H_2^0___

reduced substance ___N_2^0___

4) $\overset{0}{C} + \overset{+1 \; -2}{H_2O} \rightarrow \overset{+2 \; -2}{CO} + \overset{0}{H_2}$

oxidized substance ___C^0___

reduced substance ___H_2^{+1}___
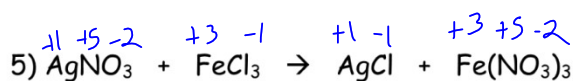
5) $\overset{+1 \; +5 \; -2}{AgNO_3} + \overset{+3 \; -1}{FeCl_3} \rightarrow \overset{+1 \; -1}{AgCl} + \overset{+3 \; +5 \; -2}{Fe(NO_3)_3}$

oxidized substance ___Nothing___

reduced substance ___Nothing___

6) $\overset{+1 \; +4 \; -2}{H_2CO_3} \rightarrow \overset{+1 \; -2}{H_2O} + \overset{+4 \; -2}{CO_2}$

oxidized substance ___nothing___

reduced substance ___nothing___

7) $\overset{+2 \; -1}{FeBr_2} + \overset{0}{Br_2} \rightarrow \overset{+3 \; -1}{FeBr_3}$
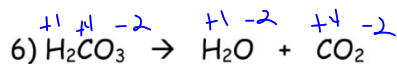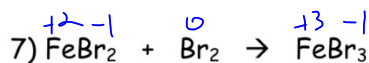
oxidized substance ___Fe^{+2}___

reduced substance ___Br^0___

8) $\overset{+4 \; -2}{MnO_2} + 4\overset{+1 \; -1}{HCl} \rightarrow \overset{+2 \; -1}{MnCl_2} + \overset{0}{Cl_2} + 2\overset{+1 \; -2}{H_2O}$
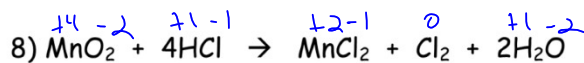
oxidized substance ___Cl^{-2}___

reduced substance ___Mn^{+4}___
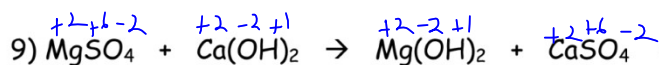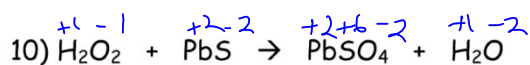
9) $\overset{+2 \; +6 \; -2}{MgSO_4} + \overset{+2 \; -2 \; +1}{Ca(OH)_2} \rightarrow \overset{+2 \; -2 \; +1}{Mg(OH)_2} + \overset{+2 \; +6 \; -2}{CaSO_4}$

oxidized substance ___nothing___

reduced substance ___nothing___

10) $\overset{+1 \; -1}{H_2O_2} + \overset{+2 \; -2}{PbS} \rightarrow \overset{+2 \; +6 \; -2}{PbSO_4} + \overset{+1 \; -2}{H_2O}$

oxidized substance ___S^{2-}___

reduced substance ___O^{-1}___

11) $\overset{+1 \; -1}{KCl} + \overset{+1 \; +6 \; -2}{H_2SO_4} \rightarrow \overset{+1 \; +1 \; +6 \; -2}{KHSO_4} + \overset{+1 \; -1}{HCl}$

oxidized substance ___nothing___

reduced substance ___nothing___

12) $\overset{+1 \; +5 \; -2}{HNO_3} + \overset{+1 \; +5 \; -2}{K_3PO_4} \rightarrow \overset{+1 \; +5 \; -2}{KNO_3} + \overset{+1 \; +5 \; -2}{H_3PO_4}$

oxidized substance ___nothing___

reduced substance ___nothing___

13) $2\overset{0}{Na} + \overset{0}{Cl_2} \rightarrow 2\overset{+1 \; -1}{NaCl}$
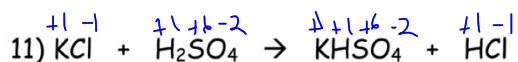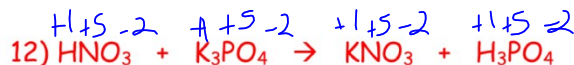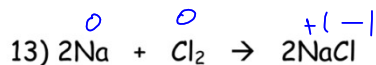
oxidized substance ___Na^0___

reduced substance ___Cl_2^0___

14) $\overset{0}{C}$ + $\overset{+1\ -2}{H_2O}$ → $\overset{+2\ -2}{CO}$ + $\overset{0}{H_2}$ oxidized substance ___$\overset{0}{C}$___

reduced substance ___H^{+1}___
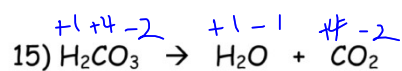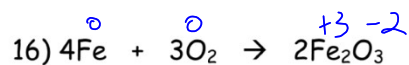
15) $\overset{+1\ +4\ -2}{H_2CO_3}$ → $\overset{+1\ -1}{H_2O}$ + $\overset{+4\ -2}{CO_2}$ oxidized substance ___nothing___

reduced substance ___nothing___

16) $4\overset{0}{Fe}$ + $3\overset{0}{O_2}$ → $2\overset{+3\ -2}{Fe_2O_3}$ oxidized substance ___$\overset{0}{Fe}$___

reduced substance ___$\overset{0}{O_2}$___

17) $2\overset{+1\ +2}{H_2S}$ + $3\overset{0}{O_2}$ → $2\overset{+4\ -2}{SO_2}$ + $2\overset{+1\ -2}{H_2O}$ oxidized substance ___S^{-2}___

reduced substance ___$\overset{0}{O_2}$___

18) $\overset{0}{Fe}$ + $\overset{+2\ +5\ -2}{Pb(NO_3)_2}$ → $\overset{0}{Pb}$ + $\overset{+2\ +5\ -2}{Fe(NO_3)_2}$ oxidized substance ___$\overset{0}{Fe}$___
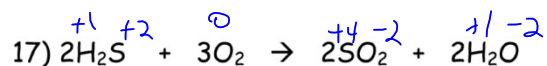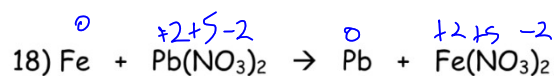
reduced substance ___Pb^{+2}___

State whether $\underset{O}{\text{oxidation}}$ or $\underset{R}{\text{reduction}}$ has occurred in the following half-reactions

19) Mg^{+2} + $2e^-$ → Mg^0 ___R___

20) Al^0 → Al^{+3} + $3e^-$ ___O___

21) Cu^0 → Cu^{+2} + $2e^-$ ___O___

22) Sn^0 → Sn^{+2} + $2e^-$ ___O___

23) Cu^+ + e^- → Cu^0 ___R___

24) Sn^{+4} + $2e^-$ → Sn^{+2} ___R___

25) Zn^0 → Zn^{+2} + $2e^-$ ___O___

26) S^{-2} → S^0 + $2e^-$ ___O___

27) $2O^{-2}$ → O_2 + $4e^-$ ___O___

28) Fe^{+3} + e^- → Fe^{+2} ___R___
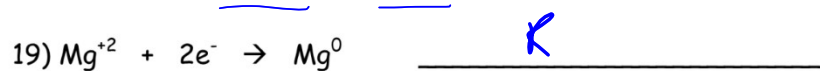
Name _____   Redox Practice

Fill in the appropriate number of electrons in each of the following reactions.

O   R
oxidation or reduction?

1) Hg^{+2} + __$2e^-$__ → Hg^0 __R__

2) Au^0 → Au^{+3} + __$3e^-$__   __O__

3) F_2 + __$2e^-$__ → $2F^-$ __R__
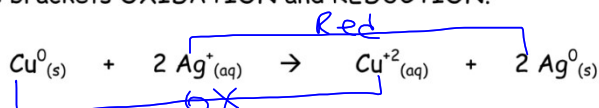
4) Zn^{+2} + __$2e^-$__ → Zn^0 __R__

5) Mn^0 → Mn^{+2} + __$2e^-$__   __O__

6) Cr^0 → Cr^{+3} + __$3e^-$__   __O__

7) Ca^{+2} + __$2e^-$__ → Ca^0 __R__

8) K^+ + __$1e^-$__ → K^0 __R__

9) Sn^{+2} + __$2e^-$__ → Sn^0 __R__

10) Ni^0 → Ni^{+2} + __$2e^-$__   __O__
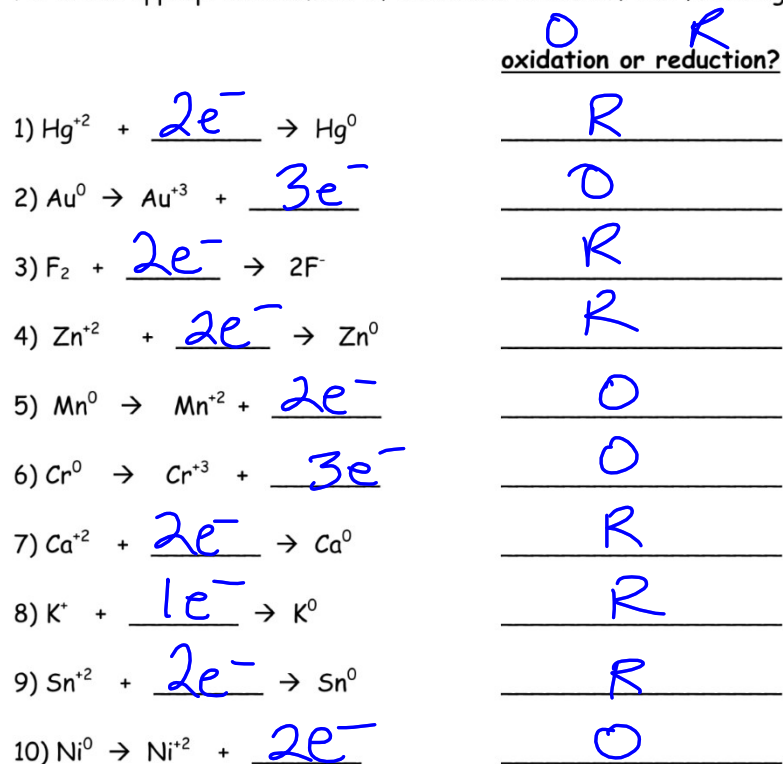
For the following reaction determine what is oxidized and what is reduced. **Draw brackets and label** the brackets OXIDATION and REDUCTION.

Red
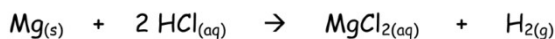
$$Cu^0_{(s)} + 2\,Ag^+_{(aq)} → Cu^{+2}_{(aq)} + 2\,Ag^0_{(s)}$$

OX

Now identify the following within the reaction:

Oxidizing agent __Ag^+__

Reducing agent __$Cu_{(s)}$__

Species being reduced __Ag^+__

Species being oxidized __Cu^0__

Is the following reaction a redox reaction? __Yes__

$$Mg_{(s)} + 2\,HCl_{(aq)} → MgCl_{2(aq)} + H_{2(g)}$$

Explain how you can tell __Single replacement reaction__

_____

Redox Half Reactions   Name _____

For the equations below:
- ① ✓ identify the substance oxidized
- ② ✓ identify the substance reduced
- ✓ identify ~~the oxid~~izing agent
- ✓ identify ~~the reducing age~~nt
- ③ ✓ write both the oxidation and reduction half reaction

1.

$$2\overset{0}{H_2} + \overset{0}{O_2} \rightarrow 2\overset{+1 \ -2}{H_2O}$$

Red (over $H_2 \rightarrow H_2O$)
Ox (under $H_2 \rightarrow H_2O$)

$\overset{Ox}{\longrightarrow}$

$$2\overset{0}{H_2} \rightarrow 2\overset{+1}{H_2} + 2e^-$$

Red

$$\overset{0}{O_2} + 2e^- \rightarrow 2\overset{-2}{O}$$

2.

$$\overset{0}{Fe} + \overset{2+}{Zn^{2+}} \rightarrow \overset{}{Fe^{2+}} + \overset{0}{Zn}$$

Red (over $Zn^{2+} \rightarrow Fe^{2+}$)
Ox (under $Fe \rightarrow Fe^{2+}$)

$$Fe^0 \overset{Ox}{\rightarrow} Fe^{2+} + 2e^-$$

Red

$$Zn^{2+} + 2e^- \rightarrow Zn^0$$

3.

$$2\overset{0}{Al} + 3\overset{2+}{Fe^{2+}} \rightarrow 2\overset{+3}{Al^{+3}} + 3\overset{0}{Fe}$$

Red: $3Fe^{2+} + 6e^- \rightarrow 3Fe^0$

Ox: $2Al^0 \rightarrow 2Al^{+3} + 6e^-$

4.

$$\overset{0}{Cu} + 2\overset{+1}{AgNO_3} \rightarrow \overset{+2}{Cu(NO_3)_2} + 2\overset{0}{Ag}$$

Red: $2Ag^{+1} + 2e^- \rightarrow 2Ag^0$

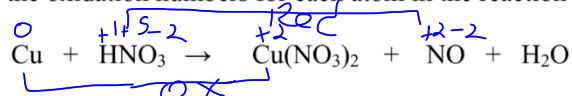Ox: $Cu^0 \rightarrow Cu^{+2} + 2e^-$

Balancing Redox Equations

Balancing redox reactions can be very difficult using the balancing strategies we have learned thus far in class. Redox reactions are tricky because we must *balance* by *mass* and *charge*. This is according to the Law of Conservation of matter and charge. There are five steps that must be followed to balance a redox reaction.
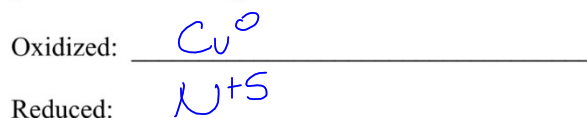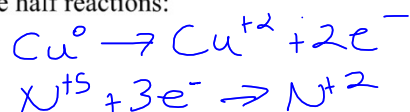
Example: Balance the following reaction

$$Cu + HNO_3 \rightarrow Cu(NO_3)_2 + NO + H_2O$$
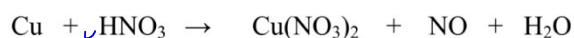
Step 1: Write the oxidation numbers for each atom in the reaction

$$\overset{0}{Cu} + \overset{+1}{H}\overset{+5}{N}\overset{-2}{O_3} \rightarrow \overset{+2}{Cu}(\overset{+5}{N}\overset{-2}{O_3})_2 + \overset{+2}{N}\overset{-2}{O} + H_2O$$

Step 2: Identify the substance being oxidized and reduced.

Oxidized: $\underline{\quad Cu^0 \quad\quad\quad\quad\quad\quad\quad}$
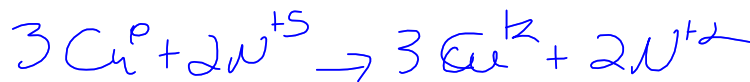
Reduced: $\underline{\quad N^{+5} \quad\quad\quad\quad\quad\quad\quad}$

Step 3: Write the half reactions:

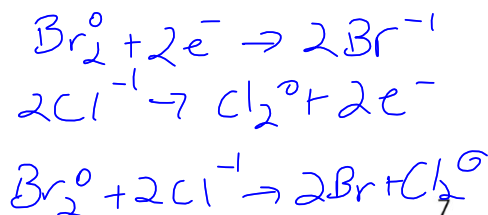$$Cu^0 \rightarrow Cu^{+2} + 2e^-$$
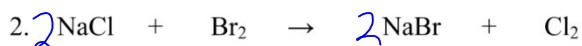$$N^{+5} + 3e^- \rightarrow N^{+2}$$

Step 4: Multiply each half reaction so the electron number is equal in both reactions.

$$3Cu^0 \rightarrow 3Cu^{+2} + 6e^-$$
$$2N^{+5} \rightarrow 6e^- \rightarrow 2N^{+2}$$
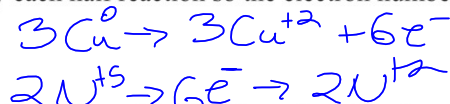
Step 5: Add the two balanced half cell reactions together to write the overall redox reaction.

$$3Cu^0 + 2N^{+5} \rightarrow 3Cu^{+2} + 2N^{+2}$$

Practice: Balance the following redox reactions using the five step procedure outlined above.

1. $\overset{+1}{Cs}\overset{-1}{F} + \overset{0}{Na} \rightarrow \overset{+1}{Na}\overset{-1}{F} + \overset{0}{Cs}$

$$Cs^{+1} + 1e^- \rightarrow Cs^0$$
$$Na^0 \rightarrow Na^{+1} + 1e^-$$
$$Cs^{+1} + Na^0 \rightarrow Cs^0 + Na^{+1}$$

2. $2NaCl + Br_2 \rightarrow 2NaBr + Cl_2$

$$Br_2^0 + 2e^- \rightarrow 2Br^{-1}$$
$$2Cl^{-1} \rightarrow Cl_2^0 + 2e^-$$
$$Br_2^0 + 2Cl^{-1} \rightarrow 2Br + Cl_2^0$$

7

$$\overbrace{\qquad\qquad}^{OX}$$

3. $\overset{+2\,-1}{MgCl_2}$ + $\overset{0}{Cr}$ → $\overset{0}{Mg}$ + $\overset{+3\,-1}{CrCl_3}$

$\underbrace{\qquad\qquad\qquad}_{red}$

Red: $(Mg^{+2} + 2e^- \rightarrow Mg^0) \times 3 \cdots\rightarrow 3Mg^{+2} + 6e^- \rightarrow 3Mg^0$

OX: $(Cr^0 \rightarrow Cr^{3+} + 3e^-) \times 2 \cdots\rightarrow 2Cr^0 \rightarrow 2Cr^{3+} + 6e^-$

$$3Mg^{+2} + 2Cr^0 \rightarrow 3Mg^0 + 2Cr^{3+}$$

4. $\overset{0}{Pb}$ + $\overset{+1\,-1}{AgNO_2}$ → $\overset{+2\,-1}{Pb(NO_2)_2}$ + $\overset{0}{Ag}$

$2Ag^{+1} + 2e^- \rightarrow 2Ag^0$

$Pb^0 \rightarrow Pb^{+2} + 2e^-$

$2Ag^{+1} + Pb^0 \rightarrow 2Ag^0 + Pb^{+2}$

5. Fe^{+2} + Cu^+ → Fe^{+3} + Cu

$Cu^{+1} + 1e^- \rightarrow Cu^0$

$Fe^{+2} \rightarrow Fe^{+3} + 1e^-$

$Cu^{+1} + Fe^{+2} \rightarrow Cu^0 + Fe^{+3}$

6. Cr + $CuBr_2$ → $CrBr_3$ + Cu

$3Cu^{+2} + 6e^- \rightarrow 3Cu^0$

$2Cr^0 \rightarrow 2Cr^{+3} + 6e^-$

$2Cr^0 + 3Cu^{+2} \rightarrow 3Cu^0 + 2Cr^{+3}$

7. Zn + CuO → ZnO + Cu

$Cu^{+2} + 2e^- \rightarrow Cu^0$

$Zn^0 \rightarrow Zn^{+2} + 2e^-$

$Cu^{+2} + Zn^0 \rightarrow Cu^0 + Zn^{+2}$

8. Al + $Cu(NO_3)_2$ → $Al(NO_3)_3$ + Cu

$3Cu^{+2} + 6e^- \rightarrow 3Cu^0$

$2Al^0 \rightarrow 2Al^{+3} + 6e^-$

$3Cu^{+2} + 2Al^0 \rightarrow 3Cu^0 + 2Al^{+3}$

Regents Chemistry   **Activity Series (Table J)**

1. Which ion is most easily reduced?
   A) Ca^{2+} B) Mg^{2+}
   C) Zn^{2+} D) Co^{2+}

2. Which element in Period 3 of the Periodic Table is the strongest reducing agent?
   A) Na   B) S   C) Cl   D) Al

3. Which of the following elements is the poorest reducing agent?
   A) Al   B) Zn   C) Ba   D) H_2

4. Which metal will spontaneously react with Zn^{2+} (aq), but will *not* spontaneously react with Mg^{2+} (aq)?
   A) Ni(s)   B) Ba(s)
   C) Mn(s)   D) Cu(s)

5. Which reaction occurs spontaneously?
   A) $Cl_2(g) + 2NaBr(aq) \rightarrow Br_2(\ell) + 2NaCl(aq)$
   B) $I_2(s) + 2NaF(aq) \rightarrow F_2(g) + 2NaI(aq)$
   C) $I_2(s) + 2NaBr(aq) \rightarrow Br_2(\ell) + 2NaI(aq)$
   D) $Cl_2(g) + 2NaF(aq) \rightarrow F_2(g) + 2NaCl(aq)$

6. Which metal reacts spontaneously with a solution containing zinc ions?
   A) copper   B) nickel
   C) silver   D) magnesium

7. According to Reference Table *J*, which of these metals will react most readily with 1.0 M HCl to produce $H_2(g)$?
   A) K   B) Ca   C) Zn   D) Mg

8. Which metal can replace Cr in Cr_2O_3?
   A) nickel   B) copper
   C) aluminum   D) lead

9. According to Reference Table J, which of these ions is most easily reduced?
   A) Ca^{2+} B) Cu^+ C) Ag^+ D) Cr^{3+}

10. Based on Reference Table J, which metal will react spontaneously with Al^{3+}?
    A) Ca(s)   B) Cu(s)
    C) Cr(s)   D) Co(s)

11. Under standard conditions, which metal will react with 0.1 M HCl to liberate hydrogen gas?
    A) Mg   B) Ag   C) Cu   D) Au

12. Referring to Reference Table J, which reaction will not occur under standard conditions?
    A) $Cu(s) + 2 HCl(aq) \rightarrow CuCl_2(aq) + H_2(g)$
    B) $Ba(s) + 2 HCl(aq) \rightarrow BaCl_2(aq) + H_2(g)$
    C) $Mg(s) + 2 HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
    D) $Sn(s) + 2 HCl(aq) \rightarrow SnCl_2(ag) + H_2(g)$

13. According to the Activity Series, which metal will react spontaneously with hydrochloric acid?
    A) Ag   B) Cu   C) Ni   D) Hg

14. According to Reference Table J, which redox reaction occurs spontaneously?
    A) $2 Ag(s) + 2 H^+ \rightarrow 2 Ag + H_2(g)$
    B) $2 Ag(s) + 2 H^+ \rightarrow 2 Ag^{2+} + H_2(g)$
    C) $Cu(s) + 2 H^+ \rightarrow Cu^{2+} + H_2(g)$
    D) $Mg(s) + 2 H^+ \rightarrow Mg^{2+} + H_2(g)$

15. Based on Reference Table J, which of the following elements will replace Pb from $Pb(NO_3)_2(aq)$?
    A) Au(s)   B) Mg(s)
    C) Ag(s)   D) Cu(s)

16. Due to it having a low activity, which element can be found in nature in the free (uncombined) state?
    A) Ba   B) Al   C) Ca   D) Au

17. According to Reference Table J, which reaction will take place spontaneously?
    A) $Au^{3+} + Al(s) \rightarrow Au(s) + Al^{3+}$
    B) $Fe^{2+} + Cu(s) \rightarrow Fe(s) + Cu^{2+}$
    C) $Ni^{2+} + Pb(s) \rightarrow Ni(s) + Pb^{2+}$
    D) $Sr^{2+} + Sn(s) \rightarrow Sr(s) + Sn^{2+}$

18. Based on Reference Table J, which molecule-ion pair will react spontaneously at 298 K?
    A) $Br_2 + Cl^-$ B) $F_2 + I^-$
    C) $I_2 + Br^-$ D) $Cl_2 + F^-$

Activity Series (Table J)

19. According to Reference Table J, which pair will react spontaneously at 298K?

    A) $Cu + H_2O$ 　　　B) $Au + H_2O$
    C) $Ca + H_2O$ 　　　D) $Ag + H_2O$

20. Based on Reference Table J, which reaction will take place spontaneously?

    A) $Ba(s) + 2 Na^+(aq) \rightarrow Ba^{2+}(aq) + 2 Na(s)$
    B) $Mg(s) + Ca^{2+}(aq) \rightarrow Mg^{2+}(aq) + Ca(s)$
    C) $I_2(g) + 2 Br^-(aq) \rightarrow 2 I^-(aq) + Br_2(g)$
    D) $Cl_2(g) + 2 F^-(aq) \rightarrow 2 Cl^-(aq) + F_2(g)$

21. According to Reference Table J, which atom-ion pair will react spontaneously?

    A) $Zn + Ca^{2+}$ 　　　B) $Ag + Au^{3+}$
    C) $Pb + Co^{2+}$ 　　　D) $Ni + Al^{3+}$

22. According to Reference Table J, which species is the strongest oxidizing agent?

    A) $F_2(g)$ 　　　B) Li^+
    C) F^- 　　　D) $Li(s)$

23. Based on Reference Table J, which metal will *not* react with 1 M HCl?

    A) $Zn(s)$ 　　　B) $Au(s)$
    C) $Ni(s)$ 　　　D) $Sn(s)$

24. Based on Reference Table J, which of the following ions in aqueous solution is most easily oxidized?

    A) Br^-　　B) I^-　　C) F^-　　D) Cl^-

25. According to Reference Table J, which species can reduce Cr^{3+} ions?

    A) Al　　B) Fe^{2+}　　C) Ni　　D) Sn^{2+}

26. According to reference Table J, which reaction will occur spontaneously?

    A) $Ag^+ + Cu(s) \rightarrow Ag(s) + Cu^+$
    B) $Fe^{2+} + Hg(e) \rightarrow Fe(s) + Hg^{2+}$
    C) $Co^{2+} + Cu(s) \rightarrow Co(s) + Cu^{2+}$
    D) $Mg^{2+} + Sn^{2+} \rightarrow Mg(s) + Sn^{4+}$

27. According to Reference Table J, which ion is most easily reduced?

    A) Ni^{2+} 　　　B) Au^{3+}
    C) Mg^{2+} 　　　D) Al^{3+}

28. According to Reference Table J, which metal will react spontaneously with H^+?

    A) Cr　　B) Au　　C) Cu　　D) Ag

29. Lead is a product of the reaction between a solution of lead (II) nitrate and

    A) Cu　　B) Fe　　C) Au　　D) Ag

30. Based on Reference Table J, which oxidation is most likely to occur?

    A) $Au \rightarrow Au^{3+} + 3e^-$
    B) $Ag \rightarrow Ag^{1+} + 1e^-$
    C) $Mg \rightarrow Mg^{2+} + 2e^-$
    D) $Cu \rightarrow Cu^{2+} + 2e^-$

31. According to Reference Table J, which ion will oxidize Fe?

    A) Ca^{2+} 　　　B) Mg^{2+}
    C) Zn^{2+} 　　　D) Cu^{2+}

32. Based on Reference Table J, which of the following elements is the most actively oxidized?

    A) Sr　　B) Cr　　C) Fe　　D) Cu

33. The half-reaction

    $$2 H^+(aq) + 2e^- \rightarrow H_2(g)$$

    will occur when $H^+(aq)$ reacts with

    A) $Hg(\ell)$ 　　　B) $Ag(s)$
    C) $Cu(s)$ 　　　D) $Pb(s)$

34. Based on Reference Table J, which reaction will take place spontaneously?

    A) $2 Au + 6 H^+ \rightarrow 2 Au^{3+} + 3 H_2$
    B) $Cu + 2 H^+ \rightarrow Cu^{2+} + H_2$
    C) $Pb + 2 H^+ \rightarrow Pb^{2+} + H_2$
    D) $2 Ag + 2 H^+ \rightarrow 2 Ag^+ + H_2$

35. According to Reference Table J, which halogen will react spontaneously with Au(s) to produce Au^{3+}?

    A) F_2　　B) I_2　　C) Cl_2　　D) Br_2

Spontaneous reactions (Table J)

Table J in your reference tables is arranged with the most reactive metals at the top of the table and the least reactive metals at the bottom of the table. What this means is that a metal listed on the table will react with the compound of a metal that is below it. For example, Zn is above Cu on the table. This means that Zn will replace Cu in a compound containing. Zn will be oxidized by a compound containing Cu. The Cu^+ ion will be reduced by elemental Zn^0.

The reaction: $Zn + Cu(NO_3)_2 \rightarrow Cu + Zn(NO_3)_2$ will spontaneously occur. The reverse reaction: $Cu + Zn(NO_3)_2 \rightarrow Zn + Cu(NO_3)_2$ will not spontaneously occur.

Please determine if a spontaneous reaction will occur. If one will occur, write the oxidation and reduction ½ reactions.

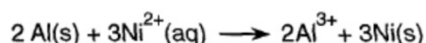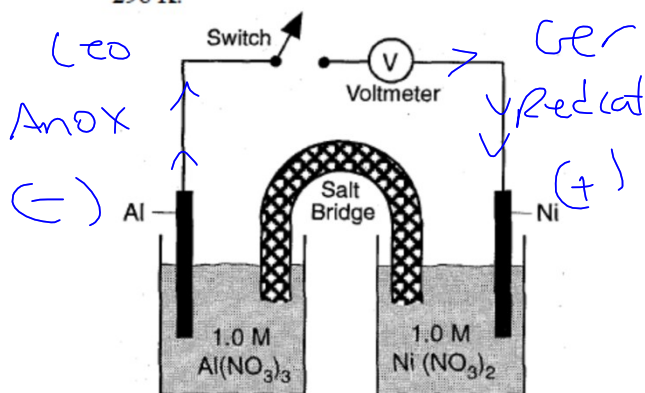1. $Zn + Pb(NO_3)_2 \rightarrow Pb + Zn(NO_3)_2$
    a. Is the reaction spontaneous? ___Yes___
    b. If yes, write the oxidation ½ reaction: $Zn^0 \rightarrow Zn^{+2} + 2e^-$
    c. If yes, write the reduction ½ reaction : $Pb^{+2} + 2e^- \rightarrow Pb^0$

2. $3Zn + 2Al(NO_3)_3 \rightarrow 2Al + 3Zn(NO_3)_2$
    a. Is the reaction spontaneous? ___No___
    b. If yes, write the oxidation ½ reaction: _____
    c. If yes, write the reduction ½ reaction : _____

3. $Ni + 2AgNO_3 \rightarrow 2Ag + Ni(NO_3)_2$
    a. Is the reaction spontaneous?___No___
    b. If yes, write the oxidation ½ reaction: _____
    c. If yes, write the reduction ½ reaction : _____

4. $Ca + 2AgNO_3 \rightarrow Ca(NO_3)_2 + 2Ag$
    a. Is the reaction spontaneous?___Yes___
    b. If yes, write the oxidation ½ reaction: $Ni^0 + Ni^{+2} + 2e^-$
    c. If yes, write the reduction ½ reaction : $2Ag^{+1} + 2e^- \rightarrow 2Ag^0$

5. $Fe + CuCl_2 \rightarrow Cu + FeCl_2$
    a. Is the reaction spontaneous?___Yes___
    b. If yes, write the oxidation ½ reaction: $Fe^0 \rightarrow Fe^{+2} + 2e^-$
    c. If yes, write the reduction ½ reaction : $Cu^{+2} + 2e^- \rightarrow Cu^0$

Regents Chemistry   **Redox: Galvanic/Voltaic Cells**

1. Which component of an electrochemical cell is correctly paired with its function?

   A) salt bridge – allows the solutions to mix
   B) external conductor – permits the migration of ions
   C) external conductor – allows the solutions to mix
   D) salt bridge – permits the migration of ions

2. Discharging a battery involves the process of

   A) redox reactions that produce electricity
   B) hydrolysis reactions that produce energy
   C) hydrolysis reactions that require energy
   D) redox reactions that require electricity

3. The diagram below represents a chemical cell at 298 K.

   Leo
   Anox
   (−)
   Ger
   Redcat
   (+)

   Switch
   V
   Voltmeter
   Al — Salt Bridge — Ni
   1.0 M Al(NO$_3$)$_3$ 1.0 M Ni (NO$_3$)$_2$

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

   When the switch is closed, electrons flow from

   A) Al(s) to Ni(s)
   B) Ni(s) to Al(s)
   C) Ni^{2+}(aq) to Al^{3+}(aq)
   D) Al^{3+}(aq) to Ni^{2+}(aq)

4. Reduction occurs at the cathode in

   A) electrolytic cells, only
   B) both electrolytic cells and voltaic cells
   C) neither electrolytic cells nor voltaic cells
   D) voltaic cells, only

5. A standard zinc half-cell is connected to a standard copper half cell by means of a wire and a salt bridge. Which electronic equation represents the oxidation reaction that takes place?

   A) $Zn^0 - 2e^- \rightarrow Zn^{2+}$
   B) $Zn^{2+} + 2e^- \rightarrow Zn^0$
   C) $Cu^0 - 2e^- \rightarrow Cu^{2+}$
   D) $Cu^{2+} + 2e^- \rightarrow Cu^0$

6. A battery consists of which type of cells?

   A) electroplating   B) electrolytic
   C) electromagnetic   D) electrochemical

7. The redox reaction in a battery during discharge can best be described as

   A) non-spontaneous and occurring in an electrolytic cell
   B) non-spontaneous and occurring in a chemical cell
   C) spontaneous and occurring in a chemical cell
   D) spontaneous and occurring in an electrolytic cell

8. The type of reaction in an electrochemical cell is best described as a

   A) non-spontaneous oxidation reaction, only
   B) spontaneous oxidation reaction, only
   C) spontaneous oxidation-reduction reaction
   D) non-spontaneous oxidation-reduction reaction

9. Which substance functions as the electrolyte in an automobile battery?

   A) PbO$_2$ B) H$_2$O
   C) PbSO$_4$ D) H$_2$SO$_4$

10. What is the voltage for a chemical cell that has reached equilibrium?

    A) 1.00 V
    B) greater than 1.00 V
    C) greater than 0.00 V and less than 1.00 V
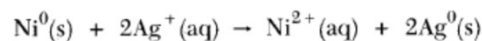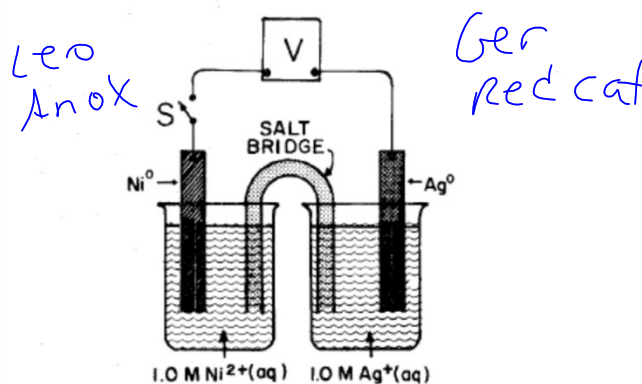   D) 0.00 V

Redox: Galvanic/Voltaic Cells

Base your answers to questions **11** and **12** on the equation and diagram below represent an electrochemical cell at 298 K and 1 atmosphere.

(handwritten notes on diagram: "e⁻ →", "Red Cat", "Anox", "(−)")

$$Mg(s) + 2Ag^+(aq) \longrightarrow Mg^{2+}(aq) + 2Ag(s)$$
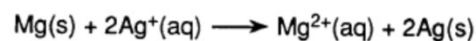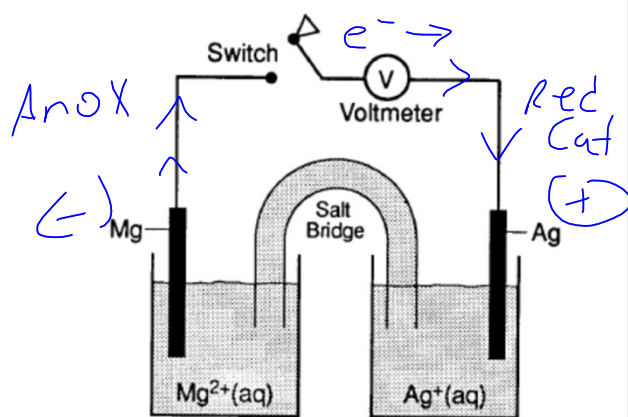
11. When the switch is closed, electrons flow from

A) $Mg^{2+}(aq)$ to $Ag^+(aq)$
B) $Ag^+(aq)$ to $Mg^{2+}(aq)$
C) $Mg(s)$ to $Ag(s)$
D) $Ag(s)$ to $Mg(s)$

12. Which species is oxidized when the switch is closed?

A) $Mg^{2+}(aq)$ B) $Ag^+(aq)$
C) $Mg(s)$ D) $Ag(s)$

13. Which energy change occurs in an operating voltaic cell?

A) electrical to chemical
B) chemical to electrical
C) nuclear to chemical
D) chemical to nuclear

14. Which statement best describes how a salt bridge maintains electrical neutrality in the half-cells of an electrochemical cell?

A) It prevents the reaction from occurring spontaneously.
B) It prevents the migration of electrons.
C) It permits the two solutions to mix completely.
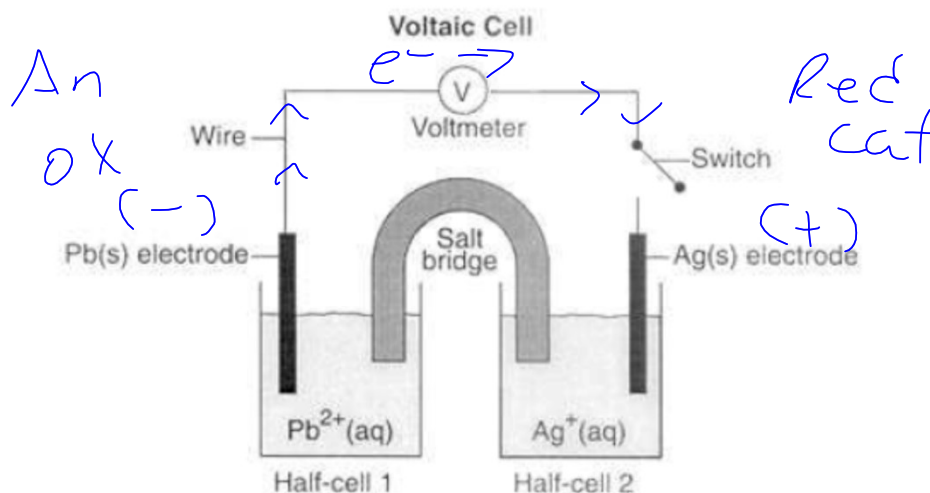D) It permits the migration of ions.

15. Base your answer to the following question on the diagram of the chemical cell at 298 K and on the equation below.

(handwritten notes on diagram: "Leo Anox", "Ger Red cat")

$$Ni^0(s) + 2Ag^+(aq) \rightarrow Ni^{2+}(aq) + 2Ag^0(s)$$

In the given reaction, the Ag^+ ions

A) gain protons   B) lose electrons
C) lose protons   D) gain electrons

16. A voltaic cell differs from an electrolytic cell in that in a voltaic cell

A) neither oxidation nor reduction occurs
B) energy is produced when the reaction occurs
C) energy is required for the reaction to occur
D) both oxidation and reduction occur

17. A student collects the materials and equipment below to construct a voltaic cell:

• two 250-mL beakers
• wire and a switch
• one strip of magnesium
• one strip of copper
• 125 mL of 0.20 M $Mg(NO_3)_2(aq)$
• 125 mL of 0.20 M $Cu(NO_3)_2(aq)$

Which additional item is required for the construction of the voltaic cell?

A) a battery   B) a salt bridge
C) a cathode   D) an anode

18. When an electrochemical cell is operating, it is

A) undergoing oxidation, only
B) undergoing reduction, only
C) approaching equilibrium
D) using external energy

13

Electrochemical Cells

Voltaic Cell

An
ox
(−)

$e^- \rightarrow$

Red
cat

(+)

Wire — Voltmeter (V)

—Switch

Pb(s) electrode —

Salt bridge

— Ag(s) electrode

Pb^{2+}(aq)

Ag^+(aq)

Half-cell 1   Half-cell 2

Based on Figure 1:

1. **Write the oxidation half-reaction for this cell.**

$$Pb^0 \rightarrow Pb^{2+} + 2e^-$$

2. **Write the reduction half reaction for this cell.**

$$Ag^{+1} + 1e^- \rightarrow Ag^0$$

3. **Write the balanced equation that can be derived from the half-reactions.**

$$Pb + 2Ag^{1+} \rightarrow Pb^{2+} + 2Ag^0$$
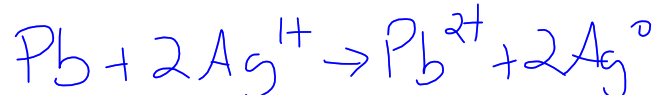
4. **If 1 mole of Ag reacts, how many moles of electrons will be transferred?**
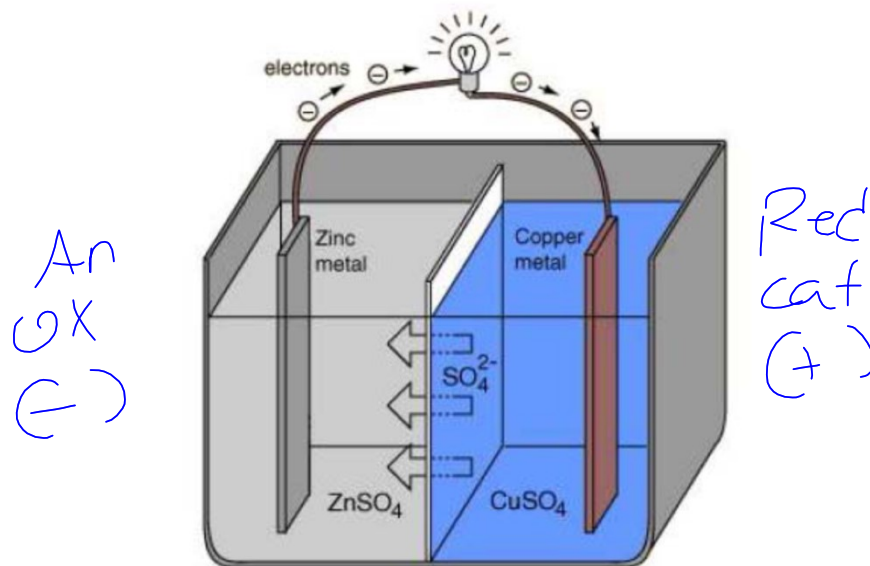
$1 \, mol \, e^-$

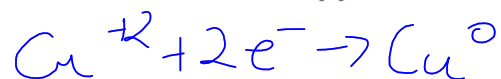5. **Of the substances Ag, Ag⁺, Pb, Pb²⁺, which are used up as the cell is used?**

Pb^0, Ag^{+1}

6. **Which of the substances referred to in question 5 increases in mass as the cell is used?**

Ag^0

Electrochemical Cells (continued)

An
ox
(-)

Red
cat
(+)

Based on Figure 2:

7. **Write the half-reaction at the copper electrode.**

$$Cu^{+2} + 2e^- \rightarrow Cu^0$$

8. **Write the half-reaction at the zinc electrode.**

$$Zn^0 \rightarrow Zn^{+2} + 2e^-$$

9. **If 2 moles of Zn react, how many moles of electrons are transferred?**

$$4 \, mol \, e^-$$

Regents Chemistry   **Redox: Electrolytic Cells**

1. The diagram below shows a spoon that will be electroplated with nickel metal.

(-1)
Ni(s)

Anode

(-) cathode

Spoon

Ni²⁺ (aq)
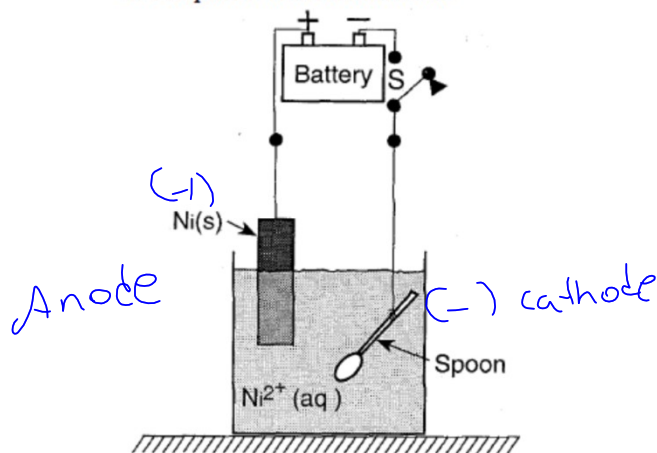
What will occur when switch S is closed?

A) The spoon will lose mass, and the Ni(s) will be reduced.
B) The spoon will gain mass, and the Ni(s) will be oxidized.
C) The spoon will gain mass, and the Ni(s) will be reduced.
D) The spoon will lose mass, and the Ni(s) will be oxidized.

2. A metal object is to be electroplated with silver. Which set of electrodes should be used?

A) a silver anode and a metal object as the cathode
B) a silver cathode and a metal object as the anode
C) a platinum anode and a metal object as the cathode
D) a platinum cathode and a metal object as the anode

Base your answers to questions **3** and **4** on the diagram below of an electrolytic cell in which the electrodes are tin and copper.

SWITCH

BEAKER

BATTERY   Sn(s)   A   B   Cu(s)

Sn²⁺(aq)
SOLUTION
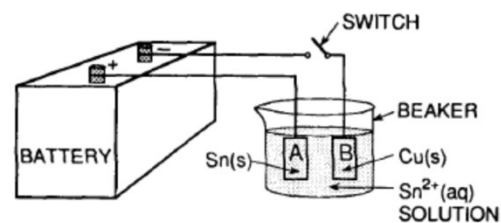
3. When the switch is closed, what will happen to the two electrodes?

A) A will dissolve and B will become coated with copper.
B) B will dissolve and A will become coated with copper.
C) A will dissolve and B will become coated with tin.
D) B will dissolve and A will become coated with tin.

4. In this electrolytic cell, electrode A is designated as the

A) anode and is negative
B) anode and is positive
C) cathode and is positive
D) cathode and is negative

Redox: Electrolytic Cells

Base your answers to questions **5** and **6** on the diagram below which represents the electroplating of a metal fork with Ag(s).
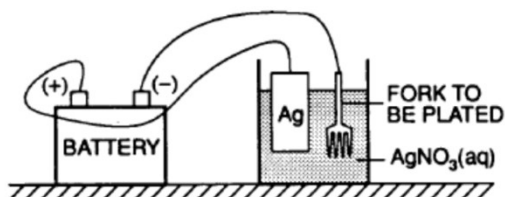
5. Which part of the electroplating system is provided by the fork?

   A) the cathode, which is the positive electrode
   B) the cathode, which is the negative electrode
   C) the anode, which is the negative electrode
   D) the anode, which is the positive electrode

6. Which equation represents the half-reaction that takes place at the fork?

   A) $AgNO_3 \rightarrow Ag^+ + NO_3^-$
   B) $Ag(s) \rightarrow Ag^+ + e^-$
   C) $Ag^+ + e^- \rightarrow Ag(s)$
   D) $Ag^+ + NO_3^- \rightarrow AgNO_3$

7. In an electrolytic cell, the positive electrode is the

   A) anode, where oxidation occurs
   B) cathode, where reduction occurs
   C) anode, where reduction occurs
   D) cathode, where oxidation occurs

8. Which statement best describes the key?

Key   Silver
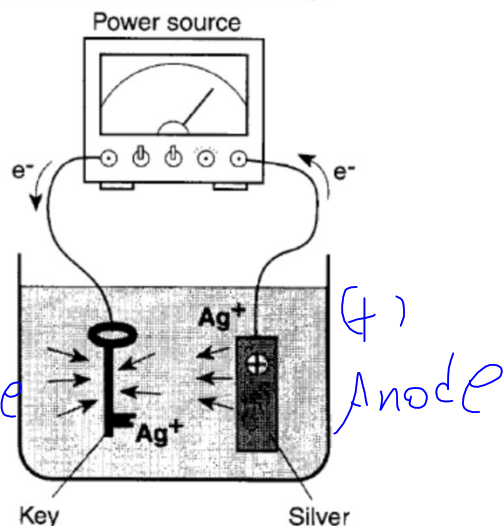
   A) It acts as the anode and is positive.
   B) It acts as the cathode and is negative.
   C) It acts as the cathode and is positive.
   D) It acts as the anode and is negative.

9. Metals from which groups are obtained by the reduction of their fused salts?

   A) Group 11 and Group 12
   B) Group 1 and Group 2
   C) Group 1 and Group 12
   D) Group 2 and Group 11

10. Which statement describes one characteristic of an operating electrolytic cell?

   A) It produces electrical energy.
   B) It requires an external energy source.
   C) It undergoes a spontaneous redox reaction.
   D) It uses radioactive nuclides.

11. Which energy conversion occurs in an operating electrolytic cell?

   A) electrical energy to chemical energy
   B) nuclear energy to thermal energy
   C) chemical energy to electrical energy
   D) thermal energy to nuclear energy