Chemistry 12

Electrochemistry I – IV Worksheet

Name: Key
Date:
Block:

1. Calculate the oxidation number of the bolded and underlined element:

$\underline{\mathbf{Cl}}O_3^-$ Cl = +5 $\underline{\mathbf{N}}_2H_5^+$ N = −2 $\underline{\mathbf{S}}_8$ S = 0

$\underline{\mathbf{Cr}}(OH)_4^-$ Cr = +3 $\underline{\mathbf{Sb}}_2O_5$ Sb = +5 $H\underline{\mathbf{P}}O_3^{2-}$ P = +3

$\underline{\mathbf{Br}}O_3^-$ Br = +5 $K_2\underline{\mathbf{U}}O_4$ U = +6 $\underline{\mathbf{C}}_3H_8$ $C = -\frac{8}{3}$

2. Balance the following reactions. Double check your work by calculating oxidation numbers. Identify the reducing agent and oxidizing agent in each:

a) $U^{4+} + MnO_4^- \rightarrow Mn^{2+} + UO_2^{2+}$

$(2H_2O + U^{4+} \rightarrow UO_2^{2+} + 4H^+ + 2e^-) \times 5$

$(5e^- + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O) \times 2$

$10H_2O + 5U^{4+} + 16H^+ + 2MnO_4^- \rightarrow 5UO_2^{2+} + 20H^+ + 2Mn^{2+} + 8H_2O$

$2H_2O + 5U^{4+} + 2MnO_4^- \rightarrow 5UO_2^{2+} + 4H^+ + 2Mn^{2+}$

RA OA

b) $Cl_2 + SO_2 \rightarrow Cl^- + SO_4^{2-}$ (basic)

$2e^- + Cl_2 \rightarrow 2Cl^-$

$2H_2O + SO_2 \rightarrow SO_4^{2-} + 4H^+ + 2e^-$

$Cl_2 + 2H_2O + SO_2 \rightarrow 2Cl^- + SO_4^{2-} + 4H^+$

$+4OH^- \quad +4OH^-$

$4H_2O$

$Cl_2 + SO_2 + 4OH^- \rightarrow 2Cl^- + SO_4^{2-} + 2H_2O$

OA RA

c) $S^{2-} + ClO_3^- \rightarrow Cl^- + S$

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

$6e^- + 6H^+ + ClO_3^- \rightarrow Cl^- + 3H_2O$

$3S^{2-} + 6H^+ + ClO_3^- \rightarrow 3S + Cl^- + 3H_2O$

RA OA

d) $HNO_2 \rightarrow HNO_3 + NO$ (basic)

$H_2O + HNO_2 \rightarrow HNO_3 + 2H^+ + 2e^-$

$(e^- + H^+ + HNO_2 \rightarrow NO + H_2O) \times 2$

$H_2O + HNO_2 + 2H^+ + 2HNO_2 \rightarrow HNO_3 + 2H^+ + 2NO + 2H_2O$

$3HNO_2 \rightarrow HNO_3 + 2NO + H_2O$

RA + OA

e) $FeHPO_3 + Cr_2O_7^{2-} \rightarrow Cr^{3+} + H_3PO_4 + Fe^{3+}$

$(H_2O + FeHPO_3 \rightarrow H_3PO_4 + Fe^{3+} + 3e^-) \times 2$

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

$2H_2O + 2FeHPO_3 + 14H^+ + Cr_2O_7^{2-} \rightarrow 2H_3PO_4 + 2Fe^{3+} + 2Cr^{3+} + 5H_2O$

$2\overset{+2}{Fe}\overset{+3}{H}PO_3 + 14H^+ + \overset{+6}{Cr_2}O_7^{2-} \rightarrow 2H_3PO_4 + 2\overset{+3}{Fe}^{3+} + 2Cr^{3+} + 5H_2O$

RA OA

f) $Sb_2S_3 + NO_3^- \rightarrow NO_2 + SO_4^{2-} + Sb_2O_5$ (basic)

$17H_2O + Sb_2S_3 \rightarrow 3SO_4^{2-} + Sb_2O_5 + 34H^+ + 28e^-$

$(e^- + 2H^+ + NO_3^- \rightarrow NO_2 + H_2O) \times 28$

$17H_2O + Sb_2S_3 + 56H^+ + 28NO_3^- \rightarrow 3SO_4^{2-} + Sb_2O_5 + 34H^+ + 28NO_2 + 28H_2O$

$22 + 22OH^- \qquad 22H_2O \qquad +22OH^- \qquad 11$

$\overset{+1}{Sb}_2\overset{-2}{S}_3 + 11H_2O + 28\overset{+5}{N}O_3^- \rightarrow 3\overset{+6}{S}O_4^{2-} + Sb_2O_5 + 28\overset{+4}{N}O_2 + 22OH^-$

RA OA

3. Classify the following combinations as spontaneous, non-spontaneous, or no reaction. If spontaneous or non-spontaneous, write out the complete reaction and calculate the cell potential.

a) Ni^{2+} and Ag

$Ni^{2+} + 2Ag \rightarrow Ni + 2Ag^+ \quad E^\circ_{total} = -1.06V$

b) Sn^{4+} and Al

$3Sn^{4+} + 2Al \rightarrow 3Sn^{2+} + 2Al^{3+} \quad E^\circ_{total} = 1.81V$

c) Al^{3+} and Ni^{2+}

no rxn

d) Mn and Pb

no rxn

e) Cr^{2+} and Fe

no rxn

f) $Cu(NO_3)$ and Ag^+

no rxn

g) I^-, Pb, and Sn^{2+}

$Pb + Sn^{2+} \rightarrow Pb^{2+} + Sn \quad E^\circ_{total} = -0.01V$

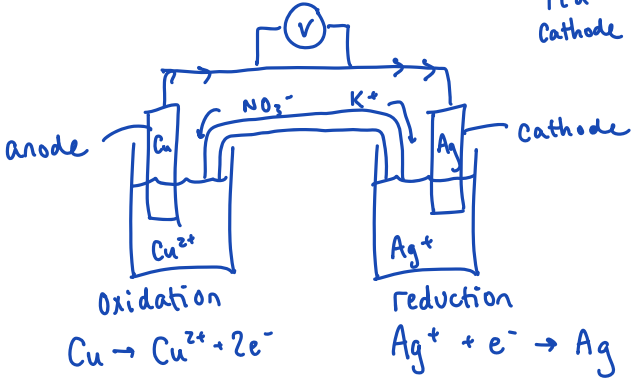
4. An electrochemical cell is constructed using Ag/Ag^+ and Cu/Cu^{+2} half cells.

RA OA RA OA

red oxi

cathode anode

a) Draw the electrochemical cell.



$Cu + 2Ag^+ + Cu^{2+} + 2Ag$

$E^\circ_{total} = 0.46V$

b) Which electrode will lose mass?

$Cu_{(s)}$ will lose mass

c) Which electrode will gain mass?

$Ag_{(s)}$ will gain mass

d) If 0.875 g of metallic copper is lost, then calculate the number of moles of silver formed.

$$0.875\,g\,Cu \times \frac{1\,mol\,Cu}{63.5\,g\,Cu} \times \frac{2\,mol\,Ag}{1\,mol\,Cu} = \boxed{0.0275\,mol\,Ag}$$

5. For the following, create an SRP table with the given information:

a) You have been given the following three half-reactions:

$A^{2+} + 2e^- \rightarrow A$
$B^{2+} + 2e^- \rightarrow B$
$C^{2+} + 2e^- \rightarrow C$

- A^{2+} reacts with C but not with B.

$B^{2+} + 2e^- \rightarrow B$
$A^{2+} + 2e^- \rightarrow A$
$C^{2+} + 2e^- \rightarrow C$

b) You have been given the following four half-reactions:

$D^{2+} + 2e^- \rightarrow D$
$E^{2+} + 2e^- \rightarrow E$
$F^{2+} + 2e^- \rightarrow F$
$G^{2+} + 2e^- \rightarrow G$

- F^{2+} reacts with D, E and G.
- No reaction occurs between D^{2+} and any of the metals.
- G^{2+} only reacts with D.

$F^{2+} + 2e^- \rightarrow F$
$E^{2+} + 2e^- \rightarrow E$
$G^{2+} + 2e^- \rightarrow G$
$D^{2+} + 2e^- \rightarrow D$

c) You have been given the following five half-reactions:

$H^{2+} + 2e^- \rightarrow H$
$I^{2+} + 2e^- \rightarrow I$
$J^{2+} + 2e^- \rightarrow J$
$K^{2+} + 2e^- \rightarrow K$
$L^{2+} + 2e^- \rightarrow L$

- K^{2+} only reacted with I and H.
- L^{2+} did not react with J.
- I^{2+} reacted with H.

$J^{2+} + 2e^- \rightarrow J$
$L^{2+} + 2e^- \rightarrow L$
$K^{2+} + 2e^- \rightarrow K$
$I^{2+} + 2e^- \rightarrow I$
$H^{2+} + 2e^- \rightarrow H$

6. Consider the following:

- **A** reacts with **B**$NO_{3(aq)}$ and **H**$Cl_{(aq)}$.
- **A** does not react with **C**$(NO_3)_{2(aq)}$.
- **C** reacts with **H**$Cl_{(aq)}$, **B**$NO_{3(aq)}$, **A**$(NO_3)_{2(aq)}$ and **D**$(NO_3)_{2(aq)}$.
- **D** reacts with **B**$NO_{3(aq)}$ but not with **H**$Cl_{(aq)}$.
- **Cl**$^-$ and NO_3^- are considered to be spectator ions.

$B^+ \;/\; H^+ > A^{2+}$

$A^{2+} > C^{2+}$

$H^+ / B^+ / A^{2+} / D^{2+} > C^{2+}$

$B^+ > D^{2+} > H^+$

If **A**, **B**, **C**, and **D** are four metals, list the **five** reduction **half-reactions** in order of decreasing reduction potential. (watch the ion charges)

$B^+ + e^- \rightarrow B$

$D^{2+} + 2e^- \rightarrow D$

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

$A^{2+} + 2e^- \rightarrow A$

$C^{2+} + 2e^- \rightarrow C$