KEY

Rest of Redox Reactions Practice Problems

1) When balancing a redox reaction, extra "leftover" electrons should be placed on the product side. (True or False) 1) _____

FALSE!

2) What are the balanced oxidation and reduction half reactions in the following unbalanced reaction. If aluminum metal is submersed in sulfuric acid, will this reaction take place? 2) _____

$Al + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2$

$Al \rightarrow Al^{3+} + 3e^-$ OXIDATION HALF REACTION

$2H^+ + 2e^- \rightarrow H_2$ REDUCTION HALF REACTION

SO_4^{2-} IS SPECTATOR ION

3) Is the following reaction spontaneous in the forward direction? 3) _____

$Mg(s) + AgNO_3(aq) \Leftrightarrow Ag(s) + Mg(NO_3)_2(aq)$

NO_3^- (SPECTATOR)

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

$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$ $E° = -2.38$ V

$Mg \rightarrow Mg^{2+} + 2e^-$ 2.38V REVERSED

$2Ag^+ + 2e^- \rightarrow 2Ag$ 0.80V

$Mg + 2Ag^+ \rightarrow Mg^{2+} + Ag$ 3.18V ← YES THIS RXN WILL HAPPEN

ALSO, YOU COULD LOOK AT THE ACTIVITY SERIES; Mg IS HIGHER THAN Ag, SO RXN WILL HAPPEN

4) Is the following reaction spontaneous in the forward direction? 4) _____

$Pb^{2+}(aq) + Cu(s) \Leftrightarrow Cu^{2+}(aq) + Pb(s)$

$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$ $E° = -0.13$ V ← KEEP AS IS

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

-0.13 V

-0.34 V

-0.47 V

NO, REACTION WILL NOT OCCUR ($E°$ IS NEGATIVE)

ACTIVITY SERIES:

$Cu_{(s)} + Pb^{2+}(SALT) \rightarrow$

↑

HIGHER "ACTIVITY", SO NO REACTION

BE CAREFULL WHEN USING THE ACTIVITY SERIES! A COMMON MISTAKE IS

$Pb^{2+} + Cu \rightarrow$

↑

HIGHER, SO RXN WILL OCCUR

NO!

5) Is the following reaction spontaneous in the forward direction? 5) _____

$$3Cu_{(s)} + 2Al(NO_3)_{3(aq)} \rightleftharpoons 2Al_{(s)} + 3Cu(NO_3)_{2(aq)}$$

$Al^{3+}(aq) + 3\,e^- \rightarrow Al(s)$ $\quad E° = -1.66$ V
$Cu^{2+}(aq) + 2\,e^- \rightarrow Cu(s)$ $\quad E° = +0.337$ V ← FLIP

ACTIVITY SERIES:

Al HIGHER, SO NO REACTION.

REDOX POTENTIALS:

$Al^{3+} + 3e^- \rightarrow Al$ $\quad -1.66$ V
$Cu \rightarrow Cu^{2+} + 2e^-$ $\quad -0.337$ V
$\Big\} -2.00$ V

↑ E° NEGATIVE, SO NO RXN

6) Is the following reaction spontaneous in the forward direction? 6) _____

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

$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$ $\quad E° = 0.77$ V
$Zn^{2+}(aq) + 2\,e^- \rightarrow Zn(s)$ $\quad E° = -0.76$ V ← FLIP

NOTICE, ACTIVITY SERIES WONT WORK FOR THIS ONE....

0.77 V
+0.76 V
1.53 V ← YES, RXN WILL OCCUR (E° POSITIVE)

7) Balance the following reaction that occurs in acidic solution. Is this reaction spontaneous in the forward direction? 7) _____

$$Cr^{2+}(aq) + O_2(g) \rightarrow Cr^{3+}(aq)$$

$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ $\quad E° = 1.23$ V
$Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$ $\quad E° = -0.42$ V ← FLIP →

1.23 V
0.42 V
1.65 V → REACTION WILL OCCUR

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

$4e^- + 2H^+ + O_2 \rightarrow 2H_2O$

1) BALANCE ALL ATOMS EXCEPT H & O
2) BALANCE OXYGEN WITH H_2O
3) BALANCE HYDROGENS WITH H^+
4) BALANCE CHARGE WITH e^-

$4Cr^{2+} \rightarrow 4Cr^{3+} + 4e^-$

$4e^- + 2H^+ + O_2 \rightarrow 2H_2O$

$4Cr^{2+} + 2H^+ + O_2 \rightarrow 4Cr^{3+} + 2H_2O$ ← BALANCED RXN IS OKAY IN ACIDIC SOLN.

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8) Balance the following reaction that occurs in basic solution? 8) _____

$Cr^{3+} + O_2^{2-} \rightarrow CrO_4^{2-}$

$2(4H_2O + Cr^{3+} \longrightarrow CrO_4^{2-} + 8H^+ + 3e^-)$

$3(2e^- + 4H^+ + O_2^{2-} \longrightarrow 2H_2O)$

$\Downarrow$

$2\cancel{8}H_2O + 2Cr^{3+} \rightarrow 2CrO_4^{2-} + \overset{4}{\cancel{16}}H^+ + \cancel{6e^-}$

$\cancel{6e^-} + \cancel{12H^+} + 3O_2^{2-} \rightarrow \cancel{6}H_2O$

$2H_2O + 2Cr^{3+} + 3O_2^{2-} \rightarrow 2CrO_4^{2-} + 4H^+$

ADD $4OH^-$ TO BOTH SIDES

$4OH^- + 2H_2O + 2Cr^{3+} + 3O_2^{2-} \rightarrow 2CrO_4^{2-} + 4H_2O$

↓ CANCEL H_2O

$4OH^- + 2Cr^{3+} + 3O_2^{2-} \rightarrow 2CrO_4^{2-} + 2H_2O$

↑ BASIC SOLUTION

9) Balance the following reaction that occurs in acidic solution? 9) _____

$SO_3^{2-} + MnO_4^- \rightarrow SO_4^{2-} + Mn^{2+} + H_2O$

$5(H_2O + SO_3^{2-} \rightarrow SO_4^{2-} + 2H^+ + 2e^-)$

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

$\Downarrow$

$\cancel{5}H_2O + 5SO_3^{2-} \rightarrow 5SO_4^{2-} + \cancel{10H^+} + \cancel{10e^-}$

$\cancel{10e^-} + \overset{6}{\cancel{16}}H^+ + 2MnO_4^- \rightarrow 2Mn^{2+} + \overset{3}{\cancel{8}}H_2O$

$6H^+ + 5SO_3^{2-} + 2MnO_4^- \rightarrow 5SO_4^{2-} + 2Mn^{2+} + 3H_2O$ ← IN ACID, SO OKAY

10) Balance the following reaction that occurs in basic solution? 10) _____

$Br_2 + Mn^{2+} \rightarrow MnO_2 + Br^-$

$2e^- + Br_2 \rightarrow 2Br^-$

$2H_2O + Mn^{2+} \longrightarrow MnO_2 + 4H^+ + 2e^-$

$2H_2O + Mn^{2+} + Br_2 \rightarrow 2Br^- + MnO_2 + 4H^+$

$\Downarrow$ BASIC, SO:

$4OH^- + 2H_2O + Mn^{2+} + Br_2 \rightarrow 2Br^- + MnO_2 + 4H_2O$

↓ CANCEL H_2O

$4OH^- + Mn^{2+} + Br_2 \rightarrow 2Br^- + MnO_2 + 2H_2O$

11) Balance the following reaction that occurs in acidic solution? 11) _____

$$Zn(s) + Cr_2O_7^{2-}(aq) \rightarrow Zn^{2+}(aq) + Cr^{2+}(aq)$$

$4\,(Zn \rightarrow Zn^{2+} + 2e^-)$

$8e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{2+} + 7H_2O$

$4Zn \rightarrow 4Zn^{2+} + 8e^-$

$8e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{2+} + 7H_2O$

$14H^+ + 4Zn + Cr_2O_7^{2-} \rightarrow 2Cr^{2+} + 4Zn^{2+} + 7H_2O$

12) Balance the following reaction that occurs in acidic solution? 12) _____

$$HCl + H_2C_2O_4 + MnO_2(s) \rightarrow MnCl_2 + CO_2(g) + H_2O$$

$H_2C_2O_4 \rightarrow 2CO_2 + 2H^+ + 2e^-$

$2e^- + 2H^+ + 2HCl + MnO_2 \rightarrow MnCl_2 + 2H_2O$

$H_2C_2O_4 + 2HCl + MnO_2 \rightarrow 2CO_2 + MnCl_2 + 2H_2O$

↑

REALLY SHOULD BE

$2H^+ + 2Cl^-$

13) Balance the following reaction that occurs in acidic solution? 13) _____

$$IO_3^- + N_2H_4 \rightarrow I^- + N_2$$

$2(6e^- + 6H^+ + IO_3^- \rightarrow I^- + 3H_2O)$

$3(N_2H_4 \rightarrow N_2 + 4H^+ + 4e^-)$

$12e^- + 12H^+ + 2IO_3^- \rightarrow 2I^- + 6H_2O$

$3N_2H_4 \rightarrow 3N_2 + 12H^+ + 12e^-$

$3N_2H_4 + 2IO_3^- \rightarrow 2I^- + 3N_2 + 6H_2O$

14) Balance the following reaction that occurs in basic solution? 14) _____

$C_2O_4^{2-}(aq) + MnO_4^-(aq) \rightarrow CO_3^{2-}(aq) + MnO_2(s)$

$3\,(2H_2O + C_2O_4^{2-} \longrightarrow 2CO_3^{2-} + 4H^+ + 2e^-)$

$2\,(3e^- + 4H^+ + MnO_4^- \longrightarrow MnO_2 + 2H_2O)$

$6H_2O + 3C_2O_4^{2-} \longrightarrow 6CO_3^{2-} + 12H^+ + 6e^-$

$6e^- + 8H^+ + 2MnO_4^- \longrightarrow 2MnO_2 + 4H_2O$

$2H_2O + 3C_2O_4^{2-} + 2MnO_4^- \longrightarrow 6CO_3^{2-} + 2MnO_2 + 4H^+$ ↘ BASIC, SO:

$4OH^- + 3C_2O_4^{2-} + 2MnO_4^- \longrightarrow 6CO_3^{2-} + 2MnO_2 + 2H_2O$

15) Balance the following reaction that occurs in acidic solution 15) _____

$VO^{2+}(aq) + Cr_2O_7^{2-}(aq) \rightarrow Cr^{3+}(aq) + VO_2^+(aq)$

VO^{2+} = "VANADYL" ION

VO_2^+ = "PERVANADYL" ION

$6\,(H_2O + VO^{2+} \longrightarrow VO_2^+ + 2H^+ + e^-)$

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

$6H_2O + 6VO^{2+} \longrightarrow 6VO_2^+ + 12H^+ + 6e^-$

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

$2H^+ + 6VO^{2+} + Cr_2O_7^{2-} \longrightarrow 6VO_2^+ + 2Cr^{3+} + H_2O$

16) Balance the following reaction that occurs in basic solution? 16) _____

$Al(s) + ClO^-(aq) \rightarrow Al(OH)_4^-(aq) + Cl^-(aq)$

$2\,(4H_2O + Al \longrightarrow Al(OH)_4^- + 4H^+ + 3e^-)$

$3\,(2e^- + 2H^+ + ClO^- \longrightarrow Cl^- + H_2O)$ ↘

$8H_2O + 2Al \longrightarrow 2Al(OH)_4^- + 8H^+ + 6e^-$

$6e^- + 6H^+ + 3ClO^- \longrightarrow 3Cl^- + 3H_2O$

$5H_2O + 2Al + 3ClO^- \longrightarrow 2Al(OH)_4^- + 2H^+ + 3Cl^-$ ↘ BASIC

$2OH^- + 3H_2O + 2Al + 3ClO^- \longrightarrow 2Al(OH)_4^- + 3Cl^-$

17) Ballance the following equation that occurs in acidic solution. How many milliliters of a 3.85 M solution of Fe^{2+} are needed to titrate 250.0 mL of a 0.125 M CrO_4^{2-} solution? 17) _____

$$CrO_4^{2-} + Fe^{2+} \rightarrow Fe^{3+} + Cr_2O_3 \quad \text{(not balanced)}$$

$6e^- + 10H^+ + 2CrO_4^{2-} \longrightarrow Cr_2O_3 + 5H_2O$

$6(Fe^{2+} \rightarrow Fe^{3+} + e^-)$

$10H^+ + 2CrO_4^{2-} + 6Fe^{2+} \longrightarrow 6Fe^{3+} + Cr_2O_3 + 5H_2O$

$$250.0\,mL \times \frac{10^{-3}\,L}{mL} \times \frac{0.125\,mol\,CrO_4^{2-}}{L} \times \frac{mol\,Fe^{2+}}{2\,mol\,CrO_4^{2-}} \times \frac{L}{3.85\,mol\,Fe^{2+}} \times \frac{mL}{10^{-3}\,L} = 4.06\,mL$$

The following are not redox related.

18) Calculate the molarity of Cl^- in 245.0 mL of a solution containing 23.4 g $BaCl_2$. 18) _____

$$\frac{23.4\,g}{245.0\,mL} \times \frac{mL}{10^{-3}\,L} \times \frac{mol\,BaCl_2}{208.24\,g} \times \frac{2\,mol\,Cl^-}{mol\,BaCl_2} = 0.917\,M$$

19) If the concentration of Na^+ in an aqueous solution of sodium sulfate is 3.2×10^{-1} mol/L, how many moles of sodium sulfate must have been dissolved per liter to make the solution? 19) _____

A) 6.4×10^{-1} B) 1.1×10^{-1} C) 9.6×10^{-1} D) 1.6×10^{-1} E) 3.2×10^{-1}

EXACTLY →

$$1\,L \times \frac{0.32\,mol\,Na^+}{L} \times \frac{mol\,Na_2SO_4}{2\,mol\,Na^+} = 0.16\,mol\,Na_2SO_4$$

20) Consider a 1.00-L solution containing 85.5 g $Al_2(SO_4)_3$ (FW = 342.15) and 21.3 g Na_2SO_4 (FW = 142.06). What are the molar concentrations of aluminum, sodium, and sulfate ions, respectively? 20) _____

	$[Al^{3+}]$,	$[Na^+]$,	$[SO_4^{2-}]$
A)	0.50	0.75	0.15
B)	0.25	0.30	0.15
C)	0.50	0.30	0.90
D)	0.25	0.15	0.40
E)	0.50	0.75	0.90

$$85.5\,g \times \frac{mol\,Al_2(SO_4)_3}{342.15\,g} \times \frac{2\,mol\,Al^{3+}}{mol\,Al_2(SO_4)_3} \times \frac{1}{1.00\,L} = 0.500\,M\ Al^{3+}$$

$$21.3\,g \times \frac{mol\,Na_2SO_4}{142.06\,g} \times \frac{2\,mol\,Na^+}{mol\,Na_2SO_4} \times \frac{1}{1.00\,L} = 0.300\,M\ Na^+$$

SO_4^{2-}:

$$85.5\,g \times \frac{mol\,Al_2(SO_4)_3}{342.15\,g} \times \frac{3\,mol\,SO_4^{2-}}{mol\,Al_2(SO_4)_3} = 0.74967\,mols\,SO_4^{2-}$$

$$21.3\,g \times \frac{mol\,Na_2SO_4}{142.06\,g} \times \frac{mol\,SO_4^{2-}}{mol\,Na_2SO_4} = 0.14994\,mols\,SO_4^{2-}$$

ADD TOGETHER → $0.900\,mol\,SO_4^{2-}$

IN 1.00 L → $0.900\,M\,SO_4^{2-}$