→ remember redox ≠ equilibrium rxn.

Cells at Equilibrium

The $E°_{cell}$ of a cell is the voltage at standard state, so solution concentrations are 1.0M. As the cell operates, reactants are being used up, so their concentrations are continually decreasing, thus the voltage of the cell starts to decrease. When all reactants are used up, the cell will cease to operate (the battery is dead), and the cell voltage will be zero. At this point, the cell is said to be at equilibrium. Therefore, the voltage of a cell at equilibrium is 0 (a dead battery).

Assignment 11: 1) Hebden p.224-225 #36abcdef, 37, p.226 #46
(36f is a disproportionation reaction)

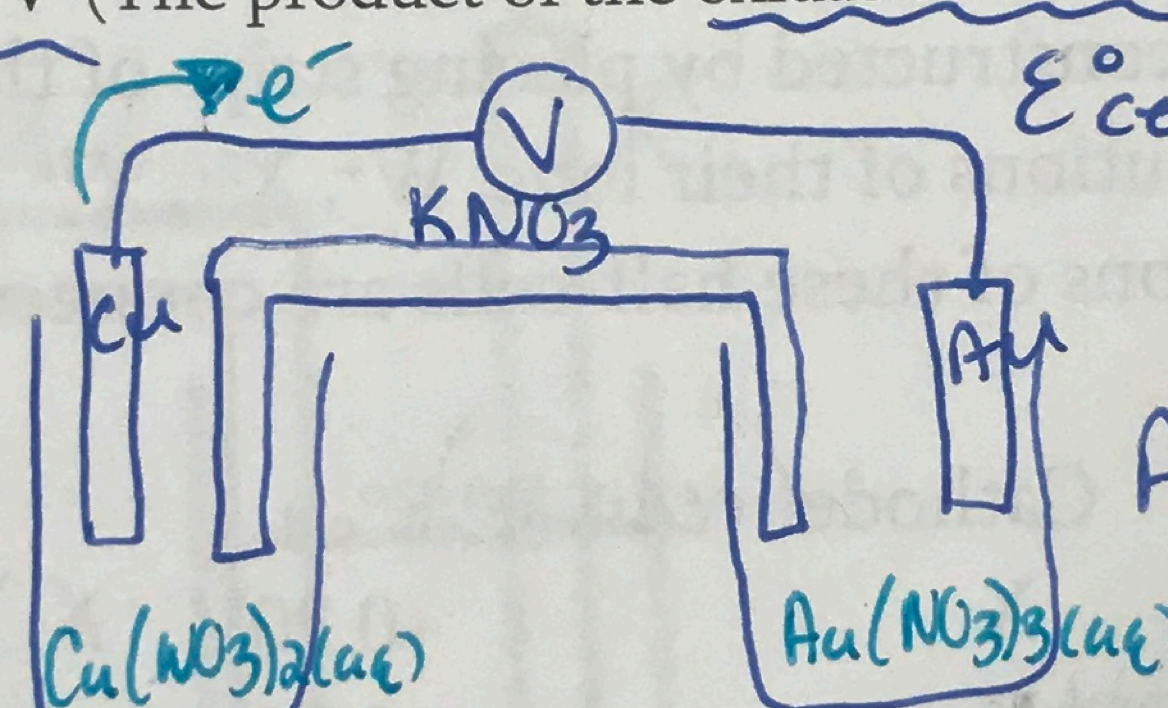
XIII) Cell Potential Practice Questions (students work on indep).

1. Draw and label an electrochemical cell using a copper anode and having an $E°_{cell}$ greater than 1.0V (The product of the oxidation is Cu^{2+}).

$E°_{cell} > 1.0V$

Anode

$Cu_{(s)} \rightarrow 2e^- + Cu^{2+}_{(aq)}$
+0.34



Cathode

$Au^{3+} + 3e^- \rightarrow Au$
+1.36

* reduction half rxn must be > 1.34 ∴ anything from Cl_2 ↑ on table is sufficient

-0.34 (oxidation)
+1.36
+1.16 V

2. If the E° for $Ni^{2+} + 2e^- \Rightarrow Ni$ were set at zero volts, what would be the E° for $Cu^{2+} + 2e^- \Rightarrow Cu$? (recall everything is measured relative to H^+)

$Ni^{2+} + 2e^- \rightarrow Ni$ -0.26V ... so if that is 0.00V, everything else is 0.26V higher

$Cu^{2+} + 2e^- \rightarrow Cu$ 0.34V so it would be 0.34V + 0.26V = $\boxed{0.60V}$

3. What will happen to an aluminum spoon if it is used to stir a solution of $Fe(NO_3)_2$? Use E° values to support your answer.

Fe^{2+} NO_3^- $2Al_{(s)} + 3Fe(NO_3)_2 \rightarrow 2Al(NO_3)_3 + 3Fe$

* single replacement... but is it spontaneous?

$Al_{(s)} \rightarrow Al^{3+} + 3e^-$ +1.66V
$Fe^{2+} + 2e^- \rightarrow Fe_{(s)}$ -0.45V
$E°_{cell}$ = +1.21V spontaneous

* the Al. spoon would oxidize (slowly disappear)

4. Four metals were used to set up the following electrochemical cells with their ions J^{2+}, L^{+}, K^{2+}, and M^{3+}:

all spontaneous

(oxidation) Anode	Cathode (reduction)	Cell Voltage	
J	L	+0.30V	L > J
L	K	+1.60V	K > L
L	M	+1.30V	M > K

K > M

O.A.	R.A
K^+	K
M^+	M
L^+	L
J	J

strong ↑ (O.A.), strong ↓ (R.A)

a) Identify the strongest reducing agent. J

M
+1.3
L
0.30V
J

b) Identify the strongest oxidizing agent. K^+

c) Calculate the voltage of a J/M cell. $+1.3 + +0.30 = \boxed{+1.60V}$

5. Four half-cells are constructed by placing strips of the four metals W, X, Y, and Z in 1.00M solutions of their ions, W^{+}, X^{2+}, Y^{3+}, and Z^{2+} respectively. Various combinations of these half-cells are connected, giving the following data:

(oxidation) Anode	Cathode (reduction)	$E°_{cell}$	
W	X	+0.20V	X > W
W	Y	+0.36V	Y > W
Z	W	+0.14V	W > Z

O.A		R.A	$E°_i$
$Y^{3+} + 3e^-$	→	Y	+0.36V
$X^{2+} + 2e^-$	→	X	+0.20V
$W^+ + e^-$	→	W	0.00V
$Z^{2+} + e^-$	→	Z	-0.14V

∴ W part of all, so let W $E° = 0.00V$

a) Which metal is the strongest reducing agent? Z

b) Which metal ion is the strongest oxidizing agent? Y^{3+}

c) Write the balanced equation for the cell reaction that would occur when half-cells X and Y are connected. $2Y^{3+} + \cancel{6e^-} \rightarrow 2Y$ ×2

$3X \rightarrow 3X^{2+} + \cancel{6e^-}$ ×3

net Redox. $2Y^{3+} + 3X \rightarrow 3X^{2+} + 2Y$

d) Calculate the voltage produced when half-cells X and Y are connected to produce a spontaneous reaction.

$Y^{3+} + 3e^- \rightarrow Y$ $\quad E°$ +0.36V

$X \rightarrow X^{2+} + 2e^-$ $\quad E°$ - 0.20V

$E°_{cell}$ 0.16V

reduction $E°$

$3V + 2Ga^{3+} \rightarrow 3V^{2+} + 2Ga$ $+0.64V$

$3V^{2+} + 2Al \rightarrow 3V + 2Al^{3+}$ $+0.46V$

oxidation

$E°_{cell} = +1.10V$

⊕ ∴ spontaneous.

6. Consider the following redox data:

Flip so 3V will cancel.

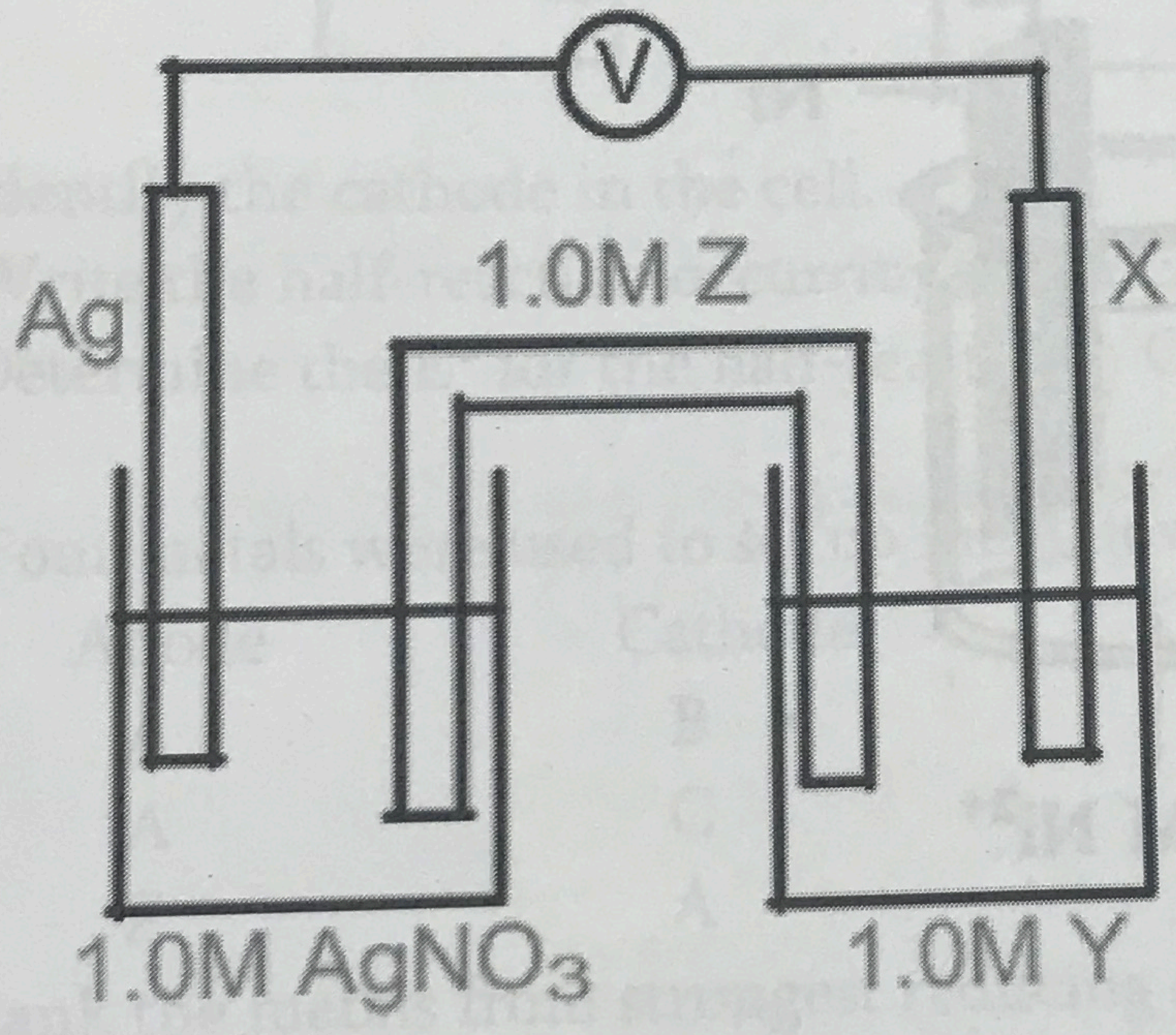
$3V^{2+} + 2Ga \Rightarrow 3V + 2Ga^{3+}$ $E° = -0.64V$

$3V^{2+} + 2Al \Rightarrow 3V + 2Al^{3+}$ $E° = +0.46V$

Based on these observations, a student concludes that Ga^{3+} and Al will react spontaneously. Evaluate this conclusion and support your answer with calculations.

Assignment 12

1. An electrochemical cell has electrodes of Pb in $Pb(NO_3)_2$ and Cr in $Cr(NO_3)_3$. Calculate $E°_{cell}$.
2. Use the following diagram of a cell at 25°C to answer the questions:



The electrochemical cell produces an initial voltage of 0.93 V.

a) Identify the metal "X"

b) Identify a suitable electrolyte "Y"

c) Identify a suitable electrolyte "Z"

d) Indicate, on the diagram the direction of electron flow.

3. Can $Fe_2(SO_4)_3$ be stored in a container made of nickel? Support with E° calculations.