S23 CHEM 1032 – *Bloom* Quiz 4 – Week 14 Circle Day and Time:

Name: Key

M		T		W		Tr		F	
8	9	10	11	12	1	2	3	4	5

Clearly write your letter answer on the line.

A 1. *(Remember)* What reaction occurs at the anode?

A. Oxidation
B. Combustion
C. Reduction
D. Neutralization

Red - Cat
Reduction at Cathode ∴ Oxidation at anode

D 2. *(Remember)* If a redox reaction is spontaneous what must be true?

A. E°cell + and ΔG° +
B. E°cell - and ΔG° +
C. E°cell - and ΔG° -
D. E°cell + and ΔG° -

$\Delta G^\ominus$ = spontaneous

$\Delta G = -nFE^\circ_{cell}$ ∴ E°_{cell} = ⊕ spontaneous

C 3. *(Understand)* What is the oxidation state of sulfur in sulfite, SO_3^{2-}?

A. - 2
B. + 1
C. + 4
D. + 6

+4 -6
+4 -2
SO_3^{2-}

B 4. *(Understand)* Balance the redox reaction below in acidic conditions. What is the coefficient for Fe^{3+}?

$NO\ (g) + Fe^{3+}\ (aq) \rightarrow NO_3^-\ (s) + Fe^{2+}\ (aq)$

A. 1
B. 3
C. 4
D. 5

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

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

$2H_2O + NO \rightarrow NO_3^- + 4H^+ + 3e^-$

$2H_2O + NO + 3Fe^{3+} \rightarrow 3Fe^{2+} + NO_3^- + 4H^+$

C 5. *(Apply)* If 3.4 A of a necessary voltage are applied to an aqueous solution of $NiCl_2$ for 54 min, how much Ni (s) would be expected to plate out?

A. 0.0039 g
B. 1.67 g
C. 3.35 g
D. 6.70 g

Ni^{2+} $2Cl^-$

$Ni^{2+} + 2e^- \rightarrow Ni_{(s)}$

$$54\ min \left|\frac{60\ s}{1\ min}\right| \frac{3.4\ C}{1\ s} \left|\frac{1\ mole^-}{96485\ C}\right| \frac{1\ mol\ Ni_{(s)}}{2\ mol\ e^-} \left|\frac{58.693\ g}{1\ mol\ Ni_{(s)}}\right| = 3.35\ g$$

A 6. *(Apply)* A galvanic cell which transfers 6 electrons per mole has an E°_{cell} of 0.043 V. What is the value of K?

A. 2.28×10^4
B. 1.001
C. 28.36
D. 7.8×10^2

$$E^\circ_{cell} = \frac{0.0592\ V}{n} \log K$$

$$0.043\ V = \frac{0.0592\ V}{6} \log K$$

D 7. *(Analyze)* Which of the diatomic halogens is the strongest reducing agent?

A. F_2 $+2.866\ V$ ← really wants to be reduced
B. Cl_2 $+1.358\ V$
C. Br_2 $+1.087\ V$
D. I_2 $+0.53535\ V$ ← closest to 0 ∴ So best reducing agent

E°

→ wants to be oxidized
↳ Things which are easily oxidized have (−) reduction potentials.

A 8. *(Analyze)* Which reaction will be the most spontaneous at standard conditions?

$\Delta G = -nFE^\circ_{cell}$

Reaction	E°cell (V)	Mole e⁻ transferred	ΔG°
A	0.431	2	−83.2 kJ
B	0.024	3	−6.9 kJ
C	0.177	4	−68.3 kJ
D	0.249	2	−48.0 kJ

B 9. *(Evaluate)* Which reaction below will yield an electrochemical cell which requires an external voltage of at least 0.90 V for the reaction to occur in the forward direction? Calculate E°_{cell}

ox = anode red = cathode

$E^\circ_{cell} = E_{cath} - E_{anode}$

A. $Na\ (s) + Fe^{3+}\ (aq) \rightarrow Na^+\ (s) + Fe^{2+}\ (aq)$ $E^\circ_{cell} = -0.997\ V - -2.71\ V = 2.26\ V$
B. $Cu^{2+}\ (aq) + Pt\ (s) \rightarrow Cu\ (s) + Pt^{2+}\ (aq)$ $E^\circ_{cell} = 0.34\ V - 1.20\ V = -0.86\ V$
C. $Co^{2+}\ (aq) + Cd\ (s) \rightarrow Co\ (s) + Cd^{2+}\ (aq)$ $E^\circ_{cell} = -0.28\ V - -0.403\ V = 0.123\ V$
D. $Ni^{2+}\ (aq) + Cu\ (s) \rightarrow Ni\ (s) + Cu^{2+}\ (aq)$ $E^\circ_{cell} = -0.257\ V - 0.34 = -0.597\ V$

→ Needs external so nonspontaneous, E°_{cell} (−). B & C are both (−) but B needs 0.90 V ... C turns on at 0.6 V

C 10. *(Create)* You want to create a galvanic cell which will produce $Sn^{2+}\ (aq)$ in solution spontaneously. Select a cathode, anode, and the concentration of reactants which will yield the desired product.

$Ni^{2+}_{(aq)} + Sn_{(s)} \rightarrow Ni_{(s)} + Sn^{2+}_{(aq)}$ $E^\circ_{cell} = -0.1195\ V$ nonspon

A. The cathode should be $Ni^{2+}\ (aq)$, anode should be Sn (s), and the initial concentration of all ions should be 0.34 M.

X B. The cathode should be $Sn^{2+}\ (aq)$, anode should be $Ni^{2+}\ (s)$, and the initial concentration of all ions should be 0.12 M. ← reactant ... we want to make this

$2Ag^+_{(aq)} + Sn_{(s)} \rightarrow 2Ag_{(s)} + Sn^{2+}_{(aq)}$ $E^\circ_{cell} = 0.9371\ V$ spon

C. The cathode should be $Ag^+\ (aq)$, anode should be Sn (s), and the initial concentration of all ions should be 0.50 M.

$Sn^{4+}_{(aq)} + 2Ag_{(s)} \rightarrow Sn^{2+}_{(aq)} + 2Ag^+_{(aq)}$

D. The cathode should be $Sn^{4+}\ (aq)$, anode should be Ag (s), and the initial concentration of all ions should be 0.01 M.

E°_{cells} ...

A. $= -0.257\ V - -0.1375\ V$
$= -0.1195\ V$

$E_{cell} = -0.1195\ V - \frac{0.0592\ V}{2} \log\left(\frac{0.34}{0.34}\right)$

$E^\circ_{cell} = -0.1195\ V$

C. $= 0.7996\ V - -0.1375\ V$
$= +0.9371\ V$

$E_{cell} = 0.9371 - \frac{0.0592}{2} \log\left(\frac{0.50}{(0.50)^2}\right)$

$E_{cell} = 0.928\ V$ most (+)

D. $= 0.151\ V - 0.7996\ V$
$= -0.6486\ V$

$E_{cell} = -0.6486 - \frac{0.0592}{2} \log\left(\frac{(0.01)\cdot(0.01)^2}{0.01}\right)$

$E_{cell} = -0.5676\ V$

Half-Reaction	***E*° (V)**
$F_2\,(g) + 2\ e^- \longrightarrow 2\ F-\,(aq)$	+2.866
$Au^{3+}\,(aq) + 3e^- \longrightarrow Au\,(s)$	+1.498
$Cl_2\,(g) + 2\ e^- \longrightarrow 2\ Cl^-\,(aq)$	+1.35827
$O_2\,(g) + 4\ H^+\,(aq) + 4e^- \longrightarrow 2\ H_2O\,(l)$	+1.229
$Pt^{2+}\,(aq) + 2\ e^- \longrightarrow Pt\,(s)$	+1.20
$Br_2\,(aq) + 2e^- \longrightarrow 2\ Br^-\,(aq)$	+1.0873
$Ag^+\,(aq) + e^- \longrightarrow Ag\,(s)$	+0.7996
$Hg_2^{2+}\,(aq) + 2\ e^- \longrightarrow 2\ Hg\,(l)$	+0.7973
$Fe^{3+}\,(aq) + e^- \longrightarrow Fe^{2+}\,(aq)$	+0.771
$I_2\,(s) + 2\ e^- \longrightarrow 2\ I^-\,(aq)$	+0.5355
$Cu^{2+}\,(aq) + 2\ e^- \longrightarrow Cu\,(s)$	+0.34
$Sn^{4+}\,(aq) + 2\ e^- \longrightarrow Sn^{2+}\,(aq)$	+0.151
$2\ H^+\,(aq) + 2\ e^- \longrightarrow H_2\,(g)$	0.00
$Pb^{2+}\,(aq) + 2\ e^- \longrightarrow Pb\,(s)$	−0.1262
$Sn^{2+}\,(aq) + 2\ e^- \longrightarrow Sn\,(s)$	−0.1375
$Ni^{2+}\,(aq) + 2\ e^- \longrightarrow Ni\,(s)$	−0.257
$Co^{2+}\,(aq) + 2\ e^- \longrightarrow Co\,(s)$	−0.28
$Cd^{2+}\,(aq) + 2\ e^- \longrightarrow Cd\,(s)$	−0.4030
$Fe^{2+}\,(aq) + 2\ e^- \longrightarrow Fe\,(s)$	−0.447
$Cr^{3+}\,(aq) + 3\ e^- \longrightarrow Cr\,(s)$	−0.744
$Mn^{2+}\,(aq) + 2\ e^- \longrightarrow Mn\,(s)$	−1.185
$Zn^{2+}\,(aq) + 2\ e^- \longrightarrow Zn\,(s)$	−0.7618
$Al^{3+}\,(aq) + 3\ e^- \longrightarrow Al\,(s)$	−1.662
$Mg^{2+}\,(aq) + 2\ e^- \longrightarrow Mg\,(s)$	−2.372
$Na^+\,(aq) + e^- \longrightarrow Na\,(s)$	−2.71
$Ca^{2+}\,(aq) + 2\ e^- \longrightarrow Ca\,(s)$	−2.868
$Ba^{2+}\,(aq) + 2\ e^- \longrightarrow Ba\,(s)$	−2.912
$K^+\,(aq) + e^- \longrightarrow K\,(s)$	−2.931
$Li^+\,(aq) + e^- \longrightarrow Li\,(s)$	−3.04

1 atm = 760 mmHg 1 mmHg = 1 torr 0 ºC = 273 K

R = 8.314 J/(mol K) = 0.08206 (L atm)/(mol K) $E°_{cell} = E°_{cathode} - E°_{anode}$

$\Delta G° = -nFE^{o}_{cell}$ F = 96,485 C/mol e^- $E^{o}_{cell} = \frac{0.0592\ V}{n} \log K$ (at T = 25 °C)

$E_{cell} = E^{o}_{cell} - \frac{0.0592\ V}{N} \log Q$ (at T = 25 °C)

Periodic Table of the Elements

1 IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 **H** Hydrogen 1.008																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012											5 **B** Boron 10.811	6 **C** Carbon 12.011	7 **N** Nitrogen 14.007	8 **O** Oxygen 15.999	9 **F** Fluorine 18.998	10 **Ne** Neon 20.180
11 **Na** Sodium 22.990	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.982	14 **Si** Silicon 28.086	15 **P** Phosphorus 30.974	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.453	18 **Ar** Argon 39.948
19 **K** Potassium 39.098	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.956	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.942	24 **Cr** Chromium 51.996	25 **Mn** Manganese 54.938	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933	28 **Ni** Nickel 58.693	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.38	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.631	33 **As** Arsenic 74.922	34 **Se** Selenium 78.971	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.798
37 **Rb** Rubidium 85.468	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.906	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.906	42 **Mo** Molybdenum 95.95	43 **Tc** Technetium 98.907	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.906	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.868	48 **Cd** Cadmium 112.414	49 **In** Indium 114.818	50 **Sn** Tin 118.711	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.6	53 **I** Iodine 126.904	54 **Xe** Xenon 131.294
55 **Cs** Cesium 132.905	56 **Ba** Barium 137.328	57-71	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.948	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.085	79 **Au** Gold 196.967	80 **Hg** Mercury 200.592	81 **Tl** Thallium 204.383	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.980	84 **Po** Polonium [208.982]	85 **At** Astatine 209.987	86 **Rn** Radon 222.018
87 **Fr** Francium 223.020	88 **Ra** Radium 226.025	89-103	104 **Rf** Rutherfordium [261]	105 **Db** Dubnium [262]	106 **Sg** Seaborgium [266]	107 **Bh** Bohrium [264]	108 **Hs** Hassium [269]	109 **Mt** Meitnerium [278]	110 **Ds** Darmstadtium [281]	111 **Rg** Roentgenium [280]	112 **Cn** Copernicium [285]	113 **Nh** Nihonium [286]	114 **Fl** Flerovium [289]	115 **Mc** Moscovium [289]	116 **Lv** Livermorium [293]	117 **Ts** Tennessine [294]	118 **Og** Oganesson [294]

Lanthanide Series	57 **La** Lanthanum 138.905	58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.908	60 **Nd** Neodymium 144.243	61 **Pm** Promethium 144.913	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.925	66 **Dy** Dysprosium 162.500	67 **Ho** Holmium 164.930	68 **Er** Erbium 167.259	69 **Tm** Thulium 168.934	70 **Yb** Ytterbium 173.055	71 **Lu** Lutetium 174.967
Actinide Series	89 **Ac** Actinium 227.028	90 **Th** Thorium 232.038	91 **Pa** Protactinium 231.036	92 **U** Uranium 238.029	93 **Np** Neptunium 237.048	94 **Pu** Plutonium 244.064	95 **Am** Americium 243.061	96 **Cm** Curium 247.070	97 **Bk** Berkelium 247.070	98 **Cf** Californium 251.080	99 **Es** Einsteinium [254]	100 **Fm** Fermium 257.095	101 **Md** Mendelevium 258.1	102 **No** Nobelium 259.101	103 **Lr** Lawrencium [262]