Dr. Zellmer | Chemistry 1220 | All Sections
Time: 7 PM Sun. | Spring Semester 2023 | April 10, 2023
40 min | Quiz X

Name _____ Rec. TA/time _____

Show **ALL** your work or **EXPLAIN** to receive full credit. R = 0.08206 L•atm/mol•K = 8.314 J/mol•K

1. (3 pts) Consider the ΔG_f^o and ΔH_f^o (kJ/mole) for the following oxides. Which oxide can be **most easily decomposed** to form the metal and oxygen gas.

	ΔG_f°	ΔH_f°
a) CdO	-228.4	-258.2
b) Cu_2O	-146.0	-168.8
c) HgO	-58.5	-90.8
d) Ag_2O	-11.2	-31.1
e) Au_2O_3	+163.1	+80.7

NOT on Carmen Quiz - Just for understanding spontaneity

2. (5 pts) For the following reaction ΔH° is −720.5 kJ/mol, ΔS° is −263.7 J/K•mol and ΔG° is −642.9 kJ/mol,

$$P_2\,(g) + 3\,Cl_2\,(g) \longrightarrow 2\,PCl_3\,(g)$$

What is the value of ΔG° (kJ/mol) at 141.0°C?

3. (5 pts) The K_p = 0.113 atm at 25.0°C and ΔH° = +57.2 kJ for the following reaction. Calculate K_p at 0.0 °C.

$$N_2O_4(g) \rightleftarrows 2\,NO_2(g)$$

NOT on Carmen Quiz. I've seen it on our midterms.

4. (13 pts) Given $\Delta H^\circ = -71.75$ kJ and $\Delta S^\circ = -268.0$ J/mol•K for the following reaction at 25°C,

$$3\ NO_2\ (g) \quad + \quad H_2O\ (\ell) \quad \rightarrow \quad 2\ HNO_3\ (\ell) \quad + \quad NO\ (g)$$

a) (2 pts) Calculate the ΔG° of the reaction at 25°C. Is the reaction spontaneous or nonspontaneous at this temperature under standard state conditions? **Show all work and explain.**

b) (4 pts) If the reaction is nonspontaneous, at what temperature would it be spontaneous, assuming ΔH^o and ΔS^o don't change with temperature. If the reaction is spontaneous, at what temperature would it be nonspontaneous. If the reaction will always be spontaneous at all temperatures or never be spontaneous at any temperature state that.

c) (2 pts) What is the equilibrium constant at 25°C? **Show all work and explain.**

d) (1 pt) This ΔG° and K corresponds to an equilibrium that is: (choose one from below & explain)

1) closer to products
2) closer to reactants
3) midway between reactants and products (significant amounts of both at equilibrium)

e) (4 pts) Is the reaction spontaneous or nonspontaneous at 25 °C when the pressures of NO_2 and NO are 2.50 atm and 0.50 atm, respectively? **Show all work and explain.**

5. (4 pts) For the redox reaction below, answer the questions. (**Show all work and explain!**)

$$3\ H_2SO_3 + 2\ HNO_3 \rightarrow 3\ H_2SO_4 + H_2O + 2\ NO$$

What element is reduced?

What element is oxidized?

What is the reducing agent?

How many electrons are being transferred?

6. Consider the following half-cell reactions and associated standard half-cell potentials and determine which species is the **best <u>reducing</u>** agent.

	E°
$S_2O_6^{2-}(aq) + 4\,H^+(aq) + 2\,e^- \longrightarrow 2\,H_2SO_3(aq)$	+0.60 V
$Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$	+0.771 V
$VO_2^+(aq) + 2\,H^+(aq) + e^- \longrightarrow VO^{2+}(aq) + H_2O(\ell)$	+1.00 V
$N_2O(aq) + 2\,H^+(aq) + 2\,e^- \longrightarrow N_2(g) + H_2O(\ell)$	+1.77 V

7. (11 pts) For the following unbalanced equation,

$$Mn^{2+}(aq) + Cr_2O_7^{2-}(aq) \rightarrow MnO_4^-(aq) + Cr^{3+}(aq) \quad (\textbf{\underline{acidic}} \text{ solution}).$$

a) (8 pts) Complete and balance the reaction in **<u>acidic</u>** solution using the **<u>half-reaction</u> method**. **Show all work and explain.**

NOT on Carmen Quiz - Just for practice

b) (2 pts) Identify the **oxidizing** and **reducing <u>agents</u>**. (**label them clearly**)

c) (1 pt) How many **electrons** are **transferred** in the reaction?

8. (12 pts) For the following unbalanced equation,

$$Cr(OH)_3\,(s) + ClO^-\,(aq) \rightarrow CrO_4^{2-}\,(aq) + Cl_2\,(g) \qquad (\textbf{basic} \text{ solution}).$$

a) (9 pts) Complete and balance the reaction in **basic** solution using the **half-reaction method**. **Show all work and explain.**

b) (2 pts) Identify the **oxidizing** and **reducing agents**. (**label them clearly**)

c) (1 pt) How many **electrons** are **transferred** in the reaction?

9. (17 pts) A **voltaic** cell is made from the following half-cells.

$Cr^{3+}(aq) + 3\,e^- \rightarrow Cr(s)$ $\quad E° = -0.74V$

$Co^{2+}(aq) + 2\,e^- \rightarrow Co(s)$ $\quad E° = -0.277V$

a) (2 pts) Write the half-reactions for the anode and cathode and label which is which. **Show all work.**

b) (3 pts) Write the overall balanced equation for the reaction and indicate the number of electrons transferred. **Show all work.**

c) (1 pts) What is the $E°_{cell}$? **Show all work.**

d) (4 pts) Write the shorthand representation for this cell as done in lecture and homework exercise.

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9. (Cont.)

e) (3 pts) What is the value of ΔG^{o} for the reaction? **Show all work.**

f) (4 pts) What is the value of the equilibrium constant? **Show all work.**

10. (3 pts) Calculate the **<u>equilibrium</u> <u>constant</u>** for the following reaction using the standard electrode potentials.

$$2\ Cr(s) + 3\ Zn^{2+}(aq) \rightleftarrows 2\ Cr^{3+}(aq) + 3\ Zn(s)$$

$Zn^{2+}(aq) + 2\ e^{-} \longrightarrow Zn(s)$ $\quad E^{\circ} = -0.760$ V

$Cr^{3+}(aq) + 3\ e^{-} \longrightarrow Cr(s)$ $\quad E^{\circ} = -0.740$ V

USEFUL INFORMATION

R = 0.08206 L-atm/mol-K = 8.3145 J/mol-K
k = 1.38 x 10^{-23} J/K
1 J = 1 C•V, 1 C = 1 A•s, F = 96,485 C/mol e−

$$\Delta G = \Delta H - T\Delta S \qquad \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta G = \Delta G^\circ + RT \bullet \ln Q \qquad \Delta G^\circ = -RT \bullet \ln K$$

$$S = k \bullet \ln W$$

$$\Delta G = -nFE \qquad \Delta G^\circ = -nFE^\circ$$

$$E = E^\circ - \frac{RT}{nF}\ln Q \qquad E = E^\circ - \frac{0.0592\,V}{n}\log Q \quad (at\ 25\,^\circ C)$$

$$E^\circ = \frac{RT}{nF}\ln Q \qquad E^\circ = \frac{0.0592\,V}{n}\log K \quad (at\ 25\,^\circ C)$$

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1.008 **H** 1																	4.003 **He** 2
2	6.941 **Li** 3	9.012 **Be** 4											10.811 **B** 5	12.011 **C** 6	14.007 **N** 7	15.999 **O** 8	18.998 **F** 9	20.179 **Ne** 10
3	22.990 **Na** 11	24.305 **Mg** 12											26.98 **Al** 13	28.09 **Si** 14	30.974 **P** 15	32.06 **S** 16	35.453 **Cl** 17	39.948 **Ar** 18
4	39.098 **K** 19	40.08 **Ca** 20	44.96 **Sc** 21	47.88 **Ti** 22	50.94 **V** 23	52.00 **Cr** 24	54.94 **Mn** 25	55.85 **Fe** 26	58.93 **Co** 27	58.69 **Ni** 28	63.546 **Cu** 29	65.38 **Zn** 30	69.72 **Ga** 31	72.59 **Ge** 32	74.92 **As** 33	78.96 **Se** 34	79.904 **Br** 35	83.80 **Kr** 36
5	85.47 **Rb** 37	87.62 **Sr** 38	88.91 **Y** 39	91.22 **Zr** 40	92.91 **Nb** 41	95.94 **Mo** 42	98 **Tc** 43	101.07 **Ru** 44	102.91 **Rh** 45	106.42 **Pd** 46	107.87 **Ag** 47	112.41 **Cd** 48	114.82 **In** 49	118.69 **Sn** 50	121.75 **Sb** 51	127.60 **Te** 52	126.90 **I** 53	131.39 **Xe** 54
6	132.91 **Cs** 55	137.33 **Ba** 56	138.91 **La** 57	178.39 **Hf** 72	180.95 **Ta** 73	183.85 **W** 74	186.21 **Re** 75	190.23 **Os** 76	192.22 **Ir** 77	195.08 **Pt** 78	196.97 **Au** 79	200.59 **Hg** 80	204.38 **Tl** 81	207.2 **Pb** 82	208.98 **Bi** 83	209 **Po** 84	210 **At** 85	222 **Rn** 86
7	223 **Fr** 87	226.03 **Ra** 88	227.03 **Ac** 89	261 **Rf** 104	262 **Ha** 105	263 **Sg** 106	262 **Ns** 107	265 **Hs** 108	266 **Mt** 109	269 110	272 111	277 112						

Lanthanide Series	140.12 **Ce** 58	140.91 **Pr** 59	144.24 **Nd** 60	145 **Pm** 61	150.36 **Sm** 62	151.96 **Eu** 63	157.25 **Gd** 64	158.93 **Tb** 65	162.50 **Dy** 66	164.93 **Ho** 67	167.26 **Er** 68	168.93 **Tm** 69	173.04 **Yb** 70	173.04 **Lu** 71
Actinide Series	232.04 **Th** 90	231.04 **Pa** 91	238.03 **U** 92	237.05 **Np** 93	**Pu** 94	**Am** 95	**Cm** 96	**Bk** 97	**Cf** 98	**Es** 99	**Fm** 100	**Md** 101	**No** 102	**Lr** 103

A PERIODIC CHART OF THE ELEMENTS
(Based on ^{12}C)