CHM 2046 Exam 3 Review

*This review is separated by topic since professors are not covering the same chapters on this exam (double check what topics are on **your** exam!)*

Chapter 20 – Thermodynamics: entropy, free energy, direction of reactions

See exam 2 review on our website for more chapter 20 practice problems

1) Which of the following reaction(s) will result in a positive change in entropy?
   ~~I:~~ The formation of gaseous water from its elements
   [✓ II:] The combustion of liquid ethanol (C_2H_5OH)
   [✓ III:] The decomposition of hydrogen peroxide (H_2O_2)
   A) I only
   B) II only
   C) I and III
   [✓ D)] II and III
   E) I, II and III

$I)\ 2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)} \quad \Delta S < 0$

$II)\ 2C_2H_5OH_{(l)} + 7O_{2(g)} \rightarrow 4CO_{2(g)} + 6H_2O_{(g)} \quad \Delta S > 0$

$III)\ 2H_2O_{2(l)} \rightarrow 2H_2O_{(l)} + O_{2(g)} \quad \Delta S > 0$

2) Phosphorylation, the addition of a phosphate group (Pi) to an organic compound, is a common reaction that happens in your body. Given the hydrolysis of ATP and the first step in glycolysis, which of the following is true?
   ATP + H_2O -> ADP + Pi , $\Delta G^o = -31.0$ kJ/mol
   glucose + Pi -> glucose-6-phosphate + H_2O, $\Delta G^o = +14.3$ kJ/mol
   ~~A)~~ The phosphorylation of glucose drives the hydrolysis of ATP
   [✓ B)] The hydrolysis of ATP drives the phosphorylation of glucose
   C) The phosphorylation of ADP drives the phosphorylation of glucose
   D) The phosphorylation of glucose drives the phosphorylation of ADP

3) Consider the following reaction:
   $2Hg(l) + O_2(g) \rightarrow 2HgO(s)$; $\Delta H^o_{rxn} = -90.79$ kJ/mol, $\Delta S^o_{rxn} = +70.27$ J/mol*K
   Which of the following is true of the free energy change at 1020°C?
   [✓ A)] ΔG^o represents the maximum work the system can do
   B) ΔG^o represents the minimum work the system can do
   ~~C)~~ ΔG^o represents the maximum work the system requires
   ~~D)~~ ΔG^o represents the minimum work the system requires

$\Delta G^\circ = (-90.79) - (1293K)(0.07027)$

$\Delta G^\circ = -181.65$

Spontaneous → system does work

$1020 + 273 = 1293K$

4) Hypobromous acid is a commonly used disinfectant in swimming pools. At 25°C HBrO dissociates with a Ka = $2.3\text{x}10^{-9}$. Is this dissociation a spontaneous process when $[H_3O^+] = 6.0\text{x}10^{-4}$ M, $[BrO^{--}]$ = 0.10 M, and [HBrO] = 0.20 M?
   A) Yes, because $\Delta G > 0$
   [✓ B)] No, because $\Delta G > 0$
   C) Yes, because $\Delta G < 0$
   D) No, because $\Delta G < 0$

$\Delta G = \Delta G^\circ + RT\ln Q$

$\Delta G = -RT\ln K + RT\ln Q$

$\Delta G = RT(-\ln K + \ln Q)$

$\Delta G = (8.314 J/mol \cdot K)(298K)\left[-\ln(2.3\times10^{-9}) + \ln\left(\frac{(6.0\times10^{-4})(0.1)}{0.2}\right)\right]$

$\Delta G = +29.18$ KJ/mol nonspontaneous

$HBrO + H_2O \rightleftharpoons H_3O^+ + BrO^-$

Chapter 21 – Electrochemistry

5) Which of the following is/are true given the following reaction?

$3\ Ni(s) + ClO_3^-(aq) + 6\ H^+(aq) \leftrightarrow 3\ Ni^{2+}(aq) + Cl^-(aq) + 3\ H_2O(l)$ with an NaCl salt bridge present

~~I:~~ The electrode in the anode gains mass

[✓ II:] $Na^+(aq)$ flows from the salt bridge into the half-cell containing ClO_3^-/Cl^-

~~III:~~ Electrons move from the half-cell containing ClO_3^-/Cl^- to the half-cell containing Ni/Ni^{2+}

- A) I only
- [✓ B)] II only
- C) I and II
- D) II and III
- E) I and III

Anode (ox.): $Ni \rightarrow Ni^{2+} + 2e^-$

Cathode (red.): $6e^- + 6H^+ + ClO_3^- \rightarrow Cl^- + 3H_2O$

$Cu + Br_2 \rightarrow Cu^{2+} + 2\ Br^-$ n=2 mol e-

6) If the E = 0.87V and E° = 0.75V for the following cell:

$Cu(s)\ |\ Cu^{2+}(0.90\ M)\ ||\ Br^{-}$ (saturated MBr_2) $|\ Br_2(l)\ |\ Pt(s)$

What is the Ksp of MBr_2? (M is any metal)

- [✓ A)] 4.9×10^{-7}
- B) 9.9×10^{-3}
- C) 9.8×10^{-5}
- D) 3.9×10^{-6}
- E) 3.1×10^{-5}

$$Q = [Br^-]^2[Cu^{2+}]$$

$$[Br^-] = \sqrt{Q/[Cu^{2+}]}$$

$$MBr_2 \rightarrow M^{2+} + 2Br^-$$
$$x \qquad 2x$$

$$E = E° - \frac{0.0592}{n}\log Q$$

$$\frac{(E° - E)n}{0.0592} = \log Q$$

$$Q = 10^{\frac{(0.75-0.87)(2)}{0.0592}}$$

$$Q = 8.83\times10^{-5}$$

$$[Br^-] = \sqrt{(8.83\times10^{-5})/0.9}$$

$$[Br^-] = 0.0099\ M$$

$$K_{sp} = [M^{2+}][Br^-]^2,\ [M^{2+}] = \frac{[Br^-]}{2} = 0.00495M$$

$$K_{sp} = (0.00495)(0.0099)^2$$

$$K_{sp} = 4.85\times10^{-7}$$

7) A current is applied to a molten mixture containing KI and MgF_2. Which of the following would be the products formed at the anode and cathode, respectively?

electrolytic

$E°_{cell} < 0$

- [✓ A)] $I_2(g)$, $Mg(l)$
- B) $I_2(g)$, $K(s)$
- C) $F_2(g)$, $Mg(l)$
- D) $F_2(g)$, $K(s)$
- E) None

Anode (ox.)	E°	Cathode (red.)	E°
$2I^- \rightarrow I_2 + 2e^-$	0.54	$K^+ + e^- \rightarrow K$	-2.93
$2F^- \rightarrow F_2 + 2e^-$	2.87	$Mg^{2+} + 2e^- \rightarrow Mg$	-2.73

$E_{cell} = E_{cat} - E_{an}$ → *least negative

8) You wish to set up a nickel-cadmium cell with an initial potential E of 0.20 V. If the initial cadmium ion concentration is 0.10 M, what must be the initial nickel ion concentration?

- A) 0.0020 M
- B) 0.020 M
- C) 2.0 M
- D) 3.6 M
- [✓ E)] 4.9 M

	E
$Ni^{2+} + 2e^- \rightarrow Ni$	-0.25
$Cd^{2+} + 2e^- \rightarrow Cd$	-0.40

$Ni^{2+} + Cd \rightarrow Cd^{2+} + Ni$ $E°_{cell} = 0.15$

$$E = E° - \frac{0.0592}{n}\log Q$$

$$Q = 10^{\frac{(0.15-0.20)\cdot(2)}{0.0592}}$$

$$Q = 0.02 = \frac{[Cd^{2+}]}{[Ni^{2+}]}$$

$$[Ni^{2+}] = \frac{0.1M}{0.02} = 4.9M$$

9) Calculate the maximum initial free energy available from the following concentration cell:

$Cr(s)|\ Cr^{3+}(0.010\ M)\ ||\ Cr^{3+}\ (1.0\ M)\ |Cr(s)$

$E°_{cell} = 0$

$$Q = \frac{\text{lower conc.}}{\text{higher conc.}}$$

- [✓ A)] -11 kJ/mol
- B) -5.7 kJ/mol
- C) -2.9 kJ/mol
- D) -1.4 kJ/mol
- E) -0.071 kJ/mol

$$E = -\frac{0.0592}{n}\log Q$$

$$E = -\frac{0.0592}{3}\log\left(\frac{0.01}{1}\right)$$

$$E = 0.0394V$$

$$\Delta G = -nFE = -(3mol)(96{,}500\ \frac{C}{mol})(0.394\ J/C)$$

$$\Delta G = -11.4\ KJ/mol$$

10) For the following concentration cell at 25°C, give the values of E°, ΔG°, K_{eq}, Q, E, and ΔG.

Zn(s) | Zn^{2+} (0.010M) || Zn^{2+} (1.0M) | Zn(s)

$E° = 0$

$\Delta G° = 0$

$K_{eq} = 1$

$Q = \frac{0.01}{1} = \boxed{0.01}$

$E = -\frac{0.0592}{2}\cdot\log(0.01) = \boxed{0.0592V}$

$\Delta G = -(2\,mol)(96{,}500\ C/mol)(0.0592\ J/C)$

$\boxed{\Delta G = -11.4\ KJ/mol}$

Chapter 23 – Transition elements, coordination compounds

See exam 2 review on our website for more chapter 23 practice problems

11) What are the charge and coordination number of the central metal ion(s) in each of the following compounds? I. $[Ni(H_2O)_6]Cl_2$ II. $[Cr(en)_3](ClO_4)_3$ III. $K_4[Mn(CN)_6]$

I: $\downarrow$ +2, $\downarrow$ −2; 6

II: $\downarrow$ +3, $\downarrow$ −3; 6

III: $\downarrow$ +4, $\downarrow$ +2, $\downarrow$ −6; 6

A) +2, 6; +3, 3; +4, 6

B) +4, 12; +6, 3; +4, 6

[✓ C)] +2, 6; +3, 6; +2, 6

D) +8, 6; +2, 3; +4, 6

E) +4, 12; 0, 3; +2, 6

en: bidentate

12) Which of these ligands can participate in linkage isomerism: I. NO_2^{-} II. SO_2 III. NO_3^{-} ?

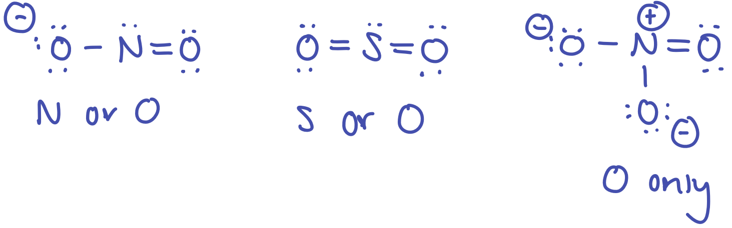
A) Only I

[✓ B)] Only I and II

C) Only II and III

D) I, II, and III

E) None of the above



complimentary colors:

red & green (christmas)

orange & blue (gators)

violet & yellow (Vikings

13) The hexaaqua complex $[Ni(H_2O)_6]^{2+}$ is green, whereas the hexaammonia complex $[Ni(NH_3)_6]^{2+}$ is violet. Why?

A) H_2O is a stronger field ligand and absorbs lower energy photons. Absorbing yellow light makes the solution violet, and absorbing red makes the solution green. Therefore, the hexaaqua compound absorbs red light which is lower in energy than yellow light.

B) H_2O is a stronger field ligand and absorbs higher energy photons. Absorbing yellow light makes the solution green, and absorbing red makes the solution violet. Therefore, the hexaaqua compound absorbs yellow light which is higher in energy than red light.

C) NH_3 is a stronger field ligand and absorbs higher energy photons. Absorbing red light makes the solution violet, and absorbing yellow makes the solution green. Therefore, the hexaammonia compound absorbs red light which is higher in energy than yellow light.

[✓ D)] NH_3 is a stronger field ligand and absorbs higher energy photons. Absorbing yellow light makes the solution violet, and absorbing red makes the solution green. Therefore, the hexaammonia compound absorbs yellow light which is higher in energy than red light.

stronger field → absorbs higher energy light

★ color wheel!

Chapter 24 – Nuclear reactions

14) What is the specific activity (in Ci/g) if 1.65 mg of an isotope emits 1.56×10^{6} alpha particles per second?

A) 4.22×10^{-5}

★ $1\ Ci = 3.7\times10^{10}\ ds/s$

$\downarrow$ $1.56\times10^{6}\ ds/s$

$$\frac{1.56\times10^{6}\ \cancel{ds}}{s}\cdot\frac{1\ Ci}{3.7\times10^{10}\ \cancel{ds/s}}\cdot\frac{1}{1.65\times10^{-3}g} = 2.56\times10^{-2}\ Ci/g$$

[✓ B)] $2.56\text{x}10^{-2}$
C) 4.22
D) 2.56
E) Not enough information

★15) The isotope ${}^{212}_{83}$Bi has a half-life of 1.01 yr. What mass (in mg) of a 2.00-mg sample will remain after $3.75\text{x}10^{3}$ h? Show your work to be eligible for partial credit.

A) 0.51 mg
B) 0.0 mg
[✓ C)] 1.49 mg
D) 0.82 mg

$$t_{1/2} = \frac{\ln(2)}{k} \qquad 3.75\times10^{3}\,h \cdot \frac{1\,day}{24\,h} \cdot \frac{1\,yr}{365\,d} = 0.428\,yr$$

$$k = \frac{\ln(2)}{t_{1/2}} = \frac{\ln(2)}{1.01\,yr} = 0.686\,yr^{-1}$$

$$\ln A_t = -(\overset{t}{\downarrow}\,0.428\,yr)(\overset{k}{\downarrow}\,0.686\,yr^{-1}) + \overset{2.00mg}{\downarrow}\ln(2)$$

$A_t = 1.49$ mg left

gamma: ${}^{0}_{0}\gamma$
alpha: ${}^{4}_{2}He$
beta: ${}^{0}_{-1}\beta$
e^- capture: ${}^{0}_{-1}e^-$
positron: ${}^{0}_{+1}\beta$

16) Which of the following have the same net effect?

A) Gamma emission and positron emission
B) Alpha decay and beta decay
[✓ C)] Electron capture and positron emission
D) Beta decay and electron capture
E) Alpha decay and positron emission

17) What is the most likely mode of decay for each? I. ^{15}C II. ^{120}Xe III. ^{224}Th

A) Beta decay, positron decay/e^{-}capture, alpha decay
B) positron decay/e^{-}capture, beta decay, alpha decay
C) positron decay/e^{-}capture, alpha decay, alpha decay
D) Beta decay, beta decay, alpha decay
E) Beta decay, alpha decay, positron decay/e^{-}capture

I) ^{15}C vs ^{12}C : ^{15}C is too heavy → ${}^{0}_{-1}\beta$

II) ^{120}Xe vs ^{131}Xe : ^{120}Xe is too light: ${}^{0}_{+1}\beta$ emission/ ${}^{0}_{-1}e$ capture

III) ^{224}Th has $Z > 83$ → alpha decay