Chem 101B Study Questions   Name: _____

Chapters 17,18

Review Tuesday 4/16/2019

Due on Exam Thursday 4/18/2019 (Exam 4 Date)

This is a homework assignment. Please show your work for full credit. If you do work on separate paper, attach the work to these.

Useful Info to be provided on exam:

$\Delta G = \Delta H - T\Delta S$	$1\ V = 1\ J/C$
$\Delta G^\circ = -RT \ln K$	$1\ A = 1\ C/s$
$\Delta G^\circ = -nF\mathcal{E}^\circ$	$R = 8.314\ J/K \cdot mol$
$\mathcal{E} = \mathcal{E}^\circ - \dfrac{RT}{nF} \ln Q$	$F = 96485\ C/mol\ e^-$
$\mathcal{E} = \mathcal{E}^\circ - \dfrac{.0591}{n} \log Q\ \ (25°C)$	
$\mathcal{E}^\circ = \dfrac{.0591}{n} \log K\ (25°C)$	
$\mathcal{E}^\circ = \dfrac{RT}{nF} \ln K$	

Also provided: Table 18.1 (Standard Reduction Potentials)

1. Which of the following shows a <u>decrease</u> in entropy?
   A) precipitation
   B) gaseous reactants forming a liquid
   C) a burning piece of wood
   D) melting ice
   E) two of these

2. Consider the following processes:
   I.   condensation of a liquid
   II   increasing the volume of 1.0 mol of an ideal gas at constant
          temperature
   III.   dissolving sugar in water
   IV.   heating 1.0 mol of an ideal gas at constant volume
   For how many of these is ΔS positive?
   A) 0
   B) 1
   C) 2
   D) 3
   E) 4

3. Which of the following statements is true?
   A) The total energy and entropy of the universe are both increasing.
   B) The total energy of the universe is increasing, but the entropy is constant.
   C) The total energy of the universe increases, while the entropy decreases.
   D) The total energy of the universe is constant, but the entropy is increasing.
   E) None of these.

4. ΔS_{surr} is _____ for exothermic reactions and _____ for endothermic reactions.
   A) positive, negative
   B) negative, positive
   C) positive, positive
   D) negative, negative
   E) Need more information to determine

5. Despite the entropy of the surroundings increase, a process may not be spontaneous.
   Explain.

6. Substance X has a heat of vaporization of 55.5 kJ/mol at its normal boiling point
   (423°C). For the process $X(l) \rightarrow X(g)$ at 1 atm and 423°C calculate the value of ΔS.
   A) 0
   B) 79.7 J/K mol
   C) 131 J/K mol
   D) −79.7 J/K mol
   E) −131 J/K mol

7. For the process $CHCl_3(s) \rightarrow CHCl_3(l)$, $\Delta H° = 9.16$ kJ/mol and $\Delta S° = 43.9$ J/mol/K. What is the melting point of chloroform?
   A) −64 °C
   B) 209 °C
   C) 129 °C
   D) 64 °C
   E) −129 °C

8. For a particular chemical reaction $\Delta H = 8.5$ kJ and $\Delta S = -27$ J/K. Under what temperature condition is the reaction spontaneous?
   A) When $T < -315$ K.
   B) When $T < 315$ K.
   C) The reaction is spontaneous at all temperatures.
   D) The reaction is not spontaneous at any temperature.
   E) When $T > 315$ K.

9. Consider the <u>freezing of liquid water</u> at −10°C. For this process what are the signs for ΔH, ΔS, and ΔG?

	ΔH	ΔS	ΔG
A)	+	−	0
B)	+	−	−
C)	−	+	0
D)	−	+	−
E)	−	−	−

10. For the reaction $A + B \rightarrow C + D$, $\Delta H° = +40$ kJ and $\Delta S° = +50$ J/K. Therefore, the reaction under standard conditions is
    A) spontaneous at temperatures less than 10 K
    B) spontaneous at temperatures greater than 800 K
    C) spontaneous only at temperatures between 10 K and 800 K
    D) spontaneous at all temperatures
    E) nonspontaneous at all temperatures

11. At constant pressure, the following reaction $2NO_2(g) \rightarrow N_2O_4(g)$ is exothermic. The reaction (as written) is
    A) always spontaneous
    B) spontaneous at low temperatures, but not high temperatures
    C) spontaneous at high temperatures, but not low temperatures
    D) never spontaneous
    E) cannot tell

Use the following to answer questions 12-13:

When ignited, solid ammonium dichromate decomposes in a fiery display. This is the reaction for a "volcano" demonstration in school science projects which was common before your time. The balanced decomposition equation below, and occurs at 25°C.

$$(NH_4)_2Cr_2O_7(s) \rightarrow Cr_2O_3(g) + 4H_2O(l) + N_2(g)$$

Substance	ΔH_f° (kJ/mol)	S° (kJ/mol K)
$Cr_2O_3(g)$	−1147	0.08115
$H_2O(l)$	−242	0.1187
$N_2(g)$	0	0.1915
$(NH_4)_2Cr_2O_7(s)$	−22.5	0.1137

12. Determine ΔS° reaction (in kJ/mol K).
    A) 0.2777
    B) 0.8612
    C) 0.7475
    D) 0.6338
    E) 0.1590

13. Determine ΔG° (in kJ/mol).
    A) −191.4
    B) −2281.4
    C) −38.9
    D) 1903.6
    E) −1555.4

14. For the reaction $Cl_2O(g) + \frac{3}{2}O_2(g) \rightarrow 2ClO_2(g)$,
    $\Delta H^\circ = 126.4$ kJ/mol and $\Delta S^\circ = -74.9$ J/K mol.
    At 384°C, what is ΔG ?
    A) 155.2 kJ/mol
    B) 49.3 kJ/mol
    C) 175.6 kJ/mol
    D) 77.2 kJ/mol
    E) 157.9 kJ/mol

15. Given the following free energies of formation:

Species	ΔG_f°
$C_2H_2(g)$	209.2 kJ/mol
$C_2H_6(g)$	−32.91 kJ/mol

calculate K_p at 298 K for $C_2H_2(g) + 2H_2(g) \rightleftharpoons C_2H_6(g)$
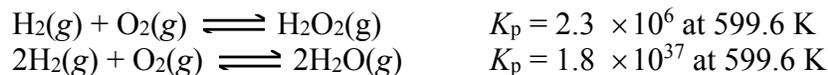   A) 97.7
   B) 1.10
   C) 7.98×10^{30}
   D) 2.75×10^{42}
   E) None of these is within a factor of 10 of the correct answer.

16. Calculate K_{sp} for the salt NaCl at 25°C.

Species	ΔG_f° (in kJ/mol)
$Na^+(aq)$	−262.0
$Cl^-(aq)$	−131.0
$NaCl(s)$	−383.7

   A) 43
   B) 2.7×10^{19}
   C) 9.3
   D) 4.3
   E) 0.43

17. Calculate ΔG° for $H_2O(g) + \frac{1}{2}O_2(g) \rightleftharpoons H_2O_2(g)$ at 599.6 K, using the following data:

$H_2(g) + O_2(g) \rightleftharpoons H_2O_2(g)$ $K_p = 2.3 \times 10^6$ at 599.6 K
$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$ $K_p = 1.8 \times 10^{37}$ at 599.6 K

   A) 141 kJ
   B) −501 kJ
   C) 501 kJ
   D) −287 kJ
   E) 287 kJ

18. Given $CH_3CO_2H(aq) \rightleftharpoons H^+(aq) + CH_3CO_2^-(aq)$ at 25°C, $K_a = 1.81 \times 10^{-5}$. What is ΔG° at 25°C?
   A) −27.1 kJ
   B) 27.1 kJ
   C) 2.27 kJ
   D) −2.27 kJ
   E) 27.1 J

Predict an increase or decrease in entropy for each of the following (19 and 20)

19. For 1 mole He at 25°C
    He(g) at 3 atm → He(g) at 1 atm

20. $2KClO_3(s)$ → $2KCl(s) + 3O_2(g)$

21. Balance the following redox reaction in <u>acidic media</u>:
    $$Fe^{2+}(aq) + Cr_2O_7{}^{2-}(aq) \rightarrow Fe^{3+}(aq) + Cr^{3+}(aq)$$

    <u>Show your work.</u>

22. Balance the following equation in acidic solution: $SO_3{}^{2-}(aq) + MnO_4{}^-(aq) \rightarrow SO_4{}^{2-}(aq)$ + $Mn^{2+}(aq)$

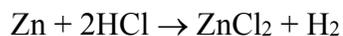   What is the value of n required for the Nernst Equation?

    <u>Show your work.</u>

23. What is the oxidation state of Hg in Hg_2Cl_2?
    A) +2
    B) −1
    C) −2
    D) +1
    E)   0

24. What is *n* for the following reaction?

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

    A) 0
    B) 1
    C) 2
    D) 4
    E) not enough information given

25. Which energy conversion shown below takes place in a galvanic cell?
    A) electrical to chemical
    B) chemical to electrical
    C) mechanical to chemical
    D) chemical to mechanical
    E) mechanical to electrical

Use the following to answer questions 26-28:

Consider the following standard cell $Zn(s) | Zn^{2+}(aq) \| Cr^{3+}(aq) | Cr(s)$ at 25°

26. Which of the following is true for the standard cell?
    A) The electrons flow from the cathode to the anode.
    B) The electrons flow from the zinc to the chromium.
    C) The electrons flow from the chromium to the zinc.
    D) The chromium is oxidized.
    E) The zinc is reduced.

27. Calculate the standard cell potential, $\mathcal{E}°$.

28. Suppose the concentration of species are as follows: $[Zn^{2+}] = 1.0M$ and $[Cr^{3+}]=0.50M$.

How would the cell potential $(\mathcal{E})$ compare to the standard cell potential $(\mathcal{E}°)$?
A) It would be the same
B) It would be greater (i.e. more positive) than the standard cell potential.
C) It would be less (i.e. more negative) than the standard cell potential.
D) This cannot be determined with the information provided.

29. You are told that metal X is a better reducing agent than metal Y. This could also mean that:
A) X^+ is a better oxidizing agent than Y^+.
B) X^+ is a better reducing agent than Y^+.
C) Y is a better oxidizing agent than X.
D) Y^+ is a better reducing agent than X^+.
E) Y^+ is a better oxidizing agent than X^+.

30. Consider the electrochemical cell shown below which takes place at 25°C:
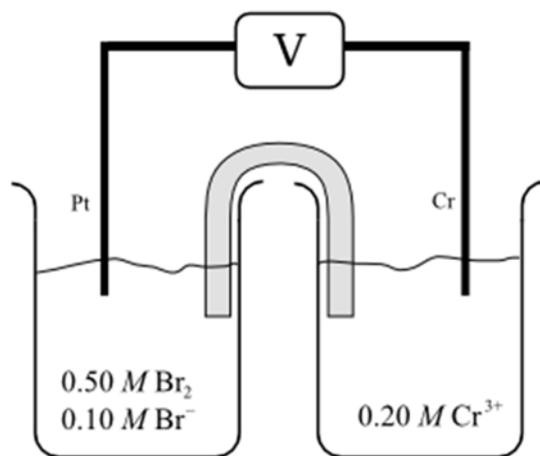
Write the balanced spontaneous cell reaction, and calculate the standard cell potential $(\mathcal{E}°)$. Which direction do the electrons flow?

Calculate the cell potential $(\mathcal{E})$ under the given conditions above. Which directions do the electrons flow?

31. Among the following species, which of the following is the best reducing agent?
    A) Cl_2
    B) H_2
    C) Mg
    D) Mg^{2+}
    E) Cl^-

32. What is the balanced chemical cell equation corresponding to the following cell diagram?
    $Ag(s) \mid Ag^+(aq) \parallel Ca^{2+}(aq) \mid Ca(s)$
    A) $2Ag(s) + 2Ag^+(aq) \rightarrow Ca^{2+}(aq) + Ca(s)$
    B) $Ca(s) + 2Ag^+(aq) \rightarrow 2Ag(s) + Ca^{2+}(aq)$
    C) $2Ag(s) + Ca(s) \rightarrow 2Ag^+(aq) + Ca^{2+}(aq)$
    D) $Ca^{2+}(aq) + Ca(s) \rightarrow 2Ag(s) + 2Ag^+(aq)$
    E) $2Ag(s) + Ca^{2+}(aq) \rightarrow 2Ag^+(aq) + Ca(s)$

33. You wish to plate out zinc metal from a zinc nitrate solution. Which metal, Al or Ni, could you place in the solution to accomplish this without using an external power source?
    A) Al
    B) Ni
    C) Both Al and Ni would work.
    D) Neither Al nor Ni would work.
    E) Cannot be determined.

34. Consider the following reduction potentials:

$Au^{3+} + 3e^- \rightarrow Au$ $\mathcal{E}° = +1.50$ V
$Ni^{2+} + 2e^- \rightarrow Ni$ $\mathcal{E}° = -0.233$ V
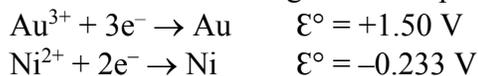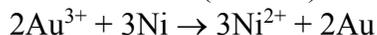
Calculate $\Delta G°$ (at 25°C) for the reaction:
$2Au^{3+} + 3Ni \rightarrow 3Ni^{2+} + 2Au$
A) 1.00×10^3 kJ
B) -7.33×10^2 kJ
C) 7.33×10^2 kJ
D) -1.67×10^2 kJ
E) -1.00×10^3 kJ

35. A common car battery consists of six identical cells, each of which carries out the reaction:
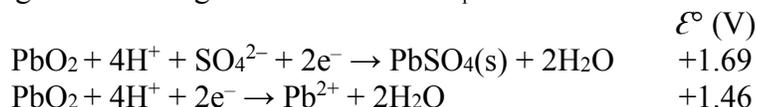$Pb + PbO_2 + 2HSO_4^- + 2H^+ \rightarrow 2PbSO_4 + 2H_2O$
The value of E° for such a cell is 2.044 V. Calculate $\Delta G°$ at 25 °C for the reaction.

36. Consider an electrochemical cell with a zinc electrode immersed in 1.000 M Zn^{2+} and a nickel electrode immersed in 0.445 M Ni^{2+}.
   $Zn^{2+} + 2e^- \rightarrow Zn$
   $Ni^{2+} + 2e^- \rightarrow Ni$
Calculate $\mathcal{E}$ (not $\mathcal{E}°$) for this cell.
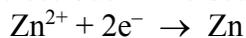
37. Using the following data to calculate K_{sp} for PbSO$_4$.

	$\mathcal{E}°$ (V)
$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4(s) + 2H_2O$	+1.69
$PbO_2 + 4H^+ + 2e^- \rightarrow Pb^{2+} + 2H_2O$	+1.46

hint: First write the equation for K_{sp} PbSO$_4$. Try Hess' Law.

38. An antique automobile bumper is to be chrome plated. The bumper, which is dipped into an acidic $Cr_2O_7^{2-}$ solution, serves as a cathode of an electrolytic cell. If the current is 10.0 amperes, how long will it take to deposit 123 grams of Cr(*s*) onto the bumper?

39. What total quantity of charge is required to reduce 33.2 g of $CrCl_3$ to chromium metal?

40. Nickel is electroplated from a $NiSO_4$ solution. A constant current of 3.53 amp is applied by an external power supply. How long will it take to deposit 100. g of Ni?

41. An unknown metal (M) is electrolyzed. It took 74.1 s for a current of 2.00 amp to plate 0.107 g of the metal from a solution containing $M(NO_3)_3$. Identify the metal.
    A) La
    B) Bi
    C) Ga
    D) Cu
    E) Rh

Answer Key

1.	E
	Chapter/Section: 17.1
2.	D
	Chapter/Section: 17.1
3.	D
	Chapter/Section: 17.2
4.	A
	Chapter/Section: 17.3
5.	Hint: 2nd Law of thermodynamics
	Chapter/Section: 17.3
6.	B
	Chapter/Section: 17.4
7.	A
	Chapter/Section: 17.4
8.	D
	Chapter/Section: 17.4
9.	E
	Chapter/Section: 17.4
10.	B
	Chapter/Section: 17.4
11.	B
	Chapter/Section: 17.4
12.	D
	Chapter/Section: 17.5
13.	B
	Chapter/Section: 17.6
14.	C
	Chapter/Section: 17.6
15.	D
	Chapter/Section: 17.8
16.	A
	Chapter/Section: 17.8
17.	A
	Chapter/Section: 17.8
18.	B
	Chapter/Section: 17.8
19.	increase in entropy At constant temperature, a decrease in pressure corresponds to an increase in volume, which imparts greater positional entropy. See Sec. 17.1, Zumdahl, *Chemistry*.
	Chapter/Section: 17.1

20.	increase in entropy
	The change in positional entropy is dominated by the relative numbers of molecules in the gas phase.
	See Sec. 17.5, Zumdahl, *Chemistry*.
	Chapter/Section: 17.5
21.	$6Fe^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq) \rightarrow 6Fe^{3+}(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$
	Chapter/Section: 18.1
22.	$6H^+(aq) + 5SO_3^{2-}(aq) + 2MnO_4^-(aq) \rightarrow 3H_2O(l) + 5SO_4^{2-}(aq) + 2Mn^{2+}(aq)$
	$n=10$
	Chapter/Section: 18.1
23.	D
	Chapter/Section: 18.1
24.	C
	Chapter/Section: 18.1
25.	B
	Chapter/Section: 18.2
26.	B
	Chapter/Section: 18.2
27.	0.03 V
28.	C
29.	E
	Chapter/Section: 18.3
30.	$2Cr(s) + 3Br_2(l) \rightarrow 2Cr^{3+}(aq) + 6Br^-(aq)$ $\mathcal{E}° = 1.82V$
	Electrons flow from the chromium electrode to platinum electrode.
	$\mathcal{E} = 1.88V$
	Electrons flow from the chromium electrode to platinum electrode.
	Note: the drawing should be reversed to show oxidation on in the left cell.
	Chapter/Section: 18.3

31.	C		37.	1.7×10^{-8}
	Chapter/Section: 18.3			Chapter/Section: 18.5
32.	E		38.	1.59 days
	Chapter/Section: 18.3			Chapter/Section: 18.8
33.	A		39.	6.07×10^4 C
	Chapter/Section: 18.3			Chapter/Section: 18.8
34.	E		40.	25.9 h
	Chapter/Section: 18.4			Chapter/Section: 18.8
35.	−394.4 kJ		41.	B
	Chapter/Section: 18.4			Chapter/Section: 18.8
36.	0.52 V			
	Chapter/Section: 18.5			