

Brooklyn College--Department of Chemistry

Chemistry 2

Second Lecture Exam

Spring 2003

Name \_\_\_\_\_

Circle the name of your lab instructor: Kazimierska, Giroto, Voloshchuk Gibbs

**Before** you begin the exam, write your name on this page and on the answer booklet.

**WARNING:** There are questions on BOTH sides of each page. Do NOT tear off this page.

Answer Questions 1-12 on the question sheet. Do questions 13-23 in the exam booklet.

For questions 13-23, show all work. Express answers with the proper units and to the correct number of significant figures. You have 90 minutes. Do not spend too much time on one question.

This exam has 4 pages. Make sure you have all of them. Calculators may be inspected.

PERIODIC CHART OF THE ELEMENTS

IA	IIA												IIIA	IVA	VA	VIA	VIIA	0
1 H 1.0079																	1 H 1.0079	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179	
11 Na 22.989	12 Mg 24.305											13 Al 26.981	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948	
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.88	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80	
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.905	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29	
55 Cs 132.91	56 Ba 137.33	57 * La 138.90	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)	
87 Fr (223)	88 Ra 226.0	89 # Ac 227.03																

\* Lanthanides

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
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# Actinides

90 Th 232.03	91 Pa 231.03	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (257)	102 No (255)	103 Lr (256)
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$$R = 0.08206 \text{ L atm/mol-K} = 8.314 \text{ J/mol-K}$$

$$F = 96,500 \text{ C/mol}$$

$$E = E^\circ - \frac{0.0592 \text{ V}}{n} \log Q \quad \text{at } 25^\circ\text{C}$$

$$\Delta G^\circ = -nFE^\circ \quad \Delta G^\circ = -RT \ln K \quad \Delta G = \Delta G^\circ + RT \ln Q$$

**Answer Questions 1–13 on these sheets.**

1. (2 pts) In thermodynamics, the symbol  $\Delta S$  means

- (a)  $\Delta S$  of the system    (b)  $\Delta S$  of the surroundings    (c)  $\Delta S$  of the universe

2. (8 pts) State whether each of the following is True or False.

- (a) In an unsaturated solution,  $Q$  is less than  $K_{sp}$ .  
(b) In every spontaneous process, the entropy of the system must increase.  
(c) The total entropy of the universe remains constant (is conserved) in all processes.  
(d) When a complex ion is formed, the ligands act as Lewis bases.

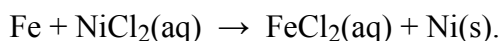
3. (3 pts) The solubility of  $\text{PbCl}_2$  in  $\text{Pb}(\text{NO}_3)_2(\text{aq})$  is

- (a) less than            (b) the same as            (c) greater than  
its solubility in pure water.

4. (7 pts) Give the oxidation number of the underlined element in each of the following:

- (a)  $\underline{\text{S}}\text{O}_3^{2-}$     (b)  $\text{K}_2\underline{\text{C}}_2\text{O}_4$     (c)  $\text{H}_2\underline{\text{O}}_2$     (d)  $\underline{\text{O}}_2$

5. (3 pts) What is the normality of a 0.40 M  $\text{NiCl}_2(\text{aq})$  solution used in the reaction



6. (5 pts.) Give the formula of

- (a) hexaamminenickel(II) ion

(b) potassium tetrachlorodiaquacobaltate(II).

7. (3 pts) Which one of these compounds is more soluble in HCl(aq) than in water?

(a) AgCN      (b) PbCl<sub>2</sub>      (c) NaNO<sub>3</sub>

8. (2 pts) If  $\Delta G^\circ$  for a reaction is negative, which of these has the larger standard-state Gibbs free energy:

(a) the reactants      (b) the products

9. (4 pts) State whether  $\Delta S$  is positive, negative, or zero for each of the following processes:

(a) 46 g of liquid water goes from 60°C to 50°C at 1 atm pressure.

(b) 7 g of N<sub>2</sub>(g) goes from 50°C and 2.0 atm pressure to 50°C and 1.0 atm pressure.

10. (2 pts) The equation  $\Delta G = \Delta H - T \Delta S$  is correct

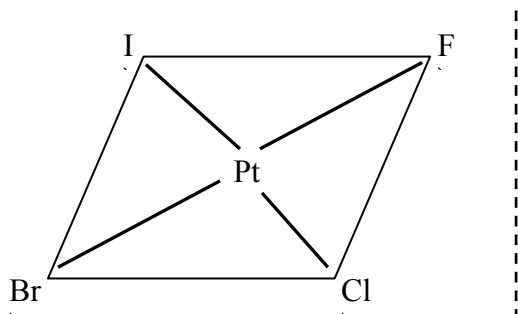
(a) for all processes

(b) only for processes that occur at constant temperature

(c) only for processes that occur at constant temperature and constant pressure.

(d) for no processes

11. (4 pts) The dashed line represents a mirror that is perpendicular to the plane of the paper



(a) At the right of the dashed line, draw the mirror image of the square-planar molecule at the left.

(b) Is the mirror image the same molecule or a different molecule than the original molecule?

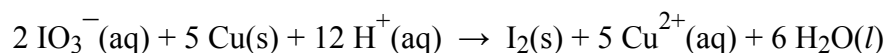
12. (3 pts) For a reaction that has a negative value of  $\Delta S^\circ$ , which statement is true at equilibrium?

(a) At very low temperatures, reactants are present in greater amounts than products.

- (b) At very low temperatures, products are present in greater amounts than reactants.
- (c) At very high temperatures, reactants are present in greater amounts than products.
- (d) At very high temperatures, products are present in greater amounts than reactants.

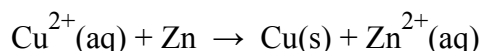
**Answer Questions 13-23 in the answer booklet. Show all work.**

13. (? pts) A student adds HCl(aq) to her cation unknown and observes a precipitate. There are several possible reactions that could have produced the precipitate. Write **net ionic** reactions for each possible reaction that might have occurred.
14. (2 pts) Find the equivalent weight of Ca for a reaction in which Ca(s) is oxidized to  $\text{Ca}^{2+}$ .
15. (6 pts) A certain current flows for 125 minutes through an electrolytic cell containing molten  $\text{CaI}_2$  and deposits 5.85 g of Ca metal. Find the value of this current.
16. (6 pts) Shirley adds 200 mL of 0.020 M  $\text{Pb}(\text{NO}_3)_2$ (aq) to 300 mL of 0.010 M of HCl(aq) at 25°C. Will a precipitate form? **Show work.** For  $\text{PbCl}_2$ (aq),  $K_{\text{sp}} = 1.7 \times 10^{-5}$  at 25°C.
17. (5 pts) A galvanic cell uses the reaction



For this cell,  $E^\circ = 0.858 \text{ V}$  at 25°C. If the ionic concentrations in the cell are 0.500 M for  $\text{IO}_3^-$ (aq), 1.20 M for  $\text{Cu}^{2+}$ (aq) and 0.600 M for  $\text{H}^+$ (aq), find the emf (voltage) of this cell at 25°C.

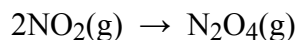
18. (7 pts) A galvanic cell has the spontaneous reaction



This cell consists of Cu(s),  $\text{CuSO}_4$ (aq) and Zn(s),  $\text{ZnBr}_2$ (aq) half-cells, and an NaCl salt bridge.

- (a) When the cell operates, which electrode (Cu or Zn) do electrons flow out of?
- (b) When the cell operates, does the mass of the Cu electrode increase, decrease, or stay the same?
- (c) When the cell operates, do bromide ions move toward the Zn electrode, away from the Zn electrode, or neither toward nor away from the Zn electrode?
- (d) Which electrode is the anode? (Reminder: answer in the exam booklet.)

19. (6 pts) Find the equilibrium constant at 25°C for the reaction



given the following data at 25°C:

	$\Delta H_f^\circ$	$\Delta G_f^\circ$	$S^\circ$
$\text{NO}_2(\text{g})$	33.8 kJ/mol	51.8 kJ/mol	240.4 J/mol-K
$\text{N}_2\text{O}_4(\text{g})$	9.7 kJ/mol	98.3 kJ/mol	304.3 J/mol-K

There is more than one way to do this problem. Do it the faster way so as to save time.

20. (6 pts) Consider a cell that consists of an Ag,  $\text{AgNO}_3(\text{aq})$  half-cell, a Cu,  $\text{CuSO}_4(\text{aq})$  half-cell, and a salt bridge. For  $\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}$  at 25°C,  $E^\circ = 0.80 \text{ V}$ .

For  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}$  at 25°C,  $E^\circ = 0.34 \text{ V}$ .

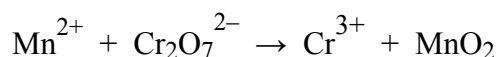
(a) Write the spontaneous cell reaction.

(b) Find  $E^\circ$  for this cell at 25°C.

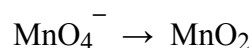
(c) Find  $\Delta G^\circ$  for the spontaneous cell reaction.

21. (2 pts) Use information near the beginning of the exam to find the charge in coulombs on one electron.

22. (8 pts) Balance the following reaction in **acidic** aqueous solution using the method of half-reactions. You **must** use the method of half-reactions.



23. (3 pts) Balance this **half-reaction** in **basic** solution (note the charge on the ion on the left):



**Extra credit – Answer in the exam booklet, not on this page**

EC1 (1 pt) Which of the two men Gibbs and Boltzmann had beards?

(a) Only Gibbs (b) Only Boltzmann (c) Both (d) Neither (Answer goes **in booklet**.)

EC2 (2 pts) The Lewis structure of  $\text{C}_3\text{F}_8$  has the three carbons in a row, has three F atoms bonded to each of the end carbons and two F atoms bonded to the central C. All bonds are single and there are no unpaired electrons on the carbons. Assign all the electrons in each bond to the more electronegative element to find the oxidation number of each carbon atom in this molecule.