

# Form G

Chemistry 1442-001

Test #3

November 13, 2003

Name (please print) \_\_\_\_\_

Last Name

First Name

IA												VIIIA						
1 H 1.01	IIA										5 B 10.81	6 C 12.01	7 N 14.01	8 O 15.999	9 F 18.998	10 Ne 20.18		
3 Li 6.94	4 Be 9.01											13 Al 26.98	14 Si 28.086	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95	
11 Na 22.99	12 Mg 24.31	IIIB	IVB	VB	VIB	VII B	VIII B		IB	IIB	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80		
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 51.996	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.38	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30	
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	80 Hg 200.59	81 Tl 204.37	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
55 Cs 132.91	56 Ba 137.33	57 La 138.91	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 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)	
87 Fr (223)	88 Ra 226.03	89 Ac 227.03	104 Unq (261)	105 Unp (262)	106 Unh (263)													

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	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 (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

## Instructions:

- This exam consists of 25 questions.
- No scratch paper is allowed. You may do the work in the test margins and on the backs of the test pages.
- Mark the answers you choose on the test itself for your own information and also on the standard answer sheet you provided. Scoring will be based on the answer sheet.
- When you finish, turn in both the test form and the answer form. The test form and your personal report will be returned to you at the next class. Write your name on both forms.

## Useful Information:

$$R = 0.08206 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K} = 8.314 \text{ J}/\text{mol}\cdot\text{K}$$

$$1 \text{ atm} = 760 \text{ mm Hg}$$

- Which of the choices below, when added to 50.0 mL of 0.10 M hydrocyanic acid, HCN, will cause the pH of the solution increase?
  - 10.0 mL of 0.50 M HCN
  - 10.0 mL of 0.10 M NaCN
  - 10.0 mL of 0.10 M HNO<sub>3</sub>
  - 10.0 mL of 0.10 M KOH
  - IV only
  - I and III
  - I and II
  - I, II and IV
  - II and IV

2. Which of the following will give a buffer solution when equal volumes of the two solutions are mixed?
- I. 0.10 M  $\text{HNO}_3$  and 0.10 M  $\text{NaNO}_3$
  - II. 0.10 M  $\text{HCN}$  and 0.10 M  $\text{NaCN}$
  - III. 0.10 M  $\text{HCl}$  and 0.10 M  $\text{NaCN}$
  - IV. 0.05 M  $\text{NaOH}$  and 0.10 M  $\text{HCN}$
  - V. 0.20 M  $\text{NaOH}$  and 0.10 M  $\text{HCN}$
- a) I and II
  - b) II and IV
  - c) II only
  - d) II, III, and IV
  - e) I, II, III, IV, and V
3. A buffer is prepared by adding 125.0 mL of 0.100 M  $\text{HCN}$  to 100.0 mL of 0.200 M  $\text{NaCN}$ . What is the pH of this buffer? ( $K_a$  for  $\text{HCN}$  is  $4.9 \times 10^{-10}$ .)
- a) 9.31
  - b) 9.61
  - c) 9.01
  - d) 9.11
  - e) 9.51
4. 100.0 mL of a buffer which is 0.10 M in  $\text{HCN}$  and 0.10 M in  $\text{KCN}$  has 20.0 mL of 0.10 M  $\text{HCl}$  added to it. What is the pH after the  $\text{HCl}$  has been added? ( $K_a = 4.9 \times 10^{-10}$  for  $\text{HCN}$ )
- a) 9.31
  - b) 9.49
  - c) 9.01
  - d) 9.13
  - e) 8.36
5. A 50.0 mL sample of 0.200 M  $\text{HBr}$  solution is titrated with 0.100 M  $\text{NaOH}$ . What is the pH of the solution after adding 80.0 mL of base?
- a) 2.69
  - b) 5.60
  - c) 1.65
  - d) 1.81
  - e) 1.53
6. Consider the titration of 25.00 mL of 0.150 M acetic acid ( $\text{HC}_2\text{H}_3\text{O}_2$ ,  $K_a = 1.8 \times 10^{-5}$ ) with 0.100 M  $\text{NaOH}$ . What is the pH after the addition of 30.00 mL of  $\text{NaOH}$ ?
- a) 5.35
  - b) 4.74
  - c) 4.14
  - d) 4.65
  - e) 4.57

7. Consider the titration of 40.00 mL of 0.100 M  $\text{NH}_3$  with 0.250 M  $\text{HCl}$ . What is the pH at the equivalence point? ( $K_b$  for  $\text{NH}_3$  is  $1.8 \times 10^{-5}$ .)
- 4.63
  - 5.20
  - 4.74
  - 7.00
  - 4.93
8. What is the  $K_{sp}$  expression for  $\text{Ca}_3(\text{PO}_4)_2$ ?
- $K_{sp} = \frac{[\text{Ca}^{2+}]^3 [\text{PO}_4^{3-}]^2}{[\text{Ca}_3(\text{PO}_4)_2]}$
  - $K_{sp} = [\text{Ca}^{2+}]^3 [\text{PO}_4^{3-}]^2$
  - $K_{sp} = \frac{[\text{Ca}_3(\text{PO}_4)_2]}{[\text{Ca}^{2+}]^3 [\text{PO}_4^{3-}]^2}$
  - $K_{sp} = (3[\text{Ca}^{2+}])^3 (2[\text{PO}_4^{3-}])^2$
  - $K_{sp} = [\text{Ca}^{2+}]^2 [\text{PO}_4^{3-}]^3$
9. At 25°C, a certain saturated solution of silver phosphate,  $\text{Ag}_3\text{PO}_4$ , has the following concentration of ions:
- $$[\text{Ag}^+] = 3.0 \times 10^{-5} \text{ M}$$
- $$[\text{PO}_4^{3-}] = 6.7 \times 10^{-5} \text{ M}$$
- What is the value of  $K_{sp}$  for silver phosphate at 25°C?
- $4.9 \times 10^{-17}$
  - $6.0 \times 10^{-14}$
  - $2.0 \times 10^{-9}$
  - $1.8 \times 10^{-18}$
  - $6.0 \times 10^{-9}$
10. The solubility of calcium phosphate,  $\text{Ca}_3(\text{PO}_4)_2$ , is  $1.6 \times 10^{-7}$  moles per liter at 25°C. What is the solubility product constant,  $K_{sp}$ , for calcium phosphate at 25°C?
- $2.8 \times 10^{-12}$
  - $6.3 \times 10^{-34}$
  - $1.5 \times 10^{-13}$
  - $4.4 \times 10^{-19}$
  - $1.1 \times 10^{-32}$
11. What is the molar solubility of strontium fluoride,  $\text{SrF}_2$ , in pure water at 25°C? ( $K_{sp}$  for  $\text{SrF}_2 = 7.9 \times 10^{-10}$  at 25°C.)
- $7.3 \times 10^{-4}$
  - $9.2 \times 10^{-4}$
  - $2.0 \times 10^{-5}$
  - $2.3 \times 10^{-4}$
  - $5.8 \times 10^{-4}$

12. What is the molar solubility of  $\text{CaF}_2$  in 0.050 M NaF?  
( $K_{\text{sp}}$  for  $\text{CaF}_2$  is  $3.9 \times 10^{-11}$ .)

- a)  $3.9 \times 10^{-9}$
- b)  $1.6 \times 10^{-8}$
- c)  $1.4 \times 10^{-5}$
- d)  $7.8 \times 10^{-10}$
- e)  $2.8 \times 10^{-5}$

13.  $K_{\text{sp}}$  for silver sulfate,  $\text{Ag}_2\text{SO}_4$ , is  $1.2 \times 10^{-5}$ . If 100 mL of 0.080 M  $\text{AgNO}_3$  is added to 100 mL of 0.015 M  $\text{K}_2\text{SO}_4$ , which statement best describes what happens to the resulting solution?

- a) The solution is supersaturated, and a precipitate will form.
- b) The solution is supersaturated, but a precipitate will not form.
- c) The solution is saturated, and no precipitate will form.
- d) The solution is unsaturated, and no precipitate will form.

14. Which of the ionic solids below will become more soluble as the pH is lowered?

- I.  $\text{AgBr}$
- II.  $\text{PbCl}_2$
- III.  $\text{Mg}(\text{OH})_2$
- IV.  $\text{ZnS}$

- a) III only
- b) I and II
- c) III and IV
- d) I, II, and IV
- e) I, III, and IV

15. Which of the following statements is true?

- a) In any spontaneous process, the entropy of the system always increases.
- b) All spontaneous processes are exothermic.
- c) In order for a process to be spontaneous, the process must be exothermic *and* the entropy of the system must increase.
- d) In any spontaneous process, the total entropy of the universe always increases.
- e) All of these statements are true.

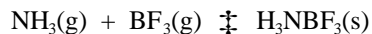
16. Consider the following processes:

- I.  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2 \text{NO}_2(\text{g})$
- II.  $\text{C}_3\text{H}_8(\text{g}) + 5 \text{O}_2(\text{g}) \rightleftharpoons 3 \text{CO}_2(\text{g}) + 4 \text{H}_2\text{O}(\text{l})$
- III.  $\text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{H}_2\text{O}(\text{l})$

Which of these processes have a positive value for  $\Delta S$ ?

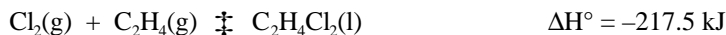
- a) I only
- b) I and II
- c) I and III
- d) I, II, and III
- e) II and III

17. Consider the following reaction, which is spontaneous at room temperature:



Which of the following statements must be true of this reaction?

- a)  $\Delta H < 0$   
 b)  $\Delta H > 0$   
 c)  $\Delta G > 0$  at all temperatures  
 d)  $\Delta G < 0$  at all temperatures  
 e) choices (a) and (d) are both correct.
18. Consider the following thermochemical equation:



Based upon a consideration of the entropy change and the Gibbs free energy change, when is this reaction expected to be spontaneous?

- a) spontaneous only at low temperatures  
 b) spontaneous only at high temperatures  
 c) spontaneous at all temperatures  
 d) not spontaneous at any temperature  
 e) not enough information is given
19. Solid carbon dioxide is commonly known as dry ice. What are the signs of  $\Delta G$ ,  $\Delta H$ , and  $\Delta S$  for the sublimation of dry ice at  $25^\circ\text{C}$ ?

	$\Delta G$	$\Delta H$	$\Delta S$
a)	-	+	-
b)	+	-	-
c)	+	+	+
d)	-	-	+
e)	-	+	+

20. The enthalpy of vaporization of benzene is  $+30.8 \text{ kJ/mol}$  at its boiling point of  $80.0^\circ\text{C}$ . What is the  $\Delta S^\circ$  of vaporization of benzene at its boiling point and  $1.0 \text{ atm}$  pressure?
- a)  $+11.5 \text{ J/mol}\cdot\text{K}$   
 b)  $+0.385 \text{ J/mol}\cdot\text{K}$   
 c)  $+385 \text{ J/mol}\cdot\text{K}$   
 d)  $+87.3 \text{ J/mol}\cdot\text{K}$   
 e)  $-11.5 \text{ J/mol}\cdot\text{K}$
21. Use the thermodynamic data below to determine the standard free energy change,  $\Delta G^\circ$ , for the following reaction at  $25^\circ\text{C}$ .



The standard molar enthalpies of these substances are as follows:

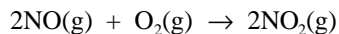
$$\text{K}(\text{s}) \quad S^\circ = 64.67 \text{ J/mol}\cdot\text{K}$$

$$\text{Cl}_2(\text{g}) \quad S^\circ = 222.96 \text{ J/mol}\cdot\text{K}$$

$$\text{KCl}(\text{s}) \quad S^\circ = 82.7 \text{ J/mol}\cdot\text{K}$$

- a)  $-473 \text{ kJ}$   
 b)  $-408 \text{ kJ}$   
 c)  $27.4 \text{ kJ}$   
 d)  $-375 \text{ kJ}$   
 e)  $-496 \text{ kJ}$

22. What is the standard free energy change,  $\Delta G^\circ$ , at 25°C for the reaction

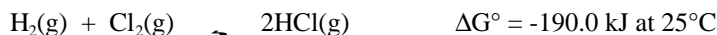


given these thermodynamic values:

$$\Delta G_f^\circ \text{ for NO}(\text{g}) = +86.55 \text{ kJ/mol}$$

$$\Delta G_f^\circ \text{ for NO}_2(\text{g}) = +51.31 \text{ kJ/mol}$$

- a) -35.24 kJ  
 b) +35.24 kJ  
 c) -70.48 kJ  
 d) +70.48 kJ  
 e) -140 kJ
23. Consider the following reaction:



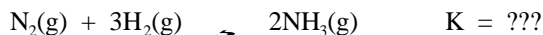
What is the value of  $\Delta G$  at 25°C when each gas is at the partial pressure specified below?

0.50 atm  $\text{H}_2(\text{g})$   
 0.50 atm  $\text{Cl}_2(\text{g})$   
 10.0 atm  $\text{HCl}(\text{g})$

- a) -159 kJ  
 b) -175 kJ  
 c) -183 kJ  
 d) -205 kJ  
 e) -197 kJ
24. The standard enthalpy of formation of ammonia,  $\text{NH}_3(\text{g})$ , is given below:

$$\Delta G_f^\circ = -16.66 \text{ kJ/mol at } 25^\circ\text{C for } \text{NH}_3(\text{g})$$

What is the equilibrium constant at 25°C for the reaction shown?



*Hint: Don't just blindly plug in numbers. Think about this!*

- a)  $6.9 \times 10^5$   
 b)  $4.7 \times 10^4$   
 c)  $8.3 \times 10^2$   
 d) 1.0  
 e)  $1.4 \times 10^{-6}$
25. What is the significance of the third law of thermodynamics? *Choose the one best answer.*
- a) The absolute entropy of a substance decreases with increasing temperature.  
 b) The entropy of the universe must increase for any spontaneous process.  
 c) The absolute value of entropy can be measured for some very pure substances.  
 d) The change in entropy of the universe equals the sum of the change in entropy of the system plus the change in entropy of the surroundings.  
 e) Energy is conserved.

#### Answers

- |      |       |       |       |       |
|------|-------|-------|-------|-------|
| 1. e | 6. a  | 11. e | 16. a | 21. b |
| 2. b | 7. b  | 12. b | 17. a | 22. c |
| 3. e | 8. b  | 13. c | 18. a | 23. b |
| 4. d | 9. d  | 14. c | 19. e | 24. a |
| 5. d | 10. e | 15. d | 20. d | 25. c |