Chem 203 - Practice Exam Two (Chapters 19, 20 and 21)

1. Consider the dissolution of MnS in water ($K_{sp} = 3.0 \times 10^{-14}$).
$MnS(s) + H_2O(l) \rightleftharpoons Mn^{2+}(aq) + HS^-(aq) + OH^-(aq)$
How is the solubility of manganese(II) sulfide affected by the addition of aqueous potassium hydroxide to the system?
A. The solubility will be unchanged.
B. The solubility will decrease.
C. The solubility will increase.
D. The amount of KOH added must be known before its effect can be predicted.
E. The pK_a of H_2S is needed before a reliable prediction can be made.

2. A voltaic cell prepared using aluminum and nickel has the following cell notation.
$Al(s) \mid Al^{3+}(aq) \mid\mid Ni^{2+}(aq) \mid Ni(s)$
Which of the following reactions occurs at the anode?
A. $Al(s) \rightarrow Al^{3+}(aq) + 3e^-$ B. $Al^{3+}(aq) + 3e \rightarrow Al(s)$
C. $Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$ D. $Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$
E. None of these choices is correct.

3. The reaction of methane with water to form carbon dioxide and hydrogen is non-spontaneous at 298 K. At what temperature will this system make the transition from non-spontaneous to spontaneous? The data refer to 298 K.
$CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g)$

Substance:	$CH_4(g)$	$H_2O(g)$	$CO_2(g)$	$H_2(g)$
$\Delta H°_f$ (kJ/mol):	–74.87	–241.8	–393.5	0
$\Delta G°_f$ (kJ/mol):	–50.81	–228.6	–394.4	0
S°(J/K·mol):	186.1	188.8	213.7	130.7

A. 658 K B. 683 K C. 955 K D. 1047 K E. 1229 K

4. Which relationship or statement best describes $\Delta S°$ for the following reaction?
$Pb(s) + Cl_2(g) \rightarrow PbCl_2(s)$
A. $\Delta S° \approx 0$ B. $\Delta S° < 0$ C. $\Delta S° > 0$ D. $\Delta S° = \Delta H°/T$
E. More information is needed to make a reasonable prediction.

5. The salts $X(NO_3)_2$ and $Y(NO_3)_2$ (where X^{2+} and Y^{2+} are metal ions) are dissolved in water to give a solution which is 0.1 M in each of them. Using the K_{sp} values listed below, decide which aqueous reagent, if any, will definitely precipitate X^{2+} before precipitating Y^{2+} from solution.
Given K_{sp} values: XCl_2, 1×10^{-5}; YCl_2, 1×10^{-10}; $X(OH)_2$, 1×10^{-10}; $Y(OH)_2$, 1×10^{-5}
A. 1 M NH_3 B. 1 M HCl C. 1 M HNO_3 D. 1 M NaCl
E. None of these reagents will accomplish the precipitation.

6. The concentration of the complex ion in each of following solutions is 1.00 M. In which of the solutions will the concentration of the uncomplexed metal ion be the greatest?

$Hg(CN)_4^{2-}$	$K_f = 9.3 \times 10^{38}$
$Be(OH)_4^{2-}$	$K_f = 4.0 \times 10^{18}$
$Zn(OH)_4^{2-}$	$K_f = 3.0 \times 10^{15}$
$Cu(NH_3)_4^{2+}$	$K_f = 5.6 \times 10^{11}$
CdI_4^{2-}	$K_f = 1.0 \times 10^{6}$

A. Hg^{2+} B. Be^{2+} C. Zn^{2+} D. Cu^{2+} E. Cd^{2+}

7. Calculate $\Delta S°$ for the reaction $4Cr(s) + 3O_2(g) \rightarrow 2Cr_2O_3(s)$

Substance:	Cr(s)	$O_2(g)$	$Cr_2O_3(s)$
S°(J/K·mol):	23.77	205.138	81.2

A. -548.1 J/K B. -147.7 J/K C. 147.7 J/K D. 310.1 J/K E. 548.1 J/K

8. When the following redox equation is balanced with smallest whole number coefficients, the coefficient for nitrogen dioxide will be _____.

$I_2(s) + HNO_3(aq) \rightarrow HIO_3(aq) + NO_2(g) + H_2O(l)$

A. 1 B. 2 C. 4 D. 10 E. None of these choices is correct.

9. What is the $E°_{cell}$ for the cell represented by the combination of the following half-reactions?

$ClO_4^-(aq) + 8H^+(aq) + 8e^- \rightleftharpoons Cl^-(aq) + 4H_2O(l)$ $E° = 1.389$ V

$VO_2^+(aq) + 2H^+(aq) + e^- \rightleftharpoons VO^+(aq) + H_2O(l)$ $E° = 0.991$ V

A. -0.398 V B. -2.380 V C. 0.398 V D. 2.380 V

E. None of these choices is correct.

10. When 20.0 mL of 0.15 M hydrochloric acid is mixed with 20.0 mL of 0.10 M sodium hydroxide, the pH of the resulting solution is

A. 0.00 B. 12.40 C. 1.60 D. 0.82 E. 7.00

11. What is the maximum mass of KCl that can be added to 1.0 L of a 0.010 M lead(II) chloride solution without causing any precipitation of lead(II) chloride? Assume that addition of KCl does not affect the solution volume. For lead(II) chloride, $K_{sp} = 1.6 \times 10^{-5}$

A. 3.0 g B. 1.5 g C. 0.8 g D. 0.8 g E. 0.2 g

12. Calculate $E°_{cell}$ and indicate whether the overall reaction shown is spontaneous or nonspontaneous.

$Co^{3+}(aq) + e^- \rightleftharpoons Co^{2+}(aq)$ $E° = 1.82$ V

$MnO_4^-(aq) + 2H_2O(l) + 3e^- \rightleftharpoons MnO_2(s) + 4OH^-(aq)$ $E° = 0.59$ V

Overall reaction:

$MnO_4^-(aq) + 2H_2O(l) + 3Co^{2+}(aq) \rightarrow MnO_2(s) + 3Co^{3+}(aq) + 4OH^-(aq)$

A. $E°_{cell} = -1.23$ V, spontaneous B. $E°_{cell} = -1.23$ V, nonspontaneous

C. $E°_{cell} = 1.23$ V, spontaneous D. $E°_{cell} = 1.23$ V, nonspontaneous

E. $E°_{cell} = -0.05$ V, nonspontaneous

13. In order for a process to be spontaneous,

A. ΔH must be less than zero. B. ΔS must be greater than zero.

C. ΔG must be greater than zero. D. it should be rapid.

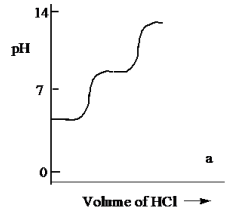
E. $\Delta S_{sys} + \Delta S_{surr}$ must be greater than zero.

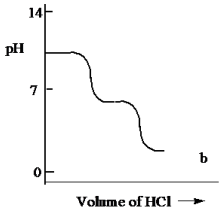
14. Calculate the solubility of strontium fluoride, SrF_2, in pure water. $K_{sp} = 2.6 \times 10^{-9}$

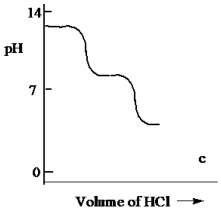
A. 1.4×10^{-3} M B. 3.4×10^{-4} M C. 8.7×10^{-4} M

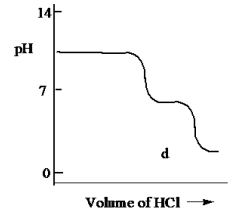
D. 5.1×10^{-5} M E. $< 1.0 \times 10^{-5}$ M

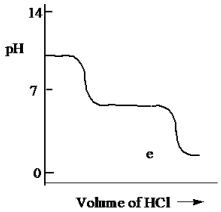
15. A diprotic acid H_2A has $K_{a1} = 1 \times 10^{-4}$ and $K_{a2} = 1 \times 10^{-8}$. The corresponding base A^{2-} is titrated with aqueous HCl, both solutions being 0.1 mol L^{-1}. Which one of the following diagrams best represents the titration curve which will be seen?

A. 

B. 

C. 

D. 

E. 

16. A popular buffer solution consists of carbonate (CO_3^{2-}) and hydrogen carbonate (HCO_3^-) conjugate acid-base pair. Which, if any, of the following such buffers can neutralize the greatest amount of added hydrochloric acid, while remaining within its buffer range?
A. 1 L of 0.9 M CO_3^{2-} and 0.1 M HCO_3^-
B. 1 L of 0.1 M CO_3^{2-} and 0.9 M HCO_3^-
C. 1 L of 0.5 M CO_3^{2-} and 0.5 M HCO_3^-
D. 1 L of 0.1 M CO_3^{2-} and 0.1 M HCO_3^-
E. They can all neutralize the same amount of hydrochloric acid.

17. Which one of the following aqueous solutions, when mixed with an equal volume of 0.10 mol L^{-1} aqueous NH_3, will produce a buffer solution?
A. 0.10 mol L^{-1} HCl B. 0.20 mol L^{-1} HCl C. 0.10 mol L^{-1} CH_3COOH
D. 0.050 mol L^{-1} NaOH E. 0.20 mol L^{-1} NH_4Cl

18. Which of the following statements about voltaic and electrolytic cells is correct?
A. The anode will definitely gain weight in a voltaic cell.
B. Oxidation occurs at the cathode of both cells.
C. The free energy change, ΔG, is negative for the voltaic cell.
D. The electrons in the external wire flow from cathode to anode in an electrolytic cell.
E. None of these choices is correct.

19. Nitric oxide reacts with chlorine to form NOCl. The data refer to 298 K.
$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$

Substance:	NO(g)	$Cl_2(g)$	NOCl(g)
$\Delta H°_f$ (kJ/mol):	90.29	0	51.71
$\Delta G°_f$ (kJ/mol):	86.60	0	66.07
S°(J/K·mol):	210.65	223.0	261.6

What is the value of $\Delta G°$ for this reaction at 550 K?
A. -143.76 kJ B. -78.78 kJ C. -22.24 kJ D. -10.56 kJ E. 66600 kJ

20. A buffer is prepared by adding 1.00 L of 1.0 M HCl to 750 mL of 1.5 M NaHCOO. What is the pH of this buffer? $K_a = 1.7 \times 10^{-4}$
A. 2.87 B. 3.72 C. 3.82 D. 3.95 E. 4.66

21. Which of the following substances has the greatest solubility in water?

A. PbI_2, $K_{sp} = 7.9 \times 10^{-9}$ B. BaF_2, $K_{sp} = 1.5 \times 10^{-6}$

C. $Ca(OH)_2$, $K_{sp} = 6.5 \times 10^{-6}$ D. $Zn(IO_3)_2$, $K_{sp} = 3.9 \times 10^{-6}$

E. Ag_2SO_4, $K_{sp} = 1.5 \times 10^{-5}$

22. What is the pH of a solution that consists of 0.50 M $H_2C_6H_6O_6$ (ascorbic acid) and 0.75 M $NaHC_6H_6O_6$ (sodium ascorbate)? For ascorbic acid, $K_a = 6.8 \times 10^{-5}$

A. 3.76 B. 3.99 C. 4.34 D. 4.57 E. 5.66

23. Calculate $\Delta G°$ for the reaction $SiCl_4(g) + 2Mg(s) \rightarrow 2MgCl_2(s) + Si(s)$

Substance:	$SiCl_4(g)$	$Mg(s)$	$MgCl_2(s)$	$Si(s)$
$\Delta G°_f$ (kJ/mol)	–616.98	0	–591.79	0

A. 566.60 kJ B. 50.38 kJ C. 25.19 kJ D. -25.19 kJ E. -566.60 kJ

24. What is the free energy change, $\Delta G°$, for the equilibrium between hydrogen iodide, hydrogen, and iodine at 453°C? $K_c = 0.020$

$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

A. 6.4 kJ B. 8.8 kJ C. 15 kJ D. 19 kJ E. 24 kJ

25. Which of the following should have the greatest molar entropy at 298 K?

A. $CH_4(g)$ B. $H_2O(l)$ C. $NaCl(s)$ D. $N_2O_4(g)$ E. $H_2(g)$

Answers

1. B 2. A 3. C 4. B 5. A 6. E 7. A 8. D 9. C 10. C 11. B 12. B

13. E 14.C 15. B 16. A 17. E 18. C 19.D 20. A 21. E 22. C 23. E 24. E 25. D