CHEM 112 - Practice Exam III

1. Which salt produces an aqueous solution with a pH of 7?
a) KBr
b) NH_4Cl
c) $NaNO_2$
d) KF
e) $ZnCl_2$

2. Calculate the pOH of a 0.21M solution of potassium cyanide, $Kb(CN^-)=2.5 \times 10^{-5}$.
a) 2.64
b) 3.92
c) 4.60
d) 11.36
e) 13.32

3. In which of these species can the central atom be a Lewis base?
a) None of the other answers
b) HCO_3^-
c) NH_3
d) BF_3
e) NH_4^+

4. Which of the following mixtures/solutions would be a buffer solution?
a) 50 mL 1 M HCl + 50 mL 1 M NH_3
b) 50 mL 1 M HCl + 50 mL 1 M NaOH
c) 25 mL 1 M NaOH + 50 mL 1 M CH_3COOH
d) 25 mL 1 M NaOH + 50 mL 1 M NH_3
e) 25mL 1M HCl + 50mL 1M NH_4Cl

5. How many grams of NH_4Cl must be added to 0.250 L of 0.375 M NH_3 to produce a buffer solution with pH = 9.45? (K_b of NH_3 = 1.8x10^{-5})
a) 3.2
b) 0.80
c) 170
d) 1.0
e) 10

6. Calculate the pH of a solution that has 0.75 M NH_4^+ and 0.25 M NH_3. (K_a of NH_4^+ = 5.6x10^{-10})
a) 4.27
b) 8.35
c) 8.77
d) 9.68
e) 9.73

7. In the titration of 20.0mL of 0.200M HCN with 0.100M NaOH, what is the pH after 20.0mL of the NaOH solution is added: K_a (HCN) = 4.0×10^{-10}?
a) 4.60
b) 5.05
c) 9.40
d) 10.10
e) 11.11

8. What is the Ksp expression for magnesium phosphate, $Mg_3(PO_4)_2$?
a) Ksp = $[Mg^{2+}]$ $[PO_4^{3-}]$
b) Ksp = $[Mg^{2+}]^2$ $[PO_4^{3-}]^3$
c) Ksp = $[Mg^{2+}]^3$ $[PO_4^{3-}]$
d) Ksp = $[Mg^{2+}]^3$ $[PO_4^{3-}]^2$ / $[Mg_3(PO_4)_2]$
e) Ksp = $[Mg^{2+}]^3$ $[PO_4^{3-}]^2$

9. What is the solubility of $Ca_3(PO_4)_2$ in pure water given its K_{sp} = $2.07x10^{-33}$?
a) $8.44x10^{-34}$ M
b) $2.07x10^{-33}$ M
c) $4.55x10^{-17}$ M
d) $2.91x10^{-7}$ M
e) $1.14x10^{-7}$ M

10. What is the solubility of AgI (Ksp=$8.52x10^{-17}$) in $1.50x10^{-3}$M iodide?
a) $9.23x10^{-9}$ M
b) $5.68x10^{-14}$ M
c) $8.52x10^{-17}$ M
d) $4.26x10^{-17}$ M
e) $1.28x10^{-19}$ M

11. At what pH will an aqueous solution of 0.210 M Mn^{2+} begin to precipitate as $Mn(OH)_2$ at 25 °C?The K_{sp} for $Mn(OH)_2$ is 2.0×10^{-13} at 25 °C.
a) 0.62
b) 1.98
c) 7.99
d) 9.99
e) 2.60

12. Calculate $\Delta_rG°$ for the reaction: $2 FeCl_2(s) + Cl_2(g) \rightarrow 2 FeCl_3(s)$ at 25°C using these data

$\Delta H_f°$	kJ/mol	-341.79	0	-399.49
S°	J/mol•K	117.95	233.08	143.3

a) −61.1kJ
b) −52.8kJ
c) 1.2kJ
d) −12,800kJ
e) 145,000kJ

12a, b. Calculate $\Delta S_{rxn}°$ and $\Delta H_{rxn}°$ for the reaction:
$$2 \, FeCl_2(s) + Cl_2(g) \rightarrow 2 \, FeCl_3(s) \text{ at } 25°C$$
using these data
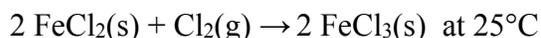
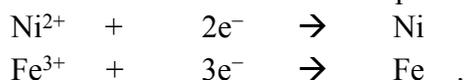|				
$\Delta H_f°$	kJ/mol	-341.79	0	-399.49
$S°$	J/mol•K	117.95	233.08	143.3

13. For which of the following reactions would you expect the entropy change to be closest to zero?
a) $2 \, H_2 \, (g) + O_2 \, (g) \rightarrow 2H_2O \, (l)$
b) $N_2 \, (g) + O_2 \, (g) \rightarrow 2 \, NO \, (g)$
c) $2 \, NO \, (g) + O_2 \, (g) \rightarrow 2 \, NO_2 \, (g)$
d) $Zn \, (s) + 2 \, H^+ \, (aq) \rightarrow Zn^{2+} \, (aq) + H_2 \, (g)$
e) $2 \, HgO \, (s) \rightarrow 2 \, Hg \, (l) + O_2 \, (g)$

14. Determine the value of E° for the product favored galvanic cell for these two half reactions:
$$Ni^{2+} \quad + \quad 2e^- \quad \rightarrow \quad Ni$$
$$Fe^{3+} \quad + \quad 3e^- \quad \rightarrow \quad Fe \quad .$$
a) 2.29V
b) 1.79V
c) 1.56V
d) 1.02V
e) 0.52V

15. Which is the best oxidizing agent?
a) F^-
b) Mg^{2+}
c) Fe^{3+}
d) Cu^{2+}
e) Cl_2

16. A current of 0.76 amps is applied to an electrolytic cell for 45 minutes. The cell reaction is: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$. How many grams of copper metal can be collected from the cell?
a) 0.72g
b) 0.68g
c) 0.36g
d) 34g
e) 42g

17. The sodium ion does not affect the pH of an aqueous solution because
a) the acid formed from the sodium ion reacting with water is one of the strong bases
b) the acid and base formed from the sodium ion reacting with water are strong
c) the acid formed from the sodium ion reacting with water is one of the weak acids
d) the base formed from the sodium ion reacting with water is one of the strong acids
e) the base formed from the sodium ion reacting with water is one of the weak bases

18. The sulfite anion affects the pH of an aqueous solution because
a) the conjugate acid of the sulfite anion reacting with water is one of the strong bases
b) the conjugate base of the sulfite anion reacting with water is one of the strong bases
c) the conjugate acid of the sulfite anion reacting with water is one of the strong acids
d) the conjugate base of the sulfite anion reacting with water is one of the strong acids
e) the conjugate acid of the sulfite anion reacting with water is a weak acid

19. Which of these gives the best conditions for a salt to produce an basic aqueous solution?
a) the cation does not affect pH, and the anion affects pH
b) the cation affects pH, and the anion affects pH where the pKa of the cation is greater than the pKb of the anion
c) the cation does not affect pH, and the anion does not affect pH
d) the cation affects pH, and the anion does not affect pH
e) none of the other answers

20. Which salt produces an aqueous solution with a pH greater than 7?
a) NaI
b) KF
c) $CuCl_2$
d) $AlBr_3$
e) $ZnCl_2$

21. To determine the pH of an aqueous solution of Na_2CO_3, which equilibrium constant must be found in a table?
a) Ka for Na^+
b) Ksp for Na_2CO_3
c) Kb for Na^+
d) Kb for CO_3^{2-}
e) Ka for CO_3^{2-}

22. Given the following Ka values,

Acid	Ka
$HC_2H_3O_2$	1.8×10^{-5}
HF	7.2×10^{-4}
HOCl	2.9×10^{-8}

Which one is the strongest acid?
Which one is the weakest acid?
What is the strongest conjugate base?
What is the weakest conjugate base?

23. Calculate the pH of a 0.15M solution of sodium carbonate, $Kb(CO_3^{2-})=2.1 \times 10^{-4}$.

24. Tell whether the resulting solution will be acidic or basic when you mix equal molar quantities of HF ($K_a = 7.2 \times 10^{-4}$) and KCN ($K_b = 2.5 \times 10^{-5}$).

25. Explain why you gave the answer in 24.

26. Identify the Lewis acid in the following equation: $Al(OH)_3 + OH^- \Leftrightarrow Al(OH)_4^-$

27. Identify the Lewis acid in the following equation: $4NH_3 + Ag^+ \Leftrightarrow [Ag(NH_3)_4]^+$

28. Rank the base strength of these bases (strongest to weakest):
   $ClO_4^-, ClO_2^-, ClO_3^-$

29. Which system would make the best aqueous buffer at pH 9.0?
a) $HC_2H_3O_2$ and $C_2H_3O_2^-$, Ka=1.8×10^{-5}
b) HF and F^-, Ka=7.2×10^{-4}
c) HCN and CN^-, Ka=4.0×10^{-10}
d) HOCl and OCl^-, Ka=2.9×10^{-8}

30) Calculate the pH of a solution that has 0.50 M CH_3COOH and 0.50 M CH_3COONa. (K_b of $CH_3COO^- = 5.6 \times 10^{-10}$)

31) Calculate the pH of a solution that has 0.25 M CH_3COOH and 0.75 M CH_3COONa. (K_a of $CH_3COOH = 1.8 \times 10^{-5}$)

32) What is the pH of a solution that results from adding 25 mL of 0.15 M HCl to 25 mL of 0.52 M NH_3? (K_b of $NH_3 = 1.8 \times 10^{-5}$)

33) What is the final pH if 0.02 mol HCl is added to 0.500 L of a 0.22 M NH_3 and 0.28 M NH_4Cl buffer solution? (K_b of $NH_3 = 1.8 \times 10^{-5}$)

33a) What is the final pH if 5.0mL of 0.10M HCl is added to 0.500 L of a 0.74 M $NaC_2H_3O_2$ and 0.024 M $HC_2H_3O_2$ buffer solution? (K_a of $HC_2H_3O_2 = 1.8 \times 10^{-5}$)

34a) A volume of 25.0mL of a 0.10M aqueous solution of ammonia (NH_3, $K_b=1.8 \times 10^{-5}$) is titrated with 0.070M HCl. What is the pH (i) initially, (ii) after 10.0mL of HCl has been added, (iii) at the halfway point, (iv) after 20.0mL of HCl has been added, (v) at the equivalence point, and (vi) after 40.0mL HCl has been added.

34b) A volume of 25.0mL of a 0.10M aqueous solution of acetic acid ($HC_2H_3O_2$ or HOAc or CH_3CO_2H, $K_a=1.8 \times 10^{-5}$) is titrated with 0.080M NaOH. What is the pH (i) initially, (ii) after 10.0mL of NaOH has been added, (iii) at the halfway point, (iv) after 20.0mL of NaOH has been added, (v) at the equivalence point, and (vi) after 40.0mL NaOH has been added.

35. In which of the following solutions would the solubility of calcium carbonate be the smallest?
a) pure water
b) 0.2 M calcium chloride
c) 0.5 M sodium chloride
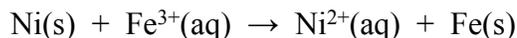d) 0.1 M sodium carbonate
e) 0.1 M HCl

36. A saturated solution of $Cu(OH)_2$ has a pH of 7.90. Determine the K_{sp} for $Cu(OH)_2$.

37. What correct statement can be made about this reaction that dissolves a salt in water:
$$AgCl(s) \Leftrightarrow Ag^+ + Cl^- \qquad K=1.8x10^{-10}$$
a) reaction is product favored, but it does not move spontaneously to equilibrium
b) reaction is product favored, and it moves spontaneously to equilibrium
c) reaction is not product favored, and it does not move spontaneously to equilibrium
d) reaction is not product favored, but it moves spontaneously to equilibrium
e) the rate law for the reaction is rate= $K[Ag][Cl]$

38. If a reaction is not kinetically favored, such as $C_{diamond} \Leftrightarrow C_{graphite}$, what does this mean?
a) the reaction is exothermic
b) the reaction is endothermic
c) the activation energy is high
d) the reaction is product favored
e) the reaction is reactant favored

39. According to the second law of thermodynamics, product-favored reactions tend to do what
    two things:
a) disperse matter and release energy
b) disperse matter and absorb energy
c) collect matter and release energy
d) collect matter and absorb energy
e) heat and work

40. If a process is exothermic and product favored, which of the following must be true?
a) $\Delta G > 0$ and $\Delta H < 0$
b) $\Delta G < 0$ and $\Delta H < 0$
c) $\Delta G < 0$ and $\Delta S > 0$
d) $\Delta H < 0$ and $\Delta S > 0$
e) $\Delta H > 0$ and $\Delta S < 0$

41. Given the reaction $H_2Se(s) \rightarrow H_2(g) + Se(s)$ has $\Delta_r H° = 60kJ/mol$ and $\Delta_r S° = 92J/molK$, make a correct statement about the relationship between a getting product favored reaction and temperature.

42. Which answer describes the motion of electrons and anions in a galvanic cell?
a) electrons move in a wire from the cathode to the anode; anions move through a salt bridge
    from the reduction half cell to the oxidation half cell.
b) electrons move in a wire from the cathode to the anode; anions move through a salt bridge
    from the oxidation half cell to the reduction half cell.
c) electrons move in a wire from the anode to the cathode; anions move through a salt bridge
    from the reduction half cell to the oxidation half cell.
d) electrons move in a wire from the anode to the cathode; anions move through a salt bridge
    from the oxidation half cell to the reduction half cell.

e) one of the above is correct, except that electrons move through the salt bridge and anions move through the wire.

43. What is the shorthand cell notation for a voltaic cell based on the reaction below?
$$Ni(s) + Fe^{3+}(aq) \rightarrow Ni^{2+}(aq) + Fe(s)$$
a) $Fe(s) | Fe^{3+}(aq) || Ni^{2+}(aq) | Ni(s)$
b) $Fe(s) || Fe^{3+}(aq), Ni^{2+}(aq) | Ni(s)$
c) $Ni(s) || Ni^{2+}(aq), Fe^{3+}(aq) || Fe(s)$
d) $Ni(s) | Fe^{3+}(aq) || Ni^{2+}(aq) | Fe(s)$
e) $Ni(s) | Ni^{2+}(aq) || Fe^{3+}(aq) | Fe(s)$

44. Write the net equation for the redox reaction that occurs in the voltaic (or galvanic) cell.
$$Cu (s) | Cu^{2+} (aq) || Ag^+ (aq) | Ag (s)$$
a) $Cu (s) + 2 Ag^+ (aq) \rightarrow Cu^{2+} (aq) + 2 Ag (s)$
b) $Cu (s) + Cu^{2+} (aq) \rightarrow 2 Ag^+ (aq) + Ag (s)$
c) $Cu^{2+} (aq) + 2 Ag (s) \rightarrow Cu (s) + 2 Ag^+ (aq)$
d) $2 Ag^+ (aq) + Ag (s) \rightarrow Cu (s) + Cu^{2+} (aq)$
e) $Cu (s) + Ag^+ (aq) \rightarrow Cu^{2+} (aq) + Ag (s)$

45. How many minutes does it take to deposit 1.48 g of chromium from a $Cr(NO_3)_3$ solution with a current of 2.50 A?

1) a, 2) a, 3) c, 4) c, 5) a, 6) c, 7) c, 8) e, 9) e, 10) b, 11) c, 12) a, 12a) -182.4J/mol K, -115.40kJ 13) b, 14) d, 15) e, 16) b, 17) b: The reaction, $Na^+ + H_2O \leftarrow NaOH + H^+$, would produce a strong conjugate base (and a strong conjugate acid). When a cation forms a strong conjugate base, the reaction is overwhelmingly reactant favored with no effect on pH. 18) e, The reaction, $SO_3^{2-} + H_2O \leftrightarrow HSO_3^- + OH^-$, produces a weak conjugate acid. Though Kb is reactant favored, effect on pH can be measured. 19) a, 20) b, 21) d, 22) HF, HOCl, OCl-, F-, 23) 11.75, 24) acidic, 25) Ka is bigger than Kb for an equal molar quantity. 26) $Al(OH)_3$, 27) Ag^+, 28) $ClO_2^- > ClO_3^- > ClO_4^-$ (Acid increases with increasing oxidation number of the central atom. Conjugate base strength increases with decreasing oxidation number of the central atom.) 29) c at 9.40, 30) 4.74, 31) 5.22, 32) 9.65, 33) 9.00, 33a) 6.22, {34a) (i) 11.13, (ii) 9.67, (iii) 9.26, (iv) 9.15, (v) 5.32, and (vi) 2.34} {34b) (i) 2.87, (ii) 4.42, (iii) 4.74, (iv) 4.99, (v) 8.70, and (vi) 12.03} 35) b, 36) $2.6x10^{-19}$, 37) d, 38) c, 39) a, 40) b, 41) the reaction becomes product favored at high temperatures, 42) c, 43) e - use standard reduction potentials instead of activity series, 44) a, 45) 54.9