# FORMULA SHEET (tear off)

| 1A | | | | | | | | | | | | | | | | | 8A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1<br>H<br>1.01 | 2A | | | | | | | | | | | 3A | 4A | 5A | 6A | 7A | 2<br>He<br>4.00 |
| 3<br>Li<br>6.94 | 4<br>Be<br>9.01 | | | | | | | | | | | 5<br>B<br>10.81 | 6<br>C<br>12.01 | 7<br>N<br>14.01 | 8<br>O<br>16.00 | 9<br>F<br>19.00 | 10<br>Ne<br>20.18 |
| 11<br>Na<br>22.99 | 12<br>Mg<br>24.31 | | | | | | | | | | | 13<br>Al<br>26.98 | 14<br>Si<br>28.09 | 15<br>P<br>30.97 | 16<br>S<br>32.07 | 17<br>Cl<br>35.45 | 18<br>Ar<br>39.95 |
| 19<br>K<br>39.10 | 20<br>Ca<br>40.08 | 21<br>Sc<br>44.96 | 22<br>Ti<br>47.87 | 23<br>V<br>50.94 | 24<br>Cr<br>52.00 | 25<br>Mn<br>54.94 | 26<br>Fe<br>55.85 | 27<br>Co<br>58.93 | 28<br>Ni<br>58.69 | 29<br>Cu<br>63.55 | 30<br>Zn<br>65.41 | 31<br>Ga<br>69.72 | 32<br>Ge<br>72.64 | 33<br>As<br>74.92 | 34<br>Se<br>78.96 | 35<br>Br<br>79.90 | 36<br>Kr<br>83.80 |
| 37<br>Rb<br>85.47 | 38<br>Sr<br>87.62 | 39<br>Y<br>88.91 | 40<br>Zr<br>91.22 | 41<br>Nb<br>92.91 | 42<br>Mo<br>95.94 | 43<br>Tc<br>[98] | 44<br>Ru<br>101.1 | 45<br>Rh<br>102.9 | 46<br>Pd<br>106.4 | 47<br>Ag<br>107.9 | 48<br>Cd<br>112.4 | 49<br>In<br>114.8 | 50<br>Sn<br>118.7 | 51<br>Sb<br>121.8 | 52<br>Te<br>127.6 | 53<br>I<br>126.9 | 54<br>Xe<br>131.3 |
| 55<br>Cs<br>132.9 | 56<br>Ba<br>137.3 | 71<br>Lu<br>175.0 | 72<br>Hf<br>178.5 | 73<br>Ta<br>181.0 | 74<br>W<br>183.8 | 75<br>Re<br>186.2 | 76<br>Os<br>190.2 | 77<br>Ir<br>192.2 | 78<br>Pt<br>195.1 | 79<br>Au<br>197.0 | 80<br>Hg<br>200.6 | 81<br>Tl<br>204.4 | 82<br>Pb<br>207.2 | 83<br>Bi<br>209.0 | 84<br>Po<br>[209] | 85<br>At<br>[210] | 86<br>Rn<br>[222] |
| 87<br>Fr<br>[223] | 88<br>Ra<br>[226] | 103<br>Lr<br>[262] | 104<br>Rf<br>[261] | 105<br>Db<br>[262] | 106<br>Sg<br>[266] | | | | | | | | | | | | |

| 57<br>La<br>138.9 | 58<br>Ce<br>140.1 | 59<br>Pr<br>140.9 | 60<br>Nd<br>144.2 | 61<br>Pm<br>[145] | 62<br>Sm<br>150.4 | 63<br>Eu<br>152.0 | 64<br>Gd<br>157.2 | 65<br>Tb<br>158.9 | 66<br>Dy<br>162.5 | 67<br>Ho<br>164.9 | 68<br>Er<br>167.3 | 69<br>Tm<br>168.9 | 70<br>Yb<br>173.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 89<br>Ac<br>[227] | 90<br>Th<br>232.0 | 91<br>Pa<br>231.0 | 92<br>U<br>238.0 | 93<br>Np<br>[237] | 94<br>Pu<br>[244] | 95<br>Am<br>[243] | 96<br>Cm<br>[247] | 97<br>Bk<br>[247] | 98<br>Cf<br>[251] | 99<br>Es<br>[252] | 100<br>Fm<br>[257] | 101<br>Md<br>[258] | 102<br>No<br>[259] |

$N_A = 6.022 \times 10^{23}$    $°C = (^5/_9)(°F - 32)$    $°F = (^9/_5)(°C) + 32$

1 amu = $1.661 \times 10^{-27}$ kg    $°C = K - 273.15$    $K = °C + 273.15$

1 atm = 760 torr = 760 mm Hg    1 atm = 1.013 bar    $pV = nRT$

R = 0.08206 L·atm/mol·K    1 L·atm = 101.3 J

R = 8.314 J/mol·K    1 J = 1 kg·m$^2$/s$^2$

F = 96485. C/mol    (1 v) (1 C) = 1 J

$\ln(p) = -\dfrac{\Delta H°_{vap}}{T} + C$    $\ln(p_2/p_1) = -(\Delta H°_{vap}/R)\{(1/T_2) - (1/T_1)\}$

$p_A = X_A p_A°$    $[B] = k\, p_B$    $\Delta p_A = X_B p_A°$

$\Delta T_b = K_b m_B$    $\Delta T_f = K_f m_B$    $\Pi = [B]RT$

$H = U + pV$    $G = H - TS$

$\Delta G_{rxn} = \Delta G°_{rxn} + RT \ln Q$    $\ln K = -\Delta G°_{rxn}/RT$    $K_p = K_C (RT)^{\Delta n}$

If $ax^2 + bx + c = 0$, then $x = \left(\dfrac{-b \pm [b^2 - 4ac]^{1/2}}{2a}\right)$

$K_a \cdot K_b = K_w = 1.0 \times 10^{-14}$ (at T = 25°C)

$\Delta G = -nFE_{cell}$    $E_{cell} = E°_{cell} - (RT/nF) \ln Q$    $\ln K = nFE°_{cell}/RT$

**GENERAL CHEMISTRY 2**
**THIRD EXAM (SAMPLE)**


**Name** _____


**Panthersoft ID** _____


**Signature** _____




**Part 1** _____ **(16 points)**


**Part 2** _____ **(32 points)**


**Part 3** _____ **(52 points)**



**TOTAL** _____ **(100 points)**




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**Do all of the following problems.  <u>Show your work.</u>**

**Part 1.  Multiple choice.**  Circle the letter corresponding to the correct answer.  There is one and only one correct answer per problem.  [4 points each]

1) Which of the following reactions goes essentially to completion in aqueous solution?
        a) The reaction of a strong acid with a strong base
        b) The reaction of a strong acid with a weak base
        c) The reaction of a weak acid with a weak base
        d) Both a and b
        e) Both a and b and c

2) Consider the following three aqueous solutions

        Solution A       0.0500 moles of $HClO_2$ (chlorous acid) + 0.0200 moles of $NaClO_2$ (sodium chlorite) dissolved in water, with final volume V = 500.0 mL

        Solution B       0.0500 moles of $HClO_2$ (chlorous acid) + 0.0200 moles of NaOH (sodium hydroxide) dissolved in water, with final volume V = 500.0 mL

        Solution C       0.0500 moles of $HClO_2$ (chlorous acid) + 0.0200 moles of NaCl (sodium chloride) dissolved in water, with final volume V = 500.0 mL

Which of the sbove solutions is a buffer solution?
        a) Solution A only
        b) Solution B only
        c) Solution C only
        d) Both solution A and solution B
        e) Both solution A and solution C

3) Consider the following four weak acids ($K_a$ values are for T = 25. °C)

        Acetic acid ($CH_3COOH$)  $K_a = 1.8 \times 10^{-5}$        Hypobromous acid (HOBr)  $K_a = 2.0 \times 10^{-9}$
        Iodic acid ($HIO_3$)         $K_a = 1.7 \times 10^{-1}$        Nitrous acid ($HNO_2$)      $K_a = 4.5 \times 10^{-4}$

Which of the following weak acid/conjugate base pairs would be best to use to prepare a buffer solution with pH = 4.4?
        a) $CH_3COOH$ and $CH_3COO^-$
        b) HOBr and $OBr^-$
        c) $HIO_3$ and $IO_3^-$
        d) $HNO_2$ and $NO_2^-$
        e) All of the above would be equally suitable to prepare the buffer

4) Consider the following three reactions

        i.        $NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$
        ii.       $2\ H_2O_2(aq) \rightarrow 2\ H_2O(\ell) + O_2(g)$
        iii.      $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$

Which of these reactions is an oxidation-reduction (redox) reaction?
        a) Reaction i. only.
        b) Reaction ii. only.
        c) Reaction iii. only.
        d) Both reaction i. and reaction ii.
        e) Both reaction i. and reaction iii.

**Part 2. Short answer.**

1) A chemist prepares an aqueous solution of nitrous acid ($HNO_2$), a weak acid. To determine the concentration of nitrous acid in the solution, she titrates a 20.00 mL sample of the solution with a 0.2447 M solution of sodium hydroxide (NaOH), a strong soluble base. The titration was carried out at T = 25. °C. The equivalence point for the titration occurs when the volume of added sodium hydroxide solution is 23.81 mL.
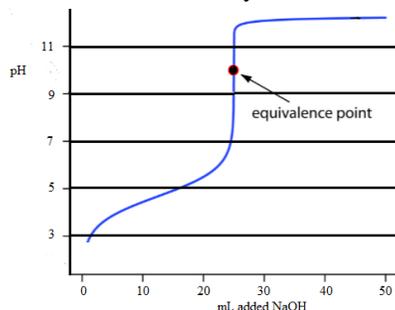


a) What is the concentration of nitrous acid in the weak acid solution prepared by the chemist ? [6 points]

b) Which of the following indicators would be the best choice to use in the above titration (circle the correct answer). [4 points]

| bromophenol blue | methyl red | bromothymol blue | phenolphthalein |
|---|---|---|---|
| $pK_a = 3.8$ | $pK_a = 5.2$ | $pK_a = 6.6$ | $pK_a = 9.0$ |

2) The molar solubility of lead II bromide ($PbBr_2$) in water is 0.012 mol/L at T = 25.0 °C. Based on this, find the numerical value for $K_{sp}$ for $PbBr_2$. [8 points]

3) What is the oxidation number for sulfur (S) in each of the following molecules or ions?  [2 points each]

$H_2S$ _____   $S_2O_3^{2-}$ _____

4) Balance the following reaction for the indicated condition.  [8 points]

$Al(s) + NO_2^-(aq) \rightarrow AlO_2^-(aq) + NH_3(aq)$          (for base conditions)

**Part 3.  Problems.**

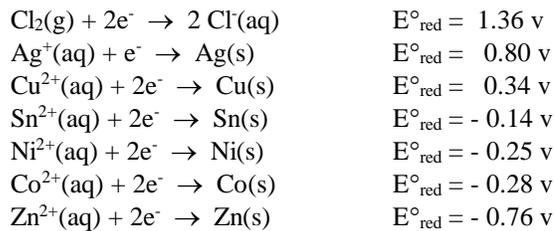1) The following question concerns the slightly soluble ionic compound silver iodide (AgI, $K_{sp} = 8.3 \times 10^{-17}$).

A student adds excess solid silver iodide (AgI, $K_{sp} = 8.3 \times 10^{-17}$) to a 0.0400 M solution of sodium iodide (NaI), and shakes the resulting mixture until no more silver iodide dissolves.  What is the concentration of $Ag^+$ present in the solution?  [10 points]

2) A chemist prepares 500.0 mL of a 0.0200 M aqueous solution of hypochlorous acid (HOCl, $K_a = 3.5 \times 10^{-8}$).

        a) What is the pH of the above solution?  [10 points]

        b) 0.00400 moles of potassium hydroxide (KOH, a strong soluble base) is added to the above solution of hydrochlorous acid.  After the addition of KOH, what is the new value for pH?  You may assume that the volume of the solution remains constant at V = 500.0 mL.  [10 points]
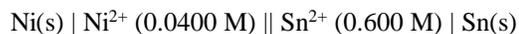
3) A portion of the electrochemical series is given below and may be of use in doing the following problem

$Cl_2(g) + 2e^- \rightarrow 2\ Cl^-(aq)$ $\quad\quad$ $E°_{red} = 1.36\ v$

$Ag^+(aq) + e^- \rightarrow Ag(s)$ $\quad\quad$ $E°_{red} = 0.80\ v$

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ $\quad\quad$ $E°_{red} = 0.34\ v$

$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$ $\quad\quad$ $E°_{red} = -0.14\ v$

$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$ $\quad\quad$ $E°_{red} = -0.25\ v$

$Co^{2+}(aq) + 2e^- \rightarrow Co(s)$ $\quad\quad$ $E°_{red} = -0.28\ v$

$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ $\quad\quad$ $E°_{red} = -0.76\ v$

a) What is the strongest reducing agent from the above table of half-cell reduction reactions (circle the correct answer)? [4 points]

$Zn(s)$ $\quad\quad\quad\quad\quad\quad$ $Zn^{2+}(aq)$ $\quad\quad\quad\quad\quad\quad$ $Cl_2(g)$ $\quad\quad\quad\quad\quad\quad$ $Cl^-(aq)$

b) Consider the following galvanic cell

$Ni(s)\ |\ Ni^{2+}\ (0.0400\ M)\ ||\ Sn^{2+}\ (0.600\ M)\ |\ Sn(s)$

Give the half-cell oxidation reaction, the half-cell reduction reaction, and the net cell reaction for the above galvanic cell. [10 points]

c) Find the values for $E_{cell}$ and $E°_{cell}$ for the above galvanic cell. [8 points]