Instructions:

Do not begin until 8:40 AM.

This exam should have 25 questions. Each question is worth 4 points for a total of 100 points. A periodic table should be on the reverse side of this page.

Use only a #2 pencil to mark the best answer on the scantron Sheet. You will turn in only the scantron sheet and your homework set 2. You should keep the rest of the exam.

On the scantron sheet, fill out your name and SS# and be sure to fill out the corresponding bubbles.

Information:

\[ K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14} \text{ (at 25°C)} \]
\[ K_a \times K_b = K_w \]
\[ pH = pK_a + \log ([A^-]/[HA]) \]
\[ pH + pOH = 14 \]
# WebElements: the periodic table on the world-wide web

http://www.webelements.com/

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<th>Element</th>
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*lanthanoids*  

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**actinoids**  

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Symbols and names: the symbols and names of the elements, and their spellings are recommended by the International Union of Pure and Applied Chemistry (IUPAC - http://www.iupac.org). Names have yet to be proposed for the most recently discovered elements 111, 112 and 114 so those used here are IUPAC's temporary systematic names. In the USA and some other countries, the spellings aluminium and caesium are normal while in the UK and elsewhere the common spelling is sulphur.

Group labels: the numeric system (1-18) used here is the current IUPAC convention.

Atomic weights: mean relative masses: Apart from the heaviest elements, these are the IUPAC 2001 values and given to 5 significant figures. Elements for which the atomic weight is given within square brackets have no stable nuclides and are represented by the element's longest-lived isotope.

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MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) A Brønsted-Lowry acid is defined as a substance that _________.
   A) acts as a proton acceptor
   B) decreases $[H^+]$ when placed in H$_2$O
   C) increases $[H^+]$ when placed in H$_2$O
   D) acts as a proton donor
   E) increases $[OH^-]$ when placed in H$_2$O

2) The conjugate base of HSO$_4^-$ is $\text{HSO}_4^- \rightleftharpoons H^+ + \text{SO}_4^{2-}$
   A) HSO$_4^+$
   B) H$_3$SO$_4$
   C) OH$^-$
   D) H$_2$SO$_4$
   E) SO$_4^{2-}$

3) The magnitude of $K_w$ indicates that _________.
   A) water autoionizes only to a very small extent
   B) the autoionization of water is exothermic
   C) water autoionizes very quickly
   D) the autoionization of water is endothermic
   E) water autoionizes very slowly

4) Which solution below has the highest concentration of hydroxide ions?
   A) pH = 9.82
   B) pH = 12.59
   C) pH = 3.21
   D) pH = 7.00
   E) pH = 7.93

5) Calculate the concentration (in M) of hydronium ions in a solution at 25°C with a pOH of 4.223.
   A) $1.67 \times 10^{-4}$
   B) $5.99 \times 10^{-19}$
   C) $1.67 \times 10^{-10}$
   D) $5.98 \times 10^{-5}$
   E) $1.00 \times 10^{-7}$

6) An aqueous solution contains 0.10 M NaOH at 25°C. The pH of the solution is _________.
   A) 1.00
   B) 13.00
   C) -1.00
   D) 7.00
   E) 0.10

   $\text{NaOH} \rightarrow \text{Strong Base} \rightarrow 0.10 \text{M} = [\text{OH}^-]$
   $[\text{OH}^-] = 1.0 \times 10^{-13}$
7) A 0.15-M aqueous solution of the weak acid HA at 25°C has a pH of 5.35. The value of $K_a$ for HA is 7) 

\[
\begin{align*}
    \text{pH} &= 5.35 \\
    \text{...} &
    \quad \frac{[H^+]}{[HA]} = 4.47 \times 10^{-6} = [A^-] \\
    HA &\rightleftharpoons H^+ + A^- \\
    K_a &= \frac{[H^+] [A^-]}{[HA]} = \frac{(4.47 \times 10^{-6})(4.47 \times 10^{-6})}{1.33 \times 10^{-10}} = 1.49 \times 10^{-5}
\end{align*}
\]

8) HA is a weak acid. Which equilibrium corresponds to the equilibrium constant $K_b$ for $A^-\text{?}$

A) $A^-\text{(aq)} + H_2O\text{(l)} \rightleftharpoons HA\text{(aq)} + OH^-\text{(aq)}$

B) $HA\text{(aq)} + H_2O\text{(l)} \rightleftharpoons H_2A^+\text{(aq)} + OH^-\text{(aq)}$

C) $A^-\text{(aq)} + OH^-\text{(aq)} \rightleftharpoons HOA^2\text{(aq)}$

D) $A^-\text{(aq)} + H_3O^+\text{(aq)} \rightleftharpoons HA\text{(aq)} + H_2O\text{(l)}$

E) $HA\text{(aq)} + OH^-\text{(aq)} \rightleftharpoons H_2O\text{(l)} + H^+\text{(aq)}$

9) The acid-dissociation constant, $K_a$, for gallic acid is $4.57 \times 10^{-3}$. What is the base-dissociation constant, $K_b$, for the gallate ion? 9)

\[
\begin{align*}
    K_a \cdot K_b &= K_w \\
    K_b &= \frac{K_w}{K_a} = \frac{1 \times 10^{-14}}{4.57 \times 10^{-3}} \\
    K_b &= 2.17 \times 10^{-12}
\end{align*}
\]

10) Of the following, which is the strongest acid?

A) $\text{HClO}_4$   B) $\text{HClO}$   C) $\text{HIO}$   D) $\text{HClO}_3$   E) $\text{HClO}_2$

11) In the reaction

\[
\text{BF}_3 + F^- \rightarrow \text{BF}_4^-
\]

BF$_3$ acts as a(n) _______ acid.

A) Arrhenius
B) Arrhenius and Brønsted-Lowry
C) Lewis
D) Arrhenius, Brønsted-Lowry, and Lewis
E) Brønsted-Lowry
12) The $K_a$ of acetic acid is $1.8 \times 10^{-5}$. The pH of a buffer prepared by combining 50.0 mL of 1.00 M potassium acetate and 50.0 mL of 1.00 M acetic acid is ________.

A) 4.77   B) 0.85   C) 2.38   D) 1.70   E) 3.40

\[
\text{pH} = \rho K_a + \log \frac{[\text{Acetate}^-]}{[\text{Acetic Acid}]} = \frac{(0.050 \text{ M})(1.00 \text{ L})}{0.100 \text{ L}} = \frac{(0.050 \text{ M})(1.00 \text{ L})}{0.100 \text{ L}}
\]

\[
\text{pH} = 4.77 + \log 10
\]

13) The addition of hydrofluoric acid and ________ to water produces a buffer solution.

A) NaNO₃  B) NaCl  C) NaBr  D) HCl  E) NaF

\[
\text{HF} \Leftrightarrow H^+ + F^- \quad \text{Need salt that produces } \text{HF}
\]

14) The pH of a solution prepared by dissolving 0.35 mol of solid methylamine hydrochloride (CH₃NH₂Cl) in 1.00 L of 1.1 M methylamine (CH₃NH₂) is _________. The $K_b$ for methylamine is $4.4 \times 10^{-4}$.

A) 10.15  B) 10.64  C) 2.86  D) 11.14  E) 1.66

Salt produces

\[
\text{CH}_3\text{NH}_3^+ = [0.35]
\]

\[
\text{CH}_3\text{NH}_3^+ \Leftrightarrow \text{CH}_3\text{NH}_2^- + H^+
\]

\[
K_a = \frac{[\text{H}^+][\text{CH}_3\text{NH}_2^-]}{[\text{CH}_3\text{NH}_3^+]} = \frac{K_b}{K_a} = \frac{1 \times 10^{-14}}{4.4 \times 10^{-4}} = \frac{(x)(1.1)}{0.35}
\]

\[
x = H^+ = 7.23 \times 10^{-12}
\]

\[
\text{pH} = 11.14
\]

15) The pH of a solution prepared by mixing 45 mL of 0.183 M KOH and 65 mL of 0.145 M HCl is ________.

A) 2.92  B) 0.74  C) 1.97  D) 70.145  E) 1.31

\[
\text{moles } \text{OH}^- = (0.045 \text{ L})(0.183 \text{ M KOH}) = 0.008335 \text{ mol OH}^- \quad \text{Strong Base}
\]

\[
\text{moles } H^+ = (0.065 \text{ L})(0.145 \text{ M HCl}) = 0.009475 \text{ mol H}^+ \quad \text{Strong Acid}
\]

\[
\text{Neutralize } \quad \frac{0.008335 \text{ mol H}^+}{0.110 \text{ L soln}} \quad \text{H}_2\text{O}
\]

\[
[\text{H}^+] = 0.0108
\]

\[
\text{pH} = 1.97
\]
16) A 25.0-mL sample of an HCl solution is titrated with a 0.139 M NaOH solution. The equivalence point is reached with 15.4 mL of base. The concentration of HCl is ______ M.

A) 0.139  B) 11.7  C) 0.0856  D) 0.267  E) 0.00214

\[
\begin{align*}
H^+ + Cl^- + Na^+ + OH^- & \rightleftharpoons H_2O + Na^+ + OH^- \\
\text{moles OH}^- & = (D. 0.0154L)(0.139M \text{ NaOH}) = 0.0021406 \\
\text{moles H}^+ & = 0.0021406 \frac{\text{moles H}^+}{0.025DL} = 0.0856
\end{align*}
\]

Consider the following table of K_{sp} values.

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<th>Formula</th>
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<td>Cadmium hydroxide</td>
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<td>Calcium fluoride</td>
<td>CaF_{2}</td>
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<td>Silver iodide</td>
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<tr>
<td>Zinc carbonate</td>
<td>ZnCO_{3}</td>
<td>1.4 \times 10^{-11}</td>
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17) Which compound listed below has the smallest molar solubility in water?

A) CaF_{2}  B) Cd(OH)_{2}  C) CdCO_{3}  D) AgI  E) ZnCO_{3}

Smallest \( K_{sp} \rightarrow A_g \)

18) The solubility of lead (II) chloride (PbCl_{2}) is 1.6 \times 10^{-2} M. What is the \( K_{sp} \) of PbCl_{2}?

A) 3.1 \times 10^{-7}  B) 4.1 \times 10^{-6}  C) 5.0 \times 10^{-4}  D) 1.6 \times 10^{-2}  E) 1.6 \times 10^{-5}

\[
K_{sp} = [Pb^{2+}] [Cl^-]^2 = \frac{1}{1.6 \times 10^{-2}M \times 1.6 \times 10^{-2}M} \times 3.2 \times 10^{-5}M
\]

\[
K_{sp} = 1.6 \times 10^{-5}
\]

19) In which of the following aqueous solutions would you expect AgBr to have the lowest solubility?

A) 0.15 M KBr  B) 0.20 M NaBr  C) pure water  D) 0.10 M AgNO_{3}  E) 0.10 M LiBr

\[
A_g B_{r(s)} \rightleftharpoons A_g^{+} + Br_{(aq)}^{-}
\]

\text{Highest concentration of common Br}^{-} \text{ion. Common ion reduces solubility,}

\text{Common ion reduces solubility.}
20) Calculate the maximum concentration (in M) of silver ions (Ag⁺) in a solution that contains 0.025 M of CO₃²⁻. The K_sp of Ag₂CO₃ is 8.1 x 10⁻¹².

A) 8.1 x 10⁻¹²  B) 1.8 x 10⁻⁵  C) 2.8 x 10⁻⁶  D) 1.4 x 10⁻⁶  E) 3.2 x 10⁻¹⁰

\[
K_{sp} = \left[ \frac{[Ag^+]^2}{[CO_3^{2-}]} \right] = 8.1 \times 10^{-12}
\]

\[
\frac{8.1 \times 10^{-12}}{0.025} = x^2
\]

\[
x = 1.8 \times 10^{-5} = [Ag^+]
\]

21) Of the substances below, ______ will decrease the solubility of Pb(OH)₂ in a saturated solution.

A) NaCl  B) Pb(NO₃)₂  C) H₂O₂  D) HNO₃  E) NaNO₃

Common ion will decrease solubility.

22) A solution is prepared by dissolving 0.23 mol of hydrazoic acid and 0.27 mol of sodium azide in water sufficient to yield 1.00 L of solution. The addition of 0.05 mol of NaOH to this buffer solution causes the pH to increase slightly. The pH does not increase drastically because the NaOH reacts with the ______ present in the buffer solution. The K_a of hydrazoic acid is 1.9 x 10⁻⁵.

A) This is a buffer solution: the pH does not change upon addition of acid or base.
B) H₃O⁺
C) H₂O
D) hydrazoic acid
E) azide

23) A 25.0-mL sample of 0.150 M nitrous acid is titrated with 26.0-mL of a 0.150 M NaOH solution. What is the resulting pH? The K_a of nitrous acid is 4.5 x 10⁻⁴.

A) 7.00  B) 13.35  C) 10.18  D) 10.65  E) 3.35

\[
\text{mol HA} = (0.250 \text{ mol}) (0.150 \text{ M HA}) = 0.0375 \text{ mol HA}
\]

\[
\text{mol OH} = (0.0260 \text{ mol}) (0.150 \text{ M OH}) = 0.0039 \text{ mol OH}^- \quad \text{(Neutralize)}
\]

\[
[\text{OH}^-] = \frac{(0.00015 \text{ mol OH}^-)}{(0.0250 + 0.0260)} = 2.94 \times 10^{-3} \text{ M}
\]

pOH = 2.53

pH = 11.47
24) The reaction that forms most of the acid in acid rain is _________.
   A) SO₂ (g) + H₂O (l) → H₂SO₄ (aq)
   B) SO₃ (g) + H₂O (l) → H₂SO₄ (aq)
   C) Cl₂ (g) + H₂O (l) → HCl (aq) + HClO (aq)
   D) SO₂ (g) + H₂O (l) → H₂SO₃ (aq)
   E) H₂S (g) + 2 O₂ (g) → H₂SO₄ (l)

25) Why is carbon monoxide toxic?
   A) It blocks acetylcholine receptor sites causing paralysis and rapid death.
   B) It causes renal failure.
   C) It binds to oxygen and causes suffocation.
   D) It induces leukemia.
   E) It binds to hemoglobin, thus blocking the transport of oxygen.