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Last KeyFirst Answer**Question 1**

9 Points

The substance **hydrocyanic acid (HCN)** is a weak acid ( $K_a = 4.90 \times 10^{-10}$ ).

What is the pH of a **0.322 M** aqueous solution of **sodium cyanide**?

	CN <sup>-</sup>	+ H <sub>2</sub> O	⇌	HCN	+ OH <sup>-</sup>
I	0.322			0	0
C	-x			x	x
E	0.322-x			x	x

$$K_{CN^-} = \frac{1 \times 10^{-14}}{4.90 \times 10^{-10}} = 2.04 \times 10^{-5}$$

$$0.322 > 100(2.04 \times 10^{-5})$$

$$\therefore 0.322 - x \approx 0.322$$

$$x = \sqrt{0.322(2.04 \times 10^{-5})}$$

$$= 2.56 \times 10^{-3} = [OH^-]$$

$$pOH = -\log_{10}(2.56 \times 10^{-3})$$

$$= 2.59$$

$$pH = 14 - 2.59$$

$$pH = \underline{11.41}$$

**Question 2**

9 Points

With respect to the following acid base reactions, indicate whether the resulting solution will be **acidic**, **basic**, or **neutral**:

1. When **35 mL of 0.40 M HClO** and **35 mL of 0.40 M sodium hydroxide** are combined:

B

2. When **35 mL of 0.400 M nitric acid** and **35 mL of 0.400 M sodium nitrite** are combined:

A

3. When **50 mL of 0.20 M ammonium iodide** and **50 mL of 0.20 M potassium hydroxide** are combined:

B**Question 3**

9 Points

The following questions pertain to a buffer solution that is **0.102 M in NH<sub>3</sub> (ammonia)** and **0.131 M in NH<sub>4</sub>Br**.

$$K_b(NH_3) = 1.8 \times 10^{-5} @ 25^\circ C$$

1. Write the net ionic equation for the removal of added **H<sub>3</sub>O<sup>+</sup>** to this buffer:



2. What is the **buffer capacity** for **addition of strong base**:

0.131

3. The choice of **NH<sub>4</sub><sup>+</sup>** suggests that the **desired pH** is close to:

9.26**Question 4**

9 Points

Identify buffer solutions from the following list.

Choose *all that apply*.

- 0.30M HNO<sub>2</sub>(aq) + 0.25M KNO<sub>2</sub>(aq)
- 0.15M NaOH(aq) + 0.30M ammonium chloride(aq)
- 0.40M Ammonium chloride + 0.30M Ammonia
- 0.30M HCl(aq) + 0.30M KF(aq)
- 0.20M HNO<sub>3</sub>(aq) + 0.15M NaNO<sub>2</sub>(aq)

**Question 5**  
9 Points

Rank the following salts from 1-3 in order of increasing solubility with 1 being the most soluble and 3 being the least soluble.

- $\text{AgCN}$   $K_{sp} = 1.2 \times 10^{-16}$  3
- $\text{CaF}_2$   $K_{sp} = 3.9 \times 10^{-11}$  1
- $\text{Zn}_3(\text{PO}_4)_2$   $K_{sp} = 9.1 \times 10^{-33}$  2

**Question 6**  
9 Points

The maximum amount of chromium(III) hydroxide that will dissolve in a 0.255M chromium(III) nitrate solution is:

Chromium(III) hydroxide:  $K_{sp} = 6.70 \times 10^{-31}$

	$\text{Cr}(\text{OH})_3(\text{s})$	$\text{H}_2\text{O}$	$\rightleftharpoons$	$\text{Cr}^{3+}$	$+$	$3 \text{OH}^-$
I	Some			0.255		0
C	-S			S		3S
E				0.255+S		3S

$0.255 + S \approx 0.255$

$$K_{sp} = [\text{Cr}^{3+}][\text{OH}^-]^3$$

$$6.70 \times 10^{-31} = 0.255 (3S)^3$$

$$27S^3(0.255) = 6.70 \times 10^{-31}$$

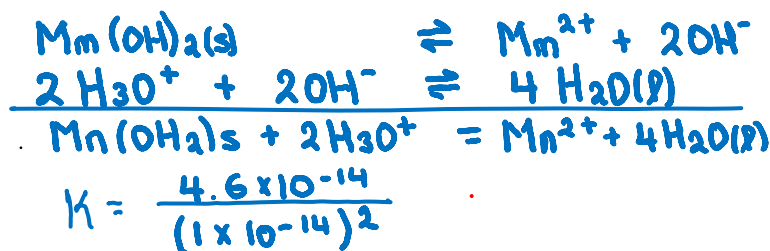
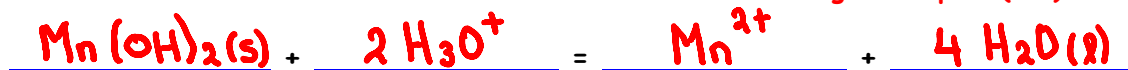
$$S^3 = \frac{6.70 \times 10^{-31}}{27(0.255)} = 9.73 \times 10^{-32}$$

$$S = \sqrt[3]{9.73 \times 10^{-32}} = 4.60 \times 10^{-11} \text{ M}$$

**Question 7**  
10 Points  
(4+6)

Write a balanced net ionic equation to show why the solubility of  $\text{Mn}(\text{OH})_2(\text{s})$  increases in the presence of a strong acid and calculate the equilibrium constant for the reaction of this sparingly soluble salt with acid.

Must show work when calculating K -  $K_{sp} \text{ Mn}(\text{OH})_2 = 4.6 \times 10^{-14}$



$$\begin{aligned} K &= 4.6 \times 10^{-14} \\ K &= (1 \times 10^{-14})^{-2} \\ K &= K_{sp}(K_w)^{-2} \end{aligned}$$

$K = 4.6 \times 10^{14}$

**Question 8**  
12 Points

Rank the following substances from 1-4 in order of increasing entropy with 1 being the lowest entropy and 4 being the highest entropy.

- $\text{CH}_3\text{CHO}(\text{g})$  3
- $(\text{CH}_3)_2\text{CO}(\text{g})$  4
- $\text{CH}_3\text{OH}(\text{g})$  2
- $\text{HCHO}(\text{g})$  1

**Question 9**  
6 Points

Consider the reaction:  $2 \text{H}_2\text{O}_2(\text{l}) \rightarrow 2 \text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$   
Using standard absolute entropies at 298K, calculate the entropy change for the system when 2.38 moles of  $\text{H}_2\text{O}_2(\text{l})$  react at standard conditions?

$S^\circ$  (J/K.mol):  $\text{H}_2\text{O}_2(\text{l}): 109.6$   $\text{O}_2(\text{g}): 205.1$   $\text{H}_2\text{O}(\text{l}): 69.9$

$$\begin{aligned} \Delta S^\circ_{\text{RXN}} &= 2S^\circ \text{H}_2\text{O}(\text{l}) + S^\circ \text{O}_2(\text{g}) - 2S^\circ \text{H}_2\text{O}_2(\text{l}) \\ &= 2(69.9) + 205.1 - 2(109.6) \\ &= 125.7 \text{ J/K} \end{aligned}$$

$$2.38 \times \frac{125.7}{2}$$

149.6 J/K

<p><b>Question 10</b> 6 Points</p>	<p>Consider the reaction: <math>2 \text{CO}(g) + 2 \text{NO}(g) \longrightarrow 2 \text{CO}_2(g) + \text{N}_2(g)</math> for which <math>\Delta H^\circ = -746.6 \text{ kJ}</math> and <math>\Delta S^\circ = -198 \text{ J/K}</math> at <math>298 \text{ K}</math>. Calculate the entropy change of the UNIVERSE when 1.57 moles of <math>\text{NO}(g)</math> react under standard conditions at <math>298 \text{ K}</math>. <math>\Delta S^\circ_{\text{Universe}} = \underline{1,811} \text{ J/K}</math></p> <ul style="list-style-type: none"> <li>Is this reaction reactant or product favored? <u>PRODUCT</u></li> </ul>																				
<p><b>Question 11</b> 6 Points</p>	<p>Without doing any calculations, match the following thermodynamic properties with their appropriate numerical value given on the right for the following endothermic reaction. <math>2 \text{H}_2\text{O}(g) + 2 \text{Cl}_2(g) \longrightarrow 4 \text{HCl}(g) + \text{O}_2(g)</math></p> <table border="0"> <tbody> <tr> <td>• <math>\Delta S_{\text{rxn}}</math></td> <td><u>1</u></td> <td>1.</td> <td>&gt; 0</td> </tr> <tr> <td>• <math>\Delta G_{\text{rxn}}</math></td> <td><u>4</u></td> <td>2.</td> <td>&lt; 0</td> </tr> <tr> <td>• <math>\Delta S_{\text{universe}}</math></td> <td><u>5</u></td> <td>3.</td> <td>= 0</td> </tr> <tr> <td></td> <td></td> <td>4.</td> <td>&gt; 0 at low T, &lt; 0 at high T</td> </tr> <tr> <td></td> <td></td> <td>5.</td> <td>&lt; 0 at low T, &gt; 0 at high T</td> </tr> </tbody> </table>	• $\Delta S_{\text{rxn}}$	<u>1</u>	1.	> 0	• $\Delta G_{\text{rxn}}$	<u>4</u>	2.	< 0	• $\Delta S_{\text{universe}}$	<u>5</u>	3.	= 0			4.	> 0 at low T, < 0 at high T			5.	< 0 at low T, > 0 at high T
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<p><b>Question 12</b> 6 Points</p>	<p>For the reaction <math>\text{Fe}(s) + 2\text{HCl}(aq) = \text{FeCl}_2(s) + \text{H}_2(g)</math>      <math>\Delta H^\circ = -7.4 \text{ kJ}</math> and <math>\Delta S^\circ = 107.9 \text{ J/K}</math></p> <p>a) The standard free energy change for the reaction of 1.63 moles of <math>\text{Fe}(s)</math> at <math>291 \text{ K}</math>, <math>1 \text{ atm}</math> would be <math>\text{kJ}</math>. <math>\underline{-63.2} \text{ kJ}</math></p> <p>b) The reaction is (reactant, product) favored under these conditions. <u>PRODUCT</u></p> <p><i>Assume that <math>\Delta H^\circ</math> and <math>\Delta S^\circ</math> are independent of temperature.</i></p>																				

Do Not Write Below This Line

Exam III Score