LAB EXERCISE 9.1.1 OXIDATION STATES OF VANADIUM

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Analysis

(a) (1) $VO_{3(aq)}^{-}$ (vanadate(V) ion from the dissociation of ammonium vanadate(V))

(2) $VO_{3(aq)}^{-} \rightarrow VO_{(aq)}^{2+} \rightarrow V_{(aq)}^{3+} \rightarrow V_{(aq)}^{2+}$

(3) $V_{(aq)}^{2+} \rightarrow V_{(aq)}^{3+}$

(4) $VO_{3(aq)}^{-} \rightarrow VO_{(aq)}^{2+}$ (**Note:** $VO_{(aq)}^{2+}$ is not reduced further by KI as indicated in (5).)

(5) $VO_{(aq)}^{2+}$ (no change)

(6) $V_{(aq)}^{2+} \rightarrow V_{(aq)}^{3+} \rightarrow VO_{(aq)}^{2+} \rightarrow VO_{3(aq)}^{-}$

(b) (1) no reaction
(2) vanadium is being reduced from +5 to +4 to +3 to +2
(3) vanadium is being oxidized from +2 to +3
(4) vanadium is being reduced from +5 to +4
(5) no change in oxidation number
(6) vanadium is being oxidized from +2 to +3 to +4 to +5

(c) (3) The $V_{(aq)}^{2+}$ is slowly changed to $V_{(aq)}^{3+}$. This is an oxidation probably caused by the reaction of oxygen in the air with $V_{(aq)}^{2+}$.

(4) The $VO_{3(aq)}^{-}$ is likely reduced to $VO_{(aq)}^{2+}$, which is blue. At the same time, iodide ions are likely being oxidized to iodine, which is yellow-brown in aqueous solution. The combination of blue and yellow-brown would produce a very dark coloured mixture.

(5) Iodide ions are not able to reduce $VO_{(aq)}^{2+}$.

(6) Permanganate ions are able to successively oxidize $V_{(aq)}^{2+}$ to $V_{(aq)}^{3+}$ to $VO_{(aq)}^{2+}$ and finally, to $VO_{3(aq)}^{-}$.

(d) This equilibrium does not alter the analysis based on oxidation numbers. The oxidation number for vanadium in both $VO_{3(aq)}^{-}$ and $VO_{2(aq)}^{+}$ is +5.

INVESTIGATION 9.3.1 SPONTANEITY OF REDOX REACTIONS

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Prediction

(a) Based on previous assumptions for chemical reactions and stoichiometry, all combinations that result in products different from reactants are spontaneous. Therefore, all metals should react with compounds of other metal ions.

Procedure

(b) 1. Clean one side of each of the four metal strips, using steel wool.
2. Add 1 drop of $Cu(NO_3)_{2(aq)}$ on each of the four metals.
3. Repeat step 2, using $Pb(NO_3)_{2(aq)}$, $AgNO_{3(aq)}$, and $Zn(NO_3)_{2(aq)}$ on different parts of the metal strips.
4. Rinse the lead and silver solutions into a labelled waste container and clean the metal strips for reuse.

Evidence

(c) **Reactions of Metals and Their Ions**

	$Cu_{(s)}$	$Pb_{(s)}$	$Ag_{(s)}$	$Zn_{(s)}$
$Cu_{(aq)}^{2+}$	slightly cleaner metal surface	red-brown precipitate	no change	red-brown precipitate
$Pb_{(aq)}^{2+}$	no change	no change	no change	black precipitate
$Ag_{(aq)}^{+}$	silver crystals	silver crystals	no change	silver crystals
$Zn_{(aq)}^{2+}$	no change	no change	no change	no change