Name Solution

CH1020

EXAM 2 (70 points)

November 14th, 2018

A

There is a total of 10 pages in the exam (including this page).
There is a total of 13 questions.
Show your work to get full credit.
The activity series table, the precipitation rules, and the periodic table are on the last 3 pages

Name_____

1. (6 Points) Complete and balance each equation. If no precipitation reaction occurs, write "NR".

a. $\underline{1}\ Na_2CO_3(aq) + \underline{2}\ AgNO_3(aq) \rightarrow$ $Ag_2CO_3(s)$ (1)

$+\ 2NaNO_3(aq)$ (1/2)

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b. $\_\_(NH_4)_2SO_4(aq) + \_\_NiCl_2(aq) \rightarrow$ NR (2)

+ _____

c. $\underline{3}\ Pb(NO_3)_2(aq) + \underline{2}\ FeCl_3(aq) \rightarrow$ $3PbCl_2(s)$ (1/2)

$+\ 2Fe(NO_3)_3$ (1/2)

2. (4 Points) Write balanced net ionic equations for each reaction:

a. $Cr_2(SO_4)_3(aq) + (NH_4)CO_3(aq) \rightarrow$

$2Cr^{3+}(aq) + 3CO_3^{2-}(aq) \rightarrow Cr_2(CO_3)_3(s)$ (1)

(1/2) (1/2)

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b. $Ba(OH)_2(aq) + FeSO_4(aq) \rightarrow$

$Ba^{2+}(aq) + 2OH^-(aq) + Fe^{2+}(aq) + SO_4^{2-}(aq) \rightarrow$

(1/2) (1/2)

$Fe(OH)_2(s) + BaSO_4(s)$

(1/2) (1/2)

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3. (4 Points) A solution contains one or more of the following ions: Ag^+, Ca^{2+} and Cu^{2+}. When you add sodium chloride to the solution, no precipitate forms. When you add sodium sulfate to the solution, a white precipitate forms. You filter off the precipitate and add sodium carbonate to the remaining solution, producing another precipitate. Which ions were present in the original solution? Write net ionic equations for the formation of each of the precipitates observed.

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1. no Ag^{2+} b/c no AgCl precipitate
2. $Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$ (1)
3. $Cu^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$ (1)

(1) (1)

Ca^{2+} and Cu^{2+} are present

4. (6 Points) A solution contains Ag^+ and Hg^{2+} ions. The addition of 0.100 L of 1.22 M NaI solution is just enough to precipitate all the ions as AgI and HgI_2. The total mass of the precipitate is 28.1 g. Find the moles of AgI that precipitate.
$M_w(AgI) = 234.8$ g/mol ; $M_w(HgI_2) = 454.4$ g/mol

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moles $(I^-) = 0.100\,L \cdot 1.22\,M = 0.122$ mole (1)

$AgI = x \quad HgI_2 = y$

$x + 2y = 0.122$ mole $\Rightarrow y = 0.061$ mol $- \frac{1}{2}x$ (1)

$x \cdot 234.8$ g/mole $+ y \cdot 454.4$ g/mol $= 28.1$ g (1)

$234.8\,\frac{g}{mol} \cdot x + (0.061\,mol - \frac{1}{2}x)\,454.4\,g/mol = 28.1\,g$

$234.8\,\frac{g}{mol} \cdot x + 27.72\,g - 227.2\,g \cdot x = 28.1\,g$ (1)

$7.6\,g \cdot x = 28.1\,g - 27.7\,g = 0.4\,g$

$x = 5.26 \cdot 10^{-2}$ mol (2)

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5. (9 Points) A sample of $3.44*10^{-4}$ mol K_3PO_4 is added to 18.0 mL of 0.050 M $FeCl_2$ solution, resulting in the formation of a precipitate. (a) Write the net ionic equation for the reaction. (b) What is the mass of the precipitate that forms? (c) What is the remaining concentration of the ion in solution that is in excess? $M_w(K_3PO_4) = 212.27$ g/mol ; $M_w(FeCl_2) = 126.75$ g/mol; (you need to determine the M_w of the precipitate yourself once you have identified its formula)

a). $3\,Fe^{2+}(aq) + 2\,PO_4^{3-}(aq) \rightarrow Fe_3(PO_4)_2(s)$ (1)

b). $\text{moles}(PO_4^{3-}) = 73\,mg \cdot \frac{1g}{1000\,mg} \cdot \frac{1\,mol}{212.27} \cdot \frac{1\,mol\,(PO_4)}{1\,mol\,(K_3PO_4)} = 3.44 \cdot 10^{-4}\,mol$

$\text{moles}(Fe_3(PO_4)_2) = 3.44 \cdot 10^{-4}\,mol \cdot \frac{1\,mol}{2\,mol} = 1.72 \cdot 10^{-4}\,mol$ (1)

$\text{moles}(Fe^{2+}) = 0.050\,M \cdot 0.018\,L = 9.00 \cdot 10^{-4}\,mol$

$\text{moles}(Fe_3(PO_4)_2) = 9.00 \cdot 10^{-4}\,mol \cdot \frac{1\,mol}{3\,mol} = 3.00 \cdot 10^{-4}\,mol$ (1)

$\Rightarrow PO_4^{3-}$ is limiting (1)

$\text{mass}(Fe_3(PO_4)_2) = 1.72 \cdot 10^{-4}\,mol \cdot 357.5\,g/mol = 0.061\,g$ (2)

C). $Fe^{2+}(\text{used}) = 1.72 \cdot 10^{-4}\,mol \cdot \frac{3\,mol\,Fe^{2+}}{1\,mol\,Fe_3(PO_4)_2} = 5.13 \cdot 10^{-4}\,mol$ (1)

$Fe^{2+}(\text{remaining}) = 9.00 \cdot 10^{-4}\,mol - 5.13 \cdot 10^{-4}\,mol = 3.87 \cdot 10^{-4}\,mol$

$[Fe^{2+}] = \frac{3.87 \cdot 10^{-4}\,mol}{0.018\,L} = 0.022\,M$ (2)

6. (5 Points) What is the definition of an Arrhenius acid and base? What is the definition of a Brønstedt-Lowry acid and base? Give an example of a Brønstedt-Lowry acid that is not an Arrhenius acid.

Arrhenius acid: produces H_3O^+ (1)

base: produces OH^- (1)

Brønstedt acid: donates H^+ (1)

base accepts H^+ (1)

e.g. $HCl(g)$ (1)

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7. (5 points) A 50.00 mL sample of an unknown phosphoric acid solution is titrated with a 0.100 M sodium hydroxide solution. The equivalence point is reached when 37.50 mL sodium hydroxide solution is added. Provide the balanced equation and calculate the concentration of the unknown phosphoric acid solution.

(2)

$H_3PO_4(aq) + 3NaOH(aq) \rightarrow Na_3PO_4(aq) + 3H_2O(\ell)$

$\text{moles } (OH^-) = 37.50\ mL \cdot \frac{1L}{1000mL} \cdot 0.100M = 0.00375\ mol$ (1)

$\text{moles}(H_3PO_4) = 0.00375\ mol \cdot \frac{1\ mol\ H_3PO_4}{3\ mol\ OH^-} = 0.00125\ mol$ (1)

$M(H_3PO_4) = \frac{0.00125\ mol}{0.0500L} = 0.025M$ (1)

8. (3 points) Provide the chemical formulas for each of the following acids:

a. hydrocyanic acid HCN (1)

b. sulfurous acid H_2SO_3 (1)

c. hydrofluoric acid HF (1)

9. (5 points) Determine the oxidation numbers for the indicated elements in the following substances:

a. $Na_2Cr_2O_7$ Na: +1 (1) Cr: +6 (1) O: −2 (1)

b. NH_4NO_2 First "N": −3 (1) Second "N": +3 (1)

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10. (6 points) Write balanced chemical equations for the following redox reactions. If no reaction occurs, write NR.

a. Fe is added to a solution of Nickel(II)sulfate

$Fe(s) + Ni(SO_4)(aq) \rightarrow FeSO_4(aq) + Ni(s)$ (2)

b. Manganese is added to a solution of iron(II)chloride

$Mn(s) + FeCl_2(aq) \rightarrow MnCl_2(aq) + Fe(s)$ (2)

c. Silver is added to a solution of Mercury(II)nitrate

NR (2)

11. (5 points) A nixture contains only $SrCl_2$ and NH_4NO_3. A 0.715 g of this mixture is dissolved in water, and an excess of $AgNO_3$ is added, producing a precipitate of AgCl. The precipitate is filtered, dried, and weighed. Its mass is 0.236 g. Calculate the mass percent of $SrCl_2$ in the mixture.

$\#\text{moles}(AgCl) = 0.236\,g \cdot \frac{1\,mol}{143.3\,g} = 1.65 \cdot 10^{-3}\,mol$ (1)

$\#\text{moles}(SrCl_2) = 1.65 \cdot 10^{-3}\,mol \cdot \frac{1\,mol}{2\,mol} = 8.23 \cdot 10^{-4}\,mol$ (1)

$\text{mass}(SrCl_2) = 8.23 \cdot 10^{-4}\,mol \cdot \frac{158.5\,g}{1\,mol} = 0.130\,g$ (1)

$\% = \frac{0.130\,g}{0.715\,g} \cdot 100\% = 18.2\%$ (2)

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12. (2 points) Complete and balance the following gas evolution reaction:

$HBr(aq) + KHSO_3(aq) \rightarrow$ $H_2SO_3(aq) + KBr(aq)$ (1)

$\rightarrow SO_2(g) + H_2O(\ell) + KBr(aq)$ (1)

13. (10 points) Complete and balance the following redox reaction in <u>acidic</u> solution

$$SO_3^{2-}(aq) + MnO_4^-(aq) \rightarrow SO_4^{2-}(aq) + Mn^{2+}(aq)$$

$SO_3^{2-} \xrightarrow{(1)} SO_4^{2-}$ $\quad MnO_4^- \xrightarrow{(1)} Mn^{2+}$

$SO_3^{2-} + H_2O \rightarrow SO_4^{2-}$ (1) $\quad MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

$SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+$ (1) $MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$

$SO_3^{2-} + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2e^-$ (1) $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

$5SO_3^{2-} + 5H_2O \rightarrow 5SO_4^{2-} + 10H^+ + 10e^-$ (1)

$2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{2+} + 8H_2O$ (1)

$5SO_3^{2-} + 5H_2O + 2MnO_4^- + 16H^+ + 10e^- \rightarrow 5SO_4^{2-} + 10H^+ + 10e^- + 2Mn^{2+} + 8H_2O$ (1)

$5SO_3^{2-}(aq) + 2MnO_4^-(aq) + 6H^+(aq) \rightarrow$

$5SO_4^{2-}(aq) + 2Mn^{2+}(aq) + 3H_2O(\ell)$ (2)