Dr. Zellmer
Time: 7 PM Sun.
40 min

Chemistry 1210
Autumn Semester 2022
Quiz IV

All Sections
September 25, 2022

Name ____________________ Rec. TA/time ____________________

Show **ALL** your work or **EXPLAIN** to receive full credit.

1. (4 pts) What is the correct **NET IONIC** equtaion from those given below to represent what happens when solutions of Na_3PO_4 and $MgCl_2$ are mixed.

This is an **exchange** (metathesis or double-replacement) reaction. Generally, when two soluble ionic compounds are the reactants it's an exchange reaction.

First exchange the partners and write the correct formulas. The charges don't change. Check the solubility table (rules) to see if anything is insoluble (forms a precipitate).

$$MgCl_2\,(aq) + Na_3PO_4\,(aq) \rightarrow Mg^{2+}\,(PO_4)^{3-}\,(s) + Na^{1+}\,Cl^{1-}\,(aq)$$

Formula Eqn: make sure it's balanced

$$3\,MgCl_2\,(aq) + 2\,Na_3PO_4\,(aq) \rightarrow Mg_3(PO_4)_2\,(s) + 6\,NaCl\,(aq)$$

Write the ionic equation and cancel out everything that appears the same way on both sides of the equation.

Ionic Eqn:

$$3\,Mg^{2+}\,(aq) + 6\,Cl^{-}\,(aq) + 6\,Na^{+}(aq) + 2\,PO_4^{3-}\,(aq) \rightarrow Mg_3(PO_4)_2\,(s) + 6\,Na^{+}(aq) + 6\,Cl^{-}\,(aq)$$

Net Ionic Eqn: (cancel "spectator ions" in ionic eqn.)

$$3\,Mg^{2+}\,(aq) + 2\,PO_4^{3-}\,(aq) \rightarrow Mg_3(PO_4)_2\,(s)$$

2. (2 pts) Which of the following are **strong** acids or **strong** bases? (Circle all that apply.)

HNO_3	$HClO_2$	**$HClO_4$**	**RbOH**	NH_3
$HBrO_3$	**$Ca(OH)_2$**	HSO_4^-	HF	CH_3CH_2OH

$HNO_3 \longrightarrow H^+ + NO_3^-$ **strong acid** - completely ionizes, strong electrolyte

The 7 strong acids are: HCl, HBr, HI, HNO_3, $HClO_3$, $HClO_4$, H_2SO_4 (1^{st} H^+ only)

$RbOH \longrightarrow Rb^+ + OH^-$ **strong base** - completely dissociates, strong electrolyte

Group 1 A and soluble group 2 A (Ca and below) hydroxides are strong bases.

$NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$ **weak base** - does NOT completely ionize, **weak electrolyte**

CH_3CH_2OH ethanol (an alcohol) - molecular compound which does **not** ionize - **nonelectrolyte**

Most molecular compounds do not ionize and are nonelectrolytes. The molecular compounds which ionize or react with water are the strong acids (strong electrolytes), weak acids (weak electrolytes) and weak bases (like NH_3, weak electrolyte).

3. (4 pts) **Predict the products** of the following reaction. **Complete and balance** the equation. **Indicate the physical state** of reactants and products (i.e. (s), (g), (l), (aq)). **(Show all work.)**

A solution of nitric acid, HNO_3, is combined with a solution of $Ca(OH)_2$.

Neutralization Rxn: Treat as an exchange rxn. - switch partners

$$\underset{\text{acid}}{HNO_3\ (aq)} + \underset{\text{hydroxide base}}{Ca(OH)_2\ (aq)} \rightarrow \underset{\text{ionic (salt)}}{Ca^{2+}\ (NO_3)^{1-}\ (aq)} + \underset{\text{water}}{H^+\ OH^-\ (\ell)}$$

charges on ions do not change when they switch partners in double replacement rxns

$$HNO_3\ (aq) + Ca(OH)_2\ (aq) \rightarrow Ca(NO_3)_2\ (aq) + H_2O\ (\ell)$$

Bal: (start w. NO_3^- - there's two of them on the right and it's on the left like a poly atomic ion. You generally want to balance polyatomic ions as a unit after balancing other things, but before H and O)

$$\underset{\text{acid}}{2\ HNO_3\ (aq)} + \underset{\text{hydroxide base}}{Ca(OH)_2\ (aq)} \rightarrow \underset{\text{ionic (salt)}}{Ca(NO_3)_2\ (aq)} + \underset{\text{water}}{2\ H_2O\ (\ell)}$$

(soluble) (soluble) (soluble)

Look in solubility table to see if substances are soluble (aq) or a precipitate (solid) or determine if one of the products breaks down to give a gas (CO_2, SO_2 or H_2S).

4. (3 pts) What are the expected products of the following reaction?

$$CaSO_3\ (s) + 2\ HNO_3\ (aq) \longrightarrow$$

$$CaSO_3\ (s) + 2\ HNO_3\ (aq) \rightarrow Ca(NO_3)_2\ (s) + H_2SO_3\ (aq)$$

Sulfurous acid is unstable and decomposes

$$H_2SO_3\ (aq) \rightarrow H_2O\ (\ell) + SO_2\ (g)$$

Overall final equation:

$$CaSO_3\ (s) + 2\ HNO_3\ (aq) \rightarrow Ca(NO_3)_2\ (s) + H_2O\ (\ell) + SO_2\ (g)$$

Exchange (double-replacement) with the formation of a **gas**.

Carbonates (CO_3^{2-}) and bicarbonates (HCO_3^-) react with acids to give H_2O (ℓ) & $\mathbf{CO_2}$ (g).

Sulfites (SO_3^{2-}) and bisulfites (HSO_3^-) react with acids to give H_2O (ℓ) & $\mathbf{SO_2}$ (g).

Sulfides (S^{2-}) react with acids to give $\mathbf{H_2S}$ (g).

5. (4 pts) Determine the oxidation number of the <u>underlined</u> element in the following compound. (**Must show all work.**)

Chg. on $\underline{\mathbf{Cr}}_2O_7^{2-}$ is -2

a) (2 pts) $\underline{\mathbf{Cr}}_2O_7^{2-}$ $2X_{Cr} + 7(-2)_O = -2;\ 2X_{Cr} - 14 = -2;\ 2X_{Cr} = +12;\ X_{Cr} = +6$

The ox. no. on chromium is **+6**.

Chg. on P_4O_6 is 0

b) (2 pts) $\underline{\mathbf{P}}_4O_6$ $4X_P + 6(-2)_O = 0;\ 4X_P - 12 = 0;\ 4X_P = +12;\ X_P = +3$

The ox. no. on phosphorous is **+3**.

6. (5 pts) Examine the reaction below and the statements concerning the reaction. Select an answer which includes **<u>ALL</u>** of the **<u>CORRECT</u>** statements given below.

$$12\ IF_5 + 15\ O_2 + 10\ Br_2 \longrightarrow 6\ I_2O_5 + 20\ BrF_3$$

1) Br has been oxidized.
2) F is reduced.
3) The oxidation number of Br changed from 0 to +3.
4) O has been oxidized.
5) The oxidation number of O changed from 0 to -2.

Ox. # inc., lost e-, Br oxidized (Br_2 red. agt.)

$$12\ IF_5 + \overset{(0)}{15\ O_2} + \overset{(0)}{10\ Br_2} \rightarrow \overset{(-2)}{6\ I_2O_5} + \overset{(+3)}{20\ BrF_3}$$

Ox. # dec, gain e-, O reduced (O_2 ox. agt.)

O: reduced (ox. num. chgs from 0 to -2)
O_2 : oxidizing agent

Br: oxidized (ox. num. chgs from 0 to +3)
Br_2 : reducing agent

1, 3 & 5 are Correct

7. (3 pts) Which of the following reactions will **NOT** occur as written?

a) 2 Cr(s) + 6 HBr(aq) → 3 H_2(g) + 2 $CrBr_3$(aq)

b) $Al(OH)_3$(s) + 3 HNO_3 (aq) → $Al(NO_3)_3$ (aq) + 3 H_2O(ℓ)

c) F_2(aq) + 2 NaBr (aq) → Br_2 (aq) + 2 NaF(aq)

d) 3 $Fe(NO_3)_2$(aq) + 2 Al(s) → 3 Fe(s) + 2 $Al(NO_3)_3$ (aq)

e)* 2 Ag(s) + $Zn(NO_3)_2$(aq) → Zn(s) + 2 $AgNO_3$ (aq)

The reactions are redox (oxidation-reduction) reactions. To be a redox (oxidation-reduction) reaction the oxidation numbers must change. More specifically the reactions are all displacement (single replacement) reactions. You need to figure out what's being oxidized and reduced. Then you use the activity series. Remember, ease of oxidation increases from bottom to top in the series. The more easily oxidized substance is higher in the table.

Remember (OIL RIG):

oxidation: loss of e-, inc. in oxidation #

reduction: gain of e-, dec. in oxidation #

reaction (a):

2 Cr(s) + 6 HBr(aq) → 3 H_2(g) + $CrBr_3$(aq) Cr oxidized H reduced
0 +1 0 +3

In the activity series table aluminum is higher than hydrogen meaning aluminum is more easily oxidized. Since Cr is being oxidized this reaction will occur as written going left to right. Thus the Cr replaces H^+ in solution.

Proceeding in this way you find reaction (**e**) can't occur as written:

2 Ag(s) + $Zn(NO_3)_2$(aq) → Zn(s) + 2 $AgNO_3$ (aq) Ag oxidized Zn reduced
0 +2 0 +1

However, from the table Zn is more easily oxidized than Ag. This reaction won't occur spontaneously left to right but instead the reverse reaction would occur.

Reaction (d) is also a redox reaction. Aluminum is above Fe in the activity series meaning it will be oxidized more easily than Fe and that's what is occurring in the reaction as written.

3 $Fe(NO_3)_2$(aq) + 2 Al(s) → 3 Fe(s) + 2 $Al(NO_3)_3$ (aq) Al oxidized Fe reduced
+2 0 0 +3

***** continued on next page *****

7. (Cont.)

Reaction (c) is a redox reaction involving the replacement of one halogen in solution with another. The order of reactivity for halogens (ease of reduction) is I < Br < Cl < F. This reaction will occur as written and F will replace Br- in solution.

F_2(aq) + 2 NaBr (aq) → Br_2 (aq) + 2 NaF(aq)				Br oxidized	F reduced
0	-1	0	-1		

Reaction (b) is an acid-base neutralization reaction between a strong acid, HNO_3, and a hydroxide base. An acid-base neutralization involving a strong acid and/or a strong base go to completion.

<u>E</u>

8. (5 pts) Which of the following is (are) an example(s) of an **<u>exchange</u>** (**double-replacement** or **metathesis**) reaction (assume all reactions occur to give products and write the products)?

1) $Pb(NO_3)_2$ (aq) + NaBr (aq) →

2) $CaSO_4$ (aq) + $(NH_4)_3PO_4$ (aq) →

3) NaI (aq) + Br_2 (ℓ) →

4) Fe (s) + HCl (aq) →

5) Ba (s) + O_2 (g) →

1 and 2 are **<u>exchange</u>** (double replacement or metathesis) reactions

1) $Pb(NO_3)_2$ (aq) + 2 NaBr (aq) → $PbBr_2$ (s) + 2 $NaNO_3$ (aq) double replacement w. ppt
ionic ionic ionic ionic

2) 3 $CaSO_4$ (aq) + 2 $(NH_4)_3PO_4$ (aq) → $Ca_3(PO4)_2$(s) + 3 $(NH_4)_2SO_4$ (aq) double replacement w. ppt
ionic ionic ionic ionic

3) NaI (aq) + Br_2 (ℓ) → NaBr (aq) + I_2 (s) single replacement
ionic halide; element halogen; ionic halide; element halogen

4) Fe (s) + 2 HCl (aq) → $FeCl_2$ (aq) + H_2 (g) single replacement
element; acid (Acts like ionic in solution); ionic; element

5) 2 Ba (s) + O_2 (g) → 2 BaO(s) combination (2 reactants → 1 product)
element; element; ionic cmpd

9. (2 pts) Which reaction(s) in question 8 is (are) an example(s) of a **redox** reaction (assume all reactions occur to give products)?

Oxidation-Reduction (Redox) reactions involve the transfer of electrons (and associated change in oxidation numbers)..

Remember (OIL RIG):

oxidation: loss of e-, inc. in oxidation #

reduction: gain of e-, dec. in oxidation #

See above answers in #8. **Displacement** (single-replacement) and **combination** rxns are some examples of redox rxns.

3) $NaI (aq) + Br_2 (\ell) \rightarrow NaBr (aq) + I_2 (s)$ — single replacement

NaI (aq)	Br_2 (ℓ)	NaBr (aq)	I_2 (s)
-1	0	-1	0
ionic halide	element halogen	ionic halide	element halogen

I oxidized (NaI reducing agent) — Br reduced (Br_2 oxidizing agent)

4) $Fe (s) + 2 HCl (aq) \rightarrow FeCl_2 (aq) + H_2 (g)$ — single replacement

Fe (s)	2 HCl (aq)	$FeCl_2$ (aq)	H_2 (g)
0	+1	+2	0
element	acid (Acts like ionic in solution)	ionic	element

Fe oxidized (Fe reducing agent) — H reduced (HCl oxidizing agent)

5) $2 Ba (s) + O_2 (g) \rightarrow 2 BaO(s)$ — combination (2 reactants → 1 product)

2 Ba (s)	O_2 (g)	2 BaO(s)
0	0	+2 -2
element	element	ionic cmpd

Ba oxidized (reducing agent) — O reduced (O_2 oxidizing agent)

(3, 4, 5)

10. (3 pts) Calculate the molarity of Na^+ when 0.832 g of Na_3PO_4 is dissolved in enough water to make 26.8 mL of solution. (Atomic weights: Na = 22.99, P = 30.97, O = 16.00)

$$? \frac{\text{mol } Na^+}{\text{1 L soln}} = \frac{0.832 \text{ g of } Na_3PO_4}{26.8 \text{ mL soln}} \times \frac{10^3 \text{ mL soln}}{\text{1 L soln}} \times \frac{1 \text{ mol } Na_3PO_4}{163.94 \text{ g } Na_3PO_4} \times \frac{3 \text{ mol } Na^+}{1 \text{ mol } Na_3PO_4}$$

$= 0.56\underline{\mathbf{8}}1 \text{ M } Na^+$

$= 0.568 \text{ M } Na^+$

Another way to do this is to first calculate the molarity of the Na_3PO_4 and then calculate the molarity of the Na+ ions. To get the molarity of the Na3PO4 that's just the first 3 steps above. That gives:

$0.18\underline{\mathbf{9}}36 \text{ M } Na_3PO_4$

Then there's 3 Na^+ ions per one formula unit of Na_3PO_4 so the molarity of Na^+ would be 3 times the molarity of the Na_3PO_4

molarity of $Na^+ = 3 * 0.18\underline{\mathbf{9}}36 = 0.56\underline{\mathbf{8}}1 \text{ M } Na^+$

Could also use a BCA table (in molarity):

	Na_3PO_4	---->	$3\ Na^+$	+	PO_4^{3-}
B	$0.18\underline{\mathbf{9}}3$		0		0
C	$-0.18\underline{\mathbf{9}}3$		$+3(0.18\underline{\mathbf{9}}3)$		$+0.18\underline{\mathbf{9}}3$
A	0		$0.56\underline{7}9$		$0.18\underline{\mathbf{9}}3$

11. (2 pts) Calculate the molarity of an H_2SO_4 solution that results when 45.0 mL of 18.0 M H_2SO_4 is diluted with 90.0 mL of H_2O assuming the volumes are additive.

Dilution problem $\quad M_2V_2 = M_1V_1$

Remember, V_1 is the initial volume of soln. and V_2 is the final volume of soln.

$M_1 = 18.0$ M $\quad M_2 = ?$
$V_1 = 45.0$ mL $\quad V_2 = 45.0 \text{ mL } H_2SO_4 + 90.0 \text{ mL } H_2O = 135.0$ mL final solution

$$M_2 = \frac{M_1V_1}{V_2} = \frac{(18.0 \text{ M})(45.0 \text{ mL})}{135.0 \text{ mL}} = 6.00 \text{ M } H_2SO_4$$