Recitation Worksheet Five

Name: Key UGA ID:

Instructions:

- Please enter your first and last name as it appears on the eLC roster (do not use a nickname that is not reflected in eLC).
- Your UGA myID is a combination of letters and numbers (example: mine is jmj81738). Do *not* enter your 81x number.
- Download this worksheet and print it if you have a printer. Write the answers in the answer boxes and show your work when appropriate. Using the instructions in the Welcome module on eLC, convert your worksheet to a PDF and then upload it to Gradescope. If you have an iPhone or Android device, you can scan and upload directly through the Gradescope app. The pages must be in the correct order or Gradescope will not be able to read it.
- If you do not have a printer, download the worksheet and type your answers in the answer boxes and upload it to Gradescope. Write your work on separate sheets of paper, convert these pages to a PDF using the instructions in the Welcome module on eLC, then upload them to the dropbox on eLC for this worksheet.
- If you are using an app to annotate the worksheet, make sure the pages are in the correct order and have the same layout as the original or Gradescope will not be able to read it.
- Answers must be written in the corresponding answer box or no credit will be awarded.
- This worksheet is due no later than **11:59 PM on the Friday of the recitation week.**
- The instructions for uploading worksheets to Gradescope can be found in the Content area of eLC in the Welcome Module.
- **You must show your work to receive credit.**

1. How many of the following compounds below are soluble in water? Answer by using an integer (e.g. 0, 1, etc.).

5

A. Rb_2SO_4
~~B. AgI~~
~~C. Ag_2CO_3~~
D. BaS
E. Na_2CO_3
~~F. $SrSO_4$~~
~~G. Hg_2I_2~~
~~H. $Ba_3(PO_4)_2$~~
I. NH_4NO_3
J. $Ba(CH_3COO)_2$

2. What is the correct balanced formula equation for the reaction between aqueous solutions of sodium sulfate and barium chloride?

E

A. $NaSO_4\ (aq) + BaCl_2\ (aq) \rightarrow BaSO_4\ (aq) + NaCl\ (aq)$

B. $NaSO_4\ (aq) + BaCl_2\ (aq) \rightarrow BaSO_4\ (s) + NaCl\ (aq)$

C. $NaSO_4\ (aq) + BaCl_2\ (aq) \rightarrow BaSO_4\ (aq) + NaCl\ (s)$

D. $Na_2SO_4\ (aq) + BaCl_2\ (aq) \rightarrow BaSO_4\ (aq) + 2\ NaCl\ (s)$

E. $Na_2SO_4\ (aq) + BaCl_2\ (aq) \rightarrow BaSO_4\ (s) + 2\ NaCl\ (aq)$

F. $Na_2SO_4\ (aq) + BaCl_2\ (aq) \rightarrow BaSO_4\ (aq) + 2\ NaCl\ (aq)$

3. Consider the reaction between aqueous hydroiodic acid and aqueous barium hydroxide. What is/are the spectator ion(s) in this reaction? Select all that apply.

BC

A. The hydrogen ion
B. The iodide ion
C. The barium ion
D. The hydroxide ion
E. There are no spectator ions in this reaction

$$2HI_{(aq)} + Ba(OH)_{2\,(aq)} \longrightarrow 2H_2O_{(l)} + BaI_{2\,(aq)}$$

$$2H^+_{(aq)} + 2I^-_{(aq)} + Ba^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow 2H_2O_{(l)} + Ba^{2+}_{(aq)} + 2I^-_{(aq)}$$

4. What is the total ionic equation for the double displacement reaction between aqueous mercury(I) nitrate and aqueous potassium iodide?

E

$Hg_2(NO_3)_{2(aq)} + 2KI_{(aq)} \rightarrow Hg_2I_{2(s)} + 2KNO_{3(aq)}$

A. $Hg^+ (aq) + NO_3^- (aq) + K^+ (aq) + I^- (aq) \rightarrow HgI (s) + K^+ (aq) + NO_3^- (aq)$

B. $Hg^+ (aq) + NO_3^- (aq) + K^+ (aq) + I^- (aq) \rightarrow Hg^+ (aq) + I^- (aq) + K^+ (aq) + NO_3^- (aq)$

C. $Hg^+ (aq) + N^{5+} (aq) + O_3^- (aq) + K^+ (aq) + I^- (aq) \rightarrow HgI (s) + K^+ (aq) + N^{5+} (aq) + O_3^- (aq)$

D. $Hg_2^{2+} (aq) + 2\ NO_3^- (aq) + 2\ K^+ (aq) + 2\ I^- (aq) \rightarrow Hg_2^{2+} (aq) + 2\ I^- (aq)\ \ 2\ K^+ (aq) + 2\ NO_3^- (aq)$

E. $Hg_2^{2+} (aq) + 2\ NO_3^- (aq) + 2\ K^+ (aq) + 2\ I^- (aq) \rightarrow Hg_2I_2 (s) + 2\ K^+ (aq) + 2\ NO_3^- (aq)$

5. What is the net ionic equation for the balanced equation given below?

$2\ KMnO_4 (aq) + 16\ HCl (aq) \rightarrow 2\ MnCl_2 (aq) + 5\ Cl_2 (g) + 2\ KCl (aq) + 8\ H_2O (l)$

A

$2K^+_{(aq)} + MnO_4^-{}_{(aq)} + 16H^+_{(aq)} + 16Cl^-_{(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 4Cl^-_{(aq)} + 5Cl_{2(g)} + 2K^+_{(aq)} + 2Cl^-_{(aq)} + 8H_2O_{(l)}$

A. $2\ MnO_4^- (aq) + 16\ H^+ (aq) + 10\ Cl^- (aq) \rightarrow 2\ Mn^{2+} (aq) + 5\ Cl_2 (g) + 8\ H_2O (l)$

B. $2\ K^+ (aq) + 2\ MnO_4^- (aq) + 16\ H^+ (aq) + 16\ Cl^- (aq) \rightarrow 2\ Mn^{2+} (aq) + 5\ Cl_2 (g) + 8\ H_2O (l) + K_2 (aq)$

C. $2\ Mn^{7+} (aq) + 4\ O^{2-} (aq) + 16\ H^+ (aq) + 16\ Cl^- (aq) \rightarrow 2\ Mn^{2+} (aq) + 10\ Cl^- (g) + 8\ H_2O (l)$

D. $2\ K^+ (aq) + 2\ Mn^{7+} (aq) + 4\ O^{2-} (aq) + 16\ H^+ (aq) + 16\ Cl^- (aq) \rightarrow 2\ Mn^{2+} (aq) + 10\ Cl^- (g) + 8\ H_2O (l)$

E. No net ionic equation exists

all potassium ions are spectators but only 6 chloride ions

6. Write the net ionic equation for the balanced equation below. Afterwards, determine the sum of the coefficients and report your answer in the box below. Remember to include a coefficient of 1 in your calculations even if it is usually left out.

$$6\ NaOH\ (aq) + 3\ Cl_2\ (g) \rightarrow NaClO_3\ (aq) + 5\ NaCl\ (aq) + 3\ H_2O\ (l)$$

18

$6Na^+_{(aq)} + 6OH^-_{(aq)} + 3Cl_{2(g)} \rightarrow Na^+_{(aq)} + ClO_3^-{}_{(aq)} + 5Na^+_{(aq)} + 5Cl^-_{(aq)} + 3H_2O_{(l)}$

Net ionic: $6OH^-_{(aq)} + 3Cl_{2(g)} \rightarrow ClO_3^-{}_{(aq)} + 5Cl^-_{(aq)} + 3H_2O_{(l)}$

6+3+1+5+3=18

7. Write the net ionic equation for the acid-base reaction between solid aluminum hydroxide and aqueous nitric acid. Afterwards, determine the sum of the coefficients and report your answer in the box below. Remember to include a coefficient of 1 in your calculations even if it is usually left out.

8

$Al(OH)_{3(s)} + 3HNO_{3(aq)} \rightarrow 3H_2O_{(l)} + Al(NO_3)_{3(aq)}$

$Al(OH)_{3(s)} + 3H^+_{(aq)} + 3NO_3^-{}_{(aq)} \rightarrow 3H_2O_{(l)} + Al^{3+}_{(aq)} + 3NO_3^-{}_{(aq)}$

$Al(OH)_{3(s)} + 3H^+_{(aq)} \rightarrow 3H_2O_{(l)} + Al^{3+}_{(aq)}$

1+3+3+1=8

8. If 60.00 mL of 0.810 M $BaCl_2$ is added to 54.20 mL of 0.170 M $AgNO_3$, and 1.12 grams of solid is collected, what is the percent yield of the reaction?

84.8 %

$BaCl_{2(aq)} + 2AgNO_{3(aq)} \rightarrow 2AgCl_{(s)} + Ba(NO_3)_{2(aq)}$

$0.810\ \frac{mol}{L}\ BaCl_2 \times 0.06000\ L \times \frac{2\ mol\ AgCl}{1\ mol\ BaCl_2} \times \frac{143.32\ g\ AgCl}{mol\ AgCl} = 13.93070\ g\ AgCl$

Excess Reagent

$0.170\ \frac{mol}{L}\ AgNO_3 \times 0.05420\ L \times \frac{2\ mol\ AgCl}{2\ mol\ AgNO_3} \times \frac{143.32\ g\ AgCl}{mol\ AgCl} = 1.320550\ g\ AgCl$

Limiting Reagent

$\% = \frac{Actual}{Theoretical} \times 100 = \frac{1.12\ g}{1.320550\ g} \times 100 = 84.8131\ \%$

9. Consider a hypothetical scenario in which you need 100.0 grams of $PbCl_2$. You go to the lab and find a limited volume of 0.600 M NaCl and an excessive amount of 0.700 M $Pb(NO_3)_2$, both of which can be combined to form $PbCl_2$. If the percent yield of the reaction is 44.25 %, what volume (in mL) of 0.600 M NaCl do you need? Hint: $Pb(NO_3)_2$ will be your excess reactant.

2.71E3 mL

$Pb(NO_3)_{2(aq)} + 2NaCl_{(aq)} \rightarrow PbCl_{2(s)} + 2NaNO_{3(aq)}$

$\frac{100.0\ g}{\text{theoretical}} = 0.4425$ theoretical $= 225.988701\ g\ PbCl_2$

$225.988701\ g\ PbCl_2 \times \frac{mol}{278.1\ g} \times \frac{2\ mol\ NaCl}{1\ mol\ PbCl_2} \times \frac{L\ NaCl}{0.600\ mol\ NaCl} \times \frac{1000\ mL}{L} = 2.71 \times 10^3\ mL$

10. What volume (in mL) of 6.74 M H_3PO_4 is produced when 2.50 metric tons of $Ca_5(PO_4)_3F$ reacts with excess H_2SO_4 and excess H_2O if the percent yield is 74.1%? Note: 1 metric ton = 1000 kg

$Ca_5(PO_4)_3F\ (s) + 5\ H_2SO_4\ (aq) + 10\ H_2O\ (l) \rightarrow$
$3\ H_3PO_4\ (aq) + 5\ (CaSO_4 \cdot 2H_2O)\ (s) + HF\ (aq)$

1.64E6 mL

$2.50\ \text{metric tons} \times \frac{1000\ kg}{1\ \text{metric ton}} \times \frac{1000\ g}{kg} \times \frac{mol}{504.31\ g} \times \frac{3\ mol\ H_3PO_4}{1\ mol\ Ca_5(PO_4)_3F} \times \frac{L\ H_3PO_4}{6.74\ mol\ H_3PO_4} \times \frac{1000\ mL}{L} \times \frac{74.1}{100}$

11. A 225.00 mL sample of 0.500 M CsCl and a 155.00 mL sample of 1.560 M CsCl is added to a beaker. Afterwards, $AgNO_3$ is added to the beaker to react with the CsCl solution. Start by writing the balanced equation, and then determine the mass of $AgNO_3$ required to completely react with CsCl.

60.2 g

$CsCl_{(aq)} + AgNO_{3(aq)} \rightarrow AgCl_{(s)} + CsNO_{3(aq)}$

$\left(0.500\ \frac{mol\ CsCl}{L} \times 0.22500\ L\right) + \left(1.560\ \frac{mol\ CsCl}{L} \times 0.15500\ L\right) = mol\ CsCl$

$0.1125\ mol + 0.2418\ mol = 0.3543\ mol\ CsCl$

$0.3543\ mol\ CsCl \times \frac{mol\ AgNO_3}{mol\ CsCl} \times \frac{169.88\ g\ AgNO_3}{mol\ AgNO_3} = 60.2\ g\ AgNO_3$

12. Label the following reactions below as an (A) acid-base, (B) precipitation, or (C) oxidation-reduction reaction. Write the corresponding letter in the boxes below.

C — $3\ Fe(NO_3)_2\ (aq) + 2\ Al\ (s) \rightarrow 3\ Fe\ (s) + 2\ Al(NO_3)_3\ (aq)$ (+2, 0, 0, +3) Fe reduced, Al oxidized

A — $2\ CH_3COOH\ (aq) + Ba(OH)_2\ (aq) \rightarrow Ba(CH_3COO)_2\ (aq) + 2\ H_2O\ (l)$ (acetic acid, base)

C — $N_2\ (g) + 3\ H_2\ (g) \rightarrow 2\ NH_3\ (g)$ (0, 0, +3 −1) N oxidized, H reduced

B — $ZnCl_2\ (aq) + 2\ NaOH\ (aq) \rightarrow 2\ NaCl\ (aq) + Zn(OH)_2\ (s)$ (+2 −1, +1, +1 −1, +2) no change in oxidation #

13. A scientist goes to the lab and finds a solution of H_3PO_4 that has an unknown concentration. Upon experimentation, they find that they can neutralize 45.00 mL of the H_3PO_4 solution by using 32.50 mL of a 1.500 M LiOH solution. Based on this information, what is the concentration of the unknown H_3PO_4 solution?

$$H_3PO_4\ (aq) + 3\ LiOH\ (aq) \rightarrow Li_3PO_4\ (aq) + 3\ H_2O\ (l)$$

0.3611 M

$$0.03250\ L\ LiOH \times \frac{1.500\ mol}{L} \times \frac{1\ mol\ H_3PO_4}{3\ mol\ LiOH} = 0.01625\ mol\ H_3PO_4$$

$$\frac{0.01625\ mol\ H_3PO_4}{0.04500\ L} = 0.3611$$

14. Recently, you learned the names of numerous polyatomic ions including those listed below. Record the oxidation state of chlorine in each of the compounds below with an integer and if applicable its charge (e.g. 0, +/- 1, +/- 2, etc.).

(a) [+1] hypochlorite ClO^-

$Cl + O = -1$

$Cl + (-2) = -1$

$Cl = +1$

(c) [+5] chlorate ClO_3^-

$Cl + 3O = -1$

$Cl - 6 = -1$

$Cl = +5$

(b) [+3] chlorite ClO_2^-

$Cl + 2O = -1$

$Cl - 4 = -1$

$Cl = +3$

(d) [+7] perchlorate ClO_4^-

$Cl + 4O = -1$

$Cl - 8 = -1$

$Cl = +7$

15. How many electrons are transferred in the following half reactions below? Answer by using an integer (e.g. 0, 1, etc.).

[2] $Mn^{2+}(aq) \rightarrow \overset{0}{Mn}(s)$

$Mn^{2+} + 2e^- \rightarrow Mn_{(s)}$

[3] $Au(s) \rightarrow \underset{+3}{AuCl_4^-}(aq)$

$Au + 4Cl = -1$

$Au - 4 = -1$

$Au = +3$

16. Consider the oxidation-reduction reaction below and answer the following questions. Write the **chemical formula** in the boxes below.

$\overset{0}{Ba}(s) + \overset{0}{Cl_2}(g) \rightarrow \overset{2+}{Ba}\overset{-1}{Cl_2}(s)$

What species is oxidized? [Ba]

$Ba \rightarrow Ba^{2+} + 2e^-$

What species is reduced? [Cl]

$Cl_2 + 2e^- \rightarrow 2Cl^-$

17. Consider the oxidation-reduction reaction below and answer the following questions.
Write the **chemical formula** in the boxes below.

$\overset{0}{Zn}\ (s) + \overset{2+\ -1}{CuCl_2}\ (aq) \rightarrow \overset{2+\ -1}{ZnCl_2}\ (aq) + \overset{0}{Cu}\ (s)$

$Cu^{2+} + 2e^- \rightarrow Cu$

What species is the oxidizing agent? | $CuCl_2$ | *must have $CuCl_2$ not just Cu^{2+}

What species is the reducing agent? | Zn | $Zn \rightarrow Zn^{2+} + 2e^-$

18. Consider the oxidation-reduction reaction below and answer the following questions.
Write the **chemical formula** in the boxes below.

$2\ Al\ (s) + 3\ Pb^{2+}\ (aq) \rightarrow 2\ Al^{3+}\ (aq) + 3\ Pb\ (s)$

must balance atoms AND electrons

What species is oxidized? | Al | $(Al \rightarrow Al^{3+} + 3e^-)\ 2$

What species is reduced? | Pb^{2+} | $(2e^- + Pb^{2+} \rightarrow Pb)\ 3$

$2Al + 6e^- + 3Pb^{2+} \rightarrow 3Pb + 2Al^{3+} + 6e^-$

Fully balance the equation and list the coefficients as whole numbers with no commas or spaces (e.g. 1234).

2323

How many electrons were transferred after balancing the equation? Answer by using an integer (e.g. 0, 1, etc.).

6

Extra Practice Questions: these questions will not be graded.

1. Consider the double displacement reaction between aqueous sodium chloride and aqueous silver nitrate. What is/are the spectator ion(s) in this reaction? Select all that apply.

AD

$NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$

$Na^+_{(aq)} + Cl^-_{(aq)} + Ag^+_{(aq)} + NO_3^-{}_{(aq)} \rightarrow AgCl_{(s)} + Na^+_{(aq)} + NO_3^-{}_{(aq)}$

A. Na^+
B. Cl^-
C. Ag^+
D. NO_3^-
E. There are no spectator ions in this reaction

2. What is the total ionic equation for the balanced equation given below?

$$2\ Cs\ (s) + 2\ H_2O\ (l) \rightarrow 2\ CsOH\ (aq) + H_2\ (g)$$

D

$2Cs^+_{(aq)} + 2OH^-_{(aq)}$

A. $2\ Cs\ (s) + 2\ H_2O\ (l) \rightarrow 2\ CsOH\ (aq) + H_2\ (g)$

B. $2\ Cs\ (s) + 4\ H^+\ (aq) + 2\ O^{2-}\ (aq) \rightarrow 2\ Cs^+\ (aq) + 2\ OH^-\ (aq) + H_2\ (g)$

C. $2\ Cs\ (s) + 4\ H^+\ (aq) + 2\ O^{2-}\ (aq) \rightarrow 2\ Cs^+\ (aq) + 2\ OH^-\ (aq) + 2\ H^+\ (aq)$

D. $2\ Cs\ (s) + 2\ H_2O\ (l) \rightarrow 2\ Cs^+\ (aq) + 2\ OH^-\ (aq) + H_2\ (g)$

E. No total ionic equation exists

3. What is the net ionic equation for the double displacement reaction between ammonium sulfate and lithium chloride?

E

$2LiCl_{(aq)} + (NH_4)_2SO_{4(aq)} \longrightarrow 2NH_4Cl_{(aq)} + Li_2SO_{4(aq)}$

all aqueous

A. $2\ Li^+\ (aq) + SO_4^{2-}\ (aq) \rightarrow Li_2SO_4\ (s)$

B. $2\ Li^+\ (aq) + SO_4^{2-}\ (aq) + 2\ Cl^-\ (aq) \rightarrow Li_2SO_4\ (s) + Cl_2\ (aq)$

C. $NH_4^+\ (aq) + Cl^-\ (aq) \rightarrow NH_4Cl\ (s)$

D. $NH_4^+\ (aq) + Cl^-\ (aq) + SO_4^{2-}\ (aq) \rightarrow NH_4Cl\ (s) + S^{6+}\ (aq) + 4\ O^{2-}\ (aq)$

E. No net ionic equation exists

4. Approximately 6.159 grams of an unknown metal chloride compound (MCl) is dissolved in water, and then precipitated out with 106.4 mL of 0.3015 M $AgNO_3$ solution. Assuming the equation provided below is balanced, determine the mass percent of chlorine.

$MCl\ (aq) + AgNO_3\ (aq) \rightarrow AgCl\ (s) + MNO_3\ (aq)$ (2)

18.46

(1) $0.1064\ L \times \frac{0.3015\ mol\ AgNO_3}{L} \times \frac{1\ mol\ MCl}{1\ mol\ AgNO_3} \times \frac{1\ mol\ Cl}{1\ mol\ MCl} \times \frac{35.45\ g\ Cl}{mol\ Cl} = 1.137221825\ g\ Cl$

$\%Cl = \frac{1.137221825\ g}{6.159\ g} \times 100 = 18.46435506$

5. If 30.00 mL of a 0.500 M K_2SO_4 solution is mixed with 20.00 mL of a 0.400 M $Pb(C_2H_3O_2)_2$ solution, and 1.813 grams of solid are collected, what is the percent yield of the reaction? Start by balancing the equation below.

$\%= \frac{1.813\ g}{2.426166\ g} \times 100$

1 $K_2SO_4\ (aq)$ + 1 $Pb(C_2H_3O_2)_2\ (aq)$ → 2 $KC_2H_3O_2\ (aq)$ + 1 $PbSO_4\ (s)$

74.7 %

$0.030000\ L\ K_2SO_4 \times \frac{0.500\ mol}{L} \times \frac{1\ mol\ PbSO_4}{1\ mol\ K_2SO_4} \times \frac{303.27\ g}{mol} = 4.549505\ g\ PbSO_4$

$0.020000\ L \times \frac{0.400\ mol}{L} \times \frac{1\ mol\ PbSO_4}{1\ mol\ Pb(C_2H_3O_2)_2} \times \frac{303.27\ g}{mol} = 2.426166\ g\ PbSO_4$

Limiting Reagent $Pb(C_2H_3O_2)_2$

6. The scientist from question 13 finishes up their reaction and is putting away their reagents. In the process, they accidentally knock over a bottle of 5.50 M H_2SO_4. To clean up the mess, they neutralize the acid using $NaHCO_3$, which is a common practice in the laboratory. If they spilled 135.51 mL of H_2SO_4, what mass (in grams) of $NaHCO_3$ will they need to completely neutralize the acid?

$$H_2SO_4\ (aq) + 2\ NaHCO_3\ (s) \rightarrow Na_2SO_4\ (aq) + 2\ H_2O\ (l) + 2\ CO_2\ (g)$$

Disclaimer: it is also common practice in the laboratory to use an excessive amount of $NaHCO_3$ as quickly as possible to neutralize an acid spill due to safety concerns.

125	g

$$0.13551\ L \times \frac{5.50\ mol\ H_2SO_4}{L} \times \frac{2\ mol\ NaHCO_3}{1\ mol\ H_2SO_4} \times \frac{84.01\ g}{mol}$$