Unit 4 Summative Assessment Practice

Show your work for each question in the space provided. Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.

1. A student performs an experiment in which a sample of a metal oxide is added to a clean, dry crucible. The crucible is heated strongly with a Bunsen burner for several minutes. Data from the experiment is shown in the table below.

mass of clean, dry crucible	24.496 g
mass of crucible and metal oxide sample before heating	26.047 g
mass of crucible and contents after heating	25.940 g

solid metal oxide $\rightarrow$ solid metal + oxygen gas

Assume that the change in mass that occurs during the heating process is the result of oxygen gas escaping from the crucible, as represented by process shown above.

(a) Based on the information in the data table, calculate the number of moles of O_2 that is released from the crucible during this experiment.

(b) The substance remaining in the crucible at the end of the experiment is a pure sample of a metal. The amount of metal present in the crucible is equal to 0.0134 mol. Based on this information and the information in the data table, calculate the molar mass of the metal, and write the elemental symbol for the most likely identity of the metal.

(c) Based on your answers to parts (a) and (b), write the empirical formula of the metal oxide that was used in this experiment.

solid metal oxide $\rightarrow$ solid metal + oxygen gas

(d) Based on your answers to parts (b) and (c), write the balanced chemical equation for the process described above.

1. (continued)

solid metal oxide → solid metal + oxygen gas

(e) Is the process represented by the equation shown above classified as a physical change or a chemical change? Justify your answer.

(f) The student determined that the solid metal conducts electricity. Explain this observation. Your explanation should refer to the presence or absence of charged particles in the sample and whether or not the charged particles can move or flow freely.

(g) The student determined that the solid metal oxide does not conduct electricity. Explain this observation. Your explanation should refer to the presence or absence of charged particles in the sample and whether or not the charged particles can move or flow freely.

2. Each of the following solutes can be dissolved in water to form an aqueous solution. Write a balanced chemical equation that represents what happens to the solute particles when the solute is dissolved in water. You do not need to include the symbols for phases of matter such as (*s*), (*l*), or (*aq*) in your equations.

Solute	Equation for the Dissolution of the Solute in Water
solid ammonium sulfate, $(NH_4)_2SO_4$	
liquid methanol, CH_3OH	
solid aluminum nitrate, $Al(NO_3)_3$	

3. An experiment is performed to determine the percentage of Cu by mass in a brass alloy containing a mixture of Cu(*s*) and Zn(*s*). A sample of the brass alloy is dissolved completely in HNO_3(*aq*), forming the aqueous ions Cu^{2+}(*aq*) and Zn^{2+}(*aq*). Data from the experiment is shown below.

Mass of brass alloy containing a mixture of Cu(*s*) and Zn(*s*)	1.25 g
Volume of 6.00 *M* HNO_3(*aq*) used to dissolve the brass alloy	20.0 mL
Final volume after distilled water is added to the solution	250.0 mL

(a) Calculate the number of moles of HNO_3(*aq*) that is added to the brass alloy in this experiment.

(b) Distilled water is added to the reaction mixture, increasing the volume of the solution to 250.0 mL. It is determined that the concentration of Cu^{2+}(*aq*) in this solution is equal to 0.0548 *M*. Calculate the number of moles of Cu(*s*) that is present in the brass alloy sample.

$$Cu(s) \ + \ 4\ HNO_3(aq) \ \rightarrow \ Cu(NO_3)_2(aq) \ + \ 2\ H_2O(l) \ + \ 2\ NO_2(g)$$

(c) The reaction between Cu(*s*) and HNO_3(*aq*) is represented by the equation shown above. Using the balanced equation and your answers to parts (a) and (b), determine which reactant is the limiting reactant in this experiment. Justify your answer. Your justification should include a comparison between the amount that is needed and the amount that is available.

(d) Calculate the percent of Cu by mass in the 1.25 g brass sample.

(e) The reaction between Cu(*s*) and HNO_3(*aq*) is an oxidation-reduction reaction. Fill in the missing information below, in order to identify the element that is oxidized and the element that is reduced.

_________ is oxidized, because its oxidation number changes from _________ to _________

_________ is reduced, because its oxidation number changes from _________ to _________

4. When solutions of sodium phosphate, $Na_3PO_4(aq)$, and magnesium nitrate, $Mg(NO_3)_2(aq)$, are combined together, a precipitate is formed.

   (a) Write the balanced molecular equation for the reaction. You do not need to include the symbols for phases of matter such as (*s*) or (*aq*) in your equation.

   (b) What is the chemical formula of the precipitate formed in this reaction? ___________________

   (c) Write the balanced net ionic equation for this precipitation reaction. You do not need to include the symbols for phases of matter such as (*s*) or (*aq*) in your equation.

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5. When solutions of potassium hydroxide, $KOH(aq)$, and nickel(II) chloride, $NiCl_2(aq)$, are combined together, a precipitate is formed.

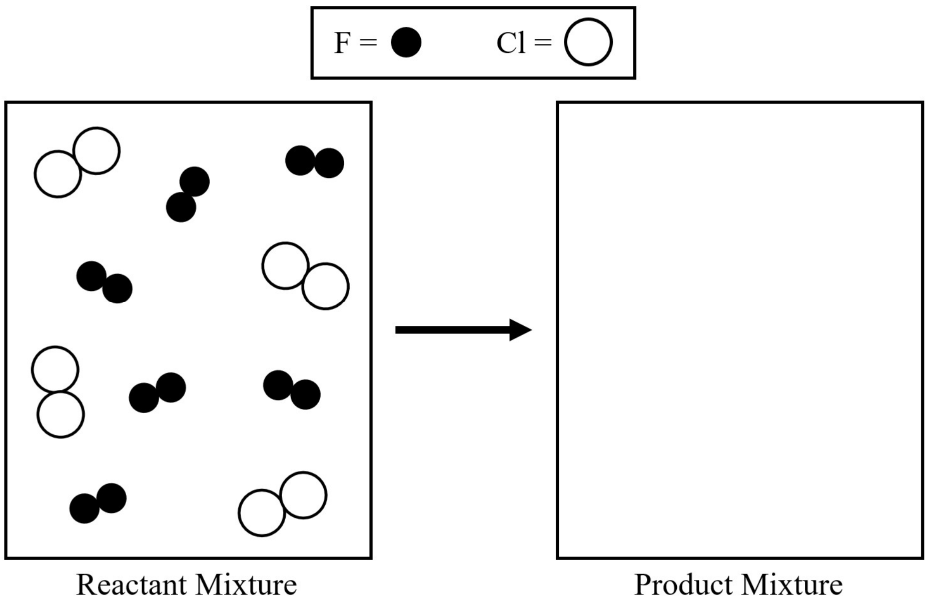
   (a) Write the balanced molecular equation for the reaction. You do not need to include the symbols for phases of matter such as (*s*) or (*aq*) in your equation.

   (b) What is the chemical formula of the precipitate formed in this reaction? ___________________

   (c) Write the balanced net ionic equation for this precipitation reaction. You do not need to include the symbols for phases of matter such as (*s*) or (*aq*) in your equation.

$$3\ F_2(g) + Cl_2(g) \rightarrow 2\ ClF_3(g)$$

6. A particle diagram representing a mixture of $F_2(g)$ and $Cl_2(g)$ in a reaction vessel is shown below in the box on the left. A chemical reaction takes place according to the equation above until one of the reactants is completely consumed. In the box below on the right, draw a particle diagram representing the contents of the reaction vessel at the completion of the reaction. Represent fluorine atoms and chlorine atoms as indicated below.



$$2\ C_5H_8O(l) + 13\ O_2(g) \rightarrow 10\ CO_2(g) + 8\ H_2O(g)$$

7. Cyclopentanone, C_5H_8O, undergoes complete combustion according to the equation shown above. In a certain experiment, a mixture of 15 g C_5H_8O and 35 g O_2 is added to a previously evacuated reaction vessel. The mixture is sparked and the reaction described by the equation above occurs until one of the reactants is completely consumed.

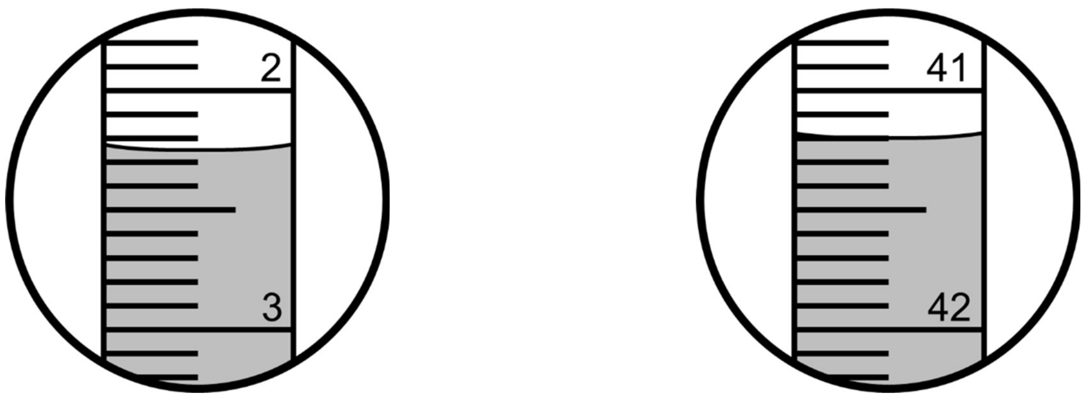
   (a) Determine the identity of the limiting reactant in this experiment. Justify your choice. Include <u>both words and calculations</u> in your justification.

   (b) Calculate the theoretical yield of $CO_2(g)$, in grams for this experiment.

$$HF(aq) \quad + \quad KOH(aq) \quad \rightarrow \quad H_2O(l) \quad + \quad KF(aq)$$

8. Hydrofluoric acid reacts with potassium hydroxide according to the equation above. A student performs a titration experiment in order to determine the concentration of HF in a HF(*aq*) solution. The student prepares a clean buret by filling it with a standard solution of 0.725 *M* KOH(*aq*).

   A sample of 50.0 mL of HF(*aq*) is measured in a graduated cylinder and transferred to an Erlenmeyer flask. A few drops of an acid-base indicator is added to the flask to ensure visual detection of the end point. The images below show close-up views of the buret containing 0.725 *M* KOH(*aq*) at the beginning of the titration (left) and at the end point (right).



(a) In the table below. record the initial and final buret readings and the calculated value for the volume of 0.725 *M* KOH(*aq*) required to reach the end point.

Initial buret reading before the titration	mL
Final buret reading at the end point	mL
Volume of 0.725 *M* KOH(*aq*) required to reach the end point	mL
Volume of HF(*aq*)	50.0 mL

(b) Based on the given information and your answer to part (a), calculate the concentration, in mol/L, of HF in the 50.0 mL sample of HF(*aq*).

8. (continued)

(c) The student performed a second trial of the titration, using a graduated cylinder to measure a 50.0 mL sample of HF(*aq*). However, the student made a mistake when the HF(*aq*) was transferred from the graduated cylinder to the Erlenmeyer flask. A few milliliters of HF(*aq*) were accidentally spilled onto the laboratory counter instead of being added to the flask. The student continued with the titration procedure. A few drops of an acid-base indicator was added to the flask, and the sample of HF(*aq*) was titrated until the end point was reached. Calculations were performed based on the assumption that the volume of HF(*aq*) was equal to 50.0 mL.

Based on this mistake, do you predict that the calculated value for the concentration of HF in Trial 2 should be less than, greater than, or the same as the value obtained in Trial 1? Justify your answer.

$$HCN(aq) + H_2O(l) \rightleftarrows CN^-(aq) + H_3O^+(aq)$$

9. Identify both sets of conjugate acid-base pairs in the reaction above.

Acid (Reactant)	Conjugate Base (Product)

Base (Reactant)	Conjugate Acid (Product)

$$CH_3NH_2(aq) + H_2O(l) \rightleftarrows CH_3NH_3^{+}(aq) + OH^{-}(aq)$$

10. Identify both sets of conjugate acid-base pairs in the reaction above.

Acid (Reactant)	Conjugate Base (Product)

Base (Reactant)	Conjugate Acid (Product)

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11. Add the following half-reactions together to produce a balanced redox equation in which the electrons are cancelled out on both sides.

Oxidation half-reaction: $C_2O_4^{2-} \rightarrow 2\ CO_2 + 2\ e^{-}$

Reduction half-reaction: $5\ e^{-} + MnO_4^{-} + 8\ H^{+} \rightarrow Mn^{2+} + 4\ H_2O$

$$NO_2^{-} + 2\ Al + 5\ H_2O + OH^{-} \rightarrow NH_3 + 2\ Al(OH)_4^{-}$$

12. Consider the balanced equation shown above.

(a) Assign oxidation numbers to each element on the left side of the equation.

N = ___________ Al = _______________ H = ___________ O = ___________

(b) Assign oxidation numbers to each element on the right side of the equation.

N = ___________ Al = _______________ H = ___________ O = ___________

(c) Which element is oxidized in this reaction? Which element is reduced in this reaction?