CHY 113 – Introduction to Stoichiometry

Guided Activity: From Mole Conversions to Mass–Mass Problems

Name: _____ Date: _____

Work through the models and questions in order. Discuss your reasoning with nearby classmates if helpful, or work independently. Show units and calculations. Use a periodic table as needed.

PART A • Guided introduction (approximately 45 minutes)

1 | What You Already Know: Mole Conversions

Recall the conversion map:



Particles ⇄ Moles ⇄ Grams

1. Complete the reminders: To convert grams → moles, _____ by molar mass. To convert moles → grams, _____ by molar mass.

2. A sample contains 0.500 mol H_2O. What is its mass? Show the conversion factor.

3a. A sample contains 36.0 g H_2O. How many moles is this? Show the conversion factor.

3b. Calcium phosphate, $Ca_3(PO_4)_2$, contains multiple polyatomic ions. How many calcium ions are in 15.5 g $Ca_3(PO_4)_2$? Show the complete grams → moles → particles → Ca^{2+} ions units conversion.

2 | Model 1: What a Balanced Equation Tells Us

Consider the balanced reaction:

$$\mathbf{2\ H_2(g)\ +\ O_2(g)\ \rightarrow\ 2\ H_2O(g)}$$

The coefficients tell us the relative amounts of substances in a reaction. For example, $2\ H_2 + O_2 \rightarrow 2\ H_2O$ means 2 mol H_2 react with 1 mol O_2 to form 2 mol H_2O.

If we start with…	The balanced equation tells us…
2 molecules H_2	2 molecules H_2O form
2 mol H_2	2 mol H_2O form
4 mol H_2	_____ mol H_2O form
1 mol O_2	_____ mol H_2O form

4. In this equation, what is the mole ratio of H_2 to H_2O? _____ : _____

5. What is the mole ratio of O_2 to H_2O? _____ : _____

6. If 3.00 mol O_2 reacts, how many moles of H_2O can form? Show how the coefficients create a conversion factor.

7. Why must the equation be balanced before its coefficients are used as mole ratios?

3 | Model 2: A New Bridge Between Mole Quantities

A balanced equation lets us move between moles of DIFFERENT substances:

moles of substance A → mole ratio from equation → moles of substance B

For the reaction $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$:

The coefficients tell us that 1 mole of N_2 reacts with 3 moles of H_2 to produce 2 moles of NH_3; therefore, the $N_2 : H_2 : NH_3$ mole ratio is 1 : 3 : 2.

8. Complete the mole conversion: 4.00 mol N_2 × (_____ mol NH_3 / _____ mol N_2) = _____ mol NH_3

9. Complete the reverse conversion: 6.00 mol NH_3 × (_____ mol N_2 / _____ mol NH_3) = _____ mol N_2

10. Explain why you cannot use molar mass alone to convert moles of N_2 into moles of NH_3.

4 | Model 3: Build a Mass–Mass Pathway

Consider the decomposition reaction:

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Question: What mass of CO_2 forms when 10.0 g $CaCO_3$ decomposes?

A mass–mass problem uses THREE bridges:

grams $CaCO_3$ → moles $CaCO_3$ → moles CO_2 → grams CO_2

11. Identify the conversion needed for each arrow:

First arrow: _____ Middle arrow: _____ Last arrow:_____

12. Find the molar masses: $CaCO_3$ = _____ g/mol; CO_2 = _____ g/mol.

13. Fill in the setup. Place each factor so units cancel:

10.0 g $CaCO_3$ × (_____ mol $CaCO_3$ / _____ g $CaCO_3$) × (_____ mol CO_2 / _____ mol $CaCO_3$) × (_____ g CO_2 / _____ mol CO_2)

14. Calculate the mass of CO_2, including units and appropriate significant figures.

15. Why would it be incorrect to convert 10.0 g $CaCO_3$ directly into grams CO_2 using only the molar mass of CO_2?

5 | Try the Complete Process

For each problem: (1) balance if needed, (2) draw a units pathway, (3) set up conversion factors, (4) calculate.

16. Magnesium reacts with oxygen: $2\ Mg(s) + O_2(g) \rightarrow 2\ MgO(s)$. What mass of MgO forms from 12.0 g Mg?

17. Nitrogen and hydrogen form ammonia: $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$. What mass of NH_3 forms from 14.0 g N_2?

CHECKPOINT: In one sentence, explain what the balanced equation contributes to a mass–mass calculation that molar masses cannot.

PART B • Additional practice (after the guided activity)

Use a periodic table. Assume the stated reaction proceeds as written and other reactants are available in sufficient amounts. Show balanced equations, pathways, conversion factors, units, and significant figures.

18. Carbon burns in oxygen: $C(s) + O_2(g) \rightarrow CO_2(g)$. What mass of CO_2 forms from 6.00 g C?

19. Aluminum reacts with chlorine: $Al(s) + Cl_2(g) \rightarrow AlCl_3(s)$. Balance the equation. What mass of $AlCl_3$ forms from 5.40 g Al?

20. Potassium chlorate decomposes: $KClO_3(s) \rightarrow KCl(s) + O_2(g)$. Balance the equation. What mass of O_2 forms from 24.5 g $KClO_3$?

21. Iron(III) oxide is reduced to iron: $Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe(s) + 3\ CO_2(g)$. What mass of Fe forms from 32.0 g Fe_2O_3?

22. Reverse direction: $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$. How many grams of O_2 are needed to form 18.0 g H_2O?

22b. Using the previous problem, how many L of O_2 are needed to form 100.0 g of H_2O, knowing that under standard conditions, 1 mole of a gas occupies 22.4L?

23. A student solves a problem by multiplying grams of reactant directly by the ratio of coefficients, then reports grams of product. Identify the mistake and describe the correct pathway.

24. Create your own mass–mass question using a balanced equation from this sheet. Trade with a classmate if available, or solve it yourself. Include a complete setup.