1. In the chemistry lab, you produce 10.0 grams of hydrogen gas from the following chemical reaction:

$$\mathbf{2HCl\ (aq) + Zn\ (s) \rightarrow H_2\ (g) + ZnCl_2\ (aq)}$$

a) What is the molar mass of HCl and H_2?

Ans. HCl:

Element	Atomic Mass	# of Atoms	Net Molar Mass
H	1.008	1	1.008
Cl	35.45	1	35.45
		Molar Mass →	36.46

H_2:

Element	Atomic Mass	# of Atoms	Net Molar Mass
H	1.008	2	2.016
		Molar Mass →	2.016

b) How many moles of H_2 are in 10.0 g?

Ans. $\#\ \text{mol of } H_2 = \left(\frac{10.0\ \text{g } H_2}{1}\right)\left(\frac{1\ \text{mol } H_2}{2.016\ \text{g } H_2}\right) = 4.96\ \text{mol } H_2$

c) How many moles of Zn are needed to produce 10.0 g of H_2?

Ans. $\#\ \text{mol of } H_2 = \left(\frac{4.96\ \text{mol } H_2}{1}\right)\left(\frac{1\ \text{mol Zn}}{1\ \text{mol } H_2}\right) = 4.96\ \text{mol Zn}$

d) How many grams of Zn are needed to produce the 10.0 g of H_2?

Ans. $\#\ \text{mol of Zn} = \left(\frac{4.96\ \text{mol Zn}}{1}\right)\left(\frac{65.41\text{g Zn}}{1\ \text{mol Zn}}\right) = 324.\ \text{g Zn}$

e) How many moles of $ZnCl_2$ are produced?

Ans. $\#\ \text{mol of } ZnCl_2 = \left(\frac{4.96\ \text{mol } H_2}{1}\right)\left(\frac{1\ \text{mol } ZnCl_2}{1\ \text{mol } H_2}\right) = 4.96\ \text{mol } ZnCl_2$

f) How many grams of $ZnCl_2$ are produced?

Ans. $ZnCl_2$:

Element	Atomic Mass	# of Atoms	Net Molar Mass
Zn	65.41	1	65.41
Cl	35.45	2	70.90
		Molar Mass →	136.31

$$\text{mass of Zn} = \left(\frac{4.96\ \text{mol } ZnCl_2}{1}\right)\left(\frac{136.31\text{g } ZnCl_2}{1\ \text{mol } ZnCl_2}\right) = 676.\ \text{g } ZnCl_2$$

2. A container with 100.0 mL of water has 25.0 grams of glucose ($C_6H_{12}O_6$) dissolved in it. When yeast is added to the solution, ethyl alcohol (or ethanol, C_2H_5OH) and carbon dioxide are produced, according to the following chemical reaction:

a) Write out the unbalanced chemical equation for this reaction.

Ans. $C_6H_{12}O_6\ (aq) \overset{\text{yeast}}{\rightarrow} C_2H_5OH\ (aq) + CO_2\ (g)$

b) Balance this chemical reaction.

Ans. $C_6H_{12}O_6\ (aq) \rightarrow 2\ C_2H_5OH\ (aq) + 2\ CO_2\ (g)$

c) What is the molar mass for glucose, ethanol and carbon dioxide respectively?

Ans. $C_6H_{12}O_6$:

Element	Atomic Mass	# of Atoms	Net Molar Mass
C	12.01	6	72.06
H	1.008	12	12.096
O	16.00	6	96.00
		Molar Mass →	180.16

C_2H_5OH:

Element	Atomic Mass	# of Atoms	Net Molar Mass
C	12.01	2	24.02
H	1.008	6	6.048
O	16.00	1	16.00
		Molar Mass →	46.07

CO_2:

Element	Atomic Mass	# of Atoms	Net Molar Mass
C	12.01	1	12.01
O	16.00	2	32.00
		Molar Mass →	44.01

d) How many moles of glucose are in the water before the yeast is added?

Ans. $\#\ \text{mol of } C_6H_{12}O_6 = \left(\frac{25.0\ \text{g } C_6H_{12}O_6}{1}\right)\left(\frac{1\ \text{mol } C_6H_{12}O_6}{180.16\ \text{g } C_6H_{12}O_6}\right) = 0.139\ \text{mol } C_6H_{12}O_6$

e) How many moles of ethanol are produced when this reaction runs to completion?

Ans. $\#\ \text{mol of } C_2H_5OH = \left(\frac{0.138\ \text{mol } C_6H_{12}O_6}{1}\right)\left(\frac{2\ C_2H_5OH}{1\ C_6H_{12}O_6}\right) = 0.278\ \text{mol } C_2H_5OH$

f) How many grams of ethanol are produced in the completed reaction?

Ans. # grams of C_2H_5OH = $\left(\frac{0.278 \text{ mol } C_2H_5OH}{1}\right)\left(\frac{46.07 \text{ g } C_2H_5OH}{1 \text{ mol } C_2H_5OH}\right)$=12.8 g C_2H_5OH

g) How many grams of carbon dioxide are produced in the completed reaction?

Ans. # grams of CO_2 = 25.0 g – 12.8 g = 12.2 g CO_2

Or, alternative solution:

grams of CO_2 = $\left(\frac{0.278 \text{ mol } CO_2}{1}\right)\left(\frac{44.01 \text{ g } CO_2}{1 \text{ mol } CO_2}\right)$=12.2 g CO_2

3. In a CH100 lab (not yours), copper(II) hydroxide precipitate is produced from 10.0 grams of copper(II) sulfate:

$2NaOH(aq) + CuSO_4(aq) \rightarrow Na_2SO_4(aq) + Cu(OH)_2(s)$

a) Calculate the molar mass of each reactant and product in this reaction.

Ans. NaOH:

Element	Atomic Mass	# of Atoms	Net Molar Mass
Na	22.99	1	22.99
O	16.00	1	16.00
H	1.008	1	1.008
		Molar Mass →	40.00

$CuSO_4$:

Element	Atomic Mass	# of Atoms	Net Molar Mass
Cu	63.55	1	63.55
S	32.07	1	32.07
O	16.00	4	64.00
		Molar Mass →	159.62

Na_2SO_4:

Element	Atomic Mass	# of Atoms	Net Molar Mass
Na	22.99	2	45.98
S	32.07	1	32.07
O	16.00	4	64.00
		Molar Mass →	142.05

$Cu(OH)_2$:

Element	Atomic Mass	# of Atoms	Net Molar Mass
Cu	63.55	1	63.55
O	16.00	2	32.00
H	1.008	2	2.016
		Molar Mass →	97.57

b) How many moles of copper(II) sulfate are consumed during this chemical reaction?

Ans. $\#\ \text{mol of } CuSO_4 = \left(\frac{10.0\ \text{g}}{1}\right)\left(\frac{1\ \text{mol } CuSO_4}{159.62\ \text{g } CuSO_4}\right) = 0.0626\ \text{mol } CuSO_4$

c) How many "molecules" of copper(II) sulfate (numerical quantity not moles) are consumed in this reaction?

Ans.

$\#\ \text{of } CuSO_4 = \left(\frac{0.0626\ \text{mol } CuSO_4}{1}\right)\left(\frac{6.022\text{x}10^{23}\ \text{molecules}}{1\ \text{mol}}\right) = 3.77\text{x}10^{22}\ \text{molecules } CuSO_4$

d) Using the coefficients of this reaction, determine how many moles of sodium hydroxide are reacted in this chemical process?

Ans. $\#\ \text{mol of NaOH} = \left(\frac{0.0626\ \text{mol } CuSO_4}{1}\right)\left(\frac{2\ \text{mol NaOH}}{1\ \text{mol } CuSO_4}\right) = 0.125\ \text{mol NaOH}$

e) How many moles of copper(II) hydroxide and sodium sulfate are produced by this reaction?

Ans. $\#\ \text{mol of } Cu(OH)_2 = \left(\frac{0.0626\ \text{mol } CuSO_4}{1}\right)\left(\frac{1\ \text{mol } Cu(OH)_2}{1\ \text{mol } CuSO_4}\right) = 0.0626\ \text{mol } Cu(OH)_2$

$\#\ \text{mol of } Na_2SO_4 = \left(\frac{0.0626\ \text{mol } CuSO_4}{1}\right)\left(\frac{1\ \text{mol } Na_2SO_4}{1\ \text{mol } CuSO_4}\right) = 0.0626\ \text{mol } Na_2SO_4$

f) How many molecules (numerical quantity not moles) of copper(II) hydroxide and sodium sulfate are produced by this reaction?

Ans.

$\#\ \text{of } Cu(OH)_2 = \left(\frac{0.0626\ \text{mol } Cu(OH)_2}{1}\right)\left(\frac{6.022\text{x}10^{23}\ \text{molecules}}{1\ \text{mol}}\right) = 3.77\text{x}10^{22}\ \text{molecules } Cu(OH)_2$

$\#\ \text{of } Na_2SO_4 = \left(\frac{0.0626\ \text{mol } Na_2SO_4}{1}\right)\left(\frac{6.022\text{x}10^{23}\ \text{molecules}}{1\ \text{mol}}\right) = 3.77\text{x}10^{22}\ \text{molecules } Na_2SO_4$

g) How many grams of copper(II) hydroxide and sodium sulfate are produced by this reaction?

Ans. $\text{mass of } Cu(OH)_2 = \left(\frac{0.0626\ \text{mol } Cu(OH)_2}{1}\right)\left(\frac{97.57\text{g}}{1\ \text{mol}}\right) = 6.11\text{g } Cu(OH)_2$

$$\text{mass of } Na_2SO_4 = \left(\frac{0.0626 \text{ mol } Na_2SO_4}{1}\right)\left(\frac{142.05g}{1 \text{ mol}}\right) = 8.89g \ Na_2SO_4$$

h) What is the % mass of each element in copper(II) hydroxide?

Ans. Start with the molar mass table constructed above then add 2 columns to calculate the mass ratio and % mass for each element:

Element	Atomic Mass	# of Atoms	Net Molar Mass	Mass Ratio	% Mass
Cu	63.55	1	63.55	0.6513	65.13%
O	16.00	2	32.00	0.3280	32.80%
H	1.008	2	2.016	0.02066	2.066%
		Molar Mass →	97.57	1.0000	100.00%