

## THEORETICAL, ACTUAL AND PERCENT YIELD

Objectives: By the end of today's class you will be able to calculate theoretical yield, actual yield and percent yield of a chemical reaction.

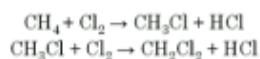
### SOME DEFINITIONS

- o **Theoretical yield** is the expected yield from given quantities of reactants.
- o **Actual yield** is the quantity that is actually produced.
- o **Percent yield** is the ratio of actual yield to theoretical yield expressed as a percent.

$$\% \text{ yield} = \frac{\text{Actual}}{\text{Theoretical}} \times 100\%$$

### EXAMPLE 1

Suppose that these reactions occur consecutively and each reaction has a 92% yield.



Starting with 112 g of  $\text{CH}_4$  in reaction and an excess of  $\text{Cl}_2$ , how many grams of  $\text{CH}_2\text{Cl}_2$  are formed in reaction?

$$\begin{aligned} M_{\text{CH}_4} &= 16.04 \text{ g/mol} \\ M_{\text{CH}_2\text{Cl}_2} &= 86.948 \text{ g/mol} \end{aligned}$$

$$112 \text{ g} \times \frac{1 \text{ mol}}{16.04 \text{ g}} \times \frac{1}{1} = 6.98 \text{ mol}$$

$$\text{actual} = 6.98 \times 0.92 = 6.42 \text{ mol}$$

$$6.42 \text{ mol} \times \frac{1}{1} \times 0.92 = 5.91 \text{ mol } \text{CH}_2\text{Cl}_2$$

then find mass



## EXAMPLE 2

Silicon nitride ( $\text{Si}_3\text{N}_4$ ), a valuable ceramic, is made by the direct combination of silicon and nitrogen at high temperature.

How much silicon must react with excess nitrogen to prepare 125 g of  $\text{Si}_3\text{N}_4$  if the percent yield of the reaction is 85%?

$$\text{theoretical} = \frac{\text{actual}}{\text{percentage}} = \frac{125}{0.85} = 147.06 \text{ g}$$

$$\frac{M_{\text{Si}_3\text{N}_4}}{M_{\text{Si}}} = \frac{140.3}{28.085}$$

$$147.06 \times \frac{1}{140.3} \times \frac{3}{1} \times \frac{28.085}{1} = \text{ANS}$$


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## EXAMPLE 3

Potassium chromate, a bright yellow solid, is produced by the reaction of solid chromite ore ( $\text{FeCr}_2\text{O}_4$ ) with solid potassium carbonate and gaseous oxygen at high temperatures. The other products of the reaction are solid iron(III) oxide and gaseous carbon dioxide.



In a particular experiment 169 kg of chromite ore, 298 kg of potassium carbonate, and 75.0 kg of oxygen were sealed in a reaction vessel and reacted at high temperature. The amount of potassium chromate obtained was 194 kg.

Calculate the percent yield of potassium chromate.

limiting  
reactant

Reactant	$m$	$M(\frac{\text{kg}}{\text{kmol}})$	$n(\text{kmol})$
$\text{FeCr}_2\text{O}_4$	169	223.8	0.75
$\text{K}_2\text{CO}_3$	298	138.2052	2.156
$\text{O}_2$	75.0	31.9988	2.344

$$0.75 \times \frac{8}{4} \times 194.2 \text{ kg/kmol} = 293 \text{ kg}$$

$$\% \text{ yield} = \frac{194}{293} \times 100\%$$

## SUGGESTED READINGS

- 4.5 Other Practical Matters in Reaction Stoichiometry

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**COURSE OVERVIEW**

1. Unit Conversions and Stoichiometry  
**(Ch. 1 – 4)**
2. Gases
3. Phases and Solutions
4. Equilibrium
5. Electrochemistry
6. Reaction Kinetics

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**REVIEW: UNIT CONVERSION**

To determine the volume of an irregularly shaped glass vessel, the vessel is weighed empty (121.3 g) and again when filled with carbon tetrachloride (283.2 g). What is the volume of the vessel, in cubic inches, given that 1 l of carbon tetrachloride weights 3.51 lb?

Answer:



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**REVIEW: UNIT CONVERSION**

Things have been financially difficult for you over the fall term and you are faced with cashing the inheritance left to you by your grandfather – a California gold nugget weighing 12.3 grains. You decide you will convert the gold nugget to Tim Horton Timbits® and at least you won't starve. You do a Google search and find that melted down raw gold from nuggets is currently bringing \$710 USD/troy ounce; the exchange rate on the USD is 1 USD = 1.1263 CA; and that you can get 40 Timbits® for \$4.49 CA. You also find out from GoldFeverProspecting.com that 31.1 grams = 1 troy ounce and that 1 gram = 15.43 grains. How many Timbits® can you get by cashing in your inheritance?

- A) 4    B) 162    C) 182    D) 2817    E) 5768



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**REVIEW: MOLAR MASS**

Chemical bottles labeled to contain blue-colored  $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$  often contain instead the green colored  $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$ . How many fewer grams of Ni are in 1.0 lb of  $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$  than would be in 1.0 lb of  $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ ?



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