**Answers to Questions from Lesson 1**

* **What is the atom economy of the reaction you are planning?**
* **Which has a better atom economy - the reaction with citric acid or with acetic acid?**

$$atom economy= \frac{molar mass of desired product}{total molar mass of reactants}×100\%$$

**Vinegar:**

Na2CO3 + 2CH3COOH 2CH3COONa + H2O + **CO2**

Reactant mass:

$\left(2(23)+12+3\left(16\right)\right)+2\left(2\left(12\right)+3(1)+2\left(16\right)+1\right)=226$ $gmol^{-1}$

Useful product mass:

$$\left(12+2\left(16\right)\right)=44 gmol^{-1}$$

$$\frac{44}{226}×100\%=19.5\%$$

**Lemon Juice:**

3Na2CO3 + 2C6H8O7 2Na3(C6H5O7) + 3H2O + **3CO2**

Reactant mass:

$3\left(23+12+3\left(16\right)\right)+2\left(6\left(12\right)+7(1)+3\left(16\right)\right)=702$ $gmol^{-1}$

Useful product mass:

$$3\left(12+2\left(16\right)\right)=132 gmol^{-1}$$

$$\frac{132}{702}×100\%=18.8\%$$

The reaction with vinegar has a higher atom economy by 0.7 %

* **Suggest 3 different metal carbonates that would give the reaction a better atom economy: Justify your answer with calculations and balanced equations.**

Possible answers are: magnesium carbonate, calcium carbonate, beryllium carbonate, sodium hydrogen carbonate, lithium carbonate, or aluminium carbonate.

**21.4%**

**21.8%**

**29.7%**

**20.0%**

**30.6%**

**22.7 %**

**23.2%**

**21.6 %**

MgCO3 + 2CH3COOH (CH3COO)2Mg + H2O + **CO2**

CaCO3 + 2CH3COOH (CH3COO)2Ca + H2O + **CO2**

BeCO3 + 2CH3COOH (CH3COO)2Be + H2O + **CO2**

NaHCO3 + CH3COOH CH3COONa + H2O + **CO2**

Li2CO3 + 2CH3COOH 2CH3COOLi + H2O + **CO2**

3NaHCO3 + C6H8O7 Na3(C6H5O7) + 3H2O + **3CO2**

3Li2CO3 + 2C6H8O7 2Li3(C6H5O7) + 3H2O + **3CO2**

Al2(CO3)3 + 2C6H8O7 2Al(C6H5O7) + 3H2O + **3CO2**

*Note: these are difficult to predict without explicitly looking at the equation*

* **The density of Ethanoic acid is 1.05 gm/L, the bottle of vinegar is 5 % by volume acetic acid and its total volume is 568 mL, do your results agree with this value? *Hint: from the density work out how many moles would be in a vinegar bottle filled with pure acetic acid.***

$density\left(CH\_{3}COOH\right)=1.05gcm^{-3}=0.017485molcm^{-3},$ RFM(CH3COOH) = 60.05 gmol-1

Vinegar bottle volume: 568 mL,

If bottle was pure acetic acid then it would contain 9.9317 moles of acetic acid,

From calculation above there are 0.00232 mol/ 2mL,

Therefore from the calculation there are 0.6588 moles in the bottle,

$\frac{0.6588}{9.9317}×100\%=6.63\%$ acidity in the bottle from our titration calculation, *c.f. 5%.*

**Answers to Questions Lesson 2**

* What is the percentage yield of the reaction of the acid + carbonate?

$$Percentage Yield=\frac{Actual Yield }{Theoretical Maximum Yield} ×100\%$$

Apply this formula to your results

* **How could the percentage yield of the procedure be improved? Give three examples.**

There may have been unreacted sodium carbonate or acetic/ citric acid.

There may have been mechanical loses when the carbon dioxide in the balloon was transferred in to the measuring cylinder and conical flask

There may have been side reactions such as some CO2 was absorbed by the water by-product.

* **Give 2 differences between atom economy and percentage yield:**

The atom economy of a reaction is fixed whereas the percentage yield varies every time the reaction is carried out. The atom economy can only be changed when different reagents are used or another use is found for a product of the reaction.

* **Suggest how the same amount of water vapour in the CO2 flask affects the results.**

Water itself is a greenhouse gas. It has a higher greenhouse factor than carbon dioxide so its presence inside the flask will actually add to the temperature gain measured by the thermometer.

* **Will nitrogen, oxygen or argon appear in the IR spectrum of air? Explain your answer.**

No, they are not greenhouse gases so they do not absorb IR radiation, so are not observed in the IR spectrum.

* **Describe a potential method to store CO2 without releasing it into the atmosphere.**

Carbon dioxide can be pumped into rock formations, in a technique known as ‘Carbon Capture and Storage’. The large cost of isolating and pumping the carbon dioxide needs to be considered.