3. This question is about Green Chemistry

Increasing concerns over the use and generation of hazardous substances in chemical processes has encouraged some chemists to look for more environmentally friendly ways to make chemical products. To help evaluate a process environmentally, chemists often use the term *'percentage atom economy'*, where

$$\% \text{ Atom Economy} = \frac{\text{RMM of desired product}}{\text{RMM of all products}} \times 100$$

An environmentally friendly chemical process would normally be expected to have a high % atom economy, indicating that a high proportion of the starting materials end up as part of the final product, hence reducing the amount of waste. Efforts are constantly being made to increase the % atom economy of chemical processes. As an example, the manufacture of ethene oxide (C_2H_4O) for many years was via the classical chlorohydrin route:

$$C_2H_4 + Cl_2 + H_2O \longrightarrow ClCH_2CH_2OH + HCl$$

$$ClCH_2CH_2OH + Ca(OH)_2 + HCl \longrightarrow C_2H_4O + CaCl_2 + 2H_2O$$

(a) i) Write a balanced equation for the overall reaction.

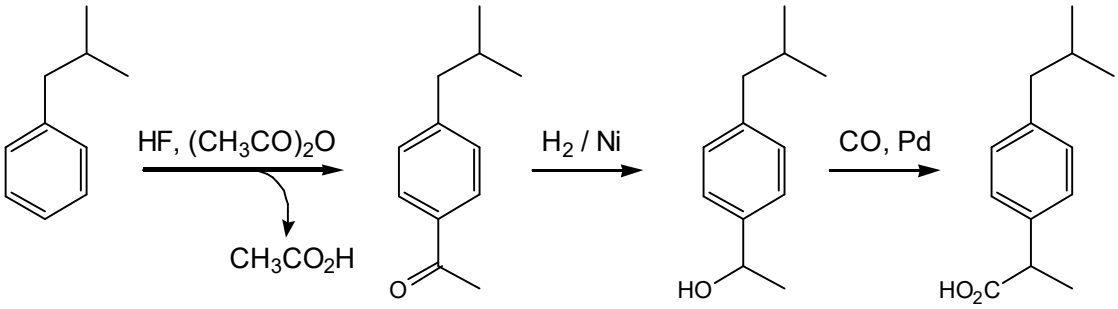
ii) Calculate the % atom economy for this process.

The modern petrochemical route involves the following reaction:

$$C_2H_4 + \tfrac{1}{2}O_2 \xrightarrow{Ag} C_2H_4O$$

(b) Calculate the % atom efficiency of this process.

Ibuprofen, a non-steroidal anti-inflammatory drug, was first synthesised by Boots using a six-step process, with a % atom economy of 40%. When the patent expired in the 1980's, several companies began developing new methods for the preparation of ibuprofen. The BHC Company synthesis, which proved highly successful, is shown below:



Ibuprofen

Step 1 involves the use of ethanoic anhydride, $(CH_3CO)_2O$.

(c) i) Calculate the % atom economy of the BHC Company process.

ii) State the purpose of the HF in step 1.

iii) What happens to the % atom economy if the ethanoic acid is reused?