Making only as much as we need PERCENTAGE YIELD and ATOM ECONOMY

AQA Module C2 (higher)

Most of the substances we use every day are made from RAW MATERIALS, often through complex chemical reactions.







Pottington









The chemical industry is a multi billion pound international industry producing millions of products vital to our civilisation and well being.

Chemical Engineers play a crucial role and are much in demand – there are many opportunities and high levels of pay!

Chemical Engineers are much concerned with:

% YIELD and ATOM ECONOMY..

% YIELD is the amount of product you actually make as a % of the amount you should theoretically make



Old fashioned example: Cement from limestone

Limekiln

PERCENTAGE YIELD 1

RAM

next slide

LIMESTONE (calcium carbonate) is used to make QUICKLIME (calcium oxide) for cement making



So, THEORETICALLY, **100 tonnes of limestone should** produce 56 tonnes of quicklime.

BUT the **ACTUAL** YIELD is only **48 tonnes**

So..the PERCENTAGE YIELD is only <u>48</u> x 100 = <u>87.5%</u> 56

PERCENTAGE YIELD 2

Very few chemical reactions have a yield of 100% because:

- The raw materials (eg limestone) may not be pure
- Some of the products may be left behind in the apparatus
- The reaction may not have completely finished
- Some reactants may give some unexpected products



Careful planning and design of the equipment and reaction conditions can help keep % yield high

Atom Economy

Compare these two industrial reactions

2Mg + O₂ → 2MgO What do you notice about each one? Think raw materials, useful products, waste products



ATOM ECONOMY is the mass of the product **you want** as a % of the mass of **all** the products you make



CALCULATING ATOM ECONOMY

Often, chemical reactions produce unwanted products along with the product you want.

ATOM ECONOMY is the mass of product you want as a % of the mass of all the products you make



Atom Economy = 56 / (56 + 44) = 56 / 100 = 56 %

ATOM ECONOMY is the mass of product you want as a % of the mass of all the products you make RAM



Atom Economy = $80 / 80 \times 100\% = 100\%$ (obviously)



Atom Economy = 112 / 244 x 100% = 45.9 %

Find the atom economy for these 2 methods of extracting copper:

1. Heat <u>copper</u> <u>oxide</u> with carbo	n		2. F	-leat <u>co</u> p <u>phide</u> w	<u>oper</u> ith oxygen	
	RAM Cu	164, O	16, C 12, S	S 32		
2CuO + C =	2Cu +	CO_2	$CuS + O_2$	= Cu	+ SO ₂	
RFM	128	44	RFM	64	64	
Mass of copper = 128	Mass of all products 128 + 44 = 172		Mass of copper = <mark>64</mark>	Mass produ = 64 -	Mass of all products = 64 + 64 = 128	
ATOM ECONOMY	= <mark>128</mark> X ²	100	ATOM ECONOMY	$=\frac{64}{128}$	X 100	
= <u>74.4 %</u>				= <u>50</u>	%	

Real example: Paracetamol





The non-prescription **analgesic** market (paracetamol, aspirin, ibuprofen) is worth about £21 billion annually.

Maximising % yield and atom economy in the reactions at left is vital to save money and conserve energy and resources

SUMMARY

% YIELD is the amount of product you actually make as a % of the amount you should theoretically make

ATOM ECONOMY is the mass of the product you want as a % of the mass of all the products you make



Raw materials are scarce and expensive and so must be carefully conserved. Also, chemical processes need to produce as little waste as possible, minimise costs, energy use and pollution.

