



# Very Large and Very Small Numbers



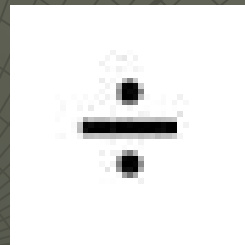
This exercise will give you practice in thinking about very large and very small numbers. We use these numbers a lot in Physics but rarely think twice about them !

# Instructions

- ◆ There are 4 questions to answer.
- ◆ Work in groups of 3/4 students. It will be useful if you have a Physicist, Chemist and Mathematician in your group!
- ◆ Discussion (5-10 mins)  
Discuss amongst yourselves:  
What information do you need to solve the problem?  
How will you use this information to work out a solution ?
- ◆ Feedback (5-10 mins)  
Report back to the whole group.
- ◆ Research (20-30 mins)  
Find the information you need from the Internet.
- ◆ Calculation (10-20 mins)  
Get busy with your calculators.
- ◆ Conclusion/Discussion (5-10 mins)  
Feedback and discussion.

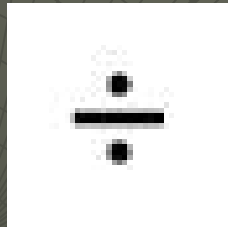
# Question 1

- ◆ How many seconds have passed since the birth of the Universe ?



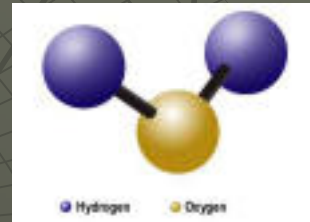
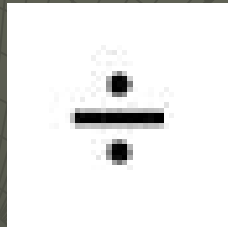
# Question 2

- ◆ How many teaspoons of water are there in the Atlantic ocean ?



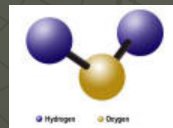
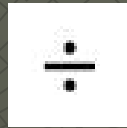
# Question 3

- ◆ How many water molecules are there in a teaspoon of water ?



# Question 4

- ◆ Compare the results from Q1-3.  
e.g. If it takes 1 second to make 1 count which would take longest to count ?. How long would it take?



## Essential Information

- (i) What information do you need to solve the problem?
- (ii) How will you use this information to work out a solution ?

### ◆ Question 1

How many seconds are there in the age of the Universe?



### ◆ Essential Information

Approximate age of the Universe

How to convert years to seconds

## Essential Information

- (i) What information do you need to solve the problem?
- (ii) How will you use this information to work out a solution ?

- ◆ Question 2

How many teaspoons of sea-water are there in the Atlantic Ocean?



- ◆ Essential Information  
Volume of Atlantic Ocean  
Volume of a teaspoon

- ◆ Hint: Make sure you have both volumes in  $m^3$ .

- ◆ Extra Information  
Conversion: The Litre  
Converting ml to  $cm^3$  to  $m^3$

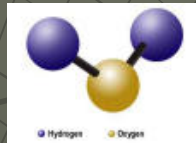
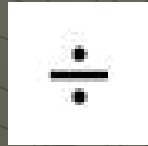
## Essential Information

(i) What information do you need to solve the problem?

(ii) How will you use this information to work out a solution ?

### ◆ Question 3

How many  $\text{H}_2\text{O}$  molecules are there in a teaspoon of water?



### ◆ Essential Information

Volume of a teaspoon

Volume of  $\text{H}_2\text{O}$  molecule

### ◆ Extra Information

To work out the volume of a single water molecule you will need to find out the 'Molar Volume of water' (this is the volume of 1 mole of water). 1 mole contains  $N_A$  water molecules where  $N_A$  is called 'Avogadro's Constant' so you will need to find this out as well!

You might not be able to find the Molar Volume of water but you can work it out if you find the 'Molar Mass of water' and the density of water (use the equation  $\text{density} = \text{mass}/\text{volume}$ ).

### ◆ Hint: Use a Chemist!

## Essential Information

- (i) What information do you need to solve the problem?
- (ii) How will you use this information to work out a solution ?

- ◆ Question 4

Compare the results from Q1-3.

e.g. If it takes 1 second to make 1 count which would take longest to count ?. How long would it take?

## Essential Information

The number of seconds that have passed since the birth of the Universe

The number of teaspoons of sea-water in the Atlantic Ocean

The number of water molecules in a teaspoon of water



# Research Feedback Essential Information



- ◆ Question 1  
How many seconds are there in the age of the Universe?
- ◆ Essential Information

Approximate age of the Universe = 16 Billion years  
1 Billion =  $1 \times 10^9$

How to convert years to seconds:

No. of Seconds = No. of years  $\times$  365  $\times$  24  $\times$  60  $\times$  60



# Research Feedback Essential Information



- ◆ Question 2  
How many teaspoons of sea-water are there in the Atlantic Ocean?

- ◆ Essential Information

Volume of Atlantic Ocean = 354,700,000 Km<sup>3</sup>

Volume of a teaspoon = 5ml

- ◆ Hint: Make sure you have both volumes in m<sup>3</sup>.

- ◆ Extra Information

Conversion: The Litre

Converting ml to cm<sup>3</sup> to m<sup>3</sup>

$$1\text{ml} = 1\text{cm}^3$$

$$100\text{ cm in } 1\text{m}$$

$$(100)^3\text{cm}^3 \text{ in } 1\text{m}^3$$

$$1 \times 10^6\text{cm}^3 = 1\text{m}^3$$

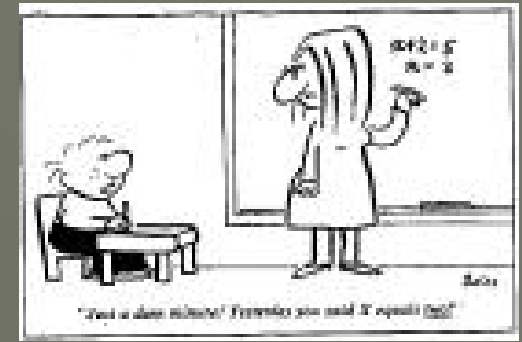


# Research Feedback Essential Information



- ◆ Question 3  
How many  $\text{H}_2\text{O}$  molecules are there in a teaspoon of water?
- ◆ Essential Information  
Volume of a teaspoon = 5ml  
Volume of  $\text{H}_2\text{O}$  molecule:  
Molar Mass of water = 18g  
(Remember 1000g = 1Kg)  
Density of water = 1000  $\text{kgm}^{-3}$   
Avogadro's Constant  $N_A$  =  $6.02 \times 10^{23}$

# Solutions



- ◆ Question 1

How many seconds are there in the age of the Universe?

- ◆ Solution:

Approximate age of the Universe = 14 Billion years =  $14 \times 10^9$  years

Approximate age of the Universe in seconds =  $14 \times 10^9 \times 365 \times 24 \times 60 \times 60$

Approximate age of the Universe in seconds =  $4.4 \times 10^{17}$  s

# Solutions



- ◆ Question 2  
How many teaspoons of sea-water are there in the Atlantic Ocean?
- ◆ Solution:  
Volume of Atlantic Ocean =  $354,700,000 \text{ Km}^3 = 354,700,000 \times 10^3 \text{ m}^3$   
  
Volume of a teaspoon =  $5 \text{ ml} = 5 \text{ cm}^3 = 5 / (100)^3 \text{ m}^3$   
 $= 5 \times 10^{-6} \text{ m}^3$   
  
No. of Teaspoons = Volume of Atlantic Ocean / Volume of a teaspoon  
  
No. of Teaspoons =  $(354,700,000 \times 10^3) / (5 \times 10^{-6})$   
  
No. of Teaspoons in Atlantic Ocean =  $7.1 \times 10^{16}$

# Solutions



- ◆ Question 3  
How many H<sub>2</sub>O molecules are there in a teaspoon of water?

- ◆ Solution:

Volume of a teaspoon = 5ml = 5cm<sup>3</sup> = 5 / (100)<sup>3</sup> m<sup>3</sup> = 5 x 10<sup>-6</sup> m<sup>3</sup> (as Question 2)

Volume of H<sub>2</sub>O molecule:

Molar Mass of water = 18g

Density of water = 100 kgm<sup>-3</sup>

Avogadro's Constant N<sub>A</sub> = 6.02 x 10<sup>23</sup>

Molar Volume = Molar Mass / Density

Molar Volume = (18/1000) / 1000

Molar Volume = 1.8 x 10<sup>-5</sup> Kgm<sup>-3</sup>

Now 1 mole of H<sub>2</sub>O contains 6.02 x 10<sup>23</sup> H<sub>2</sub>O molecules

So Volume of 1 H<sub>2</sub>O molecule = (1.8 x 10<sup>-5</sup>) / (6.02 x 10<sup>23</sup>)

Volume of 1 H<sub>2</sub>O molecule = 3 x 10<sup>-29</sup>m<sup>3</sup>

No. of molecules of H<sub>2</sub>O in a teaspoon = Volume of teaspoon / Volume of 1 molecule

No. of molecules of H<sub>2</sub>O in a teaspoon = 5 x 10<sup>-6</sup> / 3 x 10<sup>-29</sup>

No. of molecules of H<sub>2</sub>O in a teaspoon = 1.6 x 10<sup>23</sup>

# Solutions



- ◆ Question 4  
Compare the results from Q1-3.  
e.g. If it takes 1 second to make 1 count which would take longest.  
How long would it take?

Approximate age of the Universe in seconds =  $4.4 \times 10^{17} \text{ s}$

No. of Teaspoons in Atlantic Ocean =  $7.1 \times 10^{16}$

No. of molecules of H<sub>2</sub>O in a teaspoon =  $1.6 \times 10^{23}$

- ◆ There are approx. 2 million ( $2 \times 10^6$ ) times more water molecules in a teaspoon than there are teaspoons of water in the Atlantic Ocean. (Try repeating the second task 2 million times)
- ◆ It would take 300,000 times longer than the age of the Universe in seconds to count the number of water molecules in a teaspoon of water! About 4 million billion years !