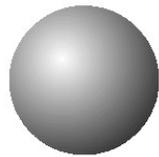


## Unit 2: Atomic Discoveries

Name: \_\_\_\_\_

### Democritus

- *atomos*, initial idea of atom
- all matter is made of tiny particles



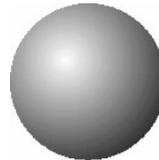
Democritus  
(400 B.C.)

### Dalton

solid sphere model of atom

#### Atomic Theory

- All elements are made of atoms
- All atoms of an element are identical
- Atoms are not created or destroyed



Dalton  
1803-1805

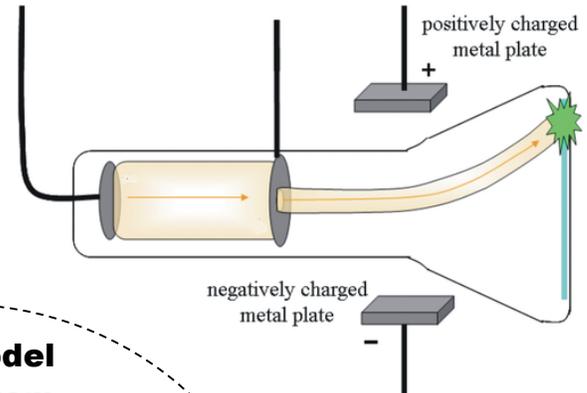
### Thomson

1896

#### discovery of the electron

#### Cathode Ray Tube experiment

- cathode ray tube sends beam
- beam is put between charged plates
- beam is attracted to positive plate
- the beam must be made of negatively charged particles!



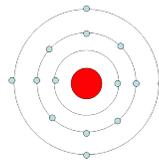
#### Plum Pudding model



### Bohr model of the atom

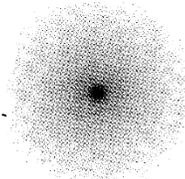
1913

"planetary model"



### Quantum Mechanical Model

"electron cloud"

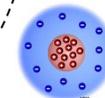


### Rutherford

1910

#### discovery of the nucleus

the atom is mostly empty space



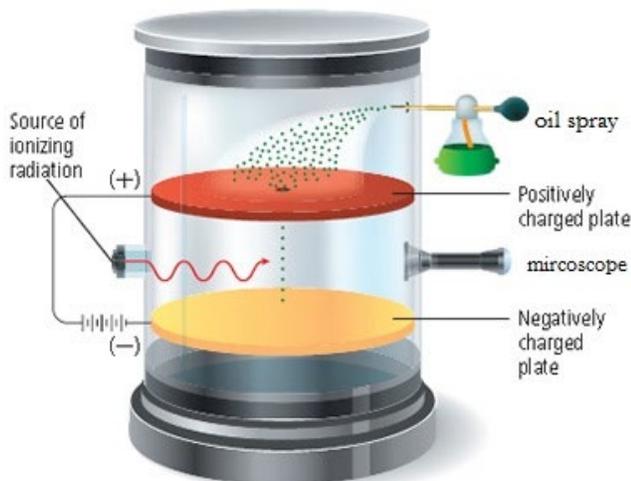
### Millikan

1909

#### discovery of charge of electron

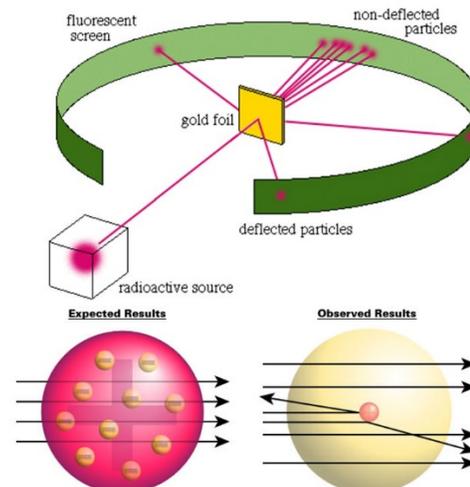
#### Oil Drop experiment

- sprayed oil drops
- gave drops negative charge
- changed speed of the falling drops



#### Gold Foil experiment

- fired particles at thin gold foil
- expected shooting particles to go through foil
- most did BUT some bounded back



## Unit 2: Atomic Structure

Name: \_\_\_\_\_

Particles	Protons Neutrons Electrons	1 amu, +1 charge 1 amu, no charge 0 amu, -1 charge
Mass number		Protons + neutrons
Atomic number		Number of protons Determines the identity of the atom
Why does the atom stay together?		<ul style="list-style-type: none"> <li>Attraction between electrons and the positive nucleus</li> <li>Neutrons are the glue that hold the nucleus together. They separate the protons from each other so they do not repel and "fly into space."</li> </ul>
Neutral atoms		protons = electrons
Ion	Cation Anion	Atom with a charge + charge, lost electrons - charge, gained electrons
Solve for charge		charge = p - e think of charge as a balance of positive and negative charges
Isotope	Isotope symbol	<ul style="list-style-type: none"> <li>Different versions on an element</li> <li>Same number of protons, different numbers of neutrons</li> </ul> <p>Method A:</p> <p style="text-align: center;">Nitrogen-14 ← mass number N-14 ← mass number</p> <p>Method B:</p> <p style="text-align: center;"><i>mass#</i> → 14 <b>N</b> -3 ← <i>charge</i> <i>atomic#</i> → 7</p>
Solve for neutrons		Mass number - atomic number (p+n) (p)
Atomic Mass		A weighted average of all isotopes of an element, with respect to their percent abundance in nature.
		$\text{Atomic Mass} = (\text{mass number } A \times \text{abundance } A) + (\text{mass number } B \times \text{abundance } B) + \dots$

## Atomic Discoveries

## Early Scientists

- Democritus – all matter is made of tiny invisible particles
  - 450 BC



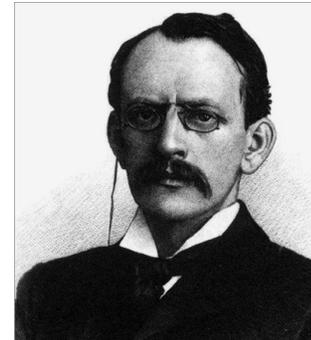
## John Dalton – Atomic Theory

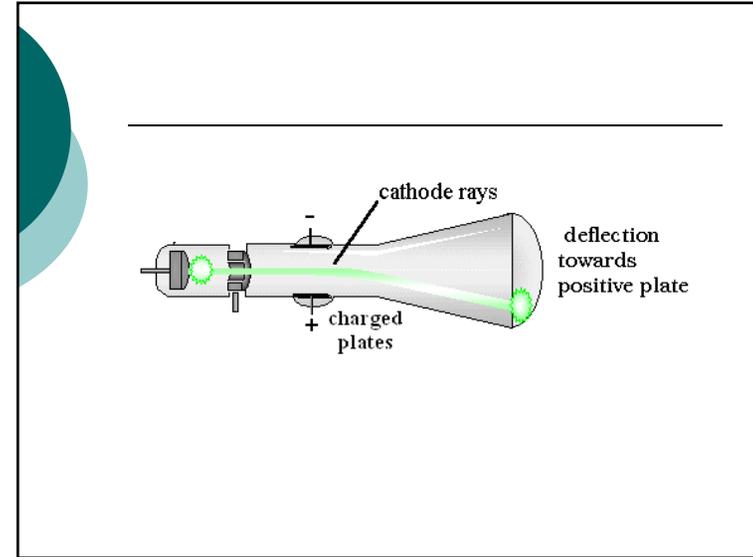
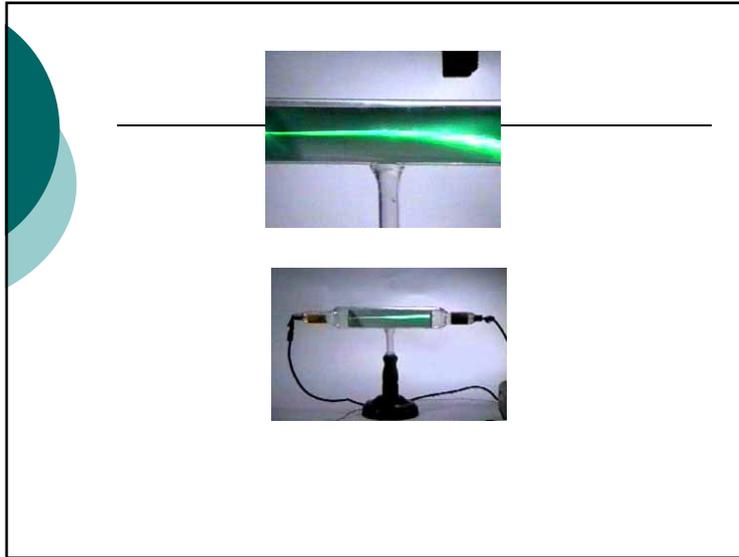


- 1803
- 1. All elements made of atoms
- 2. All atoms of element are identical
- 3. Atoms not created or destroyed
- “solid sphere model”

## J.J. Thomson

- 1896





### Thomson – “Cathode Ray Tube”

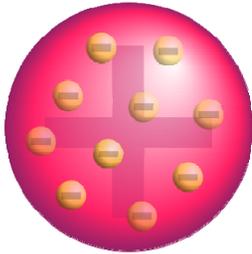
- Cathode ray tube sends beam
- Put between charged plates
- Beam drawn to positive plate
- Conclusion:
  - Beam made of negatively charged particles
  - DISCOVERED THE ELECTRON

### Plum Pudding



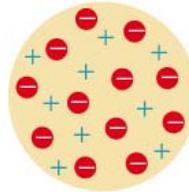
## Thomson's model of atom

- Positive goo
- Electrons floating in goo



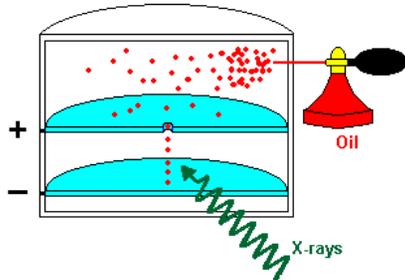
"Plum Pudding"

"Chocolate Chip  
Cookie Model"



## Millikan

- 1909



## Millikan – Oil Drop Experiment

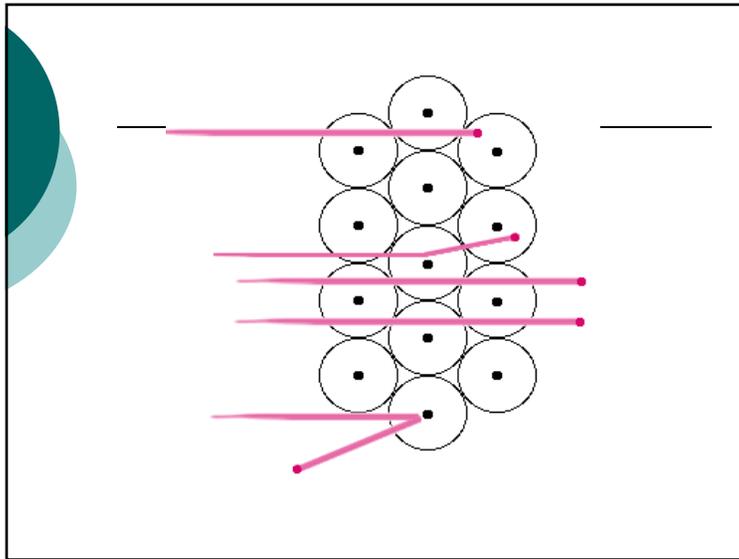
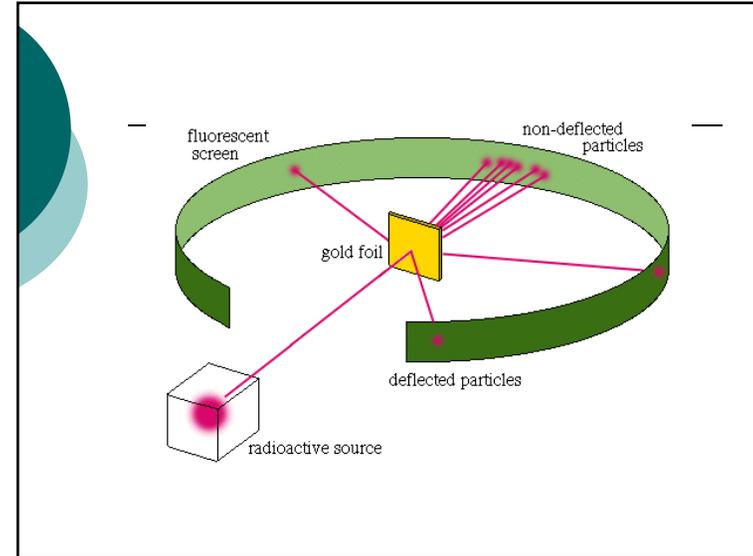
- Sprayed oil drops
- Gave drops negative charge
- Changed speed of the falling drops
- Conclusion:
  - DISCOVERED CHARGE & MASS OF THE ELECTRON

(you do not have to write this down)

- Charge of electron =  $1.6 \times 10^{-19}$  C
- Mass of electron =  $9.11 \times 10^{-28}$  g

## Rutherford

o 1909



## Rutherford – Gold Foil Experiment

- o Expected shooting particles to go through gold foil
- o Instead, some bounced back
- o Conclusions:
  - **DISCOVERED NUCLEUS** in center of atom
  - Atom is mostly empty space

## Niels Bohr

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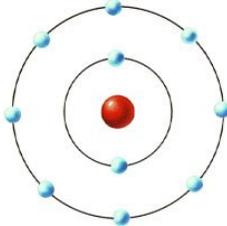
- o 1913



## Bohr Model of Atom

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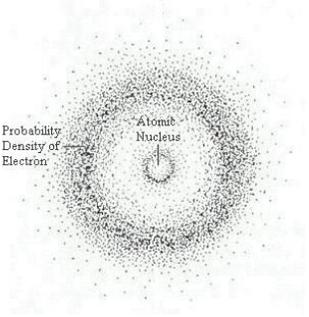
- o "planetary model"
- o electrons circling nucleus



## TODAY – Quantum Mechanical Model

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### AKA – "Electron cloud"



## Review

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Scientist	Title of Experiment?	Discovered?
Thomson		
Millikan		
Rutherford		

- o Name each scientist's model of the atom:
  - Dalton, Thomson, Bohr

## Review

Scientist	Name of model of atom	Description of atomic model
Dalton		
Thomson		
Bohr		

## Review

Scientist	Title of Experiment?	Discovered?
Thomson	Cathode ray tube exp	Electron
Millikan	Oil drop experiment	Charge of electron
Rutherford	Gold foil experiment	Nucleus

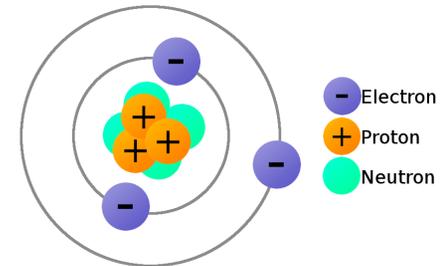
- Name each scientist's model of the atom:
  - Dalton = "solid sphere"
  - Thomson = "plum pudding"
  - Bohr = "planetary model"

## Beyond the Basics: Ions, Isotopes, and Atomic Mass



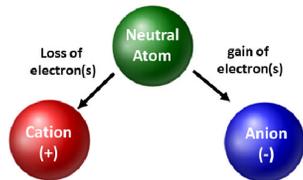
### Neutral Atoms

● # protons = # electrons



### Ion

- Atom with a charge
  - Cation = positive charge, lost electrons
  - Anion = negative charge, gained electrons



### How to determine charge or number of electrons

●  $\text{charge} = p - e$

OR

● Balance of positive or negative charges

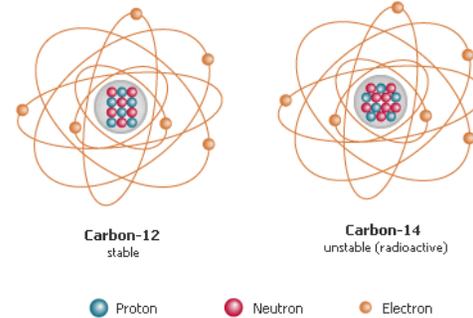
OR

● Loss or gain of electrons

## Isotopes

- Different versions of the same element
  - atoms have same # of protons
  - BUT different # neutrons
- Impact on the atom:
  - more neutrons = more mass

## Isotopes



## How to determine number of neutrons

- Neutrons = mass number - protons

Symbol	P	E	N	Mass#
Ir	77	75	115	
Zr		37	51	91
Cu		30	35	
Ag	47	47		108
Na		11		23

## Communicating Information about Isotopes

Method A:

Nitrogen-14 ← mass number

N-14 ← mass number

Method B:

*mass#* → 14    **N** - 3 ← *charge*  
*atomic#* → 7

## Abundance in Nature

- Out of 100 carbon atoms found in nature...
  - 99 of them will be C-12
  - 1 of them will be C-13
  - 0.0000000001% of the time you'll find C-14
- So what should we report as the average mass of carbon?
- What would be wrong with averaging 12, 13, 14?
- Must use a weighted average

## Atomic mass

**Atomic Mass =**

(mass A)(%abundance A) + (mass B)(%abundance B) + .... etc

- Comparison:

- Mass number = p + n
- Atomic mass = a weighted average of all isotopes of an element, with respect to their percent abundance

## Practice #1:

- Find the average atomic mass of carbon:
- C-12 = 99% abundant
- C-13 = 1% abundant

**Atomic Mass =**

(%abundance A)(mass A) + (%abundance B)(mass B) + .... etc



- 12.01 amu

- Check the Periodic Table!

## What is the difference between atomic mass & mass number?

www.sisweb.com/referenc/source/exactmas.htm

Scientific Instrument Services  
Supplies and Services for Mass Spectrometers, Gas Chromatographs & Liquid Chromatographs

Location: Home > V

Search:

SIS Newsletter

28 Aug 2013: Nanoliter Dispensing Devices can be used to plate media on the MALDI plates for MALDI/TOF instruments, but the most exciting ability of this device is to collimate droplets directly into the ion source like electrospray (ESI), the unique concept being that nearly 100% of the droplets go directly into the source versus <1% from ESI, giving a huge increase in sensitivity. We believe this could be the next big advance in LC/MS sources. [NEW]

01 June 2013: SIS June

Yttrium	Y(89)	88.905856	100.00						
Zirconium	Zr(90)	89.904706	51.45	Zr(91)	90.905644	11.27	Zr(92)	91.905039	17.17
	Zr(94)	93.906319	17.33	Zr(96)	95.908272	2.78			
Niobium	Nb(93)	92.906376	100.00						
Molybdenum	Mo(92)	91.906509	14.64	Mo(94)	93.905086	9.25	Mo(95)	94.905838	15.92
	Mo(96)	95.904676	16.68	Mo(97)	96.906018	9.55	Mo(98)	97.905405	24.13
	Mo(100)	99.907473	8.63						
Ruthenium	Ru(96)	95.907596	5.62	Ru(98)	97.905287	1.68	Ru(99)	98.905897	12.70
	Ru(100)	99.904215	19.60	Ru(101)	100.905561	17.00	Ru(102)	101.90434	31.60
	Ru(104)	103.905422	18.70						
Rhodium	Rh(103)	102.905503	100.00						
Palladium	Pd(102)	101.905609	1.02	Pd(104)	103.904026	11.14	Pd(105)	104.905075	22.30
	Pd(106)	105.903475	27.33	Pd(108)	107.903894	26.66	Pd(110)	109.905169	11.72
Silver	Ag(107)	106.905095	51.84	Ag(109)	108.904754	48.16			
Cadmium	Cd(106)	105.906461	1.28	Cd(108)	107.904156	0.89	Cd(110)	109.903007	12.49
	Cd(112)	111.902761	24.13	Cd(113)	112.904401	12.22	Cd(114)	113.903361	28.73
	Cd(116)	115.904758	7.49						
Indium	In(113)	112.904066	4.30	In(115)	114.903875	96.70			
Tin	Sn(112)	111.904826	0.97	Sn(114)	113.902784	0.65	Sn(115)	114.903348	0.36
	Sn(116)	115.901726	16.70	Sn(117)	116.902866	7.70	Sn(118)	117.901607	29.37

## Practice #2

- What is the average atomic mass of Boron if Boron-10 is 19.8% abundant and Boron-11 is 80.2% abundant?

## Practice #3

- An unknown element has three isotopes. Isotope A has a mass of 13 and is 15% abundant. Isotope B has a mass of 15 and is 10% abundant. Isotope C has a mass of 16 and is 75% abundant. What is the average atomic mass?

## The Fine Print

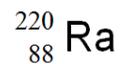
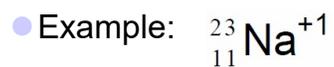
More details about our vocabulary terms.

## Comparison and Clarification

- What is the difference between an ion and an isotope?

## Comparison and Clarification

- What is the difference between an ion and an isotope?



## How do I find neutrons if no mass number is given??

- Find the number of neutrons for  $\text{Al}^{+3}$
- How many neutrons are in Copper?

## How do I find neutrons if no mass number is given??

### ● Examples:

	Element	Protons	Neutrons	Electrons	Charge	Mass #
1.	Sc				0	
2.		15			-3	
3.		38		36		
4.	K				+1	

### ● Counter Examples:

	Element	Protons	Neutrons	Electrons	Charge	Mass #
5.	O				-2	15
6.		26			+3	54

## What is the difference between atomic mass & mass number?

## What is the difference between atomic mass & mass number?

### ● Example:

### ● Look up Tin (Sn) on the periodic table.

- Atomic mass = 118.71 amu
- Mass number of a specific isotope of Tin:

Sn-120

## What is the difference between atomic mass & mass number?

### ● Tin:

Tin	Sn(112)	111.904826	0.97	Sn(114)	113.902784	0.65	Sn(115)	114.903348	0.36
	Sn(116)	115.901744	14.70	Sn(117)	116.902954	7.70	Sn(118)	117.901607	24.30
	Sn(119)	118.903310	8.60	Sn(120)	119.902199	32.40	Sn(122)	121.903440	4.60
	Sn(124)	123.905271	5.60						