



IDX G9 Chemistry N  
Study Guide Issue S1 Midterm  
By Angelina Gu Angelina Du, Edited by Sophia

**NOTE: This is an official document by Indexademics. Unless otherwise stated, this document may not be accredited to individuals or groups other than the club IDX, nor should this document be distributed, sold, or modified for personal use in any way.**

**Contents:**

1. Chapter 4-1 Early Model of the Atoms
2. Chapter 4-2 Structure of the Nuclear Atom
3. Chapter 4-3 Distinguishing among atoms
4. Chapter 5-1 5-3 Revising the Atomic Model
5. Lab Safety

**Early Model of the Atoms**

**Atoms:**

- The smallest particle of an element that retains the chemical identity of that element
  - *Scanning electron microscope*: used to produce the color-enhanced image of nickel atom
    - Use these bullet points for sub-sub-points

**Democritus:**

- all matter is made up of atoms (Greek philosopher Democritus in 5<sup>th</sup> century B.C.)

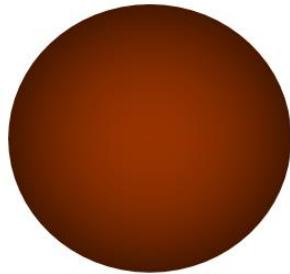
**Dalton's Atomic Theory:**

- All elements are composed of tiny indivisible particles called atoms
- Atoms of the same element are identical. The atoms of any one element are different from those of other element
- Atoms of different elements can physically mix together or can chemically combine in

- simple whole-number ratios to form compounds
- Chemical reactions occur when atoms are separated from each other, joined, or rearranged in different combinations.
- 

### Dalton's Atomic Model:

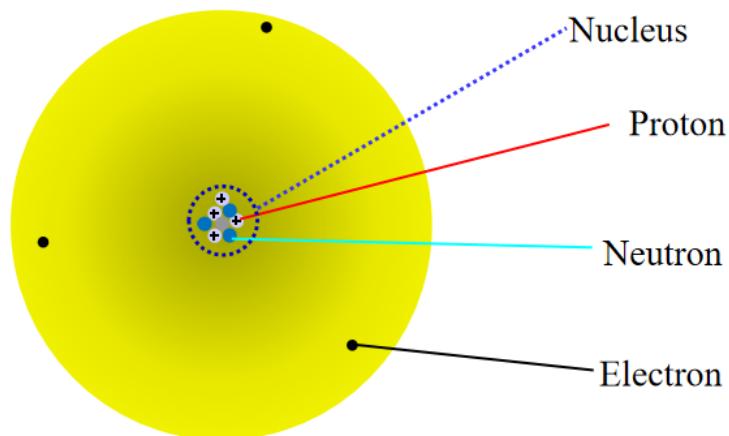
- A hard sphere that was the same throughout



### Structure of the Nuclear Atom

#### Subatomic Particles

- Includes 3 types: Electron Proton and Neutron



#### Electron:

- 1897: English physicist **J.J.Thomson** discovered the **electron**
- Cathode Ray Experiment**
  - Cathode rays are streams of negatively charged particles. Use these bullet points for sub-sub-points
  - Result: a glowing beam, or cathode ray traveled from the cathode to the anode
  - observation: cathode ray is deflected by electrically charged metal plates

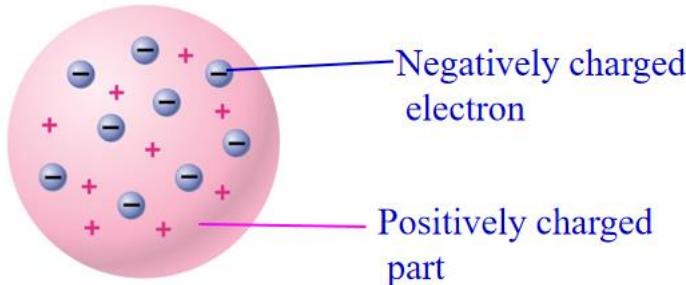
- -> A cathode ray is a stream of tiny negatively charged particles moving at high speed.
  - Measured charge-to-mass ratio: constant at  $(1.76 * 10^8)$
  - The result isn't depend on the kind of gas in the tube or the type of metal used for the electrodes.
    - -> The particles exist in all atoms, so atoms are not indivisible balls but instead have a substructure --> named **Electrons**

- **Robert A. Millikan's Oil Drop Experiment**

- Determined the **charge of an electron**:  $(1.60 * 10^{-19})$  coulomb.
  - Calculated **electron mass**:  $(9.11 * 10^{-28})$  g. [mass is  $1/1840$  the mass of a hydrogen atom]

- **Thomson's Model:**

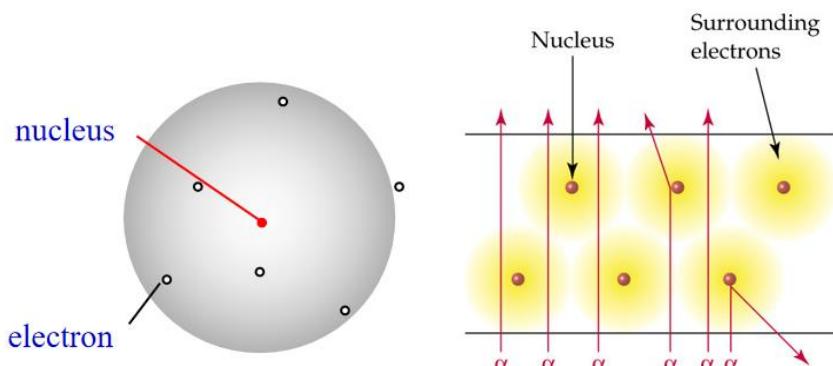
- Plum pudding model of atom – positive sphere with embedded electrons.



- 

- **Rutherford's Gold Foil Experiment**

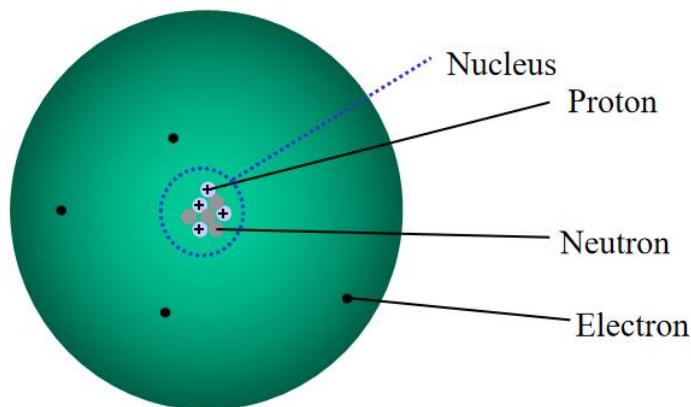
- Directed narrow beam of alpha particles (nucleus of helium with two protons and two neutrons) at gold foil.
  - Expected: Particles pass through with little or no deflection.
  - Actual: Some particles bounced back at large angles.
  - Conclusion: Atom has a small, dense, positively charged nucleus.
  - **Rutherford's Model:** Nuclear model – All of an atom's positive charge and most of its mass is concentrated in a very small core at the atom's center which is called nucleus



### Protons and Neutrons:

- The Proton: Positively charged, located in the nucleus.
- Neutron: Neutral (no charge), mass nearly equal to proton.
  - James Chadwick: Confirmed existence of neutrons.
- 

Properties of Subatomic Particles				
Particle	Symbol	Relative charge	Relative mass (mass of proton = 1)	Actual mass (g)
Electron	$e^-$	1-	1/1840	$9.11 \times 10^{-28}$
Proton	$p^+$	1+	1	$1.67 \times 10^{-24}$
Neutron	$n^0$	0	1	$1.67 \times 10^{-24}$



**For a neutral atom,  
the number of electron= The number of proton**

### Distinguishing among atoms

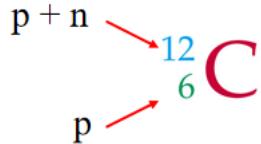
### Atomic Number:

- Number of protons in the nucleus

- Helps Identify the element

### Isotopes:

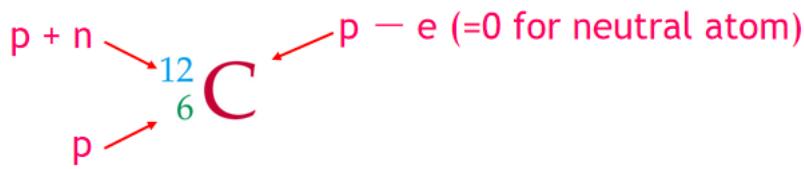
- Atoms of the same element (same number of protons) with different numbers of neutrons.
  - Same chemical properties, different masses.
  - Notation: e.g., Chlorine-37 (Cl-37), mass number = protons + neutrons.
  - 3 isotopes of H element (1 proton): *Protium* (no neutron), *Deuterium* (one neutron), *Tritium* (two neutrons)
  - Elements are always found as a mixture with fixed percentage of isotopes.
- Notation:



- or  $^{12} \text{C}$
- Number of protons in the nucleus
- Helps Identify the element

### Ions:

- Formed when atoms gain or lose electrons.
- Cation: Positive ion (loses electrons).
- Anion: Negative ion (gains electrons).
- Charge = protons (+) – electrons (-).
- E.g. Mg<sup>2+</sup> has 12 protons and 10 electrons.



- 

### (Average) Atomic Mass

- Average mass of isotopes weighted by abundance
- **Abundance**
  - The natural prevalence of different isotopes of an element on earth

$$1 \text{ amu} = \frac{\text{mass of C - 12 atom}}{12} = 1.66 \times 10^{-24} \text{ g}$$

$$\text{Atomic mass} = \sum \text{mass of isotope} \times \text{abundance}$$

Example: Chlorine atomic mass =  $(0.758 * 34.969) + (0.242 * 36.966) = 35.45$  amu.

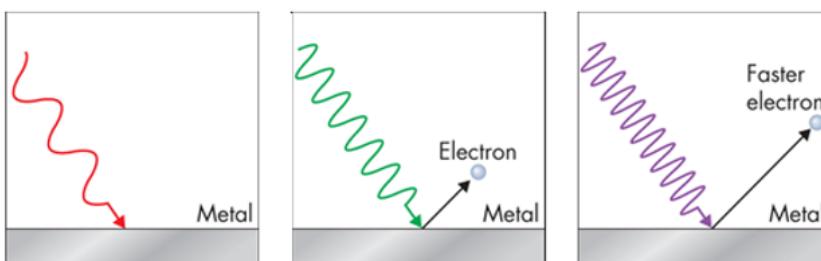
### Revising the Atomic Model

#### Electromagnetic Radiation:

- All travels in same speed,  $c = 3.00 * 10^8 \text{ m/s}$
- $c = \lambda\nu$ 
  - $\lambda$  - wavelength,  $\nu$  - frequency

#### Planck's Quantum Theory:

- Smallest quantity of energy( $E$ ) that can be emitted or absorbed is called **quantum**
- $E = h\nu$ 
  - $H$  is called **Planck's Constant**  $= 6.626 * 10^{-34} \text{ Js}$
- Albert Einstein used Planck's quantum theory to explained the **photoelectric effect** (electrons are ejected when light shines on a metal)
- Light consists of quanta of energy that behave like **photons** (tiny particles) which has energy given by Planck's equation.
- When a photon strikes the surface of a metal, it transfers its energy to an electron in a metal atom. (only when  $E_{\text{photon}} \geq$  minimum, electrons can be emitted.)



No electrons are ejected because the frequency of the light is below the threshold frequency.

If the light is at or above the threshold frequency, electrons are ejected.

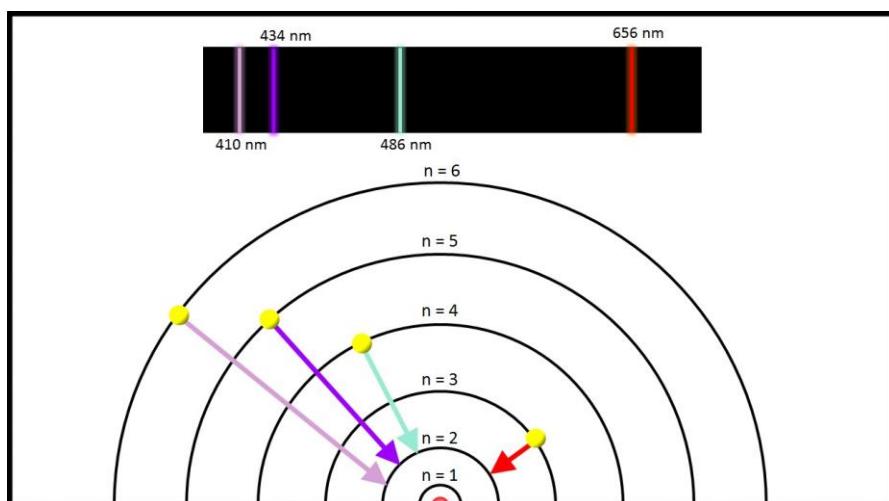
If the frequency is increased, the ejected electrons will travel faster.

#### Atomic Emission Spectra:

- Visible spectrum is an example of **continuous spectrum** (One color fades gradually into the next color.)
  - One color fades gradually into the next color.
  - Rainbow: visible spectrum
    - The sun and incandescent light bulbs emit white light which can produce continuous spectrum.
- **Atomic emission spectrum:** element's set of frequencies (lights) of the electromagnetic waves emitted by atoms of the element.

### The Bohr Model:

- Electrons move in certain circular orbits with allowed energy state around the nucleus designated by a quantum number  $n$  ( $n = 1, 2, 3, \dots$ )
- Energy is only absorbed or emitted in such way as to move an electron from one “allowed” energy (quantized energy) state to another.
- **Hydrogen’s atomic emission spectrum:**
  - Explanation: Electron can be excited to higher energy level when it absorbs energy; When electrons drop from the higher energy level to a lower energy level, certain frequencies of the radiation can be emitted.
  - $\Delta E = E_{\text{higher-energy orbit}} - E_{\text{lower-energy orbit}} = h\nu$



### Evaluations of Bohr model:

Success to:	Fail to:
Adequate for explaining single-electron atoms (hydrogen) and ions.	Failed to explain the spectrum of any other element.

The introduction of quantized energy levels leads to the current model of electronic structure.	Can't explain the different chemical behavior of various elements.
Electrons exist only in certain discrete energy levels.	Electrons don't move around nucleus in circular orbits.
Energy is involved in the transition of an electron from one level to another.	

### Louis de Broglie (French, 1892 - 1987)

- Particles of matter should behave like waves and exhibit a wavelength, just as waves of light behave like particles of matter.
- The wavelike behavior of particle is referred to as matter waves.

### The Heisenberg Uncertainty Principle:

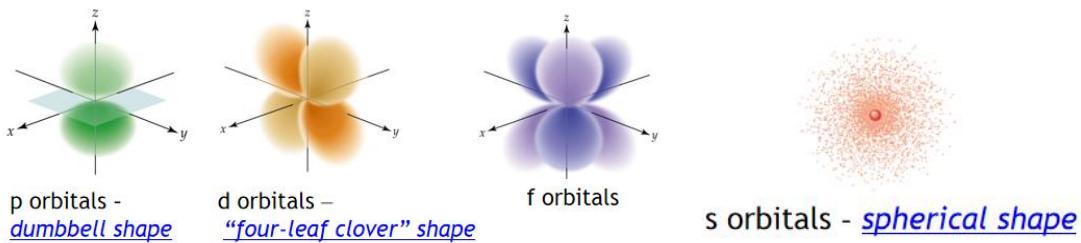
- The position and the velocity of a moving object cannot simultaneously be measured and known exactly.
- The principle is inconsequential for macroscopic object.

### Schrödinger (German, 1887-1961) Quantum Mechanical Model

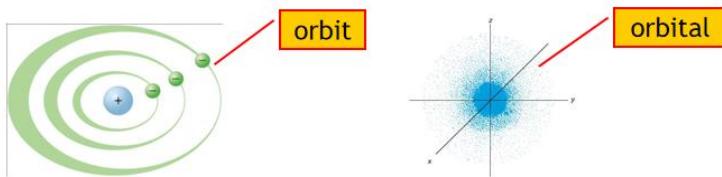
- The energy of electron is quantized.
- Electrons exhibit wavelike behavior.
- The exact position as well as momentum/velocity of an electron at any given point is impossible to know.
- The quantum mechanical model determines the allowed energies an electron can have and the probability to find the electron in various locations around the nucleus of an atom.
- The probability can be represented as electron cloud. The cloud is denser where the probability of finding the electron is high
- Solutions to the Schrödinger equation leads to a mathematical expression, called an atomic **orbital**.
  - An atomic orbital is represented pictorially as a region of space in which there is a high probability of finding an electron.

## Orbitals:

- Different atomic orbitals are denoted by letters: s, p, d and f



- For a given principal energy level greater than 1, there is one s orbital, 3 p orbitals, 5 d orbitals and 7 f orbitals. Due to the different orientation of the orbitals.
- Compare with the Bohr model:
  - For a given principal energy level greater than 1, there is one s orbital, 3 p orbitals, 5 d orbitals and 7 f orbitals. Due to the different orientation of the orbitals.
  - Unlike the Bohr model, the quantum mechanical model does not specify an exact path the electron takes around the nucleus.



Bohr's model	Quantum mechanical model
An electron is found only in specific circular paths, or <b>orbits</b> , around the nucleus.	Electron cloud- The probability of an electron move to one location.
Different energy levels ( <b>orbits</b> )	Different energy levels ( <b>atomic orbital</b> )
Has boundary	No boundary
Has no sublevels	Has sublevels

### **General safety rules:**

- Enter the lab without your bags. Only bring your pens and lab report.
- Wear the lab suit and wear safety goggles to protect your eyes from chemicals, heated materials, or things that might be able to shatter.
- Tie back or cover long hair, especially in the vicinity of an open flame.
- Listen to or read instructions carefully before attempting to do anything.
- Notify your teacher if any spills or accidents occur. If you break the glassware, be sure to use dustpan and broom to sweep it up and dispose of it in the glass waste receptacle.
- No open-toed shoes are allowed in the laboratory.
- Never put anything in your mouth while in the lab (including chemicals, solutions, equipment, food, drink, or gum).
- Never return chemicals to bottles of their origin. If you have excess, give it to another student or throw it away.
- Liquid → recycling bin
- Solid→ trash can
- Check labels on containers twice to make sure you use the right chemical and of the correct concentration. Dispose of chemicals in proper receptacle.
- Do not set the dropper down on the counter (you may contaminate it). Keep each dropper with the proper bottle. Return the dropper to the tube attached to the bottle to avoid switching.
- Keep all combustible materials away from open flames.
- Never put your face near the mouth of a container that holds chemicals. Never smell any chemical directly. When testing for odors, use a wafting motion to direct the odors to your nose.
- Keep table tops clean. Return all equipment to its original location before leaving the lab. Clean all spills immediately.

- Wash your hands before you leave the lab.

- 

### **Steps on using an Emergency Eye wash:**

- Always wash with tepid water or eye solution from the inside edges of the eyes to the outside; this will help to avoid washing the chemicals back into the eyes or into an unaffected eye.
- Water or eye solution should not be directly aimed onto the eyeball, but aimed to the base of the nose
- Flush eyes and eyelids with water or eye solution for a minimum of 15 minutes “Roll” eyes around to ensure full rinsing.
- Immediately seek medical attention.

### **Using a Safety Shower:**

- Stand directly under the shower head
- Pull handle to activate shower
- Wash with tepid water for a minimum of 15 minutes
- To turn off the shower push handle

Read each safety rules and sign the safety contract. Return the contract part to chemistry teacher.

Keep the safety rules and they may be tested in the midterm exam



## National Fire Protection Association (NFPA)



NFPA Hazard Identification System			
BLUE Diamond Health Hazard	RED Diamond Fire Hazard (Flash Points)	YELLOW Diamond Reactivity	WHITE Diamond Special Hazard
<b>4</b> Deadly	<b>4</b> Below 73 °F	<b>4</b> May Detonate	<b>ACID</b> – Acid
<b>3</b> Extreme Danger	<b>3</b> Below 100 °F	<b>3</b> Shock and Heat May Detonate	<b>ALK</b> – Alkali
<b>2</b> Hazardous	<b>2</b> Above 100 °F Not Exceeding 200 °F	<b>2</b> Violent Chemical Change	<b>COR</b> – Corrosive
<b>1</b> Slightly Hazardous	<b>1</b> Above 200 °F	<b>1</b> Unstable if Heated	<b>OXY</b> – Oxidizer
<b>0</b> Normal Material	<b>0</b> Will Not Burn	<b>0</b> Stable	<b>RA</b> Radioactive <b>WW</b> Use No Water

GHS - Hazard Pictograms and Related Hazard Classes		
<b>Exploding Bomb</b> • Explosives • Self-reactives • Organic Peroxides	<b>Corrosion</b> • Skin corrosion/burns • Eye damage • Corrosive to metals	<b>Flame Over Circle</b> • Oxidizing gases • Oxidizing liquids • Oxidizing solids
<b>Gas Cylinder</b> • Gases under pressure	<b>Enviroment</b> • Aquatic toxicity	<b>Skull &amp; Crossbones</b> • Acute toxicity (fatal or toxic)
<b>Exclamation Mark</b> • Irritant (eye & skin) • Skin sensitizer • Acute toxicity • Narcotic effects • Respiratory tract irritant • Hazardous to ozone layer (non-mandatory)	<b>Health Hazard</b> • Carcinogen • Mutagenicity • Reproductive toxicity • Respiratory sensitizer • Target organ toxicity • Aspiration toxicity	<b>Flame</b> • Flammables • Pyrophorics • Self-heating • Emits flammable gas • Self-reactives • Organic peroxides

### Equipment:

- **Balance:** used for measuring mass
- **Beaker:** used to hold, mix, and heat liquids
  - **Electronic Balance:** use appropriate container to put samples on the weighing pan, e.g. weighing paper, or beaker
    - Tarred to zero before use
    - Close doors to prevent air currents from affecting the reading
- **Clay triangle:** used to support a crucible heating
- **Crucible:** used for holding chemicals during heating to very high temperatures
- **Crucible tongs:** used to hold crucibles
- **Evaporating dish:** used to heat liquids for evaporation
- **Forceps:** used to pick up small objects
- **Erlenmeyer flask:** used to hold and mix chemicals. The small neck is to facilitate mixing without spilling
- **Funnel:** used to transfer liquids or fine-grained materials into containers with small openings. Also used for filtration.
- **Graduated cylinder:** used to measure a precise volume of a liquid
  - read the bottom of meniscus at eye level
  - First two numbers: certain digits

- Last digit (must be estimated): uncertain digit
  - Measurement: certain + uncertain digits
  - (Uncertain) Depend on the precision
  -
- **Mortar and pestle:** used to crush and grind materials
- **Test tube:** use to hold and mix liquids
- **Ring clamp:** used to hold or clamp laboratory glassware and other equipment in place, so it does not fall down or come apart.
- **Scoopula:** used to transfer solids
- **Stirring rod:** used for stirring and mixing
- **Test tube rack:** used to hold several test tubes at one time.
- **Thermometers:** used to measure temperature in Celsius
- **Wash bottle:** used to rinse piece of glassware and to add small quantities of water
- **The Alcohol Burner:**
  - Outer -> higher temperature (more oxygen to burn)
  - Don't leave it alone!
  - Keep it away from flammable materials!
  - Use wire gauze to ensure the brane is heated more evenly while heating it



Crucible tong is used to hold crucible.