SKJ Education

LC HL CHEMISTRY

FOUNDATION PROGRAM: WEEK 1

INTRODUCTION TO CHEMISTRY

Steven James
steven@skjeducation.com
www.skjeducation.com

LC HL CHEMISTRY – FOUNDATION PROGRAM

Week 1: Introduction to Chemistry

Learning Objectives

- **1.1:** Describe the structure of the atom (protons, neutrons, electrons) and define atomic number and mass number.
- **1.2:** Explain what isotopes are and calculate relative atomic mass.
- **1.3:** Write electron configurations (e.g., 2-8-2) for the first 20 elements.
- **1.4:** Identify and explain trends in the Periodic Table.

Key Terms - Week 1

- **Atom:** The smallest particle of an element that can exist. All matter is made of atoms.
- **Subatomic Particles:** The particles that make up an atom: protons, neutrons, and electrons.
- **Atomic Number (Z):** The number of protons in the nucleus of an atom. It defines the element.
- **Mass Number (A):** The sum of the number of protons and neutrons in the nucleus of an atom.
- **Isotopes:** Atoms of the same element (same atomic number) with different mass numbers due to different numbers of neutrons.
- **Relative Atomic Mass (A_r):** The weighted average mass of all the isotopes of an element, measured on a scale where an atom of carbon-12 has a mass of exactly 12.
- **Electron Configuration:** The arrangement of electrons in an atom, represented by numbers indicating electrons in each shell (e.g., 2,8,1 for sodium).
- **Periodic Table:** A tabular arrangement of all known elements, ordered by increasing atomic number, which reveals periodic patterns in their properties.
- **Period:** A horizontal row on the Periodic Table. Properties change gradually across a period.
- **Group:** A vertical column on the Periodic Table. Elements in the same group have similar chemical properties due to the same number of outer shell electrons.
- **Trend:** A predictable change in a property across a period or down a group (e.g., atomic size, reactivity).

Weekly Challenge: As you work through this week's material, try to **identify at least 3 elements or chemical principles** at work in your *daily life* (e.g., sodium in salt, chlorine in pool cleaner, helium in balloons, the conductivity of metals in your phone). Share your findings in our Google Classroom!

WEEK 1 STUDY PLAN

Day	Activities & Time Commitment	✓	Rating (1-10)
Monday	- Review Learning Objectives (5 min) - Rank your current ability (5 min) - Review Key Terms (10 min) - Complete Exercise A1 (15 min) *Focus: PREPARATION*		
Tuesday	- Complete Exercises A2 & A3 (60 min) - 1-hour online lesson (60 min) *Focus: QUESTIONING*		
Wednesday	- Reflect on content so far (what has been challenging?) (10 min) - Plan remaining study sessions (10 min) *Focus: PROCESSING*		
Thursday	- Complete Exercise B (50 min) *Focus: EXPERIMENTAL THINKING*		
Friday	- Complete Exercise C (40 min) *Focus: ERROR ANALYSIS*		
Saturday	- Complete Exam Question Assessment (D) (60 min) *Focus: EXECUTION*		
Sunday	- Correct assessment (30 min) - Complete self-reflection (15 min) - Plan next week (15 min) *Focus: REFLECTION & RECHARGING*		

Study Tips for Success

- **Active Recall:** After studying, close your notes and write down **everything you remember**. Force your brain to grow.
- **Spaced Repetition:** Review concepts **multiple times** over several days.
- **Chemistry in Action:** Look for **real-world examples** of the concepts you're learning.
- **Ask Questions:** Don't hesitate to ask for help when concepts are unclear. Reach out via *Google Classroom* or email; *steven@skjeducation.com*.
- **Celebrate Progress: Acknowledge your improvements**, no matter how small.

A1. Proficiency Drills

Learning Focus: Foundational concepts of atomic structure, isotopes, and basic chemical **definitions**.

Part 1: The Building Blocks - Subatomic Particles

Key Concepts

- **Protons:** Positively charged, found in the nucleus, mass = 1.
- **Neutrons:** Neutral (no charge), found in the nucleus, mass ≈ 1.
- **Electrons:** Negatively charged, orbit the nucleus in shells, key for bonding, mass ≈ 1/1840 (negligible).
- **Atomic Number (Z):** Number of protons an element has.
- **Mass Number (A):** Number of protons and neutrons an element has.

Memory Tip: P (+, **p**ositive) for proton, **N** for (**0**, **n**eutral) for **n**eutron.

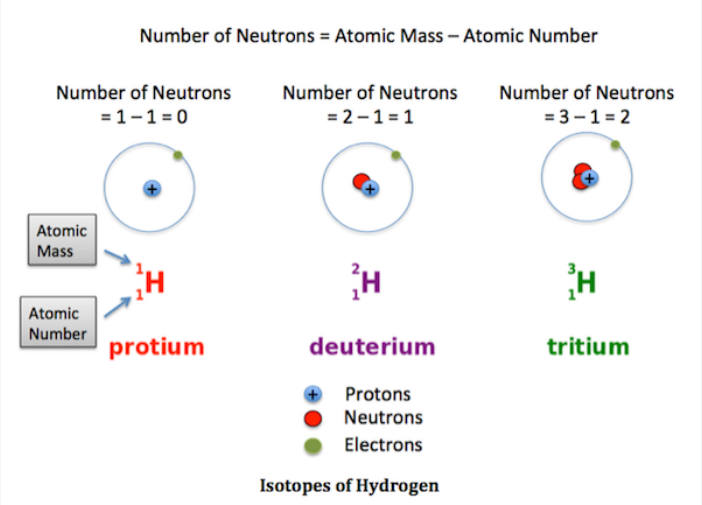
Task #1: Complete the table for the following atoms/ions.

Element	Symbol	Charge	Z	A	P	N	E
Sodium	Na		11	23			
	O^{2-}		8	16			
					13	14	10
Chlorine	Cl^{-}			35		18	
	Al^{3+}		13	27			

Part 2: Isotopes & Relative Atomic Mass - The Weighted Average

Essential Knowledge

Isotopes have the same chemical properties (i.e., same electron configuration) but different physical properties (e.g., density, reactivity, etc.).
A_r is a **weighted average**, not a simple mean, because it accounts for the abundance of each isotope.
Trace amounts of deuterium exist in nature, therefore **hydrogen's A_r = 1.008!**



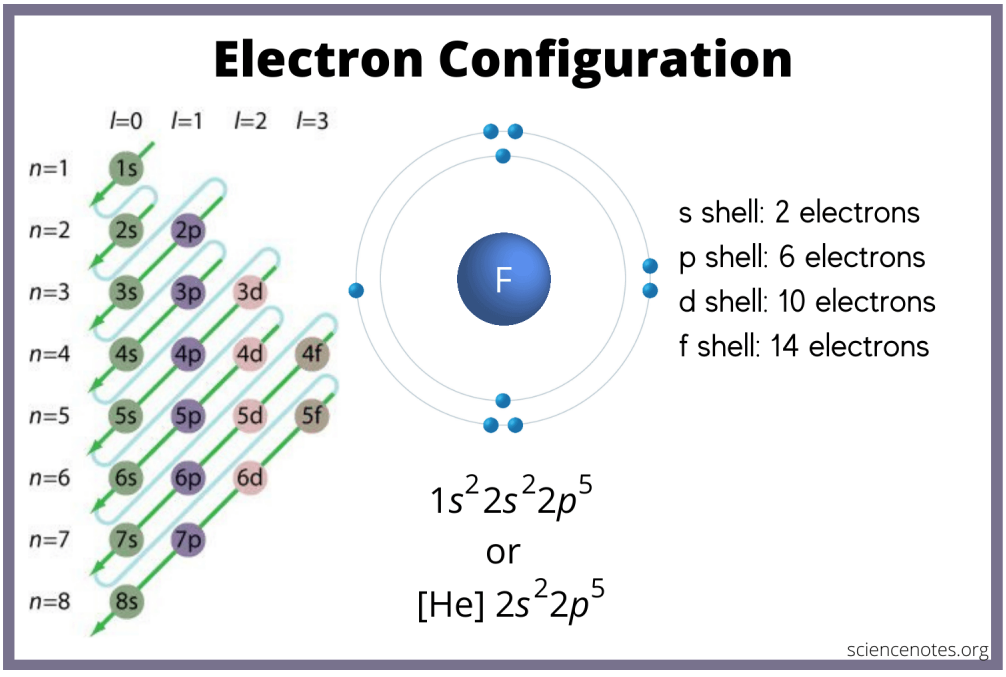
Task #2: Calculate the relative atomic mass of the following elements.

1. Boron has two isotopes: B-10 (19.9% abundance, mass = 10.01) and B-11 (80.1% abundance, mass = 11.01).
2. Chlorine has two isotopes: Cl-35 (75.0% abundance) and Cl-37 (25.0% abundance).
3. Silicon has three isotopes: Si-28 (92.23%, mass = 27.98 amu), Si-29 (4.67%, mass = 28.98 amu), and Si-30 (3.10%, mass = 29.97 amu).
4. Argon has three isotopes: Ar-36 (0.337%, mass = 35.97 amu), Ar-38 (0.063%, mass = 37.96 amu), and Ar-40 (99.60%, mass = 39.96 amu).
5. An element has two isotopes: X-105 (43.2% abundance, mass = 104.91 amu) and X-107 (56.8% abundance, mass = 106.91 amu). Identify the element.
6. An element has two isotopes: one with a mass of 120.90 amu (57.2% abundance) and another with a mass of 122.90 amu (42.8% abundance). Identify the element.
7. Magnesium has three isotopes: Mg-24 (78.99%, mass = 23.99 amu), Mg-25 (10.00%, mass = 24.99 amu), and Mg-26 (11.01%, mass = 25.98 amu).
8. Copper has two isotopes: Cu-63 (69.15%, mass = 62.93 amu) and Cu-65 (30.85%, mass = 64.93 amu).

Part 3: Electron Configurations - The Address of an Electron

Physics Vocabulary

- **Shell:** An energy level where electrons orbit. Shell 1 holds max 2 electrons, Shell 2 holds max 8, Shell 3 holds max 8 (for first 20 elements).
- **Valence Electrons:** The electrons in the outermost shell. These determine the chemical properties of an element.



Task #3: Write the electron configuration (e.g., $1s^2 2s^2 2p^3$ for Nitrogen) for these elements.

Element	Z	Configuration	Element	Z	Configuration
Hydrogen	1		Sodium	11	
Helium	2		Magnesium	12	
Lithium	3		Aluminum	13	
Beryllium	4		Silicon	14	
Boron	5		Phosphorus	15	
Carbon	6		Sulfur	16	
Nitrogen	7		Chlorine	17	
Oxygen	8		Argon	18	
Fluorine	9		Potassium	19	
Neon	10		Calcium	20	

Answers: To check your answers for these exercise, check out this online, interactive ***Periodic Table of Elements***. You can find out any detail about any element here.

Task #4: Challenge Questions

Attempt as many questions as quickly as possible in time left in your study session. Pay close attention to the **figures** and **units** in your answer.

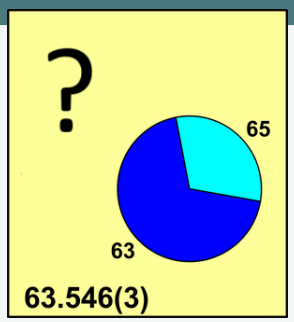
1. An atom of phosphorus has a mass number of 31. How many neutrons are in its nucleus?
2. The atomic mass of lithium is 6.94 amu. Its two isotopes are Li-6 (6.02 amu) and Li-7 (7.02 amu). Which isotope, Li-6 or Li-7, must be more abundant? Explain your reasoning in one sentence.
3. A neutral atom of an element has an electron configuration of 2,8,2. Identify the element and state its number of valence electrons.
4. How many electrons are in a chloride ion, Cl^-?
5. The element gallium has an atomic mass of 69.72 amu. If gallium-69 (68.93 amu) has a 60.1% abundance, what is the mass of its only other isotope, gallium-71?
6. A runner completes two full laps of a 400 m track. What is the total distance run? What is the runner's total displacement?
7. An ion has 13 protons, 14 neutrons, and 10 electrons. What is its symbol and charge?
8. Look at your answer for the atomic mass of copper from Task 2. A student calculates the value as 65.28 amu. What is the most likely mistake they made?

A2. Worked Example & Questions

Learning Focus: Applying **isotope** and **electron configuration** concepts to exam-style problems.

Scenario

An element X has two stable isotopes. Isotope X-63 has an abundance of 69.15% and a mass of 62.93 u. Isotope X-65 has an abundance of 30.85% and a mass of 64.93 u.
Question: Calculate the relative atomic mass of element X. Identify the element.



Solution Framework:

1. **Decode & Define:** "A_r is a weighted average. Formula: $A_r = \sum(m * y)/100$, where m = isotope mass and y = % abundance.
2. **Plan:** Multiply each isotope's mass by its percentage abundance, add these values together, and divide by 100.
3. **Execute:**

$$A_r = \frac{(62.93 \times 69.15) + (64.93 \times 30.85)}{100}$$

$$A_r = \frac{6354.10}{100} = \mathbf{63.54}\,\text{u}$$

4. **Evaluate:** "The calculated A_r is 63.54 u. Checking the periodic table, this is the atomic mass of **Copper (Cu)**. The answer makes sense and is to 2 decimal places, matching the precision of the input data."

Test Yourself

1. **(Knowledge)** Define the term *isotope*.
2. **(Application)** An atom has 13 protons and 14 neutrons.
   a) What is its atomic number (Z)?
   b) What is its mass number (A)?
   c) What element is it?
   d) Write its electron configuration.
3. **(Analysis)** The element neon has two major isotopes, Ne-20 (90.0%) and Ne-22 (10.0%). A student calculates its relative atomic mass as (20 + 22)/2 = 21.0. Why is this incorrect? Provide the correct calculation.
4. **(Synthesis)** Explain why the chemical properties of isotopes are identical, but their physical properties can differ.

A3. Thinking Like a Physicist – Challenging Assumptions

Learning Focus: Developing **critical thinking skills** about **atomic models** and **periodic trends**.

1. **Invisible Building Blocks:** We draw atoms with neat, circular shells. *But is this an accurate model?* Electrons exist in "orbitals", regions of space where there is a high probability of finding them, not neat orbits. How does this quantum mechanical model help explain why the periodic table has blocks (s-block, p-block)? Why is the 3rd shell able to hold more than 8 electrons after calcium?

   Task 1

   Sketch the classic "Bohr model" of a sodium atom (2,8,1) and then a more modern representation showing a fuzzy electron cloud. Annotate your diagrams with the strengths and limitations of each model.

2. **Predicting the Unseen:** Mendeleev left gaps in his periodic table for elements that hadn't been discovered yet. *He even predicted their properties accurately.* Imagine a new element, temporarily named "Skjium", is discovered with an atomic number of 121. Based on its position in the periodic table, predict its...
   - Likely metallic character (metal, non-metal, metalloid?).
   - Number of valence electrons.
   - How its atomic radius will compare to the element above it.
   - The formula of its most stable ion.

   Task 2

   Brainstorm the pros and cons of organising the periodic table by atomic number vs. **grouping elements with similar properties together, even if it messes up the order**. *What's the weirdest alternative periodic table you can imagine?*

3. **Let's have a pointless debate:** A friend argues: "Fluorine is the most reactive halogen because it's the smallest and has the strongest pull on electrons. Therefore, francium must be the most reactive alkali metal because it's the biggest." Another friend disagrees. Who is correct about francium and **why**? (Hint: Think about *how* alkali metals react vs. how halogens react).

   Task 3

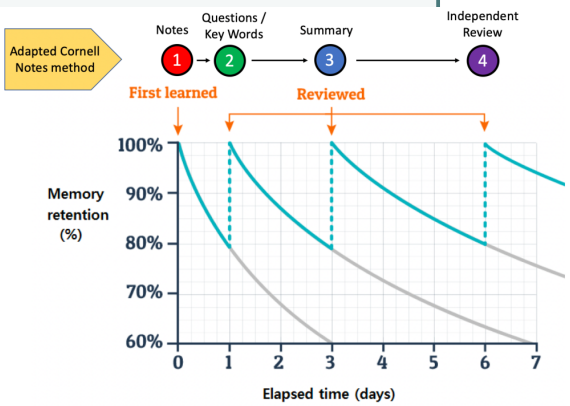
   Come up with three real-life scenarios where the **trend** in a property (e.g., conductivity, melting point) down a group or across a period is crucial for choosing the right material for a job (e.g., why aluminium for aeroplanes?).

B. Memory Retention & Learning Experiment

Learning Focus: Understanding **how memory works** and **applying the scientific method** to understand memory retention.

The Forgetting Curve Experiment

In week 1, we are not reviewing any formal LC Chemistry experiments. Instead, we will conduct an interesting experiment of our own. This will explore how well your brain can remember key Chemistry definitions and formulae over time.



Watch the following video, then attempt the quiz below. [**CLICK HERE FOR VIDEO**]

Do not look at the quiz before starting the YouTube video. DO NOT CHECK your score. For the **next 5 days**, attempt this quiz, but **DO NOT check your score**. **Do not do *any more Chemistry*** during this experiment. Fill in your scores after finishing the experiment below.

Day	Time to complete quiz (minutes and seconds)	Score (%)
Day 0 (Start)		
Day 1		
Day 2		
Day 3		
Day 4		
Day 5		

This experiment explores something very interesting about our brains, known as the forgetting curve. Check out this video: [**CLICK HERE FOR VIDEO**]

Quiz: 4 parts - Take quiz via Google Classroom

Quiz Components

Definitions: 4-5 important Chemistry definitions
Formulae: 4-5 important Chemistry formulae/equations
Random: 1-2 completely random questions about the video
Calculations: 1-2 molar calculations

C. Calculation Error Analysis: Forensic Chemistry

Learning Focus: Developing **critical analysis skills** by identifying and correcting common chemistry **misconceptions** and **calculation errors**.

Analysis Tips

1. **Locate the Error:** Is there anything wrong with this statement/calculation?
2. **Diagnose the Error:** Is this a **Procedural Error** (miscalculation), a **Conceptual Error** (misunderstanding), or an **Omission Error** (incomplete answer)?
3. **Explain the Misconception:** What does the answer reveal about their understanding of how to *communicate* this idea?
4. **Correct the Solution:** Provide the complete, textbook-quality answer.
5. **Metacognitive Reflection:** "This error is subtle because the number is right. What is one personal strategy I can adopt to ensure I never overlook a crucial detail like this under exam pressure? (e.g., making sure you can reverse your calculations and they still work)."

Forensic Chemistry Task

Your job is to find the **flaw in the thinking**. Explain why each statement/calculation is wrong and correct them.

Statement: "An atom of carbon-14 has 6 protons and 8 electrons."

Flawed Thinking

Error Analysis:

Correct Approach

Correction:

Statement: "The electron configuration for the sulfide ion (S^{2-}) is the same as that of a neutral potassium atom (K), which is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ (or 2,8,8,1) because they both have 19 total electrons."

Flawed Thinking

Error Analysis:

Correct Approach

Correction:

Statement: "The relative atomic mass of chlorine is 35.5 because it is the average of 35 and 36."

Flawed Thinking

Error Analysis:

Correct Approach

Correction:

Statement: "Isotopes of an element have the same mass number but different atomic numbers."

Flawed Thinking

Error Analysis:

Correct Approach

Correction:

Atomic Mass Calculation: Calculate the atomic mass of copper from its isotopes Cu-63 (69.2%, mass = 63.0 amu) and Cu-65 (30.8%, mass = 65.0 amu).
Incorrect Calculation: $(63.0 + 65.0)/2 = 64.0$ amu

Flawed Thinking

Error Analysis:

Correct Approach

Correction:

Subatomic Count: How many neutrons are in a $^{23}Na^{+}$ ion?
Incorrect Calculation: A=23, Z=11. Neutrons = A - Z = 12. The +1 charge means it lost an electron, so neutrons = 12 - 1 = 11.

Flawed Thinking

Error Analysis:

Correct Approach

Correction:

Statement: "The electron configuration of oxygen is 2,6 because it has 6 valence electrons in its second shell."

Flawed Thinking	Correct Approach
Error Analysis:	**Correction:**

Statement: "A neutral atom of iron-56 (^{56}Fe) has 56 electrons."

Flawed Thinking	Correct Approach
Error Analysis:	**Correction:**

Statement: "The isotope uranium-235 has an atomic number of 235."

Flawed Thinking	Correct Approach
Error Analysis:	**Correction:**

Statement: "The element with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^1$ (or 2,8,3) has 2 valence electrons and its most stable ion will have a charge of -3."

Flawed Thinking	Correct Approach
Error Analysis:	**Correction:**

Abundance Calculation: An element has two isotopes. One has a mass of 10.0 amu (20% abundance). The atomic mass is 10.8 amu. Find the mass of the other isotope.
Incorrect Calculation: $(10.0 + x)/2 = 10.8$ therefore $x = 11.6$ amu.

Flawed Thinking	Correct Approach
Error Analysis:	**Correction:**

Electron Configuration: What is the electron configuration of nitrogen (Z=7)?
Incorrect Answer: 2,5 or 4,3

Flawed Thinking	Correct Approach
Error Analysis:	**Correction:**

Reflection Time
You have seen some of the common errors and misconceptions that come up in this topic. Here are some important questions to **ask yourself**:

- **What surprised you? *Why*?**
- **What did you find difficult to grasp? *Why*?**
- **Did you recognise any of *your own mistakes* during the exercise?**
- **What is the most important thing *you have learned* this week?**

D. Weekend Assessment – Past Exam Questions

Learning Focus: Applying all week's learning to authentic exam questions under timed conditions.

Assessment Instructions

Answer as many as you can in 60 minutes. The answers are provided in the right column in white font - highlight the cell to reveal them. Try to solve them first before checking!

Question	Answer
1. What is the maximum number of electrons that can occupy the first shell (n=1)?	
2. Define the term *relative atomic mass*.	
3. The two isotopes of boron are B-10 and B-11. The relative atomic mass of boron is 10.8. Which isotope is more abundant? Justify your answer.	
4. Explain why the atomic radius of elements increases down Group 1.	
5. Write the electron configuration (e.g. 2-8-2) of an atom of silicon (Z = 14).	

Question	Answer
6. What is an isotope?	
7. The element strontium (Sr) is in Group 2 of the periodic table. Predict the formula of the compound formed between strontium and chlorine.	
8. Neon exists as three isotopes: Ne-20 (90.0%), Ne-21 (0.3%), Ne-22 (9.7%). Calculate the relative atomic mass of neon.	
9. Explain why the reactivity of the alkali metals (Group I) increases down the group.	
10. Identify an element from the first 36 that has atoms with only one electron in their outer shell.	

Self-Assessment

After completing the assessment:

- Grade your work honestly
- Identify areas needing improvement
- Scan and submit via Google Classroom
- Reflect on your performance in your weekly reflection

Another excellent week of work completed - ***well done!*** You are another step closer to *smashing your exams*, and another week closer to your summer holdiays!

Weekly Reflection Zone

What worked well this week?

What challenges did I face?

What surprised me the most this week?

Key chemistry concepts I want to review:

Goals for next week: