LECTURE L2-2

Periodic Table

Periodic Trends: Why Potassium Pills Are Safe but Pure Potassium Explodes

Duration: 60 minutes

Advanced lecture script — pre-requisite: Level 1

HOOK (3 minutes)

Teacher holds up (or shows photos of):

A potassium supplement pill (safe to swallow)

A video of pure potassium metal exploding in water (safe to watch)

A non-stick frying pan (coated with Teflon, which contains fluorine)

A bleach bottle (contains chlorine)

Teacher says: "Potassium pills are safe. You swallow them. But pure potassium metal explodes when it touches water. Same element — completely different behavior. Why?

Fluorine is the most reactive element on the periodic table — it can eat through glass. Yet it's in your non-stick pan and your toothpaste. How?

- Today's question: How can you predict an element's behavior just by looking at its position on the periodic table? *

By the end of this session, you will be able to:

Explain why reactivity trends exist (using atomic structure)

Predict whether an element will be more or less reactive than its neighbors

Understand why some elements are safe in compounds but dangerous alone"

SEGMENT 1: Review from Level 1 and Level 2-1 (5 minutes)

Teacher says: *"Before we go deeper, let's recall what you already know from Level 1 and Level 2-1."*

Review from Level 1 (Periodic Table - Basic)

Level 1 Concept	Definition	Household Example
Periodic table	A map of all known elements	Organized by atomic number
Period (row)	Horizontal row	Atomic number increases left to right
Group (family)	Vertical column	Same group = similar properties
Alkali metal	Group 1 — very reactive	Sodium, potassium (explode in water)
Alkaline earth metal	Group 2 — reactive	Magnesium, calcium
Halogen	Group 17 — toxic, corrosive	Chlorine (bleach), fluorine

Level 1 Concept	Definition	Household Example
Noble gas	Group 18 — unreactive	Helium (balloons), neon (signs)
Transition metal	Middle block — mostly safe	Iron, copper, gold

Review from Level 2-1 (Atomic Structure)

Level 2-1 Concept	Definition	Example
Atomic number	Number of protons	Carbon has 6 protons
Valence electrons	Electrons in outermost shell	Carbon has 4 valence electrons
Electron shell	Energy level where electrons live	Shell 1 (2 e^- max), Shell 2 (8 e^- max)

Teacher: "The key to understanding periodic trends is valence electrons. Elements in the same group have the same number of valence electrons. That's why they behave similarly."

> Quick check (show of hands / chat): "How many valence electrons does sodium (Group 1) have?" (1) "How many valence electrons does chlorine (Group 17) have?" (7) "How many valence electrons does neon (Group 18) have?" (8 — full shell)

Teacher: "Good. Now let's see how valence electrons explain the periodic table."

SEGMENT 2: Why Groups Behave Similarly — Valence Electrons (8 minutes)

> Teacher says: "The periodic table is organized by atomic number, but the arrangement into groups comes from valence electrons."

Electron Shells — Quick Refresher

Teacher draws or shows:

Shell Number	Maximum Electrons	Notes
Shell 1 (n=1)	2	Closest to nucleus
Shell 2 (n=2)	8	
Shell 3 (n=3)	18	But for main groups, only the outer shell matters
Shell 4 (n=4)	32	

Teacher: "Atoms are most stable when their outermost shell is full (8 electrons — octet rule, or 2 for hydrogen)."

Valence Electrons by Group (Main Group Elements)

Group Number	Valence Electrons	Stability	Reactivity
Group 1 (Alkali metals)	1	Wants to lose 1 electron	Very reactive
Group 2 (Alkaline earth)	2	Wants to lose 2 electrons	Reactive (less than Group 1)
Group 13 (Boron group)	3	Wants to lose 3	Moderately reactive
Group 14 (Carbon group)	4	Can gain or lose 4	Less reactive
Group 15 (Nitrogen group)	5	Wants to gain 3	Moderately reactive
Group 16 (Oxygen group)	6	Wants to gain 2	Reactive
Group 17 (Halogens)	7	Wants to gain 1	Very reactive
Group 18 (Noble gases)	8	Already full	Unreactive (inert)

Teacher: "Reactivity is driven by the desire to have a full outer shell. Group 1 elements want to lose 1 electron. Group 17 elements want to gain 1 electron. That's why they react so violently with each other — sodium (Group 1) gives its electron to chlorine (Group 17) to make table salt."

Household Example: Why Table Salt Is Safe

Teacher: "Sodium alone (Group 1) is a soft metal that explodes in water. Chlorine alone (Group 17) is a poisonous green gas. But when they react, sodium gives its electron to chlorine. Both end up with full outer shells. The result is sodium chloride — table salt — which is safe enough to eat."

Element	Alone	In Compound (NaCl)
Sodium	Explodes in water	Safe ion (Na^+)
Chlorine	Poisonous gas	Safe ion (Cl^-)

Physical action:

"Pretend your left hand is sodium (1 valence electron — wants to give it away)."

"Pretend your right hand is chlorine (7 valence electrons — wants to take one)."

"Clap your hands together — that's the reaction. Now both hands are full."

SEGMENT 3: Periodic Trend #1 — Atomic Radius (10 minutes)

Teacher says: "Now let's learn about periodic trends — patterns that help you predict properties without memorizing."

Atomic radius is the size of an atom (distance from nucleus to outermost electron).

Trend Across a Period (Left to Right)

Teacher: "As you move from left to right across a period, the atomic radius decreases (gets smaller)."

Why?

Left to right: protons increase (higher positive charge in nucleus)

Same number of electron shells

More protons pull electrons closer to the nucleus

Result: atom gets smaller

Show this table (Period 3 example):

Element	Symbol	Atomic Number	Atomic Radius (picometers)
Sodium	Na	11	186 pm (largest)
Magnesium	Mg	12	160 pm
Aluminum	Al	13	143 pm
Silicon	Si	14	117 pm
Phosphorus	P	15	110 pm
Sulfur	S	16	104 pm
Chlorine	Cl	17	99 pm
Argon	Ar	18	71 pm (smallest)

Teacher: "Notice: Sodium is large, chlorine is small — even though chlorine has MORE protons. The extra pull wins."

Trend Down a Group (Top to Bottom)

Teacher: "As you move down a group, the atomic radius increases (gets larger)."

Why?

Going down: add a new electron shell

Each new shell is farther from the nucleus

Result: atom gets larger

Show this table (Group 1 — Alkali Metals):

Element	Period	Atomic Radius (pm)
Lithium (Li)	2	152 pm (smallest)
Sodium (Na)	3	186 pm
Potassium (K)	4	227 pm
Rubidium (Rb)	5	248 pm
Cesium (Cs)	6	265 pm (largest)

Household Connection: Why Potassium Is More Reactive Than Sodium

Teacher: "Recall: Potassium is below sodium in Group 1. Potassium has a larger atomic radius. Its outermost electron is farther from the nucleus. That electron is easier to lose. That's why potassium explodes more violently in water than sodium."

Element	Atomic Radius	Electron Loss	Reactivity with Water
Lithium	Smallest	Hardest	Fizzes
Sodium	Medium	Easier	Explodes
Potassium	Larger	Even easier	More violent explosion

Partner talk (1 minute): "Tell your partner: As you go down Group 1 (alkali metals), what happens to atomic radius and reactivity?"

Answer: Atomic radius increases (atoms get larger), and reactivity increases (easier to lose the outer electron).

SEGMENT 4: Periodic Trend #2 — Ionization Energy (10 minutes)

Teacher says: "Ionization energy (eye-on-ih-ZAY-shun EN-er-jee) is the energy required to remove an electron from an atom."

Ionization energy = how hard it is to take an electron away.

Trend Across a Period (Left to Right)

Teacher: "As you move left to right across a period, ionization energy increases (harder to remove electrons)."

Why?

Left to right: atoms get smaller

Electrons are closer to the nucleus

More pull from protons

Harder to take an electron away

Show this table (Period 3 example):

Element	Symbol	Ionization Energy (kJ/mol)
Sodium	Na	496 (lowest — easiest to remove)
Magnesium	Mg	738
Aluminum	Al	577 (slight drop — reason: aluminum loses electron from higher energy subshell)
Silicon	Si	787
Phosphorus	P	1012
Sulfur	S	1000 (slight drop — reason: sulfur has paired electrons that repel)
Chlorine	Cl	1251
Argon	Ar	1520 (highest — hardest to remove)

Teacher: "Notice: Sodium (Group 1) has the lowest ionization energy — it really wants to lose its 1 electron. Argon (Group 18) has the highest ionization energy — it has a full shell and does NOT want to lose electrons."

Trend Down a Group (Top to Bottom)

Teacher: "As you move down a group, ionization energy decreases (easier to remove electrons)."

Why?

Going down: atoms get larger

Outer electrons are farther from nucleus

Less pull from protons

Easier to take an electron away

Show this table (Group 1 — Alkali Metals):

Element	Ionization Energy (kJ/mol)
Lithium (Li)	520 (highest — hardest to remove)
Sodium (Na)	496

Element	Ionization Energy (kJ/mol)
Potassium (K)	419
Rubidium (Rb)	403
Cesium (Cs)	376 (lowest — easiest to remove)

Household Connection: Why Cesium Is Used in Atomic Clocks

Teacher: "Cesium (Group 1, bottom) has the lowest ionization energy of any stable element. Its outer electron is very easy to move. That's why cesium is used in atomic clocks — the electron's vibrations are extremely regular."

Quick check (show of hands): "Does ionization energy increase or decrease as you go down Group 17 (halogens)?" (Decreases — easier to remove electrons) "Does fluorine (top of Group 17) have high or low ionization energy?" (High — it's small and holds electrons tightly)

SEGMENT 5: Periodic Trend #3 — Electronegativity (10 minutes)

Teacher says: "Electronegativity (e-lek-tro-neg-a-TIV-i-tee) is how strongly an atom pulls shared electrons toward itself."

Electronegativity = the "greediness" of an atom for electrons.

Trend Across a Period (Left to Right)

Teacher: "As you move left to right across a period, electronegativity increases (more greedy for electrons)."

Why?

Left to right: atoms get smaller

More protons pulling on shared electrons

More greedy

Show this table (Period 3 example):

Element	Symbol	Electronegativity
Sodium	Na	0.93 (lowest — not greedy)
Magnesium	Mg	1.31
Aluminum	Al	1.61
Silicon	Si	1.90

Element	Symbol	Electronegativity
Phosphorus	P	2.19
Sulfur	S	2.58
Chlorine	Cl	3.16 (very greedy)
Argon	Ar	N/A (doesn't form bonds — inert)

Trend Down a Group (Top to Bottom)

Teacher: "As you move down a group, electronegativity decreases (less greedy for electrons)."

Why?

Going down: atoms get larger

Shared electrons are farther from the nucleus

Less pull

Less greedy

Show this table (Group 17 — Halogens):

Element	Electronegativity	Notes
Fluorine (F)	4.0 (highest of all elements)	Most greedy — top of Group 17
Chlorine (Cl)	3.16	Still greedy — used in bleach
Bromine (Br)	2.96	Less greedy
Iodine (I)	2.66	Least greedy of halogens

Household Connection: Why Fluorine Is in Non-Stick Pans

Teacher: *"Fluorine is the most electronegative element (4.0). It pulls electrons so strongly that the bond between carbon and fluorine (C-F) is extremely strong. That's why Teflon (which has many C-F bonds) is so stable and non-reactive. Food doesn't stick to it."*

Household Connection: Why Chlorine Is in Bleach

Teacher: "Chlorine (electronegativity 3.16) is also very greedy. It steals electrons from stain molecules and germs, breaking them apart. That's why bleach removes stains and kills bacteria."

> Partner talk (1 minute): *"Tell your partner: Which is more electronegative — oxygen (3.5) or chlorine (3.16)? What does that mean for the O-Cl bond?"*

Answer: Oxygen is more electronegative (3.5 > 3.16). In the O-Cl bond, oxygen pulls shared electrons more strongly. The bond is polar with oxygen being slightly negative.

SEGMENT 6: Putting It All Together — Predicting Reactivity (10 minutes)

Teacher says: "Now let's combine all three trends to predict reactivity."

Summary Table of Trends

Trend	Across Period (Left → Right)	Down Group (Top → Bottom)
Atomic radius	Decreases (gets smaller)	Increases (gets larger)
Ionization energy	Increases (harder to remove e^-)	Decreases (easier to remove e^-)
Electronegativity	Increases (more greedy)	Decreases (less greedy)

Reactivity Rules

For Metals (Groups 1-12):

Reactivity increases DOWN a group

Why? Larger atomic radius, lower ionization energy → easier to lose electrons

For Nonmetals (Groups 14-17):

Reactivity increases UP a group

Why? Smaller atomic radius, higher electronegativity → easier to gain electrons

Show this table:

Element Type	Most Reactive	Least Reactive	Household Example
Alkali metals (Group 1)	Cesium (bottom)	Lithium (top)	Potassium explodes more violently than sodium
Halogens (Group 17)	Fluorine (top)	Iodine (bottom)	Fluorine reacts with almost anything; iodine is used as antiseptic (gentle)
Noble gases (Group 18)	Radon (bottom — but still very unreactive)	Helium (top)	Helium is completely inert; radon is slightly reactive but dangerous

Worked Example: Compare Sodium (Na) and Potassium (K)

Teacher: "Sodium and potassium are both in Group 1. Which is more reactive?"

Property	Sodium (Na)	Potassium (K)	Winner
Period	3	4	K is one period down
Atomic radius	186 pm	227 pm	K is larger
Ionization energy	496 kJ/mol	419 kJ/mol	K is lower (easier to lose e^-)
Reactivity	High	Higher	Potassium

Answer: Potassium is more reactive because it is below sodium in Group 1.

Worked Example: Compare Chlorine (Cl) and Iodine (I)

Teacher: "Chlorine and iodine are both in Group 17 (halogens). Which is more reactive?"

Property	Chlorine (Cl)	Iodine (I)	Winner
Period	3	5	Cl is above I
Electronegativity	3.16	2.66	Cl is more greedy
Atomic radius	99 pm	133 pm	Cl is smaller (easier to gain e^-)
Reactivity	Higher	Lower	Chlorine

Answer: Chlorine is more reactive because it is above iodine in Group 17.

Household connection: "Chlorine (in bleach) is more reactive than iodine. That's why bleach is a stronger disinfectant than iodine (which is used in milder antiseptics like Betadine)."

SEGMENT 7: Using the Periodic Table to Predict Safety (4 minutes)

Teacher says: "The periodic table can help you predict which chemicals might be dangerous."

Quick Safety Predictions

Element or Compound	Location on Periodic Table	Prediction	Is It Correct?
Pure sodium (Na)	Group 1, Period 3	Very reactive, explodes in water	Yes
Pure fluorine (F)	Group 17, Period 2	Extremely reactive, dangerous	Yes
Teflon (C-F bonds)	Carbon (Group 14), Fluorine (Group 17)	C-F bond is very strong, stable, non-reactive	Yes — non-stick pans are safe

Element or Compound	Location on Periodic Table	Prediction	Is It Correct?
Table salt (NaCl)	Sodium (Group 1) + Chlorine (Group 17)	Reaction product is stable, not reactive	Yes — safe to eat
Helium (He)	Group 18, Period 1	Noble gas — completely unreactive	Yes — safe for balloons

The Most Important Safety Rule from the Periodic Table

Teacher: "Elements at the far left (Group 1) and far right (Group 17) are the most reactive. They want to react with each other to become stable. That reaction creates ionic compounds like table salt — which are safe."

> "*But never handle pure alkali metals (Group 1) or pure halogens (Group 17). They can burn, explode, or poison you.*"

CLOSING — The 60-Second Challenge (4 minutes)

Teacher says: "Pair up. Person A: 60 seconds — explain why atomic radius decreases from left to right across a period. Person B: 60 seconds — explain why potassium is more reactive than sodium (using ionization energy)."

Final takeaway table (show on screen / read aloud):

You learned...	Household Example
Atomic radius decreases left → right, increases top → bottom	Sodium is larger than chlorine
Ionization energy increases left → right, decreases top → bottom	Potassium loses electrons easier than sodium
Electronegativity increases left → right, decreases top → bottom	Fluorine is most greedy (4.0)
Metals (Groups 1-12): reactivity increases DOWN	Potassium explodes more violently than sodium
Nonmetals (Groups 14-17): reactivity increases UP	Fluorine is more reactive than chlorine
Noble gases (Group 18) are unreactive	Helium balloons are safe
Table salt (NaCl) is safe because it's already reacted	Sodium + chlorine → stable compound

Final line (preview of L2-3): "Next session: Chemical Bonding (Advanced) — drawing Lewis structures, predicting molecular shapes, and why water is bent (snowflakes have six sides). See you then."

SUPPLEMENTARY MATERIALS FOR L2-2 (No Grade)

Resource	Household Connection	Description	How to Find It
PhET "Periodic Trends" simulation	Compare atomic radius, ionization energy, electronegativity	Interactive visualization	Search "PhET periodic trends"
Video: "Alkali Metals in Water"	Sodium, potassium, cesium explosions	Shows reactivity trend in Group 1	Search "alkali metals in water BBC"
Electronegativity table	Printable periodic table with values	Keep as reference	Search "Pauling electronegativity periodic table"
Article: "Why Teflon Is Non-Stick"	Carbon-fluorine bond strength	Household chemistry	Search "ChemMatters Teflon"

"This week, look at a periodic table (printed or online). Find fluorine (Group 17, Period 2) and iodine (Group 17, Period 5). Based on what you learned, which one is more reactive? (Answer: fluorine — reactivity increases UP in Group 17)."