HIGH SCHOOL CHEMISTRY

CHAPTER 3

Set 1: Light and Atomic Models

Free Sample

Sample pages from the full study set. Try them, then get the whole set.

Try it, then get the whole set

7	5	★	✓
files in the full set	sample sections	Honors kept separate	answers included

- Sample pages from the notes, revision sheets, traps, practice, flashcards and lab skills
- Answers included for every sample question
- Honors material clearly marked so Regular students can skip it

For high school chemistry, Regular and Honors. Chapter 3: Electrons and the Periodic Table.

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FREE SAMPLE · SET 1 OF 3

Try Light and Atomic Models before you buy

This free sampler shows pages from six of the seven files in the full **Light and Atomic Models** study set. If you like how these pages teach, the full set gives you the whole topic, start to finish.

What's in the full Light and Atomic Models set

File	What it does for you
1 · Complete Study Notes	Six lessons that teach the whole topic in plain words, with worked examples and quick checks.
2 · Quick Revision Sheets	The topic on a few pages: tables, road maps, memory tricks and a one-page cheat sheet.
3 · Exam Traps and Mistakes	The mistakes that cost students points, and how to dodge each one.
4 · Practice Question Bank	Questions by lesson, easy to hard, with full worked answers and a separate Honors section.
5 · Quizzes and Unit Test	Quizzes and a full unit test with a fully explained answer key.
6 · Glossary and Flashcards	Every key term defined, plus cut-out flashcards.
7 · Lab Skills for Tests	What tests ask about flame tests and spectroscopes: colors, data and sources of error, with test-style questions and answers.

NOTE | Regular or Honors?

Honors material sits in blue boxes marked ★ HONORS . Regular students can skip every one of them and still master the topic.

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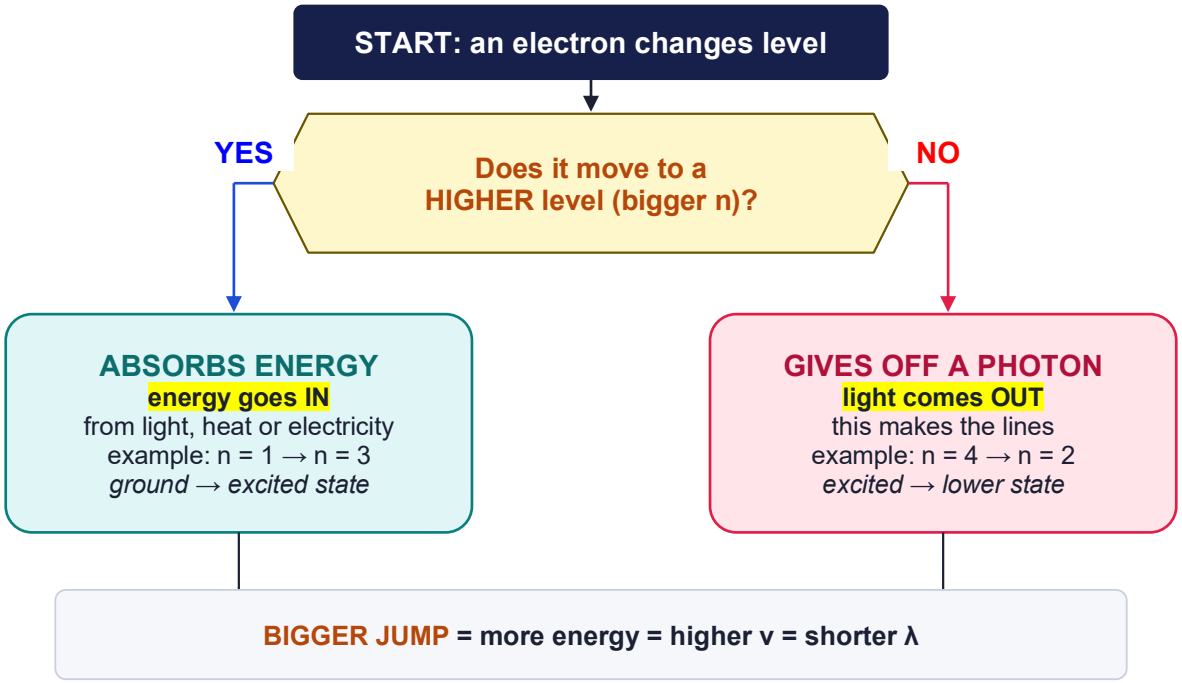
SAMPLE 1 From the Complete Study Notes

SAMPLE PAGE | FREE SAMPLE

This page is taken from Complete Study Notes, one of the seven files in the full Light and Atomic Models set.

Absorbing and giving off energy

An electron moves **up** a level only when it absorbs energy (from heat, electricity or light). An excited electron soon falls back **down**, and the energy it loses leaves the atom as a photon. **A bigger fall gives off a photon with more energy, higher frequency and shorter wavelength.**



Ask one question: is the electron moving to a **higher** level? YES means it absorbs energy. NO means it falls and gives off a photon. The bigger the jump, the more energy is involved.

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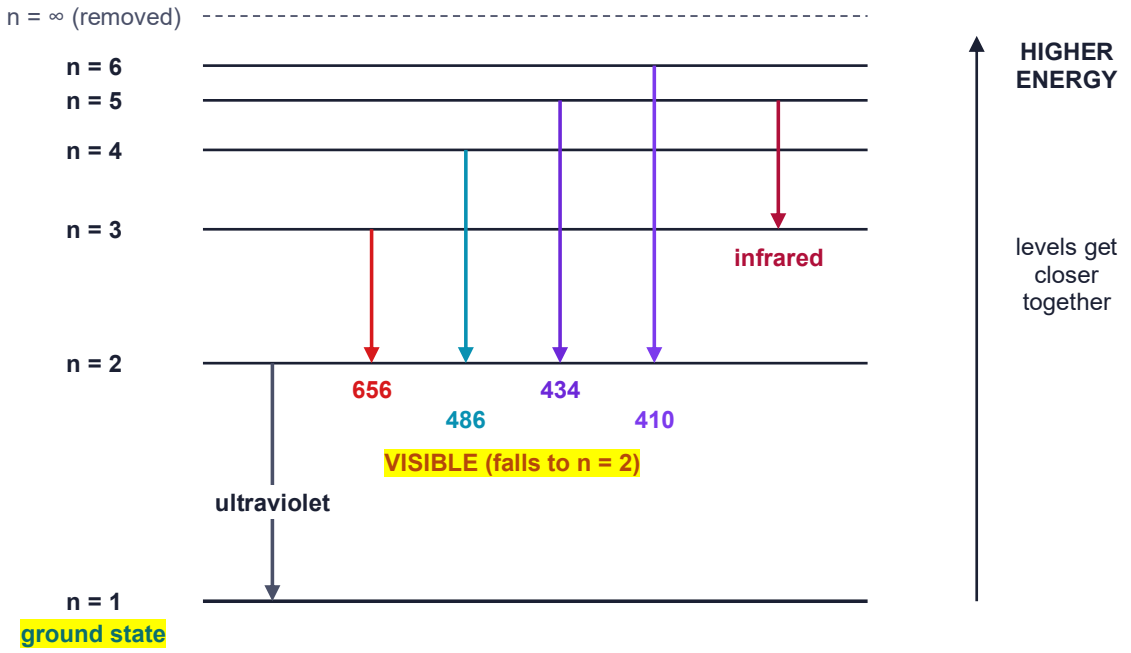
EXAM TRAP | Up absorbs, down emits

Students often mix these up. Moving **up** (to a larger n) needs energy, so the atom **absorbs**. Moving **down** (to a smaller n) releases energy, so the atom **emits** (gives off) a photon. Emission spectra come only from electrons falling **down**.



Look at the falls to n = 2: they give hydrogen's four visible lines (656, 486, 434 and 410 nm). A **longer** arrow means more energy, so a shorter wavelength. Falls to n = 1 are bigger and give ultraviolet light; falls to n = 3 are smaller and give infrared light.

WORKED EXAMPLE | Which fall gives the shorter wavelength?

Which photon has the shorter wavelength: one from a 4 → 2 fall or one from a 3 → 2 fall?

Think: the 4 → 2 fall is bigger (it crosses more of the ladder), so the photon has **more energy**. More energy means higher frequency and **shorter wavelength**.

Answer: the 4 → 2 photon (486 nm) is shorter than the 3 → 2 photon (656 nm).

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SAMPLE 2 From the Quick Revision Sheets

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This page is taken from Quick Revision Sheets, one of the seven files in the full Light and Atomic Models set.

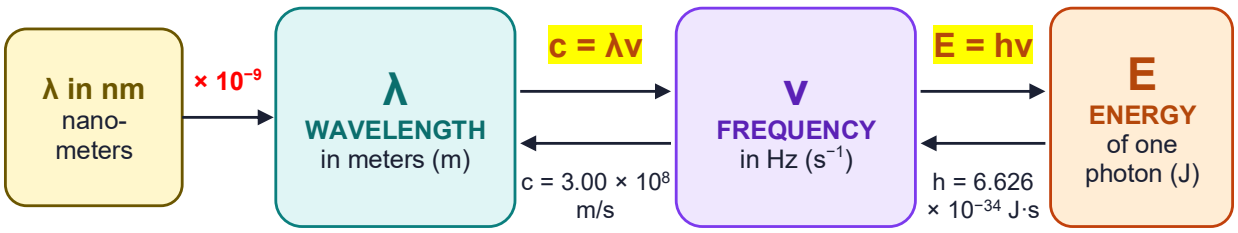
FORMULA | The two equations

$$c = \lambda \nu$$

$$E = h\nu$$

$c = 3.00 \times 10^{8}$ m/s. $h = 6.626 \times 10^{-34}$ J·s. λ in **meters**, ν in **Hz** (s^{-1}), E in **joules**.

Conversions: nm × 10^{-9} = m. MHz × 10^{6} = Hz. GHz × 10^{9} = Hz. m × 10^{9} = nm.



LONG λ → low ν → low E
SHORT λ → high ν → high E

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Three moves that cover every question

WORKED EXAMPLE | Move 1: wavelength from frequency

An FM station broadcasts at 104.3 MHz. Find λ.

$$104.3\ \text{MHz} \times \frac{10^6\ \text{Hz}}{1\ \text{MHz}} = 1.043 \times 10^8\ \text{Hz}$$

$$\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^8\ \text{m/s}}{1.043 \times 10^8\ \text{s}^{-1}} = \mathbf{2.88\ m}$$

WORKED EXAMPLE | Move 2: nanometers → frequency → energy

Find the energy of one photon of 460 nm blue light.

$$460\ \text{nm} \times \frac{10^{-9}\ \text{m}}{1\ \text{nm}} = 4.60 \times 10^{-7}\ \text{m}$$

$$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^8\ \text{m/s}}{4.60 \times 10^{-7}\ \text{m}} = 6.52 \times 10^{14}\ \text{s}^{-1}$$

$$E = h\nu = (6.626 \times 10^{-34}\ \text{J}\cdot\text{s})(6.52 \times 10^{14}\ \text{s}^{-1}) = \mathbf{4.32 \times 10^{-19}\ J}$$

WORKED EXAMPLE | Move 3: energy → frequency → wavelength

A photon has 2.90 × 10^{-19} J. Find its wavelength in nm and its color.

$$\nu = \frac{E}{h} = \frac{2.90 \times 10^{-19}\ \text{J}}{6.626 \times 10^{-34}\ \text{J}\cdot\text{s}} = 4.38 \times 10^{14}\ \text{s}^{-1}$$

$$\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^8\ \text{m/s}}{4.38 \times 10^{14}\ \text{s}^{-1}} = 6.85 \times 10^{-7}\ \text{m}$$

$$6.85 \times 10^{-7}\ \text{m} \times \frac{10^9\ \text{nm}}{1\ \text{m}} = \mathbf{685\ nm}\ \text{(red light)}$$

EXAM TRAP

Change **nm to m** before you use $c = \lambda\nu$. Sanity check: visible light has ν near **10^{14} Hz** and E near **10^{-19} J**. An answer like 10^5 Hz means you forgot the 10^{-9}.

Shortcut (never required): the two steps combine into $E = \frac{hc}{\lambda}$.

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SAMPLE 3 From Exam Traps and Mistakes

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These traps are taken from Exam Traps and Mistakes, one of the seven files in the full Light and Atomic Models set.

EXAM TRAP 13 | Forgetting to change nm to m

✗ WHAT STUDENTS WRITE	✓ WHAT EARNS THE POINTS
"For 535 nm light: $v = \frac{3.00 \times 10^8}{535} = 5.61 \times 10^5$ Hz."	535 nm = 5.35×10^{-7} m. Then $v = \frac{3.00 \times 10^8 \text{ m/s}}{5.35 \times 10^{-7} \text{ m}}$ = **5.61×10^{14} Hz**.

Why it's wrong: c is in **meters** per second, so λ must be in meters too. An answer near 10^5 Hz is a radio frequency, not green light.

MEMORY TRICK **Meters in, hertz out.**

EXAM TRAP 9 | Brighter light means more energetic photons

✗ WHAT STUDENTS WRITE	✓ WHAT EARNS THE POINTS
"A brighter red lamp gives off red photons with more energy than a dim red lamp."	Both lamps give off red photons with the **same** energy. The bright lamp gives off **more photons** each second.

Why it's wrong: The color fixes the energy of each photon ($E = h\nu$). Brightness only changes how many photons there are.

MEMORY TRICK **Color = energy each. Brightness = how many.**

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EXAM TRAP 24 | Orbit and orbital mean the same thing

✗ WHAT STUDENTS WRITE	✓ WHAT EARNS THE POINTS
“An orbital is the circular path an electron travels around the nucleus.”	An **orbit** (Bohr) is an exact path. An **orbital** (quantum model) is a **region** where the electron is **likely** to be found, about **90%** of the time.

Why it’s wrong: The words differ by three letters, so they get swapped. Tests reward the word **region** or **probability**.

MEMORY TRICK **An orbit is a track; an orbital is a cloud.**

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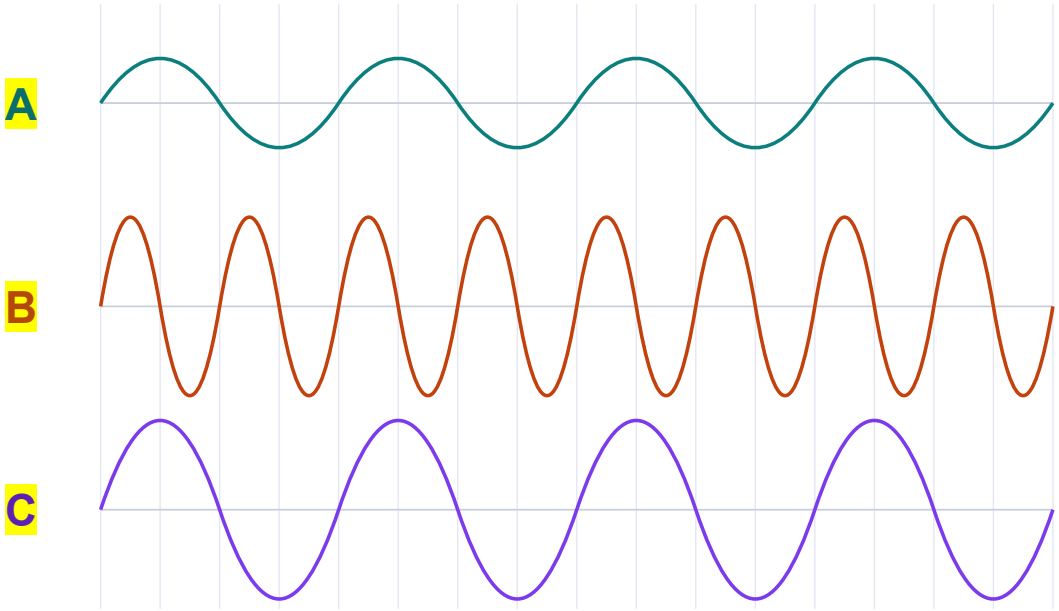
SAMPLE 4 From the Practice Question Bank

SAMPLE PAGE | FREE SAMPLE

These questions are taken from Practice Question Bank, one of the seven files in the full Light and Atomic Models set.

Answer the questions below. Then check your answers in the box under them.

Q6 The diagram shows three light waves, A, B and C, drawn on the same grid. (a) Which waves have the longest wavelength? (b) Which wave has the highest frequency? (c) Which two waves are the same color of light? (d) Which wave is the dimmest?



Each grid square is 150 nm wide. All three travel at the same speed.

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Q7 Use the diagram in the question above. Each grid square is 150 nm wide. What is the wavelength of wave B?

A. 150 nm
B. 300 nm
C. 600 nm
D. 2400 nm

Q8 If the wavelength of a light wave is doubled, its frequency

A. doubles
B. is cut in half
C. stays the same
D. becomes four times larger

Q86 L2 ★ HONORS Violet light with a wavelength of 405 nm shines on metal Z (threshold energy 3.71×10^{-19} J). What is the kinetic energy of each ejected electron?

ANSWER KEY | Answers

Q6 **(a) A and C (b) B (c) A and C (d) A**

(a) A and C repeat every 4 grid squares; B repeats every 2. (b) B has the shortest wavelength, so the most waves pass each second. (c) Same wavelength means same frequency, so A and C are the same color. (d) A has the smallest amplitude (shortest crests), so it is the dimmest. C is the same color as A, only brighter.

Q7 **B**

$$2 \text{ squares} \times 150 \text{ nm} = 300 \text{ nm}$$

Wave B goes from crest to crest in 2 squares. Choice C is the wavelength of A and C (4 squares). A 300 nm wave is shorter than violet light (about 400 nm), so B is ultraviolet.

Q8 **B**

$$c = \lambda \nu, \text{so } (2\lambda)\left(\frac{\nu}{2}\right) = \lambda \nu = c$$

The speed c never changes, so λ and ν must change in opposite directions by the same factor.

Q86 ★ HONORS **1.20×10^{-19} J**

$$\nu = \frac{c}{\lambda} = \frac{3.00 \times 10^{8} \cancel{\text{m}}/\text{s}}{4.05 \times 10^{-7} \cancel{\text{m}}} = 7.41 \times 10^{14} \text{ s}^{-1}$$

$$E = h\nu = (6.626 \times 10^{-34} \text{ J} \cdot \cancel{\text{s}})(7.41 \times 10^{14} \cancel{\text{s}^{-1}}) = 4.91 \times 10^{-19} \text{ J}$$

$$KE = 4.91 \times 10^{-19} \text{ J} - 3.71 \times 10^{-19} \text{ J} = 1.20 \times 10^{-19} \text{ J}$$

Part of the photon's energy frees the electron (the threshold energy). The rest becomes the electron's kinetic energy.

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SAMPLE 5 Flashcards and Lab Skills

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These cards are taken from Glossary and Flashcards, one of the seven files in the full Light and Atomic Models set.

Front	Back
Wavelength (λ)	The distance from one crest to the next crest (or one trough to the next). Its symbol is λ, the Greek letter lambda. Often given in nanometers: 1 nm = 10^{-9} m.
Photon	A single packet (quantum) of light energy. Its energy depends only on its frequency: E = hv.
Ground state	The lowest-energy state of an atom, with its electron in the lowest possible level. For hydrogen, that is n = 1.
Line spectrum	A spectrum of separate bright lines of specific wavelengths on a dark background. Also called a **bright-line spectrum**.

SAMPLE PAGE | FREE SAMPLE

This data set is taken from Lab Skills for Tests, one of the seven files in the full Light and Atomic Models set.

Data Set A · Flame Tests

What the student did: A student dipped a water-soaked wooden splint into each metal chloride, held the tip at the edge of a burner flame and recorded the flame color. A fresh splint was used for every sample. Three unknowns, X, Y and Z, were tested the same way.

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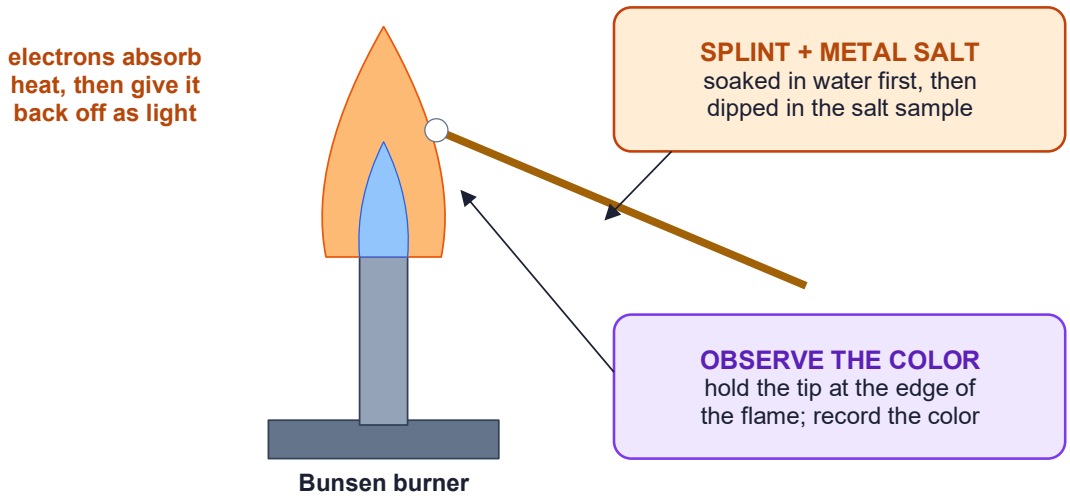

Flame test: the salt on the splint tip colors the flame; the color comes from the metal's electrons.

Sample	Flame color observed
Lithium chloride	Crimson red
Sodium chloride	Bright yellow-orange
Potassium chloride	Lilac (pale violet)
Calcium chloride	Orange-red (brick red)
Strontium chloride	Bright red
Barium chloride	Pale yellow-green
Copper(II) chloride	Blue-green
Unknown X	Pale yellow-green
Unknown Y	Bright yellow-orange; through cobalt blue glass: lilac
Unknown Z	Red

Questions

A1 Identify the metal in Unknown X.

A2 Unknown Y looked yellow-orange, but lilac through cobalt blue glass. Which two metals does it contain? Why did the blue glass help?

A3 Unknown Z gave a red flame. Why can the student not be sure which metal it is? Name two possible metals and a better way to tell them apart.

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ANSWER KEY | What the data show

A1 Barium. Its pale yellow-green flame matches barium chloride and no other known sample.

A2 Sodium and potassium. Sodium's strong yellow-orange covers potassium's faint lilac. Cobalt blue glass blocks the yellow light, so the lilac from potassium shows through.

A3 Several metals give red flames, such as lithium (crimson) and strontium (bright red). Color names are a matter of opinion, so the eye cannot tell these reds apart reliably. View the flame through a spectroscope and compare its lines with reference spectra.

The full file has two more data sets, plus how to read a spectroscope, safety, sources of error and test-style lab questions, all with answers.

Get the Full Light and Atomic Models Set

You've seen a few pages. The full set covers **all of Light and Atomic Models**, start to finish.

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- ✓ **Quick Revision Sheets:** tables, road maps, memory tricks and a one-page cheat sheet.
- ✓ **Exam Traps and Mistakes:** the mistakes that cost points, fixed.
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Also in this series: Set 2, Electron Configurations, and Set 3, Periodic Table and Trends. Each set works on its own.

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