

CHEMDU · COMMUNITY CHEMISTRY · LEVEL 1

LECTURE 11

# Nuclear Chemistry

*Radiation at Home: Smoke Detectors, Radon, and Old Glowing Watches*

■ Duration: 50 minutes

Lecture script · with hooks, segments, demos, and key takeaways

**Hook (opening 3 minutes)**

Teacher holds up (or shows photos of):

A smoke detector (contains americium-241)

A radon test kit (available at hardware stores)

An old glow-in-the-dark watch (pre-1970s, may contain radium)

The trefoil radiation symbol (☢)

Teacher says: "There is a smoke detector in your home right now. Inside it is a tiny amount of radioactive material. It's perfectly safe — but it's radioactive.

There may also be radon gas in your basement. You can't see it, smell it, or taste it. It's radioactive. And it's the #1 cause of lung cancer in people who have never smoked.

- Today's question: What is nuclear chemistry — and what do you need to know to stay safe? \*

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

*Explain the difference between alpha, beta, and gamma radiation — and which one is dangerous if you breathe it in*

*Know why you should test your home for radon*

*Decide whether an old glowing watch is safe to wear"*

**SEGMENT 1: What Is Nuclear Chemistry? (6 minutes)**

Teacher says: "Let's start with what nuclear chemistry is.

Nuclear chemistry is the study of changes that happen inside the nucleus (the center) of an atom. These changes release tiny particles or energy — called radiation.

Important difference from regular chemistry: "Regular chemistry involves electrons — the tiny particles outside the nucleus. Nuclear chemistry involves protons and neutrons — the particles inside the nucleus.

Regular chemistry: atoms rearrange bonds, but the atom stays the same element. Nuclear chemistry: an atom changes into a different element.

Everyday example of regular chemistry: Baking soda + vinegar → carbon dioxide gas. The atoms rearrange. No element changes.

Everyday example of nuclear chemistry: Uranium → radium → radon → polonium → lead. The atom changes into different elements as it decays.

Teacher continues: "Some atoms are stable — they stay the same forever. Some atoms are unstable — they break apart over time. When they break apart, they release radiation."

Stable Atom	Unstable Atom (Radioactive)
Stays the same forever	Breaks apart over time

Stable Atom	Unstable Atom (Radioactive)
Does not release radiation	Releases radiation (alpha, beta, gamma)
Example: Carbon-12 (normal carbon)	Example: Carbon-14 (used for dating fossils)

Quick poll (show hands): "Raise your hand if you've heard the word 'radioactive' before. Raise your hand if you thought all radiation is dangerous."

*Teacher: "Some radiation is dangerous. Some is not — if you handle it correctly. Let's learn the difference."*

## SEGMENT 2: The Three Types of Radiation — Alpha, Beta, Gamma (10 minutes)

Teacher says: "Unstable atoms release three main types of radiation. They are very different from each other.

Alpha (AL-fa) radiation: A heavy, slow particle made of 2 protons and 2 neutrons (the same as a helium nucleus).

Beta (BAY-ta) radiation: A fast electron (a lightweight particle).

Gamma (GAM-ma) radiation: A high-energy wave (like an X-ray, but stronger).

Show this table (read aloud and discuss):

Type	What Is It?	Speed	Stopped By	Danger Outside Body	Danger Inside Body
Alpha ( $\alpha$ )	Heavy particle (2 protons + 2 neutrons)	Slow	Sheet of paper, dead skin	None — skin stops it	High — destroys cells from inside
Beta ( $\beta$ )	Fast electron	Fast	Aluminum foil, thick clothing	Low — can burn skin	Medium — damages internal tissue
Gamma ( $\gamma$ )	High-energy wave	Speed of light	Thick lead, concrete	High — goes through body	High — goes through body

### Memorization trick:

*Alpha = heavy & slow — stopped by PAPER*

*Beta = fast electron — stopped by ALUMINUM FOIL*

*Gamma = super wave — stopped by LEAD or CONCRETE*

*Teacher continues: "The danger depends on where the radiation is."*

Location	Alpha	Beta	Gamma
Outside your body	Safe — skin stops it	Can burn skin (like sunburn)	Dangerous — goes through you
Inside your body (breathed or swallowed)	Very dangerous — destroys nearby cells	Dangerous — damages tissue	Dangerous — goes through you

**The key rule:**

Alpha particles are harmless outside your body — but deadly if you breathe them in or swallow them.

**Physical action:**

"Alpha: Make a big, slow fist moving through air — then put a piece of paper (flat hand) in front — paper stops it."

"Beta: Flick fingers fast — then put aluminum foil (flat hand) — foil stops it."

"Gamma: Wave both hands like light — show thick lead (hands far apart) — lead stops it."

## SEGMENT 3: Where Radiation Is in Your Home (8 minutes)

Teacher says: "Now let's talk about where you might actually find radiation in daily life."

Show this table (read aloud and discuss):

Source	Type of Radiation	Is It Dangerous?	What to Do
Smoke detector	Alpha (americium-241)	No — sealed inside plastic	Don't take it apart. Dispose of properly at hazardous waste facility.
Banana	Beta, gamma (potassium-40)	No — your body regulates potassium	Eat normally. You'd need millions of bananas to get sick.
Old radium watch (pre-1970s)	Gamma + alpha (radium)	Maybe — if worn daily for years or opened	Don't wear daily. Never open. Store in a box.
Granite countertop	Alpha (radon from uranium)	Very low — unless you sleep on it for decades	Safe. Ventilate kitchen.
Radon gas	Alpha (from uranium in soil)	Yes — #1 cause of lung cancer in non-smokers	TEST YOUR HOME. Test kits cost \$15–30.
Medical X-ray	Gamma (man-made)	Low — benefits outweigh risks	Get only when needed. Tell the technician if you might be pregnant.

Source	Type of Radiation	Is It Dangerous?	What to Do
CAT scan (CT scan)	Gamma (higher dose than X-ray)	Low to medium — benefits usually outweigh risks	Ask: "Is this scan really necessary?"

Partner talk (2 minutes): "Tell your partner: Name two household sources of radiation that are NOT dangerous, and one that IS dangerous if not handled correctly."

Answer: Smoke detector (safe), banana (safe), radon gas (dangerous if not tested).

## SEGMENT 4: Radon — The Invisible Danger (10 minutes)

Teacher says: "Radon is the most important nuclear safety issue for most homes. Let me explain.

Radon is a radioactive gas. You cannot see it, smell it, or taste it. It comes from uranium in the soil. Uranium decays into radium, which decays into radon gas. Radon seeps into basements and crawl spaces through cracks in the foundation.

The danger: "Radon decays further, releasing alpha particles. If you breathe in radon, those alpha particles get trapped in your lungs. They damage lung cells. Over many years, this causes lung cancer.

Statistic	Number
Lung cancer deaths caused by radon in the U.S. each year	About 21,000
Radon is the #1 cause of lung cancer in non-smokers	Yes
One in 15 homes in the U.S. has high radon levels	About 7%

How do you know if your home has radon? "You cannot tell without testing. The only way to know is to use a radon test kit.

Show this table (radon levels and what to do):

Radon Level (pCi/L)	What to Do
Below 2.0	Safe — no action needed
2.0 to 4.0	Consider fixing (especially if smokers live in the home)
4.0 or higher	Fix your home — install a radon mitigation system

### *How to test for radon:*

Step	Action	Cost
1	Buy a radon test kit at a hardware store or online	\$15–30
2	Place the kit in the lowest level of your home (basement or first floor)	Free
3	Leave it for 2–7 days (follow kit instructions)	Free
4	Mail the kit to the lab (pre-paid envelope included)	Included
5	Get your results in 1–2 weeks	Included

How to fix high radon levels: "A radon mitigation system is a pipe and fan that pulls radon gas from under your basement and vents it outside above the roof.

Cost	Time	Effectiveness
\$800–\$1,500	One day	Reduces radon by 99%

Partner talk (1 minute): "Tell your partner: Why is radon more dangerous than a smoke detector?"

Answer: Radon is a gas you breathe in without knowing it. Alpha particles inside your lungs cause cancer. Smoke detector radiation is sealed inside plastic — you don't breathe it.

Key safety rule (repeat together): "Test your home for radon. It's cheap. It's easy. It saves lives."

## SEGMENT 5: The Glowing Watch Question — Solved (6 minutes)

Teacher says: "Let's go back to the hook. You find an old glow-in-the-dark watch at a garage sale. It's from the 1950s or 1960s. Is it safe?"

Background: "Old watches used radium paint to glow. Radium is radioactive. It emits alpha, beta, and gamma radiation. The alpha is stopped by the watch case. The gamma goes through it.

### The risks:

Action	Risk Level	Why
Wearing it occasionally (once a week)	Very low	Gamma radiation is low dose — about the same as a dental X-ray per year
Wearing it every day for years	Low to medium	Cumulative exposure — gamma adds up over time

Action	Risk Level	Why
Opening the watch case	High	Radium paint can flake into dust. Breathe the dust → alpha particles in lungs → lung cancer risk
Letting a child wear or play with it	Medium	Children are more sensitive to radiation; they might open it
Sleeping with it under your pillow	Low to medium	Gamma goes through pillow — unnecessary exposure

What to do if you own an old radium watch:

Step	Action
1	Do NOT open the case
2	Store it in a box (not on your nightstand)
3	Wear it occasionally (once a week or less)
4	Keep away from children
5	Dispose of properly at a hazardous waste facility (do not throw in trash)

Quick poll (show hands): "Raise your hand if you have or have seen an old glow-in-the-dark watch."

Teacher: "Now you know: it's probably safe — but don't wear it every day, and never open it."

## SEGMENT 6: Nuclear Chemistry in Medicine (4 minutes)

Teacher says: "Not all nuclear chemistry is dangerous. Some of it saves lives."

Medical Use	What It Does	Is It Safe?
X-ray	Takes pictures of bones (teeth, chest, arms)	Very low risk — benefits outweigh risks
CT scan (CAT scan)	Takes 3D pictures inside your body	Low to medium risk — uses more radiation than X-ray
Radiation therapy (cancer treatment)	Kills cancer cells with focused gamma rays	Medium risk — can damage healthy cells, but saves lives
Nuclear medicine (PET scan)	Injects tiny amount of radioactive tracer to see organs	Very low risk — tracer decays and leaves body quickly

Teacher: "The key is benefit vs. risk. A chest X-ray gives a tiny dose of radiation (about the same as 10 days of natural background radiation). But it can find pneumonia or a broken rib. The benefit is much larger than the risk."

**What you should do:**

Get medical scans only when recommended by a doctor


Ask: "Is this scan really necessary?"

Tell the technician if you might be pregnant"

## SEGMENT 7: The Trefoil Symbol — What to Do If You See It (3 minutes)

Teacher says: "You might see this symbol: . It means radioactive material is present.

Show the trefoil symbol (draw or screen).

If You See 	Do This
On a sealed container (smoke detector, medical device)	Leave it alone. It's probably safe if not damaged.
On a door or fence (radiation area)	Do NOT enter without training. Stay away.
On a truck or container	Stay back. Let trained workers handle it.
On an old object (watch, clock, instrument)	Handle carefully. Do not open. Dispose properly.

The three rules of radiation safety (repeat together): "TIME — minimize your exposure time. DISTANCE — move away from the source. SHIELDING — put something between you and it (paper for alpha, lead for gamma)."

### CLOSING — The 30-Second Challenge (3 minutes)

Teacher says: "Pair up. Person A: 30 seconds — explain the difference between alpha, beta, and gamma radiation. Which one is dangerous if breathed in? Person B: 30 seconds — why should you test your home for radon, and what do you do if levels are high?"

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

You learned...	So you can...
Alpha = heavy, slow, stopped by paper — dangerous if inhaled	Never open old radium watches or disturb radon dust
Beta = fast electron — can burn skin	Handle beta sources with care
Gamma = high-energy wave — stopped by lead or concrete	Use distance and shielding for gamma
Smoke detectors contain americium-241 (alpha) — safe when sealed	Leave them alone; dispose properly
Radon = radioactive gas from soil — alpha emitter	TEST YOUR HOME — kits cost \$15–30

You learned...	So you can...
Radon mitigation system = pipe + fan	Reduces radon by 99% (\$800–\$1,500)
Old radium watch — safe to wear occasionally, but never open	Store in box; keep away from children
The trefoil symbol (☢) means radioactive material	Keep time short, distance far, use shielding

Final line (wrap-up of entire course): "That's the end of our 11-lecture chemistry course. You now know:

*What atoms are made of*

*How to read the periodic table*

*Why water and oil don't mix*

*How to spot dangerous chemical reactions*

*When to use cold packs vs. hot packs*

*Why tire pressure changes with temperature*

*And how to stay safe from radon and old glowing watches*

You don't need a test or a grade. You just need to remember: chemistry is everywhere — and knowing it keeps you and your family safe."

#### SUPPLEMENTARY MATERIALS FOR LECTURE 11 (No Grade)

Resource	Source	Description	Link / Search Term
Video: "Radiation Basics"	CDC / YouTube	5-minute explanation of alpha, beta, gamma	Search "CDC radiation basics"
Radon test kit information	EPA / radon	Where to buy kits, state resources	Search "EPA radon test kit"
Article: "Smoke Detector Safety"	ACS ChemMatters	How americium-241 works in smoke detectors	Search "ChemMatters smoke detector americium"
Radium watch safety	EPA / NRC	Guidance on old luminous watches	Search "EPA radium watch safety"
PhET "Alpha Decay" simulation	University of Colorado	Interactive — see alpha particles emitted from nucleus	Search "PhET alpha decay"

#### OPTIONAL "NO-PRESSURE" ASSIGNMENT

*"Between now and next session, look at the smoke detector in your home (or find one in a store). Look for the radiation symbol or the word 'americium.' Then look up how to buy a radon test kit online or at a hardware store. Next time, tell us: did you find the smoke detector label? Will you test for radon?"*

## DEFINITIONS SUMMARY FOR LECTURE 11 (Student Handout)

Term	Simple Definition	Everyday Example
Nuclear chemistry	Study of changes inside the nucleus of an atom	Uranium decaying into radon
Stable atom	An atom that stays the same forever	Normal carbon (carbon-12)
Unstable atom	An atom that breaks apart over time (radioactive)	Uranium, radium, radon
Alpha radiation	Heavy, slow particle — stopped by paper	Smoke detector (americium-241)
Beta radiation	Fast electron — stopped by aluminum foil	Carbon-14 dating
Gamma radiation	High-energy wave — stopped by lead or concrete	Medical X-ray, CT scan
Radon	Radioactive gas from soil — alpha emitter	Seeps into basements — causes lung cancer
Radon test kit	Device to measure radon levels in a home	\$15–30 at hardware store
Radon mitigation system	Pipe and fan that vents radon outside	\$800–\$1,500 — reduces radon by 99%
Trefoil symbol (☢)	Symbol meaning radioactive material is present	On smoke detectors, medical devices, warning signs
Time, Distance, Shielding	Three rules of radiation safety	Less time, more distance, put something between you and source

## COMPLETE COURSE VOCABULARY GLOSSARY (Lectures 1–11)