



Light & the Electromagnetic Spectrum

Companion worksheet — use the interactive tool to complete each part.

Name: _____ Date: _____

Key formulas

$c = \lambda \nu$	speed of light = wavelength $\times$ frequency
$E = h\nu$	energy = Planck's constant $\times$ frequency
$E = hc/\lambda$	energy in terms of wavelength directly

Tip: $c = 3.00 \times 10^8$ m/s and $h = 6.626 \times 10^{-34}$ J·s. Convert wavelength to meters before plugging into these formulas!

Part A — Wavelength, frequency & energy

Each row gives you one value. Calculate the other two, identify the EM region, then check yourself with the Explorer tool.

Problem 1

Given: Wavelength = 500 nm

Show your work:

Frequency: _____ Energy: _____ Region: _____

Problem 2

Given: Frequency = 100 MHz

Show your work:

Frequency: _____ Energy: _____ Region: _____

Problem 3

Given: Wavelength = 0.1 nm

Show your work:

Frequency: _____ Energy: _____ Region: _____



Problem 4

Given: Frequency = 5×10^{14} Hz

Show your work:

Wavelength: _____ Energy: _____ Region: _____

Quick check

Two of the problems above landed in the visible range. Without redoing the math, which one do you think produced the longer wavelength color, and which the shorter? Explain your reasoning using what you know about color and energy.



Part B — Color & energy

Use the Visible Light Zoom strip to help answer these.

1. Which has more energy: red light or violet light? Explain using the formulas above.

Show your work:

2. Rank these from LOWEST to HIGHEST energy: visible light, X-rays, radio waves, gamma rays.

Lowest: _____ → _____ → _____ → Highest: _____

3. Use the presets in the Explorer. Fill in the table below.

Preset	EM Region	More or less energy than visible light?
FM Radio (100 MHz)		
Microwave Oven (2.45 GHz)		
Red Light (650nm)		
Tanning Bed UV (300nm)		
Medical X-ray (0.1nm)		



Part C — Hydrogen Emission Lab

Play the game! For each ring you excite the electron to, record what happens when it falls.

Transition	Color produced	Wavelength (use "Show the science")
$n = 3 \rightarrow n = 2$		
$n = 4 \rightarrow n = 2$		
$n = 5 \rightarrow n = 2$		
$n = 6 \rightarrow n = 2$		

Rank the 4 transitions from LOWEST to HIGHEST energy:

Lowest: _____ $\rightarrow$ _____ $\rightarrow$ _____ $\rightarrow$ Highest: _____

Why is it called an "emission" spectrum? What is being emitted, and exactly when during the electron's fall?

Show your work:



Reflection

How does the existence of specific colored lines (instead of a continuous rainbow) support Bohr's idea that electrons can only occupy fixed, quantized energy levels? Connect this back to what you learned in the Timeline of the Atom.

Vocabulary check

Term	In your own words
Photon	
Quantized	
Ground state	
Excited state	
Emission spectrum	



TEACHER ANSWER KEY — remove or skip this page before printing for students

Part A

1. $\lambda = 500 \text{ nm} \rightarrow f \approx 6.00 \times 10^{14} \text{ Hz}$, $E \approx 3.97 \times 10^{-19} \text{ J}$ ($\approx 2.48 \text{ eV}$) — Visible (green)
2. $f = 100 \text{ MHz} \rightarrow \lambda \approx 3.00 \text{ m}$, $E \approx 6.63 \times 10^{-26} \text{ J}$ — Radio
3. $\lambda = 0.1 \text{ nm} \rightarrow f \approx 3.00 \times 10^{18} \text{ Hz}$, $E \approx 1.99 \times 10^{-15} \text{ J}$ ($\approx 12.4 \text{ keV}$) — X-ray
4. $f = 5 \times 10^{14} \text{ Hz} \rightarrow \lambda \approx 600 \text{ nm}$, $E \approx 3.31 \times 10^{-19} \text{ J}$ ($\approx 2.07 \text{ eV}$) — Visible (orange)

Part B

1. Violet light has more energy — shorter wavelength means higher frequency ($v = c/\lambda$), and energy is directly proportional to frequency ($E = hv$).
2. Lowest to highest: radio waves $\rightarrow$ visible light $\rightarrow$ X-rays $\rightarrow$ gamma rays.

Part C

$n=3 \rightarrow 2$: red, 656.3 nm (lowest energy of the 4)

$n=4 \rightarrow 2$: cyan/blue-green, 486.1 nm

$n=5 \rightarrow 2$: blue, 434.0 nm

$n=6 \rightarrow 2$: violet, 410.2 nm (highest energy of the 4)

Order lowest to highest energy: $n=3 \rightarrow 2 \rightarrow n=4 \rightarrow 2 \rightarrow n=5 \rightarrow 2 \rightarrow n=6 \rightarrow 2$

A photon is emitted at the exact instant the electron lands on $n=2$ — that's when the energy difference between levels is released as a single burst of light.

Reflection — sample answer

If electrons could have any amount of energy, atoms would emit a continuous rainbow of light. Instead, hydrogen only produces 4 exact colors in the visible range — because electrons can only drop between specific, fixed energy levels, each drop releases one exact amount of energy, and therefore one exact color. The sharp lines are direct evidence that the energy levels themselves are quantized, exactly as Bohr proposed.

Teaching notes

- The EM Spectrum Explorer uses an intentionally non-linear "broken axis" scale to keep visible light usable — worth mentioning if students ask why the bar doesn't look proportional to true wavelength.
- The Hydrogen Emission Lab's ring diagram is also intentionally evenly spaced rather than physically scaled, for the same usability reason — both are noted directly in the app.
- Part C's science toggle in the app reveals exact wavelength values — students without it will only see colors, so encourage them to toggle it on for this worksheet.