ANSWER KEY.

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Emission Spectra

Chemistry | ANSWER KEY

Use $c = \lambda\nu$ and $E = h\nu$. Change nm to m before you use an equation. Show your setup with units and round to 3 significant figures.
$c = 2.998 \times 10^{8}$ m/s $h = 6.626 \times 10^{-34}$ J·s 1 nm = 1×10^{-9} m

1. Explain what happens to an electron when an atom gives off light.

Word bank: ground state, excited state, photon, energy gap

Sentence frame: *An electron in the _____ falls back to a lower level. It gives off a _____ whose energy equals the _____.*

An electron in the excited state falls back to a lower level (toward the ground state). It gives off a photon whose energy equals the energy gap between the levels.

2. Which drop gives off a photon with more energy, n = 4 → 1 or n = 2 → 1? Which photon has the shorter wavelength?

4 → 1 is the bigger energy gap, so its photon has more energy, a higher frequency, and **the shorter wavelength**.

3. A flame test turns lilac. Which metal ion is present? Why can a red flame alone not tell you whether lithium or strontium is present?

K^+ (potassium). **Li^+ and Sr^{2+} both give red flames**, so you need their line spectra to tell them apart.

4. Sodium street lights give off light with a wavelength of 589 nm. Find its frequency.

The first step is done for you: 589 nm = 5.89×10^{-7} m. Now use $\nu = c \div \lambda$.

$\nu = (2.998 \times 10^{8}\text{ m/s}) \div (5.89 \times 10^{-7}\text{ m}) =$ **$5.09 \times 10^{14}\ s^{-1}$**

5. Hydrogen has a violet line at 410 nm. Find the energy of one photon of this light.

$\lambda = 4.10 \times 10^{-7}$ m. $\nu = c \div \lambda = 7.31 \times 10^{14}\ s^{-1}$

$E = h\nu =$ **4.85×10^{-19} J** (4.84×10^{-19} J if you round ν first)

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6. A photon has an energy of 3.20×10^{-19} J. Find its frequency and its wavelength in nm.

Rearrange first: $\nu = E \div h$ and $\lambda = c \div \nu$.

$\nu = (3.20 \times 10^{-19}\ \text{J}) \div (6.626 \times 10^{-34}\ \text{J·s}) =$ **$4.83 \times 10^{14}\ \text{s}^{-1}$**

$\lambda = c \div \nu = 6.21 \times 10^{-7}$ m = **621 nm**

7. A student looks at a fluorescent light bulb through a spectroscope and sees a bright green mercury line at 546 nm.

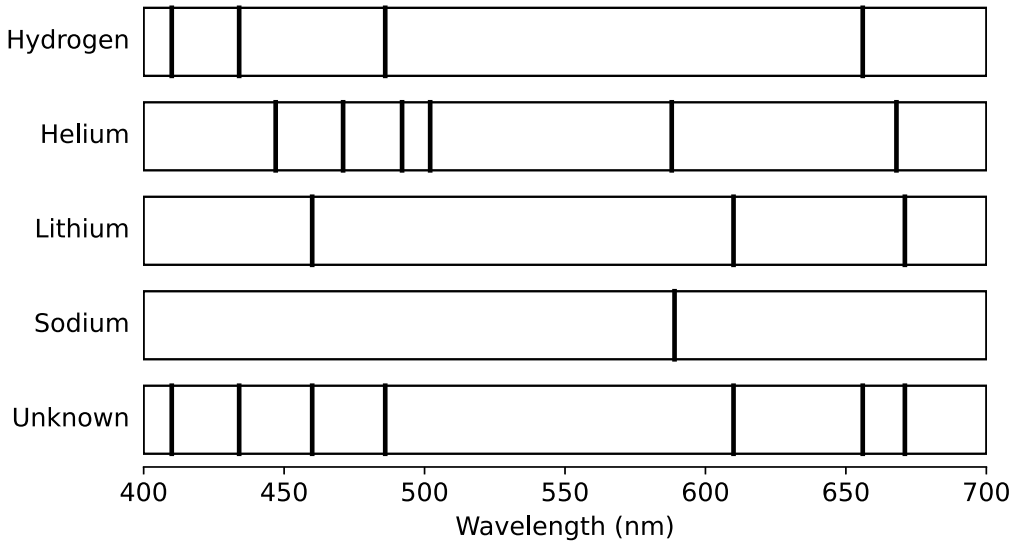
(a) What does the bulb (a discharge tube) do, and what does the spectroscope do?

(b) Find the energy of one photon of the green light.

(a) **Electricity in the tube excites the mercury atoms, so they give off light. The spectroscope spreads the light out by wavelength**, so you see separate lines.

(b) $\lambda = 5.46 \times 10^{-7}$ m. $\nu = c \div \lambda = 5.49 \times 10^{14}\ \text{s}^{-1}$. $E = h\nu =$ **3.64×10^{-19} J**

8. The bottom spectrum came from a tube with a mix of gases. Which elements are in the tube? How do you know?



Hydrogen and lithium. All of hydrogen's lines (410, 434, 486, 656 nm) and lithium's lines (460, 610, 671 nm) appear in the unknown.

Helium and sodium are not there: lines such as 447 nm (He) and 589 nm (Na) are missing.

9. Starlight passes through a cloud of cool hydrogen gas. Predict where dark lines appear in the star's spectrum, and explain.

Dark lines appear at 410, 434, 486, and 656 nm. Hydrogen absorbs the same wavelengths it gives off, because the energy gaps between its levels are the same (absorption).

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