Problem 247: Spectral Identification

Difficulty: Hard

Author: Louis Ronat, Denver, Colorado, United States

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Problem Background

It's commonly said that we're all made from the dust of the stars. But what are the stars made of?

One of the research methods used by astronomers is spectroscopy. Each chemical element emits a unique pattern of electromagnetic radiation when it is present in a star. We see this as light, but by using special equipment to decompose this light into distinct wavelengths, we can determine which chemical elements are present in a star. This allows scientists to categorize the stars based on the elements present in which ratios. Red giant stars, like our neighbor Betelgeuse, typically contain large amounts of helium, whereas our own star contains mostly hydrogen.

Problem Description

Your team is working with the Lockheed Martin Solar & Astrophysics Laboratory to develop a new spectroscopy analysis tool for NASA. Unfortunately, the equipment NASA wants you to work with is only accurate to the nearest nanometer (nm), so it may not always round numbers correctly. For example, nickel emits light at a wavelength of 299.444 nm. NASA's tool may report this as either 299 or 300 nm due to its inaccuracy.

However, the tool can always distinguish between multiple wavelengths of light, even if they're closely related. For example, magnesium emits three wavelengths: 516.733 nm, 517.270 nm, and 518.362 nm. NASA's tool will be able to report three wavelengths; but due to its inaccuracy, they could be reported as [517, 517, 518] or [516, 518, 519], or several other combinations.

Your task is to write a program that can read in a list of wavelengths as reported by the tool and print a list of the chemical elements emitting those wavelengths. If an element is present in a star, the tool will report one wavelength for each of the values associated with that element below. Your program will need to compare those wavelengths and find a list of elements that accounts for the presence of every reported wavelength.

The table on the next page lists the chemical elements, ions, and molecules that are likely to appear in a star, and the wavelengths of light they emit.

Atomic Number	Name	Chemical Symbol	Emission Wavelengths (nm)
1	Hydrogen	H	410.175, 486.134, 656.281
2	Helium	He	587.562
8	Oxygen Molecules	O2	627.661, 686.719, 759.370, 822.696, 898.765
11	Sodium	Na	588.995, 589.592
12	Magnesium	Mg	516.733, 517.270, 518.362
20	Calcium	Ca	430.774
20	Calcium Ions	Ca+	393.368, 396.847
22	Titanium Ions	Ti+	336.112
26	Iron	Fe	302.108, 358.121, 382.044, 430.790, 438.355, 466.814, 495.761, 516.891, 527.039
28	Nickel	Ni	299.444
80	Mercury	Hg	546.073

For example, if NASA's tool reports observing the following wavelengths…

$$[300 \quad 410 \quad 487 \quad 588 \quad 657]$$

…the star being observed contains hydrogen, helium, and nickel. Hydrogen emits light on three wavelengths, which are similar to the reported wavelengths of 410, 487, and 657 nm. This leaves two wavelengths unaccounted for; no element that emits light on two wavelengths does so near both 300 and 588 nm, so this must represent two separate elements. Helium emits light near 588 nm, and nickel emits near 300 nm, so those must be the other two elements we are observing.

Sample Input

The first line of your program's input, received from the standard input channel, will contain a positive integer representing the number of test cases. Each test case will include a single line containing one or more positive integers separated by spaces, representing wavelengths of light (in nanometers) detected by the spectroscopy tool. Wavelengths will be presented in increasing order.

```
3
300 410 487 588 657
300 410 486 546 656
302 336 358 382 410 430 438 467 486 496 517 517 517 518 527 656
```

Sample Output

For each test case, your program must print the list of chemical symbols that are present within the star being observed. Separate elements by spaces, and sort them by increasing atomic number (see the table above for the proper ordering, particularly when both calcium and calcium ions are present).

```
H He Ni
H Ni Hg
H Mg Ti+ Fe
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