

## PHYS 1311: In Class Problems

### Chapter 8 Solution

April 11, 2017

**Problem 1: Bar codes.** Make a list of similar and different properties by comparing the four bar codes. List as many as you can and speculate what they mean.

*Solution.* A non-exhaustive list includes:

- 12 integers with 2 being exterior on either end,
- a pattern of vertical lines with spaces and various widths,
- the numbers and lines are split in the center by 2 vertical lines,
- A pair of identical lines at the start and the end,
- Two lines of varying width for each interior number,
- First (exterior) number the same for all cases.

Speculation:

- First 5 integers in the interior correspond to a company,
- Second 5 integers to an item,
- 2 starting lines mark the beginning of the code,
- 2 ending lines mark the end of the code
- First (exterior) number maybe universal or correspond to a type of item.

Altogether, the vertical lines and numbers correspond to a unique identifier for some item.

**Problem 2: Find the element.** A gas is excited by a 3.7 eV electron beam and is observed to emit photons with energies of 1.09, 1.51, and 2.10 eV. A photon detector which can only observe photons with energy between 1.0 and 2.5 eV was used. Make an energy level diagram and determine the energy levels taking the ground state to be 0 eV. Which neutral atom is this? Go to [www.nist.gov/pml/data/asd.cfm](http://www.nist.gov/pml/data/asd.cfm), select “Levels”, enter an element symbol, and choose Level Units of eV. (Hint the element is in the third row).

*Solution*

The following combinations of energy levels ( $E_1$ ,  $E_2$ ,  $E_3$ ,  $E_4$ ) are possible:

1. 0, 1.09, 2.6, 4.7 eV,
2. 0, 1.09, 3.19, 4.7 eV,
3. 0, 1.51, 2.6, 4.7 eV,
4. 0, 1.51, 3.61, 4.7 eV,

5. 0, 2.1, 3.19, 4.7 eV,
6. 0, 2.1, 3.61, 4.7 eV,
7. 0, 2.1, 3.19, 3.16 eV,
8. others.

These result in the following photon energies, respectively, if excited by a 3.7 eV electron

1. 1.09, 1.51, 2.6 eV,
2. 1.09, 2.10, 3.19 eV,
3. 1.09, 1.51, 2.6 eV,
4. 1.51, 2.10, 3.61 eV,
5. 1.09, 2.1, 3.19 eV,
6. 1.51, 2.1, 3.61 eV,
7. 1.09, 1.51, 2.1 eV
8. others.

In the first six combinations, one of the observed photons is missing because the upper state at 4.7 eV cannot be excited by an electron with 3.7 eV of kinetic energy. Case 7 does give all three observed photons, with the two lower energy ones (1.09 and 1.51 eV) emitting from the  $E_4$  state. If we go to the NIST site, we find the energy levels for case 7 match neutral sodium (Na I).