Clicker Questions

Modern Physics

Chapter 8: "Atoms"

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Instructions

- These questions are offered in two formats: a deck of PowerPoint slides, and a PDF file. The two files contain identical contents. There are similar files for each of the 14 chapters in the book, for a total of 28 files.
- Each question is marked as a "Quick Check" or "ConcepTest."
  - Quick Checks are questions that most students should be able to answer correctly if they have done the reading or followed the lecture. You can use them to make sure students are where you think they are before you move on.
  - ConcepTests (a term coined by Eric Mazur) are intended to stimulate debate, so you don't want to prep the class too explicitly before asking them. Ideally you want between 30% and 80% of the class to answer correctly.
- Either way, if a strong majority answers correctly, you can briefly discuss the answer and move on. If many students do not answer correctly, consider having them talk briefly in pairs or small groups and then vote again. You may be surprised at how much a minute of unguided discussion improves the hit rate.
- Each question is shown on two slides: the first shows only the question, and the second adds the correct answer.
- Some of these questions are also included in the book under "Conceptual Questions and ConcepTests," but this file contains additional questions that are not in the book.
- Some of the pages contain multiple questions with the same set of options. These questions are numbered as separate questions on the page.
- Some questions can have multiple answers. (These are all clearly marked with the phrase "Choose all that apply.") If you are using a clicker system that doesn't allow multiple responses, you can ask each part separately as a yes-or-no question.

8.1 The Pauli Exclusion Principle

Suppose you have 100 particles of mass m trapped in a box, exerting no forces on each other. Which of the following is true of the total energy in the box? (Choose one.)

A. It will be higher if the particles are fermions than if they are bosons.

B. It will be higher if the particles are bosons than if they are fermions.

C. It will be the same either way.

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B. It will be higher if the particles are bosons than if they are fermions.

C. It will be the same either way.

Solution: A

Lithium in its ground state has two of its three electrons in the $n = 1$ energy level. If electrons were bosons how many would be in the $n = 1$ level in the ground state of lithium? (Choose one.)

A. 0

B. 1

C. 2

D. 3

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A. 0

B. 1

C. 2

D. 3

Solution: D

Two hypothetical particles predicted by some physics theories are the "graviton" (spin 2) and the "gravitino" (spin 1.5). Which obey(s) the Pauli exclusion principle? (Choose one.)

A. The graviton

B. The gravitino

C. Both

D. Neither

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A. The graviton

B. The gravitino

C. Both

D. Neither

Solution: B

8.2 Energy Levels and Atomic States

What is the value of l in the subshell $4f$? (Choose one.)

A. 0

B. 1

C. 3

D. 4

What is the value of l in the subshell $4f$? (Choose one.)

A. 0

B. 1

C. 3

D. 4

Solution: C

How many different values of m_l are possible in the state $4d$? (Choose one.)

A. 0

B. 1

C. 3

D. 5

E. More than 5

How many different values of m_l are possible in the state $4d$? (Choose one.)

A. 0

B. 1

C. 3

D. 5

E. More than 5

Solution: D

Which of the following subshells will fill up first as you increase Z? (Choose one.)

A. $4f$

B. $5p$

C. $5d$

D. $6s$

Which of the following subshells will fill up first as you increase Z? (Choose one.)

A. $4f$

B. $5p$

C. $5d$

D. $6s$

Solution: B

An "unpaired" electron spin is one that isn't canceled out by another electron. For example, if four electrons had spins Up-Down-Up-Up we would call that two unpaired electrons. How many unpaired electrons does carbon ($Z = 6$) have in its ground state? (Choose one.)

A. 0

B. 1

C. 2

D. 4

E. 6

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A. 0

B. 1

C. 2

D. 4

E. 6

Solution: The configuration is $1s^2 2s^2 2p^2$. The four s states will all be paired, but the two p states will point the same way by Hund’s rule, so the answer is two.

In helium, in its ground state, the total spin angular momentum is zero. If you excite it to a higher energy state, will that still be true?

A. It will definitely still be true.

B. It will definitely no longer be true.

C. It depends on the excited state.

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A. It will definitely still be true.

B. It will definitely no longer be true.

C. It depends on the excited state.

Solution: C

8.3 The Periodic Table

Which of the following properties make an atom more likely to react chemically with other atoms? (Choose all that apply.)

A. It has a low ionization energy.

B. It has a high ionization energy.

C. It has a full outer subshell.

D. It has an available state with a large negative energy ($E \ll 0$).

E. It has an available state with a small negative energy ($E \approx 0$).

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E. It has an available state with a small negative energy ($E \approx 0$).

Solution: A, D

Which of the following columns in the periodic table generally has the highest ionization energy? (Choose one.)

A. Column 1 (alkalis)

B. Column 2 (alkali earths)

C. Column 17 (halogens)

D. Column 18 (noble gases)

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A. Column 1 (alkalis)

B. Column 2 (alkali earths)

C. Column 17 (halogens)

D. Column 18 (noble gases)

Solution: D

Below is a list of all the elements with Z between 16 and 20. Which would you expect to have the highest electron affinity? (Choose one.)

A. Sulfur

B. Chlorine

C. Argon

D. Potassium

E. Calcium

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A. Sulfur

B. Chlorine

C. Argon

D. Potassium

E. Calcium

Solution: B

An element's "electronegativity" is high if it is likely to react by absorbing electrons, low if it is likely to release them. Which of the following makes a good definition of electronegativity? We're using IE and EA here to mean ionization energy and electron affinity. (Choose one. The correct choice is one of the definitions sometimes used for it.)

A. $(IE + EA)/2$

B. $(IE - EA)/2$

C. $(-IE + EA)/2$

D. $(-IE + EA)/2$

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A. $(IE + EA)/2$

B. $(IE - EA)/2$

C. $(-IE + EA)/2$

D. $(-IE + EA)/2$

Solution: A

The lowest energy photon that an atom can absorb is generally one that knocks its outermost electron up to the next available energy state. Which of the following elements would you expect to be able to absorb the lowest energy photon? (Choose one.)

A. Copper

B. Zinc

C. Krypton

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A. Copper

B. Zinc

C. Krypton

Solution: Copper.

The outermost electrons in Zinc fill the $3d$ subshell, so one would have to bump up to $4p$. The outermost electrons in Krypton fill the $4p$ subshell, so one would have to make the jump to $5s$. But Copper is working its way through the $3d$ subshell, and even Hund's rule doesn't distinguish between the last electron it added (one of those $3d$ guys) and the first one it doesn't have (another one).

8.4 X-Ray Spectroscopy and Moseley's Law

Which of the following lines would have the highest frequency? (Choose one.)

A. K_α

B. L_α

C. M_α

D. N_α

Which of the following lines would have the highest frequency? (Choose one.)

A. K_α

B. L_α

C. M_α

D. N_α

Solution: A

Each line on Moseley's plot comprises a series of points. What do all the points on one such line represent? (Choose one.)

A. They are all transitions in the same element, with electrons dropping into the same (lower) level, but from different (higher) levels.

B. They are all transitions in the same element, with electrons dropping into different (lower) levels.

C. They are all the same transition (both higher and lower levels), but in different elements.

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B. They are all transitions in the same element, with electrons dropping into different (lower) levels.

C. They are all the same transition (both higher and lower levels), but in different elements.

Solution: C

If you were to plot the frequency (not the square root of frequency!) of the K_β line as a function of Z, what would the resulting plot look like? (Choose one.)

A. A line

B. A parabola

C. An exponential

D. None of the above

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A. A line

B. A parabola

C. An exponential

D. None of the above

Solution: B

In this section we've been talking about high energy (X-ray) transitions. If you were to plot $\sqrt{\nu}$ vs. Z for photons emitted in the lowest energy transition in a multielectron atom, would the results be linear?

In this section we've been talking about high energy (X-ray) transitions. If you were to plot $\sqrt{\nu}$ vs. Z for photons emitted in the lowest energy transition in a multielectron atom, would the results be linear?

Solution: No. The lowest energy transition would be an optical transition involving the outermost electrons. As we've seen earlier in this chapter, the energies of the outer shells vary in very complicated ways with Z. For electrons with many atoms, however, the inner (X-ray) transitions vary in a simple, predictable way.