Answers to selected problems from Essential Physics, Chapter 28

1. … two electron energy levels that are 2.5 eV apart in energy.

3. It is possible for electron transitions involving this level to produce visible photons, if there is another level within 1.8 to 3.1 eV of the –60 eV level. For instance, if there was a level at –58 eV, an electron dropping from the –58 eV level to the –60 eV level would produce a photon of 2 eV, which is in the visible spectrum. Similarly, if there was a level lower than –60.0 eV, say at –62.5 eV, an electron dropping from the –60.0 eV level to the –62.5 eV level would produce a photon of 2.5 eV, which is also in the visible spectrum.

5. (a) The most probable distance is at about 13 Bohr radii from the nucleus, a value that is significantly larger than the value of 9 Bohr radii predicted by the Bohr model.
(b) The total area under the curve = 1, which corresponds to the fact that is 100% certain that the electron will be found at some distance between 0 and infinity from the nucleus.

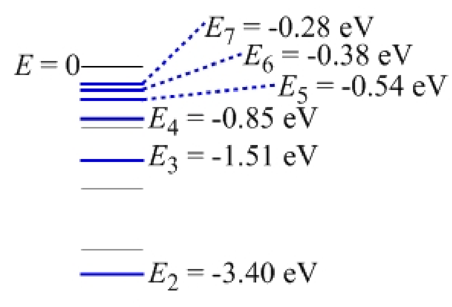
7. (1) In the Bohr model, only one quantum number is needed to quantize energy, radii, and angular momentum. In the modern quantum-mechanical picture, four quantum numbers are used. (2) In the Bohr model, the electrons travel in circular orbits of well-defined radii. In the modern view, the electrons can be at virtually any distance from the nucleus. (3) In the Bohr model, the electron is treated like a particle. In the modern view, our model of the electron is much more wave-like, with the density of the electron cloud at a particular point corresponding to the probability of finding the electron at that point. There is no equivalent probability interpretation in the Bohr model.

9. (a) 0 or 1 (b) 0, if $\ell = 0$, and –1, 0, or +1, if $\ell = 1$ (c) ±½ (d) 8

11. (a) invalid – there can not be more than 2 electrons in an s-subshell (b) valid – this could be an excited state of silicon (c) valid – this could be an excited state of aluminum (d) valid – there can not be more than 6 electrons in a p-subshell

13. (a) 2.2 eV (b) 5.3×10^{14} Hz (c) 560 nm (d) the lower level, –25.6 eV

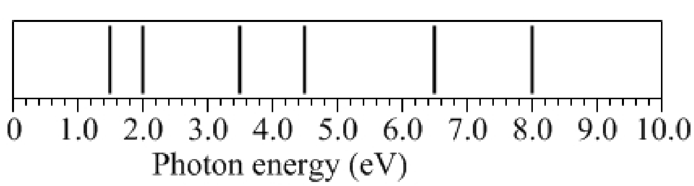
15. (a) –0.850 eV, –0.544 eV, –0.378 eV, –0.278 eV (b)



(c) 1.89 eV, 2.55 eV, 2.86 eV, 3.02 eV, 3.12 eV

(d) 657 nm, 487 nm, 434 nm, 411 nm, 397 nm

17.



19. (a) –3, –2, –1, 0, +1, +2, +3 (b) ±½ (c) 14

21. 5, 6, 7, …

23. n = 3, ℓ = 2, m_ℓ = +1, m_s = ±½

25. (a) 17.34° (b) 26.44° (c) 4 (two on each side)

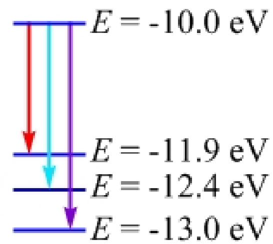
27. Neon has a number of energy levels that differ in energy from other energy levels by about 2 – 2.3 eV, so that a significant fraction of the visible light emitted by neon consists of photons with energies of 2 – 2.3 eV. These energies correspond to colors in the red and orange part of the visible spectrum.

31. There are two possibilities. The other level could have an energy of –32.27 eV, or it could have an energy of –28.29 eV.

33. It takes more energy to excite the atom from the n = 1 state to the n = 2 state than it does to excite it from the n = 2 state to the n = 100 state. The difference in energy between the n = 2 and n = 1 states is about three times larger than the difference in energy between the n = 100 and n = 2 states.

35. 2.773 eV, 2.472 eV, 2.110 eV, and 1.857 eV, respectively.

37. (a) four (b) There are an infinite number of energy-level diagrams that correspond to this emission spectrum. One of these is shown here.



39. (a) n = 3, n = 6, and n = 9 (b) Yes, it is possible to tell the two spectra apart. In addition to the emission lines it has in common with hydrogen, there will be additional emission lines in the lithium spectrum because of the additional electron levels lithium has, in between the levels it has in common with hydrogen.

41. (a) The six energies are E_1 = –60 eV, E_2 = –30 eV, E_3 = –20 eV, E_4 = –15 eV, E_5 = –12 eV, and E_6 = –10 eV. Thus, there are two transitions that produce a 10 eV photon, $E_6 \rightarrow E_3$ and $E_3 \rightarrow E_2$. (b) There are also two transitions that produce a 5 eV photon, $E_6 \rightarrow E_4$ and $E_4 \rightarrow E_3$.

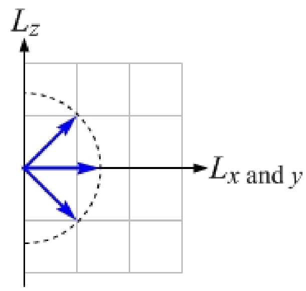
43. (a) 1.89 eV (b) 3.40 eV.

45. (a) 122 nm. (b) 91 nm.

49. (a) The most likely radius is about 5 Bohr radii, which is somewhat larger than the 4 Bohr radii predicted by the Bohr model. (b) There is about a 5% chance of finding the electron at a radius of less than 2 Bohr radii from the nucleus.

51. (a) $L = \sqrt{12}\,\frac{h}{2\pi}$ (b) the possible values are $L_z = -\frac{3h}{2\pi}, -\frac{2h}{2\pi}, -\frac{h}{2\pi}, 0, +\frac{h}{2\pi}, +\frac{2h}{2\pi}, +\frac{3h}{2\pi}$

53. (a)



(b) $L = \sqrt{2}\,\frac{h}{2\pi}$

The units on the graph are $h/(2\pi)$

55. (a) The ground state of S is $1s^2\,2s^2\,2p^6\,3s^2\,3p^4$
(b) The ground state of Se is $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^{10}\,4p^4$
(c) These elements are found in the same column in the periodic table because the outermost electrons in both elements have a similar configuration. In both cases, there are 4 electrons in the last sub-shell, which is a p sub-shell. This means that both sulfur (S) and selenium (Se) have similar chemical properties – chemical bonds generally depend on the outermost electrons.

57. (a) 53   (b) Iodine

59. In general, atoms and molecules are most stable when electrons completely fill the sub-shells. The ground-state configuration of a column-1 element is such that it has completely filled sub-shells plus one extra electron. Any column-17 element, on the other hand, is just one electron short of having completely-filled subshells. Thus, when a column-1 element donates its extra electron to a column-17 element within a molecule, both elements essentially have completely filled subshells, producing a stable arrangement.