Chapter 2 Exercises

1. Which has more energy, a photon of microwave radiation or a photon of infrared radiation? Explain your answer.

2. Arrange the following in order of increasing photon energy:
a) $\lambda = 0.2$ cm **b)** $\lambda = 1$ mi **c)** $\nu = 10^{16}\ s^{-1}$ **d)** yellow light

3. Radiation from the sun can cause the decomposition of O_2 in the stratosphere: $O_2 \rightarrow 2O$. This requires 495 kJ/mol of energy. What is the longest wavelength of light in nm that can accomplish this process? In what region of the electromagnetic spectrum (*i.e.*, infrared, visible, ultraviolet, etc.) is light of this energy found?

4. Fill in the following table:

λ (nm)	ν (s^{-1})	E/photon (J)	E/mol photons (kJ/mol)
900			
	8.00×10^{14}		
		8.50×10^{-20}	
			250

5. Fill in the following table:

λ (nm)	ν (s^{-1})	E/photon (J)	E/mol photons (kJ/mol)
333			
	6.42×10^{15}		
		1.86×10^{-18}	
			108

6. The threshold frequency for the ejection of an electron from iron is $1.1 \times 10^{15}\ s^{-1}$. Indicate whether each of the following photons has enough energy to eject an electron from iron.
a) $\lambda = 1$ mm **b)** $\lambda = 1$ nm **c)** blue light **d)** an x-ray

7. Use the Bohr model to determine the radii of the n = 2 and n = 4 orbits of a He^{1+} ion.

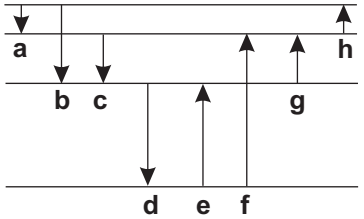
8. Use the Bohr model to determine the radii of the n = 2 and n = 4 orbits of a Be^{3+} ion.

9. Determine the energies of the n = 2 and n = 3 levels of a He^{1+} ion. What region of the spectrum (*i.e.*, infrared, visible, ultraviolet, etc.) would the n = 3 $\rightarrow$ 2 transition in He^{1+} ion occur? Is this transition an absorption or an emission?

10. Determine the energies of the n = 6 and n = 8 levels of a Be^{3+} ion. What region of the spectrum (*i.e.*, infrared, visible, ultraviolet, etc.) would the line n = 6 $\rightarrow$ 8 transition occur? Is the transition an absorption or an emission?

11. A 20 cm string, which is fastened at both sides, is plucked. What is the wavelength of the n = 5 standing wave? How many nodes does it contain? Draw the wave.

12. Consider the transitions shown in the following energy level diagram:



a) Which transitions absorb and emit photons of highest frequency?
b) Which transitions absorb and emit photons of longest wavelength?
c) Which transition involves the greatest energy change?

13. Which restriction on the quantum numbers is violated in the following:

	n	l	m_l	m_s
a)	2	1	-1	1
b)	3	-2	0	$^1/_2$
c)	2	2	0	$-^1/_2$
d)	3	2	3	$-^1/_2$

14. Which restriction on the quantum numbers is violated in the following:

	n	l	m_l	m_s
a)	3	3	-3	$^1/_2$
b)	75	74	-68	0
c)	6	-5	-5	$-^1/_2$
d)	4	0	-1	$-^1/_2$

15. What is the maximum number of electrons that can be accommodated in an n = 7 level?

16. Indicate whether each of the following transitions would be an emission or an absorption. The notation '4p $\rightarrow$ 6s' means the transition from a 4p orbital to a 6s orbital.

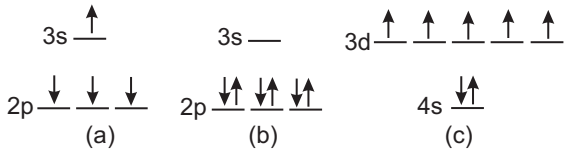
a) 4p $\rightarrow$ 6s **b)** 3d $\rightarrow$ 3p **c)** 8s $\rightarrow$ 6f **d)** 4p $\rightarrow$ 4s

17. Sketch the p orbitals. Be sure to label the axes.

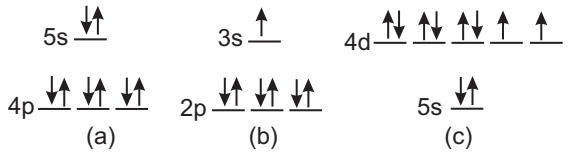
18. Sketch the d orbitals. Be sure to label the axes.

19. How many orbitals are in an h sublevel? What is the lowest n quantum number for a level with an h sublevel? How many electrons could occupy this level?

20. Write short hand notations for each of the following orbital occupancies. Arrows are used to represent the electron spin quantum number; that is, ↑ represents $m_s = +1/2$, and ↓ represents $m_s = -1/2$.



21. Write short hand notations for each of the following orbital occupancies. Arrows are used to represent the electron spin quantum number; that is, ↑ represents $m_s = +1/2$ and ↓ represents $m_s = -1/2$.



22. Give the n and *l* quantum numbers for the highest energy electrons in each of the following atoms:

a) strontium **b)** indium **c)** zinc **d)** fluorine

23. Give the n and *l* quantum numbers for the highest energy electrons in each of the following atoms:

a) ruthenium **b)** antimony **c)** barium **d)** silicon

24. Write electron configurations for the following:

a) phosphorus **b)** cobalt **c)** lead **d)** strontium

25. Write electron configurations for the following:

a) manganese **b)** thallium **c)** sulfur **d)** bromine

26. If an electron is brought closer to the nucleus, the force of attraction between the electron and the nucleus _____ and the potential energy of the electron _____. Fill in each blank with increases or decreases.

27. How many of the following are populated by at least one electron in an atom of cobalt?

a) levels **b)** sublevels **c)** orbitals

28. How many unpaired electrons are present in each of the following?

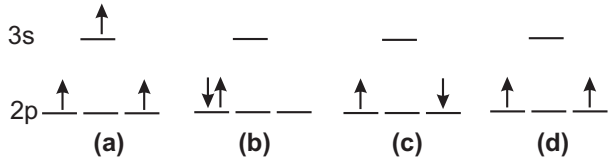
a) phosphorus **b)** cobalt **c)** lead **d)** strontium

29. How many unpaired electrons are present in each of the following?

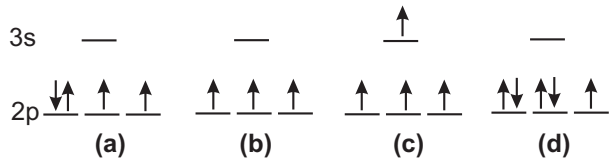
a) manganese **b)** thallium **c)** sulfur **d)** bromine

30. How many p electrons does an atom of Te (Z = 52) have? How many of the p electrons are in the outermost shell?

31. Indicate whether each of the following orbital occupancies is a ground state, an excited state or not allowed. If it is a ground state occupancy, identify the atom. If it is not the ground state, explain why. Assume the 1s and 2s sublevels are full.



32. Indicate whether each of the following orbital occupancies is a ground state, an excited state, or not allowed. If it is a ground state occupancy, identify the atom. If it is not the ground state, explain why. Assume the 1s and 2s sublevels are full.



33. What is the common feature of the electron configurations of elements in a given group (family) of the periodic table?

34. What two atoms have two unpaired electrons in the 3p sublevel?

35. Identify the atom that

a) contains five electrons in the **n** = 3 level

b) has nine electrons in the **n** = 3 level?

36. Indicate which transition in a hydrogen atom would emit the photon of greater frequency.

a) $n = 3 \rightarrow 2$ or $n = 6 \rightarrow 3$ **b)** $n = 8 \rightarrow 4$ or $n = 8 \rightarrow 6$

37. Indicate which transition in a hydrogen atom would emit the photon of longer wavelength.

a) $n = 4 \rightarrow 3$ or $n = 6 \rightarrow 3$ **b)** $n = 2 \rightarrow 1$ or $n = 12 \rightarrow 2$

38. Is the energy difference between the outermost s and p orbitals greater for carbon or for silicon? Explain.

39. Give a set of quantum numbers for all of the electrons in the outermost shell of Ga.

40. Give a set of quantum numbers for all of the electrons in the outermost shell of P.

41. Draw an orbital energy diagram similar to Figure 2.8 that describes the electrons in the outermost shell of Si and place electrons (arrows) to show the orbital occupancy.

42. Draw an orbital energy diagram similar to Figure 2.8 that describes the electrons in the outermost shell of Br and place electrons (arrows) to show the orbital occupancy.

43. Give the number of s, p, d, and f electrons in each of the following atoms.

a) Na **b)** Fe **c)** Pb **d)** Se

44. Give the number of s, p, d, and f electrons in each of the following atoms.

a) Ba **b)** Hg **c)** I **d)** Ga

45. What are the **n** and ***l*** quantum numbers for the electrons with the highest energy in the following atoms?

a) Na **b)** Fe **c)** Pb **d)** Se

46. What are the **n** and ***l*** quantum numbers for the electrons with the highest energy in the following atoms?

a) Ba **b)** Hg **c)** I **d)** Ga

47. Identify the element with each of the following electron configurations:

a) $[Ne]4s^2 3d^{10} 4p^3$ **b)** $[Ar]4s^2 3d^6$

c) $[Kr]5s^1$ **d)** $[Xe]6s^2 4f^{14} 5d^{10}$

48. Identify the element with each of the following electron configurations:

a) $[Ar]4s^2$ **b)** $[He]2s^2 2p^4$

c) $[Ar]4s^2 3d^1$ **d)** $[Kr]5s^2 4d^{10} 5p^2$

49. A hydrogen atom in its ground state absorbs a photon of frequency $\nu = 3.084 \times 10^{15}\ s^{-1}$. To what level is the electron promoted?

50. A hydrogen atom in an excited state emits a photon of frequency $\nu = 2.924 \times 10^{15}\ s^{-1}$. If the electron returns to the ground state, in which level was it before the photon was emitted?

51. How many orbitals have each of the following designations?

a) 3p **b)** n = 7 and l =3

c) n = 3 **d)** n = 2, l = 1 and $m_l = 1$