Answers to Exercises and Problems

for

CHEMISTRY

A Guided Inquiry

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Answers to Exercises and Problems

These answers may be given to students.

ChemActivity 1

1. A = 31, no. of e^- = 15. Z = 8, A = 18. $^{39}K^+$. Z = 28, no. of e^- = 26.
2. 1.674×10^{-24} g. 1.993×10^{-23} g.
3. 8.67×10^{-17} g.
4. 12.00 g.
5. 7.305×10^{-23} g.
6. a) sum of protons and neutrons in the nucleus. b) number of protons in the nucleus.
7. False. ^{18}O has 8 protons and 10 neutrons.
8. 12, 12, 12. 10, 11, 12. 17, 17, 18. 18, 17, 18. 23, 26, 30. 7, 7, 8. 10, 8, 8. 10, 13, 14.
9. $^{59}Co^{2+}$. Z = 7, A = 14, no. of e^- = 7. ^{7}Li . Z = 30, A = 58, no. of e^- = 28. Z = 9, A = 19, no. of e^- = 10.
10. All isotopes of an element have the same number of protons in the nucleus. One isotope of an element is differentiated from another isotope of the same element by the number of neutrons in the nucleus.

Problems

1. Using carbon-13 and carbon-12, approx mass of neutron = 13.0034 – 12 = 1.0034 amu. approx mass of ^{14}C = 13.0034 + 1.0034 = 14.0068 amu.
2. a) Using ^{14}C and $^{14}C^-$, mass of electron is approximately 13.0039 amu – 13.0034 amu = 0.0005 amu

   b) Using ^{1}H, mass of proton is approximately 1.0078 amu – 0.0005 amu = 1.0073 amu

   c) Using ^{1}H and ^{2}H, mass of neutron is approximately 2.0140 amu – 1.0078 amu = 1.0062 amu
   (Note that slightly different values for the masses of protons and neutrons will be obtained if different elements/isotopes are used to calculate these masses.)
3. The calculated mass of ^{12}C based on the masses of the constituent particles is 12.099 amu; and the actual mass of ^{12}C is exactly 12 amu.

ChemActivity 2

1. a) 1.008 g. b) 39.10 g.
2. a) 45.98 g. b) 57.27 g.
4. ^{37}Cl has two more neutrons in its nucleus.
5. $$\text{average mass of a marble} = \frac{1 \infty 5.00\text{ g} + 3 \infty 7.00\text{ g}}{4} = \frac{1}{4} \times 5.00\text{ g} + \frac{3}{4} \times 7.00\text{ g} =$$
   $$0.2500 \times 5.00\text{ g} + 0.7500 \times 7.00\text{ g} = 6.50\text{ g} \text{ (this is eqn (2))}$$
6. 10.44 amu
7. ^{35}Cl, 75.76%. ^{37}Cl, 24.24%.
8. a) 4.003 g b) 39.10 g

9. a) 1 He atom × $\frac{1\,mole\,He\,atoms}{6.022\,x10^{23}\,He\,atoms}$ × 4.003 g He/mole He atoms

   = 6.647 × 10^{-24} g of He.

   b) 1 K atom × $\frac{1\,mole\,K\,atoms}{6.022\,x10^{23}\,K\,atoms}$ × 39.098 g K/mole K atoms =

   6.493 × 10^{-23} g. of K
10. 60.06 g
11. 3.613 × 10^{24} atoms.
12. 2.619 × 10^{24} atoms.
13. a) 3.029 × 10^{25} atoms. b) 1.022 × 10^{19} atoms. c) 1.878 × 10^{25} atoms. d) 9.782 × 10^{27} atoms.
14. Phosphorus
15. 89.5 g I

Problems

1. Assume that mass of ^{22}Ne is 22 amu. Calculated avg mass of Ne is 20.18—close to the experimental value of 20.179.
2. a) False. 6.941 g per mole of Li atoms. b) False. No H atoms weighs 1.008 amu.
   c) True. Na atoms are more massive.
3. 17: protons in nucleus and electrons in the neutral atom. 35.453: avg amu of a Cl atom and grams of one mole of Cl atoms.
4. Re-187

ChemActivity 3

1. 5.47 × 10^{-18} J.
2. a) $IE_a = -(2)(-1)/d_1 = 2/d_1$ b) $IE_b = -(1)(-1)/2d_1 = 1/2d_1$ $IE_a > IE_b$
3. The ionization energy of case (a) is larger, 1.20 k/d_1, than that of case (b), 1.17 k/d_1.

Problems

1. large and negative
2. $V = \frac{(+2)(-1)k}{300pm} + \frac{(+2)(-1)k}{400pm} + \frac{(-1)(-1)k}{700pm}$
3. Each of the six electrons is at some distance, r_i, from the +6 nucleus and has a Coulombic Potential Energy term (six terms; all of these are attractive). Let r_{ij} be the distance between electron i and electron j; for example, r_{25} is the distance between electron 2 and electron 5. Each electron has a Coulombic Energy Term (a repulsion in this case) with every other electron as follows: 1-2, 1-3, 1-4, 1-5, 1-6, 2-3, 2-4,2-5, 2-6, 3-4, 3-5, 3-6, 4-5- 4-6, 5-6 (a total of 15 repulsion terms. Thus, the total number of Coulombic Potential Energy terms is 21.

ChemActivity 4

1. No. The ionization energy of He would be about 4× (twice the charge and half the distance) the ionization energy of H if this were the case.
2. Open ended. All three electrons at a farther distance (than in H) from the nucleus.

Problem

1. a) $$V = \frac{(+2)(-1)k}{d} + \frac{(+2)(-1)k}{d} + \frac{(-1)(-1)k}{2d}$$

   b) The IE of He is slightly less than twice the IE of H because the electron-electron repulsion makes the potential energy more positive. Note that the first two terms in 1a) are negative and the third term is positive.

ChemActivity 5

1. a) 4. b) 6. c) 5. d) 8.
2. a) +4. b) +6. c) +5. d) +8.
3. The IE of Br should be less than the IE of Cl. There is about a 0.4 MJ/mole difference between the IEs of F and Cl. Prediction: Br, 0.8 MJ/mole.
4. The IE of Li+ should be larger than the IE of He because both atoms have 2 electrons in the 1st shell and Li^+ has a core charge of +3 whereas He only has a core charge of +2.
5. The IE of F^- should be less than the IE of Ne because both atoms have eight electrons in the 2nd shell and F^- has a core charge of +7 whereas Ne has a core charge of +8.
6. IE of Kr > IE of Br because they are in the same valence shell and Kr has the higher core charge (+8 vs. +7). IE of Rb is the lowest because core charge is +1 and its valence shell (n = 5) is larger than the valence shell (n = 4) of Kr and Br.
7. One of the inner shell electrons is harder to remove because it is closer to the nucleus.

Problems

1. a) TRUE. Br is a group VII element. The number of valence electrons is seven.
   b) TRUE. The ionization energies increase as one moves from left to right across a period and as one moves up a group.
2. If the fourth electron in Be were added to a third shell, it would be easier to remove and the IE would be less than the IE of Li.

ChemActivity 6

1. Ar: predict r = 150 pm (larger than K^+ but smaller than Cl^-). N: predict r = 71 pm (larger than O but smaller than C). F^-: predict r = 90 pm (considerably smaller than Cl^-, but *probably* larger than other 2nd period neutral atoms. Ne: predict r = 50 pm (smaller than O).
2. a) False. Both have a core charge of +2 and the valence electrons of Ba are much farther away. b) False. Both have 10 electrons and sodium has more protons. c) True. Both have 18 electrons and chlorine has fewer protons. d) True. A whole shell has been added for Ar. e) False. Ar and Ca^{2+} are isoelectronic and Ca^{2+} has more protons.
3. a) N b) K^+ c) Cl d) H e) Mg^{2+}
4. Fe^{2+}
5. a) Pb b) Na c) Ba^{2+} d) H^- e) Rb f) P^{3-}

Problems

1. Na. The second electron removed would be a core electron.
2. Mg^{2+} is isoelectronic with Ne. Mg^{2+} is smaller than Ne because it has two more protons than Ne. S^{2-} is isoelectronic with Ar. S^{2-} is larger than Ar because Ar has two more protons than S. Ar is larger than Ne. Therefore, S^{2-} is larger than Mg^{2+}.

ChemActivity 7

1. False. The shorter the wavelength, the greater the frequency.
2.

Energy (J)	Wavelength (m)	Frequency (s^{-1})	Region of Spectrum
9.94×10^{-20}	2.00×10^{-6}	1.50×10^{14}	infrared
3.97×10^{-19}	0.500×10^{-6}	6.00×10^{14}	visible
9.94×10^{-19}	2.00×10^{-7}	1.50×10^{15}	ultraviolet
1.99×10^{-16}	1.00×10^{-9}	3.00×10^{17}	X-ray

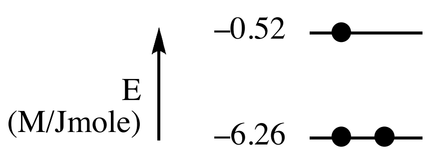
3. A blue photon is more energetic. The energy is inversely proportional to the wavelength.

Problem

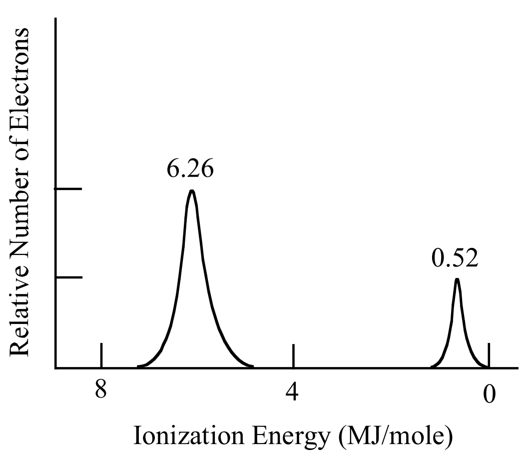
1. No. The energy required to ionize a sodium atom is 8.30×10^{-19} J. A photon with a wavelength of 500 nm has only 3.96×10^{-19} J.

ChemActivity 8

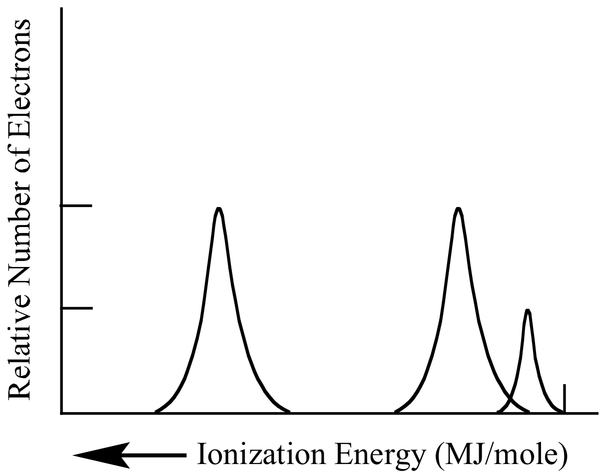
1. 140.3 MJ/mole
2. a)



(b)



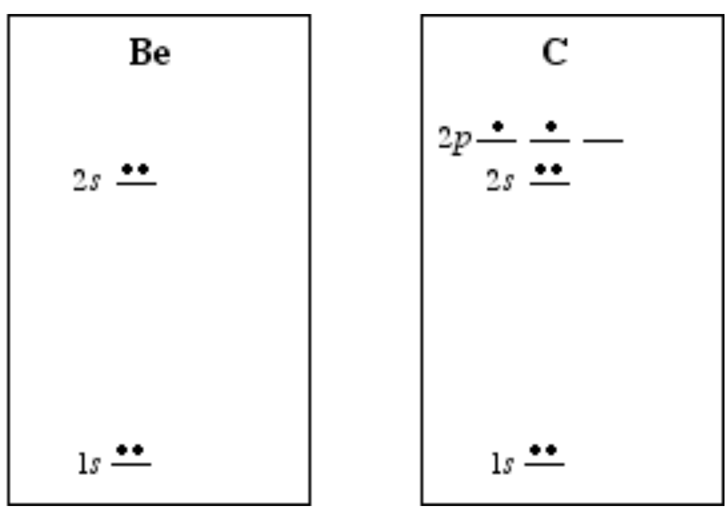
3.



ChemActivity 9

1. a) Two. b) Lower energy peak (1*s*) is 2 x the intensity of the higher energy peak (2*s*). c) The nuclear charge for H, He, and Li is 1, 2, and 3, respectively. Therefore, the electrons in the <u>first</u> shell will be held most tightly by Li and least tightly by H. d) H and Li have the same core charge; the electron is farther away in Li. Therefore, Li will hold its valence electron less tightly than H.
2. Be. Two peaks. Both peaks have the same intensity. C. Three peaks. All three peaks have the same intensity.

3.



4. Mg. Two electrons in the 1*s*. Two electrons in the 2*s*. Six electrons in the 2*p*. Two electrons in the 3*s*.

Problems

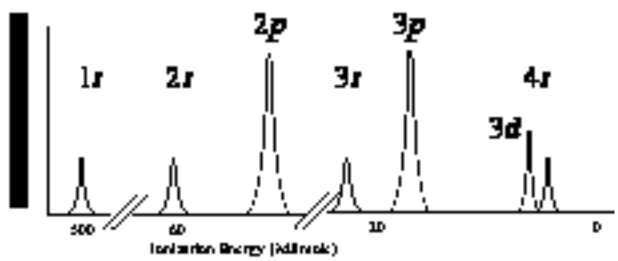
1. a) False. Both have 10 electrons. The number of peaks and the relative intensities will be the same, but the IEs of Mg^{2+} will be greater than the equivalent IEs of Ne. b) True. Both have 17 electrons and 17 protons.

2. 273 MJ/mole. The energy required to remove an electron from the 1*s* of Cl must be much higher than the energy required to remove an electron from the 1*s* of F because Cl has 17 protons in its nucleus and F only has 9 protons in its nucleus.

ChemActivity 10

1. Na has 11 protons in its nucleus and Ne only has 10 protons. Therefore, the 1*s* electrons will be held more tightly in Na.
2. It would require more than 0.50 MJ/mole because Mg^{+1} and Na are isoelectronic and Mg has an additional proton in its nucleus.
3. It would require less than 1.52 MJ/mole because Cl^{-} and Ar are isoelectronic and Cl^{-} has one fewer protons in its nucleus.

ChemActivity 11

1. Kr
2. C<Ne<Zn<Ba<Gd<Pt
3. 

4. P: [Ne] $3s^2\ 3p^3$ P^{3-}: [Ar] Ba: [Xe] 6*s*2 Ba^{2+}: [Xe] S: [Ne] $3s^2\ 3p^4$
   S^{2-}: [Ar] Ni: [Ar] $4s^2\ 3d^8$ Zn: [Ar] $4s^2\ 3d^{10}$
5. three

Problems

1. 5*d*
2. Pd [Kr] $5s^2\ 4d^8$. Pd^{2+} [Kr] $4d^8$. Gd either [Xe] $6s^2\ 5d^1\ 4f^7$ or [Xe] $6s^2\ 4f^8$ is correct (depending on how you use the periodic table to determine electron configurations; experimentally, we find the configuration to be [Xe] $6s^2\ 5d^1\ 4f^7$). Gd^{3+} [Xe] $4f^7$ (regardless of your answer for Gd!).

ChemActivity 12

1. ^{13}C has a small nucleus consisting of 6 protons (positively charged) and 7 neutrons (no charge). ^{13}C has six electrons in shells around the nucleus. Electrons (negatively charged) *1* and *2* are paired (one spin up, one spin down) in the first shell, the 1*s* orbital, which is the shell closest to the nucleus. There are four electrons in the second shell (farther from the nucleus than the 1*s* electrons). Electrons *3* and *4* are paired in the 2*s* orbital. Electron *5* is found in one of the three 2*p* orbitals in the 2*p* subshell. Electron *6* is also found in one of the three 2*p* orbitals, but not the same 2p orbital as electron *5*. Electrons 5 and 6 are unpaired (both have spins in the same direction).
2. a) True. Both have eight electrons. b) False. Si should have the same electron configuration as C, which has two unpaired electrons. c) True. Sulfur has four 2p

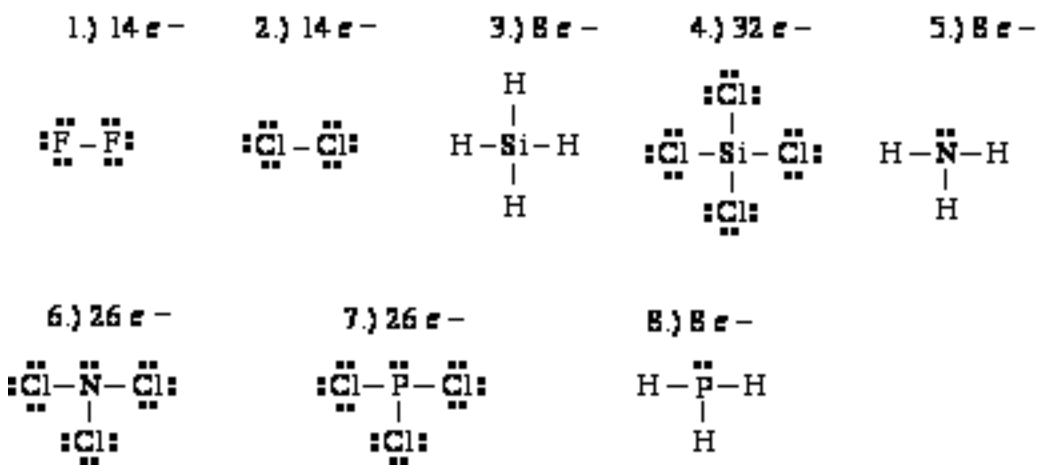
electrons; two are paired and two are unpaired. d) False. Carbon, for example, has 6 electrons and two are not paired.

3. There are three 2*p* orbitals in the 2*p* subshell. Experimental evidence indicates that N has three unpaired electrons.
4. ↑↓ ↑↓ ↑↓ ↑ ↑ Paramagnetic
5. One unpaired electron. Predicted magnetic moment, 1.7 magnetons (same as H).
6. F is smaller than Ar. F^- has no unpaired electrons. F has one unpaired electron and F^+ has two.

Problems

1. Ti (2 unpaired electrons), Na (1 unpaired electron) , Sm (6 unpaired electrons), Sm^{3+}(5 unpaired electrons) Cl (1 unpaired electron).
2. Both have four unpaired electrons.

ChemActivity 13



9. 14, 24, 18, 12, 34, 32, 20,

Problems

1. 72
2. 8
3. 14

ChemActivity 14

1. The C–C double bond is harder to break. Double bonds are stronger than single bonds.
2. The C–C triple bond is harder to break. Triple bonds are stronger than double bonds.
3. The C–N triple bond is harder to break. Triple bonds are stronger than double bonds.
4. The bond energy (in MJ/mole) is the energy required to break one mole of the specified bonds. Triple bonds share six electrons between two atoms and are stronger than double bonds, which share four electrons between two atoms. Single bonds, which share two electrons, are weaker than double bonds.