Monopoly Problems

Andrew Ye and Diva Shah

May 2024

Contents

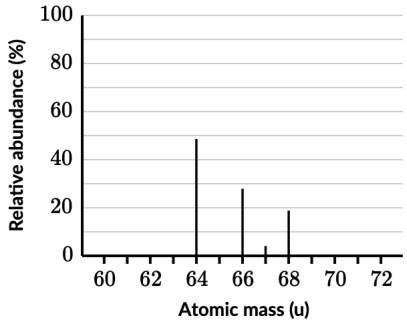
1 Unit 1: Atomic Structure and Properties

Problem 1

Calculate the number of moles in a $7.89kg$ sample of $C_9H_8O_4$

Problem 2

Given this graph, what is true about the element depicted



(a) In an average sample of the element, less than 20% of the atoms have an atomic mass of $66u$.
(b) The most abundant isotope of the element has an atomic mass of $64u$.
(c) The element has an average atomic mass of $64u$.
(d) The element has an average atomic mass between 66 and $68u$.

Problem 3

What is the percent composition of Carbon in $C_{13}H_{18}O_2$?

Problem 4

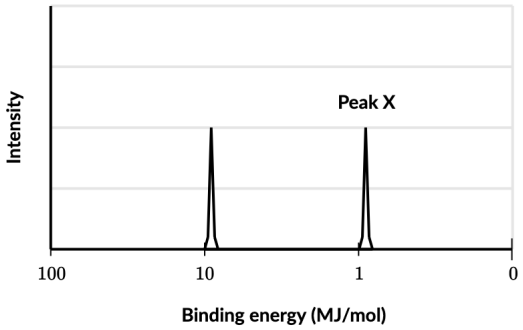
A compound contains 32.38% sodium, 22.65% sulfur, and 44.99% oxygen. What is the emperical forumula.

Problem 5

What is the full electron configuration of mercury?

Problem 6

Below, the photoelectron spectra of the $2s$ electrons of Be and Mg are shown.



Is peak X the peak associated with Be or Mg?

Problem 7

What are the periodic trends of ionization energy, atomic radius, and electronegativity? Why?

2 Unit 2: Molecular and Ionic Compound Structure and Properties

Problem 8

Which of the following bonds is likely to have the most ionic character?
(a) H —— F
(b) C —— O
(c) Na —— F
(d) Mg —— O

Problem 9

Based on the information in the table, which of the following arranges the bonds in order of decreasing polarity?

Element	Electronegativity
H	2.2
N	3.0
F	4.0
Cl	3.2
Se	2.6
I	2.7

(a) Se —— N > H —— I > Cl —— F
(b) H —— I > Se —— N > Cl —— F
(c) Cl —— F > H —— I > Se —— N
(d) Cl —— F > Se —— N > H —— I

Problem 10

Why is the lattice energy of CsF smaller than the lattice energy of KF?

Problem 11

What type of structure do metallic elements form and through what bonds?

Problem 12

What are the two types of metallic alloys and what are there differences?

Problem 13

Draw a Lewis Diagram for Acetic Acid CH_3COOH.

Problem 14

Draw the Lewis Diagram for CO_2

Problem 15

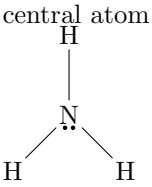
Draw the Lewis Diagram(s) for ozone, O_3

Problem 16

Write the formal charges for all three molecules above.

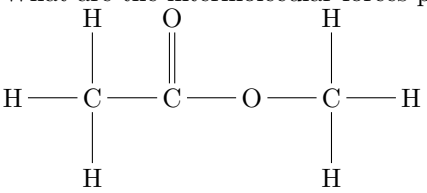
Problem 17

What is the electron geometry, molecular geometry, and hybridization of the central atom in this molecule.



Problem 18

What are the intermolecular forces present among these molecules.



3 Answers

3.1 Unit 1

Problem 1

The molar mass of $C_9H_8O_4$ is $1.008 * 8 + 12.01 * 9 + 16.00 * 4 = 180.2 \frac{g}{mol}$

$$7.89kg \times \frac{1g}{10^{-3}kg} \times \frac{1mol}{180.2g} = 43.8mol \tag{1}$$

Problem 2

(b), the tallest peak of the graph is the one at $64u$.

Problem 3

In one mole of $C_{13}H_{18}O_2$ is $206.31g$.

$$1mol\,C_{13}H_{18}O_2 \times \frac{13mol\,C}{1mol C_{13}H_{18}O_2} \times \frac{12.01g}{1mol\,C} = 156.31g \tag{2}$$

Thus, the percent composition by weight is $\frac{156.31}{206.31} = 75.764\%$

Problem 4

Take $100g$ of the substance such that there are $32.38g$ sodium, $22.65g$ sulfur, and $44.99g$ oxygen.

$$\begin{aligned} 32.38g\,\mathrm{Na} \times \frac{1mol\,\mathrm{Na}}{22.99g} &= 1.408mol\,\mathrm{Na} \\ 22.65\,g\mathrm{S} * \frac{1\,mol\mathrm{S}}{32.07g} &= 0.7063\,mol\mathrm{S} \\ 44.99\,g\mathrm{O} * \frac{1\,mol\mathrm{O}}{16g} &= 2.812\,mol\mathrm{O} \end{aligned} \tag{3}$$

Take the ratio of each compound with the smallest quantity.

$$\begin{aligned} S: \frac{0.7063}{0.7063} &= 1 \\ Na: \frac{1.408}{0.7063} &= 2 \\ O: \frac{2.812}{0.7063} &= 4 \end{aligned} \tag{4}$$

Therefore, the empirical formula is Na_2SO_4

Problem 5

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10}$

Problem 6

Be. The peak location of the peak on the x-axis means that there is less binding energy for the electrons in element X. Be has fewer protons and both electrons are in the same shell, so it peak must belong to Be.

Problem 7

- The electronegativity increases from left to right across a period. This is because if a valence shell of electrons is less than half full than it requires less energy to lose an electron than gain one. If if the valence shell of electrons is more than half full, it is easier to pull and electron into the valence shell. The electronegativity decreases from the top to the bottom of a group. This is beause there is a greater atomic radius lower on the group.
- The ionization energy increases from left to right in a period. This is because of greater valence shell stability also because of smaller atomic radius. The ionization energy also decreases from top to bottom of a group. This is because of greater electron shielding and greater atomic radius.
- Atomic radius decreases from left to right within a period. This is because there are more protons to the right of the period. Atomic radius increases from top to bottom within a group. This is because of electron shielding and there are more electron shells in the atom.

3.2 Unit 2

Problem 8

The ionic character increase the greater the electronegativity difference. In this case, Na and O had the greatest electronegativity difference.

Problem 9

(c) Cl —— F > H —— I > Se —— N

Problem 10

Cs^+ has a larger atomic radius than K^+. So the distance between the cation and anion is greater than in CsF than in KF

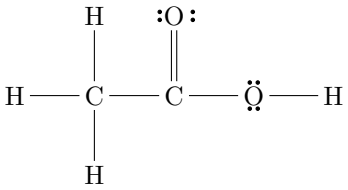
Problem 11

Most metallic elements form crystalline solids at room temperature. Their bonds are metallic bonds due to electrostatic attraction between metal cations and delocalized electrons.

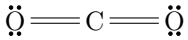
Problem 12

- Substitutional alloys. These alloys form when one atom of a similar size to the host metal replaces an atom of the host metal. The substitute atom must be of similar size. These alloys have good thermal and electrical conductivity.
- Interstitial alloys. These alloys are formed when smaller atoms fill in the gaps between the larger host atoms. This makes the metal harder and less malleable.

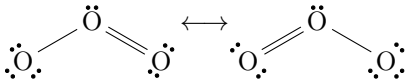
Problem 13



Problem 14

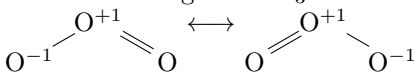


Problem 15



Problem 16

All formal charges of CH_3COOH and CO_2 are zero.



Problem 17

The electron geometry is tetrahedral. The molecular geometry is trigonal pyramidal. Hybridization of N atom is sp^3 since it has tetrahedral electron geometry.

Problem 18

Dipole-diple and london dispersion forces. The C —— O bond is polar and the molecule is asymmetrical so it is polar. There are no H —— F, H —— O, or H —— N bonds.