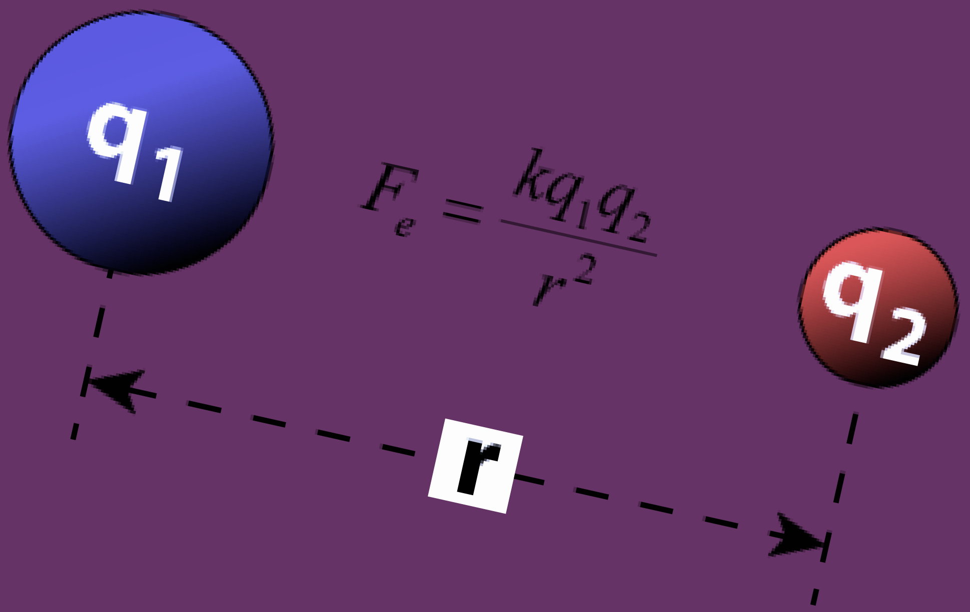
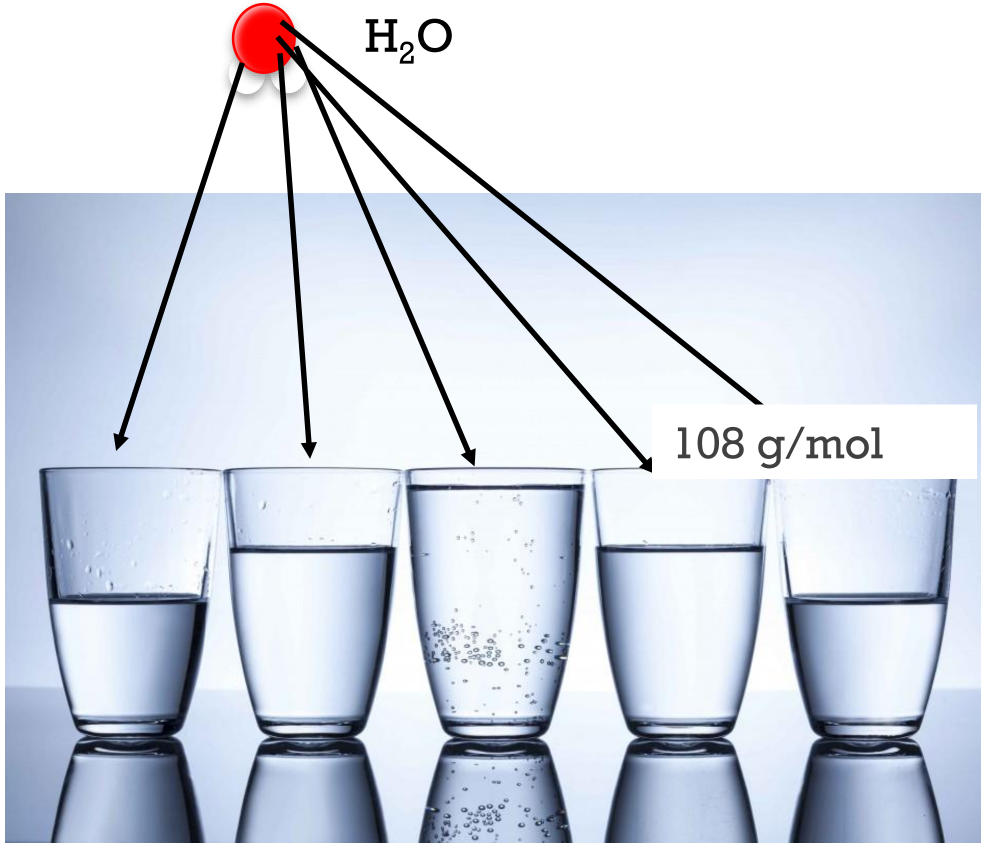


+

Big Idea #1
Properties of Matter

Source

Ratio of Masses in a Pure Sample



- All elements and molecules are made up of atoms
- Substances with the same atomic makeup will have same average masses
- The ratio of masses of the same substance is independent of size of the substance
- Molecules with the same atomic makeup (ex: H_2O) will have the same ratio of average atomic masses
  - H_2O_2 ratio would be different than H_2O due to the different chemical makeup

Video

LO 1.1: Justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory.

Source

+ # Ratio of Masses in a Pure Sample

1) A 4.5 gram sample of which of the following would have the greatest mass percent of oxygen?

A. Na_2O (molar mass = 62 g/mol)
B. Li_2O (molar mass = 30 g/mol)
C. MgO (molar mass = 40 g/mol)
D. SrO (molar mass = 104 g/mol)

Click reveals answer and explanation.

Video

LO 1.1: Justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory.

Source

+ Ratio of Masses in a Pure Sample

1) A 4.5 gram sample of which of the following would have the greatest mass percent of oxygen?

A. Na_2O (molar mass = 62 g/mol)
B. Li_2O (molar mass = 30 g/mol)
C. MgO (molar mass = 40 g/mol)
D. SrO (molar mass = 104 g/mol)

Answer:

A. 16/62 x 100 = 26 %
B. 16/30 x 100 = 53%
C. 16/40 x 100 = 40%
D. 16/104 x 100 = 15%

Video

LO 1.1: Justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory.

[Source]

Composition of Pure Substances and/or Mixtures

- Percent mass can be used to determine the composition of a substance
  - % mass can also be used to find the empirical formula
- The empirical formula is the simplest formula of a substance
  - It is a ratio between the moles of each element in the substance
  - Quick steps to solve!
    - % to mass, mass to moles, divide by the smallest and multiply 'til whole!)
  - The molecular formula is the actual formula of a substance
    - It is a whole number multiple of the empirical formula

[Video]

LO 1.2: Select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures.

Source

Composition of Pure Substances

2)

Question:

A compound is determined to contain 14g nitrogen and 32g of oxygen. The empirical formula of the compound is

a. NO
b. N_2O
c. NO_2
d. NO_3
e. N_2O_6

Click reveals answer and explanation.

LO 1.2: Select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures.

Source

Composition of Pure Substances

2)

Question:
A compound is determined to contain 14g nitrogen and 32g of oxygen. The empirical formula of the compound is

a. NO
b. N_2O
c. NO_2
d. NO_3
e. N_2O_6

Answer:
The correct answer is "c", NO_2. 14g of nitrogen would be 1 mol of nitrogen (14g / 14g mol^{-1}) while 32g of oxygen would be 2 mol of oxygen (32g / 16g mol^{-1}). Therefor the empirical formula should have a ratio of 2 oxygens for every 1 nitrogen, NO_2.

LO 1.2: Select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures.

Source

+

Identifying Purity of a Substance

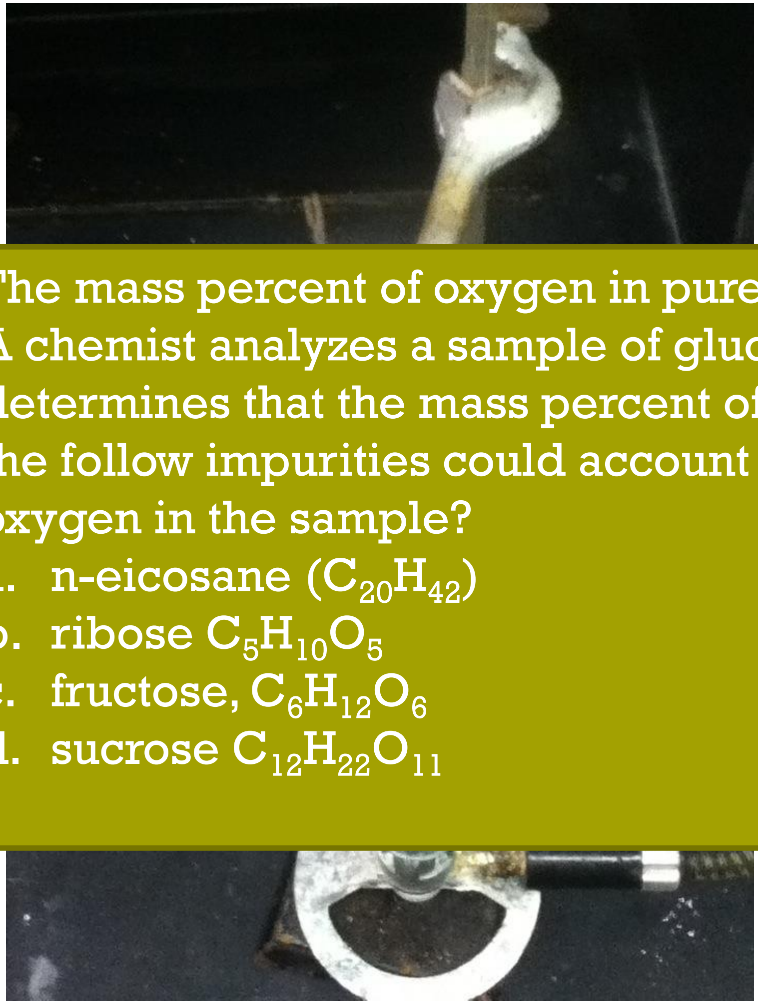
- Impurities in a substance can change the percent composition by mass
- If more of a certain element is added from an impurity, then the percent mass of that element will increase and vice versa
- When heating a hydrate, the substance is heated several times to ensure the water is driven off
  - Then you are simply left with the pure substance and no excess water

Video

LO 1.3: The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance.

Source

Identifying Purity of a Substance



- Impurities in a substance can change the percent composition by mass
- If more of a certain element is

excess water

Video

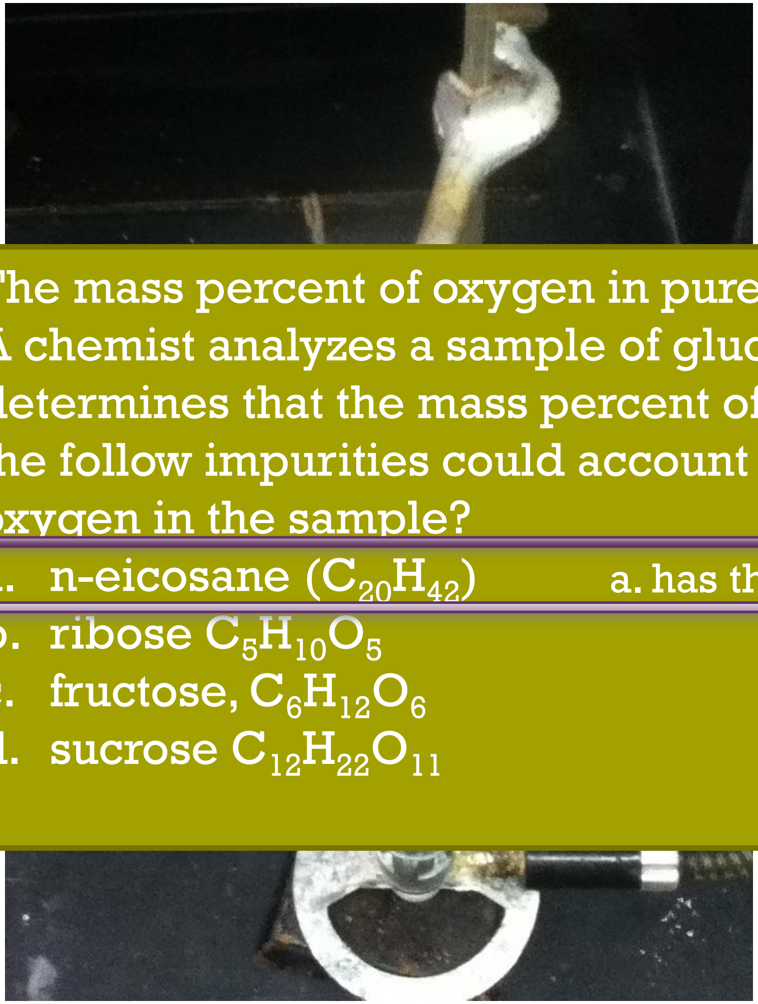
3) The mass percent of oxygen in pure glucose, $C_6H_{12}O_6$ is 53.3 percent. A chemist analyzes a sample of glucose that contains impurities and determines that the mass percent of oxygen is 49.7 percent. Which of the follow impurities could account for the low mass percent of oxygen in the sample?

a. n-eicosane ($C_{20}H_{42}$)
b. ribose $C_5H_{10}O_5$
c. fructose, $C_6H_{12}O_6$
d. sucrose $C_{12}H_{22}O_{11}$

LO 1.3: The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance.

[Source](#)

+ Identifying Purity of a Substance



- Impurities in a substance can change the percent composition by mass [Video](#)
- If more of a certain element is ... en ... ice ... e ... with ... o ... excess water

3) The mass percent of oxygen in pure glucose, $C_6H_{12}O_6$ is 53.3 percent. A chemist analyzes a sample of glucose that contains impurities and determines that the mass percent of oxygen is 49.7 percent. Which of the follow impurities could account for the low mass percent of oxygen in the sample?

a. n-eicosane ($C_{20}H_{42}$) — a. has the lowest percent by mass of O
b. ribose $C_5H_{10}O_5$
c. fructose, $C_6H_{12}O_6$
d. sucrose $C_{12}H_{22}O_{11}$

LO 1.3: The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance.

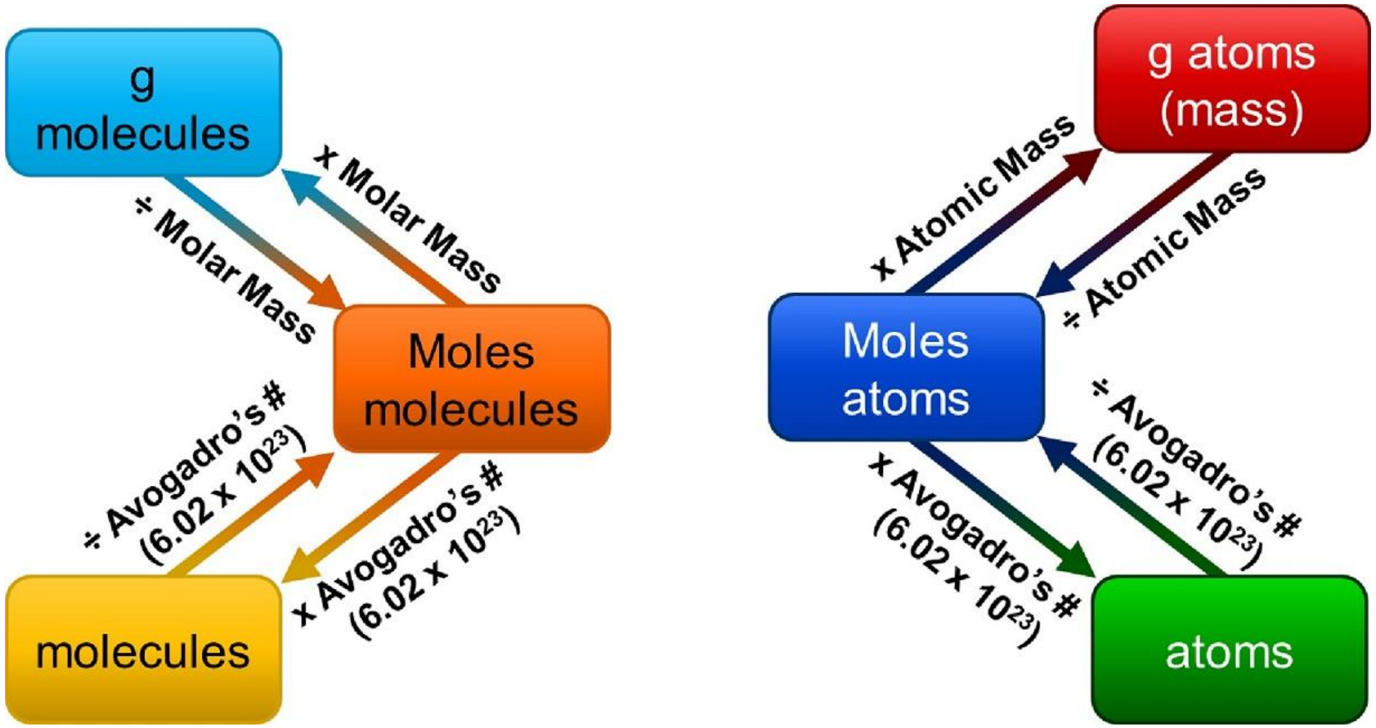
Source

+

Mole Calculations

- 1 mole = 6.02×10^{23} representative particles
- 1 mole = molar mass of a substance
- 1 mole = 22.4 L of a gas at STP

Video



LO 1.4: The student is able to connect the number of particles, moles, mass and volume of substances to one another, both qualitatively and quantitatively.

Source

Mole Calculations

4) How many moles of carbon are in 88 grams of propane, C_3H_8?

A. 2.0
B. 16.0
C. 6.0
D. 96.0

Click reveals answer and explanation.

LO 1.4: The student is able to connect the number of particles, moles, mass and volume of substances to one another, both qualitatively and quantitatively.

Mole Calculations

Source

4) How many moles of carbon are in 88 grams of propane, C_3H_8?

A. 2.0
B. 16.0
C. 6.0
D. 96.0

Answer: C

Propane has a molar mass of 44, therefore there are 2 moles of propane (88 g/ 44g/mol)

There are 3 moles of carbon in 1 mole of propane, so 2 * 3 = 6 moles of C.

LO 1.4: The student is able to connect the number of particles, moles, mass and volume of substances to one another, both qualitatively and quantitatively.

+

Electronic Structure of the Atom: Electron Configurations

[Source](#)

Electron Configurations

	At #	Increasing Energy → 1s	2s	2p	3s	Electron Configuration
H	1	↑				$1s^1$
He	2	↑↓				$1s^2$
Li	3	↑↓	↑			$1s^22s^1$
Be	4	↑↓	↑↓			$1s^22s^2$
B	5	↑↓	↑↓	↑ | |		$1s^22s^22p^1$
C	6	↑↓	↑↓	↑ | ↑ |		$1s^22s^22p^2$
N	7	↑↓	↑↓	↑ | ↑ | ↑		$1s^22s^22p^3$
O	8	↑↓	↑↓	↑↓ | ↑ | ↑		$1s^22s^22p^4$
F	9	↑↓	↑↓	↑↓ | ↑↓ | ↑		$1s^22s^22p^5$
Ne	10	↑↓	↑↓	↑↓ | ↑↓ | ↑↓		$1s^22s^22p^6$
Na	11	↑↓	↑↓	↑↓ | ↑↓ | ↑↓	↑	$1s^22s^22p^63s^1$ ([Ne]$3s^1$)
Mg	12	↑↓	↑↓	↑↓ | ↑↓ | ↑↓	↑↓	$1s^22s^22p^63s^2$ ([Ne]$3s^2$)

- Electrons occupy orbitals whose energy level depends on the nuclear charge and average distance to the nucleus
- Electron configurations & orbital diagrams indicate the arrangement of electrons with the lowest energy (most stable):
  - Electrons occupy lowest available energy levels
  - A maximum of two electrons may occupy an energy level
    - Each must have opposite spin (±½)
  - In orbitals of equal energy, electrons maximize parallel unpaired spins

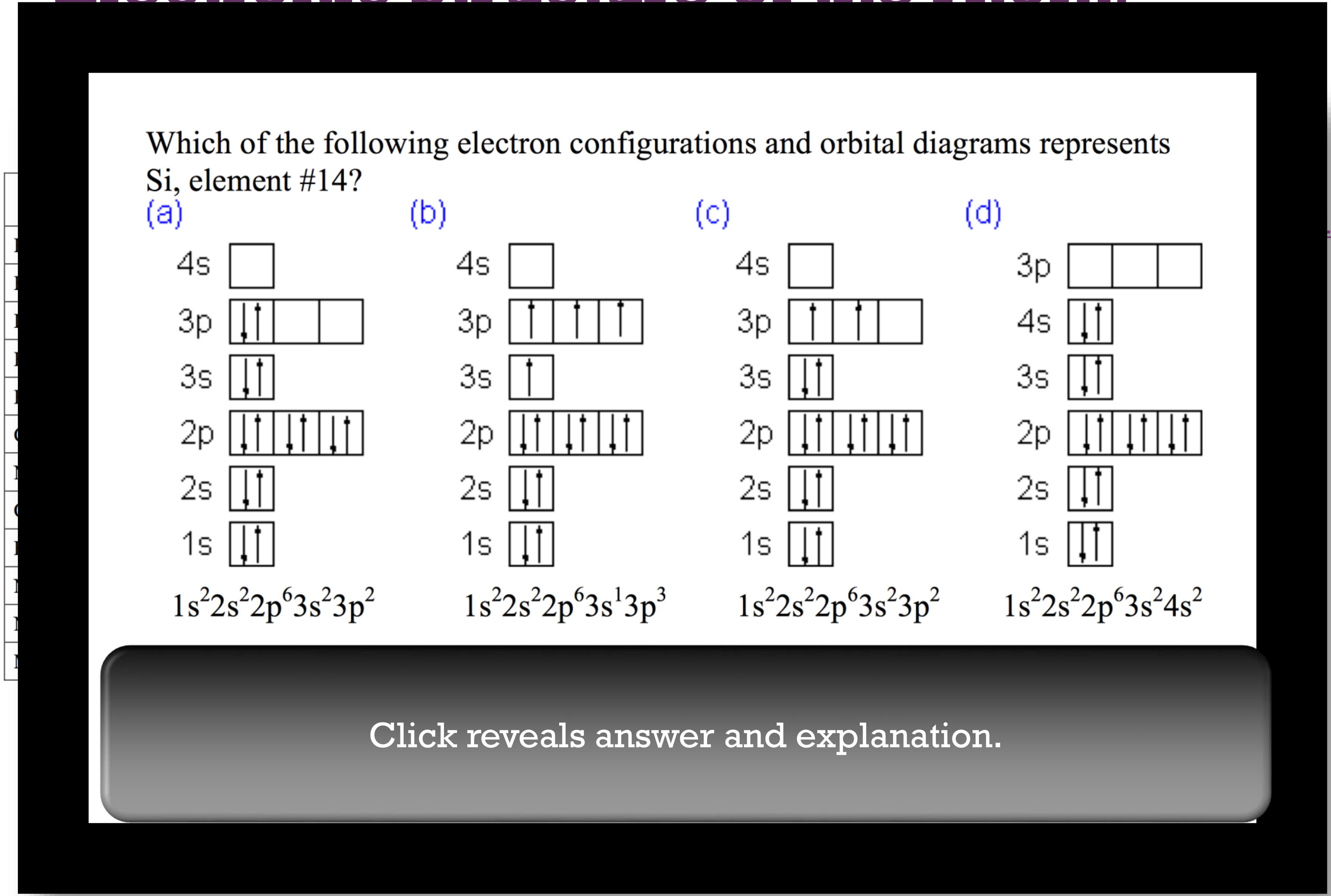
[Video](#)

LO 1.5: The student is able to explain the distribution of electrons in an atom or ion based upon data.

Source

+ Electronic Structure of the Atom:

5)



LO 1.5: The student is able to explain the distribution of electrons in an atom or ion based upon data.

+

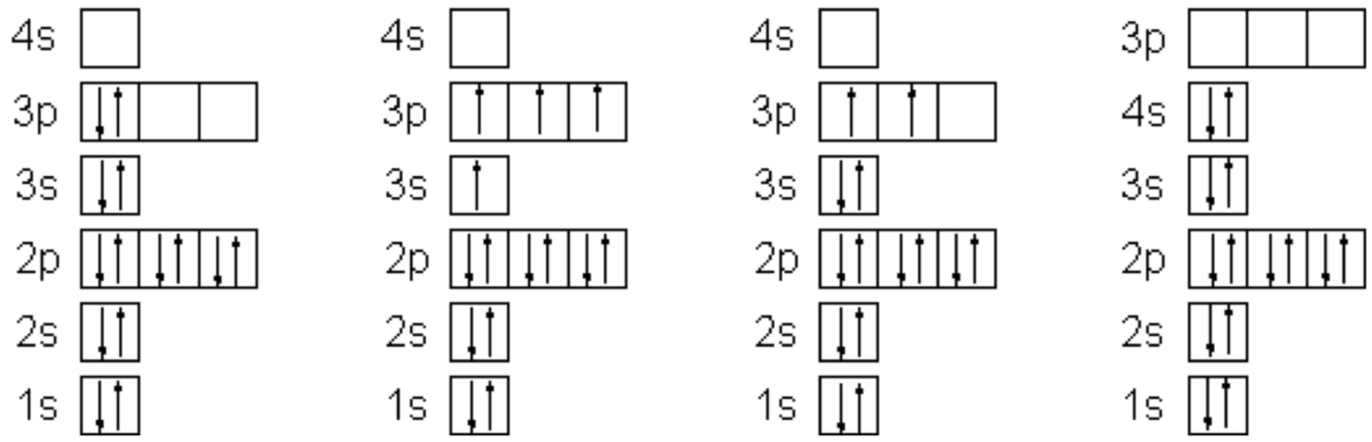
Source

Electronic Structure of the Atom:

5)

Which of the following electron configurations and orbital diagrams represents Si, element #14?

(a) (b) (c) (d)



(a) $1s^2 2s^2 2p^6 3s^2 3p^2$ (b) $1s^2 2s^2 2p^6 3s^1 3p^3$ (c) $1s^2 2s^2 2p^6 3s^2 3p^2$ (d) $1s^2 2s^2 2p^6 3s^2 4s^2$

Answer: C. The 11th & 12th electrons occupy the 3s orbital, and the last two electrons occupy the 3p orbitals, and to maximize the unpaired parallel spins, they must individually occupy different 3p orbitals.

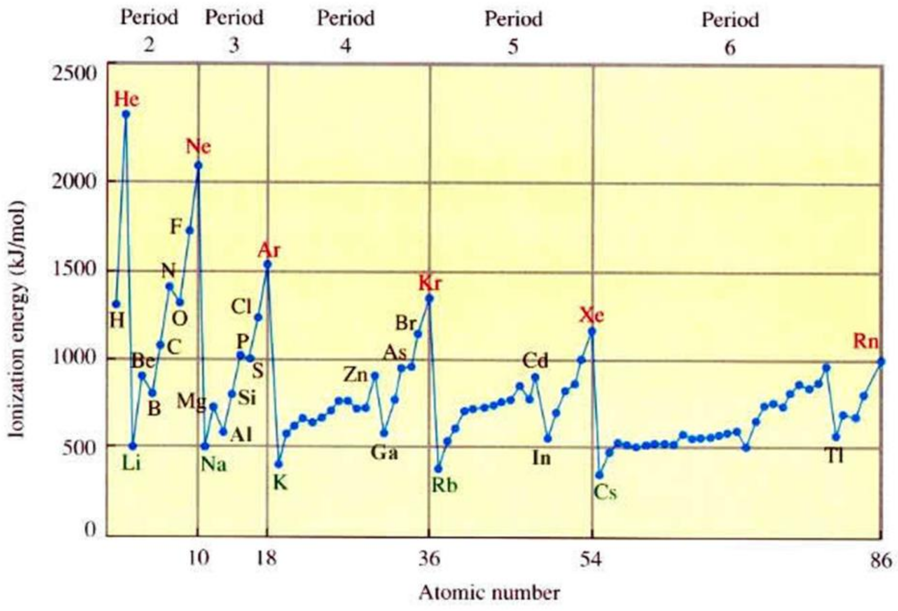
.eo

LO 1.5: The student is able to explain the distribution of electrons in an atom or ion based upon data.

+

Electronic Structure of the Atom: 1st Ionization Energy

Source



- 1st Ionization Energy (IE) indicates the strength of the coulombic attraction of the outermost, easiest to remove, electron to the nucleus:

Video

$$X(g) + IE \longrightarrow X^{+}(g) + e^{-}$$

- 1st IE generally increases across a period and decreases down a group
  - IE generally increases as #protons increases in same energy level
  - IE decreases as e^{-} in higher energy level: increased shielding, e^{-} farther from nucleus

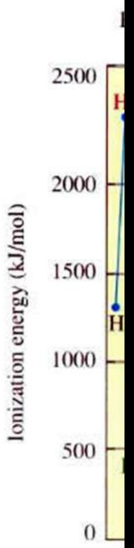
LO 1.6: The student is able to analyze data relating to electron energies for patterns and relationships.

Source

+

Electronic Structure of the Atom: 1^{st} Ionization Energy

6)



Which of the following groups of elements is arranged correctly in order of increasing first ionization energy?

A. $Mg < C < N < F$

B. $N < Mg < C < F$

C. $Mg < N < C < F$

D. $F < C < Mg < N$

Click reveals answer and explanation.

deo

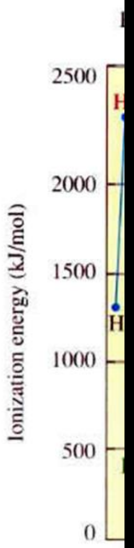
shielding, e^- farther from nucleus

LO 1.6: The student is able to analyze data relating to electron energies for patterns and relationships.

Source

Electronic Structure of the Atom: 1st Ionization Energy

6)



Which of the following groups of elements is arranged correctly in order of increasing first ionization energy?

A. Mg < C < N < F

B. N < Mg < C < F

C. Mg < N < C < F

D. F < C < Mg < N

Answer: A. Within the 2nd period, increasing nuclear charge from C – N – F increases the coulombic attraction of the electrons to the nucleus. Mg has a lower IE than its 2nd period counterpart, Be, since its valence electrons are in a higher energy level that is better shielded, so its 1st IE must also be lower than that of C.

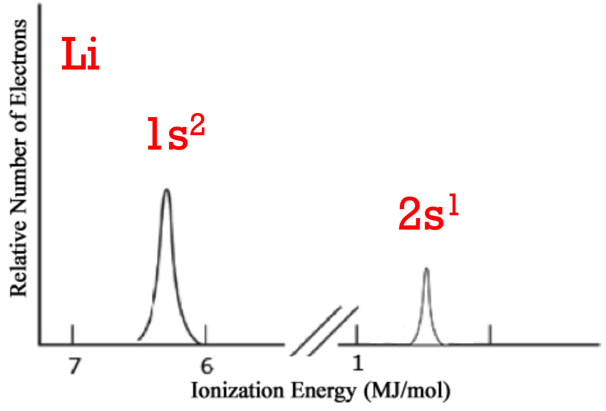
deo

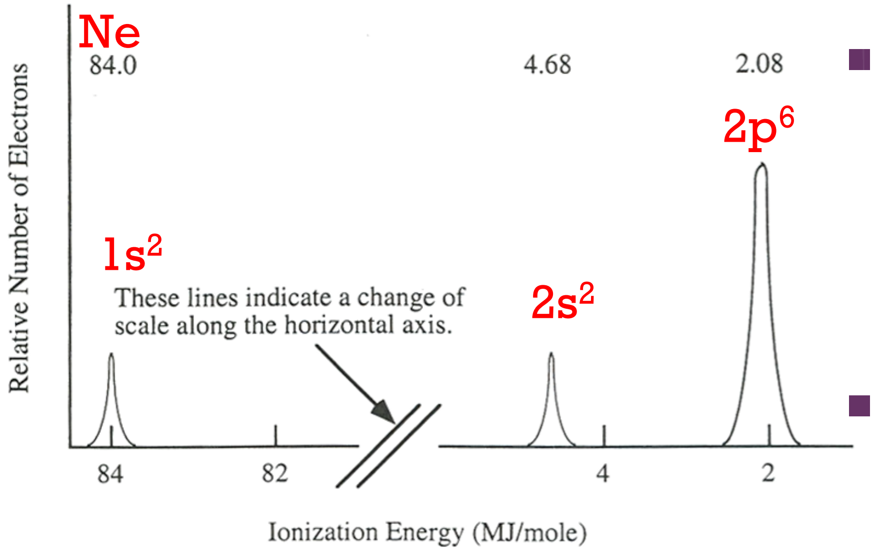
shielding, e⁻ farther from nucleus

LO 1.6: The student is able to analyze data relating to electron energies for patterns and relationships.

Source

Electronic Structure of the Atom: Photoelectron Spectroscopy (PES)





- PES uses high-energy (X-ray) photon to excite *random* e^- from atom
- KE of ejected electron indicates *binding energy* (coulombic attraction) to nucleus:

$$BE = h\varpi_{photon} - KE$$

- Direct measurement of energy and number of each electron
  - Lower energy levels have higher BE
  - Signal size proportional to number of e^- in energy level
- Elements with more protons have stronger coulombic attraction, higher BE at each energy level

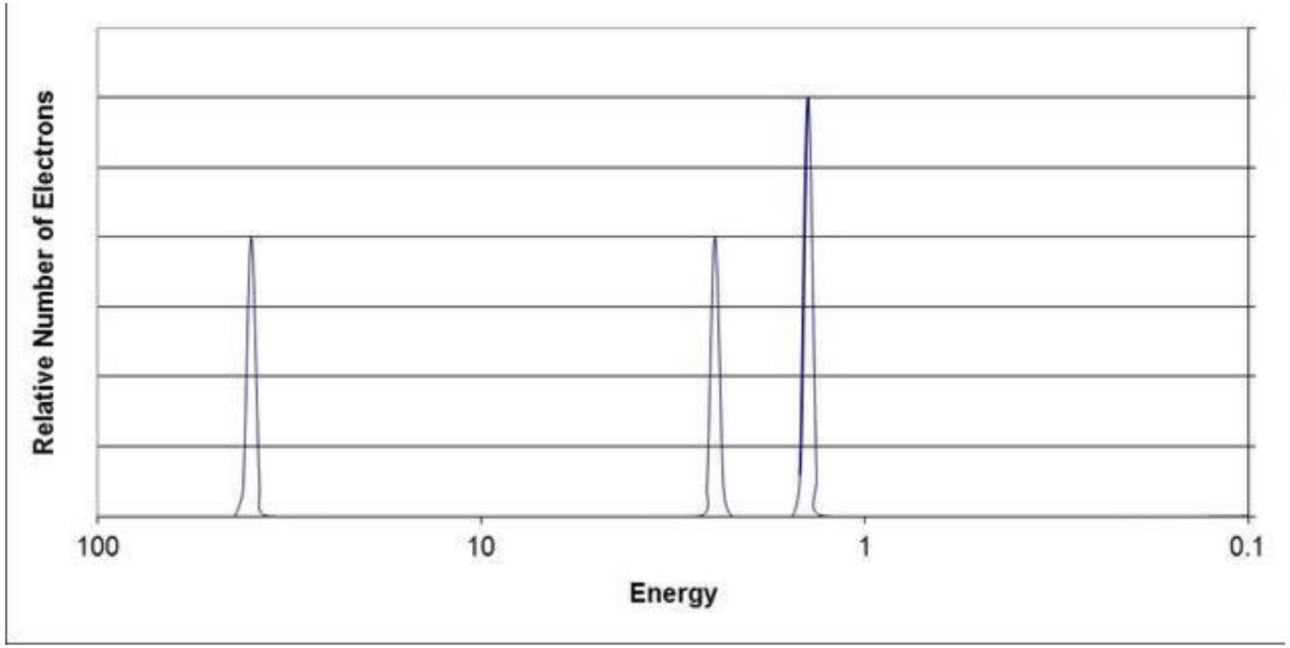
Video

LO 1.7: The student is able to describe the electronic structure of the atom, using PES data, ionization energy data, and/or Coulomb's law to construct explanations of how the energies of electrons within shells in atoms vary.

[Source](#)

+

7)



Which element could be represented by the complete PES spectrum above?

A. Li B. B C. N D. O E. Ne

Click reveals answer and explanation.

leo

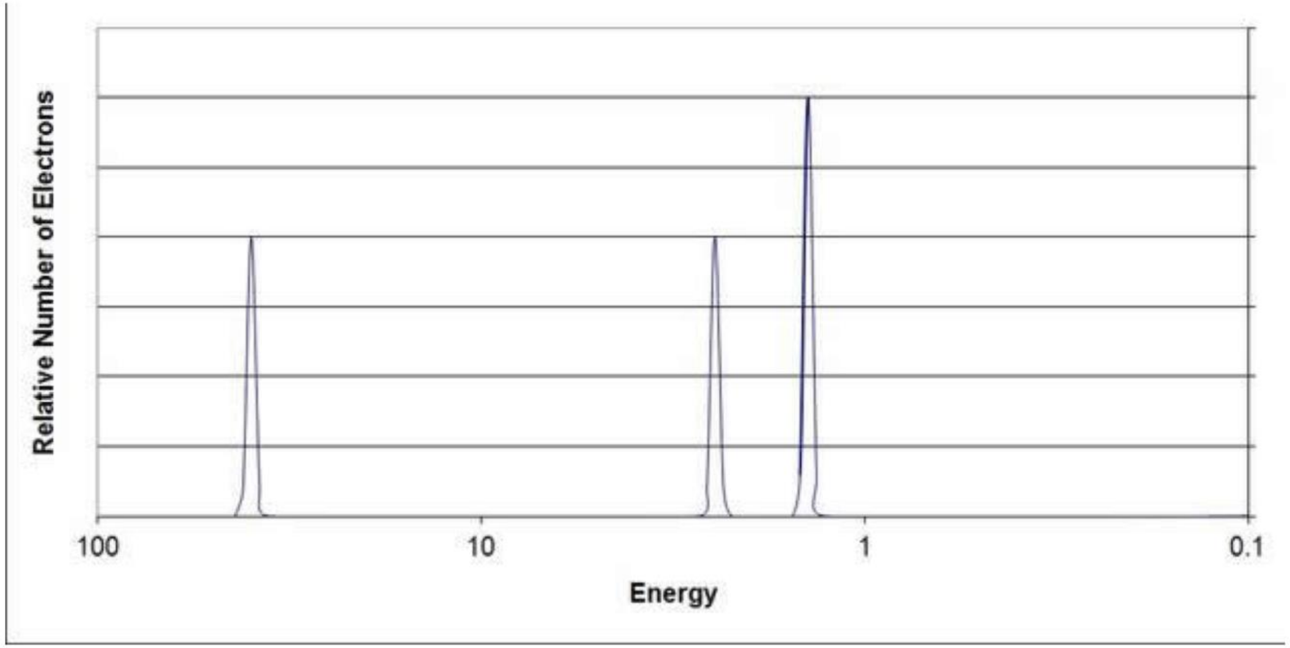
LO 1 … PES

data … ow

the energies of electrons within shells in atoms vary.

Source

7)



Which element could be represented by the complete PES spectrum above?

A. Li B. B C. N D. O E. Ne

Answer: C. The first peak at about 60 (units are MJ/mol) represents the two 1s electrons, the second peak is the two 2s electrons, and the third peak represents three 2p electrons.

eo

LO 1 [redacted] PES data [redacted] ow the energies of electrons within shells in atoms vary.

+

[Source]

Electronic Structure of the Atom: Higher Ionization Energies

Ionization Energies (kJ/mol)

	1st	2nd	3rd	4th	5th	6th	7th	8th
H	1312							
He	2372	5250						
Li	520	7297	11810					
Be	899	1757	14845	21000				
B	800	2426	3659	25020	32820			
C	1086	2352	4619	6221	37820	47260		
N	1402	2855	4576	7473	9442	53250	64340	
O	1314	3388	5296	7467	10987	13320	71320	84070
F	1680	3375	6045	8408	11020	15160	17860	92010
Ne	2080	3963	6130	9361	12180	15240	20000	23070
Na	496	4563	6913	9541	13350	16600	20113	25666
Mg	737	1450	7731	10545	13627	17995	21700	25662

Inner Core Electrons

- 2^{nd} & subsequent IE's increase as coulombic attraction of remaining e^-'s to nucleus increases

$$X^+ + IE \longrightarrow X^{2+} + e^-$$

$$X^{2+} + IE \longrightarrow X^{3+} + e^-$$

- Large jump in IE when removing less-shielded core electrons

[Video]

LO 1.8: The student is able to explain the distribution of electrons using Coulomb's law to analyze measured energies.

Source

Electronic Structure of the Atom: Higher Ionization Energies

8)

H
He
Li
Be
B
C
N
O
F
Ne
Na
Mg

deo

Ionization Energies for element X (kJ mol^{-1})				
First	Second	Third	Fourth	Five
1086	2352	4619	6221	37820

The ionization energies for element X are listed in the table above. On the basis of the data, element X is most likely to be

A. Li B. Be C. B D. C E. P

Click reveals answer and explanation.

LO 1.8: The student is able to explain the distribution of electrons using Coulomb's law to analyze measured energies.

Source

Electronic Structure of the Atom: Higher Ionization Energies

8)

deo

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The ionization energies for element X are listed in the table above. On the basis of the data, element X is most likely to be

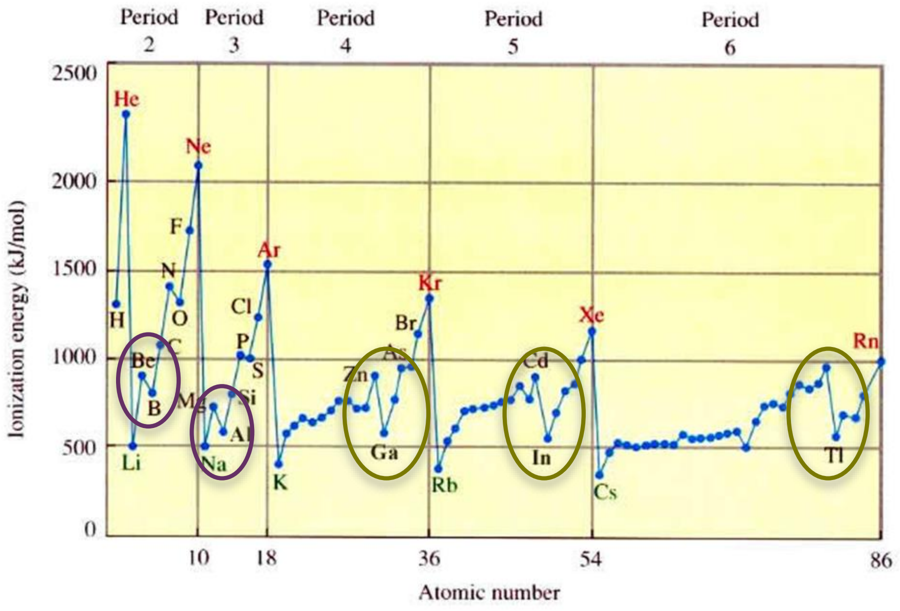
A. Li B. Be C. B D. C E. P

Answer: D. There is a large increase in IE from IE_4 to IE_5, indicating that the element has 4 valence electrons and is in group IVA. Carbon is the only listed element in group IVA.

LO 1.8: The student is able to explain the distribution of electrons using Coulomb's law to analyze measured energies.

Source

Electronic Structure of the Atom: 1st Ionization Energy Irregularities



- 1st Ionization Energy Energy (IE) decreases from Be to B and Mg to Al
  - Electron in 2p or 3p shielded by $2s^2$ or $3s^2$ electrons, decreasing coulombic attraction despite additional proton in nucleus.
  - Same effect seen in $3d^{10}$-4p, $4d^{10}$-5p and $5d^{10}$-6p
- 1st Ionization Energy decreases from N to O and P to S
  - np^4 contains first paired p electrons, e^--e^- repulsion decreases coulombic attraction despite additional proton

Video

LO 1.8: The student is able to explain the distribution of electrons using Coulomb's law to analyze measured energies.

Source

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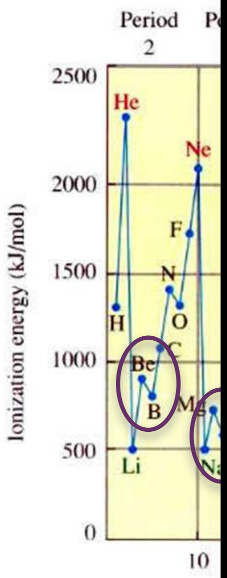

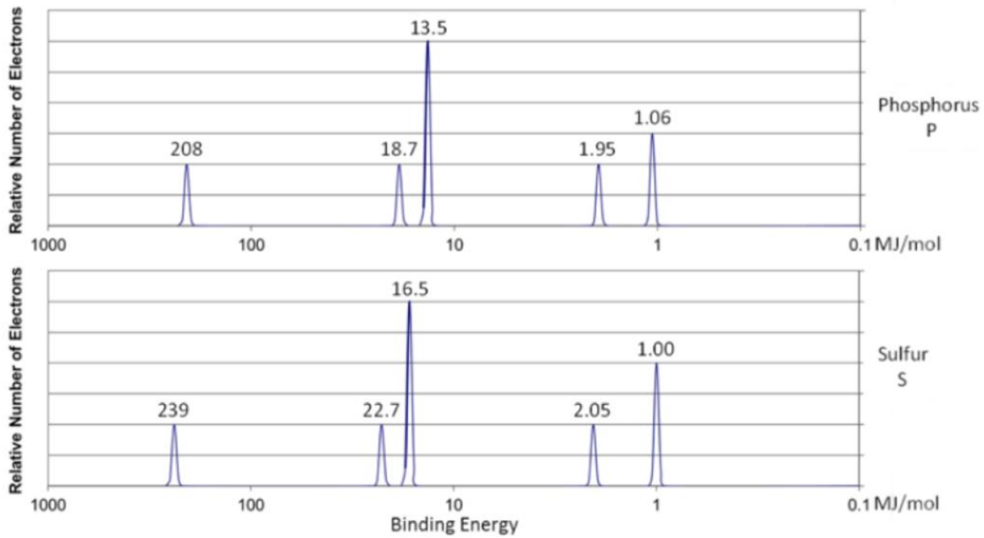

Given the photoelectron spectra above for phosphorus, P, and sulfur, S, which of the following best explains why the 2p peak for S is further to the left than the 2p peak for P, but the 3p peak for S is further to the right than the 3p peak for P?

A. S has a greater effective nuclear charge than P, and the 3p sublevel in S has greater electron repulsions than in P.
B. S has a greater effective nuclear charge than P, and the 3p sublevel is more heavily shielded in S than in P.
C. S has a greater number of electrons than P, so the third energy level is further from the nucleus in S than in P.
D. S has a greater number of electrons than P, so the Coulombic attraction between the electron cloud and the nucleus is greater in S than in P.

Click reveals answer and explanation.

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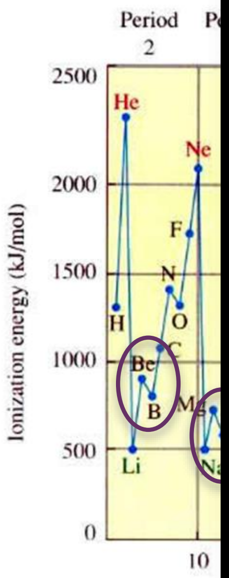

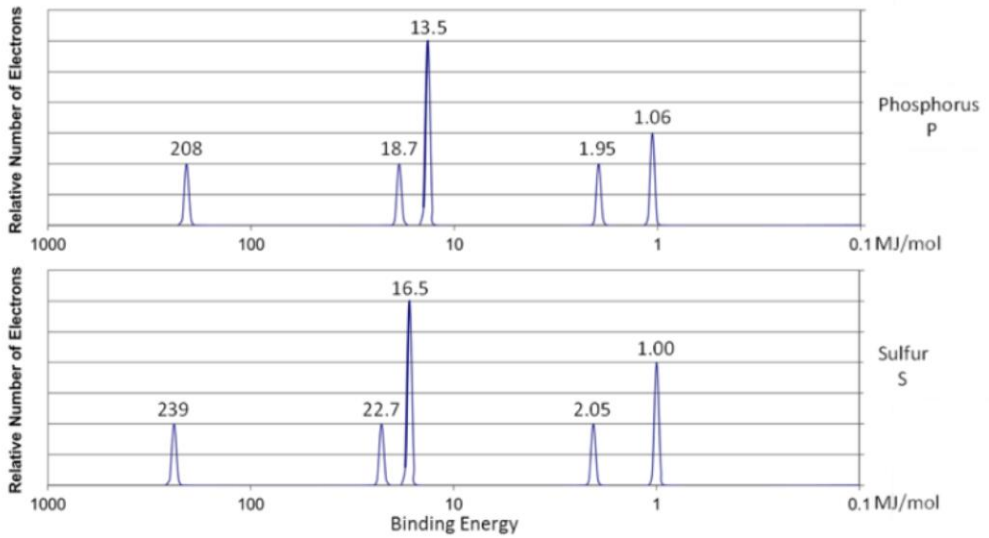

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B. S has a greater effective nuclear charge than P, and the 3p sublevel is more heavily shielded in S than in P.
C. S has a greater number of electrons than P, so the third energy level is further from the nucleus in S than in P.
D. S has a greater number of electrons than P, so the Coulombic attraction between the electron cloud and the nucleus is greater in S than in P.

Answer: A. S has one more proton than P, so a higher effective nuclear charge. However, due to the $3p^4$ configuration of S, it experiences e^--e^- repulsion due to the paired 3p electrons that are not present in the $3p^3$ configuration of P. This reduces the coulombic attraction of the 3p electrons of S to the nucleus, so it has a lower BE.

E)

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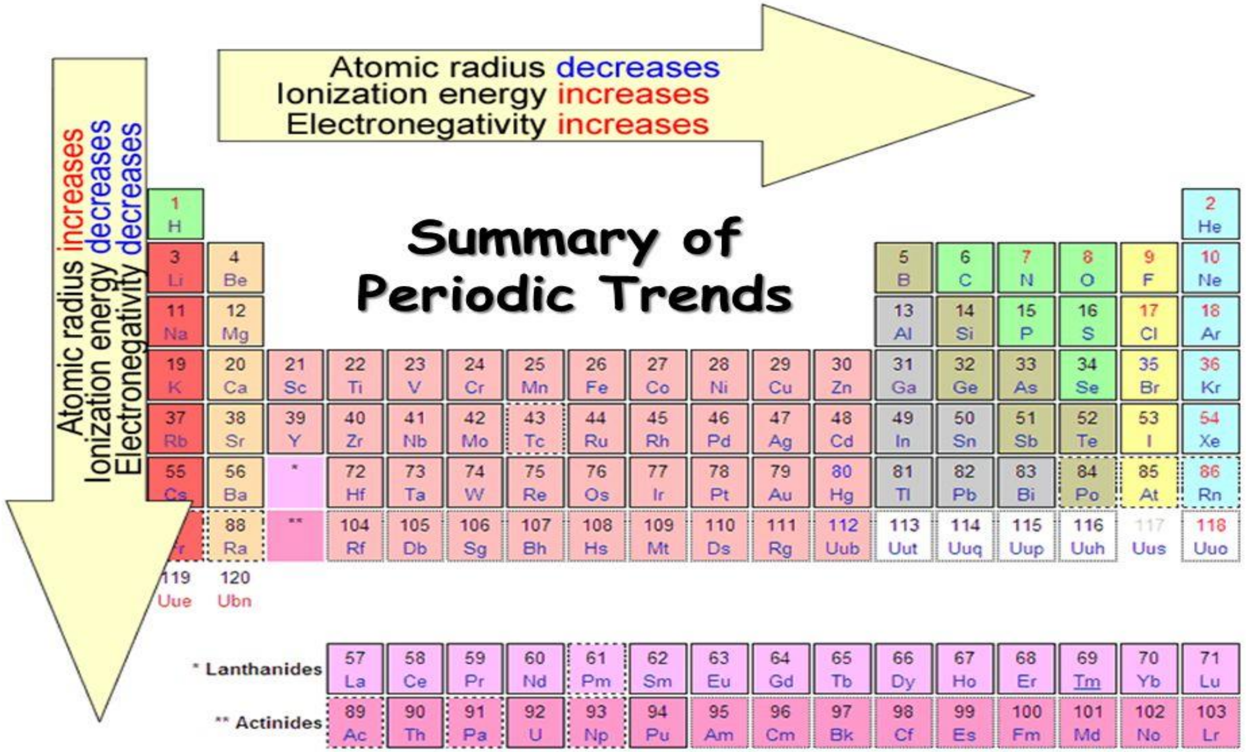
LO 1.8: The ... aw to analyze mea...

Predictions with Periodic Trends

+

Sources



Video

Coulomb's Law – Gives the electric force between two point charges.

$$F = k\frac{q_1 q_2}{r^2}$$

Inverse Square Law

k = Coulomb's Constant = 9.0×10^9 Nm^2/C^2

q_1 = charge on mass 1

q_2 = charge on mass 2

r = the distance between the two charges

The electric force is much stronger than the gravitational force.

- The following explains these trends:
  - Electrons attracted to the protons in the nucleus of an atom
    - So the closer an electron is to a nucleus, the more strongly it is attracted (Coulomb's law)
    - The more protons in a nucleus (effective nuclear force), the more strong its attracts electrons

attracts

  - Electrons are repelled by other electrons in an atom. If valence electrons are shielded from nucleus by other electrons, you will have less attraction of the nucleus (again Coulomb's law-greater the atomic radius, the greater the distance)

L.O. 1.9 The student is able to predict and/or justify trends in atomic properties based on location on periodic table and/or the shell model

10)

Question:

Given the atomic radius and first ionization energy of sodium in the chart below which pair of values would be the most likely values for magnesium?

Elements	First ionization Energy (kJ/mol)	Atomic Radius (pm)
Sodium	495.8	180
Magnesium		

a. 737.7 kJ/mol, 150 pm
b. 737.7 kJ/mol, 200 pm
c. 290.4 kJ/mol, 150 pm
d. 290.4 kJ/mol, 200 pm

law)

- The more protons in a nucleus (effective nuclear force), the more strong its attracts electrons

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b's law)

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  attracts

- Electrons are repelled by other electrons in an atom. If valence electrons are shielded from nucleus by other electrons, you will have less attraction of the nucleus (again Coulomb's law-greater the atomic radius, the greater the distance)

L.O. 1.9 The student is able to predict and/or justify trends in atomic properties based on location on periodic table and/or the shell model

Source

Chemical Reactivity

- **Using Trends**
- Nonmetals have higher electronegativities than metals --> causes the formation of ionic solids
- Compounds formed between nonmetals are **molecular**
  - Usually gases, liquids, or volatile solids at room temperature
- Elements in the 3rd period and below can accommodate a larger number of bonds
- The first element in a group (upper most element of a group) forms pi bonds more easily (most significant in 2nd row, non-metals)
  - Accounts for stronger bonds in molecules containing these elements
  - Major factor in determining the structures of compounds formed from these elements
- Elements in periods 3-6 tend to form only single bonds
- Reactivity tends to increase as you go down a group for metals and up a group for non-metals.

Video

L.O. 1.10: Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity

Source

Chemical Reactivity

11)

- **Using Trends**
- Nonmetals ha … --> causes the fo …
- Compounds … r
  - Usually gase … e
- Elements in t … e a larger numbe …
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  - Accounts fo … elements
  - Major facto … rmed from these e …

Of the elements below, __________ reacts the most quickly with water.

A) sodium

B) barium

C) calcium

D) cesium

E) magnesium

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Video

L.O. 1.10: Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity

[Source](#)

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[Video](#)

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L.O. 1.10: Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity

+

Source

Chemical Properties within a Group and across a Period

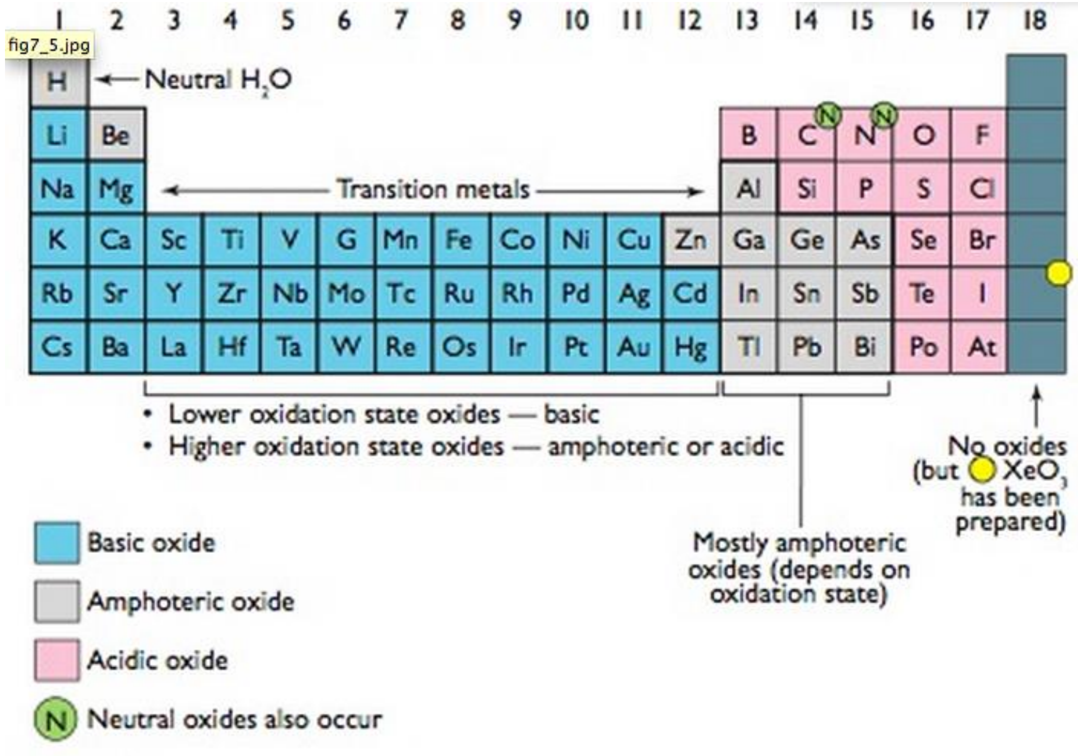


Figure 7.5
The periodic table shows that metallic oxides are mostly basic and that non-metallic oxides are mostly acidic. The elements with amphoteric oxides lie between th[e] two groupings.

attracts

- Group 1 metals more reactive than group 2 metals

Video

- Reactivity increases as you go down a group
- Metals on left form basic oxides
  - Ex. $Na_2O + H_2O \rightarrow 2\ NaOH$
- Nonmetals on right form form acidic oxides
  - Ex. $SO_3 + H_2O \rightarrow H_2SO_4$
- Elements in the middle, like Al, Ga, etc can behave amphoterically

its

- If SiO_2 can be a ceramic then SnO_2 may be as well since both in the same group

LO 1.11: Analyze data, based on periodicity & properties of binary compounds, to identify patterns & generate hypotheses related to molecular design of compounds

Source

Chemical Properties within a

12)

Question:

Which of the following groups from the periodic table would be the easiest to oxidize?

a. Halogens

b. Transition metals

c. Transuranic

d. Alkali metals

e. Alkali earth metals

Click reveals answer and explanation.

LO 1.11: Analyze data, based on periodicity & properties of binary compounds, to identify patterns & generate hypotheses related to molecular design of compounds

Source

+ Chemical Properties within a

12)

Question:
Which of the following groups from the periodic table would be the easiest to oxidize?

a. Halogens
b. Transition metals
c. Transuranic
d. Alkali metals
e. Alkali earth metals

Answer:
The correct answer is *d*. Oxidation involves the loss of electrons, so the group of elements that has the lowest ionization energy would be the easiest to oxidize. The alkali metals have the lowest ionization energy due to the low number of protons compared to the energy level of their lone valence electron.

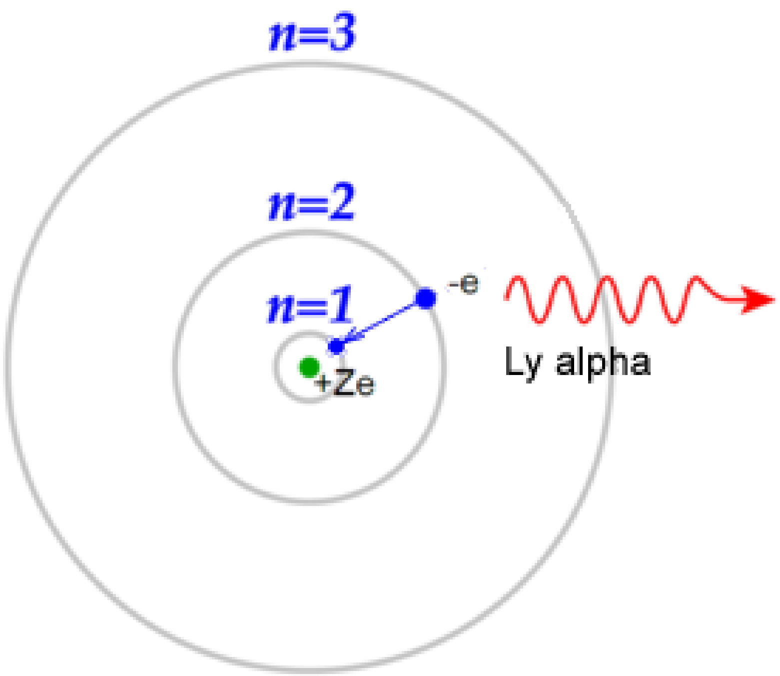
LO 1.11: Analyze data, based on periodicity & properties of binary compounds, to identify patterns & generate hypotheses related to molecular design of compounds

Source

+

Classic Shell Model of Atom vs Quantum Mechanical Model

Shell Model - Bohr



Developed by Schrodinger and the position of an electron is now represented by a wave equation

- Most ***probable*** place of finding an electron is called an **ORBITAL** (90% probability)
- Each orbital can only hold 2 electrons with opposing spins (S, P, D & F orbitals)

Evidence for this theory:

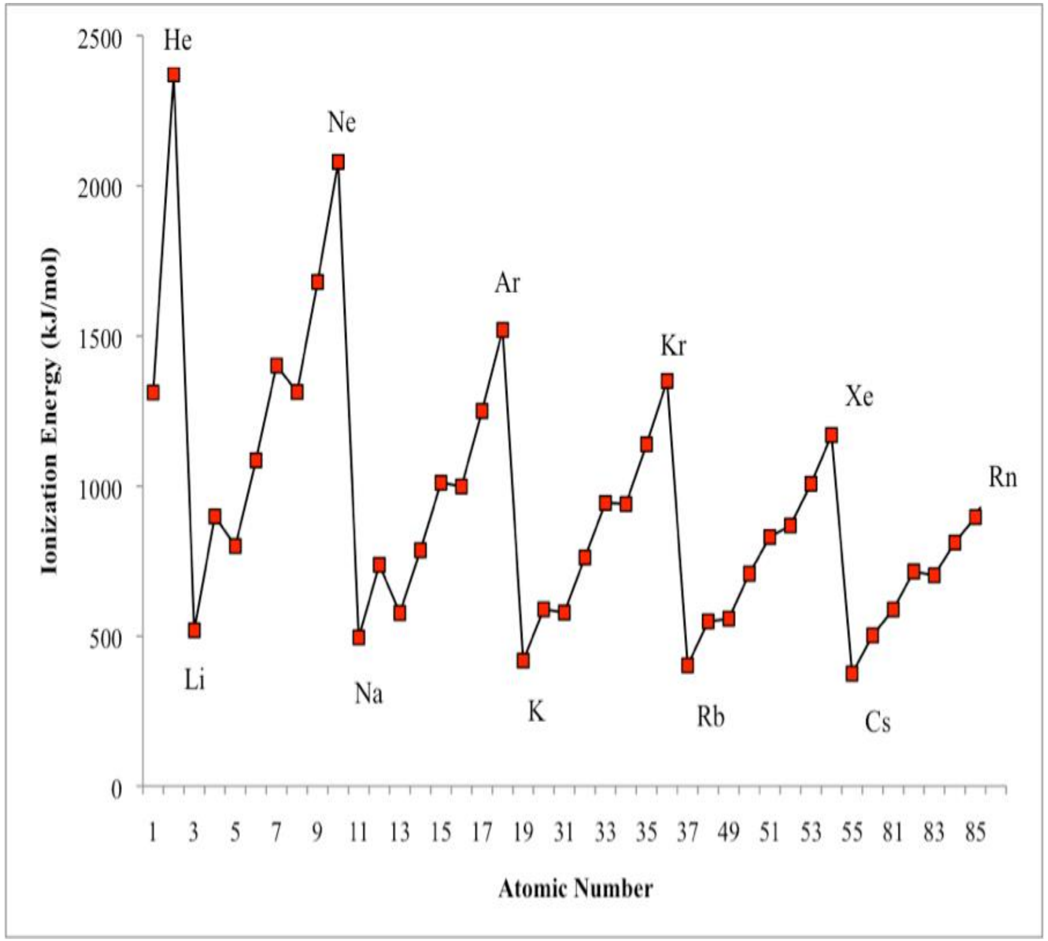
- Work of DeBroglie and Planck that electron had wavelike characteristics
- Heisenberg Uncertainty Principle - impossible to predict exact location of electron- contradicted Bohr
- This new evidence caused the Shell Theory to be replaced by the Quantum Mechanical Model of the atom

LO 1.12: Explain why data suggests (or not) the need to refine a model from a classical shell model with the quantum mechanical model

Source

+

Shell Model is consistent with Ionization Energy Data



The patterns shown by the IE graph can be explained by Coulomb's law

Video

- As atomic number increases, would expect the ionization energy to constantly increase
- Graph shows that this is NOT observed. WHY NOT?
- The data implies that a shell becomes full at the end of each period
- Therefore the next electron added must be in a new shell farther away from the nucleus.
- This is supported by the fact that the ionization energy drops despite the addition positive charge in the nucleus

LO: 1.13 Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence

Source

Shell Model is consistent with Ionization Energy Data

13)

2500 He

The patterns shown by

The data below show the first ten ionization energies, in kJ mol^{-1}, for an element that is found in period 3 of the periodic table.

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
738	1451	7733	10543	13630	18020	21711	25661	31653	35458

Identify the element.

a) Na
b) Mg
c) Si
d) S

Which ionization energies correspond to electrons that would account for the peak in the photoelectron spectrum of the element that has the lowest energy values?

a) 1st and 2nd only
b) 1st, 2nd, 3rd and 4th only
c) 9th and 10th only
d) More information is required

Atomic Number

- This is supported by the fact that the ionization energy drops despite the addition positive charge in the nucleus

LO: 1.13 Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence

Source

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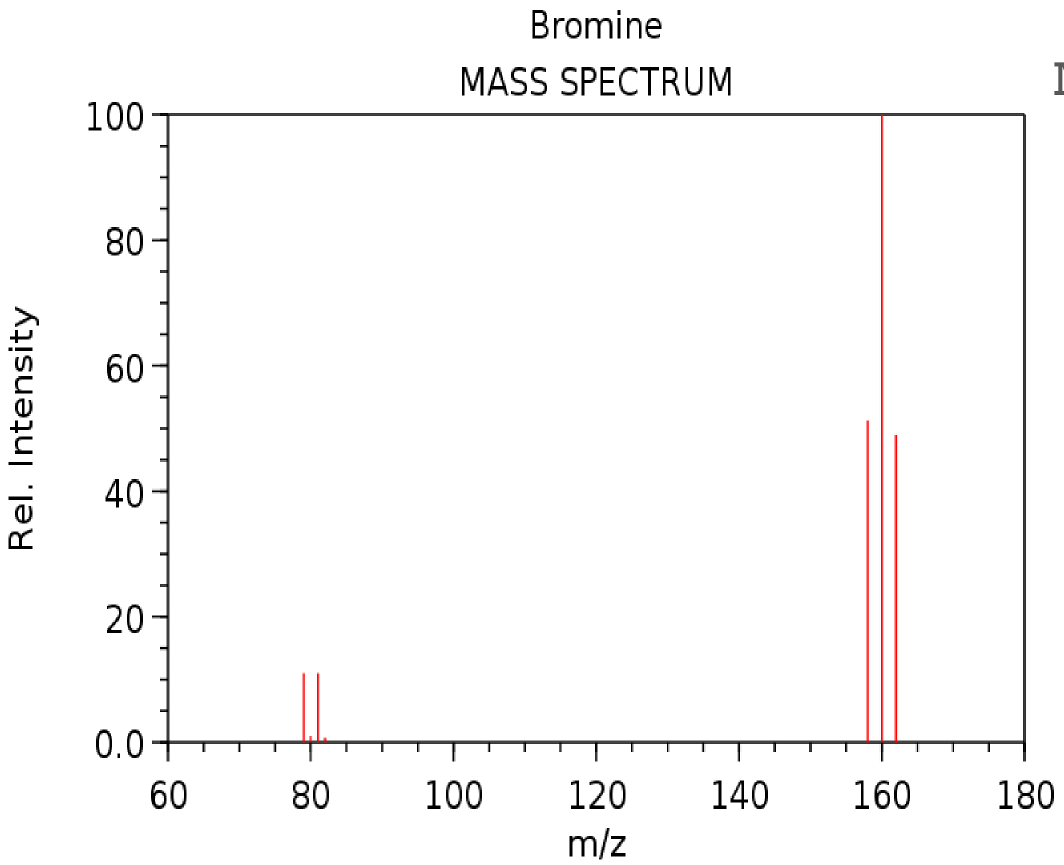
Source

+ Mass Spectrometry - evidence for isotopes



NIST Chemistry WebBook (http://webbook.nist.gov/chemistry)

Mass spectrometry showed that elements have isotopes Video

- This contradicted Dalton's early model of the atom which stated that all atoms of an element are identical
- 3 Br_2 & two Br isotopes shown in diagram
- The average atomic mass of the element can be estimated from mass spectroscopy

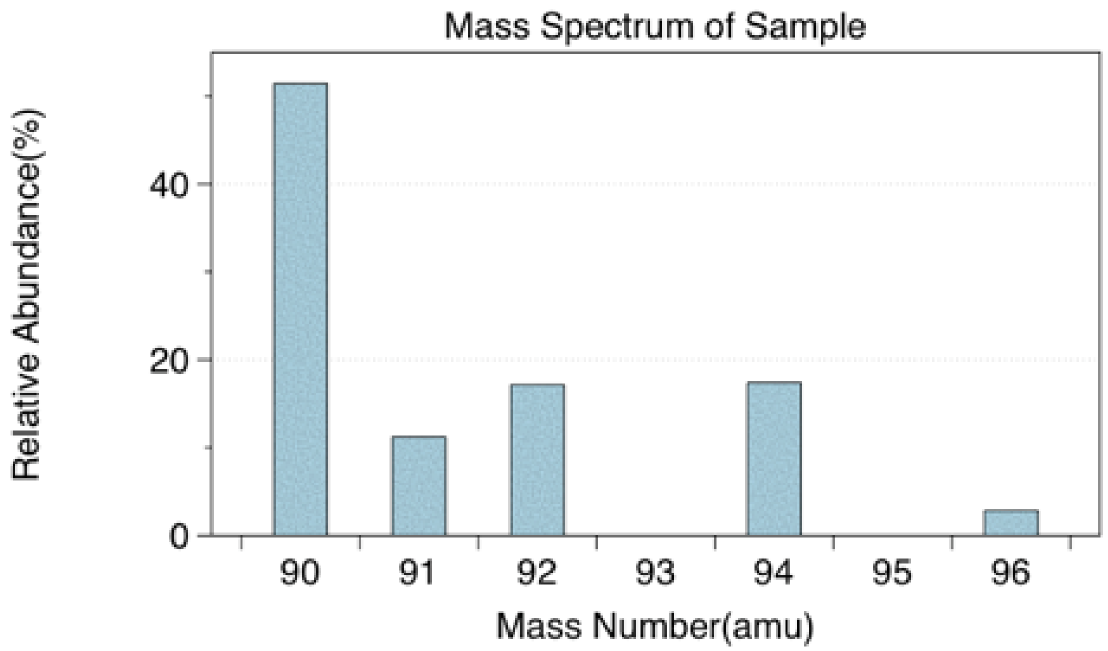
$$\text{Average Atomic Mass} = \frac{\sum(\text{mass of isotope} \times \%\text{ natural abundance})}{100}$$

LO 1.14: The student is able to use the data from mass spectrometry to identify the elements and the masses of individual atoms of a specific element

+ Mass

14)

Question:



Both Zr and Nb have similar average atomic masses. Above is the mass spectrum of a sample that was believed to have both Zr and Nb. Which of the following statements would be the best explanation for deciding that the sample contained only Zr?

a. Both elements will form ions with many different charges.
b. Zr has 2 unpaired electrons while Nb has 3.
c. Zr has a lower first ionization energy than Nb.
d. Nb has only one stable isotope with a mass of 93 amu.

Rel. Intensity

NI

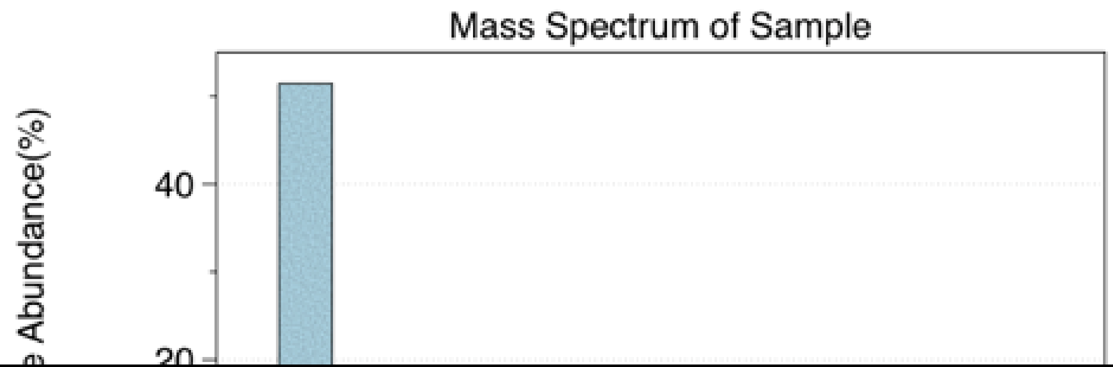
L

e

Mass

14)

Question:



Answer:
The correct answer is "d" Nb has only one stable isotope with a mass of 93 amu. While all of the statements are true only answer d would indicate that Nb is missing from the sample. If Nb's stable isotope has a mass of 93 amu we would expect some peak at that mass in the mass spectrum. Since there were no atoms measured with that mass, we can conclude that there is no Nb in the sample.

a. Both elements will form ions with many different charges.
b. Zr has 2 unpaired electrons while Nb has 3.
c. Zr has a lower first ionization energy than Nb.
d. Nb has only one stable isotope with a mass of 93 amu.

NI

L
e

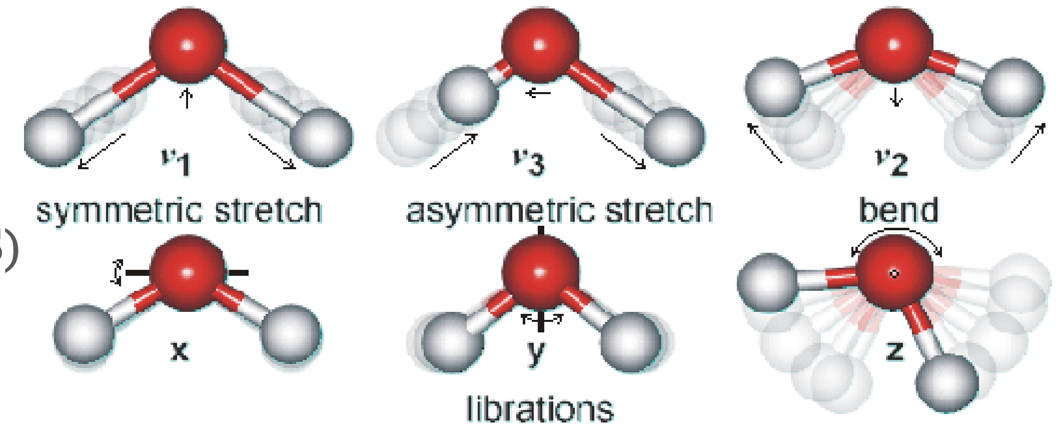
Source

+

Using Spectroscopy to measure properties associated with vibrational or electronic motions of molecules

IR Video
UV Video

IR Radiation - detects different types of bonds by analyzing molecular vibrations



UV or X-Ray Radiation

- Photoelectron Spectroscopy(PES)
- Causes electron transitions
- Transitions provides info on electron configurations

LO: 1.15 Justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules

Source

+ Using Spectroscopy to measure properties associated with vibrational or ele

15)

Which one of the following contains a transition paired correctly with an area of high absorption in the electromagnetic spectrum?

a. Electronic transition, microwaves
b. Electronic transition, infrared radiation
c. Molecular rotation, infrared radiation
d. Molecular vibration, infrared radiation

IR Video
UV Video

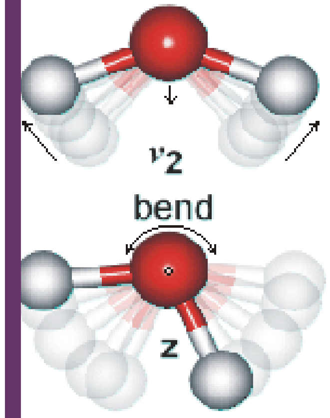
IR Radiati ... cular

vibrations

UV or X-Ra

- Photoelect
- Causes ele
- Transition

electron con



LO: 1.15 Justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules

Source

+

Using Spectroscopy to measure properties associated with vibrational or ele

15)

IR Radiati

vibrations

cular

IR Video
UV Video

UV or X-Ra

- Photoelect
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electron con

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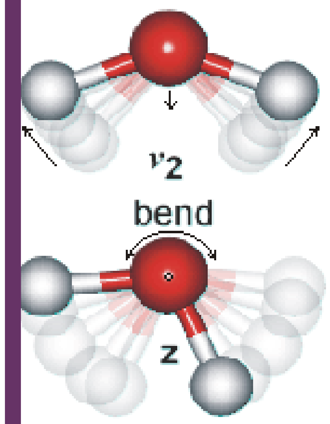
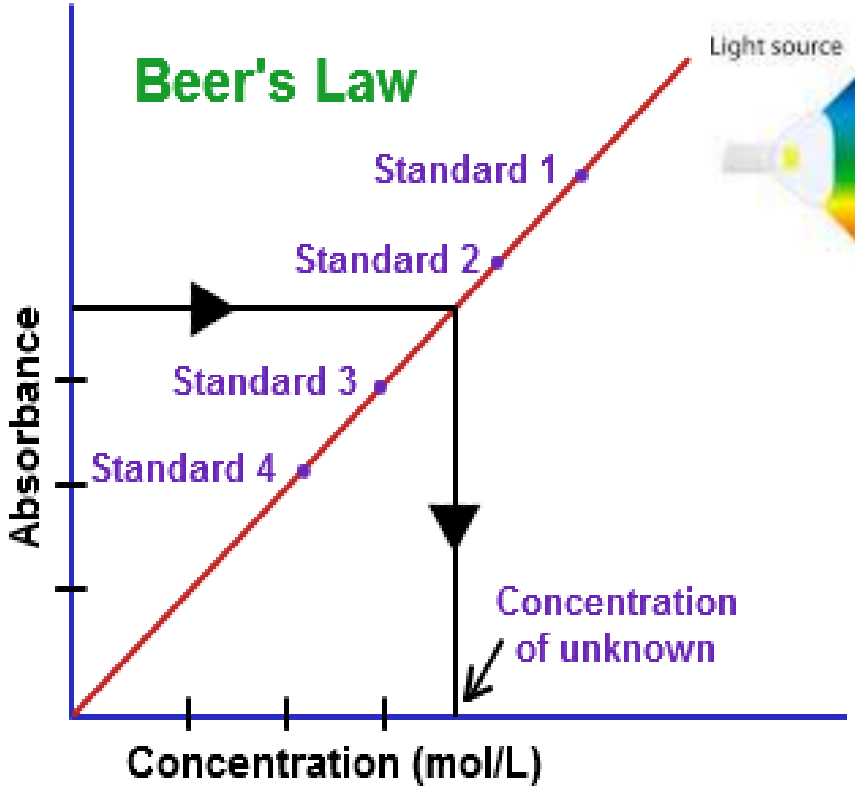


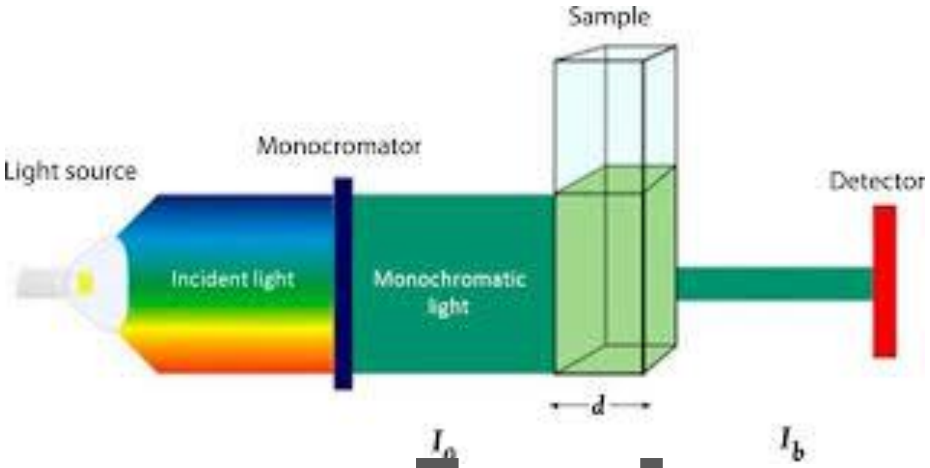
LO: 1.15 Justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules

Beer-Lambert Law - used to measure the concentration of ***colored*** solutions

[Source 1, 2](#)

[Video](#)





A = abc

A = absorbance

a = molar absorptivity (constant for material being tested)

b = path length (cuvette = 1 cm)

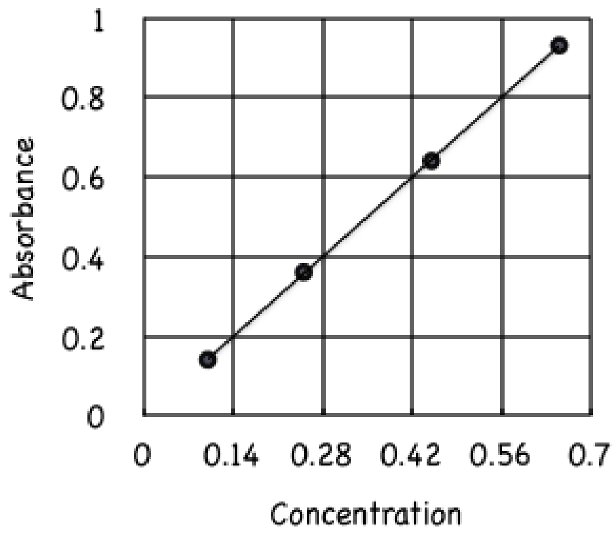
c = concentration

- Taken at fixed wavelength

LO1.16: Design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in solution

16)

Question:



Using the absorbance vs. concentration graph given above. A student is trying to determine the concentration of an unknown substance. If the student measures the absorbance to be 0.4 what would be the concentration of the unknown?

a. 0.04
b. 0.28
c. 0.40
d. 0.42
e. 0.56

Click reveals answer and explanation.

Video

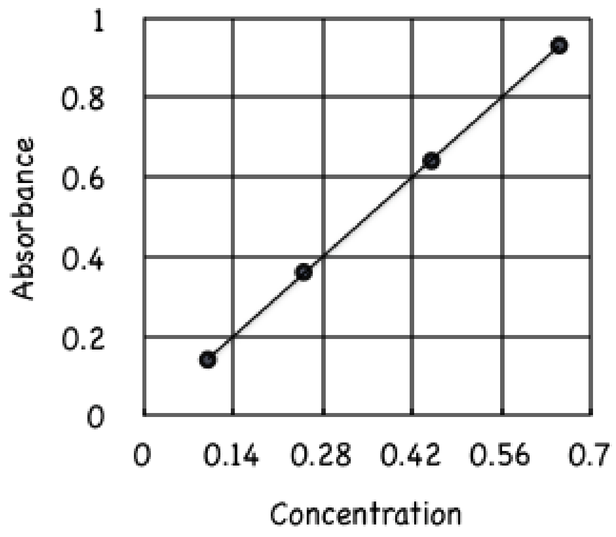
LO1.16: ... absorpti... solution

+ Be
m
16) co

rce 1, 2

Video

Question:



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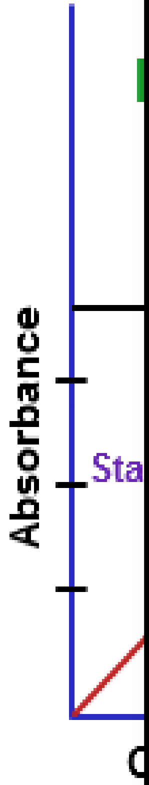
a. 0.04
b. 0.28
c. 0.40
d. 0.42
e. 0.56

Answer:
The correct answer is "b" 0.28. Based on the Beer-Lambert law, for small concentration ranges there is a linear relationship between absorbance and concentration. For an absorbance of 0.4 the corresponding concentration is 0.28.

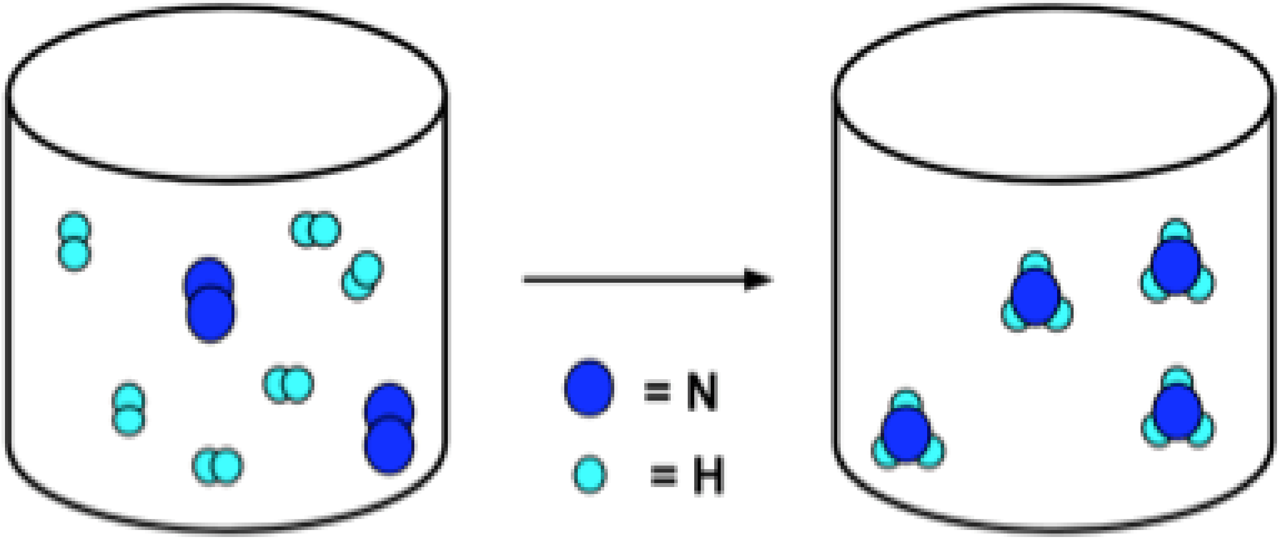


LO1.16:
absorpti solution

Source

Law of Conservation of Mass

Video



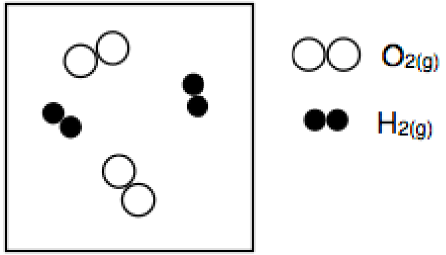
$$N_2 + 3H_2 \rightarrow 2NH_3$$

LO1.17: Express the law of conservation of mass quantitatively and qualitatively using symbolic representations and particulate drawings

Source

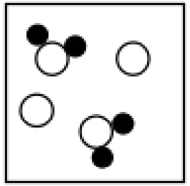
Law of C

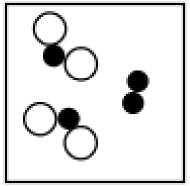
17)

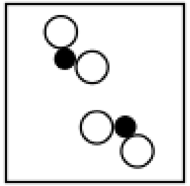


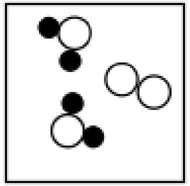
The picture above is a representation of H2(g) and O2(g) in a sealed container. Which of the following pictures would be the best representation of the products if the reaction below were to run to completion?

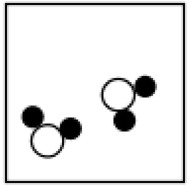
$$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$$

a. 

b. 

c. 

d. 

e. 

Click reveals answer and explanation.

Video

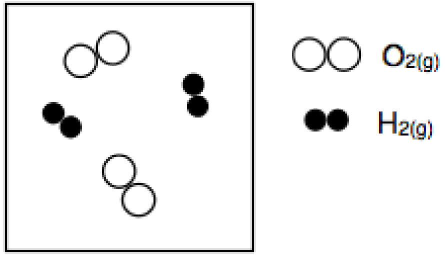
LO1.17: I ... vely using symbolic

Law of C

Source

Video

17)



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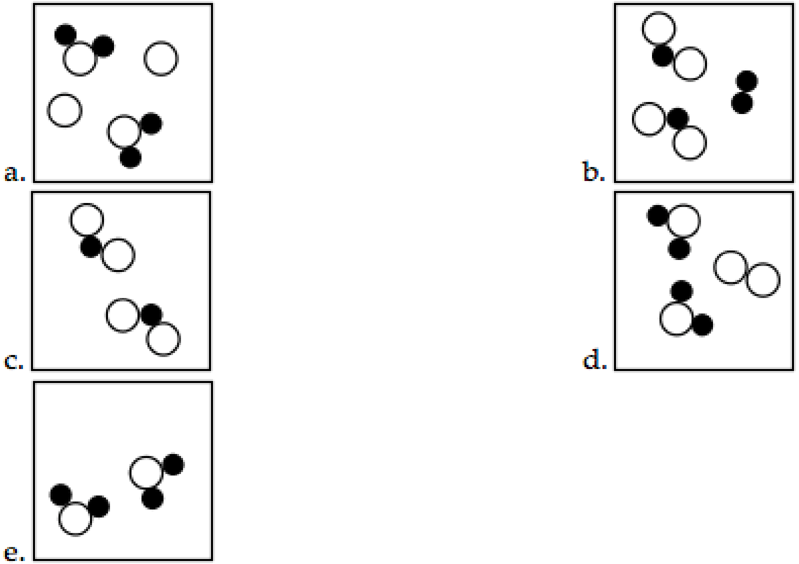


Answer:
The correct answer is “d”. In the balanced chemical equation we need 2 hydrogen atoms for each oxygen atom to form water. We will use up all the hydrogen molecules and have one oxygen molecule left over.

LO1.17: I ... vely using symbolic

Source

Use Mole Ratio in balanced equation to calculate moles of unknown substance

Chemical Reactions

Using Mole Ratios

Using the *balanced* reaction below for the combustion of propane, calculate the number of moles of CO_2 produced if 3.52 g C_3H_8 are burned in excess O_2.

$$\underset{3.52\text{ g}}{C_3H_8\,(g)} + 5O_2\,(g) \rightarrow \underset{?\text{ moles}}{3CO_2\,(g)} + 4H_2O\,(g)$$

$$\text{mass } C_3H_8 \xrightarrow{\text{molar mass}} \text{moles } C_3H_8 \xrightarrow{\text{mole ratio}} \text{moles } CO_2$$

Video

molar mass C_3H_8

C: 12.01 g/mol * 3 = 36.03 g/mol

H: 1.01 g/mol * 8 = 8.08 g/mol

44.11 g/mol

$$3.52\,\cancel{g}\,C_3H_8 \times \frac{1\text{ mole }C_3H_8}{44.11\,\cancel{g}} = 0.0798\text{ mol }C_3H_8$$

mole ratio: $\dfrac{1\text{ mole }C_3H_8}{3\text{ moles }CO_2}$

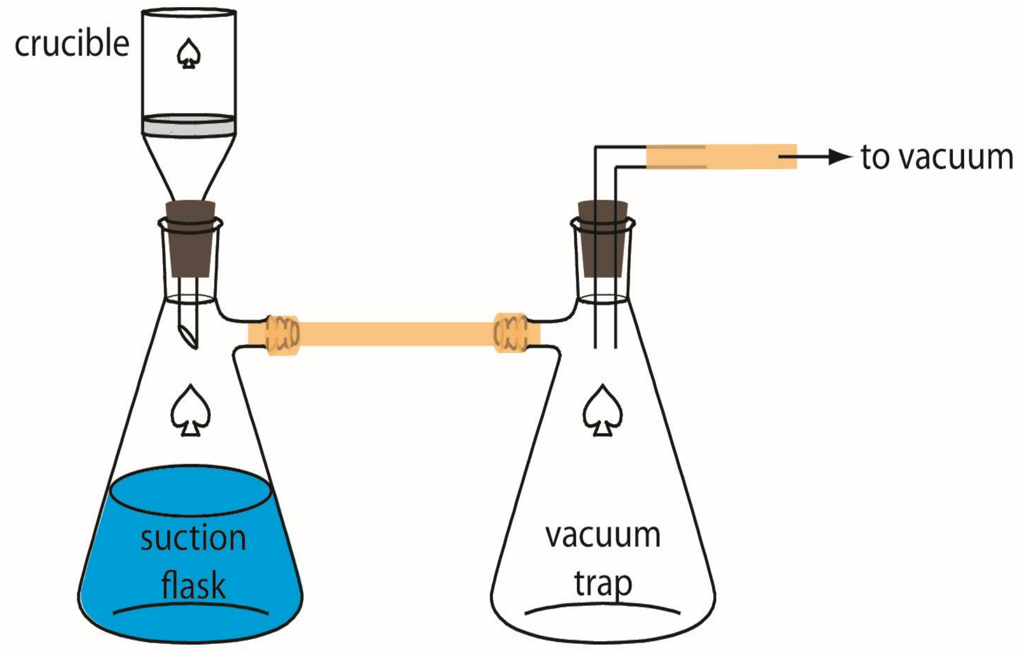
$$0.0798\,\cancel{\text{mol }C_3H_8} \times \frac{3\text{ mol }CO_2}{\cancel{1\text{ mole }C_3H_8}} = 0.239\text{ mol }CO_2$$

LO1.18: Apply the conservation of atoms to the rearrangement of atoms in various processes.

Source

Gravimetric Analysis

Buchner Filtration Apparatus



Video

How much lead (Pb^{2+}) in water?

$Pb^{2+}(aq) + 2Cl^{-}(aq) \rightarrow PbCl_2\ (s)$

- By adding excess Cl- to the sample, all of the Pb^{2+} will precipitate as $PbCl_2$
- Solid product is filtered using a Buchner Filter and then dried to remove all water
- Mass of $PbCl_2$ is then determined
- This can be used to calculate the original amount of lead in the water

LO 1.19: Design and/or interpret data from, an experiment that uses gravimetric analysis to determine the the concentration of an analyte in a solution.

+ Grav

18)

cru

Mass of KI tablet	0.425 g
Mass of thoroughly dried filter paper	1.462 g
Mass of filter paper + precipitate after first drying	1.775 g
Mass of filter paper + precipitate after second drying	1.699 g
Mass of filter paper + precipitate after third drying	1.698 g

1. A student is given the task of determining the I^- content of tablets that contain KI and an inert, water-soluble sugar as a filler. A tablet is dissolved in 50.0 mL of distilled water, and an excess of 0.20 *M* $Pb(NO_3)_2(aq)$ is added to the solution. A yellow precipitate forms, which is then filtered, washed, and dried. The data from the experiment are shown in the table above.

   (a) For the chemical reaction that occurs when the precipitate forms,

   (i) write a balanced, net-ionic equation for the reaction, and

   (ii) explain why the reaction is best represented by a net-ionic equation.

   (b) Explain the purpose of drying and weighing the filter paper with the precipitate three times.

   (c) In the filtrate solution, is $[K^+]$ greater than, less than, or equal to $[NO_3^-]$? Justify your answer.

   (d) Calculate the number of moles of precipitate that is produced in the experiment.

   (e) Calculate the mass percent of I^- in the tablet.

   (f) In another trial, the student dissolves a tablet in 55.0 mL of water instead of 50.0 mL of water. Predict whether the experimentally determined mass percent of I^- will be greater than, less than, or equal to the amount calculated in part (e). Justify your answer.

(s)

d

e

LO

analysis to determine the the concentration of an analyte in a solution.

Grav

18)

cru

(a) For the chemical reaction that occurs when the precipitate forms,

(i) write a balanced, net-ionic equation for the reaction, and

$Pb^{2+} + 2\,I^- \rightarrow PbI_2$	1 point is earned for a balanced net-ionic equation.

(ii) explain why the reaction is best represented by a net-ionic equation.

The net-ionic equation shows the formation of the $PbI_2(s)$ from $Pb^{2+}(aq)$ and $I^-(aq)$ ions, omitting the non-reacting species (spectator ions), $K^+(aq)$ and $NO_3^-(aq)$.	1 point is earned for a valid explanation.

(b) Explain the purpose of drying and weighing the filter paper with the precipitate three times.

The filter paper and precipitate must be dried several times (to a constant mass) to ensure that all the water has been driven off.	1 point is earned for a valid explanation.

(c) In the filtrate solution, is $[K^+]$ greater than, less than, or equal to $[NO_3^-]$? Justify your answer.

$[K^+]$ is less than $[NO_3^-]$ because the source of the NO_3^-, the 0.20 M $Pb(NO_3)_2(aq)$, was added in excess.	1 point is earned for a correct comparison with a valid explanation.

L

analysis to determine the the concentration of an analyte in a solution.

+ Grav

18)

cr

(d) Calculate the number of moles of precipitate that is produced in the experiment.

$1.698\text{ g} - 1.462\text{ g} = 0.236\text{ g PbI}_2(s)$ $0.236\text{ g PbI}_2 \times \frac{1\text{ mol PbI}_2}{461.0\text{ g PbI}_2} = 5.12 \times 10^{-4}\text{ mol PbI}_2$	1 point is earned for the correct number of moles of $PbI_2(s)$ precipitate.

(e) Calculate the mass percent of I^- in the tablet.

$5.12 \times 10^{-4}\text{ mol PbI}_2 \times \frac{2\text{ mol I}^-}{1\text{ mol PbI}_2} = 1.02 \times 10^{-3}\text{ mol I}^-$ $1.02 \times 10^{-3}\text{ mol I}^- \times \frac{126.91\text{ g I}^-}{1\text{ mol I}^-} = 0.130\text{ g I}^-$ in one tablet	1 point is earned for determining the number of moles of I^- in one tablet.
$\frac{0.130\text{ g I}^-}{0.425\text{ g KI tablet}} = 0.306 = 30.6\%\ \text{I}^-$ per KI tablet	1 point is earned for calculating the mass percent of I^- in the KI tablet.

(f) In another trial, the student dissolves a tablet in 55.0 mL of water instead of 50.0 mL of water. Predict whether the experimentally determined mass percent of I^- will be greater than, less than, or equal to the amount calculated in part (e). Justify your answer.

The mass percent of I^- will be the same. $Pb^{2+}(aq)$ was added in excess, ensuring that essentially no I^- remained in solution. The additional water is removed by filtration and drying, leaving the same mass of dried precipitate.	1 point is earned for correct comparison with a valid justification.

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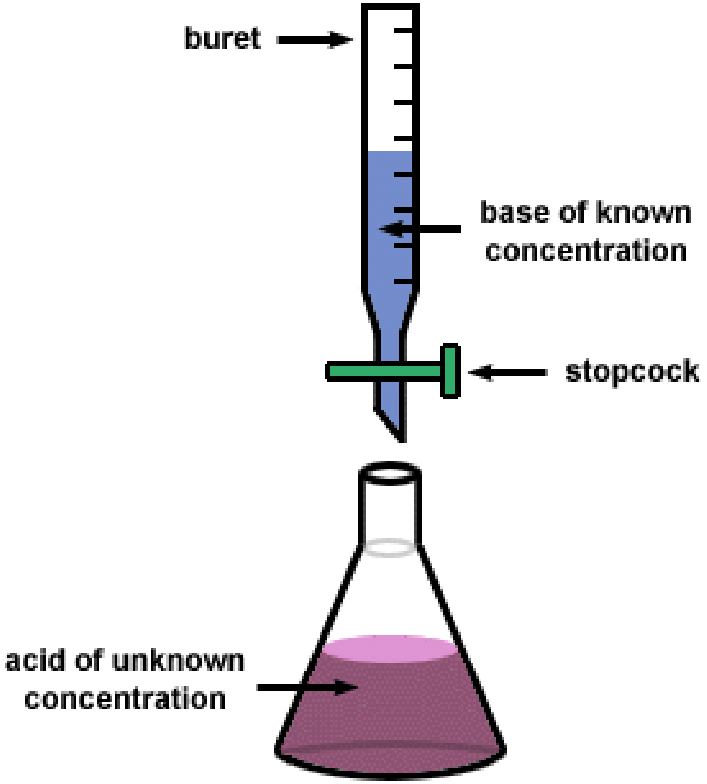
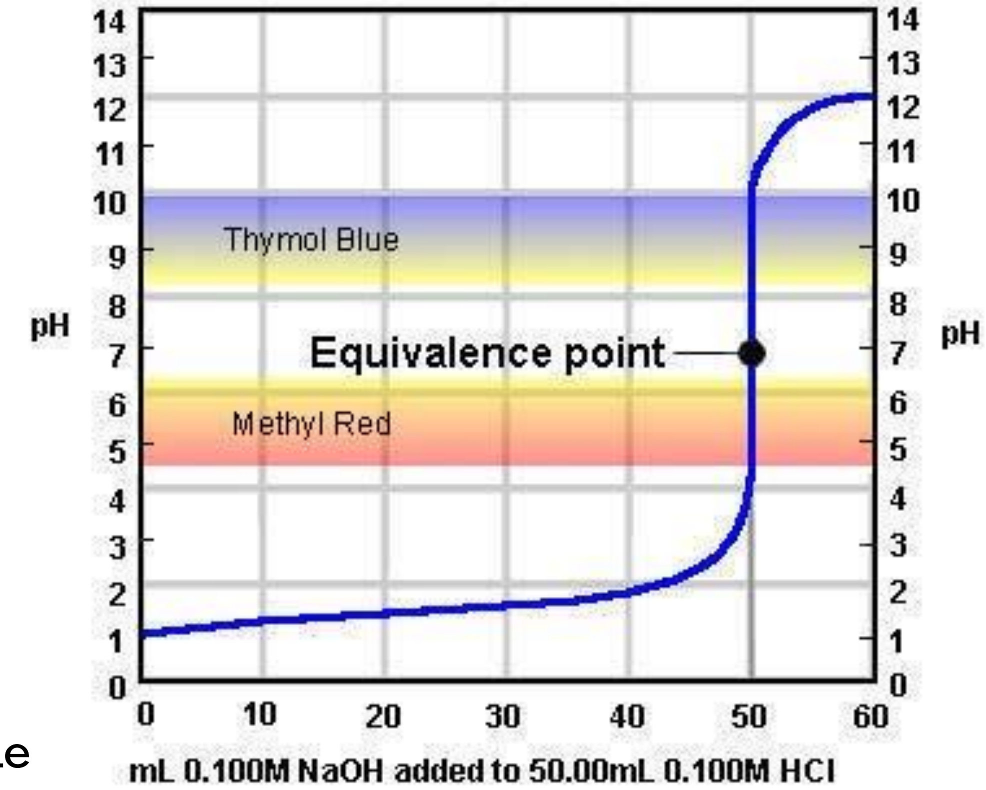
Source

Using titrations to determine concentration of an analyte





Video

At the equivalence point, the stoichiometric molar ratio is reached

LO1.20: Design and/or interpret data from an experiment that uses titration to determine the concentration of an analyte in a solution.

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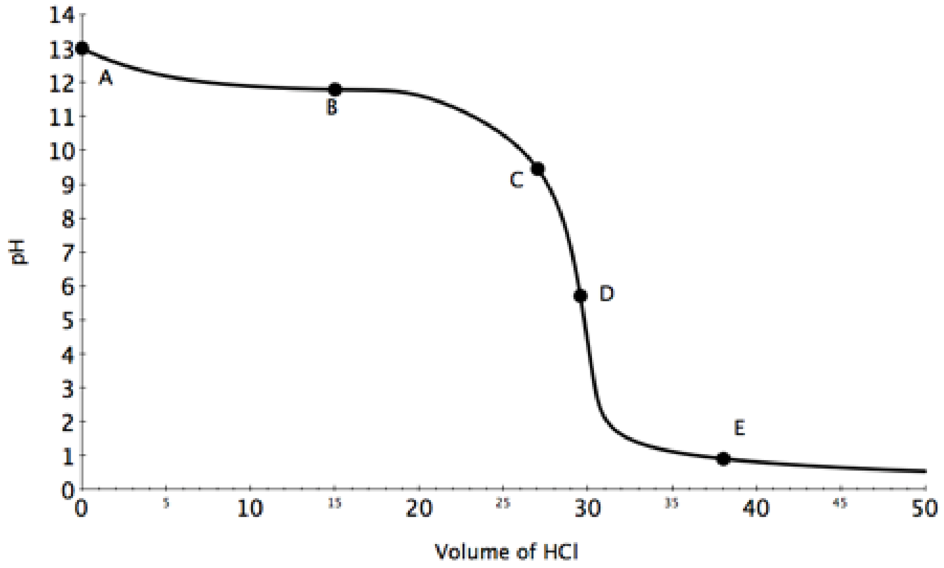
The graph below is of the titration of a weak base with hydrochloric acid. Based on the graph which point would represent the pH of the solution at the equivalence point?



a. A
b. B
c. C
d. D
e. E

Click reveals answer and explanation.

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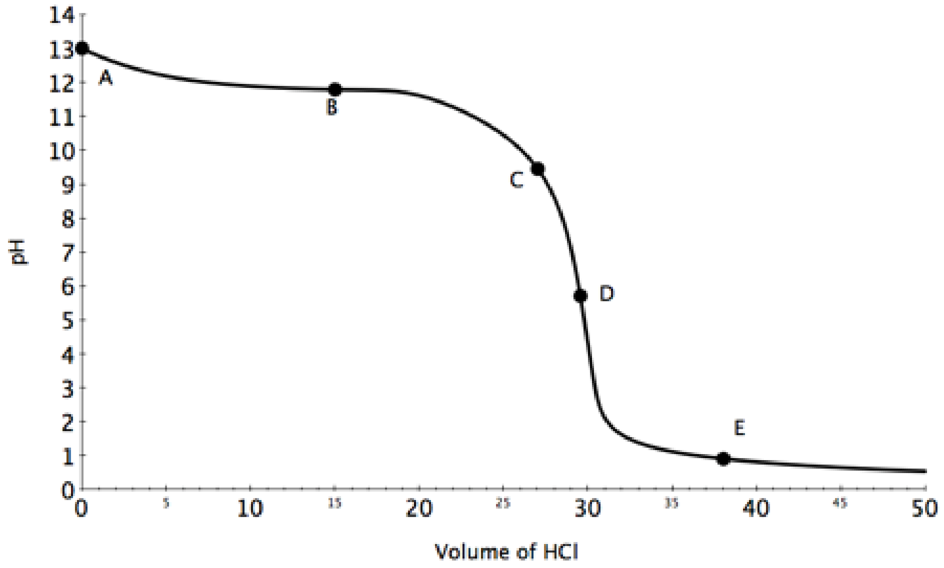
The graph below is of the titration of a weak base with hydrochloric acid. Based on the graph which point would represent the pH of the solution at the equivalence point?



a. A
b. B
c. C
d. D
e. E

Answer:
The correct answer is "d" D. The equivalence point of a titration is when the moles of acid are equal to the moles of base. On a titration curve it is the middle of the vertical section. For the titration of a week base the pH at the equivalence point will be less than 7 so point D is the correct answer.

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