MOUNT NOTRE DAME
Empowering Young Women

Welcome to AP Chemistry!

I am looking forward to next year and hope that you feel the same. AP Chemistry is a very fast paced course as we cover 2 college semesters of material and labs to be prepared for the test in early May. This summer assignment will help you review concepts you have learned in your previous chemistry course and increase your chances of a successful year. I encourage you to pace yourself so that you do not end up trying to cram all the material in right before school starts.

Attached is a document with Unit 1 Topic questions and problems. Each Topic has corresponding textbook chapter / section. Use the text and online resources to complete the questions and problems. Be sure to write on the hard copy. The Unit 1 assignment is due August 26th. Concepts which are new, not review from first year chemistry, will be covered in more detail in class. The Unit 1 test will be within the first two weeks of school.

Some online resources you may find helpful:

Ms. Giordan's Topic videos

Ms. Barkhume Topic Videos

Bozeman Science AP Chemistry – not in current Unit order

Knowing element and ion information will be essential. Key elements are atomic numbers 1-54 and Au, Hg, Pt, U and Pb. See the attached for a listing of ions and tips on memorization. We will have quizzes on the elements and ions starting the 2nd day of school.

If you have any questions this summer, please email me at grutschilling@mndhs.org. I will periodically check this account and look forward to hearing from you.

Have a restful and fun-filled summer. See you in August!

Mrs. Rutschilling

Common Ions and Their Charges

A mastery of the common ions, their formulas and their charges, is essential to success in AP Chemistry You will always be allowed a periodic table, which makes identifying the monoatomic ions automatic." For tips on learning the ions, see the next page.

From the table:	
Cations	**Name**
H^+	Hydrogen
Li^+	Lithium
Na^+	Sodium
K^+	Potassium
Rb^+	Rubidium
Cs^+	Cesium
Be^{2+}	Beryllium
Mg^{2+}	Magnesium
Ca^{2+}	Calcium
Ba^{2+}	Barium
Sr^{2+}	Strontium
Al^{3+}	Aluminum
Anions	**Name**
H^-	Hydride
F^-	Fluoride
Cl^-	Chloride
Br^-	Bromide
I^-	Iodide
O^{2-}	Oxide
S^{2-}	Sulfide
Se^{2-}	Selenide
N^{3-}	Nitride
P^{3-}	Phosphide
As^{3-}	Arsenide
Type II Cations	**Name**
Fe^{3+}	Iron(III)
Fe^{2+}	Iron(II)
Cu^{2+}	Copper(II)
Cu^+	Copper(I)
Co^{3+}	Cobalt(III)
Co^{2+}	Cobalt(II)
Sn^{4+}	Tin(IV)
Sn^{2+}	Tin(II)
Pb^{4+}	Lead(IV)
Pb^{2+}	Lead(II)
Hg^{2+}	Mercury(II)

Ions to memorize:	
Cations	**Name**
Ag^+	Silver
Zn^{2+}	Zinc
Hg_2^{2+}	Mercury(I)
NH_4^+	Ammonium
Anions	**Name**
NO_2^-	Nitrite
NO_3^-	Nitrate
$SO3^{2-}$	Sulfite
$SO4^{2-}$	Sulfate
HSO_4^-	Hydrogen sulfate (bisulfate)
OH^-	Hydroxide
CN^-	Cyanide
PO_4^{3-}	Phosphate
HPO_4^{2-}	Hydrogen phosphate
$H_2PO_4^-$	Dihydrogen phosphate
NCS^-	Thiocyanate
CO_3^{2-}	Carbonate
HCO_3^-	Hydrogen carbonate (bicarbonate)
ClO^-	Hypochlorite
ClO_2^-	Chlorite
ClO_3^-	Chlorate
ClO_4^-	Perchlorate
BrO^-	Hypobromite
BrO_2^-	Bromite
BrO_3^-	Bromate
BrO_4^-	Perbromate
IO^-	Hypoiodite
IO_2^-	iodite
IO_3^-	iodate
IO_4^-	Periodate
$C_2H_3O_2^-$	Acetate
MnO_4^-	Permanganate
$Cr_2O_7^{2-}$	Dichromate
CrO_4^{2-}	Chromate
O_2^{2-}	Peroxide
$C_2O_4^{2-}$	Oxalate
NH_2^-	Amide
BO_3^{3-}	Borate
$S_2O_3^{2-}$	Thiosulfate

Tips for Learning the Ions

"From the Table"

These are ions can be organized into two groups.

1. Their place on the table suggests the charge on the ion, since the neutral atom gains or loses a predictable number of electrons in order to obtain a noble gas configuration.
    a. All Grp 1 Elements lose one electron to form an ion with a 1^+ charge
    b. All Grp 2 Elements lose two electrons to form an ion with a 2^+ charge
    c. Grp 13 metals like aluminum lose three electrons to form an ion with a 3^+ charge
    d. All Grp 17 Elements gain one electron to form an ion with a 1^- charge
    e. All Grp 16 nonmetals gain two electrons to form an ion with a 2^- charge
    f. All Grp 15 nonmetals gain three electrons to form an ion with a 3^- charge

    Notice that cations keep their name (sodium ion, calcium ion) while anions get an "-ide" ending (chloride ion, oxide ion).

2. Metals that can form more than one ion will have their positive charge denoted by a roman numeral in parenthesis immediately next to the name of the cation.

Polyatomic Anions

There are a number of patterns that can greatly reduce the amount of memorizing required.

1. "ate" anions have one more oxygen then the "ite" ion, but the same charge. If you memorize the "ate" ions, then you should be able to derive the formula for the "ite" ion and vice-versa.
    a. sulfate is SO_4^{2-}, so sulfite has the same charge but one less oxygen (SO_3^{2-})
    b. nitrate is NO_3^-, so nitrite has the same charge but one less oxygen (NO_2^-)

2. If you know that a sufate ion is SO_4^{2-}, then to get the formula for hydrogen sulfate ion, you add a hydrogen ion to the front of the formula. Since a hydrogen ion has a 1^+ charge, the net charge on the new ion is less negative by one.
    a. Example:

PO_4^{3-},	➔	HPO_4^{2-}	➔	$H_2PO_4^-$
phosphate		hydrogen phosphate		dihydrogen phosphate

3. Learn the hypochlorite ➔ chlorite ➔ chlorate ➔ perchlorate series, and you also know the series containing iodite/iodate as well as bromite/bromate.
    a. The relationship between the "ite" and "ate" ion is predictable. Learn one and you know the other.
    b. The prefix "hypo" means "under" or "too little" (think "hypodermic", "hypothermic" or "hypoglycemia")
        i. Hypochlorite is "under" chlorite, meaning it has one less oxygen
    c. The prefix "hyper" means "above" or "too much" (think "hyperkinetic")
        i. the prefix "per" is derived from "hyper" so perchlorate (hyperchlorate) has one more oxygen than chlorate.
    d. Notice how this sequence increases in oxygen while retaining the same charge:

ClO^-	➔	ClO_2^-	➔	ClO_3^-	➔	ClO_4^-
hypochlorite		chlorite		chlorate		perchlorate

TOPIC 1.1 Moles and Molar Mass

ENDURING UNDERSTANDING **SPQ-1** The mole allows different units to be compared

LEARNING OBJECTIVE **SPQ-1.A** Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.

ESSENTIAL KNOWLEDGE **SPQ-1.A.1** One cannot count particles directly while performing laboratory work. Thus, there must be a connection between the masses of substances reacting and the actual number of particles undergoing chemical changes

SPQ-1.A.2 Avogadro's number (*N*A = 6.022 × 1023 mol-1) provides the connection between the number of moles in a pure sample of a substance and the number of constituent particles (or formula units) of that

What is the mole?	The word 'mole' represents a specific number. Give at least one common example of a word that represents a specific number:

Molar mass vs formula mass:

What is the formula mass of a substance?	What is the molar mass of a substance?
What is the formula mass of Calcium Phosphate? Show your work!	Calculate the molar mass of Calcium phosphate. Show your work!

Use the information below to complete the graphic organizer on the next page (fill in the bubbles).

1 mole = molar mass of a	1 mole = 22.4 L of	1 mole = 6.022×10^{23}

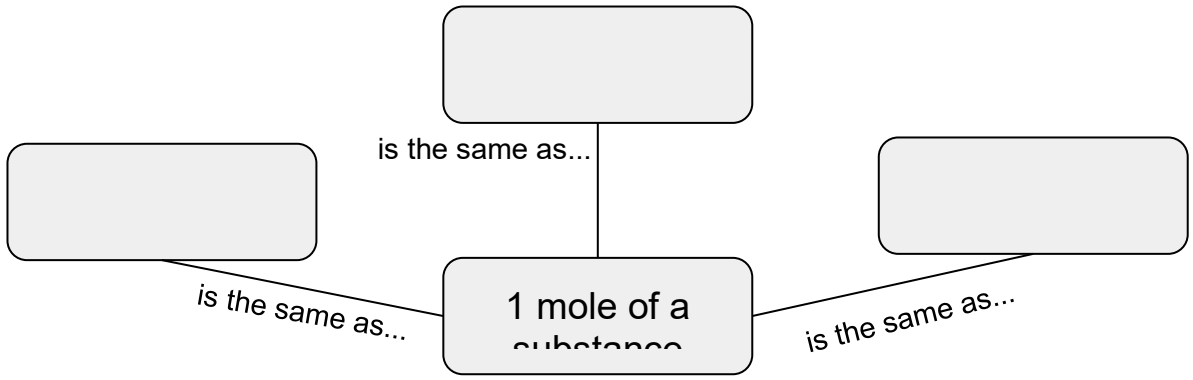
substance.

SPQ-1.A.3 Expressing the mass of an individual atom or molecule in atomic mass units (amu) is useful because the average mass in amu of one particle (atom or molecule) or formula unit of a substance will always be numerically equal to the molar mass of that substance

EQN: n = m/M

Brown :1.7, 2.4, 3.4

substance	gas at STP	particles



To convert between units you must use a conversion factor: $\frac{desired\ units}{given\ units}$

You have 6.022x10^{23} particles of a substance. What would the conversion factor be to go from the number of particles to the number of moles of that substance?	You have 18.016 g of H2O. What would the conversion factor be to go from the molar mass to moles of water?

What would be the number of phosphorus atoms in a 2.34 g sample of calcium phosphate? Show all your work!

TOPIC 1.2 Mass Spectroscopy of Elements

ENDURING UNDERSTANDING **SPQ-1** The mole allows different units to be compared.

LEARNING OBJECTIVE **SPQ-1.B** Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes.

ESSENTIAL KNOWLEDGE **SPQ-1.B.1**The mass spectrum of a sample containing a single element can be used to determine the identity of the isotopes of that element and the relative abundance of each isotope in nature.

SPQ-1.B.2 The average atomic mass of an element can be estimated from the weighted average of the isotopic masses using the mass of each isotope and its relative abundance.

X Interpreting mass spectra of samples containing multiple elements or peaks arising from species other than singly charged

Calculate the elemental atomic mass of Cr if the naturally occurring isotopes are $^{50}_{24}Cr$, $^{52}_{24}Cr$, $^{53}_{24}Cr$, $^{54}_{24}Cr$. Their masses and abundances are as follows:

Isotope	Atomic Mass	Isotopic Abundance	Show your work here:
$^{50}_{24}Cr$	49.946050 u	4.345%	
$^{52}_{24}Cr$	51.940512 u	83.789%	
$^{53}_{24}Cr$	52.940654 u	9.501%	
$^{54}_{24}Cr$.	53.938885 u	2.365%	

The mass spectrum of an element gives the masses and the relative abundances of the individual isotopes of that

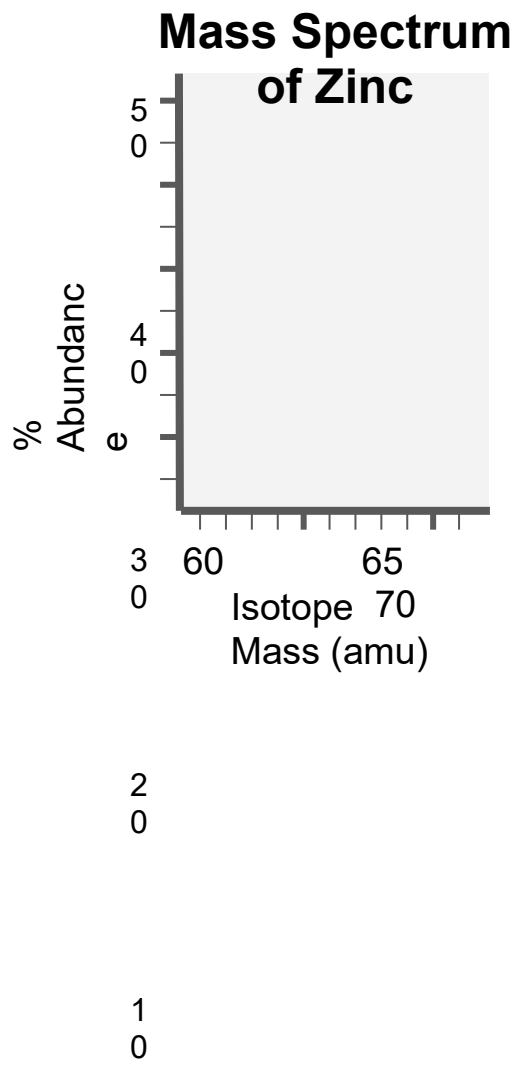
monatomic ions will not be assessed on the AP Exam.

Brown: 2.3, 2.4

element. For the data given in the table, create a Mass Spectrum and determine the average atomic mass of Zinc.

Isotope	Mass (amu)	Abundance (%)
Zinc-64	63.929	48.63
Zinc-66	65.926	27.90
Zinc-67	66.927	4.10
Zinc-68	67.925	18.75
Zinc-70	69.925	0.62

Show your work here:



ENDURING UNDERSTANDING **SPQ-2** Chemical formulas identify substances by their unique combination of atoms.

LEARNING OBJECTIVE
SPQ-2.A
Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance.

ESSENTIAL KNOWLEDGE
SPQ-2.A.1
Some pure substances are composed of individual molecules, while others consist of atoms or ions held together in fixed proportions as described by a formula unit.

SPQ-2.A.2
According to the law of definite proportions, the ratio of the masses of the constituent elements in any pure sample of that compound is always the same.

SPQ-2.A.3
The chemical formula that lists the lowest whole number ratio of atoms of the elements in a compound is the empirical formula.

Brown: 3.4, 3.5

Circle the right word to complete the sentence:
Empirical formulas represent the (lowest/highest) ratio of atoms in a substance.

Substances can share the same (empirical/molecular) formula but have a different (empirical/molecular) formula.

Ex: Analysis of 37.40 g of an unknown substance revealed that it contained 22.814 g carbon, 5.7596 g hydrogen and 8.8638 g nitrogen. What is the percent composition and the empirical formula of this compound? Show your work!

Different types of substances are made up of different types of representative particles. For each of the following, is this an example of a formula unit, or molecule? Draw an example of a particle diagram of the representative particle of the following:

An ionic compound	A covalent compound

A single drop of water contains 3.34×10^{21} atoms of hydrogen. How many oxygen atoms are in the same sample?

ENDURING UNDERSTANDING **SPQ-2** Chemical formulas identify substances by their unique combination of atoms.

LEARNING OBJECTIVE
SPQ-2.B
Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture.

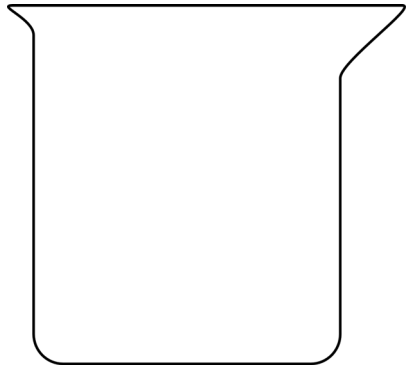
ESSENTIAL KNOWLEDGE
SPQ-2.B.1
While pure substances contain molecules or formula units of a single type, mixtures contain molecules or formula units of two or more types, whose relative proportions can vary.

SPQ-2.B.2
Elemental analysis can be used to determine the relative numbers of atoms in a substance and to determine its purity.

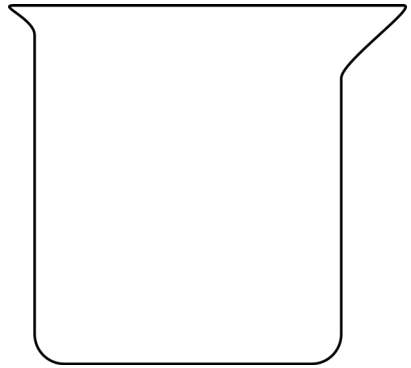
Brown: 1.2, 3.5

Draw a particle diagram for each of the following descriptions (draw at least 3 units of each substance in the sample.):

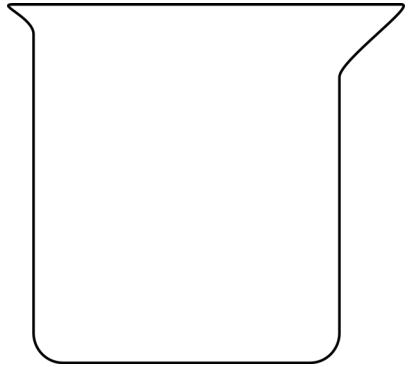
1) A diatomic element



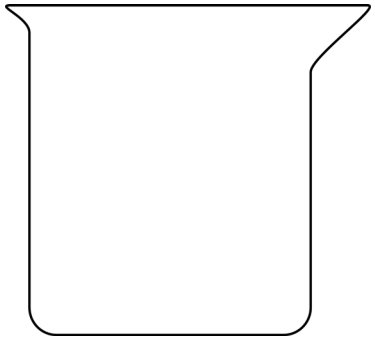
2) A compound



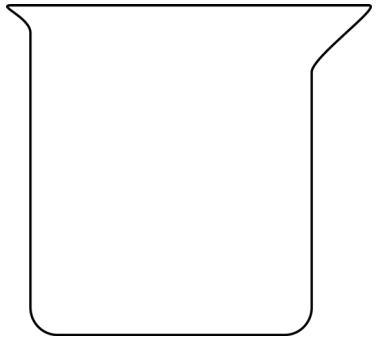
3) A compound and a monatomic element:



4) A diatomic and a monatomic element



5) A diatomic element and a compound



List the beakers that contain a pure substance:

List the beakers that contain a mixture:

In your own words, what is a pure substance?

TOPIC 1.5 Atomic Structure and Electron Configuration

ENDURING UNDERSTANDING **SAP-1** Atoms and molecules can be identified by their electron distribution and energy.

LEARNING OBJECTIVE
SAP-1.A
Represent the electron configuration of an element or ions of an element using the Aufbau principle.

ESSENTIAL KNOWLEDGE
SAP-1.A.1
The atom is composed of negatively charged electrons and a positively charged nucleus that is made of protons and neutrons.

SAP-1.A.2
Coulomb's law is used to calculate the force between two charged particles.

EQN: $F_{coulombic} \propto \frac{q_1 q_2}{r^2}$

SAP-1.A.3
In atoms and ions, the electrons can be thought of as being in "shells (energy

Using the Diagonal Rule or the Periodic Table for reference, give the long electron configuration and noble gas configuration for each of the following:

	Electron Configuration	Noble Gas Configuration
Mg		
S		
K^+		
N^{-3}		

In the box on the right, draw a diagram of a carbon atom showing the protons, neutrons and electrons in their correct numbers and locations in the atom.

How many energy levels are found in a chlorine atom?

Circle the correct word: Each electron in an atom as (the same/different) ionization energy.

Match the correct term: Electrons in an atom are of 2 types. The inner electrons, also called the (core/valence) electrons and the outer electrons, also called the (core/valence) electrons

levels)" and "subshells (sublevels)," as described by the electron configuration. Inner electrons are called core electrons, and outer electrons are called valence electrons. The electron configuration is explained by quantum mechanics, as delineated in the Aufbau principle and exemplified in the periodic table of the elements.

X *Assignment of quantum numbers to electrons in specific subshells does not increase students' understanding of the structure of the atom. It will not be on the AP Exam*

SAP-1.A.4
The relative energy required to remove an electron from different subshells of an atom or ion or from the same subshell in different atoms or ions (ionization energy) can be estimated through a qualitative application of Coulomb's law. This energy is related to the distance from the nucleus and the effective (shield) charge of the nucleus.

Brown: 6.8, 6.9. 7.2, 7.4

Core electrons have (higher/lower) ionization energy than valence electrons.

In your own words, describe how the shielding effect is involved in these periodic trends.

	Atomic Radius	Ionization Energy	Electronegativity
When going Left to Right on the periodic table			
When going Top to Bottom on the periodic table			

Arrange the following elements based on your knowledge of Periodic Trends: Cr, K, Br, Kr

1) Increasing atomic radius:

2) Decreasing ionization energy:

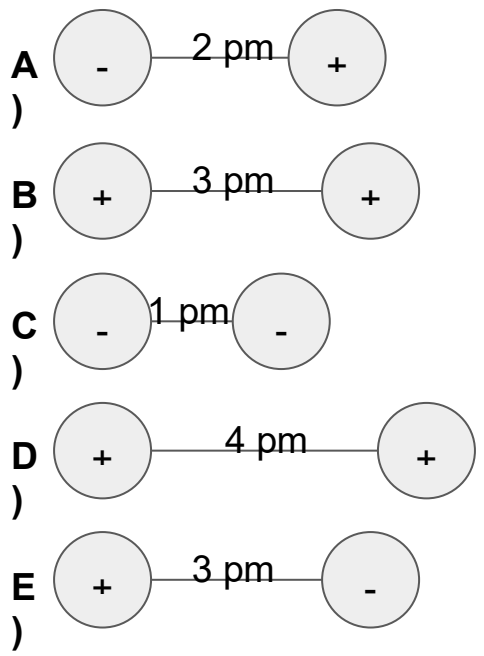
3) Increasing electronegativity:

Answer the questions using the system of charged particles on the right (labeled A-E). Which pair of charged particles are the...

Most attractive:

Most repulsive:

If the distance between the valence electrons and the nucleus were doubled, what would happen to the force between the two particles?



TOPIC 1.6 Photoelectron Spectroscopy

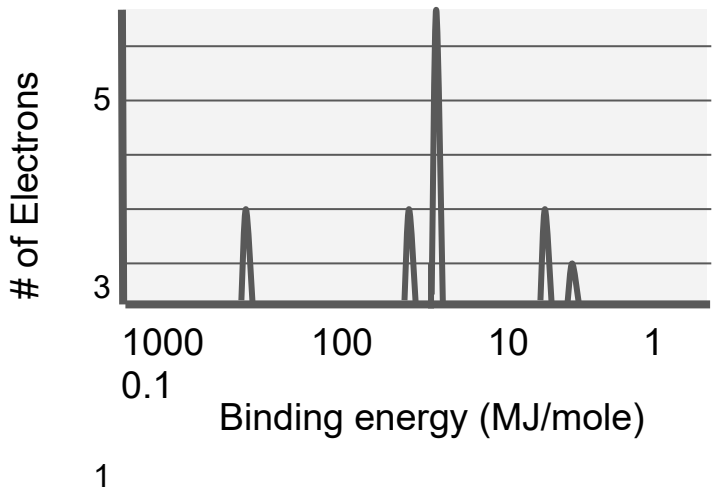
ENDURING UNDERSTANDING **SAP-1** Atoms and molecules can be identified by their electron distribution and energy.

LEARNING OBJECTIVE
SAP-1.B
Explain the relationship between the photoelectron spectrum of an atom or ion and:
a. The electron configuration of the species.
b. The interactions between the electrons and the nucleus.

ESSENTIAL KNOWLEDGE
SAP-1.B.1
The energies of the electrons in a given shell can be measured experimentally with photoelectron spectroscopy (PES). The position of each peak in the PES spectrum is related to the energy required to remove an electron from the corresponding subshell, and the height of each peak is (ideally) proportional to the number of electrons in that subshell.

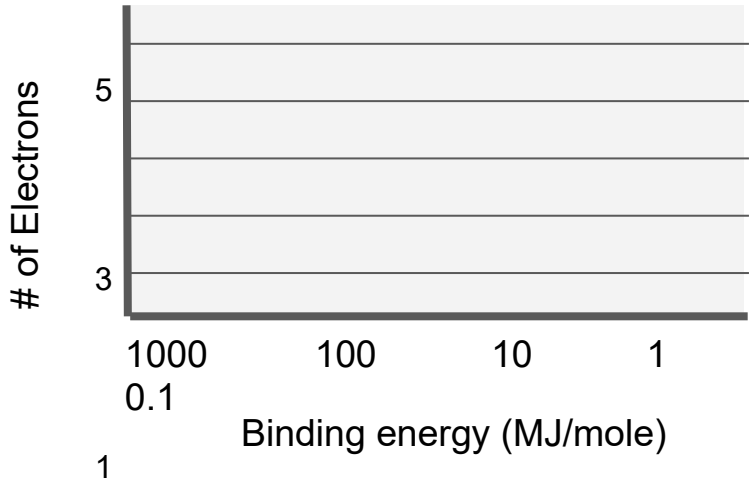
Brown: not in text

Study the photoelectron spectrum to the right. What is the name of this element? What is the electron configuration for this element?



Given the following e^- configuration, construct a photoelectron spectrum and identify the element.

$1s^2 2s^2 2p^6 3s^2 3p^4$



TOPIC 1.7 Periodic Trends

ENDURING UNDERSTANDING **SAP-2** The periodic table shows patterns in electronic structure and trends in atomic properties.

LEARNING OBJECTIVE
SAP-2.A
Explain the relationship between trends in atomic properties of elements and electronic structure and periodicity.

ESSENTIAL KNOWLEDGE
SAP-2.A.1
The organization of the periodic table is based on the recurring properties of the elements and explained by the pattern of electron configurations and the presence of completely or partially filled shells (and subshells) of electrons in atoms.

X WRITING THE ELECTRON CONFIGURATION OF ELEMENTS THAT ARE EXCEPTIONS TO THE AUFBAU PRINCIPLE WILL NOT BE ASSESSED ON THE AP EXAM. Rationale: The mere rote recall of the exceptions does not match the goals of the curriculum revision.

SAP-2.A.2
Trends in atomic properties within the periodic table (periodicity) can be qualitatively understood through the position of the element in the periodic table, Coulomb's law, the shell model, and the concept of shielding/effective nuclear charge. These properties include:
a. Ionization energy
b. Atomic and ionic radii c. Electron affinity
d. Electronegativity.

Complete the table with either 'increases' or 'decreases'.

Trend	Period (Left to Right)	Group (Top to Bottom)
Ionization energy		
Electronegativity		
Atomic radius		

Explain each of the periodic trends in terms of atomic structure (Zeffective, energy level, sublevel, orbital, etc.)

Atomic Radius	Ionization Energy	Electronegativity

Brown: 7.1, 7.3, 7.4, 7.5, 8.4

SAP-2.A.3 The periodicity (in SAP-2.A.2) is useful to predict /estimate values of properties in the absence of data.	

TOPIC 1.8 Valence Electrons and Ionic Compounds

ENDURING UNDERSTANDING **SAP-2** The periodic table shows patterns in electronic structure and trends in atomic properties.

LEARNING OBJECTIVE
SAP-2.B
Explain the relationship between trends in the reactivity of elements and periodicity.

ESSENTIAL KNOWLEDGE
SAP-2.B.1
The likelihood that two elements will form a chemical bond is determined by the interactions between the valence electrons and nuclei of elements.

SAP-2.B.2
Elements in the same column of the periodic table tend to form analogous compounds.

SAP-2.B.3
Typical charges of atoms in ionic compounds are governed by their location

Periodic Trends "Who am I?"

I have 1 valence electron and 10 core electrons. What is my name?	My valence electrons are located in a 3p. I am the smallest element in this period. What is my name and group number?	I have the lowest electronegativity and the lowest ionization energy. I am never found free in nature. What is my name?
I am a transition metal. I have an IE less than cobalt but more than manganese. What is my name?	We are in Group 14. Our AR is less than Germanium. What are our names and period numbers? (two elements)	I have an oxidation number of -3. I have the lowest ionization energy in my group. What is my name?

Why do members of the same group on the periodic table form similar compounds?

Which of the following elements will bond with oxygen in a 1:1 ratio: Calcium, Potassium, or Aluminum? Justify your choice using your knowledge of valence electrons and groups on the periodic table.

on the periodic table and the number of valence electrons. **Brown: 6.9, 7.7, 7.8, 8.1**	Given the following chemical formula, $SrCl_2$, explain how this formula is derived. Justify your answer using the location of the elements on the periodic table.