The Mole

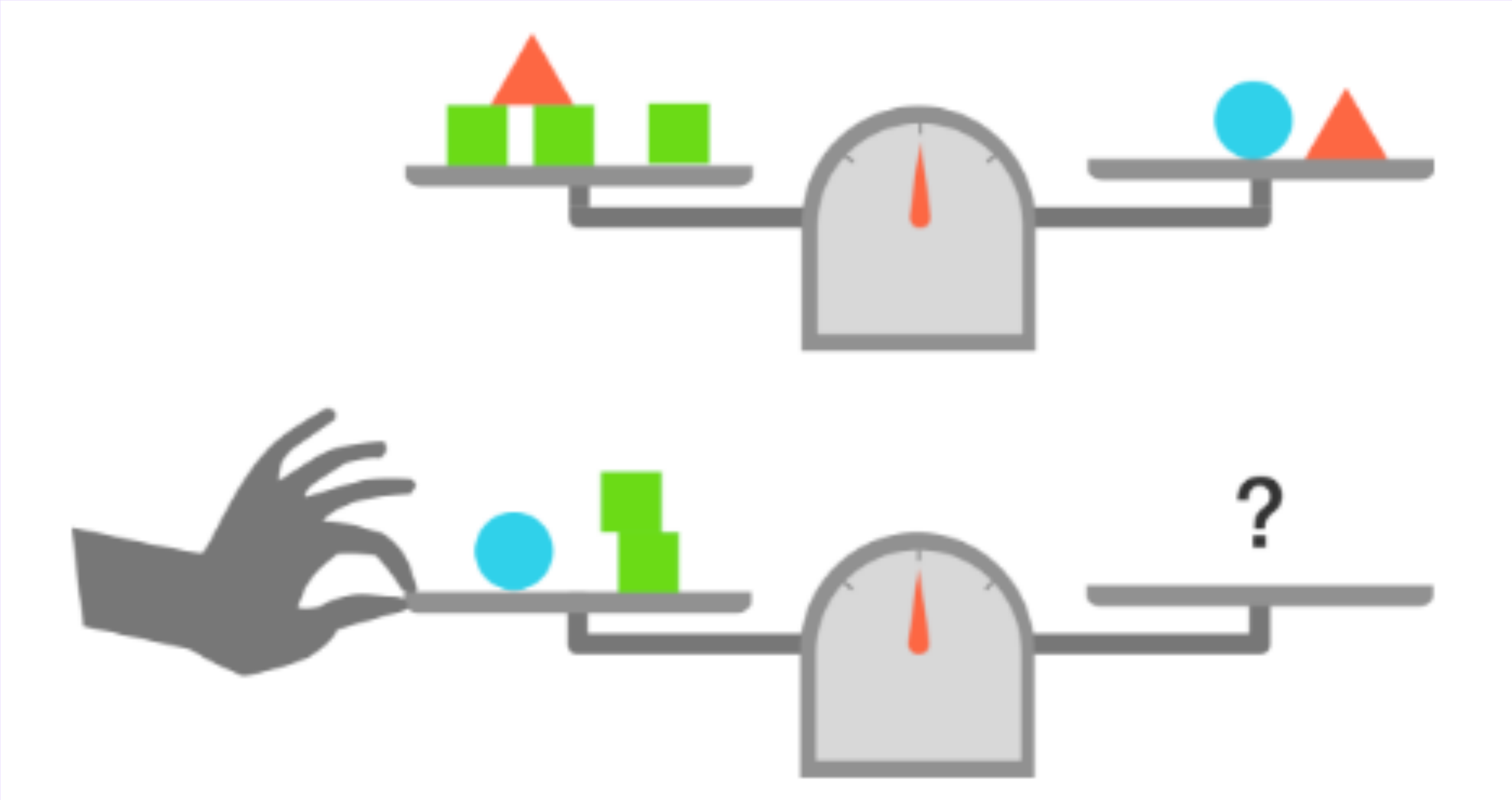
Empirical & Molecular Formulas

Chapter 3
Sections 3.1 & 2.2

I am always looking for good wrong answers for future use. So if the answer you really wanted wasn't among the choices, please tell me (or at the very least, write down the slide # and submit your suggestion.)

How many green squares should be placed on the right side of the bottom scale in order to make it balanced when released?

A. 3
B. 4
C. 5
D. 6
E. 7



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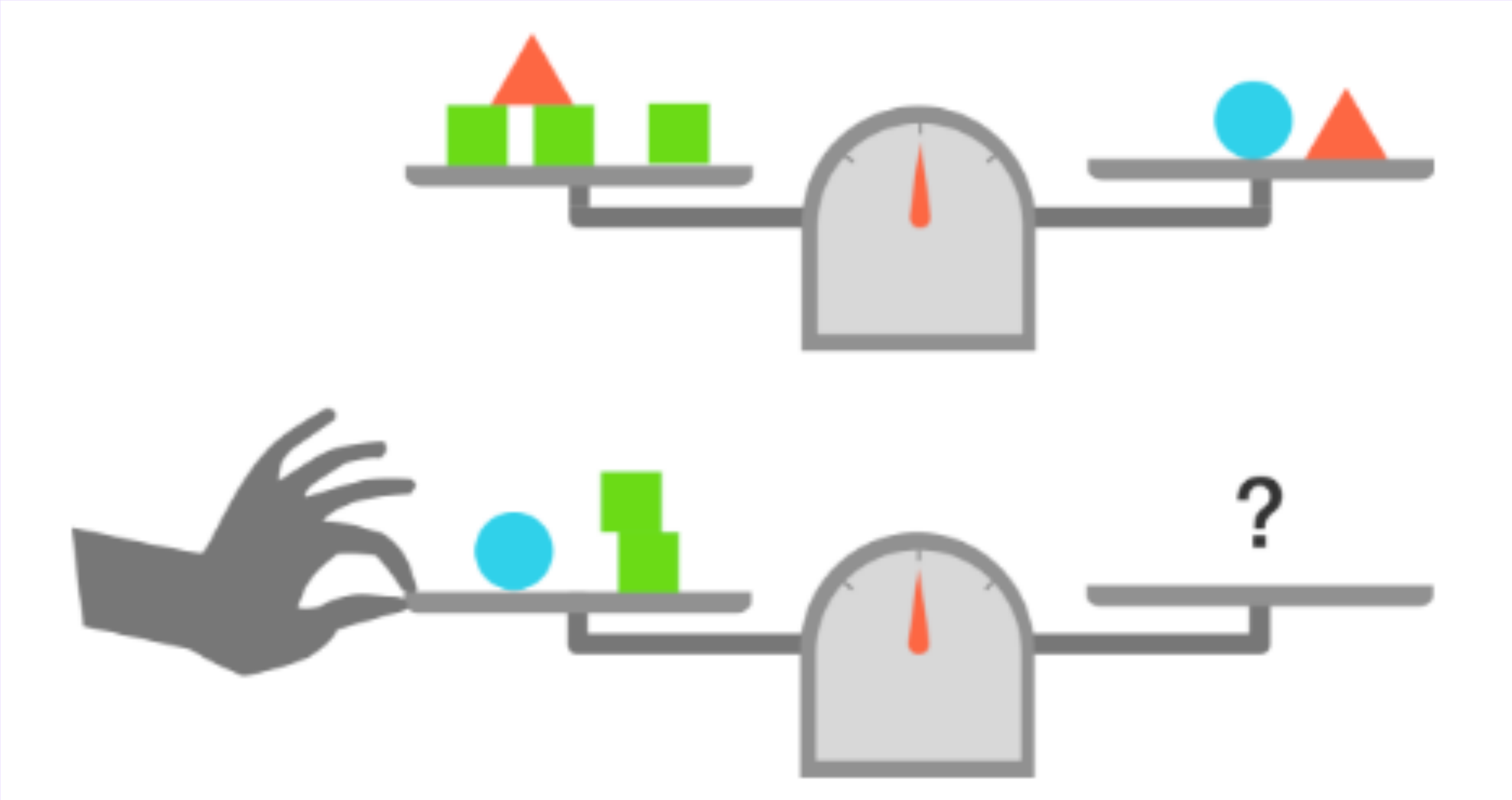
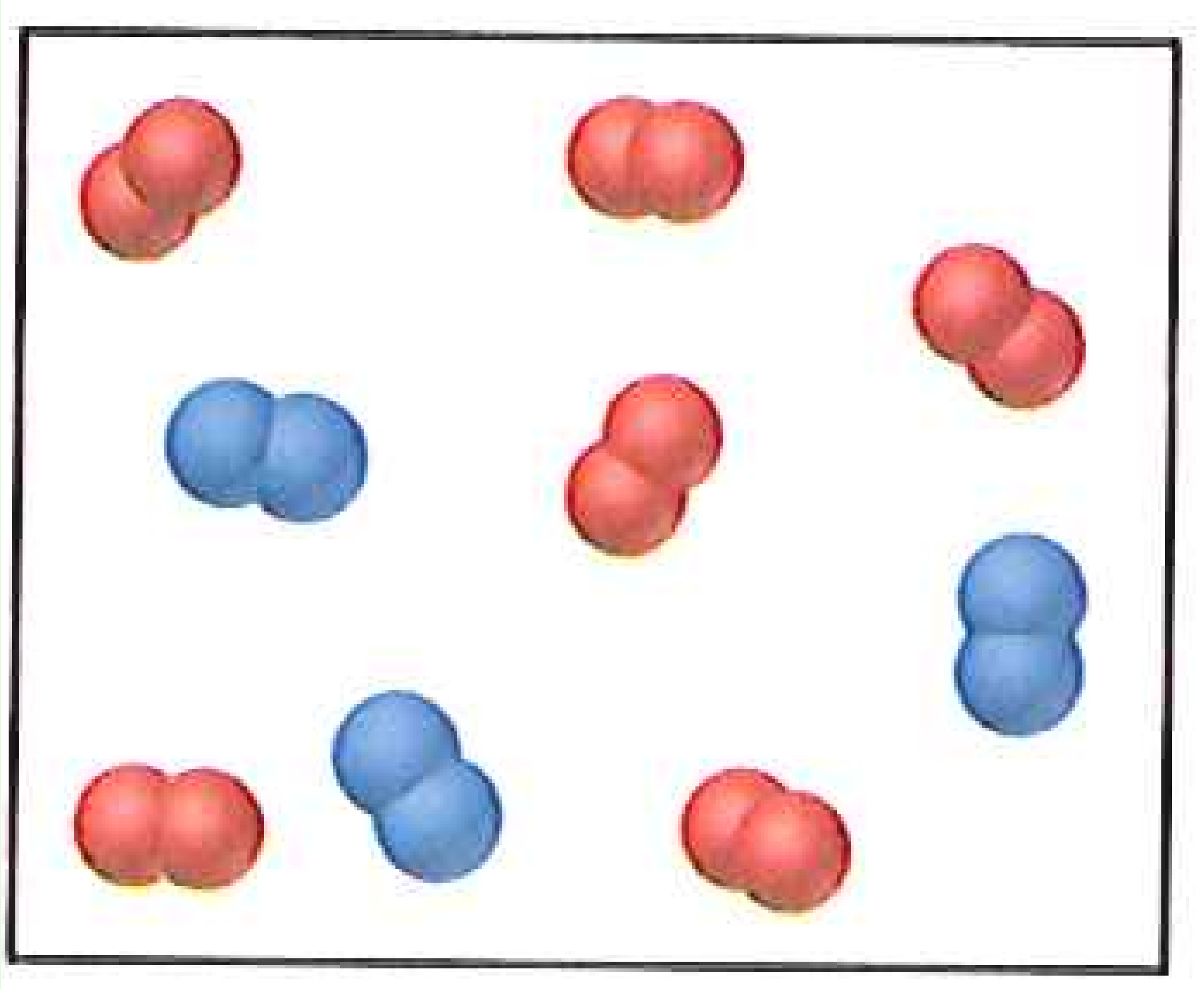


The following diagram represents the collection of elements formed by the decomposition of a compound. The blue spheres represent nitrogen atoms and the red spheres represent oxygen atoms, what was the *empirical* formula of the original compound?

1. N_6O_{12}
2. N_3O_6
3. NO_2
4. NO
5. NO_3



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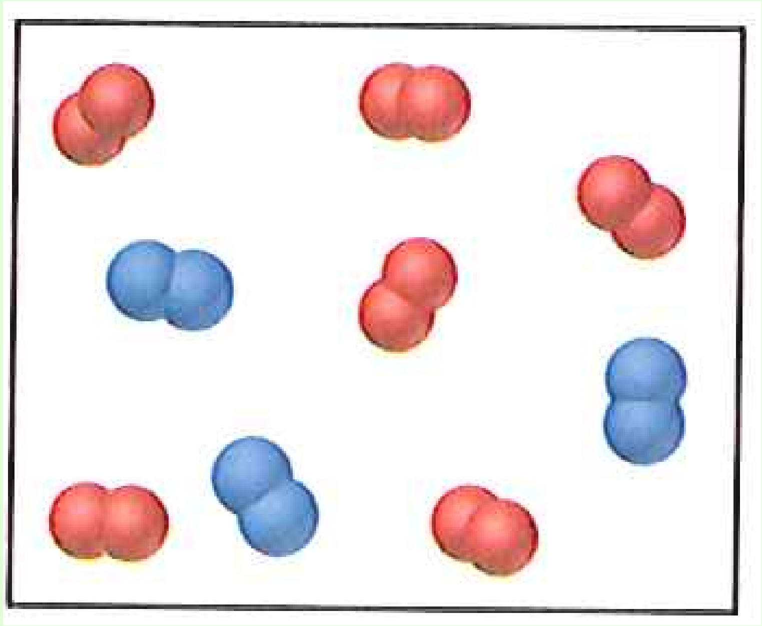
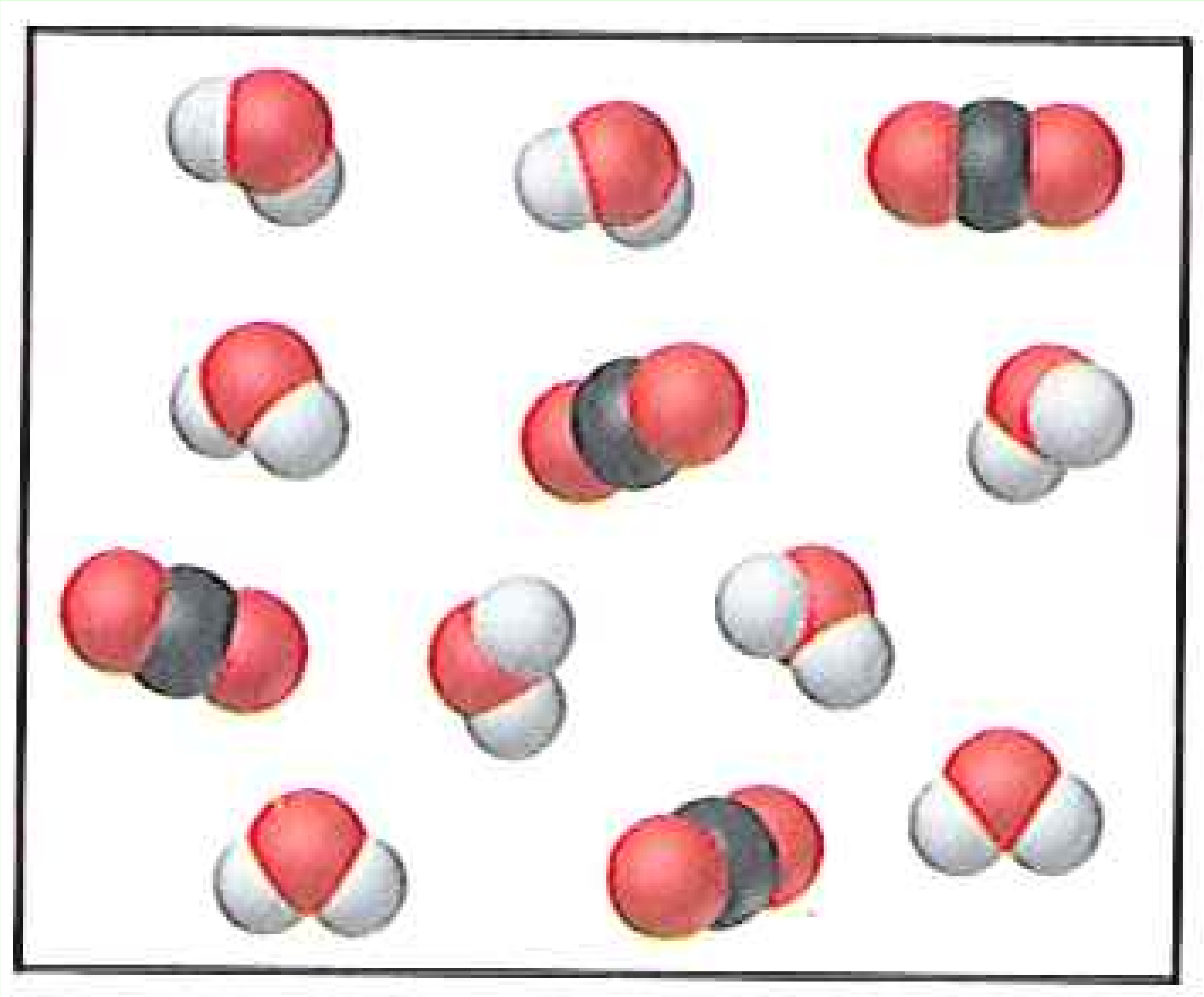


1. N_6O_{12}
2. N_3O_6
3. NO_2
4. NO
5. NO_3

- We can not know the molecular formula from the information given.
- We only know the ratio of N's to O's in the original compound.

The following diagram represents the collection of carbon dioxide and water formed by the combustion of a hydrocarbon. What was the empirical formula of the original hydrocarbon?

1. C_4H_{16}
2. C_2H_4
3. C_2H_8
4. CH_4
5. CH_2



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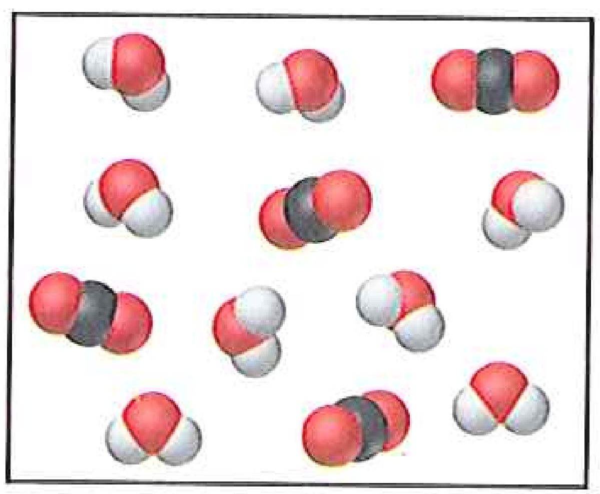

1. C_4H_{16}
2. C_2H_4
3. C_2H_8
4. CH_4
5. CH_2
6. While the diagram indicates 4 carbons, and you might think there could have been 1 C_4H_{16}, 2 C_2H_8, or 4 CH_4.

- However, the maximum number of H's that can attach to C's is C_nH_{2n+2}. Thus to achieve the 1:4 C:H ratio, both the empirical and molecular formula must have been CH_4.

Mass Percent Problems

Staple your Data Table to the back of your LAD A1 sheets
Hand in over by the window
Clickers Today

Analysis of a tellurium oxide compound indicated 84.22 % tellurium. The molar mass is approximately 600 g/mole. Determine the molecular formula.

Yes, Calculators

1. TeO
2. Te_2O_3
3. Te_2O
4. TeO_2
5. TeO_3
6. Te_3O
7. Te_4O
8. TeO_4
9. Te_4O_6

Analysis of a tellurium oxide compound indicated 84.22 % tellurium. The molar mass approximately 600 g/mole.
Determine the molecular formula.

- The Molecular Formula is Te_4O_6.

$$\frac{84.22}{127.6} = 0.66 \qquad \frac{0.66}{0.66} = 1 \times 2 = 2$$

$$\frac{15.78}{16} = 0.986 \qquad \frac{0.986}{0.66} = 1.5 \times 2 = 3$$

- Te_2O_3 MM = 303.2 thus Te_4O_6.

Determine the empirical formula of a nerve gas that gave the following analysis: 39.10% C, 7.67% H, 26.11% O, 16.82% P, 10.32 % F.

Yes, Calculators

- The Formula is $C_vH_wO_xP_yF_z$.

Determine the empirical formula of a nerve gas that gave the following analysis: 39.10% C, 7.67% H, 26.11% O, 16.82% P, 10.32 % F.

- The Empirical Formula is $C_6H_{14}O_3PF$

$$\frac{39.1}{12} = 3.26 \qquad \frac{3.26}{0.543} = 6\ C$$

$$\frac{7.67}{1} = 7.67 \qquad \frac{7.67}{0.543} = 14\ H$$

$$\frac{26.11}{16} = 1.63 \qquad \frac{1.63}{0.543} = 3\ O$$

$$\frac{16.82}{31} = 0.543 \qquad \frac{0.543}{0.543} = 1\ P$$

$$\frac{10.32}{19} = 0.543 \qquad \frac{0.543}{0.543} = 1\ F$$

How many grams of zinc nitrate(189 g/mol) contain 48 grams of oxygen atoms?

No Calculator

1. 95 g
2. 125 g
3. 145 g
4. 165 g
5. 189 g
6. none of the above

How many grams of zinc nitrate(189 g/mol) contain 48 grams of oxygen atoms?

$$48gO \times \frac{1mol}{16g} \times \frac{1Zn(NO_3)_2}{6O's} \times \frac{189g}{1mol} =$$

1. 95 g
   - Look for easy math. $Zn(NO_3)_2$
   - 3 O's = 48g, since 2 NO_3's per zinc nitrate, you only need 0.5 mol of zinc nitrate = half of molar mass
2. 125 g
3. 145 g
4. 165 g
5. 189 g

No Calculator

In which compound below is the mass ratio of copper to sulfur closest to 2:1?

No Calculators

1. CuS_2
2. CuS
3. Cu_2S
4. Cu_2S_3
5. Cu_3S_2

In which compound below is the mass ratio of copper to sulfur closest to 2:1?

1. CuS_2 ~1:1
2. CuS ~2:1
3. Cu_2S ~4:1
4. Cu_2S_3 ~4:3
5. Cu_3S_2 ~6:4

Expect easy math.

MM Cu=63.6 and S=32.

For calculation purposes assume 64 and 32

No Calculators

A certain compound contains only one sodium atom and is 5% sodium by mass. What is the molar mass of the compound?

No Calculators

1. 460 g/mol
2. 230 g/mol
3. 110 g/mol
4. 55 g/mol
5. none of the above

A certain compound contains only one sodium atom and is 5% sodium by mass. What is the molar mass of the compound?

No Calculators

1. 460 g/mol
    - make the math easy. molar mass of Na is 23, so 23 is 10% of 230, and thus 5% of 460.
2. 230 g/mol
3. 110 g/mol
4. 55 g/mol
5. none of the above

For those of you who have found this last material too easy....

Try these next three challenge problems to stimulate your brain and keep you sharp.

These would NOT likely show up on an AP exam.

Special Challenge Problem #1

When aluminum is heated with an element from Group 6A of the periodic table an ionic compound is formed. When an experiment is performed with an unknownı element of group 6A, the product is 18.56% aluminum by mass. Determine the identity of the reacting element and the formula of the compound.

- Type in the atomic number of the element.

Special Challenge Problem

When aluminum is heated with an element from Group 6A of the periodic table an ionic compound is formed. When an experiment is performed with an unknownı element of group 6A, the product is 18.56% aluminum by mass. Determine the identity of the reacting element and the formula of the compound.

- Hint #1
- Since the element is in group 6A, we know that the formula must be Al_2X_3

Special Challenge Problem #1

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- Hint #2
- Set up a ratio to determine the total molar mass of the compound compared to the total mass of aluminum, using the molar masses.
- 54/MM = 18.56/100%
- MM = 291

Special Challenge Problem #1

When aluminum is heated with an element from Group 6A of the periodic table an ionic compound is formed. When an experiment is performed with an unknownı element of group 6A, the product is 18.56% aluminum by mass. Determine the identity of the reacting element and the formula of the compound.

- And finally...
- Knowing the molar mass of Al, solve for the MM of X
- 291 - 54 = 237
- X_3 = 237 so MM of X = 79
- Thus it must be Se

Special Challenge Problem #2

An element X forms a compound with two chlorine attached (XCl_2) and with 4 chlorines attached (XCl_4). Treatment of 10.00 g of XCl_2 with excess chlorine forms 12.55 g of XCl_4. Calculate the atomic mass of X and identify which element it is likely to be.

- Type in the atomic number of the element.

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- Hint #1
- $XCl_2 + Cl_2 \text{ --> } XCl_4$
- Determine the mass of Cl_2 in XCl_4
- Then the moles of Cl_2 which is the same as the moles of X
- Which can lead you to the molar mass of X

Special Challenge Problem #2

An element X forms a compound with two chlorine attached (XCl_2) and with 4 chlorines attached (XCl_4). Treatment of 10.00 g of XCl_2 with excess chlorine forms 12.55 g of XCl_4. Calculate the atomic mass of X and identify which element it is likely to be.

- Hint #2
- 10 g of XCl_2 + Cl_2 --> 12.55 g of XCl_4
- Thus there must be 2.55 g Cl_2 in the XCl_4 and thus there must also be 2.55 g Cl_2 in the XCl_2

Special Challenge Problem #2

An element X forms a compound with two chlorine attached (XCl_2) and with 4 chlorines attached (XCl_4). Treatment of 10.00 g of XCl_2 with excess chlorine forms 12.55 g of XCl_4. Calculate the atomic mass of X and identify which element it is likely to be.

- Hint #3
- Determine the moles of Cl_2 in XCl_2, and since there is a 1:1 ratio of X:Cl_2, we would know the moles of X.
- 2.55g of Cl_2 * 1 mole Cl_2/71 g * 1 mole X/1mole Cl_2 = 0.0359 moles X in XCl_2,

Special Challenge Problem #2

An element X forms a compound with two chlorine attached (XCl_2) and with 4 chlorines attached (XCl_4). Treatment of 10.00 g of XCl_2 with excess chlorine forms 12.55 g of XCl_4. Calculate the atomic mass of X and identify which element it is likely to be.

- and finally...
- Since 2.55g of the 10g of XCl_2 is Cl, 7.45g of the 10g must be X. Calculate the molar mass of X
- 7.45 g /0.0359 moles = ~207g/mole.
- Thus X might be lead.

Special Challenge Problem #3

A 1.500 g sample of a mixture containing only CuO and Cu_2O was treated with hydrogen to produce 1.252 g of pure copper metal. Calculate the percent composition of the mixture.

(i.e. What percent of the mixture is each of the two compounds?)

- Type in the % of the CuO compound.

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- Hint #1
- Solving this problem will require two variables, thus two equations.
- First equation:
  - The mass of each compound in the mixture will equal the total mass.
- Second equation:
  - The moles of copper in each compound will equal the moles of copper in the total mixture.

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(i.e. What percent of the mixture is each of the two compounds?)

- First equation - total mass:
- You could name the mass of Cu_2O as x and the mass of CuO as y. The two substances make up the 1.500 total mass of mixture.
- $x_g + y_g = 1.500_g$

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(i.e. What percent of the mixture is each of the two compounds?)

- Second equation - total moles:
- We know that the moles of copper in the two compounds will add up to the total moles of copper.
- Xg * 1 mole Cu_2O/143.1 g * 2 Cu/1 Cu_2O = moles of copper in Cu_2O
- Yg * 1 mole CuO/79.55 g * 1 Cu/1 CuO = moles of copper in CuO
- 1.252 g Cu * 1 mole/63.55 g = total moles Cu
- 0.01398 x + 0.01257 y = 0.0197

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- and finally...
- Simply the last equation
  - 0.01398 x + 0.01257 y = 0.0197
  - 1.112 x + y = 1.567
- Subtract the other x y equation.
  - 1.112 x + y = 1.567 (-x -y = -1.500)
  - equals: 0.112 x = 0.067 thus X = 0.6 g Cu_2O
- 0.6 g Cu_2O / 1.500 g = 40% Cu_2O in mixture
- Thus 60% CuO in mixture