[TP] The molar mass of Cl is 35.453 g. ^{37}Cl has a natural abundance of 24.24%. Which of the following statements is true?

75% 1. The mass of one atom of naturally occurring Cl is 35.453 g divided by Avogadro's number

17% 2. The mass of one atom of naturally occurring Cl cannot be 35.453 g divided by Avogadro's number.

8% 3. Neither of the statements is true.

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Lecture 2 CH131 Summer 1 2021

Tuesday, May 25, 2021

- Quizzes and final exam using Gradescope
- Atomic weight
- Chemist's dozen: The mole
- Example problems: Chemical formulas, equations, and reaction yields
- Limiting reagent recipe

Begin ch3: Chemical bonding: The classical description

- Ionization energy: $X(g) \rightarrow X^{+}(g) + e^{-}$

Next lecture: Anatomy of electron clouds; $IE_1 \rightarrow$ electron cloud expansion; Electron affinity: $X^{-}(g) \rightarrow X(g) + e^{-}$; Electronegativity: $EN \sim IE_1 + EA$; Dipole moment and ionic character: $\sim \Delta EN$

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Quizzes and final exam using Gradescope

Show your work for each question in the space provided in the question. You may do this in one of two ways:

(1) download this document, write your work on it, and then scan the completed document as a PDF, or

(2) do your work directly on the PDF of this document using a tablet device.

When you have finished, submit your PDF to Gradescope following the instructions on the handouts page.

If do not have a tablet device or printer, please email me at dan@bu.edu.

I'll provide a practice quiz shortly. 866522

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Atomic weight = magnitude of average mass

The atomic weight of K is 39.098 (no units!)

The atomic weight of Br is 79.904

The atomic weight of H is 1.008

The atomic weight of an element is the number given on the periodic table.

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[TP] The molar mass of Cl is 35.453 g. ^{37}Cl has a natural abundance of 24.24%. Which of the following statements is true?

0%	1. The mass of one atom of naturally occurring Cl is 35.453 g divided by Avogadro's number
77%	2. The mass of one atom of naturally occurring Cl cannot be 35.453 g divided by Avogadro's number.
23%	3. Neither of the statements is true.

^{a}X = 10, 50%
^{b}X = 20, 50%
atomic weight 15
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Terms to distinguish

Relative atomic mass, A_r: ratio of mass of an isotope relative to mass of 1/12 of one ^{12}C atom

A_r of ^{13}C is 13.00335 (unitless)

Atomic mass unit, u: 1/12 mass of one ^{12}C atom

1 u = (1/12) × (12 g) / N_A = g / N_A = 1.66054 × 10^{-24} g

Atomic weight: average of relative atomic masses of an element

Atomic weight of C is 12.01 (unitless) ^{12}C ^{13}C ^{14}C

Molar mass, M: Mass in grams numerically equal to atomic weight; that is, the mass in grams of N_A "average atoms" of an element

Molar mass of C is 12.01 g

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Mole: Count by weighing

The mass in g of 1 mol of any element is called its molar mass

Number of particles in 1 mol is N_A = 6.02214076 x 10^{23}

Each of these amounts contains the same number of atoms

Si 28.086

28.086 g of Si contains N_A = 6 × 10^{23} atoms of Si.

Cu 63.546

63.546 g = N_A of "average" Cu atoms

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[TP] Which contains the most molecules?

0%	1. 1 g of H_2
0%	2. 45 g of Cl_2
0%	3. 28 g of N_2
100%	4. 24 g of CH_4
0%	5. Not sure

convert g mole

H_2: 1 g × 1 mol / 2 g = 0.5 mol

28 g N_2 × 1 mol N_2 / 28 g = 1 mol N_2

CH_4: 24 g × 1 mol / 16 g = 1.5 mol CH_4

Cl_2: 45 g × 1 mol / 70 g = 2/3 mol

866 52

H_2 2 g/mol
Cl_2 70 g/mol
N_2 28 g/mol
CH_4 16 g/mol

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Mass to molecules

Which contains the most molecules?

1 g of H_2: $1\text{ g} \times \frac{\text{mol}}{2\text{ g}} = 0.5\text{ mol}$

45 g of Cl_2: $45\text{ g} \times \frac{\text{mol}}{(2\times35)\text{ g}} = 0.64\text{ mol}$

28 g of N_2: $28\text{ g} \times \frac{\text{mol}}{(2\times14)\text{ g}} = 1.0\text{ mol}$

24 g of CH_4: $24\text{ g} \times \frac{\text{mol}}{(12+4\times1)\text{ g}} = 1.5\text{ mol}$

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[TP] Which of the following contains the least number of atoms?

8% 1. 187 g of liquid mercury, Hg
92% 2. 1400 u of uranium, U
0% 3. 6×10^{24} atoms of sodium, Na
0% 4. 2 mol of hydrogen gas, H_2 = 4 moles of H
0% 5. Not sure

12u of C, how many atoms – just 1.

Hg 201 U 238

$187\text{ g} * \frac{1\text{ mol}}{201} * N_A \approx 0.9 * 6\times10^{23}$ atoms

$1400\text{ u} * \frac{1\text{ atom}}{238\text{ u}} \approx 7$ atoms

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[TP] Which of the following contains the greatest number of atoms?

0% 1. 187 g of liquid mercury, Hg
0% 2. ~~1400 u of uranium, U~~
100% 3. 6×10^{24} atoms of sodium, Na
0% 4. 2 mol of hydrogen gas, H_2
0% 5. Not sure

6×10^{24} atoms

$2\text{ mol }H_2 * \frac{2\text{ mol H}}{\text{mol }H_2} * 6\times10^{23}\frac{\text{atoms}}{\text{mol H}}$

2.4×10^{24} atoms

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Problem: 7e 2.7; 8e 1.31

A_2 49 atoms
A 51 atoms

7. The vitamin A molecule has the formula $C_{20}H_{30}O$, and a molecule of vitamin A_2 has the formula $C_{20}H_{28}O$. Determine how many moles of vitamin A_2 contain the same number of atoms as 1.000 mol vitamin A.

7e	8e
2.7	1.31
2.33	2.21
2.35	2.23
2.39	2.27
2.47	2.35
2.49	2.37

# of atoms in A $= 1.000\text{ mol A} * \frac{51\text{ mol atoms}}{1\text{ mol A}} * \frac{N_A}{\text{mol}}$
$= 1.000 * 51 * N_A$

# of atoms in $A_2 = x\text{ mol }A_2 * \frac{49\text{ mol atom}}{\text{mol }A_2} * \frac{N_A}{\text{mol}}$
$= x * 49 * N_A$

atoms in A = # atoms in A_2
$1.000 * 51 * N_A = x * 49 * N_A$
$x = \frac{51}{49} * 1.000$

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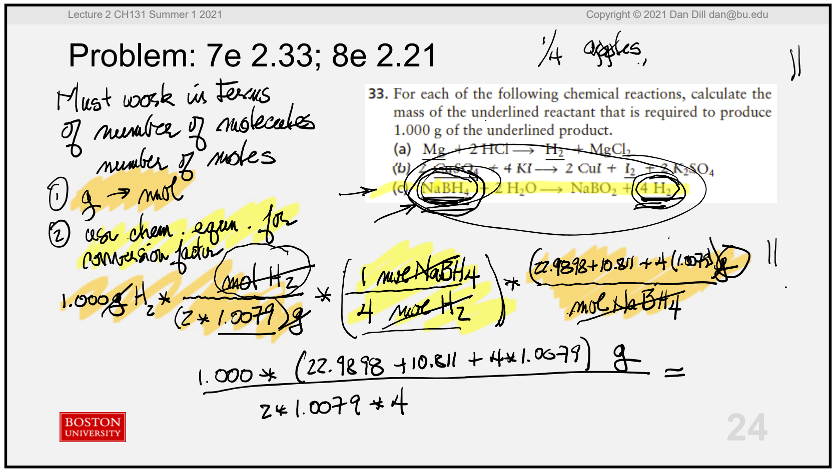
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Problem: 7e 2.33; 8e 2.21
33. For each of the following chemical reactions, calculate the mass of the underlined reactant that is required to produce 1.000 g of the underlined product.
(a) Mg + 2 HCl → H2 + MgCl2
(b) 2 CuSO4 + 4 KI → 2 CuI + I2 + 2 K2SO4
(c) NaBH4 + 2 H2O → NaBO2 + 4 H2
Must work in terms of number of molecules number of moles
① g → mol
② use chem. eqn. for conversion factor
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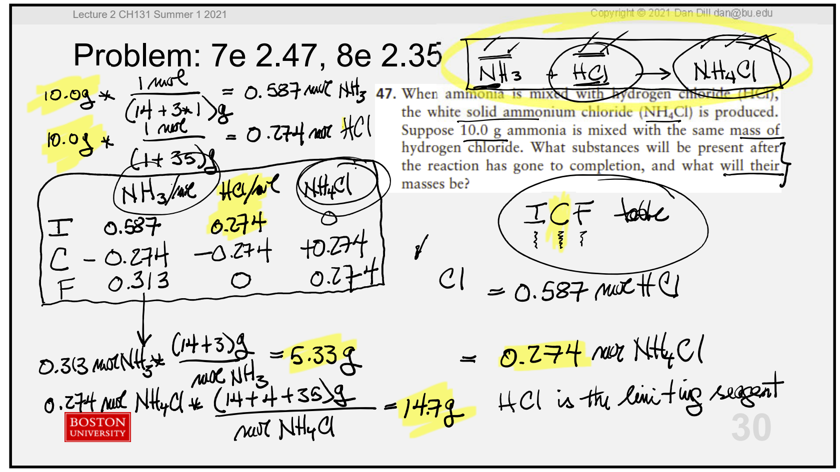
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Problem: 7e 2.47, 8e 2.35
47. When ammonia is mixed with hydrogen chloride (HCl), the white solid ammonium chloride (NH4Cl) is produced. Suppose 10.0 g ammonia is mixed with the same mass of hydrogen chloride. What substances will be present after the reaction has gone to completion, and what will their masses be?
ICF table
HCl is the limiting reagent
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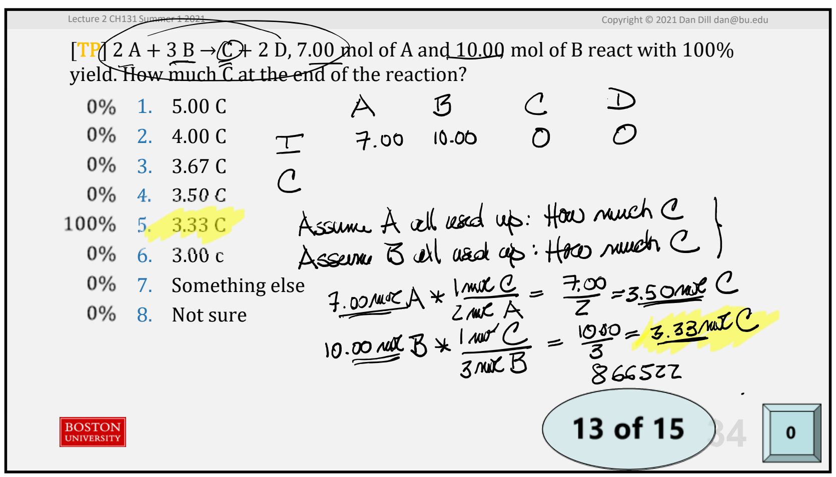
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[TP] 2 A + 3 B → C + 2 D, 7.00 mol of A and 10.00 mol of B react with 100% yield. How much C at the end of the reaction?
0% 1. 5.00 C
0% 2. 4.00 C
0% 3. 3.67 C
0% 4. 3.50 C
100% 5. 3.33 C
0% 6. 3.00 c
0% 7. Something else
0% 8. Not sure
Assume A all used up: How much C
Assume B all used up: How much C
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0
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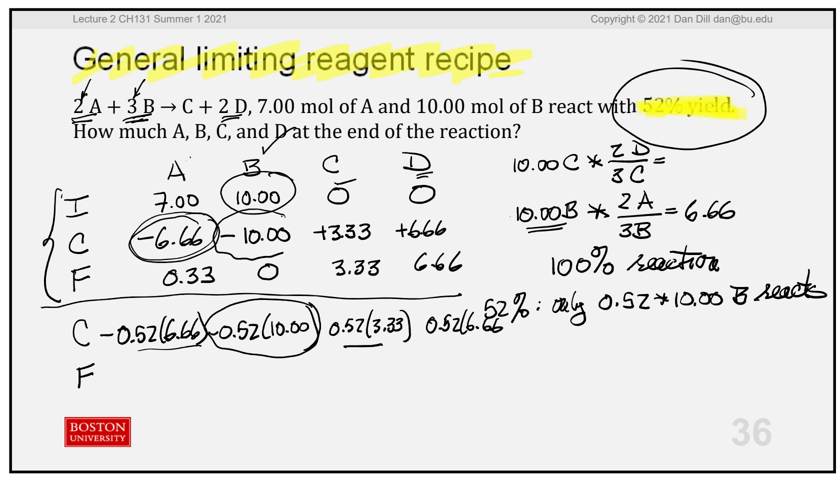
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General limiting reagent recipe
2 A + 3 B → C + 2 D, 7.00 mol of A and 10.00 mol of B react with 52% yield.
How much A, B, C, and D at the end of the reaction?
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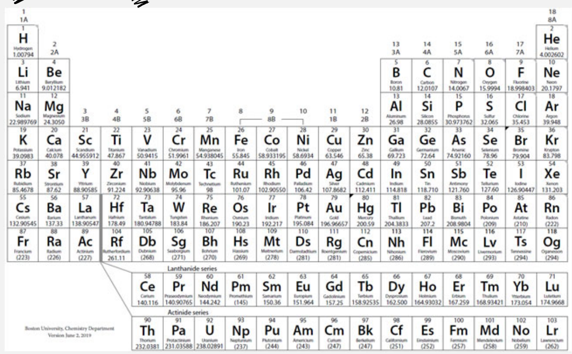
IE, EA, and EN



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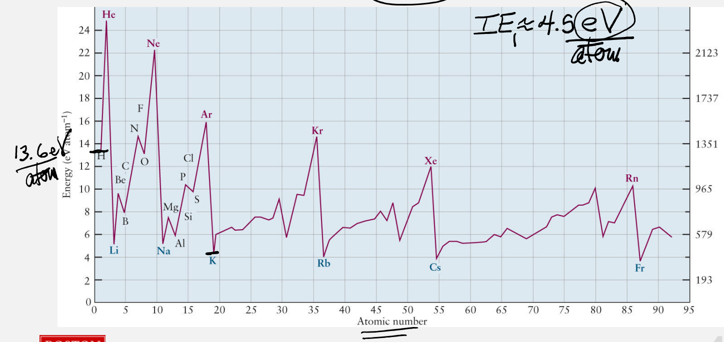
First ionization energy, IE_1

$K(g) \rightarrow K^+(g) + e^-$

$IE_1 \approx 4.5 \frac{eV}{atom}$



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eV/atom and kJ/mol

charge × voltage = energy

1 eV is the energy of 1 electron charge in a potential of 1 V = 1 J/C

$e^- = 1.6022 \times 10^{-19}$ C

1 eV = 1.6022×10^{-19} C × 1 J/C = 1.6022×10^{-19} J

charge voltage

voltage = energy / charge

1 V = 1 J / C

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eV/atom and kJ/mol

For H atom (only; not other atoms),

$IE_1 = 13.6 \frac{\text{eV}}{\text{atom}} = 13.6 \frac{\text{eV}}{\text{atom}} \times 1.6022 \times 10^{-19} \frac{\text{J}}{\text{eV}} = 21.8 \times 10^{-19} \frac{\text{J}}{\text{atom}}$

$IE_1 = 21.8 \times 10^{-19} \frac{\text{J}}{\text{atom}} \times \frac{N_A\ \text{atom}}{\text{mol}} = 21.8 \times 10^{-19} \times 6.022 \times 10^{23}$ J/mol

$= 1.31 \times 10^6 \frac{\text{J}}{\text{mol}} = 1310 \frac{\text{kJ}}{\text{mol}}$

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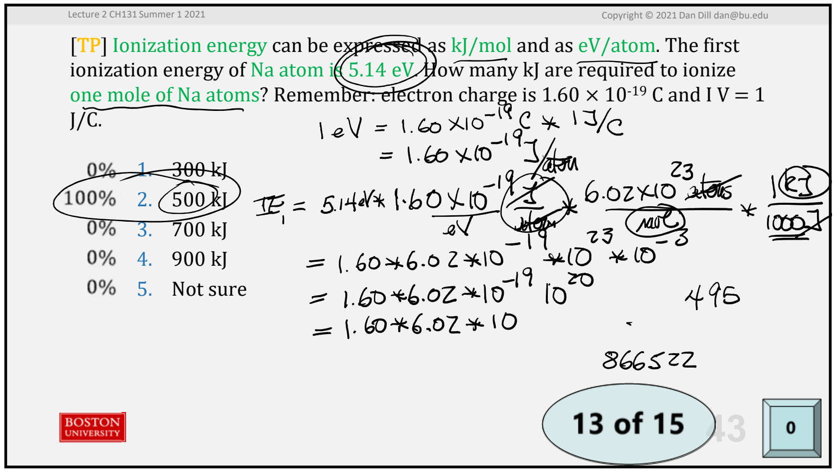
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[TP] Ionization energy can be expressed as kJ/mol and as eV/atom. The first ionization energy of Na atom is 5.14 eV. How many kJ are required to ionize one mole of Na atoms? Remember: electron charge is 1.60 × 10-19 C and 1 V = 1 J/C.
0% 1. 300 kJ
100% 2. 500 kJ
0% 3. 700 kJ
0% 4. 900 kJ
0% 5. Not sure
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0

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