Lecture 1 CH131 Summer 1

Tuesday, May 21, 2019

Course overview

Begin Ch1: The atom in modern chemistry
- Periodic table: Master key to chemistry
- Isotopes → atomic weight

Next lecture: Chemist's dozen: The mole. Ch 2: Chemical formulas, equations, and reaction yields

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Course overview

Dan Dill, dan@bu.edu
http://quantum.bu.edu/courses/ch131-summer-1-2019
../schedule.html

- Lectures and discussions will be held in PRB/150
- Holiday (no class) Monday, May 27
- Makeup lecture Friday, May 31

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Course overview

Dan Dill, dan@bu.edu
http://quantum.bu.edu/courses/ch131-summer-1-2019
../schedule.html

- First discussion tomorrow: 9–9:50 pm, PRB/150
- Six discussion quizzes: first one this Thursday, May 23
- First lab tomorrow, Wednesday, May 22, 1 pm, SCI/268
- Two lecture exams: Monday, June 3 and June 17
- Final exam: Thursday, June 27

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We will cover chapters 1—3 and 9—17 of Oxtoby et al.
.../syllabus.html#lecture

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Lecture quizzes

- Each lecture, based on the material covered during that lecture
- Administered using TurningPoint
- To receive credit, you must be registered
- Registration details at .../TP.html:
  - TP account
  - TP license
  - TP clicker
  - TP clicker registration

Course grade

Your scores for each part of the course will always be available to you on Blackboard, at https://goo.gl/3Eui7a learn.bu.edu

Course grade is based on your overall course score

Contribution to overall course score	
Discussion quizzes	10%
Lecture quizzes	15%
Lecture exams	30%
Final exam	20%
Lab	25%

Other questions?

dan@bu.edu

Please refer to the course web site

http://quantum.bu.edu/courses/ch131-summer-1-2019

Academic conduct

You are bound by the provisions of the academic conduct code,

http://goo.gl/k78iy

Remember, we treat cheating with zero tolerance.

Periodic table: Master key to chemistry

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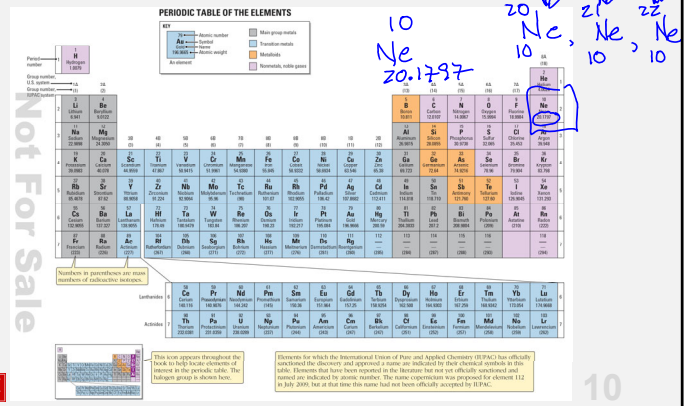
9



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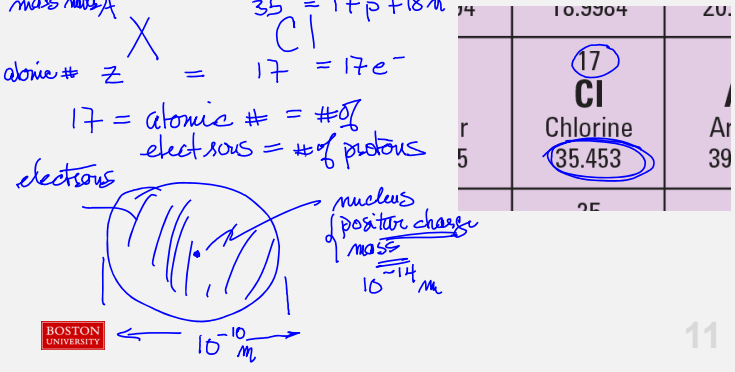
10

Periodic table: Master key to chemistry



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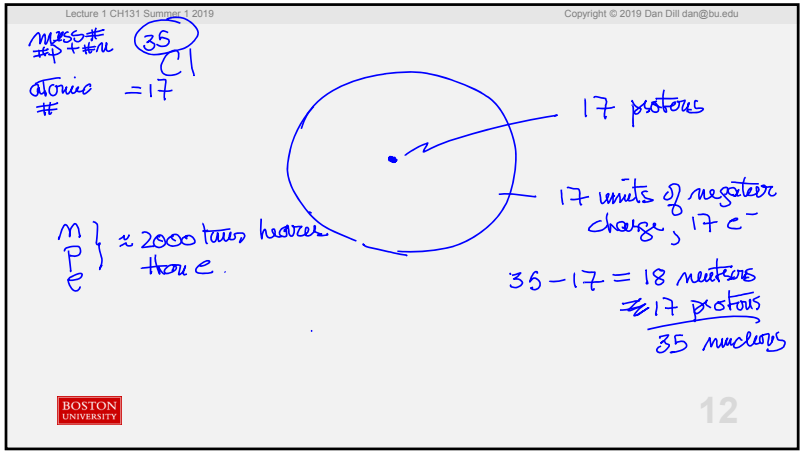
11



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12

Isotopes → atomic weight

$^{35}_{17}Cl$ and $^{37}_{17}Cl$

17p +18n

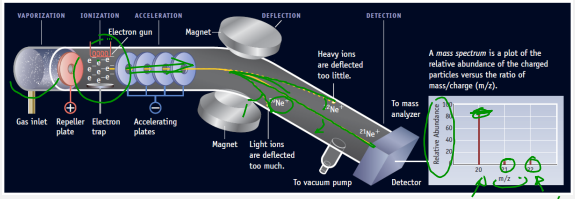
17p+ 20n

Cl-35 isotope

Cl-37 isotope

17 Cl 35.453

Mass spectrometer "weighs" atoms



Strip away an electron, accelerate positive ions, and then deflect them in a magnetic field.

Less deflection, heavier mass

Neon has three "isotopes": ^{20}Ne, ^{21}Ne, and ^{22}Ne

Relative peak heights → isotopic abundance

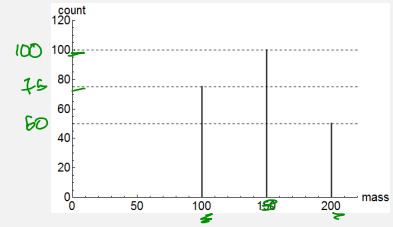
Average mass of CH131 students?

75 students weigh 100 lbs

100 students weigh 150 lbs

50 students weigh 200 lbs

Sketch the "mass spectrum" of the class, using just "counts" for the vertical axis



[TP] For our hypothetical class,
75 students weigh 100 lbs,
100 students weigh 150 lbs, and
50 students weigh 200 lbs.

Based on your "mass spectrum" sketch, roughly (guesstimate), what will the average be?

1. Less than 100 0%
2. Between 100 and 150 100%
3. Between 150 and 200 0%
4. Greater than 200 0%

Average mass of CH131 students?

75 students weigh 100 lbs

100 students weigh 150 lbs

50 students weigh 200 lbs

What is the expression for the fraction of students with mass 150 lbs, f_{150}?

$f_{150} = \frac{\#\text{ w/ mass 150}}{\text{total \#}} = \frac{100}{225} =$

Average mass of CH131 students?

75 students weigh 100 lbs

100 students weigh 150 lbs

50 students weigh 200 lbs

In terms of f_{100}, f_{150}, and f_{200}, write the expression that evaluates to the exact average.

2. $f_{100} + f_{150} + f_{200} = 1$

7. $(f_{100} + f_{150} + f_{200})/3 = 1/3$

8. $f_{100} * 100 + f_{150} * 150 + f_{200} * 200$

Average mass of CH131 students?

75 students weigh 100 lbs

100 students weigh 150 lbs

50 students weigh 200 lbs

total mass = 75 × 100 lbs + 100 × 150 lbs + 50 × 200 lbs

average mass = total mass / (75 + 100 + 50)

= total mass / 225

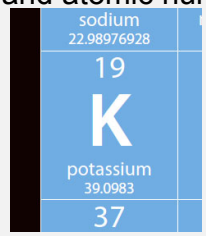
= (75/225) × 100 lbs + (100/225) × 150 lbs + (50/225) × 200 lbs

= f_{100} × 100 lbs + f_{150} × 150 lbs + f_{200} × 200 lbs

[TP] For our hypothetical class, average weight of a CH131 student is 144 lbs. Which of the following statements is true for this class?

1. The weight of each student is 144 lbs **0%**
2. No student weighs 144 lbs **100%**
3. Neither of the statements is true. **0%**

Element identity and atomic number Z



Number of protons = atomic number $Z = 19$

Relative atomic weight = 39.0983

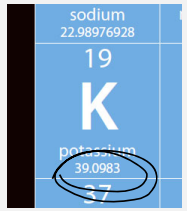
Where does the number 39.0983 come from?

Atoms of an element come in different "flavors"

Atoms with the same number of protons ...
but with different numbers of neutrons ...
are chemically the same ...
but have different masses

We call such different flavors of atoms of an element isotopes

39.0983 u is the average mass of the different kinds of atoms (isotopes) of K that are in a sample of K.



Atomic mass unit u

Atomic mass unit u

1 u defined to be exactly (1/12) mass of 1 atom of ^{12}C

Exactly 12 g of ^{12}C contains $N_A = 6.02214 \times 10^{23}$ atoms

Therefore, the mass of one ^{12}C atom is ...

$12\ g/N_A = 1.99265 \times 10^{-23}\ g$

And so, 1 u = ...

$(1/12) \times 1.99265 \times 10^{-23}\ g = 1.66054 \times 10^{-24}\ g$

$1\ u = \frac{g}{N_A}$

Average mass of an atom of K

Two isotopes: K-39 and K-41

K-39 peak at 38.9637 u, height 933

K-41 peak at 40.9618 u, height 67

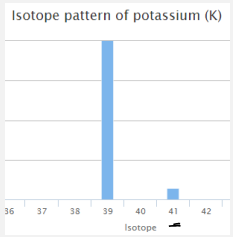
Write and then evaluate the expression whose value is the average mass in u of an atom of K.

f_{39} 38.9637 u + f_{41} 40.9618 u = 39.098 u

$f_{39} = \frac{933}{933+67} = 0.933$ $f_{41} = \frac{67}{100}$

$f_{39} \times 38.9637\text{u} + f_{41} \times 40.9618\text{u}$

0.933 0.067



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Average mass of an atom of K

Two isotopes: K-39 and K-41

K-39 peak at 38.9637 u, height 933

K-41 peak at 40.9618 u, height 67

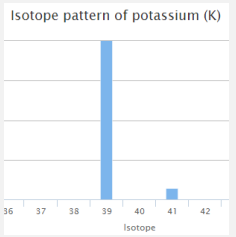
The average mass in g of an atom of K is

$= 39.098\text{ u}$

$= 39.098 \times (1/12) \times 12\text{ g} \times (1/N_A)$

$= 39.098\text{ g} / N_A$

$= 6.4923 \times 10^{-23}\text{ g}$



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Average mass of any atom

The average mass of an atom of K is 39.098 g/N_A

The average mass of an atom of Br is 79.904 g/N_A

The average mass of an atom of H is 1.008 g/N_A

The average mass of any atom in g/N_A is the number given on the periodic table.

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Molar mass of any element

Molar mass is the mass of N_A "average" atoms of an element.

The average mass of an atom of K is 39.098 g/N_A

The molar mass of K is $N_A \times (39.098\text{ g}/N_A) = 39.098\text{ g}$

The molar mass of Br is 79.904 g

The molar mass of H is 1.008 g

The molar mass of any element in g is the number given on the periodic table.

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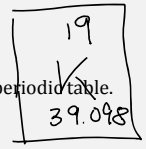
Atomic weight = magnitude of average mass

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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[Quiz] 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?

1. The mass of one atom of naturally occurring Cl is 35.453 g divided by Avogadro's number 0%
2. The mass of one atom of naturally occurring Cl cannot be 35.453 g divided by Avogadro's number. 93%
3. Neither of the statements is true. 7%

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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

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

Atomic weight: average of relative atomic masses of an element

Atomic weight of C is 12.01 (unitless)

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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