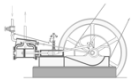
Chem 108
Introductory Chemistry

Dr. Ron Rusay

CONNECTIONS: Chemistry ⇆ STE(A)M

STE(A)M

S Science
T Technology
E Engineering
M Mathematics



< A: Arts & Applications

Chemistry Connections (CHEM 108)

- *STE(A)M ⇆ Chemistry ⇆ Allied Careers*
  - *Linked by the Scientific Method*

Chemistry focuses on the study of

- *Energy & Matter: Classification, Behavior & Properties*

All Science, Technology, Arts & Engineering involves:

- *Observations & Measurements: (Qualitative & Quantitative)*
- *Applying metric & related units*

Chemistry ⇆ Physics ⇆ Engineering
The Scientific Method (A Unifying Practice)

- *Energy & Matter: central in all three areas* *eg. Forces & Gravity*
- *Observations: Visible & Measureable*
- *Mathematics: Calculations & Models*

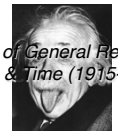
Progressions & Connections:
Arithmetic⇆Algebra⇆Calculus⇆Differential Equations⇆Partial Differential Equations⇆Linear Algebra⇆Non-linear Equations⇆Non-deterministic Systems

RESULTS: Protocols, Explanations, Predictions & Products

Examples: GPS, Cosmology, Space Travel, Space Probes, New Materials: Structural, Mechanical, Industrial & Molecular

Law or Theory of Gravity?

Hipparchus and Erastothenes (~ 270 B.C.E.)
Galileo (~1600) & Isaac Newton (1687)



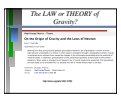
Theory of General Relativity: Space & Time (1915-2015)

The key idea of Einstein's theory of general relativity is that gravity is not an ordinary force, but rather a property of space-time geometry.
https://www.youtube.com/watch?v=wtsNOMTtS7E

Which falls faster, a feather or a hammer? ……. in a vacuum? …… on the moon?

Chemistry ⇆ Physics
The Scientific Method (A Unifying Practice)



Chemistry ⇆ Physics

Law vs. Theory

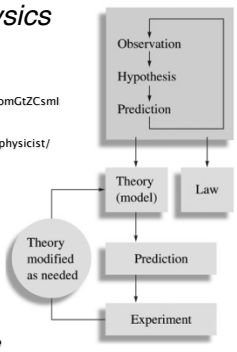
A New Explanation of Gravity
http://www.youtube.com/watch?v=vyomGtZCsml

The Case of Gravity
http://www.science20.com/hammock_physicist/it_bit_case_gravity

Law(s)? vs. Theory

Spinoza Prize €2.5 x 10⁶

"The NWO Spinoza Prize is the highest Dutch award in science; that is awarded to Dutch researchers who rank among the absolute top of science."



QUESTION

Theories are best validated, proven or disproven by

A. observations.
B. models.
C. laws.
D. experiments.
E. guesses.

QUESTION

The difference between a scientific law and a scientific theory can, at times, be confusing. For example, we will refer to the "Atomic theory" or perhaps the "Law of Gravity." Should the Law of Gravity be changed to the Theory of Gravity?

A. Yes, no one can see gravity, it is better described as a theory.
B. No, scientific laws are based on summaries of many observations and gravity observations are well known and predictable. More than one theory may explain the observations.
C. Yes, gravity is better described as a theory because gravity explains why masses attract each other and theories are about explaining observations.
D. No, keep it as a law, laws offer explanations and gravity explains why masses attract each other and laws are about explaining observations.

Some Possible Steps in the Scientific Method

1. *Observations*
   - *qualitative (general, descriptive, subjective)*
   - *quantitative (numbers, values)*
2. *Formulating hypotheses*
   - *possible explanation(s) for the observation(s)*
3. *Performing experiments*
   - *gathering new information*
   - *testing whether the hypotheses are valid*
4. *Developing a theory*
5. *Testing & Refining*

QUESTION

Which statement most resembles a scientific theory?

A. *When the pressure of a sample of oxygen gas is increased 10%, the volume of the gas decreases by 10%.*
B. *The volume of an ideal gas doubles when the pressure of the gas is reduced by one half.*
C. *Gases are composed of very small particles that are constantly moving. They collide with the surface of containers which hold them, producing pressure.*
D. *A gas sample has a mass of 15.8 grams and a volume of 10.5 Liters.*

Energy & Matter

$E = mc^2$

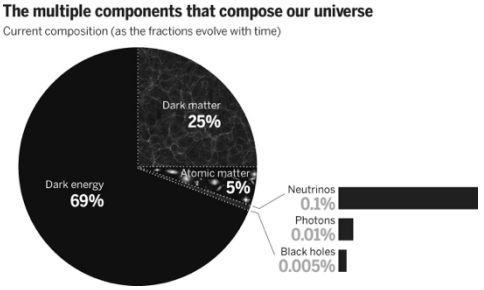
http://energy.gov/articles/livestream-our-latest-nobel-prize-winner

Based on the standard model of cosmology, the total mass/energy of the universe is comprised of 4.9% ordinary matter, 26.8% dark matter and 68.3% dark energy.[1][2] Thus, dark matter is estimated to constitute 84.5% of the total matter in the universe and 26.8% of the total content of the universe.[3]

Dark matter is matter that is undetectable by emitted or absorbed radiation, but whose presence can be inferred from gravitational effects.

1) Ade, P. A. R.; Aghanim, N.; Armitage-Caplan, C.; et al. (Planck Collaboration) (22 March 2013). "Planck 2013 results. I. Overview of products and scientific results – Table 9.". Astronomy and Astrophysics (submitted). arXiv:1303.5062. Bibcode:2013arXiv1303.5062P.
2) Francis, Matthew (22 March 2013). "First Planck results: the Universe is still weird and interesting". Arstechnica.
3) "Planck captures portrait of the young Universe, revealing earliest light". University of Cambridge. 21 March 2013. Retrieved 21 March 2013.

Fig. 1 The multiple components that compose our universe.Dark energy comprises 69% of the mass energy density of the universe, dark matter comprises 25%, and "ordinary" atomic matter makes up 5%.



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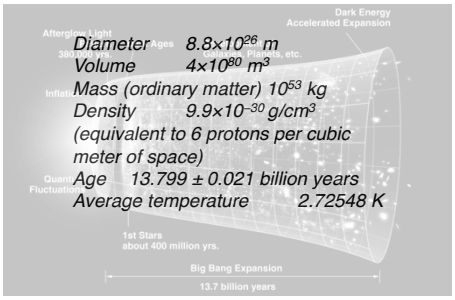
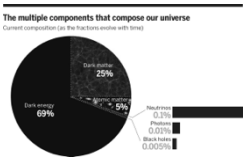
Properties of the Universe



Diameter 8.8×10^{26} *m*
Volume 4×10^{80} m^3
Mass (ordinary matter) 10^{53} *kg*
Density 9.9×10^{-30} g/cm^3
(equivalent to 6 protons per cubic meter of space)
Age 13.799 ± 0.021 billion years
Average temperature 2.72548 K

QUESTION



The estimated total mass of observable ordinary atomic matter in the universe is 10^{53} kg. Based on this estimate, the amount of dark matter is:

A. 25 x 10^{53} kg
B. 10^{265} kg
C. 5 x 10^{53} kg
D. 1 x 10^{53} kg
E. 30 x 10^{53} kg

Percent

A comparison based on normalization to 100.

In mathematics, a percentage is a number or ratio expressed as a fraction of 100. It is denoted by the percent sign, %, and is a dimensionless (pure) number.

- *George Washington University:*
- *64 unsealed addressed envelopes with $10 in each were dropped on campus in two different classrooms.*
- *In economics 18 of 32 were mailed back, in [business, history and psychology] 10 of 32 were mailed.* ***(WSJ)***

QUESTION

George Washington University:
64 unsealed addressed envelopes with $10 in each were dropped on campus in two different classrooms.

•In economics (econ) 18 of 32 were mailed back, in [business, history and psychology (bhp)] 10 of 32 were mailed. What is the percent for each of the 2 groups of students?

A. 28% econ 72% bhp
B. 56% econ 44% bhp
C. 56% econ 31% bhp
D. 79% econ 31% bhp
E. 79% econ 44% bhp

QUESTION
Percent Continued

- *64 unsealed addressed envelopes with $10 in each were dropped on campus in two different classrooms.*
- *The professor conducting the study received 43.75% of the original $640 in the mail. How much did he receive?*

A. $28.00
B. $43.75
C. $140.00
D. $280.00
E. $360.00

(WSJ)

QUESTION
Percent Continued

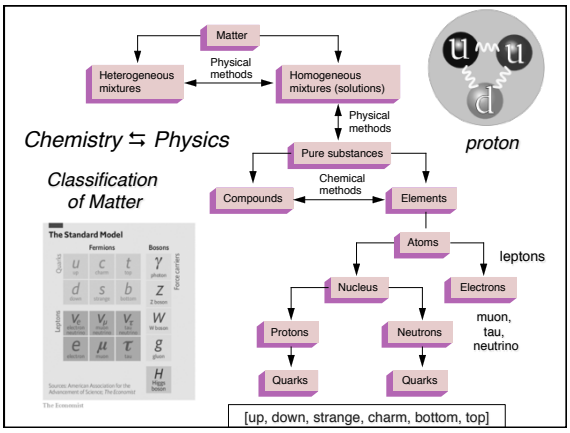
- *Would you mail the envelop presuming no one knows you found it?*
- *One student mailed an empty envelop with the return address:*
- *Mr. IOU, 1013 Indebted Lane, Bankrupt City, MS*

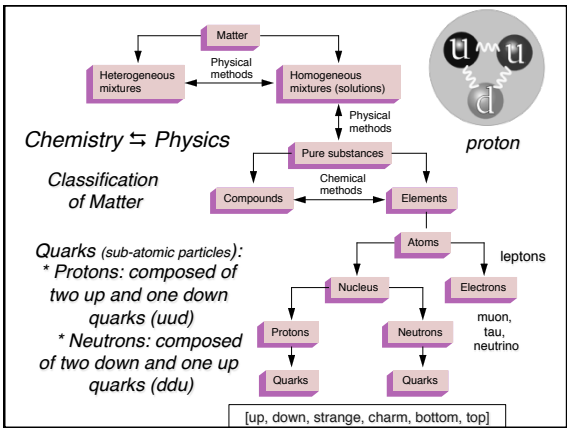
Did the professor count this envelope in the data?

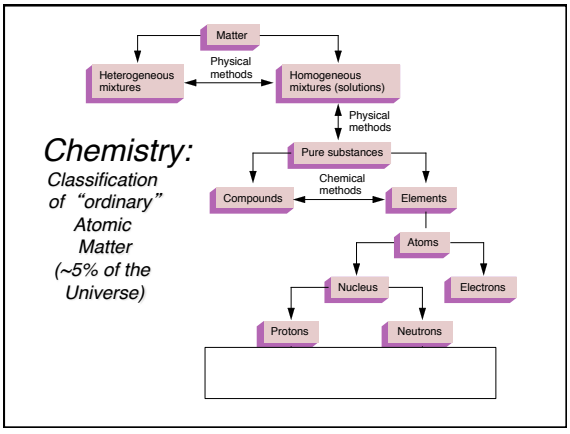
A. YES
B. NO

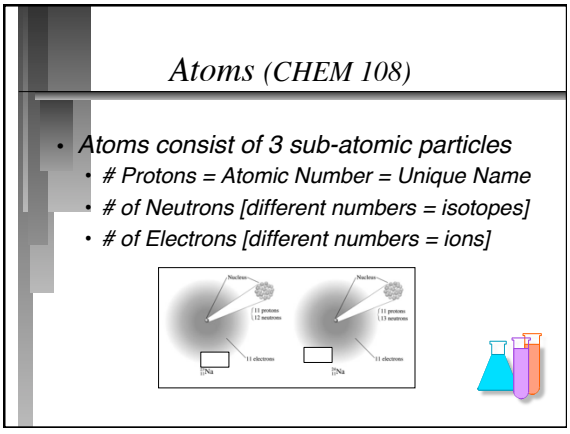
Be prepared to explain your answer.

(WSJ)







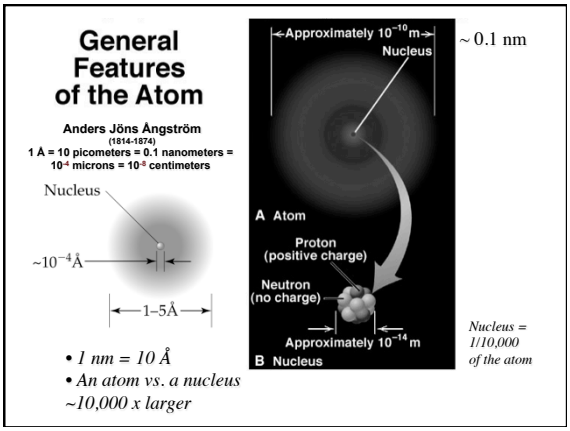


QUESTION

Which statement is incorrect for the three atoms in the following table.

Atom	# protons	# neutrons	# electrons
1	6	6	5
2	6	7	6
3	6	8	7

A. Atoms 1, 2, and 3 have the same name.
B. Atoms 1, 2, and 3 are isotopes.
C. Atoms 1, 2, and 3 are ions.
D. Atoms 1, 2, and 3 are not identical.



CHEMISTRY of the Atom

FUNDAMENTAL PARTICLES:

	Mass	Charge	Symbol
Nucleus:			
• PROTON	1 amu	+1	H+, H, p
• 1.67 x 10^{-27} kg			
• NEUTRON	1 amu	0	n
• 1.67 x 10^{-27} kg			
• ELECTRON	very small	-1	e^-
• ≈ 2000 x smaller than a proton or neutron			

The particle is said to "hold" or "bond" atoms together in molecules.

QUESTION

Which statement is correct for the three atoms in the following table.

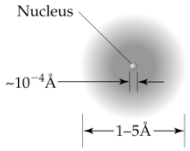
Atom	# protons	# neutrons	# electrons
1	6	6	5
2	6	7	6
3	6	8	7

A. Atoms 1, 2, and 3 have the same mass.
B. Atoms 1, 2, and 3 have the same charge.
C. Atoms 1 and 3 have the same charge.
D. Atoms 1, and 3 have the same mass.
E. Atoms 1, 2, and 3 have different masses and different net charges.

http://science.kqed.org/quest/video/the-worlds-most-powerful-microscope/

Can we "see" individual atoms using a microscope?

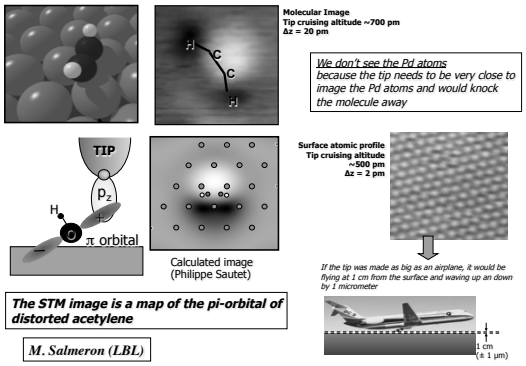
With TECHNOLOGY: Yes, using atomic force microscopy (AFM) and a variety of instruments such as Scanning Transmission Electron Microscopes.



- 1 nm = 10 Å
- An atom vs. a nucleus ~10,000 x larger

TEAM 0.5:
LBL's **T**ransmission **E**lectron **A**berration-corrected **M**icroscope
Resolution:
+/- 0.5 Å (0.05 nm)

Imaging: acetylene on Pd(111) at 28 K



The STM image is a map of the pi-orbital of distorted acetylene

M. Salmeron (LBL)