Online quizzes and blended/flipped learning in CHEM 101

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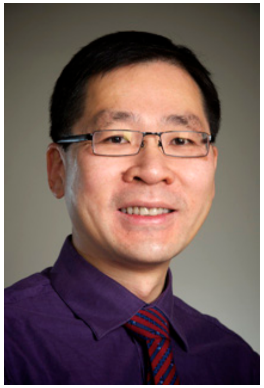

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Grunt

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Sessional instructor

CHEM 101 Introductory University Chemistry

What's the deal?

- Humongous multisection course (>1700 students/year)
- Some sections co-taught with Chem 103 (for engineers)
- Core requirement (Science and ALES); elective (Arts, Education, …)
- Diverse student backgrounds, interest, preparedness
- "Common" curriculum, different teaching styles, traditional lectures

Investment in blending/flipping and quizzes in CHEM 101

	Veinot	Mar	McDermott	Apeblat	Jensen
High school review quiz		+	+		+
Problem sets (not for marks)	+	+	+	+	+
Regular online quizzes (for marks)		+			+
Pre-class videos, “concept quizzes”					+
Video tutorials with self-assessments	+	+	+	+	+
Quizzes on video tutorials			+	+	+
Blended lecture attendance optional			+	+	
Exam sequels		+			

High school review quiz

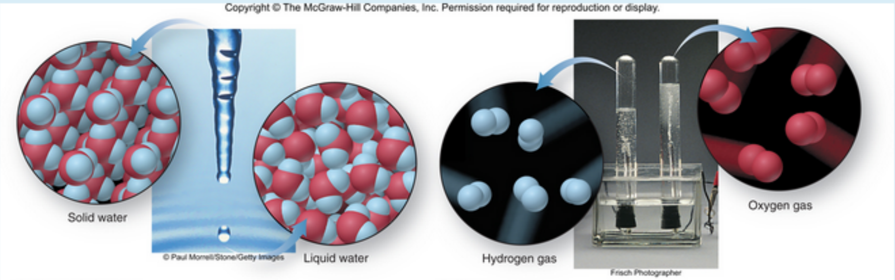
Grade 11 Chem 20 → Grade 12 Chem 30 → University Chem 101 → University Chem 102

- Defines expectations of prerequisite knowledge
    - basic concepts and definitions, significant figures, naming and formulas, moles and stoichiometry
- Eliminates one week of in-class "review" (Chapters 1-4)
- Familiarizes students to Moodle platform and quiz formatting
- Provides feedback on preparedness for Chem 101
- Unlimited attempts but need >50% to access further online quizzes for marks

High school review: Physical vs. chemical changes

Physical and chemical changes

Fig. 1.1 in your textbook shows the difference between physical and chemical change:



A Physical change:
Solid form of water becomes liquid form. Particles before and after remain the same, which means composition did ***not*** *change.*

B Chemical change:
Electric current decomposes water into different substances (hydrogen and oxygen). Particles before and after are different, which means composition ***did*** *change.*

Physical properties (e.g., melting point, density) are characteristics of a substance shown by itself, without changing into or interacting with other substances. In a **physical change**, a substance changes its physical properties but not its composition.

Chemical properties (e.g., flammability, reactivity with acids) are characteristics of a substance as it changes into or interacts with another substance. In a **chemical change (or reaction)**, a substance is converted into different substance(s).

Tutorial

Identifying physical and chemical changes

Indicate whether these processes are physical or chemical changes:

Gasoline fumes are ignited by a spark in a car engine. [chemical] ✓

On a hot summer day, the sweat on your skin evaporates. [physical] ✓

A sugar cube dissolves in a cup of tea. [chemical] ✗

Check

Question

Ignition of gasoline is a chemical reaction of hydrocarbons with oxygen, to form carbon dioxide and water.

Evaporation of sweat is a physical change of water from liquid to gaseous states.

In dissolution, the sugar molecules previously arranged regularly in a crystalline state are now dispersed and surrounded by water molecules, but individual sugar molecules remain intact.

Feedback

High school review: Limiting reactant calculation

Limiting reactant tutorial

How many grams of solid aluminum sulfide are prepared by reaction of 10.0 g of aluminum and 15.0 g of sulfur?

(1) Write the balanced reaction (write any coefficients of "1" explicitly):

___ Al(s) + ___ S(s) → ___ Al_2S_3(s).

(2) Determine the moles of each reactant:

___ mol Al(s)

___ mol S(s)

(3) Determine limiting reactant:

There are several ways to do this: (i) brute force (calculate the amount of products formed considering both possibilities alternately; (ii) compare the experimental mole ratios of the reactants with the required mole ratios from the balanced equation; (iii) divide the experimental moles by the coefficients in the balanced equation. The important thing to realize is that the limiting reactant is not necessarily the one with the fewest moles (a common mistake).

___ is the limiting reactant.

(4) Calculate amount of product, based on limiting reactant:

mass of Al_2S_3(s) = ___ grams

Check

Tutorial, step-by-step

Warning about common mistakes

Limiting reactant

How many grams of copper(II) carbonate precipitate after 105 g of sodium carbonate is added to 1.50 L of a 0.800 M solution of copper(II) nitrate?

The balanced reaction (write any coefficients of "1" explicitly) is:

___ Na_2CO_3(s) + ___ $Cu(NO_3)_2$(aq) → ___ $NaNO_3$(aq) + ___ $CuCO_3$(s)

The moles of each reactant are: ___ mol Na_2CO_3(s) and ___ mol $CuNO_3$(aq).

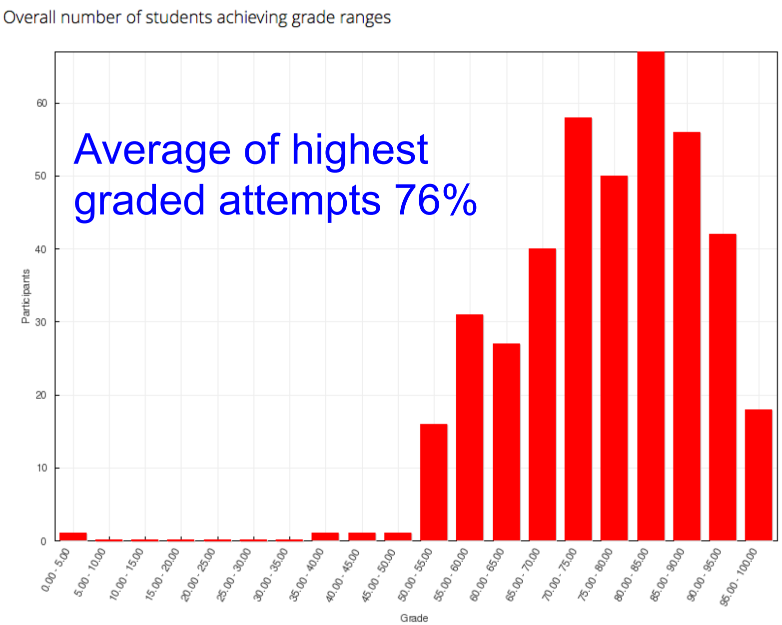
The limiting reactant is: ___

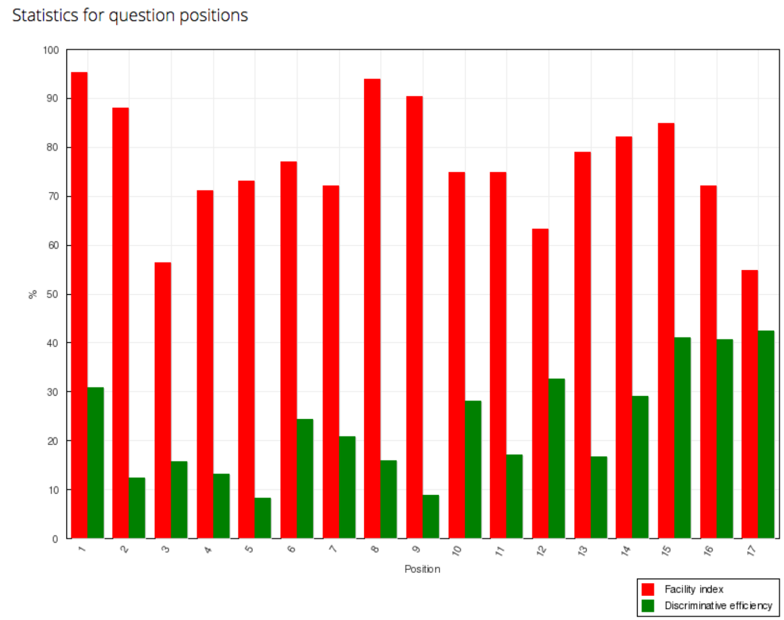
The mass of $CuCO_3$(s) formed is: ___ grams

Check

Similar follow-up question, without guidance

High school review quiz: Performance





	Q1	Q14	Q15
Facility index	95	82	85
Discriminative efficiency	31	29	41

After one week of classes:

- 367/406 students (90%) completed first attempts
- average 71%
- 11 students have never accessed eClass

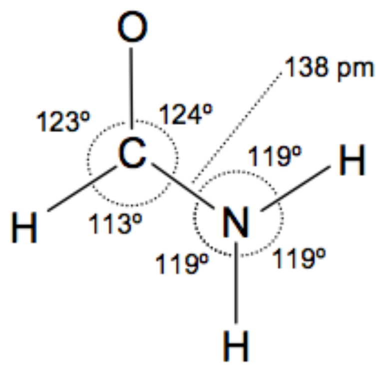
Problem sets: If you build them, they will <u>not</u> come

"Problem sets will be posted regularly. It is highly recommended that you work them out on your own as the questions resemble those on exams."

PROBLEM SET 4: MOLECULAR SHAPES; VALENCE-BOND AND MO THEORY
CHEM 101/103 (Section H1 Mar) Oct. 9, 2014

References: 10.2–10.3 Molecular shapes; 11.1–11.3 Valence bond theory, MO theory
Similar problems in Silberberg: Chap. 10: 34–48 even, 55, 57; Chap. 11: 13, 25, 32–42 even, 55

3. (Final exam, 2008) Formamide, with the skeletal structure shown, is used to manufacture pharmaceuticals such as penicillin.
   (a) Draw possible Lewis structures, indicate formal charges, and explain which is the best resonance structure.
   (b) Propose a bonding scheme based on the most important resonance structure.
   (c) Predict the molecular geometry and bond angles around the N atom from VSEPR theory, based on the best resonance structure. Then suggest an explanation for the bond angles of 119° that are actually observed from experiment.

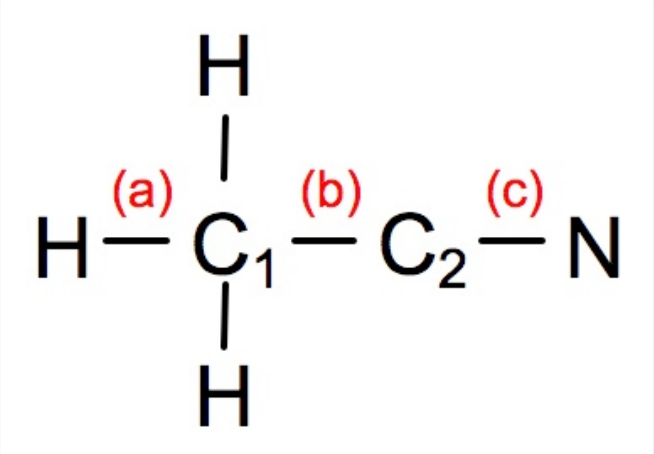


"To ensure that you are doing homework regularly, you will complete online assessments (for marks) periodically."

Online quizzes: They will come

Valence bond theory

The **skeletal** structure for acetonitrile (CH_3CN) is shown. Draw for yourself the best Lewis structure. Propose a bonding scheme by indicating the **hybridization** of the central atoms and the **orbital overlaps** for each bond.



Limitations:

- cannot ask for drawings as answers
- difficult to ask for explanations as answers
- free-format answers vs. multiple choice
- technical problems in formatting symbols

The bond labeled **(a)** forms from [σ] ✓ -overlap of a C_1 [sp3] ✓ orbital and a H [1s] ✓ orbital.

The bond labeled **(b)** forms from [σ] ✓ - overlap of a C_1 [sp3] ✓ orbital and a C_2 [sp] ✓ orbital.

The bond labeled **(c)** forms from:

- **one** [σ] ✓ -overlap of a C_2 [sp] ✓ orbital and a N [sp] ✓ orbital, and
- **two** [π] ✓ -overlaps of a C_2 [2p] ✓ orbital and a N [2p] ✓ orbital.

Lewis structures do <u>not</u> attempt to portray 3D shape, but you can predict the molecular geometry from VSEPR theory.

The ideal bond angle <(H-C_1-H) around the C_1 atom is [109.5] ✓ degrees.

The ideal bond angle <(C_1-C_2-N) around the C_2 atom is [180] ✓ degrees.

Check

Question types available in Moodle

Types	My opinions:
True-false Multiple choice	• T/F virtually useless • MC use intelligently but sparingly
Matching Random short-answer matching	• Use sparingly
Short answer Numerical Essay (requires manual marking)	• Must account for all possible entries, including misspellings and misformatting
Cloze (embedded answers)	• Best compromise available
Calculated simple Calculated Calculated multichoice	• Applicable if result can be coded by single mathematical formula • Range of randomized variables • Complex to code, often not worth the hassle

Simple questions

Multiple choice in multiple versions

Real gases

Under which conditions is the gas most likely to behave according to the ideal gas law?

Select one:

- He gas at 37.5 K and 750 torr — cross out
- Ne gas at 375 °C and 0.75 atm — cross out
- CH_4 gas at 37.5 °C and 7.5 atm — cross out
- H_2O gas at 375 K and 750 torr — cross out
- SF_6 gas at 375 °C and 0.75 atm — cross out

Check

Real gases

Under which conditions is the gas least likely to behave according to the ideal gas law?

Select one:

- Ar gas at 37.5 °C and 75 torr — cross out
- H_2 gas at 37.5 K and 7.5 atm — cross out
- Ne gas at 37.5 °C and 75 torr — cross out
- O_2 gas at 37.5 K and 75 torr — cross out
- Cl_2 gas at 37.5 K and 7.5 atm — cross out

Check

Real gases

Under which conditions is the gas least likely to behave according to the ideal gas law?

Select one:

- SO_2 gas at 37.5 K and 7.5 atm — cross out
- He gas at 37.5 K and 750 torr — cross out
- Ne gas at 37.5 K and 7.5 atm — cross out
- N_2 gas at 37.5 °C and 75 torr — cross out
- N_2O gas at 37.5 °C and 750 torr — cross out

Check

Matching

Interparticle forces

Determine the **dominant** interparticle force present in these substances.

$MgCl_2$(s) — ✓ Choose... / dipole – induced dipole / ionic bonding / London dispersion / ion – dipole / dipole – dipole / H-bonding

CH_3OH(l)

cocaine hydrochloride ($[C_{17}H_{21}O_4NH]Cl$) in water

CH_3CH_3(g)

PCl_3(l) — Choose...

CO_2(g) in water — Choose...

Check

Formal charge

Evaluate the formal charge of the atom indicated in these molecules.

N in NO_2^- — Choose...

O in BrO^- — Choose...

N in CN^- — Choose...

P in PCl_3 — Choose...

P in PH_4^+ — ✓ Choose... / 1– / 0 / 1+

Check

Calculation questions

Question:

Isotopes and natural abundance

A hypothetical element X has two naturally occurring isotopes: A with an isotopic mass of 64.465 and B with an isotopic mass of 62.601. If the element X has an atomic mass of 63.518, what is the percent abudance of isotope A?

Provide your answer as a simple number (not scientific notation), without the % symbol. For full credit, your answer must be within 1% of the correct value.

Answer:

Check

If you instruct students to write in scientific notation, this is what you get: 6.022E-23, 6.022*10^-23, 6.022E*^10-23, 6.022#@!-23. So best to avoid!

Important to define a tolerance and clarify this to students

Editing:

Question text*

Isotopes and natural abundance

A hypothetical element X has two naturally occurring isotopes: A with an isotopic mass of {mass1} and B with an isotopic mass of {mass2}. If the element X has an atomic mass of {atmass}, what is the percent abudance of isotope A?

Provide your answer as a simple number (not scientific notation), without the % symbol. For full credit, your answer must be within 1% of the correct value.

Answers

Answer 1 formula =

({atmass}-{mass2})/({mass1}-{mass2})*100 Grade 100%

Tolerance ±

0.01 Type Relative

Wild cards parameters used to generate the values

Generate 1 new set(s) of wild card(s) values

Display 1 set(s) of wild card(s) values

Cloze questions

Question:

Gaseous hydrocarbon

A 0.217-g sample of a gaseous hydrocarbon (C_xH_y) occupies 189 mL at 22.0 °C at 753 torr. Calculate the molar mass of this hydrocarbon in g/mol. *Express your answer as a simple number without units (not scientific notation); for full credit, the last digit of your answer should be within ±1 of the correct value, with an appropriate number of significant figures.*

Molar mass: [28.0] ✓ g/mol.

Complete combustion of 1.523 g of this gaseous hydrocarbon (C_xH_y) yields 4.779 g of carbon dioxide and 1.957 g of water. Calculate the moles of C and H in this amount of the hydrocarbon. *Express your answers as simple number without units (not scientific notation); for full credit, the last digit of your answer should be within ±2 of the correct value, with an appropriate number of significant figures.*

[0.109] ✗ moles C in C_xH_y

[.216] ✗ moles H in C_xH_y

Determine the empirical and molecular formulas of this hydrocarbon. *If a subscript in the formula is "1", enter it explicitly.*

Empirical formula: C [2] ✗ H [4] ✗.

Molecular formula: C [2] ✓ H [3] ✗.

Check

Editing:

Question text*

Gaseous hydrocarbon

A 0.217-g sample of a gaseous hydrocarbon (C_xH_y) occupies 189 mL at 22.0 °C at 753 torr. Calculate the molar mass of this hydrocarbon in g/mol. *Express your answer as a simple number without units (not scientific notation); for full credit, the last digit of your answer should be within ±1 of the correct value, with an appropriate number of significant figures.*

Molar mass: {4:NUMERICAL:=28.1:0.1} g/mol.

Complete combustion of 1.523 g of this gaseous hydrocarbon (C_xH_y) yields 4.779 g of carbon dioxide and 1.957 g of water. Calculate the moles of C and H in this amount of the hydrocarbon. *Express your answers as simple number without units (not scientific notation); for full credit, the last digit of your answer should be within ±2 of the correct value, with an appropriate number of significant figures.*

{2:NUMERICAL:=0.1086:0.0002} moles C in C_xH_y

{2:NUMERICAL:=0.2172:0.0002} moles H in C_xH_y

Determine the empirical and molecular formulas of this hydrocarbon. *If a subscript in the formula is "1", enter it explicitly.*

Empirical formula: C{1:SA:=1}H{1:SA:=2}.

Molecular formula: C{1:SA:=2}H{1:SA:=4}.

Cloze format allows mix of question types in one block of text, approaching how we really do calculations by hand.

Problem sets vs. online quizzes: Activity reports

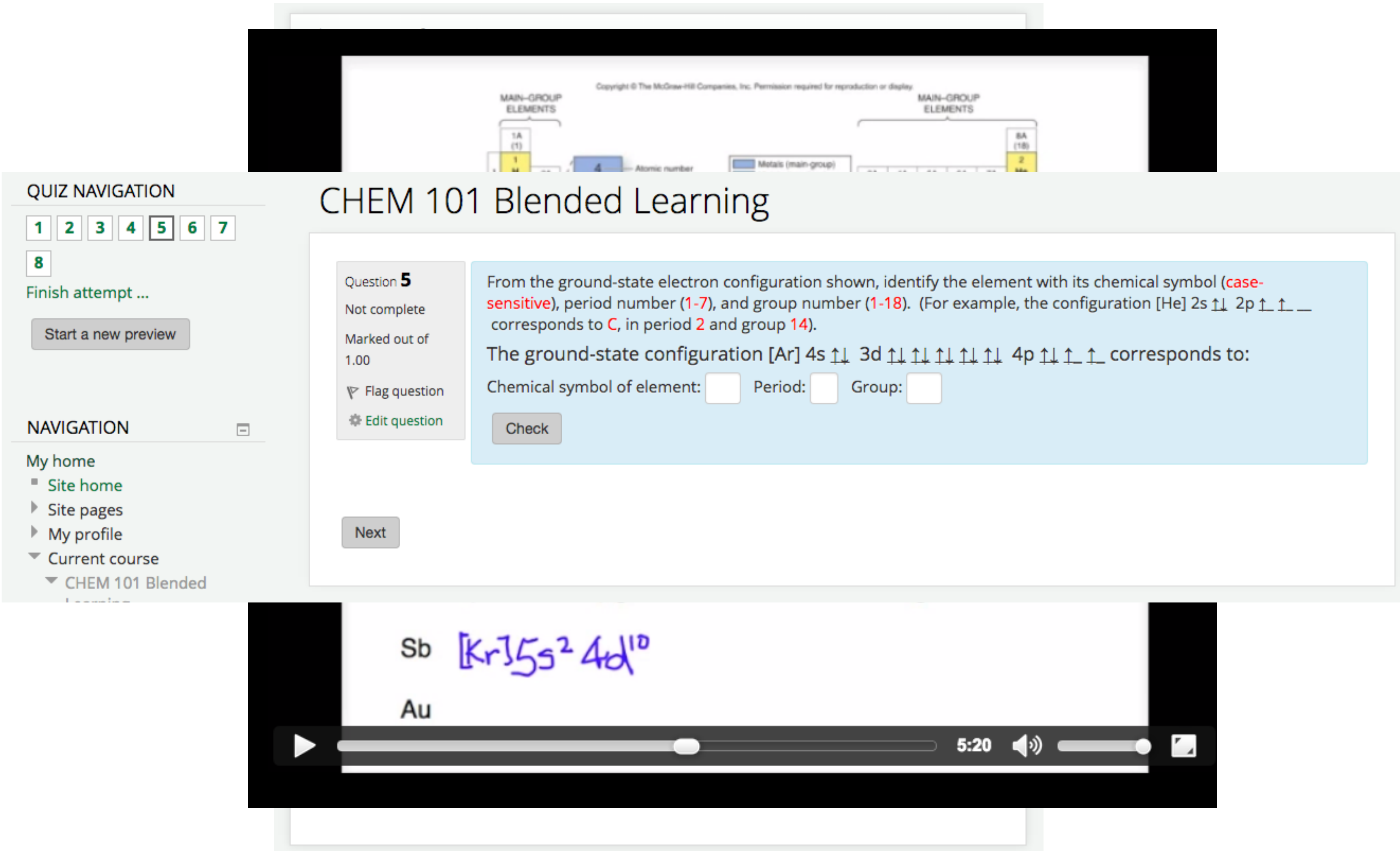
Unit 1. Atoms	
Lectures	1942
Problem Sets	3765
Online quiz 1. One-electron atoms	5751
Online quiz 2. Many-electron atoms	4413

Unit 2. Molecules	
Lectures	975
Problem Sets	3050
Online quiz 3. Models of chemical bonding	3882
Online quiz 4. Molecular shapes and bonding theories	4197
Online quiz 5. Main-group elements; acids and bases	3397

Unit 3. Gases, Liquids, and Solids	
Lectures	689
Problem Sets	1638
Online quiz 6. Gases and kinetic molecular theory	3600
Online quiz 7. Phase changes and intermolecular forces	2847

- Are online lecture notes really essential?
- Do students only do assignments for marks?

Video tutorial: Electron configurations



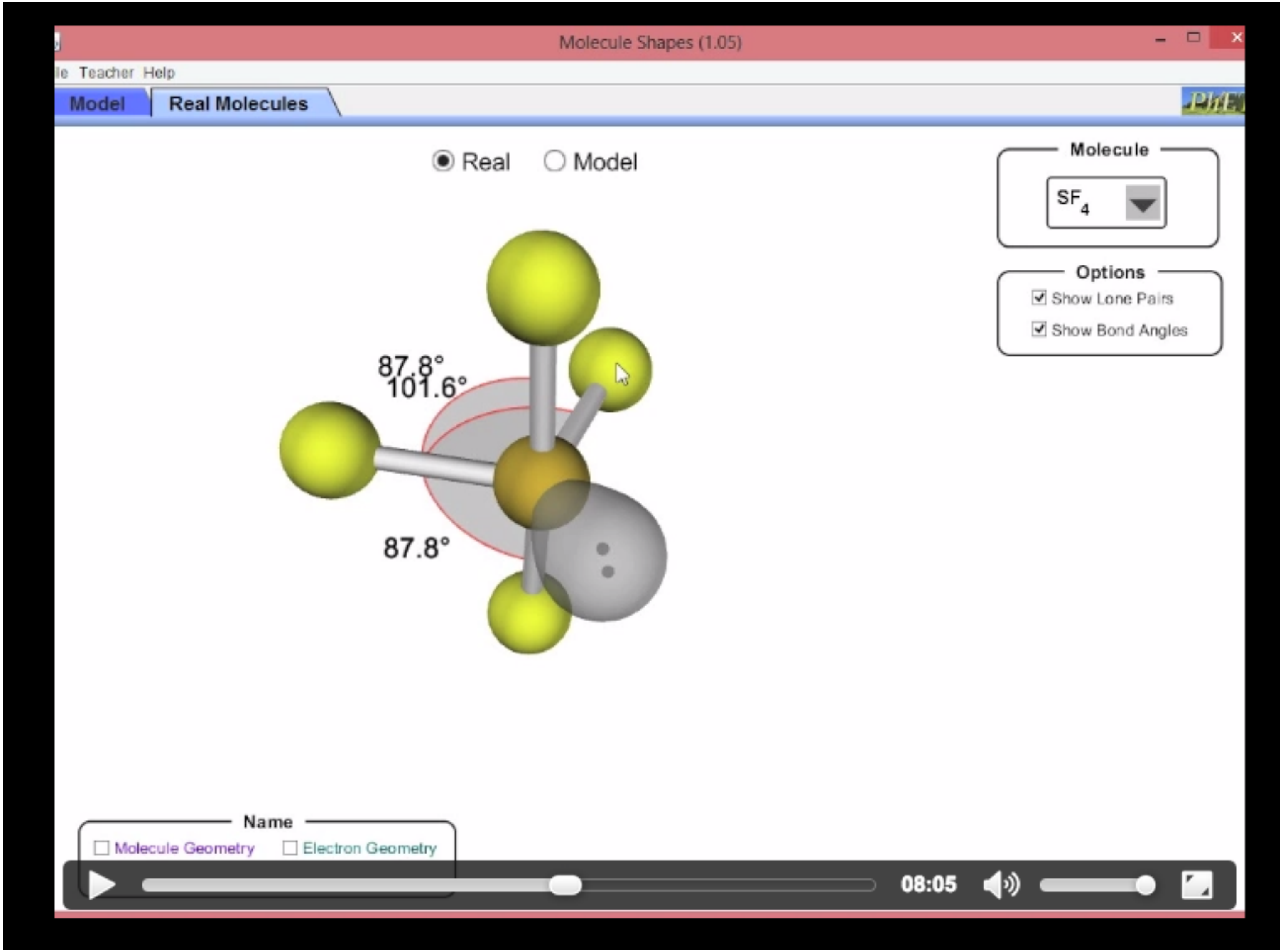
Part 3 of video tutorial

Part 3: The periodic table in s, p, d, f blocks

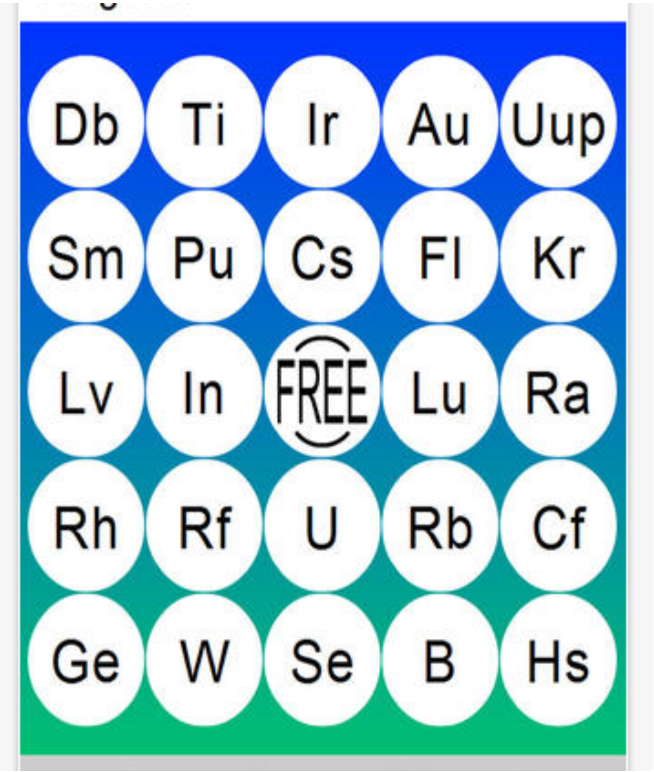
(1) Identify the *s, p, d, f blocks* in periodic table and relate to order of orbital filling.

(2) Write electron configurations for *any* main-group element and *some* transition metals.

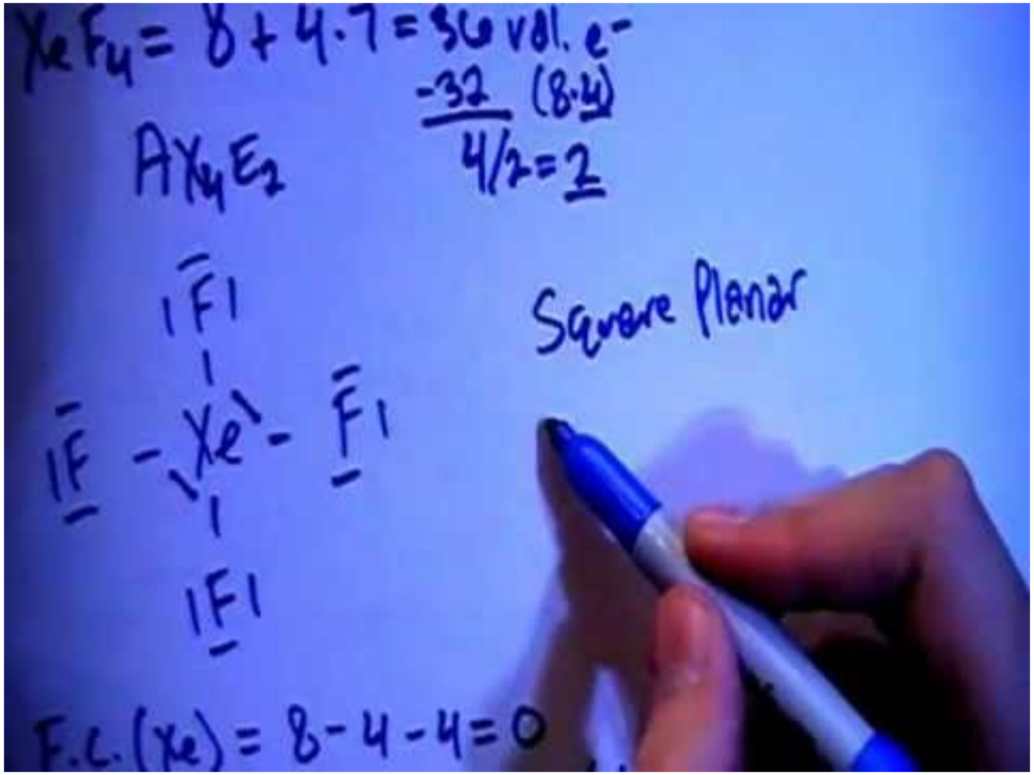
Video tutorial: Molecular shapes



In-class activities



Write electron configurations for these elements



Draw Lewis structures for these molecules

Video lectures and assessments: Activity reports

Chem 101/103 (TR 0930-1050)

~380 students Dr. Mar (Optional)

Electron Configurations Video Lecture	
Worksheets - Click first and print out	611
Elec. Conf. Part 1	737
Elec. Conf. Part 1 Self-Assessment	1548
Elec. Conf. Part 2	458
Elec. Conf. Part 2 Self-Assessment	912
	62

Topic discussed in class on Sept. 18

Completed Part 1 assessment:

Before Sept. 18 class: 19/380 students (5%)

Before Sept. 25 quiz: 130/380 students (34%)

Before final exam: 244/380 students (64%)

Unlimited access

Chem 101 (MWF 1000-1050)

~340 students Dr. Apelblat (Required)

Electron Configurations (lecture 7 - Friday, Sept 19, 2014)	
Online lecture - PowerPoint presentation	527
Lecture 7 - My original notes on electron configuration	734
Worksheets - Print me first!	667
Worksheet 1	210
Worksheet 2	153
Electron Configurations Part I	1057
	?167
Electron Configurations Part III Assessment (not for marks)	1302
Electron Configurations Quiz	2066

Topic discussed in class on Sept. 19

Completed Part 1 assessment:

Before Sept. 19 class: 295/340 students (87%)

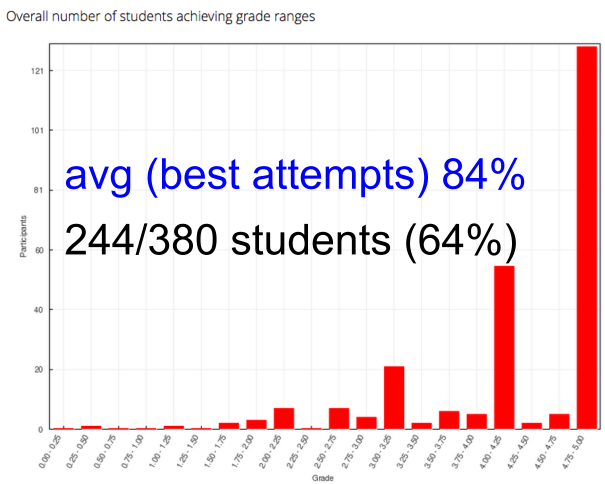
Accessible only until Sept. 20

Video lecture assessments: Performance

Chem 101/103 (TR 0930-1050)

~380 students Dr. Mar (Optional)

Part 1 assessment



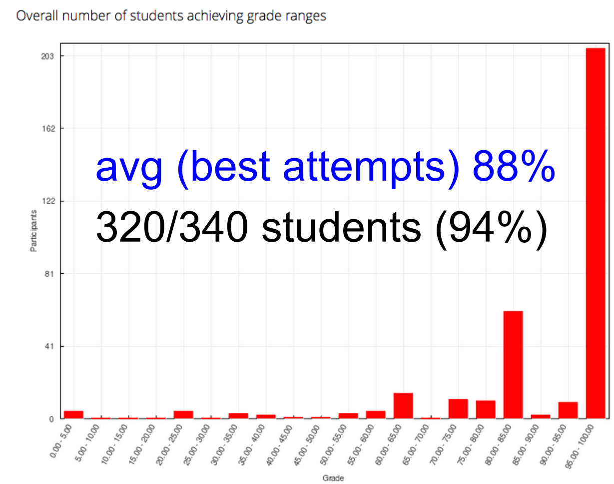
avg (best attempts) 84%

244/380 students (64%)

Chem 101 (MWF 1000-1050)

~340 students Dr. Apelblat (Required)

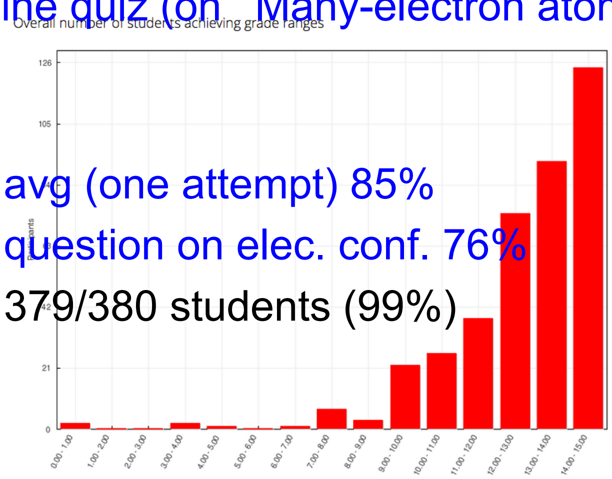
Part 1 assessment



avg (best attempts) 88%

320/340 students (94%)

Online quiz (on "Many-electron atoms")

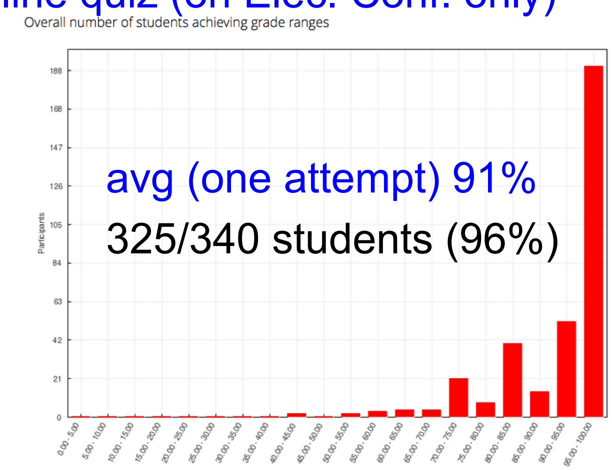


avg (one attempt) 85%

question on elec. conf. 76%

379/380 students (99%)

Online quiz (on Elec. Conf. only)



avg (one attempt) 91%

325/340 students (96%)

"Can I do something for extra credit?"

Question from in-class quiz 2:

(2) Identify the acid and the base among the reactants, and indicate which definitions (Arrhenius, Brønsted-Lowry, Lewis) apply.

$$NaH + H_2O \rightarrow H_2 + NaOH$$

"Exam sequel" question:

Acid-base definitions

Many students had difficulty analyzing the reaction of LiH or Na

$NaH + H_2O \rightarrow H_2 + NaOH$

NaH is an example of a hydride, that is, a compound between hy
about combinations of hydrogen with nonmetals, with transitio

What kind of hydride is NaH? [ionic hydride] ✓

What is the oxidation state of hydrogen in NaH? [-1] ✓

In the Arrhenius definition, an acid is a source of H^+(aq) and a base is a source of OH^-(aq). Does NaH contain H^+ or OH^- in its formula? [no] ✓ Does the Arrhenius definition apply to this reaction? [no] ✓

In the Brønsted-Lowry definition, an acid donates H^+ and a base accepts H^+. (Note that there is no requirement for the reaction to be in aqueous solution in this definition.) You can neglect Na^+ from both sides of the reaction because it is just a spectator ion; the products are really just H_2 and OH^-. The OH^- species is derived by transfer of H^+ among the reactants [from H2O to the hydride ion in NaH] ✓. Therefore, the Brønsted-Lowry definition does apply; the acid is [H2O] ✓ and the base is [NaH] ✓.

- Gives more detailed guidance on how to reason through this question
- Optional but worth so negligibly little (<0.01% to overall mark) that student ranking is unaffected

Summary

Benefits

- Defines minimal expectation for student homework
- Regular assignments staves off cramming
- Provides feedback to students and instructor on mastery of topics
- Serves as useful tool for review

Challenges

- Extremely time-consuming to set up question bank, poor organization tools in Moodle
- Limited range of questions possible, cannot ask for written explanations or rationale for answers
- Must explain to students that online questions are <u>not</u> necessarily representative of real exam questions