

For links to work, save as PDF from Word and delete pages at top and bottom.

YOUR ORIGINAL POST OF THE 8 PAGES WAS RIDDLED WITH ANSWER ERRORS ON EVERY PAGE. uNpROOFED!

SO IT WAS ALL WRONG LAST YEAR, TOO. All year.

This is unmanageable. quit.

ThisIs MathOfChem.pdf

It calls these PDFs: Brain101, MathAssessment, ExpoMetric, MathOfChemPages (all 15)

MathOfChemPracticeCover, MentalMathPractice (just 8) ABMathToInstructors, ElectroPrepToInstructors.

Rename this to MentalMath and MathReview to cover old posts

4/9/21

Look back in folder 18- for stuff from the top to include here.

Like the announcement formats for FaceBook

Look at 55* more recent Arithmetic files with Adds.

Change name to ChemMathReview.pdf

It is both with and without a calculator. Calculator and estimation.

You do teach both. And you should.

The audience for this is limited to those who believe calculations are important to teach.

You have good access to AP and not-good to college anything.

You need to get on to doing the movers and shakers.

No one in education will agree with you. Must be leadership pressure.

So offer it to AP and Gen and walk away.

3/6/21

Goal is to get the basics up. Short. Tweak it later.

Read old stuff eventually and put some back in.

3/5/2021

Until now, you have been updating file Arithmetic55*

Now try to move to here MM2021

Take out the old stuff from here – It's in Arithmetic if you need it.

Make this short.

Break ExpoNote assignment into Numeracy, then expo calcs., then estimation.

Make them send an email to get the quizzes. You need a measure of who is using.

5. Teaching Dimensional Homogeneity

To assist students in solving dimensional analysis calculations with more success, a packet with 12 pages of student in-class and homework assignments is available.. Strategies describe how, by adding a few steps before the multiplication of conversion factors, problems solving is simplified.

Interested in helping students use DA with more success?

I have posted a packet of tips that help students organize their data before they begin to arrange DA conversions. Using the tips, an instructor recently reported in *JCE* a 20 percentile gain in ACS Gen Chem Exam scores.

The packet is posted at www.ChemReview.Net/DHone.pdf .

A packet containing 12 pages of in-class

5/17/21

Correction on Math Review

Two days ago I sent out info on a Math Review for summer packets. In a hurry to get them out, several of the answer keys in section 4 I thought I had checked I had not. I think they have now been fixed. The link below should take you to corrected versions dated 5/21/21. My apologies. – mortified Eric Nelson.

For Summer Packets -- Math Review --

IF you do a summer assignment – posted at

<https://www.ChemReview.Net/MathOfChem.PDF>

are over 60 pages of instruction and practice in the math needed for chemistry calculations – *both* with and without a calculator.

These are self-study homework assignments, with answers, that can be used for summer packets, or as a fall AP math review, or in Chem I classes at a gradual pace. Quizzes are also available to “encourage” homework completion.

Topics include calculations with exponential notation, conversions to scientific notation, estimation to check calculator answers, metric system fundamentals, and rules when math includes numbers and exponential terms and units.

Many pages can also be used in pre-AP for in-class practice OR as homework assignments to reinforce lecture.

8 practice sheets on “mental math” are included – good for getting ready for MCQ’s.

These may also help if you are required to “turn in sub plans” for either Chem I or AP (or both).

This year’s packet has been updated and simplified. Hope it helps! -- Eric (rick) Nelson

5/20/21:

Correction on Math Review

Two days ago I sent out info on a Math Review. Several of the answer keys in section 4 I thought I had checked my typing on I had not. I think they have now been fixed. The link below should take you to corrected versions. My apologies. – mortified Eric Nelson.

Homework Math Review

At <https://www.ChemReview.Net/MathOfChem.PDF>

I have posted over 60 pages of instruction and practice in the math needed for chemistry calculations – *both* with and without a calculator.

These are self-study homework assignments, with answers, that can be used as a fall math review in General Chemistry -- or in Chem I/Prep Chem classes at a gradual pace. Quizzes are also available to “encourage” homework completion.

Topics include calculations with exponential notation, conversions to scientific notation, estimation to check calculator answers, metric system fundamentals, and rules when math includes numbers and exponential terms and units.

Hope this helps! -- Eric (rick) Nelson

2/19/2021

This is the new version in an easy to difficult sequence.

Take out refs to AP and HS.

Mental Math Practice Sheets Available

Looking for resources to teach “no calculator” calculations.

I have posted a file containing resources to help students on the multiple choice “calculations without a calculator.”

New this year are pages aimed specifically at “AP Level Mental Math:” Explanations plus 60 questions of multiple types -- with answers.

For Honors/Pre-AP, mental math practice sheets are included as well.

The material may be viewed and pages of interest may be printed at www.ChemReview.Net/MentalMath.PDF

-- Eric Nelson

No must save to wanted only then save from Word as PDF to keep links reliably, **That’s true.** Or you can change the repeated “here” links to direct links.

Mental Math Practice Sheets Available

At the link below, I have posted online an updated file containing over 20 pages of resources and tutorial lessons aimed at helping students in the “mental math” needed on the multiple choice “calculations without a calculator.”

Activities are included that I believe would be appropriate in both AP and Honors/Pre-AP level classes.

Individual lessons can be selected that can be used during class, or as “sub day” lesson assignments. A combination of multiple lessons could be used as part of an “AP summer packet” (I hope I am posting in time!) or as an AP fall homework fundamentals review.

The material may be viewed and pages of interest may be printed at www.ChemReview.Net/MentalMath.PDF (click and check your PDF downloads).

Hope this helps!

-- Eric (rick) Nelson

In first 2 hrs, got 34 likes in AP, 2 in national, 1 comment in ceeb 56 in AP by 3 days later, but some quiz requests were added once the file links were repaired.

Mental Math Practice Sheets Available

(Repost: For those interested in the Mental Math Worksheets in the previous post, quizzes are available, but the links to the quizzes were broken in the original file. They are fixed and will work if you re-download the file at the link below. Sorry! -- rick)

At the link below, I have posted an updated file containing over 20 pages of resources and tutorial lessons aimed at helping students in the “mental math” needed on the AP multiple choice “calculations without a calculator.”

Activities are included that I believe would be appropriate in both AP and Honors/Pre-AP level classes.

Individual lessons can be selected that can be used during class or as “sub day” lesson assignments.

A combination of multiple lessons could be used as part of an “AP summer packet” (I hope I am posting in time!) or as an AP fall homework fundamentals review.

The material may be viewed and pages of interest may be printed at www.ChemReview.Net/MentalMath.PDF (click and check your PDF downloads).

Hope this helps! -- Eric (rick) Nelson

Make copies of this file named ChemMathReview.Net and MentalMath.pdf and MathReview.Pdf and any others you have advertised in the past.

To Instructors --

Homework Review of the Math Needed for Chemistry — With and Without a Calculator

For instructors in college General Chemistry, GOB, AP Chemistry, and all courses aimed at *preparing* students for college chemistry courses, this packet provides over 60 pages of homework assignments (with quizzes) that review the math students need in chemistry.

In General, GOB, Engineering, and AP Chemistry, these assignments save class time by flipping a part of the review of pre-requisite math to study time.

In AP, the assignment may be used as part of a “summer packet.”

In HS Honors or college Preparatory Chemistry, the lessons can be used as homework to reinforce math and metric topics when they are covered in lecture.

The lessons are available *both* online *and* as paper copies for students who have limited access to computers and/or the internet.

Quick Preview

To see all pages of student assignments in this packet, see <https://ChemReview.Net/MathOfChemPages.PDF>

Summary of Activities

The packet contains 8 topic sections:

1. Why Review Math?

For instructors, topic 1 is a two-page summary of why cognitive experts say a brief review of the math of chemistry, both with and without a calculator, will improve student success in solving calculations *and* conceptual understanding.

2. Assessment

Topic 2 is a 15-minute quiz on fundamentals in arithmetic, decimal equivalents, exponential calculations, simplifying fractions, solving algebraic equations, and logarithms. Results can be used to identify math gaps and plan review.

3. Math and Metric Review

Topic 3 contains 9 self-study lessons on mental arithmetic, calculations involving exponential notation, solving exponential notation with a calculator, estimating answers to calculations without a calculator, metric fundamentals, making chemistry flashcards, and calculations that mix numbers, exponential terms, and units.

4. **Additional Mental Math Review**

In Topic 4 are 8 pages of *mental math* worksheets with rules, strategies and practice in converting fractions to decimal equivalents, simplifying exponentials and fractions, and fractions, estimates, and exponentials.

5. **Improving Dimensional Analysis**

To assist students in solving dimensional analysis calculations with more success, three PDF packets include 42 pages of student in-class and homework assignments. Strategies include how, by adding a few steps before multiplying conversion factors, solving problems is simplified.

6. **Acid-Base Math Review**

For later in the course, these 2 pages provide review of rules and practice in the math of solving for $[H^+]$ in strong acid and base solutions – both with a calculator and by mental math.

7. **Prep for Electrochemistry**

The first half of this 5 page assignment may be used during the introduction to redox reactions. All 5 pages may be used as homework in Gen and AP chem to prepare students in the initial vocabulary and calculations in electrochemistry.

8. **Other Math Review Resources.**

A listing of additional available math review lessons, by topic.

9. **How the Student Brain Learns Chemistry**

For instructors, three pages summarizing cognitive research on how we can help students prepare for careers in the sciences.

Editable quizzes on all of the student lessons are available to instructors – see the topic details below.

Updates

Please download on occasion an updated (and sometimes corrected...) version of this document, which may include new material, by clicking on <https://www.ChemReview.Net/MathOfChem.pdf>

Additional ideas for assignments in Gen/GOB/AP/Prep/Honors chemistry are posted at www.ChemReview.Net/blog .

Feedback, corrections, and suggestions on this packet are most appreciated. Hope this helps!

-- Eric Nelson, retired instructor, EANelson (at) ChemReview.Net, [@RNelson696](https://twitter.com/RNelson696)

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Detail: Math Review Topics

Topic 1

Why Review Math – and Why Mental Math?

Instructors may ask why chemistry should include math *review*, and why the review should include *mental* math. What follows are the personal views and research of the packet author.

Why Review Math?

Calculations are central in the sciences and engineering. Chemistry is where students first encounter math applied to *measurements* (numbers with units attached). Unfortunately, over the past 20 years, state K-12 math standards in most states have de-emphasized teaching the topics in math needed for scientific calculations (see References 1 and 2 below).

This has put chemistry instructors in a difficult position. We want to focus on chemistry, but given the states' de-emphasis of computation, unless we review the math topics needed for chemistry, many students will struggle to solve calculations they are expected to solve in science courses and careers.

The intention of this packet is to help students and instructors by reviewing math needed for chemistry as *homework*, to limit the impact of math review on class time.

Why Review Mental Math?

In the lessons in this packet, math is reviewed both with and without a calculator. Why should students be asked to know mental math?

Scientists who study how the brain solves problems cite many reasons, including:

- For students to learn concepts with numeric components, students learn more quickly if examples and sample problems are contrived to have very simple numbers that can be solved by mental math. The reason involves freeing slots in *working memory* (which is where the brain solves problems) to process conceptual linkages.
- A key finding of recent cognitive research: Working memory has essentially infinite room for facts and procedures that quickly be recalled from long-term memory, but very limited ability to hold and process facts and procedures not well-memorized.
- Working memory's limits mean that if math fundamentals can be recalled "with **automaticity**" (quickly and accurately), working memory has more space to note concepts and contexts, which deepens understanding.

Cognitive scientist Daniel Willingham suggests that instructors

"[E]xplain to students that automaticity in facts is important because it frees their minds to think about concepts."⁵

- In addition, if fundamentals are not well-memorized, working memory tends to overload during problem solving, and confusion tends to result.

There are also practical reasons to ask students to practice mental math:

- If students can solve a complex fraction simplification or exponential notation calculation that has simple numbers *without* a calculator, they are better able to remember the sequence of calculator buttons to press when the numbers and/or operations are complex, and
- If students cannot estimate to check an answer calculated by technology, they are less likely to pass testing required for many scientific careers. As one example, the Medical College Admissions Test (MCAT), which 60,000 undergraduates take each year, has several sections of calculations with simple numbers - and the test is “no calculator.”

In general in health care and engineering, to be able to estimate to check a calculator answer is a frequently evaluated skill.

- Chemistry is a quantitative science. Math is an essential foundation for chemistry. If students cannot estimate an answer to a chemistry calculation, do they know chemistry?

For mental math to help students, after years of calculator overuse, many in the current generation need to “refresh their memory” of math fact fundamentals.

Studies have shown that brief review of pre-requisite math and mental math as a part of chemistry measurably improves student achievement (see Reference 3 and 4).

More on the Science of Learning

Knowing the unexpected ways that science has found the brain works, we can design better lessons. For more on the science of learning, see *Topic 8 – How the Student Brain Learns Chemistry* -- in this packet.

References:

1. See *Addressing Math Deficits With Cognitive Science* (2017) at <https://confchem.ccce.divched.org/content/2017fallconfchemp8> with a summary at: *J. Chem. Educ.*, **2018**, 95 (8), pp 1440–1442
2. See “Cognitive Science and the Common Core Math Standards” at <http://nonpartisaneducation.org/Review/Articles/v13n3.pdf>
3. Craig, P. R. Building Student Confidence with Chemistry Computation. *J. Chem. Educ.* 2018, 95 (8), 1434-1435; and at <https://confchem.ccce.divched.org/content/2017fallconfchemp5>
4. Penn, L. S. Estimation—An Empowering Skill for Students in Chemistry and Chemical Engineering. *J. Chem. Educ.* 2018, 95 (8), 1426-1427; and at <https://confchem.ccce.divched.org/2017fallconfchemp1>
5. Willingham, D. T. Is It True That Some People Just Can’t Do Math? *Am. Educ.* **2009**, 33 (4), 14-19. At <http://www.aft.org/pdfs/americaneducator/winter2009/willingham.pdf>

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Topic 2

Math Assessment

To the Instructor

Topic 2 is a 15-minute quiz on math needed for chemistry. Given at the start of the course, the quiz will identify, for sections and/or individual students, areas of math in which your particular group of students would benefit from review.

This quiz has been found to identify who will do well in college first-year chemistry (see discussion below). It will identify topics where your students have gaps in preparation that, if you fill them in with some math review, in class or by homework, will result in their doing better in college chemistry. They need to do well in college chem to succeed STEM majors.

So give the quiz, find

The quiz is posted at <https://www.ChemReview.Net/MathAssessment.PDF>

Calculator or no Calculator?

The quiz is labeled “no calculator.” You can instead allow a calculator. Done that way, the quiz will show you where they can’t do this math even with a calculator, and that’s good to know.

BUT -- what you want to know is what this quiz measures: Can they do problems with really simple arithmetic without the calculator? If they can’t, they will need to be taught the rules for the math operation involved, because

- If they don’t know those fundamental rules, when they need to know a number of different types of calculator operations with a mix of numbers and exponents, they will have real difficulty remembering the order in which to press the buttons,
- When the calculations get complex, they are more likely to get the answer number right if they do the numbers on the calculator but exponential terms separately, by mental math,
- In the upper level classes you are preparing them for, they will be tested on whether they can estimate an answer without a calculator, as a check on their calculator use, and
- On future exams like the MCAT (Medical College Admissions Test) which many in chem hope to take and do well on, there are many calculations, and calculators are not allowed.

Results

Does this short quiz predict what topics they need math review on to do well in chemistry? Yes.

This quiz was given by faculty in sections of college general chemistry at multiple four-year colleges. In peer-reviewed papers, those faculty reported that when given “no calculator,” the quiz score for each student was highly correlated to subsequent grades in General Chemistry.

When the quiz was given “calculator allowed,” *higher* quiz scores were correlated with *lower* grades in the course.

These findings are consistent with cognitive research on the importance of “automaticity in fundamentals.”

To read the papers, see

1. "MUST-Know Pilot—Math Preparation Study from Texas" at https://confchem.ccce.divched.org/sites/confchem.ccce.divched.org/files/2017FallConfChemP2_0.pdf
2. "Impact of basic arithmetic skills on success in first-semester general chemistry" in *Chemistry Education Research and Practice*, 2020, 21, 51-61 at <https://pubs.rsc.org/en/content/articlehtml/2020/rp/c9rp00077a>
3. "Impact of arithmetic automaticity on students' success in second-semester general chemistry" in *Chemistry Education Research and Practice*, 2020, 21, 1028-1041 at <https://pubs.rsc.org/en/content/articlehtml/2020/rp/d0rp00006j>

Follow-Up

Most of the quiz questions have *two* components: Knowledge of the procedure steps and ability to do simple mental arithmetic. You may want to analyze:

- On question one: What percentage of your students could correctly multiply two digits times two digits without a calculator?
- On questions 2-8, what was the percentage correct for each of these questions? For problems where a number of students had difficulty, did the difficulty appear to be with the rules of the math operation, or the mental arithmetic, or both?

If mental arithmetic (recall of math facts) is a problem, there are two possibilities. One is that students once knew their math facts *well*, but have forgotten them due to calculator use. Science tells us that in this case of *forgetting*, the information is still stored in memory, but the neural "wiring" to reach it needs to be re-grown by practice. Forgotten memories will "refresh" (re-wire) relatively quickly with practice in recall.

The second possibility is that students were never required to "memorize their times tables." In some states prior to 2014, state K-12 math standards required teachers to have students use calculators to do arithmetic starting for *third grade* state testing, rather than memorize facts. Since 2014, Common Core-type standards have restored a partial emphasis on computational fluency, but this means in many states, current students at some point went from one set of standards to another in the middle of their K-8 schooling. Those students may need substantial practice to gain the fluency in recall of math facts that science says they need to ease scientific problem solving. (On state math standards, see references 1 and 2 for Topic 1 of this packet)

If the quiz and subsequent exercises indicate that some students need help with mental arithmetic, the activities in this packet provide options for additional practice.

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Topic 3

Math and Metric Review

Posted online for student use are 50 pages of self-study tutorials (9 lessons in 2 chapters) that help students review (or learn) math and metric fundamentals that are a foundation for chemistry. The tutorials may be viewed and downloaded at:

<https://www.ChemReview.Net/ExpoMetric.PDF>

The tutorial lessons, individually or in groups, can be assigned as homework at the start of General or AP Chemistry, or as part of an AP summer packet. In other courses, the homework can be assigned at any point when students are asked to solve calculations involving

- exponential and scientific notation,
- estimation,
- metric calculations,
- mental math, and
- calculations that mix numbers, exponentials, and units.

Suggestions for a format to assign the tutorials are included in the PDF at the link above.

Assignment Length

In Gen Chem/AP, these topics should be review. Students should be able to complete the two chapters in the assignment in a homework week.

For Prep Chem or HS Honors students, lessons can be assigned to reinforce lecture at a more gradual pace.

Quizzes

To encourage timely homework completion, quizzes are provided on the tutorial content. For access, click www.ChemReview.Net/QuizRequest.html

Quizzes are available for both Chapter 1 only and Chapters 1 and 2 combined.

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Topic 4

Additional Mental Math Review

To the Instructor

Topic 4 is a sequence of five 1-2-page lessons with rules, strategies and practice on

- The standard algorithms for multi-digit multiplication and division,
- Simplifying fractions,
- Converting fractions to decimal equivalents,
- Simplifying exponential terms in fractions, and
- Estimating answers using mental math.

Depending on the class level, you may want to assign selected lessons.

The practice sheets are printed below with suggestions for the instructor with each. The practice sheets for students (without the notes to instructors, are in an 8-page PDF at www.ChemReview.Net/MentalMathPractice.pdf

A 5 minute quiz covering the assignments is included in this packet after the practice sheets.

In General, GOB, or AP Chemistry, you may want to assign selected pages or all 8 pages as one homework assignment.

In college Prep Chem or high school introductory courses, the lessons can be assigned at a gradual pace as reinforcement when teaching the math of calculations.

The problems can be completed “from the screen” without paper copies, but students would need to copy most questions. IF you are able to copy and hand out the pages you assign, the assignment will be easier for students to complete.

A suggested assignment format would be:

* * * * *

Online Homework:

- Download the 8-page PDF at www.ChemReview.Net/MentalMathPractice.pdf and complete the problems on pages X to X.
- Be ready for a quiz - which will be similar to the questions in the lessons - on (date).

Or – If handed out:

- Complete the pages in this packet. Be ready for a quiz - which will be similar to the questions in the lessons - on (date).

* * * * *

Detail for each of the 5 assignments is below.

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Practice 4A - Multi-digit Multiplication and Division

To the Instructor

Practice 4A and 4B are similar to the coverage of these topics in Lesson 1.2 of the homework tutorials.

In Gen/GOB/AP chem, it may be Practice 4A and 4B can be skipped. What is in Lesson 1.2 will likely suffice.

In HS Honors/Prep Chem, students may benefit from both lecture coverage and homework reinforcement. You may want to use 4A and 4B in class to introduce the topics and provide feedback as students work the problems a few at a time. Some problems can be left to complete as homework, or as a warmup review at the start of the next class.

Practice 4A below reviews the standard algorithms for multiplication and for simple long division. This practice is recommended *if* mental arithmetic gaps were identified in the fluency quiz.

Using the multiplication “standard algorithm” requires *practicing recall* of multiplication and addition. The division algorithm requires practicing multiplication, division and subtraction fact recall.

The benefits of requiring students to occasionally perform these types of calculations include

- They are a way to practice the *overlearning* of math fundamentals science says is essential for student understanding of quantitative concepts;
- Problems like these can be put on the board at the start of a class throughout the term for productive student “refreshing of memory” while you tend to administrative necessities.

The explanation of the two algorithms is the same as that in Lesson 1.2 in the homework tutorials, but the problems have different numbers. This sheet will supply additional practice.

The Common Core and current math standards in most states require teaching both of these standard algorithms, but until 2014 in many states, students were not asked to learn long division. Even now, this may impact your students.

To start, you may want to assign one problem each of multiplication and division, then glance at a few papers to get an idea of what background your students have in these procedures.

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Practice 4A: Multi-digit Multiplication and Division

To understand the numeric relationships in science, you need to be able to do arithmetic quickly “in your head.” One way to keep mental math skills sharp is to occasionally solve simple multi-digit multiplication and division without a calculator. To do this without overwhelming “working memory” (where you think), you need to apply a “standard algorithm.”

1. The multiplication algorithm usually taught in the US includes these steps. For $76 \times 42 = ?$

$$\begin{array}{r} \text{Step 1: } \begin{array}{r} 176 \\ \times 42 \\ \hline 152 \end{array} \qquad \text{Steps 2 and 3: } \begin{array}{r} 276 \\ \times 42 \\ \hline 152 \\ 304 \\ \hline 3192 \end{array} \quad \leftarrow (\text{putting a } 0 \text{ after the } 4 \text{ is an option}) \end{array}$$

Without a calculator, multiply these:

$$\begin{array}{llll} \text{a.} & \begin{array}{r} 95 \\ \times 16 \\ \hline \end{array} & \text{b.} & \begin{array}{r} 84 \\ \times 73 \\ \hline \end{array} & \text{c.} & \begin{array}{r} 39 \\ \times 62 \\ \hline \end{array} & \text{d.} & \begin{array}{r} 57 \\ \times 48 \\ \hline \end{array} \end{array}$$

2. The “long division” algorithm usually taught in US education includes these steps:

$$\text{For } 2048 \div 8 = \begin{array}{r} 2 \\ 8 \overline{) 2048} \\ \underline{16} \\ 44 \\ \underline{44} \\ 0 \end{array} \qquad \begin{array}{r} 256 \\ 8 \overline{) 2048} \\ \underline{16} \\ 44 \\ \underline{40} \\ 48 \\ \underline{48} \\ 0 \end{array} = 256$$

Without a calculator, try these “evenly divisible” cases (the answer will be a multi-digit whole number -- no decimals or remainders).

$$\begin{array}{lll} \text{a.} & \overline{6) 516} & \text{b.} & \overline{9) 2187} & \text{c.} & \overline{8) 5560} \end{array}$$

Answers: 1a. 1520 1b. 6132 1c. 2418 1d. 2736 2a. 86 2b. 243 2c. 695
(Permission by *ChemReview.Net* granted for use. See *www.ChemReview.Net/blog*)

Practice 4B

Additional Mental Arithmetic Practice

To the Instructor

Practice 4B covers numeric simplification operations that are useful both during simple calculations and when estimating to check a calculator answer.

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Practice 4B: Using Mental Arithmetic to Simplify Fractions

WithOUT a calculator, use your mental arithmetic skills to reduce these fractions to a one or two digit whole number. Show your work on this paper. Check your answers at the bottom.

Each problem may have multiple ways to cancel and solve. Any way to a correct answer works.

$$1. \text{ Example: } \frac{8 \times 15 \times 3}{72} = \frac{\cancel{8} \times 15 \times 3}{\cancel{72} 9} = \frac{\cancel{8} \times 15 \times \cancel{3}}{\cancel{72} \cancel{3}} = \frac{15}{3} = 5$$

(When doing multiple cancellations, you may want to re-write at some point, as in the “next to last” step above, to keep your progress clear.)

Hint: It usually helps to try to reduce the larger numbers on both the top and bottom first.

$$2. \frac{49 \times 2 \times 8}{4 \times 7} =$$

$$7. \frac{72 \times 4 \times 6}{8 \times 9} =$$

$$3. \frac{42 \times 20 \times 5}{2 \times 6 \times 7} =$$

$$8. \frac{8 \times 12 \times 14}{2 \times 96} =$$

$$4. \frac{63 \times 4 \times 42}{6 \times 7 \times 9} =$$

$$9. \frac{10 \times 18 \times 56}{8 \times 2 \times 30} =$$

$$5. \frac{48 \times 6 \times 11}{4 \times 18} =$$

$$10. \frac{8 \times 27 \times 56}{7 \times 9 \times 32} =$$

$$6. \frac{35 \times 2 \times 8}{40 \times 14} =$$

$$11. \frac{28 \times 60}{12 \times 7 \times 2} =$$

12. Double these: 42 17 36 45 16 24 32 48

13. Cut these values in half: 44 98 86 38 46 78 56

Answers: 2. 28 3. 50 4. 28 5. 44 6. 1 7. 24 8. 7 9. 21 10. 6
 11. 10 12. 84 34 72 90 32 48 64 96 13. 22 49 43 19 23 39 28

Practice 4C: - Converting Fractions to Decimal Equivalents

To the Instructor

The 2-pages of Practice 4C are printed below. It is suggested that you take a look at those two pages now, then return [here](#).

In Topic 3, tutorial Lesson 1.2, students are asked to commit to memory the decimal equivalents of eight commonly encountered fractions. Practice 4C, 4D, and 4E ask students to apply those values to calculate additional decimal equivalents and solve calculations.

Practice 4C-E work best if students have previously been given a quiz that required memorization of the fundamental decimal equivalents. Students should have these answers *very* well memorized, using flashcards if necessary (see tutorial Lesson 2.3).

You may want to post 4C Question 1 in some format at the start of class for several days in the first weeks of the semester, to drive these into memory.

If the memorization of the decimal equivalents has not yet been assigned, it is suggested that in class, you ask students to complete worksheet question one, go over the answers and various ways to calculate them, and then assign the remaining problems either in class or as homework.

If Practice 4C is used in-class instead of as homework

In HS Honors/Prep Chem, Practice 4C could be scheduled for 20-30 minutes at the start of a class period. The content could be projected, but it will limit “recopying the question” if the 2 pages are handed out.

Most problems can be solved in multiple ways. In intro classes, this worksheet can be used for the student to try the problem first, then for the instructor to answer questions, provide feedback, and demonstrate multiple ways to solve, especially on the tougher questions.

A possible procedure would be to ask students to answer Questions 1 to 5, allow 5 minutes, and then ask someone how they did 4c. Then ask for someone else to offer a different way (addition 3 times, or multiplication, or adding 0.125 to 0.250 could be shown on the board).

You might then ask they finish Questions 6 and 7, and pick one part of each question to ask for multiple ways to solve that can be written up on the board.

To “distribute” this practice, you may want to have students complete page one on the first day and page 2 the second.

On Question 9, you might ask students to do two parts at a time, ask for how they solved, stop when it seems most are getting it, and ask that they finish the remaining parts for homework.

Some students may have difficulty with the “place value” concepts in $0.040 + 0.040$ and 5×0.040 . This is math that in some state standards has been “de-emphasized.” The fundamental arithmetic may need to be demonstrated a few times -- step by step.

Follow-Up

Practice 4D and 4E build on Practice 4C. A quiz on 4C to 4E is in Topic 4F.

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Practice 4C: Converting Fractions to Decimal Equivalents

On this exercise, do NOT use a calculator.

1. Every numeric fraction Y/X (if $X \neq 0$) has a numeric decimal equivalent. In Lesson 1.2, for the eight fractions encountered most often in scientific calculations, you were asked to commit the decimal equivalents to memory.

From memory, write the decimal equivalents for those fractions.

a. $\frac{1}{2} = 0.50$ b. $\frac{1}{3} =$ c. $\frac{1}{4} =$ d. $\frac{1}{5} =$
e. $\frac{2}{3} =$ f. $\frac{3}{4} =$ g. $\frac{1}{8} =$ h. $\frac{3}{2} =$

2. If you know the decimal equivalent for a fraction $1/X$, you can calculate the value of any decimal equivalent Y/X by *adding* the $1/X$ decimal equivalent Y times.

Because $\frac{2}{5} = \frac{1}{5} + \frac{1}{5} = 0.2 + 0.2 = \mathbf{0.4}$, then (finish) $\frac{3}{5} =$

3. Or, knowing $1/X$, you can find a decimal equivalent for Y/X using $Y/X = Y(1/X)$.

Finish the calculation below by multiplication to find the decimal equivalent.

$$\frac{4}{5} = 4 \times \frac{1}{5} = 4 \times \quad =$$

4. Some decimal equivalents can be solved by reducing the fraction to obtain a Y/X that can be recalled from memory or is easier to solve.

Fill in any blanks in these fractions, then write the decimal equivalent in the form 0.XXX

a. $\frac{1}{8} = \mathbf{0.}$ b. $\frac{2}{8} = \frac{1}{\quad} =$
c. $\frac{3}{8} = \mathbf{0.}$ d. $\frac{4}{8} = \frac{1}{\quad} =$

5. What is the trend in the Question 4 answers?

6. Using any of the strategies above, convert these fraction to a decimal equivalent value in the format 0.XXX

a. $\frac{5}{8} =$ f. $\frac{6}{8} =$
c. $\frac{7}{8} =$

7. Given that $1/25 = 0.040$, convert these to a decimal equivalent in the format 0.XXX

a. $\frac{2}{25} =$ b. $\frac{3}{25} =$ c. $\frac{5}{25} =$
d. $\frac{9}{25} =$ e. $\frac{12}{25} =$

8. When a non-memorized fraction has an odd number in the numerator, but you know the value for $1/X$, it often helps to split the numerator into two added parts where the second is $1/X$. The formula is:

$$\frac{Y_{\text{odd}}}{X} = \frac{Y-1}{X} + \frac{1}{X} \quad Y_{\text{odd}} - 1 \text{ is even, giving a fraction that can often be reduced to a fraction with a familiar decimal equivalent.}$$

Follow the steps of this worked example:

$$\frac{7}{8} = \frac{6}{8} + \frac{1}{8} = \frac{3}{4} + \frac{1}{8} = 0.75 + 0.125 = \mathbf{0.875}$$

On separate paper, convert these to 0.XXXX:

- a. If $1/12 = 0.0833$, then $7/12 = ?$ b. If $1/16 = 0.0625$, then $5/16 = ?$
 c. If $1/16 = 0.0625$, then $13/16 = ?$
9. If a denominator ends in a single zero before the decimal, the decimal equivalent will be the same as the equivalent for the denominator without the zero, but the equivalent will have its decimal moved one to the left.

But let's explain that with a formula and some examples.

$$\text{If } \frac{Y}{X} = 0.ABC \text{ then } \frac{Y}{X0} = 0.0ABC \quad \text{Examples:}$$

$$\text{Since } \frac{1}{5} = 0.200, \text{ then } \frac{1}{50} = 0.020 \quad \text{Since } \frac{3}{4} = 0.75, \text{ then } \frac{3}{40} = 0.075$$

Follow the logic of the math:

$$\frac{3}{50} = \frac{3}{5} \times \frac{1}{10} = 3 \times \frac{1}{5} \times \frac{1}{10} = 3 \times 0.200 \times 0.10 = 0.600 \times 10^{-1} = \mathbf{0.060}$$

On a separate paper, convert these to a decimal equivalent in the format 0.XXXX

- a. $\frac{1}{40}$ b. $\frac{1}{80}$ c. $1/20$ d. $13/20$ e. $5/80$
10. On separate paper, using any strategy you choose, convert these to the form 0.XXX
- a. $\frac{1}{20}$ b. $\frac{3}{12}$ c. $\frac{7}{20}$ d. $\frac{9}{72}$ e. $\frac{8}{40}$ f. $\frac{2}{30}$ g. $\frac{3}{50}$ h. $\frac{8}{120}$

Answers: 1b. 0.333 1c. 0.25 1d. 0.20 1e. 0.667 1f. 0.75 1g. 0.125 1h. 1.5 2. 0.6
 3. $4 \times 0.20 = 0.80$ 4a. 0.125 4b. $\frac{1}{4} = 0.250$ 4c. 0.375 4d. $\frac{1}{2} = 0.500$ 5. Each answer increases by 0.125
 6a. 0.625 6b. 0.750 6c. 0.875 7a. 0.080
 7b. 0.120 7c. 0.200 7d. 0.360 7e. 0.480 8a. 0.5833 8b. 0.3125 8c. 0.8125
 9a. 0.0250 9b. 0.0125 9c. 0.0500 9d. 0.6500 9e. 0.0625 10a. 0.050 10b. 0.250
 10c. 0.350 10d. 0.125 10e. 0.200 10f. 0.067 10g. 0.060 10h. 0.067

Practice 4D: Exponentials and Fractions

To the Instructor

The practice pages are printed below. Take a look at the pages now, then return [here](#).

Practice 4D is 2-pages combining the decimal equivalent work in Topic 3 with the exponential notation review in tutorial Chapter 1. It is intended to be started in class at any time after both Topic 3 and Chapter 1 have been completed.

These pages can be assigned as homework or completed in class.

If Used In-Class

You might start by asking students to complete Parts a and b on Questions 1 and 2, demo how you would do one part of each question, and then handle Questions 3 and 4 the same way, leaving un-done parts for homework or for class tomorrow.

How many parts each student will need to complete to become confident will depend on many factors, including the grade in which they were allowed to first use calculators for arithmetic (which will vary by state and district). Student skills in mental math *should* improve a bit with each passing year, since most states since 2014 have forbidden calculator use until 7th grade.

#

Practice 4D: Fractions and Exponentials

On this sheet, do NOT use a calculator.

1. Convert each term to a whole number power of 10 (such as 10^{-4}), then simplify. Write your final answer as a whole number power of 10.

a. $\frac{100 \times 0.10}{0.0001 \times 0.010} = \underline{\hspace{2cm}} =$

b. $\frac{1}{1,000 \times 0.010} = \underline{\hspace{2cm}} =$

c. $\frac{10 \times 0.0010}{10,000 \times 0.010} =$

d. $\frac{0.10 \times 0.010}{1,000 \times 100,000} =$

2. Calculate, then convert the final answer to scientific notation with 3 digits in the significant.

a. $\frac{3 \times 10^{-5}}{4 \times 10^{-2}} =$

b. $\frac{2 \times 10^9}{8 \times 10^{-2}} =$

c. $\frac{1}{80 \times 10^{-2}} =$

d. $\frac{3 \times 0.0010}{5 \times 0.010} =$

3. Zeros *before* the decimal but *after* all other numbers can “cancel on the top and bottom.”

Example: $\frac{60 \times 4,000}{800} = \frac{\cancel{60} \times 4,00\cancel{0}}{\cancel{800}} = \frac{2400}{8} = \mathbf{300}$

Below, cancel zeros top and bottom, then simplify using mental arithmetic. Write the answer as a fixed decimal number.

a. $\frac{600 \times 40}{10 \times 30} =$

b. $\frac{7500 \times 90}{30 \times 25} =$

c. $\frac{160 \times 300}{3200 \times 60} =$

4. Fractions with zeros in the denominator *before* the decimal but *after* all other numbers can be separated into two parts and converted to exponential notation.

$$\text{Example: } \frac{3}{500} = \frac{3}{5 \times 100} = \frac{3}{5} \times \frac{1}{100} = 0.60 \times 10^{-2} = 6.0 \times 10^{-3}$$

Separate these into two parts, then simplify. Write the final answer in scientific notation with two digits in the significand.

a. $\frac{64}{160} =$

b. $\frac{144}{1200} =$

c. $\frac{63}{7,000} =$

5. Convert these to fixed decimal values in the form 0.XXX

a. $\frac{7}{28 \times 2} =$

b. $\frac{70}{2 \times 50} =$

c. $\frac{4 \times 45}{30 \times 9} =$

d. $\frac{400}{20 \times 60} =$

6. Re-write each of the two quantities to scientific notation, multiply or divide, then convert to scientific notation with a 2-digit significand.

a. $(7,000 \times 10^{-2}) (0.080 \times 10^{-11}) =$

b. $(0.090 \times 10^9) (0.0070 \times 10^{-8}) =$

c. $\frac{8 \times 10^{-3}}{200 \times 10^{-2}} = \text{-----} =$

d. $\frac{72 \times 10^{-3}}{900 \times 10^7} = \text{-----} =$

Answers: 1a. 10^7 1b. 10^{-1} 1c. 10^{-4} 1d. 10^{-11} 2a. 7.50×10^{-4} 2b. 2.50×10^{10}
 2c. 1.25×10^0 2d. 6.00×10^{-2} 3a. 80 3b. 900 3c. 0.25 4a. 4×10^{-1}
 4b. 1.2×10^{-1} 4c. 9.0×10^{-3} 5a. 0.125 5b. 0.700 5c. 0.667 5d. 0.333
 6a. 5.6×10^{-11} 6b. 6.3×10^{-3} 6c. 4.0×10^{-3} 6d. 8.0×10^{-12}

Practice 4E: Fractions, Estimates, and Exponentials

To the Instructor

Practice 4E can be started in class at any time after both Practice 4D and tutorial Chapter 1 have been completed.

Some students may have difficulty with long division with a decimal point involved. This is a topic that in some state standards omitted between 1990 and 2014.

If Used In-Class

On this sheet, problems are grouped with several of each type in a row. To cover each type, you might ask students to complete every 2nd or 3rd problem, then assign and go over a similar part in the question if a particular type of problem gives them difficulty.

#

Practice 4E: Fractions, Estimation, and Exponentials

On this sheet, do NOT use a calculator.

1. $1/9 = 0.1111\dots$ $2/9 = 0.22222$ (you get the picture) $8/9 = 0.8888\dots$

Convert to the form 0.XXXX : a. $2/90 =$ b. $7/900 =$

2. To simplify fractions composed of fixed decimal numbers, the decimals on the top and bottom can be moved the same number of places – to get an easy division problem or a fraction with a familiar decimal equivalent.

$$\text{Example: } \frac{0.440}{0.020} = \frac{\overset{\cup\cup\downarrow}{0.440}}{\underset{\cup\cup\uparrow}{0.020}} = \frac{44.0}{2.0} = 22 \quad (\text{Move to get 2 in the denominator})$$

Convert to either whole numbers or decimal equivalents in the form 0.XXXX :

a. $\frac{0.025}{0.075} = \text{-----} =$

b. $\frac{5.6}{0.70} = \text{-----} =$

3. If you see a simple division or fraction that can be gotten by moving decimals different amounts in the numerator and denominator, write the simple numbers, add a power of 10 to each to keep its value the same, and use exponential math to solve.

$$\text{Example: } \frac{0.0060}{2400} = \frac{6 \times 10^{-3}}{24 \times 10^2} = 0.25 \times 10^{-5} = 2.5 \times 10^{-6}$$

On separate paper, convert to scientific notation with 2 digits in the significant:

a. $\frac{4000}{0.090}$ b. $\frac{0.56}{800}$ c. $\frac{60}{1.8 \times 10^{-14}}$

4. Re-write each of the two quantities to scientific notation, multiply or divide, and then convert your final answer to scientific notation with a 2-digit significant.

a. $\frac{200 \times 10^{12}}{0.40 \times 10^4} = \text{-----} =$

b. $\frac{0.010 \times 10^3}{0.50 \times 10^{-7}} = \text{-----} =$

c. $\frac{0.10}{0.004} = \text{-----} =$

d. $\frac{0.020}{5,000} = \text{-----} =$

e. $\frac{0.048}{0.008} = \text{-----} =$

5. Round these value, then *estimate* to an answer with one non-zero digit.

a. $\frac{183}{21 \times 2} =$

b. $\frac{24}{5 \times 53} =$

c. $\frac{4 \times 27}{525} =$

6. Solve these in any way you choose. Convert your final answer to scientific notation with a 2-digit significant.

a. $\frac{0.00062}{0.20} =$

b. $(4.5 \times 10^{-4})(0.020 \times 10^7) =$

c. $\frac{96 \times 10^{-3}}{120 \times 10^{-1}} =$

d. $\frac{75 \times 10^{16}}{0.025 \times 10^{-4}} =$

7. Decimal equivalents may also be solved by long division.

$$5/6 = ? = 5 \div 6 = \frac{0.833...}{6 \overline{) 5.000}} = 0.83\overline{3}$$

$$\begin{array}{r} 0.833... \\ 6 \overline{) 5.000} \\ \underline{48} \\ 20 \\ \underline{18} \\ 20 \dots \end{array}$$

On separate paper, solve by long division. Round to 3 places past the decimal.

a. $5/12$ b. $4/11$

Answers:

- 1a. 0.0222 1b. 0.0078 2a. $25/75 = 1/3 = 0.3333$ 2b. $56/7 = 8$
 3a. 4.4×10^4 3b. 7.0×10^{-4} 3c. 3.3×10^{15}
 4a. 5.0×10^{10} 4b. 2.0×10^8 4c. 2.5×10^1 4d. 4.0×10^{-6} 4e. 6.0×10^0
 5a. Between 3 and 6 5b. Close to 0.1 5c. Close to 0.2
 6a. 3.1×10^{-3} 6b. 9.0×10^1 6c. 8.0×10^{-3} 6d. 3.0×10^{23}
 7a. 0.417 7b. 0.364

Topic 4F: Exponentials and Fractions: 5 Minute Quiz

To the Instructor

Below are 4 quizzes on the previous mental arithmetic homework worksheets. The suggested timing for the quiz would be:

- Assign the worksheets to be completed, gradually or all at once.
- When the last is assigned, announce a quiz on their content will be given in 2-4 days.

An announced quiz tends to encourage homework completion.

The quiz is “no calculator.” It should take 5 minutes. It is designed to be easy if students completed the homework.

There are 4 different copies -- with simple but scrambled numbers. All 4 copies may be shuffled and handed out if security is a concern.

You may want to hand out or project one copy as a practice quiz on the day before the real quiz, let them work for 5 minutes, then post answers and solicit how to solve for a few.

The real quiz is intended to be closed notes and given in a class meeting when security can be maintained.

If errors are found, please email: ToTheAuthors (at) ChemReview.Net .

Answer Key

Quiz 32 in numerator

1a. 0.888 1b. 0.250 1c. 0.240

2a. 10^3 2b. 10^9

3a. 4.2×10^5

3b. 4.0×10^{-11}

3c. 5.0×10^{11}

3d. 2.2×10^1

3e. 4.0×10^{-3}

Quiz 16 in numerator

1a. 0.444 1b. 0.125 1c. 0.640

2a. 10^2 2b. 10^6

3a. 4.2×10^4

3b. 4.0×10^{-8}

3c. 5.0×10^{11}

3d. 5.6×10^1

3e. 4.0×10^{-4}

Quiz 28 in numerator

1a. 0.778 1b. 0.150 1c. 0.480

2a. 10^1 2b. 10^7

3a. 2.1×10^3

3b. 2.0×10^{-9}

3c. 2.0×10^{13}

3d. 4.4×10^1

3e. 2.0×10^{-13}

Quiz 20 in numerator

1a. 0.556 1b. 0.100 1c. 0.320

2a. 10^4 2b. 10^8

3a. 2.1×10^2

3b. 8.0×10^{-10}

3c. 2.0×10^{11}

3d. 3.3×10^1

3e. 2.0×10^{-14}

Name: _____ Section _____

Quiz On Fractions and Exponential Mental Math

Do *not* use a calculator. Show your work on this paper.

1. Convert to 0.XXX :

a. $32/36 =$

b. $\frac{10 \times 15}{12 \times 50} =$

c. $1/25 = 0.04$; $\frac{6}{25} =$

2. Answer as a 10^x

a. $\frac{100 \times 0.10}{0.010} =$

b. $\frac{1}{10^{-8} \times 0.10} =$

3. Write the final answer in scientific notation with two digits in the significand.

a. $(0.0060 \times 10^9) (0.070) =$

b. $\frac{16}{400 \times 10^9} =$

c. $\frac{10^5}{2.0 \times 10^{-7}} =$

d. $\frac{0.20}{0.009} =$

e. $\frac{48 \times 10^{-5}}{120 \times 10^{-3}} =$

Name: _____ Section _____

Quiz On Fractions and Exponential Mental Math

Do *not* use a calculator. Show your work on this paper.

1. Convert to 0.XXX :

a. $16/36 =$

b. $\frac{5 \times 15}{12 \times 50} =$

c. $1/25 = 0.04$; $\frac{16}{25} =$

2. Answer as a 10^x

a. $\frac{10 \times 0.10}{0.010} =$

b. $\frac{1}{10^{-5} \times 0.10} =$

3. Write the final answer in scientific notation with two digits in the significand.

a. $(0.0060 \times 10^8) (0.070) =$

b. $\frac{16}{400 \times 10^6} =$

c. $\frac{10^5}{2.0 \times 10^{-7}} =$

d. $\frac{0.50}{0.009} =$

e. $\frac{48 \times 10^{-5}}{120 \times 10^{-2}} =$

Name: _____ Section _____

Quiz On Fractions and Exponential Mental Math

Do *not* use a calculator. Show your work on this paper.

1. Convert to 0.XXX :

a. $28/36 =$

b. $\frac{6 \times 15}{50 \times 12} =$

c. $1/25 = 0.04 ; \frac{12}{25} =$

2. Answer as a 10^x

a. $\frac{100 \times 0.010}{0.10} =$

b. $\frac{1}{10^{-6} \times 0.10} =$

3. Write the final answer in scientific notation with two digits in the significand.

a. $(0.0030 \times 10^7) (0.070) =$

b. $\frac{16}{800 \times 10^7} =$

c. $\frac{10^5}{5.0 \times 10^{-9}} =$

d. $\frac{0.40}{0.009} =$

e. $\frac{24 \times 10^{-5}}{120 \times 10^7} =$

Name: _____ Section _____

Quiz On Fractions and Exponential Mental Math

Do *not* use a calculator. Show your work on this paper.

1. Convert to 0.XXX :

a. $20/36 =$

b. $\frac{4 \times 15}{12 \times 50} =$

c. $1/25 = 0.04$; $\frac{8}{25} =$

2. Answer as a 10^x

a. $\frac{1000 \times 0.10}{0.010} =$

b. $\frac{1}{10^{-7} \times 0.10} =$

3. Write the final answer in scientific notation with two digits in the significand.

a. $(0.0030 \times 10^6) (0.070) =$

b. $\frac{16}{200 \times 10^8} =$

c. $\frac{10^5}{5.0 \times 10^{-7}} =$

d. $\frac{0.30}{0.009} =$

e. $\frac{24 \times 10^{-5}}{120 \times 10^8} =$

Topic 5

Improving Dimensional Analysis

Would you like to help students solve calculations with higher rates of success?

<https://www.ChemReview.Net/DHone.pdf> and <https://ChemReview.Net/DHtwo.pdf> include 28 pages of worksheets that help to teach students to organize their data before they begin to “chain conversion factors. The worksheets can be used in-class in “first courses” in chemistry and as a fast review or homework “preparation for lecture” in Gen Chem, GOB, and AP courses.

Topics include word problem strategies, grams, moles, and molecule conversions, stoichiometry, and molarity calculations.

These strategies have been tested – and, as reported in *J Chem Ed*, raised ACS Gen Chem Examination scores 20 percentiles. Quizzes for instructor use are included.

Topic 6

Acid-Base Math Review

Topic 6 is intended for use when you reach solving for $[H^+]$ in strong acid and base solutions. It is intended as a “just-in-time refreshing of memory” of the math for those calculations.

The topic includes 2 pages of math practice and a quiz.

Detail is at <https://www.ChemReview.Net/ABMathToInstructors.pdf>

Topic 7

Preparation for Electrochemistry

Topic 7 is a 5 page assignment designed as homework in General, Engineering, and AP Chem to prepare students in the initial vocabulary and calculations for electrochemistry.

Detail is at www.ChemReview.Net/ElectroPrepToInstructors.pdf

Topic 8

Other Math Review Resources

The Math and Metric Review tutorials in Topic 3 are taken from the first two chapters of the textbook *Calculations in Chemistry - An Introduction*, available from W. W. Norton. The publisher has granted the authors of the text permission to post the first two chapters for free use by students and instructors at all times during the school year.

All **college and high school** instructors may request a free examination copy of all 24 chapters of the paperback or eBook. To receive a copy, click <http://books.wwnorton.com/books/Calculations-in-Chemistry/> and use the "Request Exam Copy" box near the bottom.

Or you can purchase a used copy. For review or used copies, the authors (who include me) receive no royalties – so I don't receive income from suggesting you read the text.

The textbook includes the following additional lessons which provide additional review of the math topics of chemistry, both with and without a calculator:

- Chapter 3 Significant Figures
- Chapter 4 Dimensional Analysis
- Chapter 5 Word Problem Strategies
- Lesson 12.1 Solving for Ratio Units
- Lessons 12.3 Fraction and Percentage Calculations
- Lesson 16.3 Cancellation of Complex Units
- Lesson 17.1 Choosing Consistent Units
- Lesson 17.4 Choosing the Right Equation
- Lesson 21.1 Powers and Roots of Exponential Notation
- Lesson 22.1 Acid-Base Math -- Review
- Lesson 23.1 Base 10 Logarithms
- Lesson 24.3 Natural Logarithms

These lessons may provide ideas for math review lessons you can design on your own.

(I was asked on Facebook about how *students* could use the text from which the Exponential and Metric lessons are taken. Here's what I said:)

I am a co-author, but the book is from WWNorton. They did the typesetting, proofing, eBook programming, orders – the tough and \$\$\$ part.

IF you teach in college or in private schools where students buy their books, they can buy the paperback. It's under \$50.

For public High Schools that by law must supply books free, a license for the full 24 chapters of the eBook is available from Norton for \$6 per year if purchased for a 6-year adoption (\$36 per six year license). Details are www.ChemReview.Net/ClassSets.html .

You might say: Schools never have money. Normally, true. But in the recent "Rescue Plan" bill, the feds gave public schools a good chunk of stimulus money to "recover from the pandemic." When that filters down, your admins will tell you: "We have money we need to spend this week." That may get you a class set or 3.

If \$\$\$ is limited, what may work is getting enough licenses to use for review homework in AP for six weeks, then have Honors/PreAP use the licenses as online homework reinforcement of lecture the rest of the year.

And that helps for the next six years. Renting an eBook text for \$6 a year is a good deal. A standard eBook text is \$30 plus to rent per year.

OR you can get a free copy, type with modifications into 150+ one per day worksheets, and have school pay for xerox copies. It's more work for you and costs school more, but schools are not always rationale places, are they?

In class, can you put up on the screen a few pages for class use? Probably. But check with your school librarian -- the expert on "fair use and copyright."

Hope that helps! -- totally un-biased co-author

#

Topic 9

How the Student Brain Learns Chemistry

For Instructors

A 4 page introduction to scientific research on how the student brain solves chemistry problems – and learns to solve problems – is posted at

<https://www.ChemReview.Net/Brain101.pdf>

This is new science that the author believes will markedly improve the design of your lessons, the success of your students hoping to enter science majors, and your career satisfaction.

See what you think!

(End of Packet)

Feedback

These materials are from www.ChemReview.Net/MentalMath.PDF .

Check back on occasion for updates. Version dates are noted at the top of the file.

Feedback on this material is appreciated! ChemReviewTeam@ChemReview.Net .

(Version 3)

Topic #13

Mental Arithmetic 4-Minute Quiz

To the Instructor

Topic #13 is a quiz that tests the ability of students to add, subtract, multiply, and divide simple numbers without a calculator. The quiz is included in this PDF but it is also in the MSWord *.docx file at www.ChemReview.Net/WeekOneEditable.docx in a format you may *edit* if you choose.

In the case of college students scheduled into “preparatory chemistry” by a placement test that *includes* “math without a calculator,” the placement test *may* take the place of the initial 4-minute quiz and you may want to assign the skill building to all of the “prep chem” students.

For classes in which mental math has not previously been assessed, the quiz will identify students who need additional practice in mental arithmetic.

- Page 1 is the quiz instructions; Page 2 is the quiz, to be printed on the back of Page 1.
- The paper is to be folded in half and stapled so that the page 2 quiz is hidden inside, but the Page 1 instructions outside can be read by the student before the timed quiz begins.

There are two versions of Page 2. The questions are the same but in a different order on each quiz. To discourage looking around, you may want to print half with one Page 2, half with the other, shuffle and hand them out randomly, then separate the versions when you grade.

It is recommended that the total time limit for these 60 questions be **4 minutes**. To have the automaticity that is necessary to avoid bottlenecks in working memory, students must be able to *recall* rather than calculate fundamentals. Students who know their math facts are often able to finish with perfect scores in less than 3 minutes.

You may want to announce when there are 2 minutes remaining. Not all will finish.

If a grade of “R” (Re-test) is quickly assigned when need is obvious, it should speed grading.

The instructions include language on *re-tests* that you may want to edit. In our experience, if students expect they will be able to take re-tests or that “the lowest grade will be dropped,” they tend to find excuses not to study. However, we suggest the re-test should be offered in this *one* case (because the results depend in part on K-12 state math policies over which students had no control), while making it clear this is an exception.

In states with math standards that emphasized mental arithmetic, many students may not need Topic #2 to strengthen their mental math, but the quiz should identify those students who do.

We suggest a tough grading scale. Students need to be able to do mental math quickly and *accurately*. Those borderline or rusty will benefit from the practice in Topic #2.

Suggested oral quiz instructions:

1. (Before handing out): “Do *not* open this quiz. Do read the instructions.”

-
2. (After handing out): “Do not open the quiz until I say ‘begin.’ This is a timed quiz. You may *not* use a calculator. Write your answers quickly. Skip questions you cannot answer quickly. Cross out errors – don’t erase. You may use pencil or pen. Ready? Begin.”

#

(staple)

Mental Arithmetic Quiz

PRINT your name here. → _____

Directions:

Do NOT open this to view the inside until you are told to do so. This is a timed quiz. It tests how well you can do *arithmetic automatically* -- withOUT a calculator.

This quiz counts. However, if “fast math” is something you need to practice, you will be given an opportunity to study and to take a re-quiz that will replace this grade.

Usually, this course does *not* allow re-tests. This first quiz is an exception because this material has not been taught in this course but you may need to review.

Nearly always in chemistry, you need to work carefully and check your work. But, on *this* one quiz, work quickly to get as many problems right as you can. If you cannot answer a question within **2-4** seconds, *skip* to the next question.

Answer all questions in the *boxes* provided on this paper. Make corrections if needed by crossing out errors (not erasing). You may NOT use ANY type of calculator.

Your instructor will tell you the time limit and when to begin. Do not open to the quiz on the inside page until you are told to do so.

(fold) - - - - -

Arithmetic Timed Quiz

Answer each *quickly* in the box provided. *Skip* questions you *cannot* answer quickly.

1. Multiplication. Fill in the boxes below.

$8 \times 9 =$		$8 \times 4 =$		$9 \times 5 =$		$3 \times 9 =$	
$4 \times 3 =$		$6 \times 6 =$		$5 \times 4 =$		$8 \times 3 =$	
$7 \times 5 =$		$7 \times 9 =$		$8 \times 8 =$		$5 \times 5 =$	
$8 \times 6 =$		$5 \times 3 =$		$5 \times 7 =$		$7 \times 8 =$	
$6 \times 4 =$		$7 \times 7 =$		$5 \times 8 =$		$7 \times 4 =$	
$9 \times 4 =$		$6 \times 5 =$		$6 \times 3 =$		$9 \times 6 =$	

2. Addition:

$8 + 9 =$		$8 + 4 =$		$9 + 5 =$		$3 + 9 =$	
$4 + 13 =$		$16 + 6 =$		$25 + 4 =$		$8 + 33 =$	
$4 + 45 =$		$7 + 59 =$		$8 + 88 =$		$5 + 64 =$	

3. Subtraction:

$18 - 9 =$		$8 - 4 =$		$9 - 5 =$		$13 - 9 =$	
$24 - 13 =$		$16 - 6 =$		$25 - 4 =$		$28 - 3 =$	
$54 - 45 =$		$67 - 5 =$		$88 - 18 =$		$25 - 13 =$	

4. Division (/ means "divided by") :

$18 / 9 =$		$32 / 4 =$		$45 / 5 =$		$63 / 9 =$	
$42 / 7 =$		$54 / 6 =$		$72 / 12 =$		$27 / 3 =$	
$96 / 8 =$		$56 / 7 =$		$12 / 24 =$		$3 / 12 =$	

(staple)

Arithmetic Timed Quiz

Answer each *quickly* in the box provided. *Skip* questions you *cannot* answer quickly.

1. **Multiplication.** Fill in the boxes below.

$8 \times 4 =$		$8 \times 9 =$		$3 \times 9 =$		$9 \times 5 =$	
$6 \times 6 =$		$4 \times 3 =$		$8 \times 3 =$		$5 \times 4 =$	
$7 \times 9 =$		$7 \times 5 =$		$5 \times 5 =$		$8 \times 8 =$	
$5 \times 3 =$		$8 \times 6 =$		$7 \times 8 =$		$5 \times 7 =$	
$7 \times 7 =$		$6 \times 4 =$		$7 \times 4 =$		$5 \times 8 =$	
$6 \times 5 =$		$9 \times 4 =$		$9 \times 6 =$		$6 \times 3 =$	

2. **Addition:**

$8 + 4 =$		$8 + 9 =$		$3 + 9 =$		$9 + 5 =$	
$16 + 6 =$		$4 + 13 =$		$8 + 33 =$		$25 + 4 =$	
$7 + 59 =$		$4 + 45 =$		$5 + 64 =$		$8 + 88 =$	

3. **Subtraction:**

$8 - 4 =$		$18 - 9 =$		$13 - 9 =$		$9 - 5 =$	
$16 - 6 =$		$24 - 13 =$		$28 - 3 =$		$25 - 4 =$	
$67 - 5 =$		$54 - 45 =$		$25 - 13 =$		$88 - 18 =$	

4. **Division** (/ means "divided by") :

$32 / 4 =$		$18 / 9 =$		$63 / 9 =$		$45 / 5 =$	
$54 / 6 =$		$42 / 7 =$		$27 / 3 =$		$72 / 12 =$	
$56 / 7 =$		$96 / 8 =$		$3 / 12 =$		$12 / 24 =$	

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To the Instructor -- Mental Arithmetic Assignment #14 --

Mental Math Homework -- Practice and Online Quizzes

This assignment is recommended for students who did not achieve a near perfect score on the 4-minute quiz.

In this assignment, to improve their arithmetic fluency, students practice recall of math fact fundamentals, then take an online quiz and submit their results by email.

It helps with motivation if students assume their emails “count,” and the work they do on the assignment will indeed count in improving their skills. However, these emails should not need to be read or evaluated by instructors (though keeping the emails is suggested in case questions arise at a later date about student grades and efforts in the course).

Rather than grading the emails, it is suggested that the “4-minute quiz” be re-administered at some point soon after the deadline for the third assignment. This should simplify and speed grading, with the higher grade of the two quizzes the one that “counts.”

At this point, it will help if you would read and try a portion of the assignment on the next page as far as the end of **Quiz 1**, then return here.

* * * * *

The assignment is included in this PDF for viewing but it is also in the MSWord *.docx file at www.ChemReview.Net/WeekOneEditable.docx . You will need to substitute at the points **in red**. Once that is done, the file can be saved as a PDF and web-posted or copied and handed out.

You may want to set up a special email address to receive these -- or a filter that sends *.Quiz” to a special folder in your in-box.

Each assignment sets a standard that all students should be able to reach with effort. On the multiplication and division, it is important that the students be able to solve by fast automated recall, rather than slower “calculation.”

On deadlines: allowing at least 3 calendar days per assignment is recommended. For students who were not required to learn their times tables in the past, practice for several days will be required to build long-term retention. If most students need only “refreshing their memory” on these fundamentals, 2 days per assignment may be sufficient.

Alternatives

Some students may need more “instruction” and varied practice than this assignment provides. Given the wide variety of K-12 math approaches used in states and districts in the past 10 years, student outcomes are difficult for the authors to predict. Our advice would be to give the 4-minute quiz, try Topic #2, re-quiz and evaluate how many students need additional work.

In Topic #4, we suggest ways to have students locate additional programs that may be used to teach and quiz on mental math. With the technology changing quickly, you may want to evaluate and substitute those for this assignment in future years.

The two pages of Topic #2 to be posted or handed out to students are on the following pages.

Addendum:

The assignment in Topic #2 is “flash-based.” A note about trying different browsers has been added for cases in which this is an issue. We are looking for an assignment option which works on tablets and smartphones. We will update this assignment with that as soon as a possibility is found.

Meanwhile, on most computers/laptops with standard keyboards, a browser should be available that will work with the current project as written.

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Mental Math Homework -- Practice and Re-Quiz

To solve science problems, you need to be able to do *simple* math quickly and accurately without a calculator. If your math facts are rusty, this exercise will catch you up.

You will take 3 online quizzes – no calculators allowed.

You will need a *computer* with a *numeric keypad* that is easy for you to use, plus a way to take “screen shots.” Instructions for taking screenshots on a standard “windows” computer are given below. To use a different computer, search “screen shots” and your operating system.

To start, go to <http://www.mathsisfun.com/numbers/math-trainer-multiply-old.html>

(The “trainer” is “flash based.” If the “math trainer” shown in the middle of the screen on the next page is not visible, try accessing the link above from a different browser. If the option is given to “load flash,” do so for this application.)

Quiz 1: Set the **workout** type in the left side window to **Add** . Click on the *next to last* button below ($2+2$ to $12+12$) . Set the timer at **zero** and practice until you know them all, fast. You will get better as you practice!

It takes a few tries to learn the system. After entering an answer, you will likely not need to hit *enter*). The backspace key usually works if the first digit of two is typed incorrectly.

To vary practice, try some of the other types of practice on this site, *or* make flashcards, *or* download a set of flashcards for your smartphone that you can use for practice during “downtimes.”

Then set the timer at **one** minute and take a **one** minute quiz. You may re-take the quiz as many times as you like.

Then, via email, send me your *best* score via email that has at least **94%** right. If you get to **26 or more right** with 94% or better accuracy, *stop*, email the screenshot with that score, and move on to the next assignment.

Use the “How to Send” instructions below. The deadline for **Quiz 1** is: **X PM Xdate**.

Quiz 2: Set the **workout** type in the left side window to **Subtract** . Click on the *last* button below ($9-2$ to $20-12$). Set the timer at **zero**, practice until you know them all, fast.

Then set the timer at **one** minute and take a **one** minute quiz. Email me your best score based on the “94%/26” rule above and “send” instructions below.

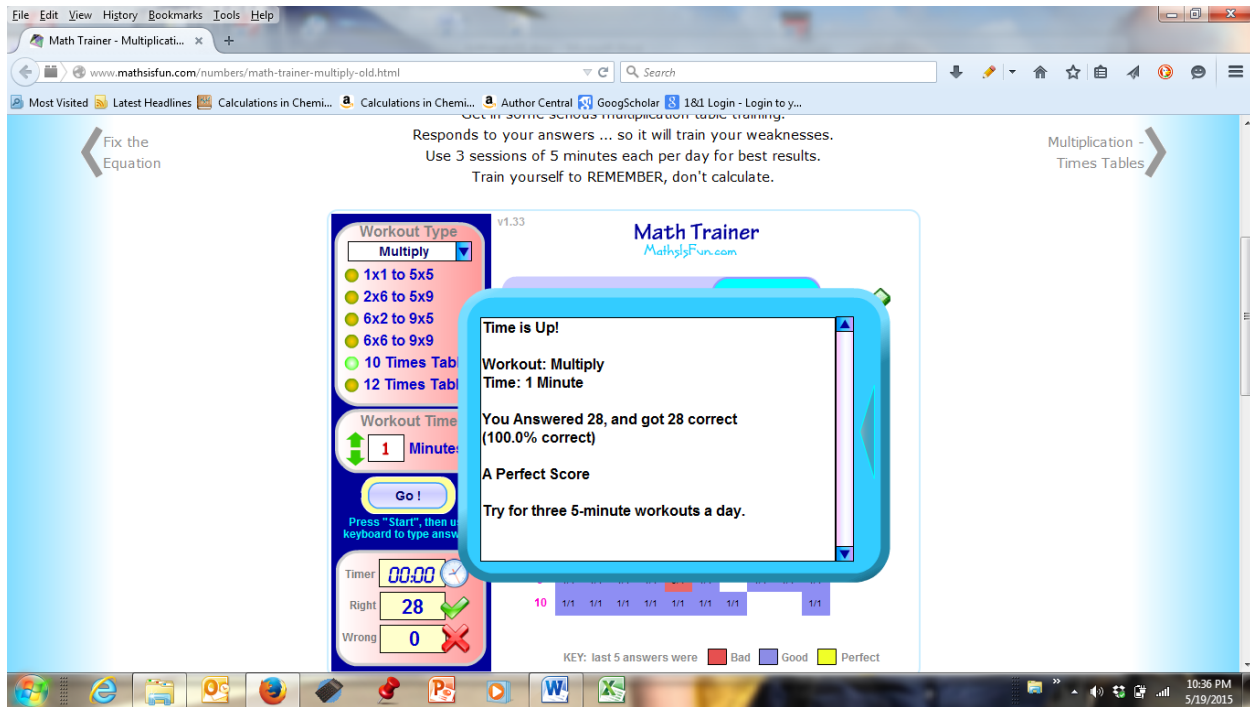
Deadline for **Quiz 2**: **X PM Xdate**.

Quiz 3: Set the **workout** type in the left side window to **Multiply** . Click the radio button that says “**12** times tables.” Set the timer at **zero**. Then practice your multiplication tables until you know them all and know them fast. Then set the timer at **one** minute and take a **one** minute quiz. Email your best score using the same rules as above.

Deadline for **Quiz 3**: **X PM Xdate**.

How to Send In Your Scores:

At the end of the 1 minute quiz, you will have a screen that looks something like this:



1. SAVE your screenshot when you get a quiz score that you think is the best you can do for now. *To save:*

Make sure the blue score window in the middle -- and the current date and time somewhere (see bottom right here) -- all show.

Press PRTSC to copy a “full” screen shot like the one above that shows the “Workout Test” type and 1 minute. Then

 - a. Paste it into the PAINT program listed at START>All Programs>Accessories that comes with Windows OR paste it into any program that will save the screen shot .
 - b. SAVE the file in the filename format: Your last name DOT Firstname DOT QuizNumber DOT Your number right on the quiz.
 - Example: Smith.Jane.Quiz1a.26.(ext) for your first Quiz1 submission.*
 - c. If you get a better score later, save as Quiz1b in name, and Quiz2a and 2b for quiz 2, etc.
2. To send your *best* score:
 - a. Send your saved screenshot file in an email as an attachment
 - b. On the subject line, put the name of the attachment above.
 - c. Email it to **XXXXXX** .
3. To be sure you meet the deadline, you may email up to two files. This lets you send a good score, but then a higher score if you get one just before the deadline. But at 94% or above right with 26 or above right, send that email and go to the next assignment.

That’s it! Get started working on Quiz 1 quickly! Practice several times a day!

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(End of packet)