Key

Mental Math and Units

or *what to do when you can't use a Calculator!*

AP Chemistry Exam

- **Multiple Choice Section**
  - 60 MCQ over the 117 Learning Objectives
  - 90 minutes
  - Conceptual and calculations
    - **NO CALCULATOR**
- **Free Response**
  - 7 free response questions, 1 hr, 45 min
    - Points for Set-up, calculation, significant figures and ***UNITS***
- **Unit Exams in AP Chem *(this class!)***
  - Multiple Choice: **NO CALCULATOR**
  - Free Response: No units = no credit
  - Both parts Timed

All values need units!!

Set-up each problem with units, show canceling units

$T = \frac{PV}{nR}$ $\quad T = \frac{(1.0\ atm)(1.0L)}{(.25mol)(0.08206L\ atm)/(mol\ K)}$ $\quad T = 49K$

Using dimensional analysis for conversions:

$\frac{60g\ H_2O}{} \times \frac{1\ mole\ H_2O}{18.0g\ H_2O} \times \frac{6.009kJ}{1\ mol\ H_2O}$

= 20kJ

Convert to a J, where 1000 J = 1kJ

$20kJ \times \frac{1000\ J}{1\ kJ} = 20{,}000\ J$

Significant Figures

Atlantic/Pacific Rule

Decimal Present – shoot arrow left to right stop at first number-count

0.00030 2 SF → 203.47 5 SF

Decimal Absent – shoot arrow right to left stop at first number-count

789000 3 SF 4 ← 1 SF

Multiply/Divide: answer to match least number SF

2.50 x 2 = 5 (1*SF*) 3 SF 1 SF

880.0/11.0 = 80.0 (3*SF*) 4 SF 3 SF

Add/Subtract: answer to match least number of digits to right of decimal.

2.52 + 12.2 = 14.72 round to 14.7 one past the decimal

2 past 1 past

639.822 – 33.31 = 606.512 round to 606.51 two past the dec.

3 past 2 past

Rounding for *easy calculations*

- 32.2g/61.054L Calculate the density of the substance.

$\frac{32.2g}{61.054L} \sim \frac{30g}{60L} \sim \frac{1g}{2L} \sim 0.5\frac{g}{L}$

- 88.4mol/10.7L Calculate the concentration.

$\frac{88.4mol}{10.7L} \approx \frac{\cancel{90}}{\cancel{11}} \approx \frac{88}{11} \sim 8$

round so its easy to solve!

Multiplication/Division

Know your multiplication facts to 12 (15 is better)!

- Move the decimal: Multiplying/dividing by 10, 100, etc, move decimal by # of zeros. Multiplying: move right. Dividing: move left.
- 0.0624 x 1,000 = 62.4 — move 5 → 3 zeros
- 0.47/100 = 0.0047 — 0.0 ← 2 zeros
- 0.42 x 10,000 = 4 zeros — 0.4200 — 4200.0
- 74.6/1,000 = 3 zeros — 0.0746 — 0.0746

0.0624 × 1,000 makes this 1

- Distribute: *To multiplying "big" numbers – break them up first.*
- 15 x 75 = (10+5) x 75 = (10x75) + (5x75) = 750 + 375 = 1125
- 9 x 14 = $9(10+4) = (9\times10)+(9\times4)$ $= 90 + 36 = 126$

$\begin{array}{r} 14 \\ 9 \\ \hline 126 \end{array}$

- 7 x 18 = $7(10+8) = 70 + \cancel{60} = \cancel{130}$ 56 126

$\begin{array}{r} 18 \\ 7 \\ \hline 130 \end{array}$

Bounding

when your values are not "easily" round-able

For MC look for answer closer to 0.5

- 2.256g ÷ 4.00g/mol Calculate the number of moles. (actual = 0.564)

$\frac{2.256}{4.00}$ — $\frac{3}{4} = 0.75$ — closer $\frac{2}{4} = 0.5$

- 3.47g x 1mol/12.0g Calculate the number of moles. (actual = 0.289)

$\frac{3.47g}{12.0\frac{g}{mol}}$ — $\frac{4}{12} = \frac{1}{3} = 0.33$ — $\frac{3}{12} = \frac{1}{4} = 0.25$

$\frac{1}{2}$ way between $0.33 - 0.25 = 0.08$ add $\frac{1}{2}(0.08)$ to 0.25

$+04 = 0.29$

(3.47 ~ 3.5 which is $\frac{1}{2}$ way between 3-4)

Factor

(What can you divide each number by to reduce?)

- 540.0g/ 12.0 g/mol. Calculate the number of moles

$\frac{54\cancel{0}}{12} = \frac{27}{6} = 4\frac{3}{6} = 4.50\times10$ (3 SF) 45.0

(× 10)

or $\frac{540}{12} = \frac{270}{6} =$

- 84.0g / 28g/mol. Calculate the number of moles

$\frac{84.0}{28} = \frac{42}{14} = \frac{6}{2} = 3.0$ (2 SF)

Know your Fractions!

Think of quarters/dollar

- 1/4 = 0.25
- 1/2 = 0.5
- 3/4 = 0.75
- 4/4 = 1

➢1/8 = 0.125
➢2/8 = 0.25
➢3/8 = 0.375
➢4/8 = 0.50
➢5/8 = 0.625
➢6/8 = 0.75
➢7/8 = 0.875

◆1/3 = 0.333
◆2/3 = 0.667

❖1/5 = 0.2
❖2/5 = 0.4
❖3/5 = 0.6
❖4/5 = 0.8

▶1/9 = 0.111
▶2/9 = 0.222
▶3/9 = 0.333
▶4/9 = 0.444
▶5/9 = **0.555**
▶6/9 = 0.666
▶7/9 = 0.777
▶8/9 = 0.888

$\frac{3}{8} = \frac{1}{8} + \frac{2}{8}$

$= 0.125$
0.250
0.375

$\frac{5}{8} = \frac{4}{8} + \frac{1}{8}$

0.125
0.500
0.625

$\frac{7}{8} = \frac{6}{8} + \frac{1}{8} = \frac{3}{4} + \frac{1}{8}$

$= 0.75 + 0.125 = 0.875$

Fractions Practice

Example: 0.75 x 0.5 = ¾ x ½ = 3/8 = 0.325

- 0.375 x 0.8 = $\frac{3}{\cancel{8}_{2}} \times \frac{\cancel{4}}{5} = \frac{3}{2} \times \frac{1}{5} = \frac{3}{10} = 0.3$
- 0.667 mol x 12.0 g/mol. Calculate the mass in grams

$= \frac{2}{\cancel{3}} \times \cancel{12}^{4} = 8.00g$

- 2.4 mol / 0.75L. Calculate the concentration in M $= \frac{mol}{L}$

(dividing = flip and multiply)

$\frac{2.4\,mol}{\frac{3}{4}\,L} = 2.4 \times \frac{4}{3} = \cancel{24}^{8} \times 10^{-1} \times \frac{4}{\cancel{3}} = 32 \times 10^{-1}$

$= 3.2M$

- $K_{eq} = 5.0 \times 10^5$. What is the K_{eq} for the reverse reaction (inverse)

$\frac{1}{5.0 \times 10^5} = \frac{1 \times 10^0}{5.0 \times 10^5} = \frac{1}{5} \times 10^{0-5} = 0.2 \times 10^{-5}$

$= 2.0 \times 10^{-6}$

-6 is smaller than -5

Scientific Notation (Exponents)

I D

- Know I.D 2,034.0 = 2.0340×10^3 0.0087 = 8.7×10^{-3}

move left 3 = Inc Exp move decimal 3 right decrease exp

- Recognize the larger number: 2×10^{-7} or 8×10^{-10}

0.0000002 larger than 0.0000000008

- Multiplication – add exponents

$(10^y)(10^x) = 10^{(y+z)}$

- Exponents w/exponents

$(10^y)^3 = 10^{(3y)}$

- Division – subtract exponents

$\frac{(10^y)}{(10^x)} = 10^{(y-x)}$

- Distribution

$(2 \times 10^y)^3 = 2^3 \times 10^{3y}$

Increase Exp when move decimal Left

Decrease Exp move decimal Right

Note: The larger the # for a neg exponent the smaller the actual #

$10^{-1} > 10^{-2} > 10^{-3} > 10^{-4}$

Scientific NotationPractice - Know I.D

- $K_{eq} = 0.000000088 / (0.000002)^3$. Calculate the K_{eq}

$\frac{8.8 \times 10^{-8}}{(2 \times 10^{-6})^3} = \frac{8.8 \times 10^{-8}}{2^3 \times (10^{-6})^3} = \frac{8.8 \times 10^{-8}}{8 \times 10^{(-6 \times 3)}}$

$\frac{8.8 \times 10^{-8}}{8 \times 10^{-18}} = \frac{\cancel{88}^{11} \times 10^{-9}}{\cancel{8} \times 10^{-18}} = 11 \times 10^{-9-(-18)}$

$= 11 \times 10^9$

- 0.0375L x 0.0000000060M. Calculate the number of moles

$(3.75 \times 10^{-2})(6.0 \times 10^{-9}) = (3.75 \times 6.0) \times 10^{-2+(-9)}$

$= 3.75 \times 6.0 \times 10^{-11}$

or $(0.375 \times 10^{-1})(6.0 \times 10^{-9})$

$= \left(\frac{3}{8} \times 6.0\right)\left(10^{-1+(-9)}\right)$

$= \frac{18}{8} \times 10^{-10} = 2\frac{2}{8} \times 10^{-10} = \boxed{2.25 \times 10^{-10}}$

Logarithms

Base 10 log is the number (exponent) 10 must be raised to equal that number
Log of a number smaller than 10 is negative

What this looks like with exponents:

$10^0 = 1$	log 1 = 0	$\log 10^1 = 1$
$10^1 = 10$	log 10 = 1	$\log 10^2 = 2$
$10^2 = 100$	log 100 = 2	$\log 10^3 = 3$
$10^3 = 1000$	log 1000 = 3	$\log 10^4 = 4$
$10^4 = 10{,}000$	log 10,000 = 4	
$10^{-1} = 0.1$	log 0.1 = -1	$\log 10^{-1} = -1$
$10^{-2} = 0.01$	log 0.01 = -2	$\log 10^{-2} = -2$
$10^{-3} = 0.001$	log 0.001 = -3	$\log 10^{-3} = -3$
$10^{-4} = 0.0001$	log 0.0001 = -4	$\log 10^{-4} = -4$

Logarithms

$\boxed{\log 1 = 0}$

Operations using logs:

$\log(a \times b) = \log a + \log b$

$\log a^n = n\log a$

$\log \frac{a}{b} = \log a - \log b$

Inverse log (antilog)

$\text{invlog}X = 10^x$

Examples:

- $\log(1\times10^x) = \log 1 + \log 10^x$
- $= 0 + X\log 10$
  $= 0 + X(1)$
  $= X$

shortcut: $\log 10^x = X$

A solution with $[H_3O^+] = 0.000010M$. Calculate the pH *(use bounding)* 1.0×10^{-5}

$pH = -\log[H_3O^+] = -\log(1.0\times10^{-5})$
$= -\log 10^{-5} = -(-5)$
$= 5$

Logarithms Practice

- A solution with $[H_3O^+] = 0.000000000010M$. Calculate the pH

$pH = -\log(1\times10^{-12}) = 12$

- $[H_3O^+] = (0.0000875)$ Calculate the pH *(use bounding)*

closer

8.75×10^{-5} — $10\times10^{-5} = 1\times10^{-4}$ $-\log(1\times10^{-4}) = 4$

$1\times10^{-5} = 1\times10^{-5}$ $-\log(1\times10^{-5}) = 5$

actual = 4.06

I.D

$10^{-4} > 10^{-5}$

- $[H_3O^+] = (0.000000125)$ Calculate the pH *(use bounding)*

1.25×10^{-7}

1.25×10^{-7} — 10×10^{-7} 1.0×10^{-6} $-\log(1.0\times10^{-6}) = 6$

closer

1×10^{-7} 1.0×10^{-7} $-\log(1.0\times10^{-7}) = 7$

actual 6.90

HINTS:

✓Eliminate very small or large numbers with scientific notation

$0.0075 = 7.5\times10^{-3}$

✓Split problems into parts

0.0075mol x 110 g/moL

$(75 \times 110) \times 10^{-4}$

$((70\times110) + (5\times110)) \times 10^{-4}$

$(7700 + 550) \times 10^{-4}$

$8250 \times 10^{-4} = 0.8250g$

MEMORIZE:
100mL = 0.1L
10mL = 0.01L
1mL = 0.001L

Need more help?

1) You Tube Video

AP Chem Exam Review: Mental Math

2) Mrs. H Calendar

AP Chem Math Independent Study Packet