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ABSTRACT

A brief overview of CHEMEX--a problem-solving, tutorial style computer-assisted instructional course--is provided and sample problems are offered. In CHEMEX, students receive problems in advance and attempt to solve them before moving through the computer program, which assists them in overcoming difficulties and serves as a review mechanism. Problems based upon those contained in the booklet "Chemical Calculations: An Audiotutorial Approach" and covering the following topics are currently available in CHEMEX: 1) units and conversion factors, figures, temperature, and density; 2) atomic and molecular weights; 3) chemical equations, stoichiometry, and balancing; 4) simple chemical reactions: ions, acids, oxidation number, properties and oxides, hydroxides, hydrides of the elements; 5) solutions, concentration, dilution, and titration; 6) oxidation-reduction equations; 7) properties of gases; 8) solubility product calculations; and 9) acids, bases, and pH calculations. CHEMEX is written in Coursewriter III, Version 2 and supported on the IBM 360/370 systems. (For related document, see EM 011 373.) (PB)

CHEMEX

understanding and solving problems in CHEMISTRY

a computer-assisted instruction program for general chemistry

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instructor's manual

4/73

INTRODUCTION

CHEMEX is a problem-tutorial c.a.i. course, designed both to help students who are experiencing difficulty in problem solving, and to furnish an interesting and interactive means by which the more accomplished students can review this material.

The problems covered in CHEMEX are set out on printed sheets that are given to the students in advance, perhaps as part of a "homework" assignment. Students should be encouraged to try solving the problems on their own before coming to CHEMEX. Within the program, the student is asked to indicate which problem he wishes to discuss. The problem is then broken down into small steps, but the student himself must ultimately "do the work", although use of the "desk calculator" function makes this work much less tedious. Where certain basic fundamentals are required, the program attempts to gauge the student's understanding of these principles, and to provide a small amount of remedial background where necessary.

It should be emphasized that CHEMEX is not intended to serve as a substitute for reading and study, nor does it assume a lack of any previous exposure to the subject matter. If it is misused in this way, the students may well be able to "work" the problems, but the pedagogical value of the exercise will be considerably diminished. For maximum effectiveness, the course instructor should very carefully define the precise role that this material and its manner of presentation is to play in the context of the overall course.

PROBLEM COVERAGE

The problem sets on which CHEMEX is based are those contained in the booklet "CHEMICAL CALCULATIONS: AN AUDIOTUTORIAL APPROACH". Of the eighteen problem units, only the ones indicated by an asterisk are presently available in CHEMEX:

- * CC 1 *Units and conversion factors, significant figures, temperature, density*
- * CC 2 *Atomic and molecular weights, combining weights, formulas*
- * CC 3 *Chemical equations, stoichiometry, and balancing*
- * CC 4 *Simple chemical reactions; ions, acids, oxidation number; properties of oxides, hydroxides, and hydrides of the elements.*
- * CC 5 *Solutions; concentration, dilution, and titration*
- CC 6 *Physical and colligative properties of solutions*
- * CC 7 *Balancing oxidation-reduction equations*
- * CC 8 *Properties of gases*
- CC 9 *Chemical equilibrium*
- * CC 10 *Solubility product calculations*
- * CC 11 *Acids and bases; concepts and definitions, pH calculations*
- CC 12 *Acids and bases; hydrolysis, buffers, indicators, complex equilibria*
- CC 13 *Electrical properties of solutions; conductivity and electrolysis*
- CC 14 *Chemical energetics and thermodynamics; the First Law*
- CC 15 *Thermodynamics and equilibrium; the Second Law*
- CC 16 *Galvanic cells, electrode potentials, and chemical equilibrium*
- CC 17 *Chemical dynamics and kinetics*
- CC 18 *Nuclear chemistry and reactions*

The audiotapes and other materials associated with "CHEMICAL CALCULATIONS" are not required when CHEMEX alone is used.

On the following pages are shown a number of sample problems and c.a.i. dialogues taken from various sections of CHEMEX. No attempt has been made to demonstrate the branching, answer- processing and remediation capabilities that have been built into the course; in actual practice, it would be highly unusual for a student to proceed through the material in as straightforward and error-free manner as is shown here.

1-5. The density of iron is 7.28 g/mℓ. What is the weight (in grams) of a cubic inch of iron? If thrown into a container of water, what weight of water would it displace? What would the iron weigh in water?

PROBLEM 1-5

Problem 1-5 really consists of four separate though related questions, so we'll take them one by one.
Firstly, we must find the weight of 1.00 cubic inch (cu in or in**3) of iron from its density expressed in gm/ml. 1 milliliter is, for our purposes, the same as 1 cubic centimeter (cc, cu cm, or cm**3). All we must do here is find the number of cu cm in 1.00 cu inch, and then multiply the weight of 1.00 cu cm (7.28 gm) by this number.
Give the number of cm there are per inch, using the number of sig figs that is consistent with our density measurement(7.28 gm/ml).
So, how many cm are there in one inch?

***** 2.54

OK, now how many cm**3 are there in 1.00 in**3?

***** calc 2.54**3

16.38702

***** 16.4

Good- the volume of the iron is 16.4 ml. What does each ml (or cubic cm) of iron weigh?

***** 7.28g

+
This, of course, is just its DENSITY. We have 16.4 ml of iron, having a density of 7.28 g/ml. What is the total mass (weight)?

***** calc 7.28 x 16.4

119.392

***** 119g

Next, what weight of water would be displaced?

***** 16.4ml

The units here should be of MASS, not VOLUME. Try again.

***** 16.4g

Good--and finally, we must find the (apparent) weight of the iron in water. The actual (air) weight and the apparent weight in water will differ owing to the effect of buoyancy. Do you understand this effect?

***** yes

Good--then we can go on.
Let W(m) = weight of the metal (in air):
W(w) = weight of the water displaced.
Now what is the expression for finding the apparent weight of the iron in water? (You may leave out parentheses if you prefer.)

***** Wm-Ww

Right--we'll leave it to you to do the subtraction!
END OF PROBLEM

333.54

***** 333g

2-5. Estimate the atomic weight of bromine, using only the data in the following table. Assume that, like Cannizzaro in 1860, you do not know the correct formulas of the compounds listed. How could the molecular weight data have been obtained? (Suggestion: start by calculating the weight of bromine in one mole of each compound, and then apply the law of multiple proportions).

Compound	Molecular wt.	%-bromine
hydrogen bromide	81	98.7
aluminum bromide	267	89.8
sulfur bromide	224	71.4
phosphorus bromide	431	92.8
methylene bromide	174	91.9
bromobenzene	159	50.3

PROBLEM 2-5

Notice here that we do not know the formulas of the compounds listed in the problem--this is not necessary. We are given the weight-composition of bromine in each substance; this is an experimentally-determinable number that is independent of any assumptions we make about bromine or the compounds. We are also given the molecular weights of the compounds--as you may already know, molecular weights can be determined from the properties of gases--and the substances listed all happen to exist as gases.

From these two sets of data, then, you should be able to find the number of grams of bromine in one mole of each compound. For example, let's take the first compound in the table--hydrogen bromide. How many grams of hydrogen bromide are there in 1.0 mole of this substance?

***** 81

Of course!
Now how many grams of bromine are contained in 1.0 mole of hydrogen bromide?

***** calc .987 x 81

79.947

***** 79.9

Great- there are 79.9 (call it 80) g of Br in 1 mole of hydrogen bromide. This does not tell us much unless we compare it with several other substances. Pick any other compound from the table given in the problem and type in its molecular weight.

***** 174

OK, methylene bromide contains 91.9% bromine;
How many grams of bromine are in 1.0 mole of this compound?

***** calc .919 x 174

159.906

***** 160g

Now select another compound from the table and type in its mol. wt.

***** 159

OK, bromobenzene contains 50.3% bromine;
How many grams of bromine are in 1.0 mole of this compound?

***** calc .503 x 159

79.977

***** 80 g

That's 2 of them; now type in the mol. wt. of another from the table.

***** 431

over

OK, aluminum bromide contains 89.8% of bromine;
How many grams of bromine are in 1.0 mole of this compound?

***** calc .898 x 267

239.766

***** 240

OK- we have the following:

hydrogen bromide	80	grams of bromine per mole
aluminum bromide	240	" " " " "
sulfur bromide	160	" " " " "
phosphorus bromide	400	" " " " "
methylene bromide	160	" " " " "
bromobenzene	80	" " " " "

(...you will notice that I have rounded off the answers a bit!)
Now let's assume that most of these compounds are fairly simple, in that the first four, anyway, contain only ONE atom of the other element. Their formulas are therefore HBrx, AlBrx, SBrx, etc., where "x" is a "small, whole number". Now since these compounds contain different amounts of bromine, the value of "x" will vary from one to the other.
Call the molecular wt. of Bromine "M". If x = 1 in a compound, how many grams of bromine will 1 mole of the compound contain?

***** m

Right! Because 1 mole of Br weighs "M" grams.
And if the value of x is 3, how many grams of Br would the compound contain per mole?

***** 3m

So what we should do is look at the figures in the above table to see what value of "M" fits in here- what number appears in various multiples (i.e., various values of "x")?

***** 80

Right!
So this must be the molecular weight of bromine. Notice that our whole reasoning here depends on law of multiple proportions, which says that these values of "x" in the various formulas are "small whole numbers". We can now go on to find the formulas of some of these compounds. First, let's ASSUME that hydrogen bromide is a simple molecule whose formula is HBr- i.e., 1 H atom and 1 Br atom. If this is true, how many Br atoms would there be for each aluminum atom in aluminum bromide?

***** 3

Very good! So what will the formula of aluminum bromide be?

***** AlBr3

Correct!
Now try writing a formula for sulfur bromide. (sulfur = S)

***** SBr2

Excellent!
Now try phosphorus bromide.

***** PBr5

OK, phosphorus bromide contains 92.9% bromine;
How many grams of bromine are in 1.0 mole of this compound?

***** calc 431 x .929

400.399

***** 400g

That's 3 of them; now type in the mol. wt. of another from the table.

***** 224

OK, sulfur bromide contains 71.4% bromine;
How many grams of bromine are in 1.0 mole of this compound?

***** calc 224 x .714

159.936

***** 160

Only one cmpd left now; please type in its mol. wt.

***** 267

3-7. The appearance of a rock indicates that it is a mixture of magnesite ($MgCO_3$) and quartz (SiO_2). It is found that 1.00 g of the rock, on treatment with hydrochloric acid (HCl) yields 0.430 g of CO_2. Calculate the percentage of magnesite and the percentage of quartz in the rock.

PROBLEM 3-7
In this problem, a certain mass of carbon dioxide (CO2) is measured. Where does it come from?

***** magnesite

Right!
We can write a partial equation for this transformation: MgCO3 --> CO2
This equation is not complete, but it does show the molar relation between the magnesite and the CO2, since all the C ends up as CO2. How many moles of CO2 will 1 mole of MgCO3 in the rock produce?

***** 1

Of course!
And how much does each mole of CO2 weigh?

***** 44g

Right!
Now in this experiment, we get 0.430 g of CO2. What fraction of a mole does this amount to?

***** calc .430/44

0.0097727

***** .00977

Very good!
We find that 0.00977 (or 9.77 E-3) mole of CO2 was produced. This means that there must have been an equivalent number of moles of MgCO3 in the rock. How much does one mole of MgCO3 weigh?

***** data

At wts: Mg = 24.3, C = 12.0, O = 16.0.

***** calc 24.3 + 12 + 48

84.3

***** 84.3g

Correct.
And how much does 0.00977 mole of MgCO3 weigh?

calc .00977 x 84.3

0.823611

***** .824g

Right.
The rock evidently contained 0.824 g of MgCO3. The weight of the rock was just 1.00 g.
What is the percent of magnesite in the rock?

***** 82.4

Very good.
END OF PROBLEM
Time on last problem = 5 minutes; please type the number of any other problem you desire.

4-6 What is the oxidation number of the underlined element in each of the following: <u>Fe</u>O, <u>Fe</u>$_2$O$_3$, <u>Fe</u>O$_4^{=}$, <u>Fe</u>$_3$O$_4$, H$_2$<u>S</u>, H$_2$<u>S</u>O$_4$, <u>S</u>O$_2$, <u>S</u>O$_3$, H<u>S</u>O$_3^-$, <u>N</u>O, <u>N</u>$_2$O$_3$, <u>N</u>H$_2$OH, H$_2$<u>P</u>O$_2^-$, H$_2$<u>P</u>$_4$O$_7$

Problem 4-6
In the following examples, find the oxidation number of the underlined element. I will type the formula, and you enter the oxidation number of the underlined element. Please remember to specify each oxidation number as "+" or "-". Just to make sure that you understand the basic idea here, let me ask you first--what is the common oxidation number of O (oxygen) in most of its compounds?

***** -2

Good--and hydrogen?

***** 1

Oops! You forgot the sign!! Please try again.

***** +1

OK, now let's get started.

<u>Fe</u>O?

***** +2

<u>Fe</u>2O3?

***** +6

That's the TOTAL (positive) oxidation no. of ALL the Fe. Now what is the oxidation no. of EACH Fe atom here?

***** +3

OK, very good- now how about
<u>Fe</u>O4-- ? (Notice that this is a negative ion)

***** +3

NO--you are just guessing! Try again.

***** -8?

Try again, Genius! This would give you an ion with an overall charge of -16.

***** +8

NO--you are not taking the overall negative charge of the ion into account. Please try again or type "?".

***** ?

What is the total oxidation number of oxygen in FeO4-- ?

***** +8

Take another look at that sign. You blew it. Try again.

***** -8

OK, now what number must the total POSITIVE oxidation numbers in the molecule add up to?

***** +8

No, don't forget that this particular molecule is an ion--it carries two negative charges. These charges result from an imbalance of the total positive and negative oxidation numbers--the negative oxidation number is in excess. Please try again.

***** +6

OK, so what will be the oxidation number of Fe in
<u>Fe</u>O4-- ? (Notice that this is a negative ion)

***** +6

Good! Admittedly, that's an odd one.

5-6. What volume of 0.04 M NO_3^- solution can be prepared from

a) 2.00 gm of $Sr(NO_3)_2$;

b) 32 ml of 0.1 M $Sr(NO_3)_2$ solution?

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PROBLEM 5 - 6
This problem has two parts - which do you want to go through?  (Both, or a, or b?)

***** both

OK, we'll start with Part (a) first.
In Part (a), we start with 2.00 grams of solid strontium nitrate.  How many MOLES of
Sr(NO3)2  (MW = 212 g/mole)  do we have here?

***** calc 2/212

        0.0094339

***** .00943

OK, now how many moles of NITRATE ION (NO3-) does this give us?

***** .0189

Very good - we have a total of 0.0189 mole of nitrate ion to work with.  We want to find
how many liters of solution we can make, each liter containing 0.0400 mole of nitrate ion.
Can you work this out?

***** calc 189/400

        0.4725

***** .4721

Right!  Good work!
In Part (b) of Problem 5-6, we want to find how many liters of 0.0400 molar nitrate ion
solution can be prepared from 32.0 ml of 0.100 molar Sr(NO3)2 solution.
First, how many moles of Sr(NO3)2 are contained in each ml of this 0.100 M solution?

***** .0001

Very good!  Now how many moles of Sr(NO3)2 are there in 32.0 ml of 0.100 M solution?

***** .0032

OK - this is the number of moles of Sr(NO3)2 in 32.0 ml of solution; now how many moles
of NITRATE ION (NO3-) are present?

***** .0064

Right!  OK, we want to prepare a solution containing 0.0400 mole of NO3- ion per liter, and we
have 0.00640 mole of this ion to work with.  This is less than 0.0400 mole, so we
obviously cannot prepare even one liter of 0.0400 molar solution.  How much CAN we prepare?

***** calc .0064/.04

        0.16

***** .160 l

Very good - that's it on this one!
END OF PROBLEM
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PROBLEM 7-2

$Cr_2O_7^{--}$ + H_2SO_3 --> Cr^{+++} + HSO_4^-

dichromate ion + sulfurous acid --> chromic ion + hydrogen sulfate ion

Which two elements change their oxidation numbers in this reaction?

***** S and Cr

Right;
The two elements directly involved here are Cr and S. Is chromium oxidized or reduced in this reaction? (answer o or r)

***** r

How many electrons does each Cr atom gain?

***** 6

NO- that's the no. of electrons gained by BOTH of the Cr atoms in Cr2O7--;
each single Cr gains only 3 electrons.
Now fill in the blanks (use the space bar to position the typeball):

$Cr_2O_7^{--}$ + ______e- --> _____Cr^{+++}

***** 6 2

We have:

$Cr_2O_7^{--}$ + 6e- --> $2Cr^{+++}$ + _______

What substance must go in the blank space as the next step in balancing this half-reaction?

***** O

NO - oxygen is NOT a product of this reaction.
Now this reaction is carried out in acidic solution, meaning that excess hydrogen ion (H+) is present. In this case, any "excess" oxygen atoms will be taken up to produce molecules of WATER.
How many water molecules are produced here?

***** 7

We now have:

_____ + $Cr_2O_7^{--}$ + 6e- --> $2Cr^{+++}$ + $7H_2O$

What must be added to the blank space to balance this half-reaction?

***** H+

How many H+'s are required?

***** 14

The reduction half reaction is now:

$14H^+$ + $Cr_2O_7^{--}$ + 6e- --> $2Cr^{+++}$ + $7H_2O$

Let's see if it is ELECTRICALLY balanced.
What is the total charge shown on the right hand side of the equation?

***** +3

NO - remember that there are TWO Cr+++ ions.

***** 6

And what is the total charge on the LEFT side?

***** +6

OK, so the reduction half-reaction equation is balanced.

Let's turn now to the OXIDATION half reaction. What element is oxidized here?

***** sulfur

How many electrons does each sulfur atom LOSE?

***** 2

We have:

______ + H_2SO_3 --> HSO_4^- + 2e-

What substance shall we add to the left side in order to balance the equation for OXYGEN atoms?

***** h2o

This gives us:

H_2O + H_2SO_3 --> HSO_4^- + 2e- + ________

What's left over, that goes in the blank space?

***** H+

How many H+ ions?

***** 2

There are 4 HYDROGENS shown on the left, but only ONE on the right. Now answer the question.

***** 3

We now have:

H_2O + H_2SO_3 --> 2e- + HSO_4^- + 3H+

What is the total electric charge shown on the RIGHT side?

***** 0

Correct. And what's the total charge on the LEFT?

***** the same

So the equation is completely balanced. #Our reaction is therefore a combination of the two steps:

14H + $Cr_2O_7^{--}$ + 6e- --> $2Cr^{+++}$ + $7H_2O$ (reduction)

H_2O + H_2SO_3 --> 2e- + HSO_4^- + 3H+ (oxidation)

First, how many oxidation steps are required for each reduction that takes place?

***** 3

Our pair of equations becomes:

14H+ + $Cr_2O_7^{--}$ + 6e- --> $2Cr^{+++}$ + $7H_2O$

$3H_2O$ + $3H_2so_3$ --> 6e- + $3HSO_4^-$ + 9H+

Notice that H+ ions appear on both sides of the equations. After you add the two equations together and "cancel" them out, how many H+ will you have?

***** 5

And on which side of the equation (answer r or l)?

***** l

Correct.
The summed equation is:

$Cr_2O_7^{--}$ + $3H_2SO_3$ --> $2Cr^{+++}$ + $3HSO_4^-$ + ___H_2O

What number goes in the blank on the right?

***** 4

This balances the equation.

END OF PROBLEM

8-7. A biscuit made with baking powder has a volume of 20 mℓ, of which one-fourth consists of empty space made by gas bubbles produced by the baking powder. What weight of sodium bicarbonate ($NaHCO_3$) was contained in the baking powder in that biscuit? Assume the gas reached its final volume during the baking process when the temperature was 400°C.

PROBLEM 8-7 ▸

We have here a practical application of the gas law. The NaHCO3 contained in the baking powder is converted into CO2. From the volume of CO2 produced at the temperature of the oven, we are to find the number of moles of CO2 produced, and the weight of the sodium hydrogen carbonate (NaHCO3) contained in the baking powder.
In this problem, we will make use of the ideal gas law PV = nRT.
Do you understand the meaning of this relation?

***** yes

Good.
We want to find the value of n, the number of moles of CO2 gas, from the values of P, V, and T during the baking process. First, what will the pressure be (approximately)?

***** 1 atm

Right.
We can assume that the pressure within the biscuit is essentially the atmospheric pressure at all times- as more CO2 is produced, the biscuit expands, and the pressure is kept from rising. We can call the pressure P = 1 atm. Now how about T?

***** 400 deg

OK, but please express it in deg-K.

***** 673 deg

Very good.
And now, the volume. What is the volume of CO2 produced, measured at the temperature and pressure of baking?

***** 20 ml

NO- this is the volume of the entire biscuit; the CO2 only accounts for one-quarter of this volume.

***** 5 ml

OK, but please express the volume in LITERS, so we can substitute into the equation of state.

***** .005 l

Right!
We now have:
P = 1 atm   V = 0.005 liter   T = 673 deg K
and we want R in units of liter-atm: R = 0.820 liter-atm/deg
Now write the equation of state PV = nRT in terms of n, the number of moles.

***** n=PV/RT

Very good.
You can now substitute in the values of V, R, T, and P, and solve for n:
n = (1 atm)(0.005 liter)/((0.820 liter-atm/deg)(673 deg))
Work this out and enter your value of n.

***** calc (.005)/(.820x673)

0.000009

***** .000009

You don't have enough sig figs in your answer. If you used CALC to evaluate the expression, you lost a lot of sig figs if you entered ".005" and divided by the denominator. Try using "500" instead, and then expressing your answer as an exponential.

calc 500/(.820 x 673)

0.9060268

***** 9.06e-6

Very good!
We get 9.06 E-6 mole of CO2.
Now how many moles of sodium hydrogen carbonate did we start out with?

***** same no.

Good.
The formula weight of NaHCO3 = 23 + 01 + 12 + 3(16) = 84 g/mole.
What is the mass of NaHCO3 in the baking powder?

***** calc 9.06x84

761.04

***** .00076g

Very good.
END OF PROBLEM

10-7. A solution is 0.10 M in Cl^- and 0.30 M in CrO_4^{--}.

a) If solid $AgNO_3$ is gradually added to this solution (assume no volume change), which will precipitate first - AgCl ($K_{sp} = 1.0 \times 10^{-10}$), or Ag_2CrO_4 ($K_{sp} = 2.4 \times 10^{-12}$)?

b) What will be the concentration of Cl^- when the second substance begins to precipitate?

c) At this point, what percent of the Cl^- originally present still remains in solution?

PROBLEM 10-7

In this problem we are concerned with equilibria involving three different ions, two of which are anions (negative ions). Please name these two anions.

***** chloride and chromate

OK, and does their concentration in the solution increase, decrease or remain constant during the process described in the problem? Type "inc", "dec" or "no change"

***** no chenge

But according to the problemm, precipitates containing both ions are eventually formed; a certain amount of each of these ions is accordingly removed from the solution, and their concentration accordingly decreases. Anyway, precipitates are formed. What is the cation in the precipitates?

***** Ag+

OK, and does the silver ion concentration increase, decrease, or remain constant? Please type one of increase, decrease, or no change.

***** increase

Very good--you seem to have the picture! Notice that silver ion is involved in two solubility equilibria here. Each of these equilibria is described by a solubility product expression. Write out the KSP expression whose value is 1.0e-10.

***** (Ag+)(Cl-) = 1.0e-10

Perfect!
We now have (Ag+)(Cl-) = 1.0e-10 .
Now the concentration of chloride ion is given in the problem as 0.1 molar.
What value of (Ag+) is required to precipitate AgCl?

***** 1.0e-9

Very good! At first, there is no Ag+ ion in the solution; as Ag+ is added, its concentration increases until it reaches this value. At this point, AgCl precipitate begins to form. But let's now look at the silver chromate equilibrium. Write out the Ksp expression for Ag2CrO4.

***** (Ag++##
# PLEASE REPEAT
(Ag+)**2(CeO4--) = 2.4e-12

Great!

(→ continued)

Or, now if you solve this expression for (Ag+), you get:

(Ag+) = (2.4e-12 / (CrO4--))**0.5 or sqrt((2.4e-12 / (CrO4--))

The chromate ion concentration is given as 0.3 molar. You should now be able to find the silver ion concentration at which precipitation of Ag2CrO4 commences, using the calc function if necessary (but remember to leave the "e-12" part out - calc cannot handle large exponentials; the sqrt of 10**-12 is of course 10**-6, and you can reinsert this after your calculation.
Try it now, using CALC. Then type in the answer. Type "help" if you have trouble with CALC.

***** calc sqrt 2.4

Good-
So the chromate begins to ppt. when (Ag+) = 2.83 E-6 M, and the Cl- comes down when (Ag+) = 1.0 E-9 M. Now which salt precipitates FIRST?

***** AgCl

Of course!
Now the next thing we must do is find the (Cl-) ion concn remaining in solution when the SECOND ion (CrO4--) begins to precipitate. What is the Ag+ ion concn at this point?

***** 2.83e-6

Right.
Now from the relation
(Ag+)(Cl-) = 1.0E-10 = Ksp,
you can substitute to find the Cl- ion concn. Please do this and enter your answer.

***** calc 1/2.83

0.3533568

***** .353e-4

Very good!
And finally, we want to find the percent of the original (0.1 M) Cl- still in the solution- i.e., that was not removed by the Ag+ at the point that the second ion begins to ppt. This is just the ratio of the final Cl- ion concn (that you just calculated) to its initial value (0.1), expressed as apercent. Please enter this result.

***** .00353

Your decimal location seems to be out. Try again.

***** .035

Excellent- that's it!
END OF PROBLEM

11-2 a) List the conjugate acids of

H_2O Cl^- SO_4^{--} NH_3 $Al(H_2O)_5(OH)^{++}$

b) List the conjugate bases of

H_2O HBr NH_3 $HO-\overset{O}{\overset{\|}{\underset{O}{\underset{\|}{S}}}}-OH$ H_3C-CH_2-OH

PROBLEM 11-2

This problem is concerned with conjugate species - acids and bases. Do you understand what conjugate species are?

***** yes

Very good.

What is the conjugate acid of the base A-?

***** HA

Fine!

Remember that:

an ACID and its CONJUGATE BASE, and a BASE and its CONJUGATE ACID, EACH DIFFER BY THE PRESENCE OR ABSENCE OF ONE PROTON.

Now let's get to work on the problem.

Problem 11-2 is divided into two parts; Part (a) is on conjugate acids, part (b) on conjugate bases. Which section do you wish to go through first? (Answer "a" or "b")

***** a

OK, type in the formula of the conjugate ACID of each substance indicated.

H2O (water):

***** H3O+

Good.

H2O + H+ --> H3O+

Water is acting as a BASE here (it accepts a proton). The resulting species H3O+ can now act as an acid, so it is the CONJUGATE ACID of H2O.

Now on to the next one:

Cl- (chloride ion):

***** HCl

Right.

H+ + Cl- --> HCl

Cl- ion is the conjugate BASE of HCl, so HCl is the conjugate ACID of Cl-. Since HCl is a very STRONG ACID, its conjugate base Cl- is a very WEAK BASE; it does not tend to back-react. So the other little gem for you to remember is that:

The conjugate BASE of a STRONG acid is WEAK;

The conjugate ACID of a WEAK base is STRONG;

...(and vice versa!)

Now on to greater things;

SO4-- (sulfate ion; note the two negative charges):

***** H2SO4

You've gone too far! H2SO4 is the conjugate acid of the conjugate acid of SO4--. You only want to add one proton here. Please try again.

***** HSO4-

Right!

H+ + SO4-- --> HSO4-

This is called the hydrogen sulfate (sometimes "bisulfate") ion. Next one is:

NH3 (ammonia):

***** NH4+

Very good.

NH3 + H+ --> NH4+

Ammonia is known as a base because it undergoes this reaction, producing ammonium ion. NH3 is all in the form of NH4+ ion in acidic solutions (where there are plenty of H+ ions around), and partly so in plain water, where NH3 is a strong enough base to pull a few protons off the H2O.

Each problem in CHEMEX is a separate unit, independent of the others both in sequence and means of access. (Within any one CHEMICAL CALCULATIONS unit, problems of a higher number tend to be more sophisticated or employ concepts developed in earlier problems, but other than in this sense, no one problem is really prerequisite to another).

The course as a whole is segmented; each segment contains the material associated with three of the problem units, and except for segment-00, the various segments are numbered according to the number of the first problem unit they contain. Labels associated with each problem unit commence with a different letter of the alphabet, and the first digit in the label identifies the number of the problem within the unit.

Segmentation is transparent to the students, however, so no special instructions are necessary.

The various problems are accessed through a directory that resides in segment-00. All students are branched to this directory on restart; this means that if a student signs off before completing a problem, he will have to start over if he wishes to complete it.

After a problem has been completed, the student is branched back to the "directory" section, and invited to choose another problem. Students also have the option of discontinuing work at any point within a problem and accessing the directory at any time by typing "go to other".

In certain problem sections, students requesting the material are branched first to a section that checks their background and offers them some preliminary exercise in the subject. For registered students, a switch is usually loaded to prevent subsequent choices of problems in these sections to route them through this background material.

In most parts of CHEMEX, the command "HELP" is treated as a regular student answer; the keyword fragment "he", along with other fragments intended to pick up similar student comments, are stored in b4 and elicit a prompting or remedial response where this is appropriate. Throughout most of the course, spaces and carriage control characters are edited from student responses, and all inputs are shifted to lower case. Backspace correction is also allowed.

CHEMEX requires the use of a number of user-written functions. We also strongly recommend the implementation of certain system modifications. External users should obtain current versions of these items when implementing new releases of the program. System supervisors should note that parameters 20, 29, and 30 (which are unassigned in CWIII.2) are required with CHEMEX.

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segment	*labels*	*problem units*
chemex-00	*k-----*	*1*
	ℓ-----	*2*
	m-----	*3*
chemex-04	*n-----*	*4*
	o-----	*5*
chemex-07	*r-----*	*8*
chemex-10	*b-----*	*10*
	c-----	*11*