CHEM105L Name ______________________

Uncertainty Analysis Practice

Solve the problems given in the following table. You will be calculating X using measured values A – J and their absolute uncertainties. Report your answer, absolute uncertainty, and % relative uncertainty with the **correct sig figs**. Show your work:

Show work in this column	Calculated value	Absolute uncertainty	Relative uncertainty (show as %)
$q_{tot} = -(q_{cal} + q_{surr})$ $q_{cal} = 4.345 \pm 0.003$ kJ $q_{surr} = 3.45 \pm 0.05$ kJ	$q_{tot} =$		
E = mad $m = 1.0 \pm 0.5$ kg $a = 170.0 \pm 0.1$ m/s^2 $d = 10.00 \pm 0.01$ m	E =		
$C = f^2$ $f = 5 \pm 1$	C =		
X = H + I - J $H = 14.5 \pm 0.6$ $I = 76.5 \pm 0.4$ $J = 4.0 \pm 0.3$	X =		
Given: 1.053M NaOH solution Use volumetric glassware Dilute: 1.00mL of the NaOH solution Into: 1000.00mL total volume What is the final concentration? (uncertainties for volumetric glassware can be found in the lab manual appendix)			
Given: 1.0M solution of HCl Use volumetric glassware Dilute: 1.00ml of HCl solution Into: 100.00ml total volume What is the final concentration? (uncertainties for volumetric glassware can be found in the lab manual appendix)			

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Uncertainty Analysis Practice - answers

Show work in this column	Calculated value	Absolute uncertainty	Relative uncertainty (show as %)
$q_{tot} = -(q_{cal} + q_{surr})$ = -(4.345 + 3.45) = -7.795 kJ but we're adding and 3.45 only has precision to 100ths place, so we round to 100ths place q_{cal} = 4.345 ± 0.003 kJ q_{surr} = 3.45 ± 0.05 kJ For a sum, AU = ΣAUs = 0.003 + 0.05 = 0.053 kJ but we round to 1 sf, so AU = 0.05 kJ. For a sum, we have to calculate RU from the calculated AU (before we rounded), so RU = AU/|q_{tot}| = (0.053 kJ)/(7.795 kJ) = 0.0068, so, rounded to 1 sf, RU = 0.7%	q_{tot} = -7.80 kJ q_{tot} and AU have the same precision, so we don't need to worry about rounding to make them agree.	0.05 kJ	0.7%
E = mad = (1.0)(170.0)(10.00)J = 1700.00J but we're multiplying and m only has 2 sig figs, so we round to 2 sig figs m = 1.0 ± 0.5 kg a = 170.0 ± 0.1 m/s^2 d = 10.00 ± 0.01 m For a product, RU = ΣRUs = (.5)/(1.0) + (.1)/(170) + (.01)/(10) = 0.502 but we round all uncertainties to 1 sf, so RU = 0.5 = 50%. Note that this is basically coming entirely from m, which has 50% uncertainty. For a product, we have to calculate AU from the calculated RU (before we rounded), so AU = RUx|E| = (0.502)(1700J) = 853, so, rounded to 1 sf, AU = 9 x 10^2 J	E = 1.7x10^2 J Again, E and AU have the same precision, so we don't need to worry about rounding to make them agree.	9 x 10^2 J	50%
C = f^2 = 5^2 = 25 but we're multiplying and f only has 1 sig fig, so we round to 1 sig fig. C = 2x10 (an exact 5 rounds to the nearest even number) f = 5 ± 1 For a product, RU = ΣRUs = 1/5 + 1/5 = 2/5 = 0.4 to 1 sf, so RU = 40%. Notice that f^2 has twice the uncertainty of f. For a product, we have to calculate AU from the calculated RU (use un-rounded numbers), so AU = RUx|f| = (0.4)(25) = 10 1 sf, AU = 1 x 10	C =2x10 Again, E and AU have the same precision, so we don't need to worry about rounding to make them agree.	1x10	40%
X = H + I - J= 14.5 + 76.5 - 4.0 = 87.0 and since we're adding and subtracting, and all numbers are precise to the tenths place, we	X =87 In this case, the	1	1%

round to the tenths place H = 14.5 ± 0.6 I = 76.5 ± 0.4 J = 4.0 ± 0.3 For adding or subtracting, AU = ΣAUs = 0.6 + 0.4 + 0.3 = 1.3 but we round to 1 sf, so AU = 1. For addition/subtraction, we have to calculate RU from the calculated AU (un-rounded), so RU = AU/$\lvert X\rvert$ = (1.3)/(87.0) = 0.0149, so, rounded to 1 sf, RU = 0.01 = 1%. Don't round too early! If you had rounded 0.0149 to 0.015, you would have then rounded to 0.02.	precision of X and AU differed, so we had to round both to match the least precise, which was AU, which was precise to the 1s place.		
Given: 1.053M NaOH solution Use volumetric glassware Dilute: 1.00mL of the NaOH solution Into: 1000.00mL total volume What is the final concentration? We need to work this problem in moles. We need to figure out how many moles of NaOH are in the 1.00mL volumetric pipette and then the concentration in the final container. There are **1.053mol/L x 1.00x10^{-3}L = 1.053x10^{-3} moles** of NaOH in the pipette. In the final container, the concentration will be **1.053x10^{-3} moles / 1.00000L = 1.053x10^{-3} M**. Now we look back at sig figs. In the first multiplication, the pipette has only 3 sig figs, so we need to round our answer to 3 sig figs. So in the division, we really only knew one of the numbers to 3 sig figs, so its answer will also be 3 sig figs. For uncertainty, the pipette has AU = 0.0006mL. For the flask we could estimate AU = 0.4mL. Assume there is no uncertainty in the concentration. For a multiplication/division, RU = ΣRUs = 0.0006/1 + 0.4/1000 = 0.001 so RU = 0.1%. For multiplication/division, we have to calculate AU from the calculated RU, so AU = RUx$\lvert M\rvert$ = (0.001)(1.05x10^{-3} M) = 1.05x10^{-6} M, rounded to 1 sf is AU = 1 x 10^{-6}M	1.05x10^{-3} M	0 M In this case, the precision of conc and AU differed, so we had to round both to match the least precise, which was conc, which was precise to the 10^{-5} place. So AU becomes zero!	0.1%

Given: 1.0M solution chemical Z Use volumetric glassware Dilute: 1.00ml of solution Z Into: 100.00ml total volume What is the final concentration? We need to work this problem in moles. We need to figure out how many moles of NaOH are in the 1.00mL volumetric pipette and then the concentration in the final container. There are **1.0mol/L x $1.00x10^{-3}$L = $1.00x10^{-3}$ moles** of NaOH in the pipette. In the final container, the concentration will be **$1.00x10^{-3}$ moles / 0.10000L = $1.00x10^{-2}$ M**. Now we look back at sig figs. In the first multiplication, the concenetration only 2 sig figs, so we need to round our answer to 2 sig figs. So in the division, we really only knew one of the numbers to 2 sig figs, so its answer will also be 2 sig figs. For uncertainty, the pipette has AU = 0.0006mL. The flask has AU = 0.03mL. Assume there is no uncertainty in the concentration. For a multiplication/division, RU = ΣRUs = 0.0006/1 + 0.03/100 = 0.0009 so RU = 0.09%. For multiplication/division, we have to calculate AU from the calculated RU, so AU = RUx|M| = (0.0009)($1.0x10^{-2}$ M) = AU = $9x10^{-6}$ M	$1.0x10^{-2}$ M	0 M In this case, the precision of conc and AU differed, so we had to round both to match the least precise, which was conc, which was precise to the 10^{-3} place. So AU becomes zero!	0.09% Note: 0.09 rounded to one sig fig doesn't equal 0.1! Just like 9 rounded to 1 sig fig doesn't equal 10.