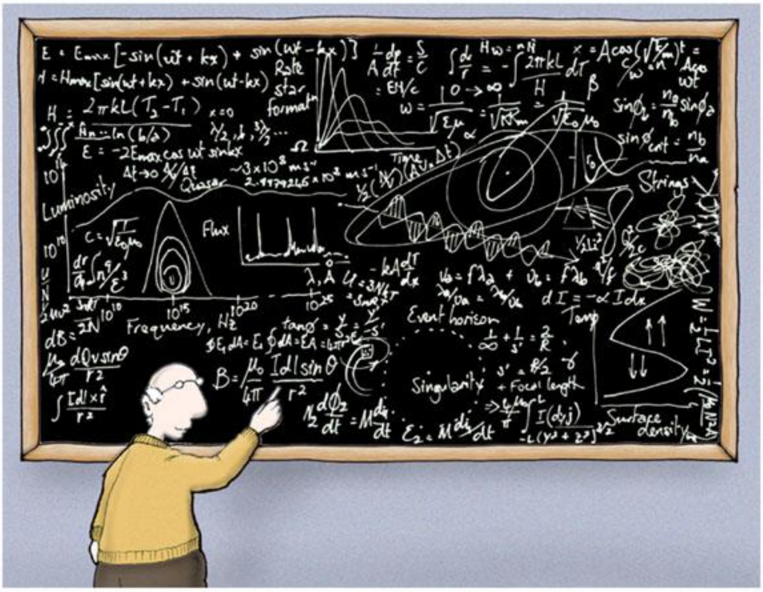
STEPPING UP TO SCHOLARSHIP CHEMISTRY

HUTT WORKSHOP

6 JUNE 2018



Astrophysics made simple

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IUPAC Periodic Table of the Elements

Key:

atomic number **Symbol** **name** conventional atomic weight standard atomic weight

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** hydrogen 1.008 [1.0078, 1.0082]																	2 **He** helium 4.0026
3 **Li** lithium 6.94 [6.938, 6.997]	4 **Be** beryllium 9.0122											5 **B** boron 10.81 [10.806, 10.821]	6 **C** carbon 12.011 [12.009, 12.012]	7 **N** nitrogen 14.007 [14.006, 14.008]	8 **O** oxygen 15.999 [15.999, 16.000]	9 **F** fluorine 18.998	10 **Ne** neon 20.180
11 **Na** sodium 22.990	12 **Mg** magnesium 24.305 [24.304, 24.307]											13 **Al** aluminium 26.982	14 **Si** silicon 28.085 [28.084, 28.086]	15 **P** phosphorus 30.974	16 **S** sulfur 32.06 [32.059, 32.076]	17 **Cl** chlorine 35.45 [35.446, 35.457]	18 **Ar** argon 39.948
19 **K** potassium 39.098	20 **Ca** calcium 40.078(4)	21 **Sc** scandium 44.956	22 **Ti** titanium 47.867	23 **V** vanadium 50.942	24 **Cr** chromium 51.996	25 **Mn** manganese 54.938	26 **Fe** iron 55.845(2)	27 **Co** cobalt 58.933	28 **Ni** nickel 58.693	29 **Cu** copper 63.546(3)	30 **Zn** zinc 65.38(2)	31 **Ga** gallium 69.723	32 **Ge** germanium 72.630(8)	33 **As** arsenic 74.922	34 **Se** selenium 78.971(8)	35 **Br** bromine 79.904 [79.901, 79.907]	36 **Kr** krypton 83.798(2)
37 **Rb** rubidium 85.468	38 **Sr** strontium 87.62	39 **Y** yttrium 88.906	40 **Zr** zirconium 91.224(2)	41 **Nb** niobium 92.906	42 **Mo** molybdenum 95.95	43 **Tc** technetium	44 **Ru** ruthenium 101.07(2)	45 **Rh** rhodium 102.91	46 **Pd** palladium 106.42	47 **Ag** silver 107.87	48 **Cd** cadmium 112.41	49 **In** indium 114.82	50 **Sn** tin 118.71	51 **Sb** antimony 121.76	52 **Te** tellurium 127.60(3)	53 **I** iodine 126.90	54 **Xe** xenon 131.29
55 **Cs** caesium 132.91	56 **Ba** barium 137.33	57-71 lanthanoids	72 **Hf** hafnium 178.49(2)	73 **Ta** tantalum 180.95	74 **W** tungsten 183.84	75 **Re** rhenium 186.21	76 **Os** osmium 190.23(3)	77 **Ir** iridium 192.22	78 **Pt** platinum 195.08	79 **Au** gold 196.97	80 **Hg** mercury 200.59	81 **Tl** thallium 204.38 [204.38, 204.39]	82 **Pb** lead 207.2	83 **Bi** bismuth 208.98	84 **Po** polonium	85 **At** astatine	86 **Rn** radon
87 **Fr** francium	88 **Ra** radium	89-103 actinoids	104 **Rf** rutherfordium	105 **Db** dubnium	106 **Sg** seaborgium	107 **Bh** bohrium	108 **Hs** hassium	109 **Mt** meitnerium	110 **Ds** darmstadtium	111 **Rg** roentgenium	112 **Cn** copernicium	113 **Nh** nihonium	114 **Fl** flerovium	115 **Mc** moscovium	116 **Lv** livermorium	117 **Ts** tennessine	118 **Og** oganesson

57 **La** lanthanum 138.91	58 **Ce** cerium 140.12	59 **Pr** praseodymium 140.91	60 **Nd** neodymium 144.24	61 **Pm** promethium	62 **Sm** samarium 150.36(2)	63 **Eu** europium 151.96	64 **Gd** gadolinium 157.25(3)	65 **Tb** terbium 158.93	66 **Dy** dysprosium 162.50	67 **Ho** holmium 164.93	68 **Er** erbium 167.26	69 **Tm** thulium 168.93	70 **Yb** ytterbium 173.05	71 **Lu** lutetium 174.97
89 **Ac** actinium	90 **Th** thorium 232.04	91 **Pa** protactinium 231.04	92 **U** uranium 238.03	93 **Np** neptunium	94 **Pu** plutonium	95 **Am** americium	96 **Cm** curium	97 **Bk** berkelium	98 **Cf** californium	99 **Es** einsteinium	100 **Fm** fermium	101 **Md** mendelevium	102 **No** nobelium	103 **Lr** lawrencium

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

For notes and updates to this table, see www.iupac.org. This version is dated 28 November 2016.

LOGICAL PLANNED COHERENT ANSWERS

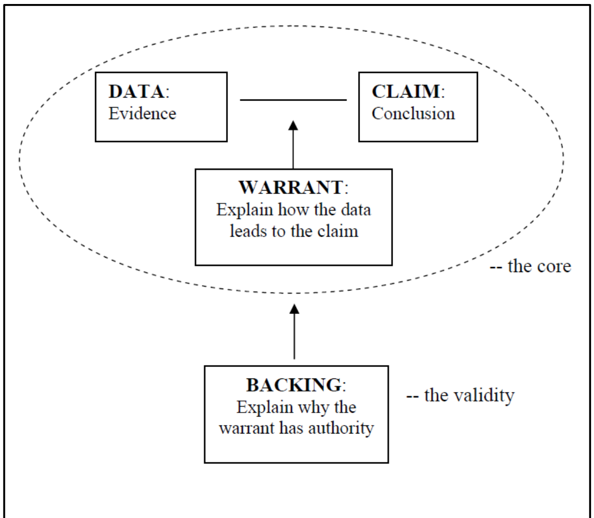
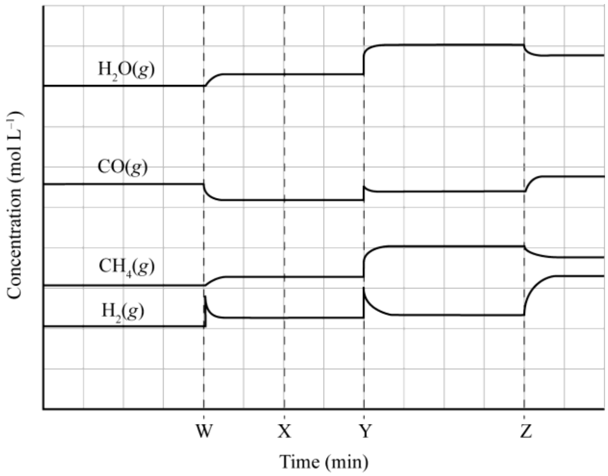


Figure 1. Toulmin's model of argumentation.

Claim
a conclusion derived from the data / focus of the argument
Data
Measurements / observations on which the claim is based / evidence
Warrant
links data to the claim / supports the claim
Backing
additional information or support for the warrant
Qualifier
may indicate the strength of the leap from the data to the claim / limitations of the claim

COMMUNICATION EXERCISE 1 (SCHOLARSHIP 2007)
The graph below shows changes in the concentration of the species present in a system involving the following reaction at equilibrium. The reaction is endothermic in the forward direction.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$



Discuss the nature of the stresses applied to the system at positions **W, X, Y** and **Z**, and how these stresses result in the changes in the concentrations of the species present in the system.

COMMUNICATION PRACTICE 2 (SCHOLARSHIP 2007)

You have 5 bottles labelled A to E. Each bottle contains one of the following liquids:

propanone, water, propan-2-ol, methanol, hexane

Determine the identity of the Compounds A to E using the data below. Relate the data to the structure and bonding in the compounds.

Time for 1 drop of each sample to evaporate at room temperature:

Sample	**Time(s)**
A	135
B	more than 1200
C	65
D	30
E	20

Solubility of glucose, $C_6H_{12}O_6$, in each liquid (at room temperature)

B dissolved in glucose in the greatest amount
A and C dissolved in a small amount of glucose
E dissolved even less glucose than A and C
D dissolved almost no glucose

Miscibility (ability of two liquids to mix):

B and D were not miscible, forming two distinct layers
A, B, C and E were miscible with one another

REDOX TITRATIONS

- Titrations can be performed for any reaction that goes to completion provided that the end-point can be observed. Redox reactions are frequently employed in analysis. For example, the permanganate ion is particularly convenient because the appearance or disappearance of its intense colour is an ideal criterion for the end-point of the reaction.
  e.g. $6H^+ + 2MnO_4^- + 5(COOH)_2 \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$
- Iodine is widely used as a reagent for the volumetric determination of strong reductants such as tin(II) chloride ($SnCl_2$), and thiosulfate ($S_2O_3^{2-}$). A starch indicator is used to determine the end point of the reaction. Starch is blue in the presence of iodine.
  Neither iodine nor sodium thiosulfate are suitable as primary standards. However, potassium iodate is a powerful oxidising reagent and a 'good' primary standard and standard 'iodine' solutions can be prepared from potassium iodate via the reaction. The liberated iodine is titrated with sodium thiosulfate.

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O \qquad 2S_2O_3^{2-} + I_2 \rightarrow 2I^- + S_4O_6^{2-}$$

TITRATION PROBLEM 1 (SCHOLARSHIP 2014)

A bottle of household bleach contains the following information:

Active ingredients: Sodium hypochlorite 42 g L^{-1} (available chlorine 4.0% m / V), available chlorine by 'use by date' 2.0% m / V, sodium hydroxide 9 g L^{-1}.

The following procedure is carried out to determine the extent of the decomposition of the contents of the bottle of household bleach described above.

A 20.00 mL sample of the bleach is diluted to 250.00 mL, using a volumetric flask. Excess potassium iodide is added to a 10.00 mL sample of the diluted bleach solution, along with 10 mL of dilute sulfuric acid.

$$H^+ + 2I^- + OCl^- \rightarrow I_2 + Cl^- + OH^-$$

The liberated iodine is titrated with a standard sodium thiosulfate, $Na_2S_2O_3$, (0.04562 mol L^{-1}). The end point is determined by the change of colour of a starch indicator.

$$2S_2O_3^{2-} + I_2 \rightarrow 2I^- + S_4O_6^{2-}$$

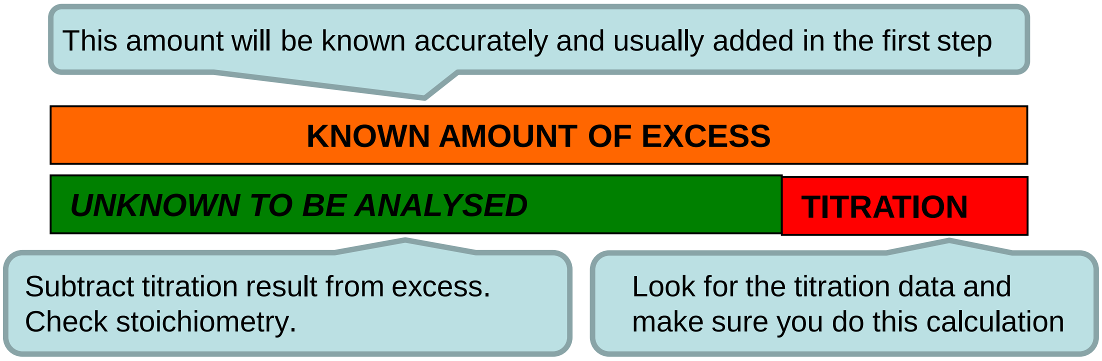
The titration data is given here:

Titre	Final volume /mL	Initial volume /mL
1	16.88	0.16
2	33.56	16.88
3	16.98	0.02
4	33.64	16.98

Determine the extent of the decomposition of the bleach by comparing the available chlorine (% m/V) in the bottle, with that given on the label.

BACK TITRATION

- Used if reactions are slow, there are competing reactions, there is no easy way to detect the end point
- A measured amount of reagent is added all at once, in excess of that needed to completely react with the sample)
- The amount of unreacted reagent (excess) is determined using a standard solution



TITRATION PROBLEM 2

25.00 mL of 0.100 mol L^{-1} NaOH were added to 10.00 mL of a solution of NH_4Cl. The volume was diluted to about 150 mL and then gently boiled till no more ammonia was evolved. The solution was cooled and then the amount of unreacted NaOH was measured by titrating against H_2SO_4. 15.50 mL of 0.0521 mol L^{-1} H_2SO_4 were required for complete reaction.

Calculate the concentration of the NH_4Cl solution

TITRATION PROBLEM 3 (SCHOLARSHIP 2009)

15.35 g of a mixture of sodium nitrate, $NaNO_3$, and magnesium nitrate, $Mg(NO_3)_2$, was heated until no more gases were evolved. The $NaNO_3$ decomposes giving $NaNO_2$ and oxygen gas, while the $Mg(NO_3)_2$ decomposes to give the metal oxide, NO_2 and oxygen. The water soluble part of the residue produced on heating was used to prepare a 1.00 L solution. 10.00 mL of this solution was reacted with 20.00 mL of acidified $KMnO_4$ (which oxidises NO_2^- to NO_3^-). The excess potassium permanganate required 10.25 mL of 0.0500 mol L^{-1} oxalic acid, $H_2C_2O_4$, for complete reaction in which CO_2 is produced.

Write balanced equations for all the reactions and calculate the mass, in grams, of each metal nitrate present in the original mixture.

TITRATION PROBLEM 4 (SCHOLARSHIP 2004)

Alcohol levels in blood samples can be determined by back titration. The alcohol is first removed from the blood by distillation and then heated with a known excess of acidified potassium dichromate solution. Excess potassium iodide is added and the resulting solution is titrated with standard sodium thiosulfate solution. Starch indicator is added near the end point.

Equations for the reactions are:

$3CH_3CH_2OH + 2Cr_2O_7^{2-} + 16H^+ \rightarrow 3CH_3COOH + 4Cr^{3+} + 11H_2O$

$Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 7H_2O + 3I_2$

$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$

(a) Discuss the method described above, justifying the need for each step involved.

(b) A blood sample has been removed from a suspected adult drunk driver. The alcohol from 10.0 mL samples is added to 10.0 mL of acidified 0.0492 mol L^{-1} $K_2Cr_2O_7$ solution and warmed in a water bath. When oxidation is complete, excess KI is added and the sample is titrated with 0.105 mol L^{-1} $Na_2S_2O_3$ solution. The titre values for four successive 10.0 mL blood samples from the same driver were: 17.94, 17.86, 17.70 and 17.84 mL.

Calculate the concentration of alcohol in the blood and determine if the sample is above the legal limit of 80 mg alcohol per 100 mL of blood.

(c) A student decides to use this analytical method to determine the amount of alcohol present in some home brew. Initial trials of diluted samples of the home brew gave titre values of less than 1 mL.

TITRATION PROBLEM 5: (SCHOLARSHIP 2005)

Hydroxylammonium chloride ($^+NH_3OHCl^-$) reacts with Fe^{3+} ions to produce Fe^{2+}

1.00 g of hydroxylammonium chloride was dissolved in distilled water and diluted to 250.0 mL.

25.00 mL of this solution was added to a solution containing an excess of iron(III) ions and sulfuric acid. The mixture was boiled. After cooling it was then titrated with a solution of 0.0200 mol L^{-1} potassium permanganate. 28.90 mL was needed to reach the equivalence point.

Determine which of N_2, NO, N_2O, N_2O_4 or NH_3 is the nitrogen-containing product of the reaction between the hydroxylammonium chloride and iron(III) and hence write a balanced equation for the reaction of iron(III) with hydroxylammonium chloride.