

Dissolution to Bring a Resolution – The Italian Job

Now if one is to enter into the spirit of this scientific exercise and ignore the proposed solution apparently supplied by one Michael Caine himself via the film's makers (it is understood that the Producers of "The Italian Job" would have changed the equilibrium of the situation by turning the engine on, have everyone sit exactly where they were until all the petrol had run out (after four hours) thus tipping the bus in the right direction allowing everyone to jump out with the gold ending up over the cliff) then I would like to present to you.....

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Clearly Croker knew that melting the gold wouldn't be quickest way to get rid of some of the haul (despite possessing a huge magnifying glass with which to focus the sun onto the bars creating sufficient heat to reach the melting point of 1064.43°C) no quick as flash Croker knew that dissolution of the gold would be the quickest and most effective way of saving everyone from almost certain death.

The Narrative

"Grab those three buckets, now you lot pee in them!" demanded Croker.

"Tell Big William to pass back those two canisters behind the passenger seat. One of them should be grey with a yellow band on it".

Everyone stared in astonishment.

"What are you playing at Croker?" said Yellow.

"Didn't you learn anything at school?"

"Did you sleep through Chemistry?"

Crokers' comments were greeted with blank stares.

"Those two cylinders we've kept in the bus for making explosives (for only blowing the bloody doors off!), they're nitrogen dioxide and hydrogen chloride gas and they might just be our last hope".

"If I dissolve them separately into water, that's your pee Tony, I'll get nitric acid and hydrochloric acid, now if I mix those two together, do you know what I get?"

“No Croker tells us?”

“It’s “royal water” or “aqua regia” you numb skulls and do you know what that is? It’s probably the only bloody thing that will dissolve gold! Mind you the fumes might kill us but I don’t figure we’ve much to lose”. “This thing is literally in the balance but if I can get rid of some those bloody bars by dissolving them then I reckon they’ll wash out the back end of the bus between the gaps in the doors tilting this thing the right way; saving our necks”.

This, indeed, was Croker’s thinking when he said "Hang on a minute lads, I've got a great idea! Err..." and do you know what, the job was a good one. He only went and burnt the bloody doors off as well!

The Science

i) Engineering

The predicament presents a classical case of The Principle of Moments (of course famously the operating principle of the lever as discovered by Archimedes) whereby “the sum of moments of several forces about a point is equal to the moment due to the resultant of the forces” or the moment of force represents the magnitude of force applied to a rotational system at a distance from the axis of rotation. In mathematical terms...

Weight times (distance from fulcrum) on one side = Weight times (distance from fulcrum) on the other side.

The unit for moment being the newton meter (Nm).

We know that the back end of the bus was “teetering” over the edge of the cliff and that the bus was pivoted on this edge. As the situation was in fine balance and from the principle of moments, we know that the weight of gold and its distance from the fulcrum must roughly equate to the distance from the fulcrum and the weight of the men. The schematic provided would suggest the bus wouldn’t topple however assuming that the men can stand in a straight line the furthest distance from the fulcrum and that the situation is static, one way to successfully “ground” the bus on terra firma would be to reduce the amount of gold in a very short space of time. If we take the following:

No. of men = 10

Average mass of each man = 70 kg

Combined Force of men = 6867 N

Distance of men from fulcrum = 79 m (atomic number of Au as it just so happens)

Moment on right hand side = 542493 Nm

This being the case and as the centre of gravity of the gold resides 18.69 m (just happens to be the year the Periodic Table of Elements was launched!) from the fulcrum then

the Combined Force of gold must roughly equate to 29025 N

The mass of Gold would then be = 2960 kg

Density of Gold (near room temperature) = 19.3 g cm⁻³

Volume of a Gold Bar = 728 cm³

No. of Gold Bars = 210

Removal of only a small number of these bars would have the bus rotating in the right direction.....

ii) *The Chemistry*

The question is whether to dissolve the Gold or melt it?

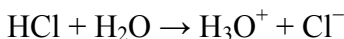
If the team were successful in doing either of these with a relatively small amount of the Gold then it could be possible to create a more stable situation as the melted or dissolved Gold slipped through the gaps in the rear doors.

Well we know Crokers intuitive thoughts; with a

Heat of fusion = 12.550 kJ/mol

It would take too long to melt some of the Gold even if the required temperature could be reached. No the quickest way would be the highly improbable (this IS a work of fiction remember!) but practical within the 30 minutes allowed dissolution of some of the Gold.

Using urine as the source of water; both nitric acid and hydrochloric acid could be prepared using the gases nitrogen dioxide and hydrogen chloride respectively.

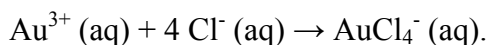
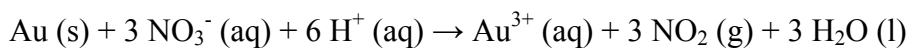


Mixing these two acids in a volumetric ratio of 1:3 nitric acid and hydrochloric acid respectively would produce "Aqua Regia".

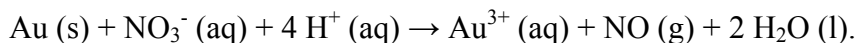
Upon mixing of concentrated hydrochloric acid and concentrated nitric acid, chemical reactions occur. These reactions result in the volatile products nitrosyl chloride and chlorine as evidenced by the fuming nature and characteristic yellow color of aqua regia



Aqua regia dissolves Gold, even though neither constituent acid will do so alone, because, in combination, each acid performs a different task. Nitric acid is a powerful oxidizer, which will actually dissolve a virtually undetectable amount of Gold, forming Gold ions (Au^{3+}). The hydrochloric acid provides a ready supply of chloride ions (Cl^-), which react with the Gold to produce chloraurate anions, also in solution. The reaction with hydrochloric acid is an equilibrium reaction which favors formation of chloraurate anions (AuCl_4^-). This results in a removal of Gold ions from solution and allows further oxidation of Gold to take place thus the Gold is dissolved. In addition, Gold may be oxidized by the free chlorine present in aqua regia. Appropriate equations are

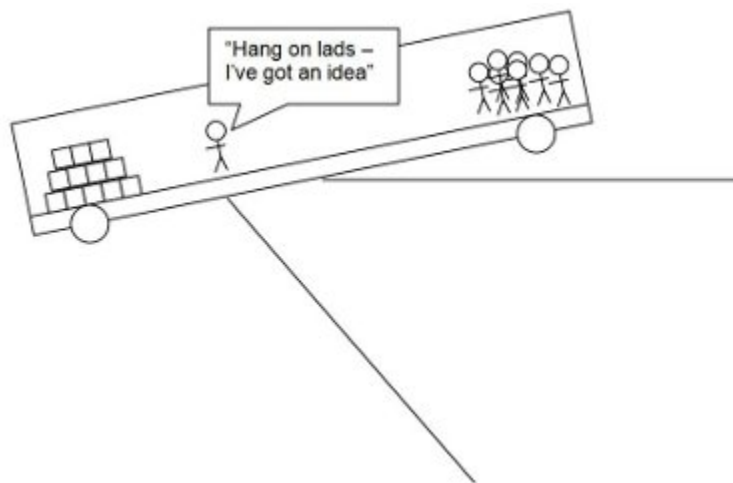


The oxidation reaction can also be written with nitric oxide as the product rather than nitrogen dioxide:



These equations conclude my.....

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Other (more Ribald) Titles that were considered:

- Taking the Piss with the Principle of Moments – The Only Solution ...
- Urine in Turin

Sorry, I wouldn't use these merely for your own amusement!!

One final point: How adapt the use of urine or ironic rather given that Alchemists long ago thought that the yellow color of urine came from Gold and attempted to extract gold from it rather than use to lose Gold! I would put this in any publication.

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