Apollo 13: Background, Scene Description, & After Viewing Comments

Included here are some of the comments, discussions, and questions used when viewing *Apollo 13* in chemistry and biochemistry classes. The film is useful for both general chemistry classes (science and non-science major courses) and more advanced biochemistry courses.

A. Background

1. Description of Apollo Mission (comment: foreign policy/political climate of 50's, 60's)
2. Describe spacecraft components
   a) CSM (command/service module, sometimes just called CM or *Odyssey*)
   b) LM (lunar module or *Aquarius*)
3. Describe function of O_2 tanks in energy generation (emphasize distinct requirement from O_2 for breathing, as some students have trouble with this).
4. Describe stirring of O_2 tanks causes explosion (later determined due to faulty coil). This occurs at $^{Chap}19{:}^{H}0{:}^{M}49{:}^{S}09$ on DVD.
5. Describe complete shutdown of power in CM (They closed fuel cell reactor valves.) in effort to conserve O_2 ***for power generation***. This failed.
6. Describe crew (all 3) transfer to LM because of **no** power in CM. This had to be completed in 15 minutes, including power up of the LM computer. Comment on checking gimbal settings with slide rules!!!
7. Describe decrease in power use by LM (60 amps down to 12 amps) required because the LM was not originally designed to be inhabited for 5 days. That is why the astronauts were cold, lighting was dim, *etc*. Later (after fixing CO_2 problem) they had to do course correction burn manually (*i.e.*, with no computer).
8. Respiratory chemistry comments.
   a) Why, chemically, do humans inhale and exhale?
   b) What is the optimum pH of human blood? What happens away from optimum?
   c) Scrubbing CO_2 from air by chemical reaction. (Describe pumping air through cartridges.)

B. Scene description

1. Start viewing at $^{Chap}35{:}^{H}1{:}^{M}19{:}^{S}32$ on DVD. "...situation brewing with the carbon dioxide."
2. CO_2 filter (scrubber) problem on LM
   a) 5 round filters on LM, designed for "... 2 guys for a day and a half."
   b) plenty of square CO_2 filters on CM, but they do not fit into the LM system.

3. If time is short, you can stop at $^{Chap}35:^{H}1:^{M}20:^{S}38$ on DVD, "Let's build a filter." and skip to $^{Chap}36:^{H}1:^{M}26:^{S}48$ on DVD. This 6 minutes and 10 seconds deals mostly with human interest aspects of the storyline. However, I try to show it because it is fairly emotionally gripping. Viewing the scene seems to get the students more involved in solution of the CO_2 problem, as well as emphasizing the gravity of the situation.
4. Comment on CO_2 warning light and units (mm Hg) on CO_2 gauge.
5. Mention in scene of LiOH cannister, re. specific chemical rxn.
6. Stop viewing $^{Chap}39:^{H}1:^{M}32:^{S}29$ on DVD, "And you sir, are a steely-eyed missile man."

C. After Viewing Comments/Questions for the students

1. Identify specific chemical reactions that were important in this event.

a) Fuel cell reaction:

$2\ H_2 + O_2 \rightarrow 2\ H_2O$ + energy This is why O_2 loss was a problem.

b) Human metabolic reactions producing CO_2:

$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ This isn't the only way we make CO_2.

c) Dissolution of CO_2 in water and reaction of CO_2 to form carbonic acid:

$$CO_2(g) \xrightarrow{H_2O} CO_2(aq)$$

$$CO_2(aq) + H_2O(l) \rightarrow H_2CO_3(aq)$$

d) Acid dissociation reactions of carbonic acid:

$$H_2CO_3(aq) + H_2O(l) \rightarrow HCO_3^-(aq) + H_3O^+(aq)$$

$$HCO_3^-(aq) + H_2O(l) \rightarrow CO_3^{2-}(aq) + H_3O^+(aq)$$

e) Neutralization of the acidic oxide CO_2 by the base LiOH (other options?):

$$CO_2(g) + LiOH(s) \rightarrow LiHCO_3(s)$$

2. Comment/question on use of LiOH instead of the less expensive NaOH (or KOH).

3. Comment on Lovell's observation, "Houston, we are venting something out into space... It's definitely a gas of some sort... It's got to be the oxygen." Prior to this observation, both the flight crew and the ground crew were having difficulty getting a grip on the situation (relative to "...losing your grip.") The observation of gas venting allowed all concerned to focus their thoughts more appropriately.

4. Comments about respiratory gas exchange, blood pH. For more advanced classes, comment on blood pH and Bohr effect (hemoglobin function).

5. Above all, emphasize that the problem at this stage in the flight ***was high CO_2 levels, not shortage of breathable O_2***. Some of the less-involved students have difficulty realizing the importance of blood pH in human physiology.

6. Finally, make sure the students know before the discussion/viewing of the film starts that there will be test questions or graded homework associated with the film. This motivates them to view at a higher level of interest than just entertainment.

Additional resources:

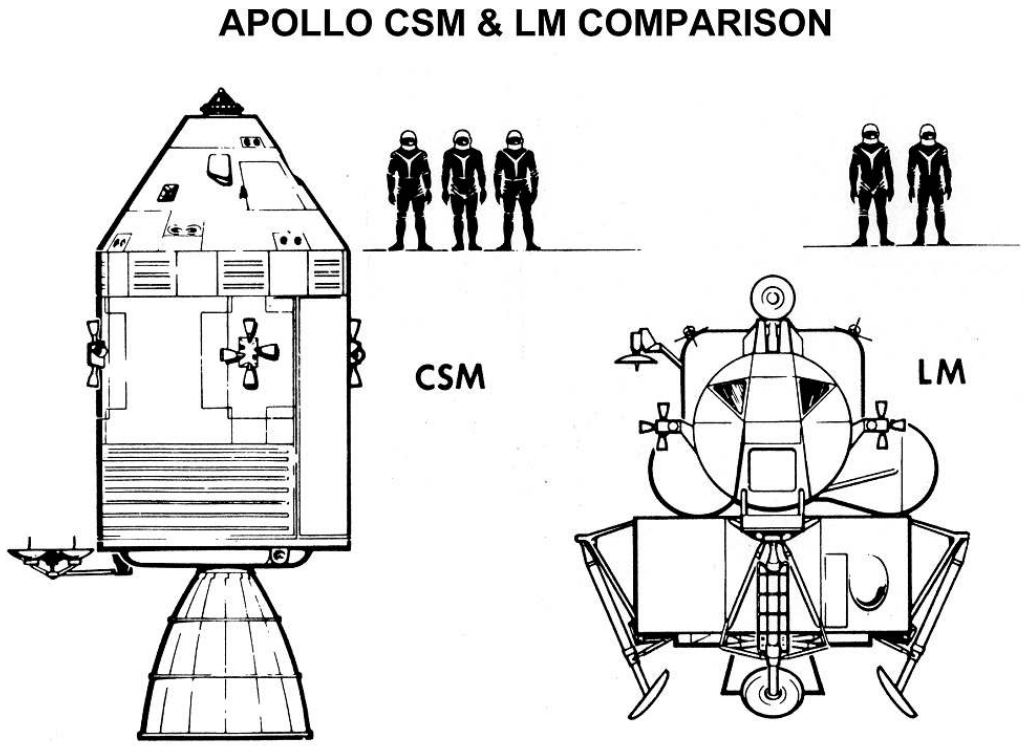
1. Apollo Project home page: http://science.ksc.nasa.gov/history/apollo/apollo.html

2. Original tapes of Apollo 13 Mission communications:
   http://www.apolloarchive.com/

3. NASA history of Apollo 13 Mission:
   http://www.ksc.nasa.gov/history/apollo/apollo-13/apollo-13.html

4. Beautiful images from Apollo Project Missions:
   http://images.jsc.nasa.gov/iams/html/pao/apollo.htm

Apollo 13 Spacecraft Components

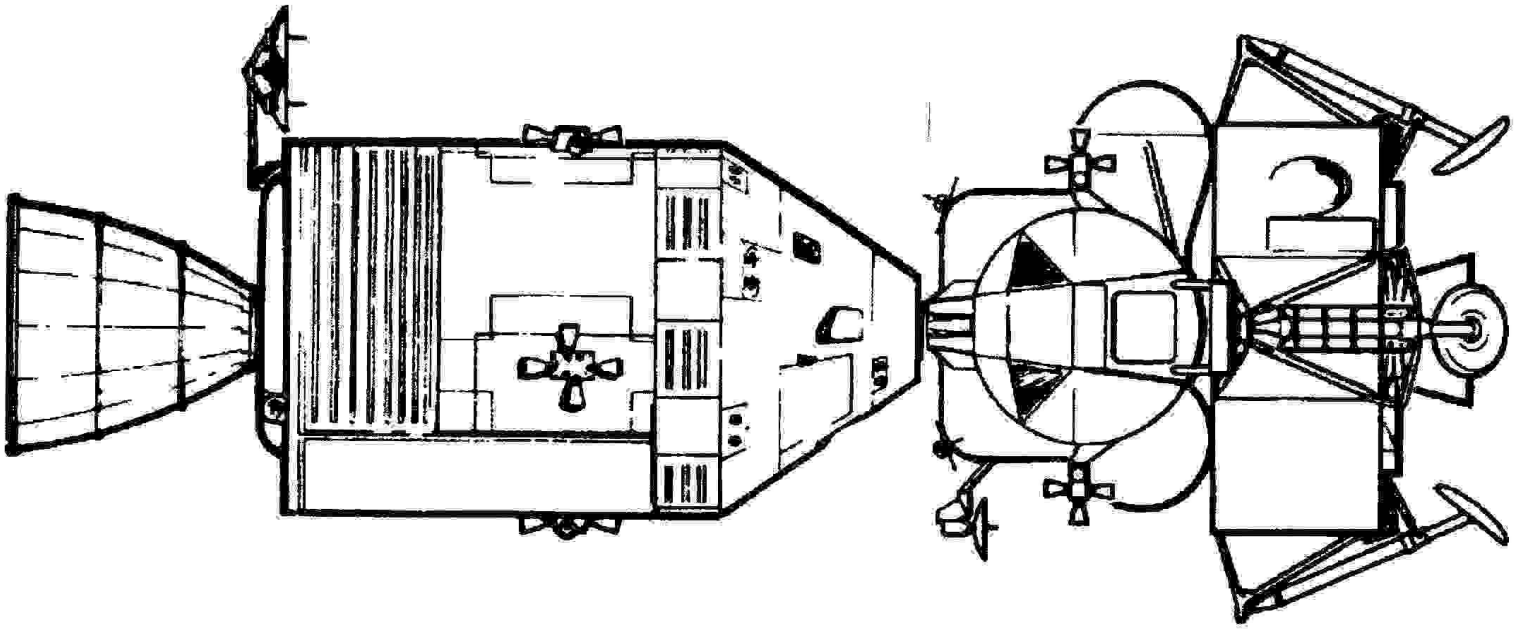


CSM = Command/
Service Module

LM = Lunar Module

Source: NASA web site (http://www.hq.nasa.gov/office/pao/History/diagrams/apollo.html)

Apollo 13 CSM & LM Linked for Trip to Moon



CSM (*Odyssey*) LM (*Aquarius*)

This linkage of units allows main engines from both CSM and LM to be used. The LM landing legs would be more extended during flight than shown here.

Source: Composite made from NASA web site figures (http://www.hq.nasa.gov/office/pao/History/diagrams/apollo.html