The Strange Case of Mole Airlines Flight 10^{23}

Background and reference information

At 6:02:21 a.m. mole airlines flight 10^{23} radioed that they were making an emergency landing after a commotion in the cabin. However, shortly after radioing in the situation, the plane crashed. You and your team of medical examiners are called to the scene of a plane crash.

You find evidence of a pre-crash explosion. A section of the plane has been blown apart by an explosion. It appears as if the explosion happened before the crash. Residue from the explosion site shows the following elemental analysis: 16.22% carbon, 2.72% hydrogen, 37.84% nitrogen, and 43.22% oxygen

Eight victims are found at the scene, but none are identifiable by witnesses, dental records, or DNA evidence. You find evidence suggesting the commotion radioed in before the crash was a passenger being murdered. The flight manifest shows the names and some information about the victims. You must use the available tools and information to identify each victim. You must also solve the murder mystery.

Table 1 & 2 below give reference information (possible compounds and unidentified passengers from the flight manifest) to help identify the victims.

Table 1. Possible Compounds (not all will be used)

Identity	**Empirical formula**	**Molecular formula**	**Notes/uses**
Acetaminophen	$C_8H_9NO_2$	same	Painkiller (Tylenol)
Amphetamine	$C_9H_{13}N$	same	Prescription drug for treatment of ADHD
Aspartame	$C_{14}H_{18}N_2O_5$	same	Artificial sweetener
Aspirin	$C_9H_8O_4$	same	Pain killer
Batrachotoxin	$C_{31}H_{42}N_2O_6$	same	Poison used on darts.
Caffeine	$C_4H_5N_2O$	$C_8H_{10}N_4O_2$	Stimulant found in coffee and many sodas
Cocaine	$C_{17}H_{21}NO_4$	same	Narcotic, illegal
Dimetacrine	$C_{10}H_{13}N$	same	Prescription antidepressant
Glutamine	$C_5H_{10}N_2O_3$	same	A protein found in wheat gluten
Hydrocodone	$C_{18}H_{21}NO_3$	same	Painkiller, prescription-controlled
Hydrogen cyanide	HCN	same	highly poisonous gaseous compound
Ibuprofen	$C_{13}H_{18}O_2$	same	Over-the-counter muscle relaxer and painkiller
Methamphetamine	$C_{10}H_{15}N$	same	Illegal stimulant drug
Mirtazapine	$C_{17}H_{19}N_3$	same	Prescription antidepressant
Nitroglycerine	$C_3H_5N_3O_9$	same	Explosive and also a heart medication
RDX (Research Dept. Explosive)	$CH_2N_2O_2$	$C_3H_6N_6O_6$	Major ingredient in C-4 explosives
Strychnine	$C_{21}H_{22}N_2O_2$	same	Rat poison
Sucrose	$C_{12}H_{22}O_{11}$	same	Table sugar
Theobromine	$C_7H_8N_4O_2$	same	A heart stimulant found naturally in chocolate
Trinitrotoluene	$C_7H_5N_3O_6$	same	Explosive (TNT-dynamite)
Vanilla	$C_8H_8O_3$	same	Flavoring

Table 2: The passenger manifest lists the following passengers who boarded the flight at takeoff.

Name	**What's been learned about the person**
Karla Baker	Sleep deprived ex-vet with a secret heart condition
Brian Skete	A graduate student with a sweet-tooth and ADHD
Charisa Morton	Suspected drug dealer and addict
Enrique Chesterson	A disgruntled civil engineer specializing in demolition
Jason Uitz	An environmental engineer suffering from clinical depression.
Charles Dunlap	Works as a baker in bakery
Sharon Turner	Pharmacist with chronic back pain
Tom Zumpela	A science teacher addicted to diet Coke

The Strange Case of Mole Airlines Flight 10^{23} Period: _____ Name _____
Chemistry Date: _____

1. Determine the empirical formula for the substance found at the site of the pre-crash explosion (the 16.22% carbon, 2.723% hydrogen, 37.84% nitrogen, and 43.22% oxygen) show your work with units and unit canceling in work.

16C 16U 8P $\frac{16.22\ \cancel{g\ C}}{1} \cdot \frac{1\ mol\ C}{12.0108\cancel{g\ C}} = 1.350$ mol C $\frac{2.723\cancel{g\ H}}{1} \cdot \frac{1\ mol\ H}{1.00795\cancel{g\ H}} = 2.702$ mol H

$\frac{37.84\cancel{g\ N}}{1} \cdot \frac{1\ mol\ N}{14.0067\cancel{g\ N}} = 2.702$ mol N $\frac{43.22\cancel{g\ O}}{1} \cdot \frac{1\ mol\ O}{15.9994\cancel{g\ O}} = 2.701$ mol O

$\frac{1.35\ mol\ C}{1.35} = 1.000$ mol C $\frac{2.702\ mol\ H}{1.350} = 2.001$ mol H $\frac{2.702\ mol\ N}{1.350} = 2.001$ mol N $\frac{2.702\ mol\ O}{1.350} = 2.001$ mol O

   a. 3C 3P Empirical formula: $CH_2N_2O_2$ Substance name: RDX Could this substance cause an explosion capable of bringing down the plane? Yes (it is an explosive afterall)

   b. C P Molecular formula (or write "same"): $C_3H_6N_6O_6$

   c. Molar mass of the actual substance in the molecular formula. Show your work:

9C 9U 5P $\frac{3\ \cancel{mol\ C}}{1} \cdot \frac{12.0108\ g\ C}{1\ \cancel{mol\ C}} = 36.0324$ g C + $\frac{6\ \cancel{mol\ H}}{1} \cdot \frac{1.00795\ g\ H}{1\ \cancel{mol\ H}} = 6.0477$ g H + $\frac{6\ \cancel{mol\ N}}{1} \cdot \frac{14.0067\ g\ N}{1\ \cancel{mol\ N}} = 84.0402$ g N + $\frac{6\ \cancel{mol\ O}}{1} \cdot \frac{15.9994\ g\ O}{1\ \cancel{mol\ O}}$ = 95.9964 g O $= 222.1167 \frac{g\ C_3H_6N_6O_6}{mol\ C_3H_6N_6O_6}$

2. Write the number of moles of each element (assuming 100g sample), the mole ratios relative to the smallest number of moles, and then the whole number from the ratio below that. Record the empirical formula and identify the substance for each of the compounds.

Passenger	Compound number and info.	Percent composition				Empirical formula and compound name	Most likely name of passenger with how you know.
		C	H	N	O		
1	**1 (found in pockets)**	**80.48**	**10.13**	**9.386**	**0.000**	$C_{10}H_{15}N$ Methamphetamine	Charissa Morton: The victim had illegal drugs in the blood and on the body, and Charissa Morton is a drug dealer/addict
	Moles for 100g total mass	6.7006	10.050	0.67011	0		
	Mole ratio with 4 sig. fig.	9.999	15.00	1.000	0		
	Whole number mole ratio	10	15	1	0		
	2 (found in blood)	**67.31**	**6.978**	**4.617**	**21.10**	$C_{17}H_{21}NO_4$ Cocaine	
	Moles for 100g total mass	5.6041	6.9230	0.32963	1.3188		
	Mole ratio with 4 sig. fig.	17.00	21.00	1.000	4.001		
	Whole number mole ratio	17	21	1	4		

Passenger	Compound number and info.	Percent composition				Empirical formula and compound name	Most likely name of passenger with how you know.
		C	H	N	O		
2	**1 (found in pockets)**	**75.69**	**8.795**	**0.000**	**15.51**	$C_{13}H_{18}O_2$ Ibuprofen	Sharon Turner: The victim had pain killers in the blood as well as on the body, and Sharon Turner would need pain killers with chronic back pain
	Moles for 100g total mass	6.3018	8.7256	0	0.96941		
	Mole ratio with 4 sig. fig.	6.501	9.001	0	1.000		
	Whole number mole ratio	13	18	0	2		
	2 (found in blood)	**72.22**	**7.071**	**4.679**	**16.03**	$C_{18}H_{21}NO_3$ Hydrocodone	
	Moles for 100g total mass	6.0129	7.0152	0.33405	1.0019		
	Mole ratio with 4 sig. fig.	18.00	21.00	1.000	2.999		
	Whole number mole ratio	18	21	1	3		
3	**1 (found in blood)**	**15.87**	**2.219**	**18.50**	**63.41**	$C_3H_5N_3O_9$ Nitroglycerine	Karla Baker: The victim had a heart medicine and caffeine in the blood and Karla baker has a heart condition and is sleep deprived.
	Moles for 100g total mass	1.3213	2.2015	1.3208	3.9633		
	Mole ratio with 4 sig. fig.	1.000	1.667	1.000	3.000		
	Whole number mole ratio	3	5	3	9		
	2 (found in blood)	**49.48**	**5.190**	**28.85**	**16.48**	$C_4H_5N_2O$ Caffeine	
	Moles for 100g total mass	4.1196	5.1491	2.0597	1.0300		
	Mole ratio with 4 sig. fig.	4.000	4.999	2.000	1.000		
	Whole number mole ratio	4	5	2	1		
4	**1 (found in blood)**	**76.95**	**7.217**	**15.84**	**0.000**	$C_{17}H_{19}N_3$ Mirtazapine	Jason Uitz: The victim had an antidepressant and had eaten chocolate
	Moles for 100g total mass	6.4067	7.1601	1.1309	0		
	Mole ratio with 4 sig. fig.	5.665	6.331	1.000	0		
	Whole number mole ratio	17	19	3	0		

Passenger	Compound number and info.	Percent composition				Empirical formula and compound name	Most likely name of passenger with how you know.
		C	H	N	O		
4	**2 (found in stomach)**	**46.67**	**4.476**	**31.10**	**17.76**	$C_7H_8N_4O_2$ Theobromine	(often makes people feel better), and Jason Uitz has clinical depression.
	Moles for 100g total mass	3.8857	4.4407	2.2204	1.1100		
	Mole ratio with 4 sig. fig.	3.501	4.001	2.000	1.000		
	Whole number mole ratio	7	8	4	2		
5	**1 (found in blood)**	**79.95**	**9.691**	**10.36**	**0.000**	$C_9H_{13}N$ Amphetamine	Brian Skete: The victim had a medicine for ADHD in the blood and had eaten sugar, and Brian Skete has ADHD and has a sweet-tooth.
	Moles for 100g total mass	6.6565	9.6146	0.73965	0		
	Mole ratio with 4 sig. fig.	9.000	13.00	1.000	0		
	Whole number mole ratio	9	13	1	0		
	2 (found in stomach)	**42.11**	**6.478**	**0.000**	**51.42**	$C_{12}H_{22}O_{11}$ Sucrose	
	Moles for 100g total mass	3.5060	6.4269	0	3.2139		
	Mole ratio with 4 sig. fig.	1.091	2.000	0	1.000		
	Whole number mole ratio	12	22	0	11		
6	**1 (found in stomach)**	**57.14**	**6.165**	**9.519**	**27.18**	$C_{14}H_{18}N_2O_5$ Aspartame	Tom Zumpela: The victim had an artificial sweetener in stomach and a toxin on the body. Tom Zumpela likes diet Coke (hence the sweetener) and might have access to a toxin as a science teacher.
	Moles for 100g total mass	4.7574	6.1164	0.67960	1.6988		
	Mole ratio with 4 sig. fig.	7.000	9.000	1.000	2.500		
	Whole number mole ratio	14	18	2	5		
	2 (found in pockets)	**69.12**	**7.859**	**5.200**	**17.82**	$C_{31}H_{42}N_2O_6$ Batrachotoxin	
	Moles for 100g total mass	5.7548	7.7970	0.37125	1.1138		
	Mole ratio with 4 sig. fig.	15.50	21.00	1.000	3.000		
	Whole number mole ratio	31	42	2	6		

Passenger	Compound number and info.	Percent composition				Empirical formula and compound name	Most likely name of passenger with how you know.
		C	H	N	O		
7	**1 (found in stomach)**	**41.09**	**6.897**	**19.17**	**32.84**	$C_5H_{10}N_2O_3$ Glutamine	Charles Dunlap: The victim had eaten gluten and had used a flavoring used commonly in baking, and Charles Dunlap is a baker
	Moles for 100g total mass	3.4211	6.8426	1.3686	2.0526		
	Mole ratio with 4 sig. fig.	2.499	4.998	1.000	1.499		
	Whole number mole ratio	5	10	2	3		
	2 (found in pockets)	**63.15**	**5.3**	**0**	**31.55**	$C_8H_8O_3$ Vanilla	
	Moles for 100g total mass	5.2578	5.2582	0	1.9719		
	Mole ratio with 4 sig. fig.	2.666	2.666	0	1.000		
	Whole number mole ratio	8	8	0	3		
8	**1 (found in blood)**	**69.12**	**7.859**	**5.2**	**17.82**	$C_{31}H_{42}N_2O_6$ Batrachotoxin	Enrique Chesterson: The victim had an explosive used in demolition of buildings on the body. Enrique Chesterson works as a demolition expert.
	Moles for 100g total mass	5.7548	7.7970	0.37125	1.1138		
	Mole ratio with 4 sig. fig.	15.50	21.00	1.000	3.000		
	Whole number mole ratio	31	42	2	6		
	2 (found in pockets)	**16.22**	**2.723**	**37.84**	**43.22**	$CH_2N_2O_2$ RDX (Research Dept. Explosive)	
	Moles for 100g total mass	1.3505	2.7015	2.7016	2.7014		
	Mole ratio with 4 sig. fig.	1.000	2.001	2.001	2.001		
	Whole number mole ratio	1	2	2	2		

3. Solve the murder mystery, write the name of the passenger:

Who was the murder victim? Enrique Chesterson, who murdered that person? Tom Zupela

What was used to murder the victim? Batrachotoxin (poison dart)

4. Who does the evidence lead to as a suspect for causing the pre-crash explosion? Enrique Chesterson How do you know?

Mr. Chesterson is the only victim with RDX on his body, and RDX was found at the pre-crash explosion site.