

The logo features the word "AVENGERS" in a stylized, metallic font with a red "MARVEL" logo above it. Below "AVENGERS" is the word "S.T.A.T.I.O.N." in a large, bold, sans-serif font. Underneath "S.T.A.T.I.O.N." is the text "SCIENTIFIC TRAINING AND TACTICAL INTELLIGENCE OPERATIVE NETWORK" in a smaller, all-caps font. At the bottom right, there is a small copyright notice: "© MARVEL 2014".

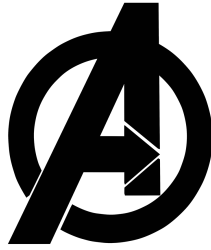
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ATTN: Agents in training
RE: UNIDENTIFIED SHIP

Agents in training, we have a mission of top priority status for you. Recent data reports coming in have detected a possible crash site for a ship. We had no registered Avengers crafts in the area. The data coming in shows strange readings and suggests it might not be of earthly origin.

Form a team of scientists to investigate the provided data on the crash site. You are to analyze the material the ship is made of, determine its point of origin, and classify the type of engine it uses. We need to know what this thing is as soon as possible. Once you have completed your mission, you are to present your findings to your teacher, who is an undercover Agent of Avengers with level 5 classified clearance. Your teacher will then relay the information directly to Avengers. Good luck, the world is depending on you.

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MISSION OVERVIEW_

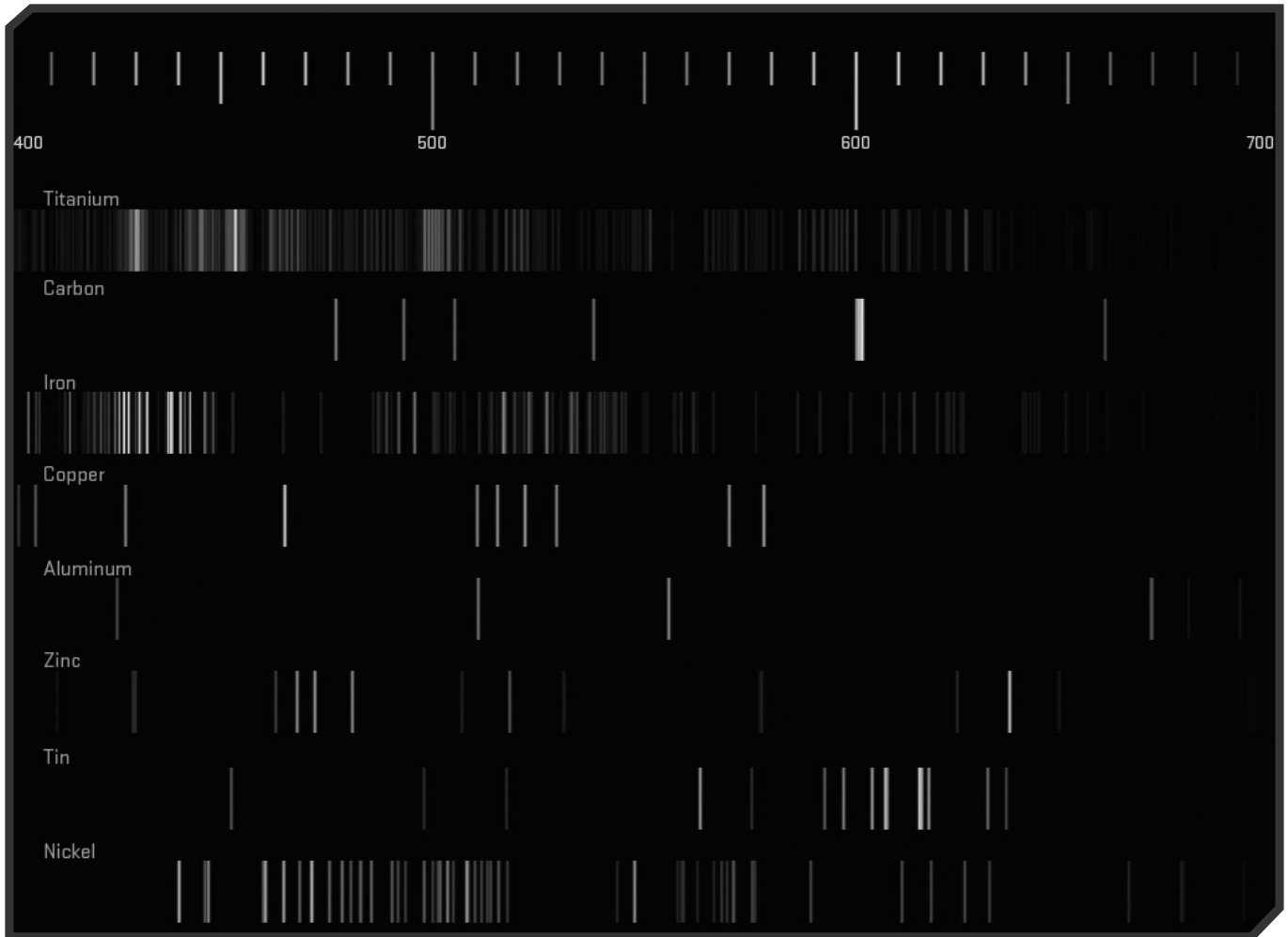
Recent data reports coming in have detected a possible crash site for a ship. We had no registered Avengers crafts in the area. The data coming in shows strange readings and suggests it might not be of earthly origin.

MISSION BRIEF_

Our Avengers agents were able to retrieve various debris from the crash site that we believe comprised the hull of the ship. If we can identify which metals the hull was made out of, it can help us identify the origin and nature of the ship. We ran a spectral analysis of the debris and have provided you with the results. As you may know, when elements are heated, they radiate light at very specific wavelengths. We can use these emissions to identify what elements make up the sample. Use the data enclosed to identify the samples, fill out this report, and enter your results into the Avengers database.

[SPECTROGRAPH SIGNATURES]

SECURITY LEVEL 3



Refer to this table when attempting to identify the three samples.

[ANALYSIS OF SAMPLES]

[SAMPLE 01]

Most of the debris is made of an element with this emission signature:

- Numerous emission lines ranging from 420 nm to 450 nm
- Numerous emission lines of high intensity around 520 nm

Our instruments also detected a small amount of this element in the metal with this emission signature:

- Few emission lines. Only 2 emission lines under 500 nm
- Cluster of emission lines at 600 nm

Other notable characteristics:

- Magnetic
- Dense and very rigid

[SAMPLE 02]

Most of the debris is made of an element with this emission signature:

- Few emission lines
- Emission line around 510 nm
- Emission line around 555 nm

Our instruments also detected a small amount of this element in the metal with this emission signature:

- Four emission lines spaced between 500 nm to 540 nm

Other notable characteristics:

- Non- magnetic
- Very reflective
- Good electrical conductor

[SAMPLE 03]

This material is made of entirely one element, and has the same emission signature as the secondary element from Sample 1:

- Few emission lines. Only 2 emission lines under 500 nm
- Cluster of emission lines at 600 nm

Other notable characteristics:

- Remarkable stiffness
- Remarkable low density
- Remarkable thermal and electrical conductivity
- Under a microscope the material has a cylindrical structure
- Cylindrical structure made of hexagonal shapes



Avengers Report:
Re: Hull Analysis

1. What type of analysis was the debris subject to?
2. Justify this type of analysis. Why was this method of analysis chosen?
3. How does it work? Why is it possible to identify elements using this method?
4. Based on the spectral analysis indicate what element(s) are present. Justify your selection by citing evidence.

Sample 1:

Sample 2:

Sample 3:

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SCIENTIFIC TRAINING AND TACTICAL INTELLIGENCE OPERATIVE NETWORK

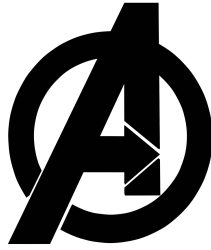
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Form a team of scientists to investigate the provided data on the crash site. You are to analyze the material the ship is made of, determine its point of origin, and classify the type of engine it uses. We need to know what this thing is as soon as possible. Once you have completed your mission, you are to present your findings to your teacher, who is an undercover Agent of Avengers with level 5 classified clearance. Your teacher will then relay the information directly to Avengers. Good luck, the world is depending on you.

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**POINT OF ORIGIN AND TRAJECTORY
ANALYSIS****MISSION OVERVIEW_**

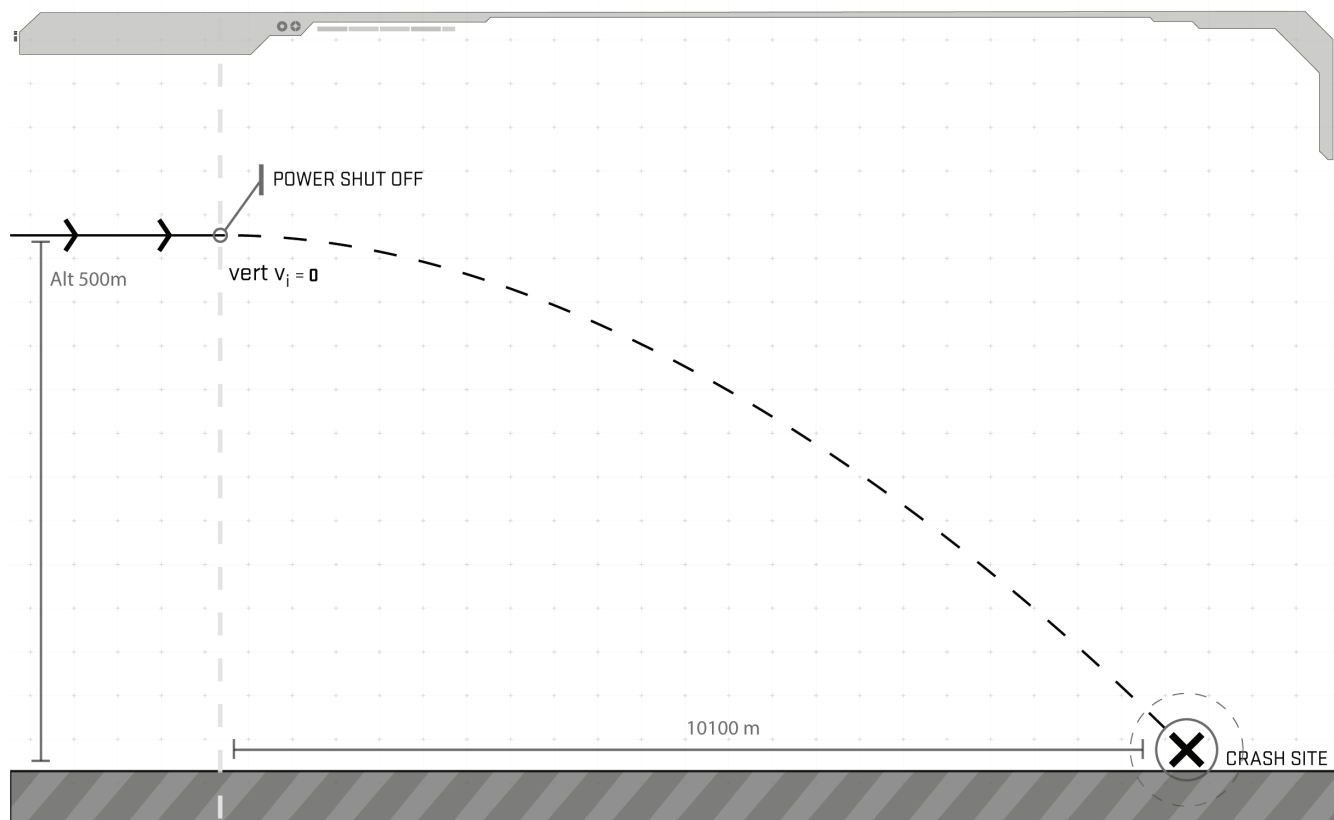
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MISSION BRIEF_

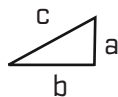
Agents, if we can figure out where the ship was traveling from, it can help us identify it. You are to determine the ship's point of origin, as well as run some calculations surrounding the impact site. The first data scan is the trajectory analysis. Based on the size of the crater we were able to trace back the ship's flight path and force upon impact. The second is the point of origin scan, and after your analysis of the trajectory scan, you can use this to figure out where the ship came from. Fill out this report and enter your results into the Avengers database.

POINT OF ORIGIN AND TRAJECTORY ANALYSIS

[CRASH TRAJECTORY]

**Relevant Information:**

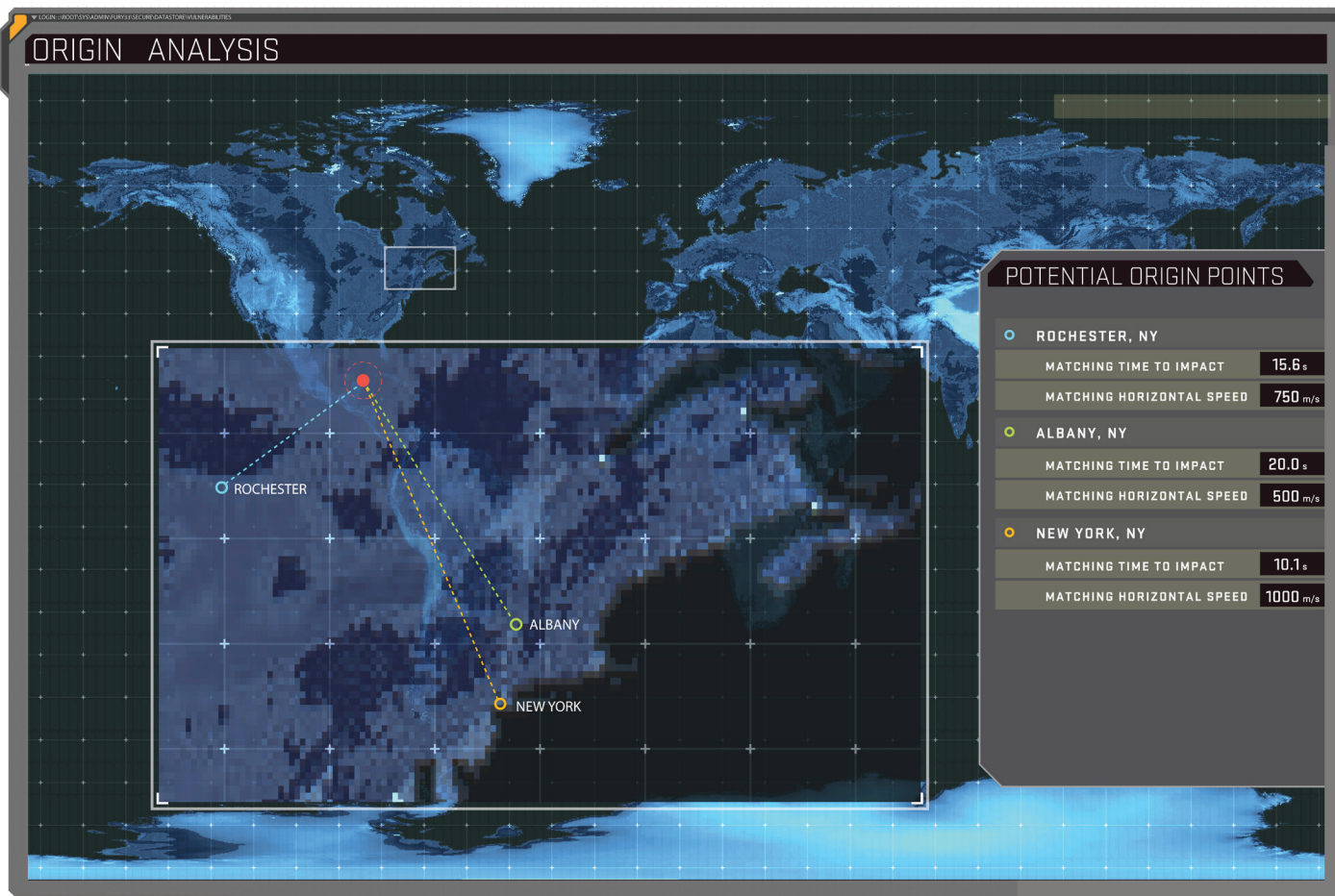
- ▶ Acceleration of gravity: 9.8 m/s^2
- ▶ Distance equation: $d = v_i t + \frac{1}{2} a t^2$
- ▶ Rate equation: $v = d/t$
- ▶ Final velocity equation: $v_f^2 = v_i^2 + 2ad$
- ▶ Pythagorean's Theorem: $a^2 + b^2 = c^2$



- ▶ $\tan(\theta) = \text{opposite} / \text{adjacent}$ (referring to the sides of a triangle)
- ▶ v_i = initial velocity
- ▶ v_f = final velocity
- ▶ d = distance
- ▶ v = velocity
- ▶ t = time
- ▶ a = acceleration (of gravity in this case)

POINT OF ORIGIN AND TRAJECTORY
ANALYSIS

[SCAN OF POSSIBLE ORIGIN]





Avengers Report:
Re: Point of Origin and Trajectory Analysis

1. Correctly label all force vectors on the provided diagram.
2. Calculate the initial horizontal speed.
3. Calculate the time it took to impact from the point it lost power.
4. Calculate how fast it was traveling vertically when it hit the ground.
5. Calculate the total velocity when it hits the ground, and the angle of impact from the horizontal.
6. Using the possible origin scan, match your findings with one of the paths.
What was the ship's point of origin?

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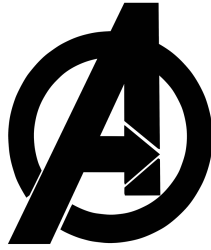
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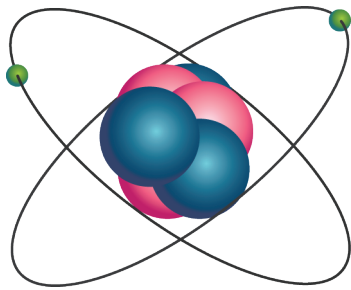


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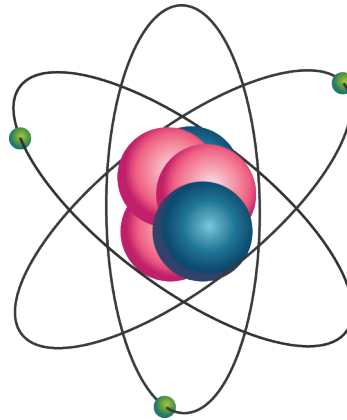
MISSION BRIEF_

Amongst the debris of the crash site, we've found what appears to be a small thrust engine. Through our initial analysis, we've concluded that it may be some type of ion drive, which is interesting because they are primarily used in deep-space travel. The design of this "ion drive" does not match any of the current designs that exist today. We've provided you with an annotated chart of the standard parts of an ion drive, definitions of key terms and processes, an annotated periodic chart, and our analysis of the elements of this unidentified ion drive. Your job is to help us understand how the unidentified ion drive operates by explaining the process of ionization, if magnets are present, and what type of elements are being used. When you complete your task, input the findings into the Avengers search engine to find any known references.



[POSITIVE ION]

- ▶ 3 Protons
- ▶ 2 Electrons



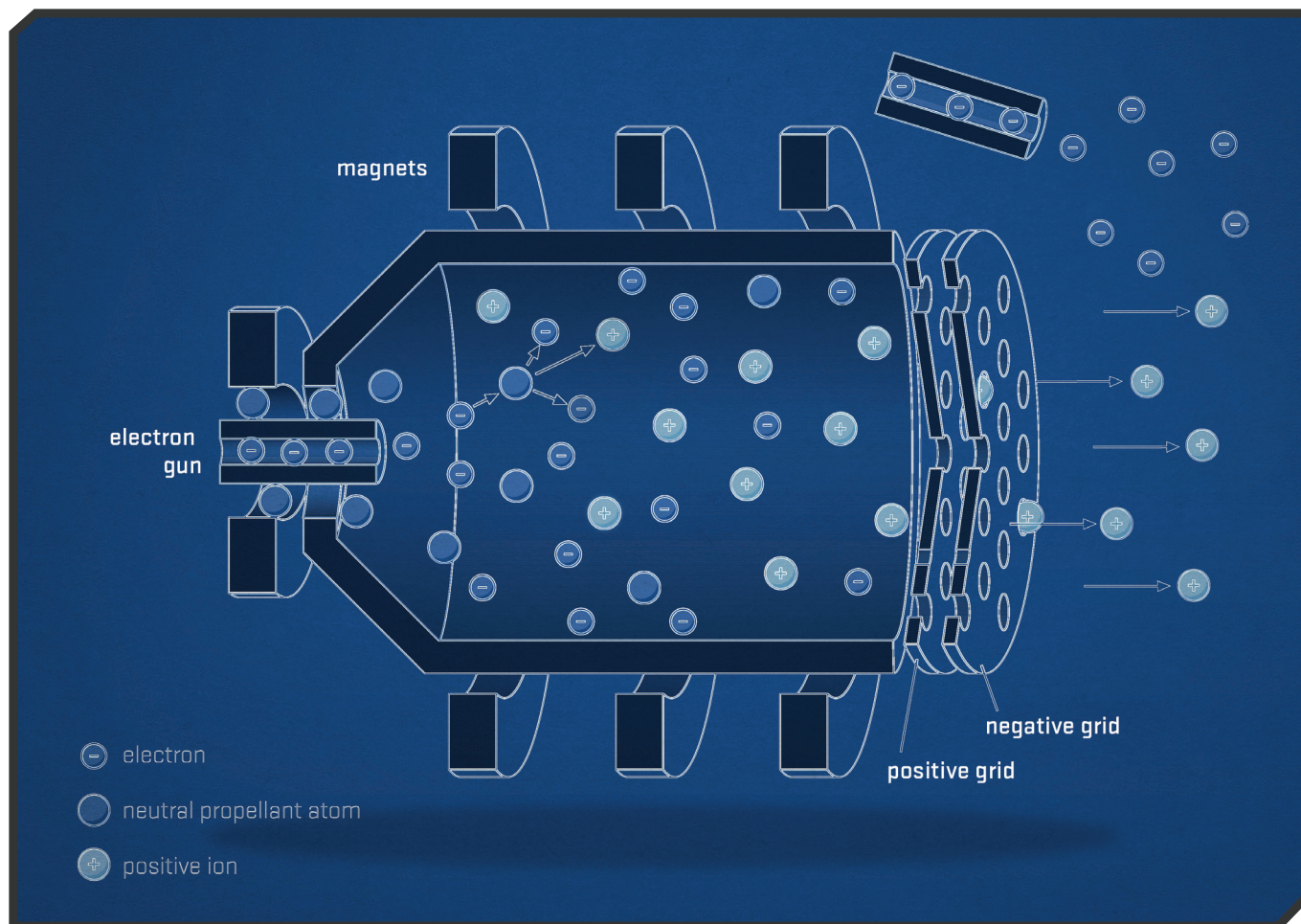
[NEGATIVE ION]

- ▶ 2 Protons
- ▶ 3 Electrons

Ionization

Ionization occurs when a neutral atom or molecule of an element gains a positive or negative charge by gaining or losing electrons. Ionization can occur in many ways, including through chemical reaction, high temperature, radiation, and particle collision. When an atom's total number of electrons is not equal to its total number of protons, it becomes electrically positively/negatively charged, meaning it will be attracted to opposite electric charges and be repelled by similar charges. Negative ions occur when there are more electrons than protons and positive ions occur when there are more protons than electrons. Although ions naturally exist in the world, ionization allows us to create charged atoms or molecules that are normally neutral.

[STANDARD ION DRIVE]



Ion Drives

Ion drives (or ion thrusters) work by firing electrons out of a nozzle at a high speed, generating particle collision ionization. Typical ion drives use the noble gas Xenon because of its stability; when squirted into the chamber, the gas will not be reactive at its present state. Then, using an electron gun, electrons are fired at the atoms, creating negative and positive ions. The positive ions are attracted to the back of the chamber by magnets and a highly charged negative grid. The positive ions are ejected out the back, and in accordance with Newton's Third Law, propels the spacecraft in the other direction. Finally, an electron gun positioned on the exterior neutralizes the positive ions in order to ensure that they do not re-enter the engine.

The Periodic Table of the Elements

group 1

1

Hydrogen

1.00794
1.00812

2

2

Lithium

6.941
6.941

3

3

Sodium

22.98976928
22.98976928

4

4

Potassium

39.0983
39.0983

5

5

Rubidium

85.4678
85.4678

6

6

Cesium

132.90545
132.90545

7

7

Francium

223
223

8

8

Helium

4.002602
4.002602

9

9

Neon

20.1797
20.1797

10

10

Argon

39.948
39.948

11

11

Potassium

39.0983
39.0983

12

12

Calcium

40.078
40.078

13

13

Gallium

69.723
69.723

14

14

Germanium

72.64
72.64

15

15

Arsenic

74.9216
74.9216

16

16

Selenium

78.96
78.96

17

17

Bromine

79.904
79.904

18

18

Krypton

83.798
83.798

19

19

Strontium

87.62
87.62

20

20

Yttrium

88.90584
88.90584

21

21

Zirconium

91.224
91.224

22

22

Niobium

92.90638
92.90638

23

23

Molybdenum

95.94
95.94

24

24

Technetium

98
98

25

25

Ruthenium

101.07
101.07

26

26

Rhodium

102.9055
102.9055

27

27

Palladium

106.42
106.42

28

28

Copper

63.546
63.546

29

29

Zinc

65.38
65.38

30

30

Ga

69.723
69.723

31

31

Ge

72.64
72.64

32

32

As

74.9216
74.9216

33

33

Se

78.96
78.96

34

34

Br

79.904
79.904

35

35

Kr

83.798
83.798

36

36

Rb

85.4678
85.4678

37

37

Sr

87.62
87.62

38

38

Y

88.90584
88.90584

39

39

Zr

91.224
91.224

40

40

Nb

92.90638
92.90638

41

41

Mo

95.94
95.94

42

42

Tc

98
98

43

43

Ru

101.07
101.07

44

44

Rh

102.9055
102.9055

45

45

Pd

106.42
106.42

46

46

Ag

107.8682
107.8682

47

47

Cd

112.411
112.411

48

48

In

114.818
114.818

49

49

Sn

118.710
118.710

50

50

Sb

121.760
121.760

51

51

Te

127.60
127.60

52

52

I

126.90445
126.90445

53

53

Xe

131.293
131.293

54

54

Ba

137.327
137.327

55

55

La

138.90471
138.90471

56

56

Ce

140.12
140.12

57

57

Pr

140.90765
140.90765

58

58

Nd

144.24
144.24

59

59

Pm

144.9126
144.9126

60

60

Sm

150.36
150.36

61

61

Eu

151.964
151.964

62

62

Gd

157.25
157.25

63

63

Tb

158.92534
158.92534

64

64

Dy

162.50
162.50

65

65

Ho

164.93032
164.93032

66

66

Er

167.259
167.259

67

67

Tm

168.93032
168.93032

68

68

Yb

173.0447
173.0447

69

69

Lu

174.967
174.967

70

70

Hf

178.49
178.49

71

71

Ta

180.94786
180.94786

72

72

W

183.84
183.84

73

73

Re

186.207
186.207

74

74

Os

190.23
190.23

75

75

Ir

192.222
192.222

76

76

Pt

195.084
195.084

77

77

Au

196.96657
196.96657

78

78

Hg

200.59
200.59

79

79

Tl

204.3833
204.3833

80

80

Pb

207.2
207.2

81

81

Bi

208.9804
208.9804

82

82

Po

209
209

83

83

At

210
210

84

84

Rn

222
222

85

85

Fr

223
223

86

86

Ra

226
226

87

87

Ac

227
227

88

88

Th

232.0377
232.0377

89

89

Pa

231.03688
231.03688

90

90

U

238.02891
238.02891

91

91

Np

237.04817
237.04817

92

92

Pu

244.06422
244.06422

93

93

Am

243.06138
243.06138

94

94

Cm

247.07035
247.07035

95

95

Bk

247.07035
247.07035

96

96

Cf

251.0833
251.0833

97

97

Es

252.0833
252.0833

98

98

Fm

257.1037
257.1037

99

99

Mn

54.938044
54.938044

100

100

Fe

55.845
55.845

101

101

Co

58.933194
58.933194

102

102

Ni

58.6934
58.6934

103

103

Cu

63.546
63.546

104

104

Zn

65.38
65.38

105

105

Ga

69.723
69.723

106

106

Ge

72.64
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107

107

As

74.9216
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78.96
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109

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Br

79.904
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110

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Kr

83.798
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111

111

Rb

85.4678
85.4678

112

112

Sr

87.62
87.62

113

113

Y

88.90584
88.90584

114

114

Zr

91.224
91.224

115

115

Nb

92.90638
92.90638

116

116

Mo

95.94
95.94

117

117

Tc

98
98

118

118

Ru

101.07
101.07

119

119

Rh

102.9055
102.9055

120

120

Pd

106.42
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121

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107.8682
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140.12
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132

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140.90765
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133

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Nd

144.24
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134

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144.9126
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137

137

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157.25
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162.50
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167.259
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Rn

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Tb

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214

214

Dy

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162.50

215

215

Ho

164.93032
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216

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217

217

Tm

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168.93032

218

218

Yb

173.0447
173.0447

219

219

Lu

174.967
174.967

220

220

Hf

178.49
178.49

221

221

Ta

180.94786
180.94786

222

222

W

183.84
183.84

223

223

Re

186.207
186.207

224

224

Os

190.23
190.23

225

225

Ir

192.222
192.222

226

226

Pt

195.084
195.084

227

227

Au

196.96657
196.96657

228

228

Hg

200.59
200.59

229

229

Tl

204.3833
204.3833

230

230

Pb

207.2
207.2

231

231

Bi

208.9804
208.9804

232

232

Po

209
209

233

233

At

210
210

234

234

Rn

222
222

235

235

Fr

223
223

236

236

Ra

226
226

237

237

Ac

227
227

238

238

Th

232.0377
232.0377

239

239

Pa

231.03688
231.03688

240

240

U

238.02891
238.02891

241

241

Np

237.04817
237.04817

242

242

Pu

244.06422
244.06422

243

243

Am

243.06138
243.06138

244

244

Cm

247.07035
247.07035

245

245

Bk

247.07035
247.07035

246

246

Cf

251.0833
251.0833

247

247

Es

252.0833
252.0833

248

248

Fm

257.1037
257.1037

249

249

Mn

54.938044
54.938044

250

250

Fe

55.845
55.845

251

251

Co

58.933194
58.933194

252

252

Ni

58.6934
58.6934

253

253

Cu

63.546
63.546

254

254

Zn

65.38
65.38

255

255

Ga

69.723
69.723

256

256

Ge

72.64
72.64

257

257

As

74.9216
74.9216

258

258

Se

78.96
78.96

259

259

Br

79.904
79.904

260

260

Kr

83.798
83.798

261

261

Rb

85.4678
85.4678

262

262

Sr

87.62
87.62

263

263

Y

88.90584
88.90584

264

264

Zr

91.224
91.224

265

265

Nb

92.90638
92.90638

266

266

Mo

95.94
95.94

267

267

Tc

98
98

268

268

Ru

101.07
101.07

269

269

Rh

102.9055
102.9055

270

270

Pd

106.42
106.42

271

271

Ag

107.8682
107.8682

272

272

Cd

112.411
112.411

273

273

In

114.818
114.818

274

274

Sn

118.710
118.710

275

275

Sb

121.760
121.760

276

276

Te

127.60
127.60

277

277

I

126.90445
126.90445

278

278

Xe

131.293
131.293

279

279

Ba

137.327
137.327

280

280

La

138.90471
138.90471

281

281

Ce

140.12
140.12

282

282

Pr

140.90765
140.90765

283

283

Nd

144.24
144.24

284

284

Pm

144.9126
144.9126

285

285

Sm

150.36
150.36

286

286

Eu

151.964
151.964

287

287

Gd

157.25
157.25

288

288

Tb

158.92534
158.92534

289

289

Dy

162.50
162.50

290

290

Ho

164.93032
164.93032

291

291

Er

167.259
167.259

292

292

Tm

168.93032
168.93032

293

293

Yb

173.0447
173.0447

294

294

Lu

174.967
174.967

295

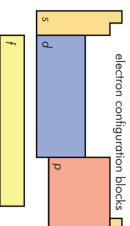
295

Hf

178.49
178.49

296

296</



electron configuration blocks

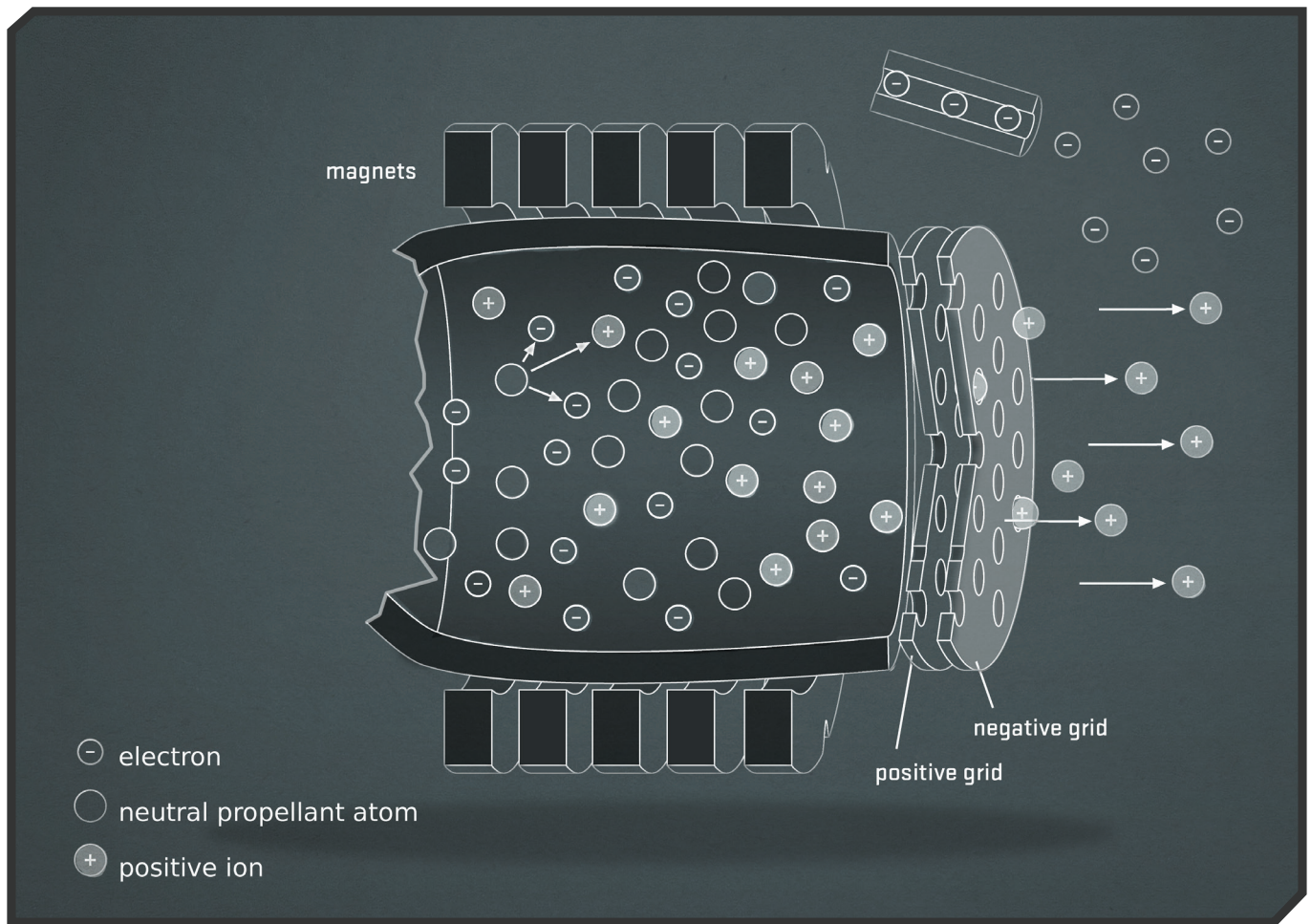
ies

- as of yet, elements 113-118 have no official name designated by the IUPAC

- $1 \text{ kJ/mol} \approx 96.485 \text{ eV}$.

- all elements are implied to have an oxidation state of zero.

[UNIDENTIFIED ION DRIVE]

**Characteristics Report on Unidentified Ion Drive**

- The ion drive was using some type of gas that was being sent out of the chamber. The gaseous element is colorless, tasteless, and odorless, but it's radioactive.
- Our analysis shows that it takes less energy (approximately 100 kJ/mol less) to ionize the gaseous element present in the unidentified ion drive than in most ion drives we're aware of (which use Xenon).
- As seen in the image above, the area where the electrons and gaseous element go into the chamber is damaged. Our analysis shows that this ion drive was operational and used while inside the Earth's atmosphere and generated enough thrust to go at a very high velocity. Given that most ion drives are used for deep-space missions and generate relatively minimal acceleration, this is extremely peculiar.
- There are more magnets attached to this ion drive, which may indicate that the rate of ions being shot out of the chamber is higher than a standard ion drive.



Avengers Report:
Re: Engine analysis

1. Explain, in your own words, or illustrate what happens to an atom when it is ionized.

1b. What is a positive ion? What is a negative ion?

2. Explain the purpose of an ion drive. (NOTE: Will be able to answer this more fully with outside research.)

2b. Explain, step-by-step, the process of an ion drive.

3. What other noble gases are there?

3b. What do you notice about how the noble gases are organized? What does this mean?

4. What are some characteristics of noble gases? (NOTE: Will be able to answer this more fully with outside research.)

5. A typical ion drive uses Xenon ions. Does this unidentified ion drive use the same element? If not, which element is it?

6. If the ion drive was able to create enough force to generate high acceleration, what does that tell us about the amount of gas inside the ion drive?