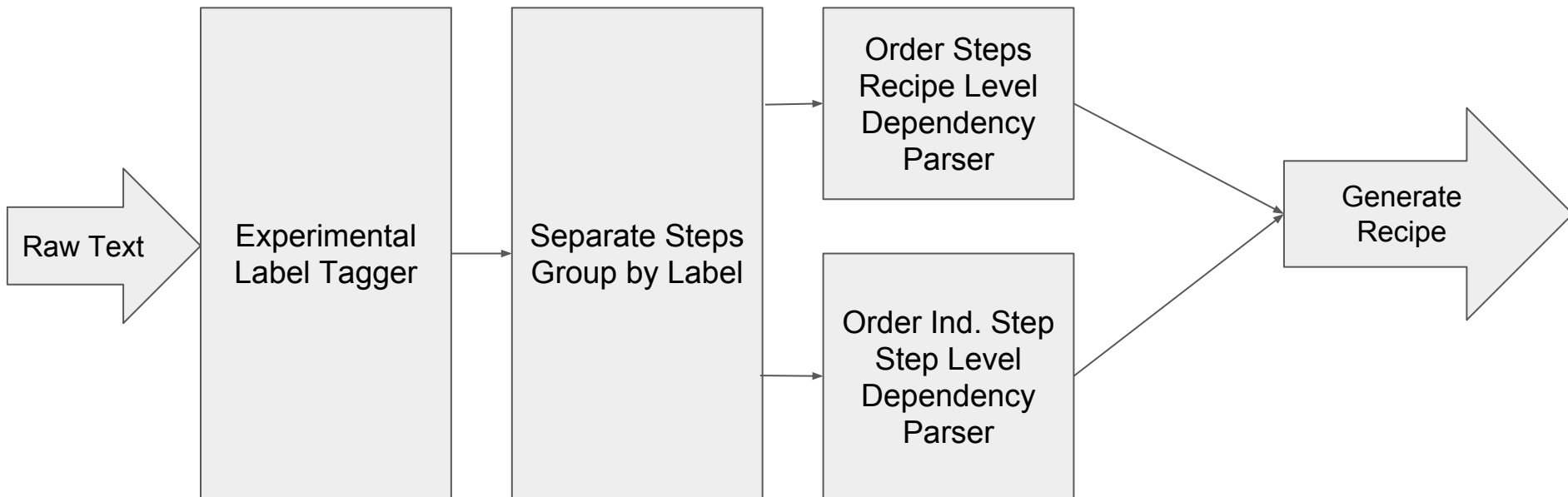


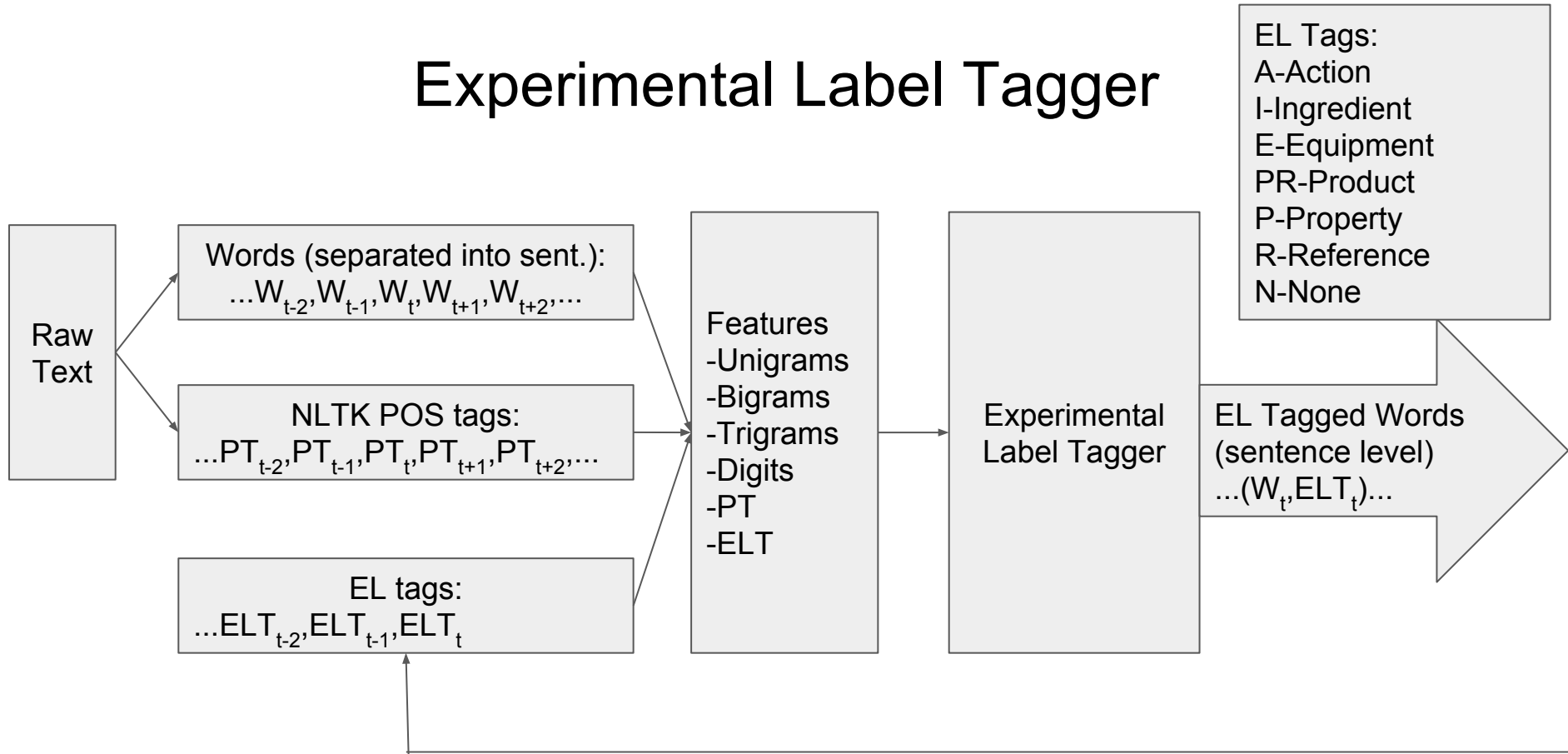
Turning Experimental Procedures into Machine- Readable Recipes

William Spitzer, Menghsuan Sam, Iveel Tsogsuren

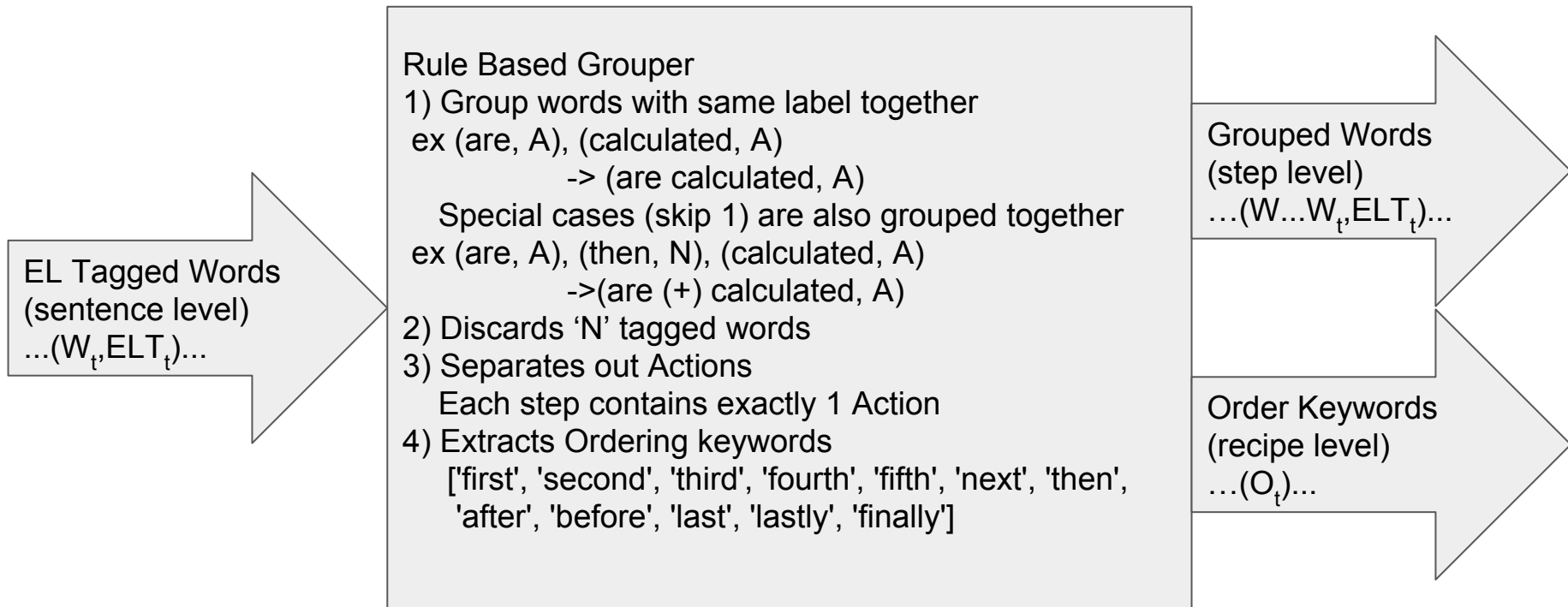
Process



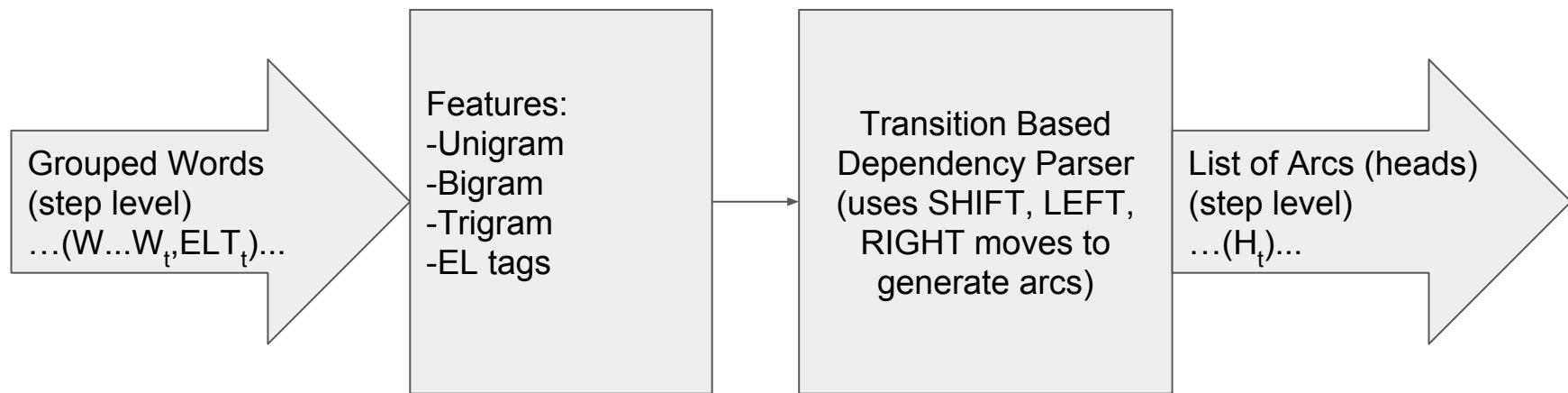
Experimental Label Tagger



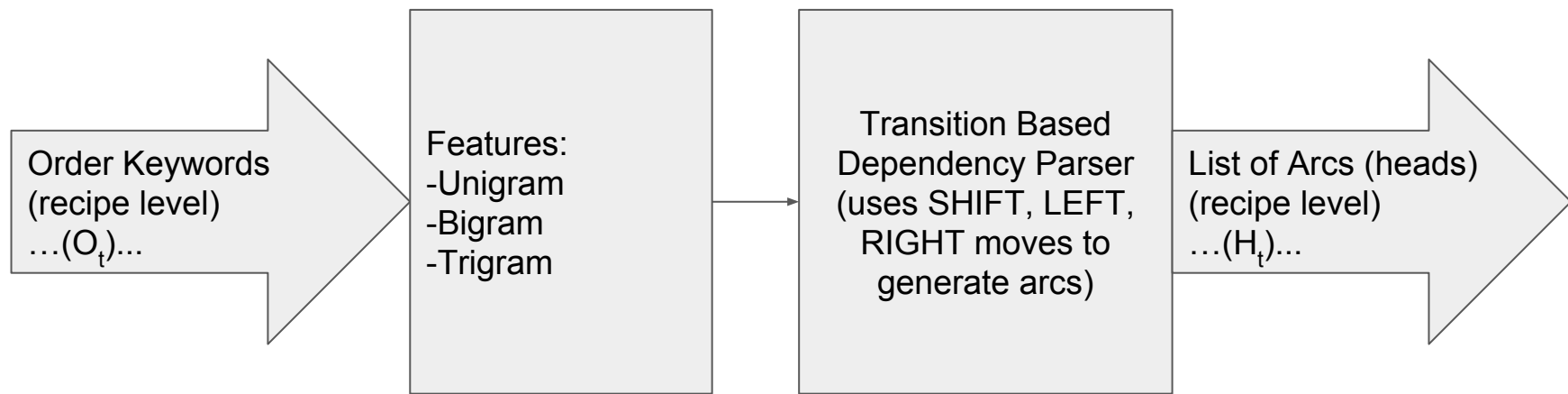
Experimental Label Grouper and Step Sorter



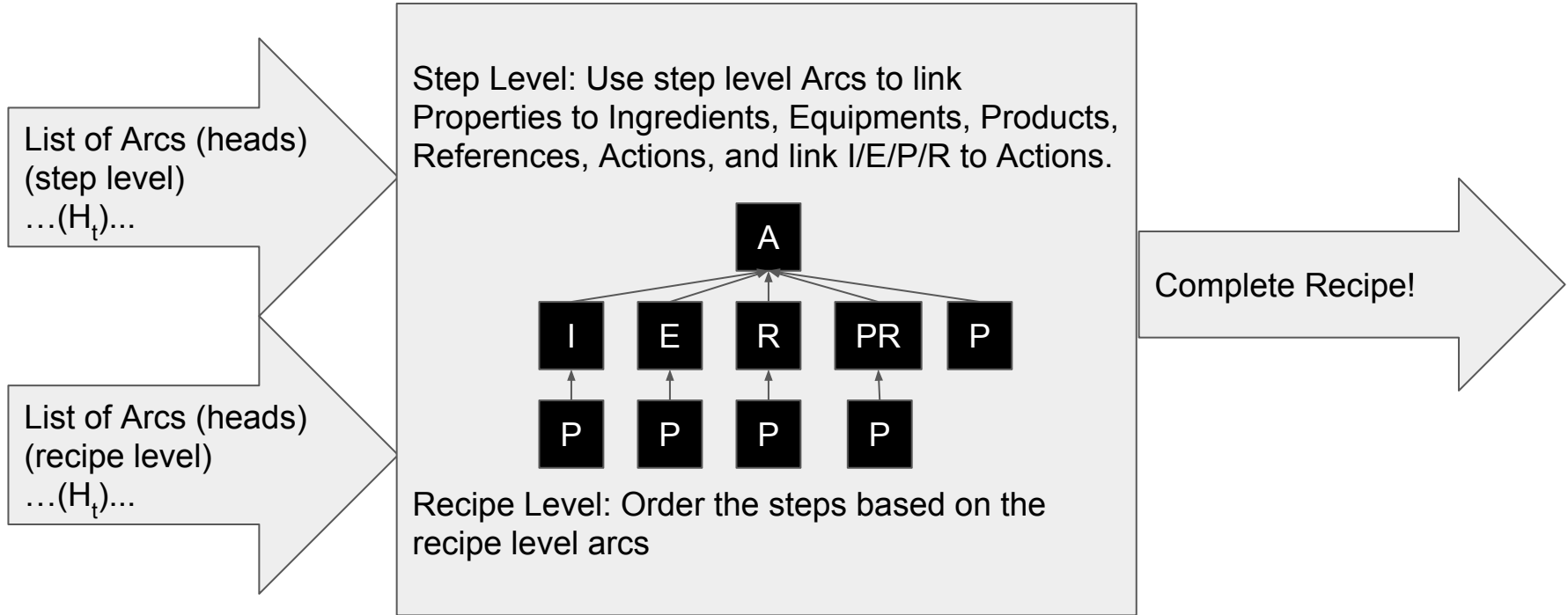
Dependency Parser for Grouped Words



Dependency Parser for Recipe Steps



Generating Complete Recipe



Sample Output

```
Python 2.7.10 Shell
File Edit Shell Debug Options Window Help
Step 1:
{'A': [{'were pulverized', 'E': [{'S/C composites', {}}, {'ball mill', {}]}]}
Step 2:
{'A': [{'sieved', 'P': [{'25 m opening stainless steel sieve .', {}]}]}
Step 3:
{'A': [{'were prepared', 'I': [{'anhydrous N-methyl-2-pyrrolidinone (NMP)', 'P': [{'1 wt %'}]}], 'P': [{'ratio of 1:5', {}}, 'E': [{'S/C composites', {}}, {'solution', {}]}]}]}
Step 4:
{'A': [{'were applied', 'PR': [{'slurries', {}}, 'P': [{'10', {}}, {'120 C (+ 4 h', {})}]}]}
Step 5:
{'A': [{'prepared', 'P': [{'24.1 wt % sulfur loading', 'P': [{'25.2 wt % were'}]}], 'E': [{'identical procedure', {}]}]}
Step 6:
{'A': [{'was used', 'E': [{'S/C', {}]}]}
Step 7:
{'A': [{'were assembled', 'PR': [{'batteries', {}}, 'P': [{'Swagelok', {}}, {'7', {}}, {'10 mm diameter', {}}, 'E': [{'S/C composite coated aluminum foil (10 mm diameter', {}}, {'lithium foil (7 mm thickness', {}}, {'organic', {}}, 'I': [{'Celgard 3225 separator (10.3 mm diameter', {})}]}]}]}
Step 8:
{'A': [{'were', 'PR': [{'organic electrolytes', {}}, 'I': [{'(trifluoromethane)sulfonamide lithium (LiTFSI) (99.95% trace', {}}, {'(DOL)', {}}, 'P': [{'55: 40', {}]}]}]}
Step 9:
{'PR': [{'organic electrolyte', 'A': [{'filled', {}]}]}
Step 10:
{'A': [{'were pressed', 'E': [{'spring', {}]}]}
Step 11:
{'A': [{'were tested', 'PR': [{'batteries', {}}, 'E': [{'Maccor 4000 series battery tester', {}]}]}]}
Step 12:
{'A': [{'were cycled', 'PR': [{'batteries', {}}, 'P': [{'between 1.0 to 3.6 V', {}]}]}]}
Step 13:
{'A': [{'was started', {}]}]}
Step 14:
{'A': [{'were tested', 'P': [{'0.5 mA', {}}, 'R': [{'batteries', {}]}]}]}
Step 15:
{'A': [{'was set', 'P': [{'0.05', {}]}]}]}
Step 16:
{'A': [{'is', 'I': [{'discharge', {}}, {'sulfur', {}]}]}]}
>>>
```