

1 Cognitive reasoning in the chemical sciences 4.10

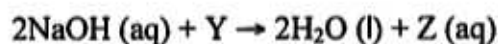
Let's Play Jeopardy!

1. A 4.0 L sample of O₂ gas has a pressure of 1.0 atm. A 2.0 L sample of N₂ gas has a pressure of 2.0 atm. If these two samples are mixed and then compressed in a 2.0 L vessel with temperature constant, ...
2. 4.00 g of sulfur and 9.48 g of element Q react completely to yield a compound with molecular formula SQ₄.
3. A piece of Ca is irradiated with light of wavelength 410 nm, ejecting electrons with speed 3.29×10^5 m/s
4. Copper (Cu) atoms occur in nature with only two different isotopes. The more common type has mass 62.9296 u and the natural abundance 69.171%. ...
5. The nuclear charge experienced by an electron in an atom results from shielding by the other electrons. Here are two rules for estimating this shielding.
 - (i) An electron with the same principal quantum number shields 0.35|e| of nuclear charge, meaning that electrons of the same principle quantum number spend approximately 35% of their time closer to the nucleus.
 - (ii) An electron with a lower principal quantum number shields 1.0|e| of nuclear charge, meaning that electrons of the same principle quantum number spend approximately 100% of their time closer to the nucleus.

An atom of phosphorous (P) absorbs light, taking a 3p electron to a 4s orbital.

6. An atom of hydrogen can emit light in a process that leaves the electron in its lowest energy state. The longest wavelength of light that can be emitted in such a process is called λ_a , and the next longest wavelength is called λ_b .
7. A compound containing only carbon (C), Hydrogen (H) and oxygen (O) was analyzed using combustion. After complete combustion a 7.310 g sample of this compound produced 14.606 g of CO₂ and 5.9805 g of H₂O. Another analysis shows that the molecular mass of this compound is between 50 and 100 g/mole.
8. Two evacuated bulbs of equal volume are connected by a tube of negligible volume. One of the bulbs is placed in a constant-temperature bath at 225.0 K and the other bulb is placed in a constant-temperature bath at 350.0 K. Exactly 1 mole of an ideal gas is injected into the system. ...
9. A compound is 85.6% carbon by mass. The rest of the compound is hydrogen. When 10.0 grams of the compound is evaporated at 50.0 °C, the vapor occupies 6.30 L at 1.00 atm pressure. ...
10. The first ionization of one atom of Na is 8.233×10^{-19} J.
11. The combustion of ammonia, NH₃, produces only NO and water, H₂O. 7.41 g of O₂ are combined with 5.23 g NH₃, and the reaction proceeds
12. The density of a 20.0% by mass of ethylene glycol (C₂H₆O₂) solution in water is 1.03 g/mL. ...
13. A compound contains only C, O and H. During combustion, 3 water (H₂O) molecules are produced for every molecule of compound consumed. Combustion of 10.0 g compound in excess oxygen yields 24.0 g carbon dioxide (CO₂) and 4.90 g water (H₂O).

14. For the ground state of the Li atom, the Z_{eff} for a 2s electron is 1.28. An excited state of Li corresponds to the orbital configuration $1s^2 2p^1$, and it is found that Z_{eff} for the 2p electron in the excited state Li atom is 1.02.
15. A compound contains only atoms C, H, O, and S. The combustion of 5.00 g of compound produces 4.83 g CO_2 , 1.48 g H_2O and 3.52 g SO_2 .
16. The compound whose empirical formula you determined in the problem above is called Y. Compound Y reacts with aqueous sodium hydroxide to produce water and a product called Z, according to the balanced equation.



5.00 g of compound Y and 27.5 mL of 2.00 M NaOH (aq) react completely, with neither material left over.

17. Hard water often contains dissolved Ca^{2+} and Mg^{2+} cations. One way to soften water is to add phosphates. The phosphate anion (PO_4^{3-}) combines with the cations to form insoluble precipitates [$\text{Ca}_3(\text{PO}_4)_2$ and $\text{Mg}_3(\text{PO}_4)_2$], removing the cations from solution. Suppose that a solution is 0.050 M in CaCl_2 and 0.085 M in $\text{Mg}(\text{NO}_3)_2$. You have 1.5 L of this solution ...
18. Chlorine atoms exist in nature as 2 isotopes: ^{35}Cl with mass 34.969 u and ^{37}Cl with mass 36.966 u. Imagine that extraterrestrials visit and replace each atom of ^{37}Cl with one atom of super-heavy Cl isotope of mass 49.933 u.
19. Each carbon atom in a sample absorbs one photon of light at a wavelength of 150.0 nm. All of the carbon atoms then relax back to their original states. The total amount of energy emitted by the carbon sample is 1.98×10^5 J. ...
20. An excited hydrogen atom with an electron in the $n=5$ state emits light having a frequency of $6.90 \times 10^{14} \text{ s}^{-1}$