1 Cognitive reasoning in the chemical sciences 4.10

Let's Play Jeopardy!

1. A 4.0 L sample of O_2 gas has a pressure of 1.0 atm. A 2.0 L sample of N_2 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 SQ_4.

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 CO_2 and 5.9805 g of H_2O. 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, NH_3, produces only NO and water, H_2O. 7.41 g of O_2 are combined with 5.23 g NH_3, and the reaction proceeds

12. The density of a 20.0% by mass of ethylene glycol ($C_2H_6O_2$) solution in water is 1.03 g/mL. …

13. A compound contains only C, O and H. During combustion, 3 water (H_2O) molecules are produced for every molecule of compound consumed. Combustion of 10.0 g compound in excess oxygen yields 24.0 g carbon dioxide (CO_2) and 4.90 g water (H_2O).

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 problrm above is called Y. Compound Y reacts with aqueous sodium hydroxide to produce water and a product called Z, according to the balanced equation.

$$2NaOH\ (aq) + Y \rightarrow 2H_2O\ (l) + Z\ (aq)$$

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 [$Ca_3(PO_4)_2$ and $Mg_3(PO_4)_2$], removing the cations from solution. Suppose that a solution is 0.050 M in $CaCl_2$ and 0.085M in $Mg(NO_3)_2$. 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 6.90×10^{14} s^{-1}. ...