# 1 Cognitive reasoning in the chemical sciences 5.12

1 Let's play Jeopardy!

1. A widely prescribed allergy medication is entirely composed of C, H, Cl, N, and O. It is 54.62 mass percent C, 5.89 mass percent H, 23.02 mass percent Cl and 6.07 mass percent N. Its molar mass is less than 600 g/mol.

2. An electron in a Li^{2+} occupies the $4p_x$ atomic orbital. Light is absorbed by this ion, causing an electron to fly off with speed 1.60×10^6 m s^{-1}.

3. An unmanned space probe *Titania* visits the surface of the newly discovered planet Oz. The probe determines the surface atmospheric pressure is 4.37 times that of the Earth's atmosphere, the surface temperature is 357.4 K, and that the atmosphere contains only two types of molecules, water and oxygen (O_2). An 10.0 L flask is filled with a gas sample from Oz's atmosphere and then tightly sealed. The gas in the flask has a mass of 52.7 g.

4. Given below is the contour map of an atomic orbital. *Dark grey* is positive and *light grey* is negative.
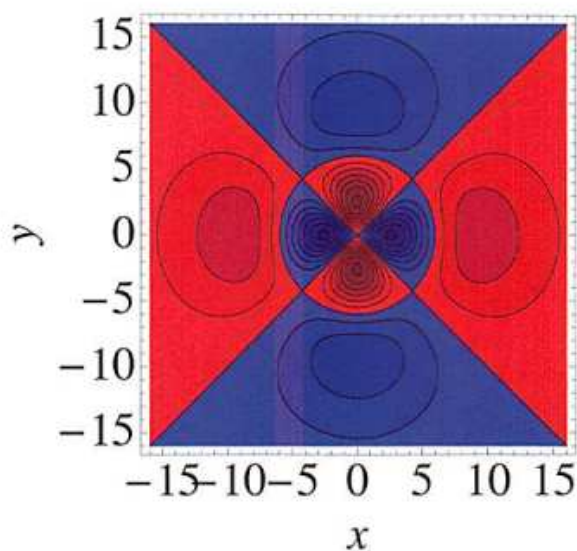
5. Three radial functions given below could correspond with the contour map given in the problem above.
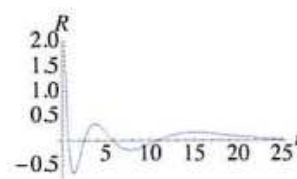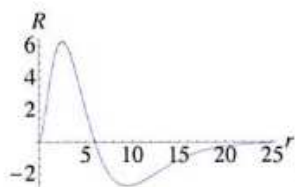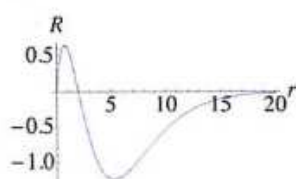
6. After three weeks of Chem 2070 you have an upset stomach and decide to take Pepto-Bismol. You know from reading the bottle that the active ingredient contains *at least three* (there

could be another) elements: C, H, Bi. Combustion of 0.22105 g of the active ingredient produced 0.1422 g of Bi_2O_3, 0.1880 g of CO_2 and 0.02750 g of water.

7. An explorer visits a new planet. The atmosphere is entirely composed of H_2 and Ar. A flask capable of effusion is filled with a sample of this gas. On a gram basis 78.4% of the effusing gas is Ar.

8. Upon heating, 120.34 g of a mixed $AlCl_3$ and $CaCl_2$ sample is reduced into 33.456 g of a metallic alloy which contains no chlorine. No metal atom leaves the sample.

9. The OH radical has been observed in interstellar space. In making an MO diagram for this molecule consider only the O $2p$ AOs and the H $1s$ AO. The O $2p$ AOs can combine with the H $1s$ orbital. The O $2p$ AO energy is -15.8 eV and the H $1s$ AO energy is -13.6 eV.

10. A 50 mg sample of dental cement, composed of a single chemical compound, contains 16.58 mg oxygen, 8.02 mg phosphorous, and 25.40 mg zinc. The molecular mass of this compound is between 250 and 400 g/mol.

11. An ion has a single electron. The longest wavelength of radiation absorbed by this ion in its lowest energy state is 7.60 nm.

12. In the thermite reaction, Fe_2O_3 reacts with aluminium to produce Al_2O_3 and iron. 59.3 g of Fe_2O_3 is mixed with 14.8 g aluminium.

13. Liquid ethyl mercaptan, C_2H_6S has a density 0.84 g/mL combusts entirely into carbon dioxide, water, and sulfur dioxide. You have a sample of 6.21 mL ethyl mercaptan.

14. A solid mixture of $MgCO_3$ and $CaCO_3$ is heated and decomposes into MgO, CaO and CO_2. A 36.00 g sample of this mixture produces 18.00 grams carbon dioxide.

15. An unknown compound X undergoes the reaction

$$2X + H2SO_4 \longrightarrow 2HX + SO_4^{2-}.$$

19.32 g of pure X compound reacts with 18.3 mL of 6.00 M H_2SO_4 solution, completely converting the acid into sulfate ions and completely converting all the X into HX.