Stoichiometry and ideal gases exam

Name:

Unless otherwise stated, present your results with 3 sf.
Show your calculations and/or write your reasoning in all exercises.

1. Calculate:
a) How many moles of nitric acid are there in 77g? [2]

b) How many grams of sulfuric acid are there in 0.0086 mol? [2]

2. Butane (C_4H_{10}) reacts with oxygen in a combustion reaction.

a) Write and balance said reaction [2]

b) If we have 44g butane and 100g oxygen, which is the limiting reactant? [2]

c) Which is the limiting reactant if we have the same amount of butane as in b but we have 150g oxygen? [2]

d) In the case of section c, how much (in g) will be left of the other reactant? [3]

3. We want to prepare 250ml of a solution of potassium permanganate $KMnO_4$ $3 \cdot 10^{-4}$ M.
a) How much (in g) potassium permanganate must we weight in the balance? [2]

b) It turns out that the solution we prepared in a is too concentrated for our experiment, so in order to save time, we pour the entire solution in a 2l flask and add water until the volume reaches 2l. What would be the new concentration? [2+1bonus]

4. We wish to prepare 500 ml of a phosphoric acid solution 0.5M, and for this we have two bottles of phosphoric acid, the first one is an opened bottle of a concentrated solution of 85% w/w and density 1.68 g/ml, but this bottle contains only 50ml. The second bottle is an unopened bottle of phosphoric acid 2M.
Will we have enough with the first bottle? If so, how many ml will we have to use? If not, how many ml of the second bottle will we need to add? [4]

5. We wish to prepare 0.5l of a 8M solution of hydrochloric acid, and for this we have a large bottle of HCl 20% w/w and a density of 1.15 g/ml.
Explain how you would prepare the required solution [3]

6. Capsaicin is the chemical compound that gives food the “hot” feel by overactivating the heat receptors in the mouth (and indeed everywhere it touches). Its molecular formula is $C_{18}H_{27}NO_3$
Calculate the percentage of the weight that is due to each element that makes up capsaicin. [2]

7. Theobromine, the main alkaloid present in chocolate, has a molecular mass somewhere around 200 amu, of which 46.66% is due to carbon atoms, 4.484 % is due to hydrogen, 17.76% is oxygen and 31.1% is due to nitrogen.
Find the molecular formula of theobromine. [4]

8. Aluminium sulphate is used to treat sewage. It can be made by making aluminium hydroxide $Al(OH)_3$ react with sulphuric acid.
a) Write and balance this chemical equation [2]

b) If we have 500g aluminium hydroxide, how much sulphuric acid (in g) would be needed? [2]

c) If we want to prepare 12kg aluminium sulphate and the reaction has a nice percentage yield of 92%, how much (in g) of each reactant do we need? [3]

9. A hydrochloric acid solution 0.6M is titrated with a solution of a special base that is used as primary standard. For the sake of simplicity we will call this base $B(OH)_2$
A 0.1M solution of $B(OH)_2$ is prepared very carefully using the high-precision scale, and said solution is used to titrate the hydrochloric acid solution.
30ml of hydrochloric acid solution required 60ml of the $B(OH)_2$ solution to be neutralised.
a) Discuss what the concentration of hydrochloric acid solution is and how you can tell. [4]

10. An antacid tablet contains sodium hydrogen carbonate $NaHCO_3$. This compound reacts with stomach acid to generate carbon dioxide and water, in a number of possible reactions all of which generate one mole of carbon dioxide per mole of $NaHCO_3$.
a) Assuming that a tablet contains 1g sodium hydrogen carbonate, calculate the volume of the carbon dioxide at STP conditions. [3]

b) Intestinal gas is most often gas that is not generated in the intestine but rather air that has been ingested or sometimes carbon dioxide that has not been released via eructation.
Assuming that the carbon dioxide in section a passes into the lower intestine and that the body applies a pressure of 0.06 atm on its organs, calculate the volume of this gas in the intestine, at a cozy temperature of 36.5ºC. [3]

c) Discuss whether this gas will occupy less or more space when it eventually is released [3]

11. One of the possible ways in which stored bleach (sodium hypochlorite, NaOCl) could spontaneously degrade in the warm spanish summer is this:

$NaOCl_{(aq)} \rightarrow NaCl_{(aq)} + O_{2\,(g)}$ note: not balanced

If we have an IBC tank containing 600 l of NaOCl solution 4M, calculate the volume of oxygen that would be released if half of the bleach decomposes (assume 1.006 atm and a temperature of 43ºC). [4]