Stoichiometric calculations test

Chemistry IB11

Name:
Date:

Show all calculations.
Unless stated otherwise, all results must be provided with three significant figures.
Use the atomic weights from the periodic table provided

1 H 1																	2 He 4
3 Li 6	4 Be 8											5 B 10	6 C 12	7 N 14	8 O 16	9 F 19	10 Ne 20
11 Na 23	12 Mg 24											13 Al 27	14 Si 28	15 P 31	16 S 32	17 Cl 35.5	18 Ar 40
19 K 39	20 Ca 40	21 Sc 45	22 Ti 48	23 V 51	24 Cr 52	25 Mn 55	26 Fe 56	27 Co 59	28 Ni 58.7	29 Cu 63.5	30 Zn 65	31 Ga -	32 Ge -	33 As 75	34 Se 79	35 Br 80	36 Kr 85
37 Rb 84.5	38 Sr 87.5	39 Y -	40 Zr -	41 Nb -	42 Mo -	43 Tc -	44 Ru -	45 Rh 103	46 Pd 106.5	47 Ag 108	48 Cd -	49 In -	50 Sn 119	51 Sb -	52 Te -	53 I 127	54 Xe 131
55 Cs 133	56 Ba 137	57 La -	58 Hf -	59 Ta -	60 W -	61 Re -	62 Os 190	63 Ir 192	64 Pt 195	65 Au 197	66 Hg 200.5	67 Tl -	68 Pb 207	69 Bi -	70 Po -	71 At -	72 Rn 222
73 Fr -	74 Ra -	75 Ac -															

1. a) Calculate the number of atoms in 0.000001 g of fluorine. (2 0 0)
b) Calculate the weight of 689954754754 atoms of osmium. (2 0 0)

2. A pyrotechnic is preparing thermite for a demonstration, and he mixes 300g of iron (III) oxide Fe_2O_3 and 90g aluminium. The unbalanced reaction that takes place is

$$Fe_2O_3 \ + \ Al \quad \rightarrow \quad Al_2O_3 \quad + \quad Fe$$
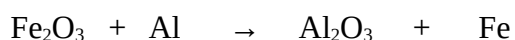
The reaction releases a large amount of heat and, although the reagents are solid, the resulting iron is extremely hot and therefore molten.
The pyrotechnic seeks to optimize the blend so that as little of the reagents as possible is wasted, so

he reasons that, since there are only 90g of aluminium, he should try again with 100g of said reagent.

a) Given the intially described amounts (300 and 90 g respectively), which is the limiting reagent? (3 2 0)

b) How much of the other one won't react? (0 2 0)

c) How many grams of iron will form if the yield is only 67%? (1 2 0)

d) How could the pyrotechnic change the amounts in order to optimize the blend? (0 1 2)

3. Hydrochloric acid is an aqueous solution of hydrogen chloride HCl, which in standard conditions is a gas.
A solution of HCl has a concentration of 36% in weight and a density of 1190.

a) How much HCl (in grams and mols) is there is 110 ml of this solution? (0 2 0)

b) A bottle with 1 l of this solution is accidentally left open inside its refrigerated cabinet, which is at 2 degrees celsius and has a volume of 0.6 . If all the hydrogen chloride in the solution evaporates out of the solution, how much (in grams) will leak out of the cabinet? (assume that the inside of the refrigerated cabinet ends up full of pure HCl) (2 2 1)

4. A gas is trapped in a container with a movable lid as shown in the figure.
The weight on the lid ensures that the pressure is 3.5 atm.
Prove that if the temperature rises from 0 to 100 ºC the volume will increase by 36.63% (0 2 2)
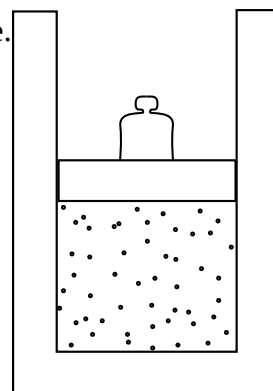
5. We want to prepare 1.2 l of a 0.09 M solution of silver nitrate $AgNO_3$
Calculate the weight of silver nitrate we have to use. (1 1 0)

6. A lab assistant needs to prepare 2.3 l of phosphoric acid H_3PO_4 1.5 M, and she has an opened bottle of phosphoric acid 75% in weight and a density of 1.69 kg/l , but it only contains 250 ml. There is another unopened bottle of H_3PO_4 10% in weight and density 1.05 kg/l which contains 5l of the solution.

a) Is there enough phosphoric acid in the opened bottle to prepare the solution? If so, how much of it (in ml) must she pick? If not, how much of the other solution must she add? (2 2 0)

Bonus
b) The lab assistant reasons that, in order to minimize measuring errors, she should pick only from one bottle, either the opened one or the unopened one. Is this possible? (0 1 2)

7. Amphetamine is a strong stimulant drug that acts in the neurons forcing them to activate. It was widely used in the 80s by people who wanted to lose weight, but its use was restricted due to its addictiveness. Its elemental composition is:
80.00% C
9.6296% H
rest: N
Mass spectrometry also revealed that it only contains one atom of nitrogen.
Calculate its empirical and molecular formulas. (2 2 0)

8. An acid-base titration has been carried out in order to determine the concentration of nitric acid in an old bottle whose label is partially illegible.
The base used as a titration agent is calcium hydroxide $Ca(OH)_2$ with a concentration of 0.250 M which has been accurately prepared (by the lab assistant from exercise 6) by measuring the appropriate mass of $Ca(OH)_2$ and dissolving it in water until reaching a final volume of one litre.
The unbalanced reaction is:

$$Ca(OH)_2 \ + \ HNO_3 \ \rightarrow \ Ca(NO_3)_2 \ + \ H_2O$$
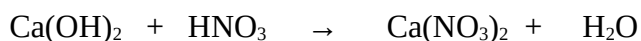
In the erlenmeyer we put 6.80 ml of the solution found in the bottle, and in order for the indicator to change colour, 15.15 ml of the $Ca(OH)_2$ solution had to be added.

a) Balance the equation (1 0 0)
b) Calculate the concentration of the nitric acid in the bottle. (1 2 0)

Bonus
c) The professor pops up by the lab and mentions that the bottle cannot possibly be of nitric acid, because they used to have a different type of label, the bottle is surely sulfuric acid H_2SO_4 .
Recalculate the concentration knowing this. (0 2 1)