Chem 12

Unit 1 Review Questions… so far… **ANSWER KEY**

PLEASE NOTE! The chemical reactions given throughout this worksheet ARE NOT BALANCED!

1. Ozone is an important component of the atmosphere that protects us from the ultraviolet rays of the Sun. Certain pollutants encourage the decomposition of Ozone:
$O_3 (g) \rightarrow O_2 (g)$, at a rate of 6.5×10^{-4} M/s. (remember that M = **moles/L**)
How many molecules of O_2 gas are formed in each litre of atmosphere every day by this process?

$2O_3 (g) \rightarrow 3O_2 (g)$

$\frac{6.5 \times 10^{-4} \text{ moles}}{\text{L/s}} \times \frac{3\ O_2}{2O_3} \times \frac{6.02 \times 10^{23} \text{ molecules}}{\text{mole}} \times 1\text{ L} \times \frac{60\text{s}}{\text{min}} \times \frac{60\text{ min}}{\text{hr}} \times \frac{24\text{ hr}}{\text{day}} = 5.1 \times 10^{25}\ O_2 \text{ molecules/day}$

2. Propane gas combusts in camp stoves to produce energy to heat your dinner. Assume that the gas is combusted at a rate of 1.10 g of C_3H_8 /min. How long would it take to produce 6.75 L of CO_2 gas measured at STP?

$C_3H_3 (g) + 5\ O_2 (g) \rightarrow 3CO_2 (g) + 4\ H_2O (g)$

$\frac{1.10\text{g}}{\text{min}} \times \frac{1\text{ mole}}{44.0\text{g}} = 0.0250 \text{ mole/min}$ $\qquad$ 0.0750 mole/min

$6.75\text{ L} \times \frac{1\text{ mole}}{22.4\text{L}} \times \frac{1\text{ min}}{0.075\text{ mole}} = 4.02\text{ min}$

3. A 2.65 g sample of calcium metal is placed into water. The metal is completely consumed in 25.0 s. Assuming the density of water is 1.00 g/ml at the reaction temperature, how long would it take to consume 5.00 mL of water as it converts into products?

$Ca (s) + 2H_2O (l) \rightarrow Ca(OH)_2 (aq) + H_2 (g)$

$2.65\text{g Ca} \times 1\text{ mole}/40.1\text{ g} = 0.661\text{ mole Ca}$

$0.661\text{ mole Ca} / 25.0\text{ s} = 0.00264\text{ moles / s}$

$Ca (s) + 2H_2O (l) \rightarrow Ca(OH)_2 (aq) + H_2 (g)$
0.00264 moles / s $\qquad$ 0.00529 mole/s

$5.00\text{ ml} \times \frac{1.00\text{g}}{\text{ml}} \times \frac{1\text{ mol}}{18.0\text{g}} \times \frac{1\text{ s}}{0.00529\text{ mole}} = 52.5\text{ s}$

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4. Consider the following reaction:
$Cu(s) + HNO_3(aq) \rightarrow CuNO_3(aq) + H_2O(l) + NO_2(g)$

a) if 5.00 g of copper solid is completely reacted in 250.0 mL of excess nitric acid in 7.00 min. at STP, calculate the rate of the reaction in:
i) g Cu/min.

$Cu(s) + 2\ HNO_3(aq) \rightarrow CuNO_3(aq) + H_2O(l) + NO_2(g)$

g Cu/min.
= 5.00g / 7.00 min
= 0.714 g / min

ii) mol HNO_3/min.

$$\frac{0.714\ g}{min} \times \frac{1\ mol}{63.5\ g} \times \frac{2\ HNO_3}{1\ Cu} = 0.0224\ mol/min$$

iii) g NO_2/min

$$\frac{0.0112\ mol\ Cu}{min} \times \frac{1\ NO_2}{1\ Cu} \times \frac{46.0\ g}{mol} = 0.519\ g/min$$

Please note that I do not round off as I go along – I only round off to the appropriate number of sig figs when I am DONE the calculation. So my answers may have a different final digit that the answer you achieved. Remember the last digit of any number is the uncertain digit. So if your answer was 0.515 g/min, consider it correct.

b) Assume the reaction continues at this average rate for 10.0 min total time. Determine the final:
i) mL NO_2 formed at STP

$$\text{Average rate} = \frac{0.0112\ mol}{Min} \times \frac{1\ NO_2}{1\ Cu} \times 10\ min \times \frac{22.4\ L}{mol} = 2.51\ L = 2510\ ml$$

ii) molarity of $CuNO_3$

$$5.00g\ Cu \times \frac{1\ mol}{63.5g} \times \frac{1\ CuNO_3}{1\ Cu} = 0.0787\ mol\ CuNO_3^{**}$$

$$[CuNO_3] = \frac{.0787\ mol}{250.0\ ml\ \text{of original solution volume}} = 0.315\ mol/L$$

** The question said "Determine the final" - since the original question said 5.00 g of copper is completely reacted, I know that 5.00 g of copper (or 0.0787 moles) totally reacts. This means that due to the 1:1 ratio, 0.0787 moles of $CuNO_3$ is formed. Note: some of you are tempted to used the 0.112 mol/min and multiple by 10 minutes. However, the most accurate way to get the moles of $CuNO_3$ formed is by mole stoichiometry of the limiting reagent, Cu, with the original data.) Some of you would debate that 0.448 mol/L is the correct answer, (if we are following the instructions in question b as per the 10 minute reaction time). There is a time discrepancy in the set up of this question (is it 7.00 minutes of total reaction time or 10 min???), and we could also take a second look at our answer for the mL NO_2 formed at STP.

c) Describe SIX ways you might measure the reaction rate. Include the equipment required, measurements made, and units for the rate. You may use a labeled diagram.
Please refer to your notes entitled: 6.3 How rates are measured.

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5. Consider the graph for this reaction:

$CaCO_3\,(s) + 2\,HCl\,(aq) \rightarrow CaCl_2\,(aq) + H_2O\,(l) + CO_2\,(g)$

a) Determine the instantaneous rate at the following times:

NOTE! The most accurate way to determine instantaneous rate is to draw a tangent line at that point, and calculate the slope of the tangent.

i) the instant after 0 min. ("initial rate") = slightly higher than 0 ml/min; possibly as high as 20 ml/min depending on where you are looking.

ii) 1 min. = approx. 20 ml / min

iii) 4 min. = approaching 0 ml/min (Calculus! As reaction comes to a finish, the rate will approach zero).

b) How do these rates compare? What do you suppose causes this pattern?

The rate starts at zero (as it did in our lab experiment) since the reactants have not started reacting yet. Very soon after the 0 min start time, the rate increases rapidly to an average rate. The rate is almost level (almost a horizontal tangent line) at 4 min. as the reactants are starting to be used up and the reaction is slowing to a stop.

6. Given the following reactants, complete this reaction:

$Sr\,(s) + 2HCl\,(aq) \rightarrow SrCl_2\,(aq) + H_2\,(g)$

a) Calculate the average rate of reaction in moles of HCl consumed per second over the first 50.0 s.

$$\text{Rate} = \frac{72.0\text{ ml} - 0\text{ ml}}{50.0\text{s} - 0\text{s}} = 1.44\text{ ml/s } H_2$$

$$1.44\ \frac{\text{ml}}{\text{s}} \times \frac{10^{-3}\text{ L}}{1\text{ ml}} \times \frac{1\text{ mol}}{22.4\text{ L}} \times \frac{2\text{ mol HCl}}{1\text{ mol } H_2} = 0.000129\text{ mol/s HCl}$$

b) Calculate the mass of strontium consumed in this 50.0s period.

$$\frac{0.000129\text{ mol HCl}}{\text{s}} \times \frac{1\text{ Sr}}{2\text{ HCl}} \times \frac{87.6\text{ g}}{\text{mol}} \times 50.0\text{ s} = 0.282\text{ g Sr}$$

c) Why did the volume of gas collected decrease in each increment until 50.0 s?

The volume of H_2 gas produced in each 10 s increment gets less as the reaction proceeds because the rate slows as reactants get used up in the reaction.

d) Why did the volume of gas remain unchanged from 50.0 s to 60.0 s?

The reaction was done at 50 s. All reactants are consumed by this time.