Extra Rates Questions

1. After increasing the concentration of the acid, the rate of hydrogen gas production increased from 0.20 moles/minute to 0.020 moles/s. (No typo; 0.020 moles/s is a greater rate than 0.20 moles/minute. Show why.). Find the ratio of t_2/t_1, where t_2 is the new reaction time and t_1 is the original reaction time for the lower concentration of acid.

R_1= 0.20 moles/min = 0.20 moles/(60 s) = 0.00333…moles/s
$R_1\ t_1 = R_2\ t_2$
$t_2/t_1 = R_1 / R_2$ = 0.00333… moles/s /0.020 moles/s = 0.17 (2 SF like 0.20 and 0.020).
Notice the answer has no unit and the answer means that at this faster rate, it will only take about 17% as much time to produce the same amount of hydrogen.

2. If the rate of CO_2 formation, r, for the following reaction

$$NO_2 + CO \rightarrow NO + CO_2$$

is given by $r = k[NO_2]^2$

a) what will happen to the rate if we reduce the concentration of CO gas to half of its original concentration?

No change. The reaction is zero order with respect to CO, meaning that CO does no appear in the rate expression

b) Why?

CO is not involved in the slow, rate determining step.

c) What will happen to the rate if $[NO_2] = 0.125[NO_2]_{original}$?

$R_2 / R_1 = [0.125{*}NO_{2original}]^2 / [NO_2]_{original} = 0.0156$

$R_2 = 0.0156\ R_1$.

d) What units will k have if the rate is expressed in mol/L per second?

$r = k[NO_2]^2$

$$\frac{mol}{Ls} = k\left[\frac{mol}{L}\right]^2$$

$$\frac{mol}{Ls} = k\left[\frac{mol^2}{L^2}\right]$$

$$k = \frac{mol}{Ls} \div \left[\frac{mol^2}{L^2}\right]$$

$$k = \frac{mol}{Ls} \times \left[\frac{L^2}{mol^2}\right]$$

$$k = \frac{L}{mol * s}$$

3. Given:

Step 1:	$HBr + O_2 \rightarrow HOOBr$	Slow
Step 2:	$HOOBr + HBr \rightarrow 2\ HOBr$	Fast
Step 3:	$HOBr + HBr \rightarrow H_2O + Br_2$	Fast
Step 4:	$HOBr + HBr \rightarrow H_2O + Br_2$	Fast
Overall:	$4\ HBr + O_2 \rightarrow 2\ H_2O + 2\ Br_2$	

a) Write the expression for the rate of Br_2 production.

Based on the slow step:

$R=k[HBr][O_2]$

b) Will steam(H_2O) be produced at the same rate? Why or why not?

Yes. The ratio of bromine to steam is 2:2 or 1;1

c) What will happen to the rate if we double(2.0) the concentration of oxygen and change the concentration of HBr by a factor of 0.25?

$$\frac{r_2}{r_1} = \frac{k[0.25Br_2][2O_2]}{\mathrm{k[Br_2][O_2]}} = 0.50$$

$r_2 = 0.50\ r_1$