Friday Worksheet **Name: …….**

Ammonia production worksheet 1

1) The Haber process for the formation of ammonia from hydrogen and nitrogen gasses is given by the equation below.

$3H_2(g) + N_2(g) \rightarrow 2NH_3\ (g)\ (\Delta H = -92\ kJ/mol)$

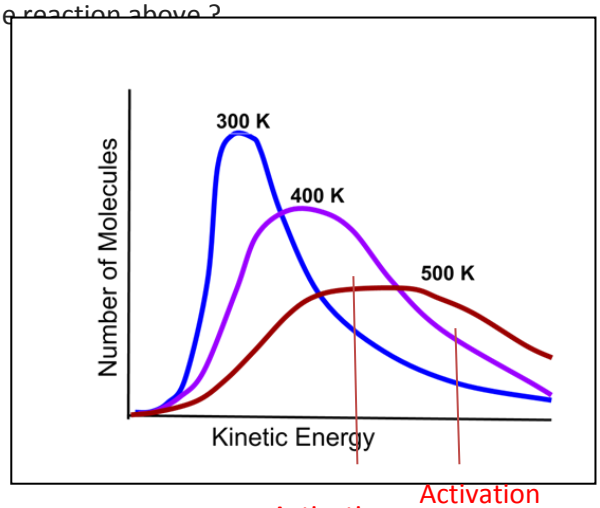
a) What conditions would maximise yield ? Describe how these conditions are at odds with the rate of the reaction above ?

Low temperature, however, reduces the rate of the reaction.

b) Explain how an increase in temperature maximises the rate of the reaction. Use the chart on the right
Increase in temperature increase the average kinetic energy of the particles. At a higher temperature more particle have the activaton energy reuired in order to react

c) Explain how a catalyst increases the rate of the reaction. Refer to the diagram on the right.

The activation energy is reduced in the presence of a catalyst hence more particles are able to react at a given temperature.



d) 2.15 litres of hydrogen gas completely reacts with nitrogen gas to form ammonia at STP. The energy given out is used to heat 200.0 grams of water at 20.0 ^{O}C. Assuming no energy is lost what is the final temperature of the water?

Step 1 find the mol of H_2 at STP.
=> 2.15/22.4 = 0.0960
Step 2 findthe energy released by 0.0960 mol of H_2
=> since 3 mol of H_2 releases 92 kJ of energy 0.0960 mol should release
=> (0.0960 / 3) X 92 =2,994 J
Step 3 Find the temperature increase
E = 4.18j/g/^{o}C X 200.0 X ΔT
=> 2994/ (200.0 X 4.18) = ΔT = 3.58

Final temperature = 23.6 ^{o}C

e) In a 1.00 litre vessel 1.00 mol of H_2 gas and 1.00 mol of N_2 gas were mixed, at a given temperature and allowed to reach equilibrium. Two minutes after the gases were mixed

the reaction mixture had reached equilibrium and it was found that 0.400 mol of NH_3 was present.
At the 6 minute mark the volume was suddenly doubled and the system allowed to reach equilibrium once again. At the 10 minute mark the temperature of the reaction vessel was increased slightly.

i. What is the equilibrium expression for this reaction?

$$\frac{[NH_3]^2}{[N_2][H_2]^3} = K$$

ii. Calculate the value of the equilibrium expression at the 2 minute mark

$[NH_3] = 0.400$, $[N_2] = 0.800$, $[H_2] = 0.400$
$\Rightarrow [0.400]^2/([0.800][0.400]^3) = 3.13\ M^{-2}$

iii. What is the value of the equilibrium expression at the 8 minute mark
$3.13\ M^{-2}$

iv. Use the set of axis, on the right, to graph the concentration vs time graph of each gas present in the mixture. Sketch the graphs and show the general trends of $[H_2]$, $[N_2]$ and $[NH_3]$.