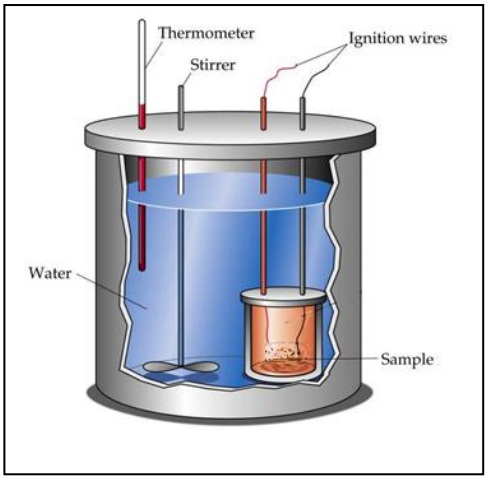
**Friday Worksheet** **Name: …….**

**Ammonia production worksheet 2**

1) Hydrogen and nitrogen gases were mixed in a bomb calorimeter and allowed to react according to the equation below.




$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) \quad \Delta H = ?$$

1) The bomb calorimeter contained 25.0 g of water at 20.0$^o$C. At completion of the reaction the final temperature of the water was recorded at 23.0 $^o$C. Once the reaction was complete it was found that 0.126 grams of ammonia was formed.
a) Determine the ΔH for the equation above. Show all working.

b) The ΔH of the reaction has being determined accurately at a value of -92.0 kJ/mol. Compare your result you obtained in a) above and give a possible explanation for the discrepancy .

c) Consider the equation below

$$3H_2(g) + N_2(g) \rightarrow 2NH_3(g) \quad \Delta H = -92 \text{ kJ/mol} \text{ ------- 1)}$$

Will the magnitude of the calculated ΔH (X) of the equation below be less than, equal to or more than the magnitude of the ΔH of equation 1)?

$$3H_2(g) + N_2(g) \rightarrow 2NH_3(l) \quad \Delta H = -X \text{ kJ/mol}$$

Explain

2) 0.200 mol of $H_2$ gas and 0.350 mol of $N_2$ gas were placed in another bomb calorimeter at 23.0 $^o$C. If the volume of the container is 2.31 litres calculate the pressure, in mmHg, exerted by the gasses before any reaction takes place.

3) A window cleaner contains ammonia. The concentration of ammonia is 10.0 M. What is the concentration of ammonia in %w/v

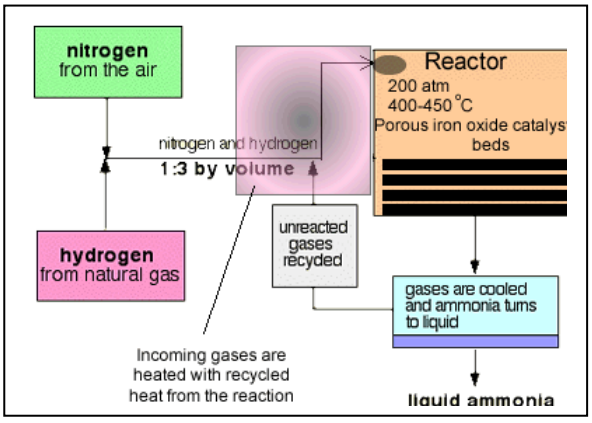

4) Explain, with reference to the structure of the ammonia molecule, why ammonia is highly soluble in water.

5) The image below shows a summary of the Haber process. Under normal reaction conditions, the Haber process has a yield around 15% with each pass through the reaction chamber. Through different strategies the yield is increased to 98% on average.
a) Aside from temperature and pressure, discuss strategies employed by industrial chemists to achieve such a high yield.

b) Describe the source of each of the reactants.

c) Why are the reactants added in a $1N_2 : 3H_2$ ratio.

d) In one particular country the supply of hydrogen gas is very expensive compared to the supply of nitrogen which is taken straight from the atmosphere. Suggest one way to ensure that most of the expensive reactant is used up.




e) Heating the reactant mixture to temperatures between 400 and 450 $^{o}$C can be problematic as it is very expensive. How is this problem solved.

6) Nitrogen gas can be converted into nitrogen compounds by bacteria known as nitrogen fixing bacteria. A family of bacteria called Rhizobiaceae convert atmospheric nitrogen into compounds such as $NH^{+}$, $NO_2^{-}$, $NO_3^{-}$.

a) Atmospheric nitrogen is converted to $NH_4^{+}$
   i. Is this an oxidation, reduction or acid base reaction?
   ii. Write the half equation for this reaction.

b) $NO_2^{-}$ is converted to $NO_3^{-}$.
   i. Is this an oxidation, reduction or acid base reaction?
   ii. Write the half equation for this reaction.