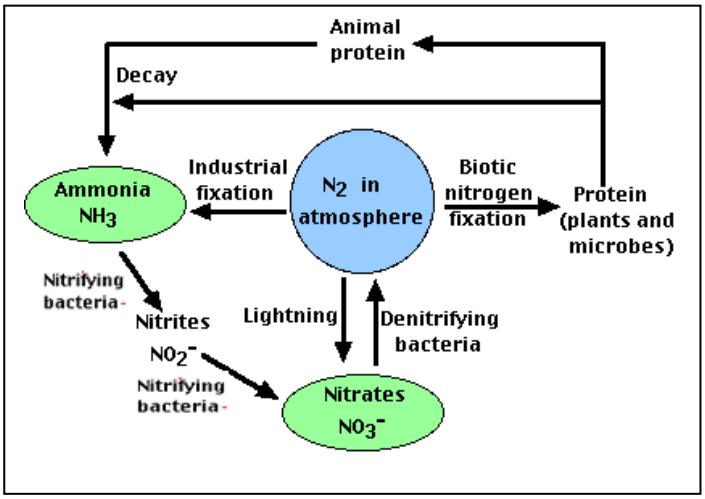
Friday Worksheet **Name: …….**

Ammonia production worksheet 6

1) Nitrogen is essential to life and abundant in the atmosphere but is inaccessible to all organisms. Nitrogen fixation is a process by which nitrogen gas is converted to soluble nitrogenous products, such as ammonium or nitrate ions, that can be used by organisms. Nitrifying bacteria convert ammonia into usable compounds as shown in the diagram below.



a) Give the balanced half equation for the process carried out by nitrifying bacteria in converting ammonia into nitrites

b) Give the balanced half equation for the process carried out by denitrifying bacteria in converting nitrates into nitrogen gas.

c) NO_2 gas is a pollutant from car exhaust. Nitrogen dioxide undergoes the following reaction to produce dinitrogen tetroxide (N_2O_4). N_2O_4 reacts with liquid water to produce nitric acid according to the equation below.
$3N_2O_4(g) + 2H_2O(l) \rightarrow 4HNO_3(aq) + 2NO(g)$
What type of reaction is this? Give a reason.

2) The chemical equation for the Haber process is given below
$3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$ $\Delta H = 92.3$ kJ/mol
3.00 mol of H_2 gas and 6.00 mol of N_2 gas were placed in a 2.00 L, high pressure reaction vessel and allowed to react. At equilibrium the mixture contained 0.88 mol of NH_3.

a) Calculate the mol of the following at equilibrium.
   i. Nitrogen gas
   Ii Hydrogen gas

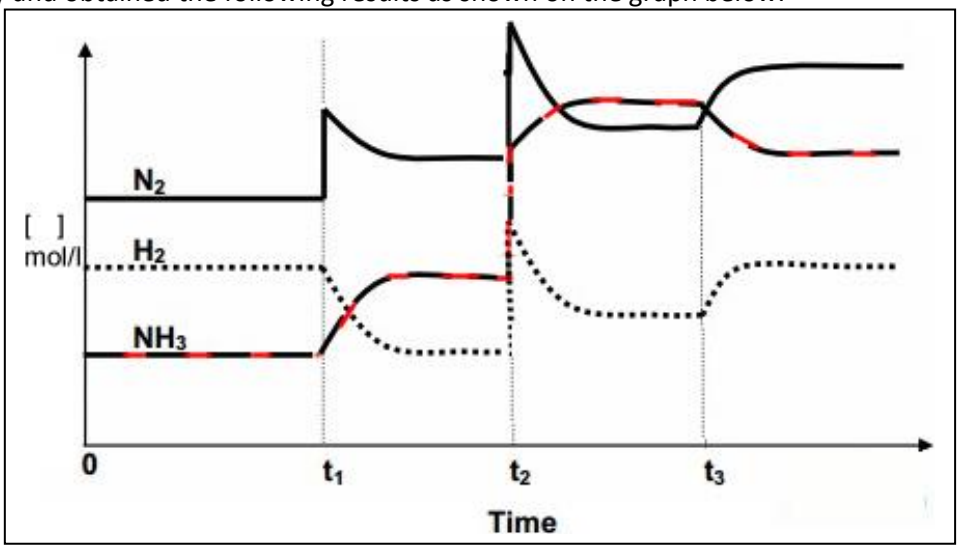
b) Calculate the energy produced by this reaction to the right number of significant figures.

c) Calculate the equilibrium constant at this temperature.

d) Calculate the pressure, in atm, exerted on the vessel walls at a temperature of 100.0°C

e) Hydrogen and nitrogen gases were mixed in a bomb calorimeter containing 50.0 mL of water at 22.0 °C. After the reaction, a total amount of 340.0 grams of ammonia was formed. Assuming 55.0% of the energy produced went into directly heating up the water calculate the final temperature of the water.

3) The chemical engineer of a large ammonia manufacturing plant was instructed to make adjustments to increase the yield of ammonia. The engineer conducted small scale trials in the laboratory and obtained the following results as shown on the graph below.

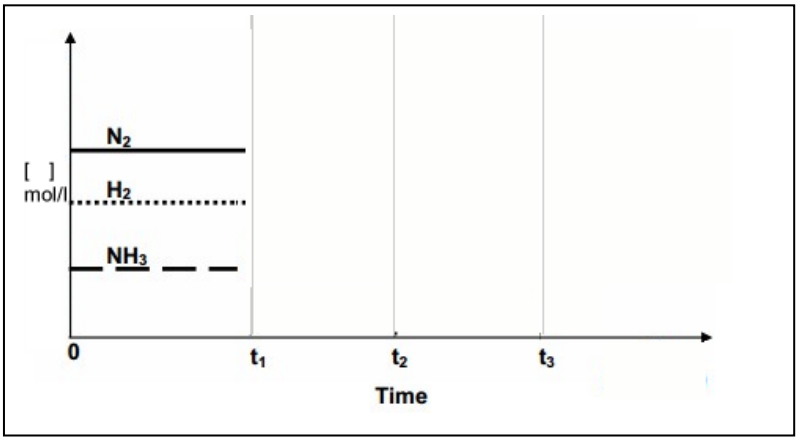


a) At time t_1 what is likely to have happened? Explain how this impacted on the yield

b) At time t_2 what is likely to have happened? Explain how this impacted on the yield

c) At time t_3 what is likely to have happened? Explain how this impacted on the yield

d) Complete the graph on the right if the following changes take place.
t_1 - Pressure is increased through the introduction of helium gas
t_2 - Volume of the reaction chamber is doubled.
t_3 - Catalyst is added



e) Which of the following will cause an increase in the yield? Give reasons for your choice.

i. Heating the gases as they enter the reaction chamber.

ii. Increasing the pressure of the reaction vessel by decreasing its volume.

ii. Adding a catalyst.

iii. Removing product and recycling the gases.