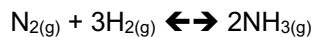


### AP WORKSHEET 07DGI: The Haber Process

The Haber process is the name given to the industrial scale manufacture of ammonia from hydrogen and nitrogen gases. It utilizes the equilibrium reaction shown below.



Under a typical set of conditions a mixture of 1.00 mole of nitrogen gas to every 3.00 moles of hydrogen gas are exposed to the temperatures shown in the table below and the equilibrium is established.

In each case, the system is under a total pressure of 10.0 atm.

Temperature in °C	Partial pressure of NH <sub>3</sub> in atm
355	0.741
455	0.211
555	0.081

(a) For each temperature calculate the partial pressure of each reactant. (6)

(b) For each temperature, calculate  $K_p$ . (6)

- (c) What is the the sign of  $\Delta H^\circ$  for the reaction? (2)
- (d) The experiment is repeated and the conditions adjusted so the total pressure is 40.0 atm. The partial pressure of ammonia at equilibrium under these new conditions is found to be 11.4 atm.
- (i) Without doing any calculations, comment upon the significance of the data in terms of Le Châtelier's principle. (2)
- (ii) Calculate  $K_p$  under the new conditions. (4)
- (e) The reaction is often carried out using a catalyst. What is the purpose of the catalyst, and how does it affect the value of  $K$  for the reaction? (2)