Established in 1879

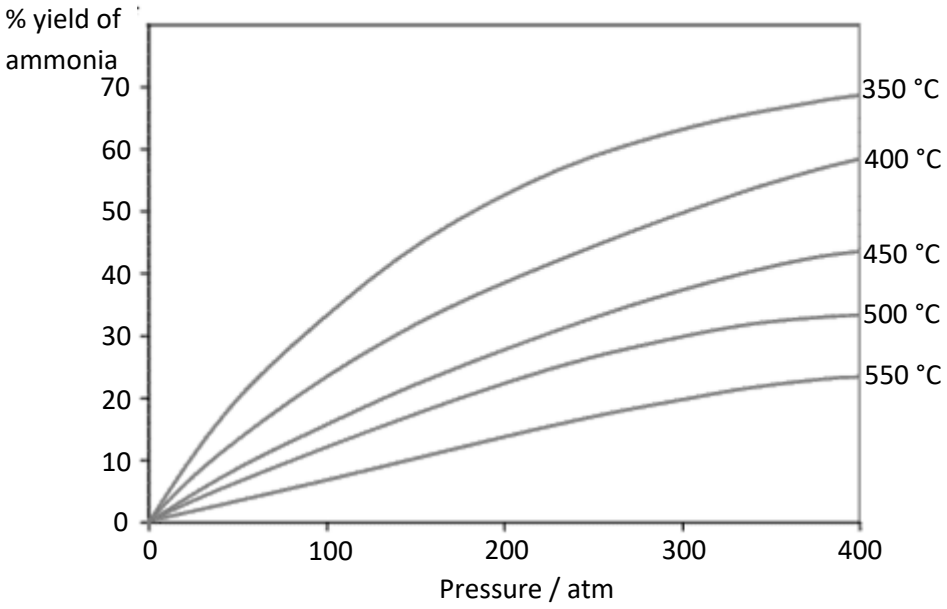
RAFFLES GIRLS' SCHOOL (SECONDARY)
RAFFLES PROGRAMME
CHEMISTRY YEAR 4

Name : _____ ( ) Class : _____
Date : _____

CHEMICAL EQUILIBRIUM

Assignment

1. The Haber process involves the extraction of hydrogen, extraction of nitrogen and combination of hydrogen and nitrogen to make ammonia.



(a) State how nitrogen is extracted to make ammonia.

(b) State a suitable catalyst for the Haber process.

(c) According to the graph, what are the optimum conditions to produce the maximum yield of ammonia?

(d) According to the graph, how does temperature and pressure affect the % yield of ammonia?

(e) Sketch on the graph above the curve showing the % yield of ammonia at 450^{o}C.

(f) Explain why the typical conditions of 250 atmospheres and 450^{o}C are used for the Haber process in the industries.

2. (Adapted from O Level 2018 P2A Q6)

The process of making ammonia from raw materials has several stages.

The equations show two stages in the process.

Stage 1: Methane reacts with steam to make hydrogen.

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\ H_2(g)$ $\quad \Delta H = +210$ kJ/mol

Conditions:
30 atm
nickel oxide catalyst
800 °C

Stage 2: The hydrogen formed reacts with nitrogen to make ammonia in a reactor.

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

Conditions:
25 – 150 atm
iron catalyst
450 °C

(a) Less energy is needed to maintain the temperature for stage 2 than is needed for stage 1.

Suggest **two** reasons why the reaction in stage 2 requires less energy.

(b) The gases from stage 1 are separated. The waste gas produced in stage 1 is burned as a fuel.

Explain why it is important that this gas is collected and burned.

(c) In stage 2, nitrogen and hydrogen are mixed in definite proportions before they enter the reactor.

The table shows the percentages of each gas in the mixture by volume and by mass.

	nitrogen	hydrogen
percentage by volume	25	75
percentage by mass	82	18

(i) Explain why these percentages by volume are chosen.

(ii) Explain why the percentages of the gases are different when they are measured by volume and when they are measured by mass.

(iii) The gases leaving the reactor contain unreacted nitrogen and hydrogen and about 15% ammonia by volume. Unreacted nitrogen and hydrogen are fed back into the reactor in stage 2.
Give **two** reasons why the unreacted gases are fed back into the reactor.