FERTILISERS

Overview

1 Why is nitrogen important to plants?

_____

_____

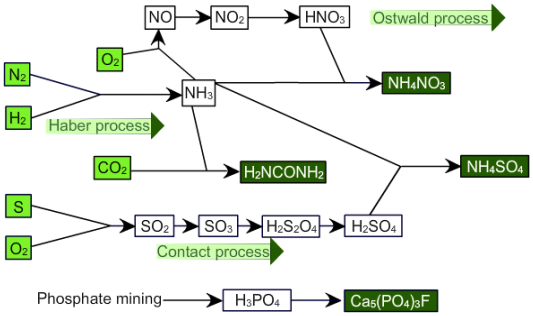
2 In what forms can plants absorb nitrogen?

_____

_____

3 Complete to summarise the industrial processes:

Industrial production of fertilisers



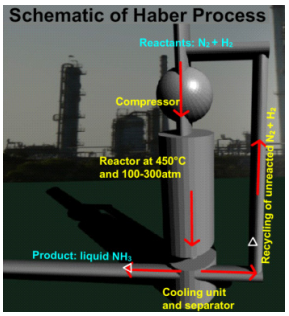
Process	Reactants	Products of step 1	Products of step 2	Final products
Haber		not applicable		
Ostwald				
Contact				

Haber Process

4 What is the purpose of the Haber Process?

To produce _____

from _____ and _____.



5 Write a balanced equation for the Haber Process's reversible reaction:

_____ + _____ ⇌ _____

6 Name some uses of ammonia.

_____

_____

7 Name two conditions which must be met for a reaction to reach equilibrium.

_____

_____

8 Name two characteristics of equilibrium.

_____

_____

9 In the Haber Process an iron oxide catalyst is usually used. Ruthenium can also be used. What does a catalyst do in a reaction, and how does it do this?

_____

_____

10 Circle the correct option (True / False) for each of the following:
   i A catalyst speeds up the Haber Process's forward reaction more than the reverse. [True / False]
   ii A catalyst will cause more product to be formed. [True / False]
   iii A catalyst will decrease the time it takes to reach equilibrium because it speeds up both forward and reverse reactions. [True / False]
   iv A catalyst speeds both forward and reverse reactions equally. [True / False]

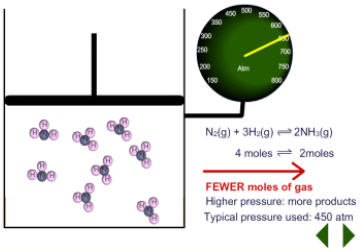
11 Link each element from Column A with its corresponding element in Column B. Write the letter from A next to each item in B in the last column.

Column A	Column B	A
a dynamic equilibrium	absorbs heat	_____
b endothermic	a measure of the average kinetic energy of particles	_____
c exothermic	disturbs equilibrium, favours increased crowding: more molecules	_____
d Le Chatelier's principle	273 K and 101,3 kPa	_____
e decrease in pressure	disturbs equilibrium, favours exothermic reaction	_____
f increase in pressure	releases heat	_____
g removing heat	a state in which forward and reverse reactions occur at equal rates	_____
h adding heat	force per area, in gases related to rate of particle collisions	_____
i temperature	disturbs equilibrium, favours decreased crowding, fewer molecules	_____
j pressure	disturbs equilibrium, favours endothermic reaction	_____
k STP	when a system which is in equilibrium is disturbed, it will respond in such a way as to counteract the disturbance	_____

Le Chatelier: Effect of pressure

12 Complete the explanation by filling the gaps or choosing from the options. Do this before, or after, but not during, watching the animations. Mark during re-watching.

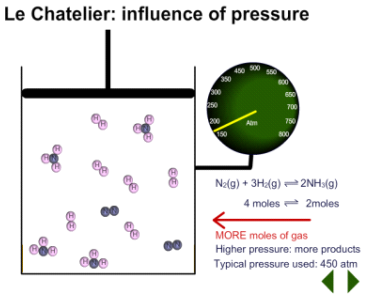
Le Chatelier: influence of pressure



Increased pressure

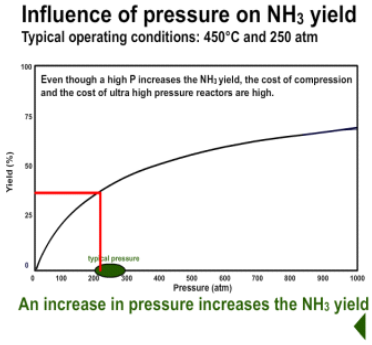
According to _____ principle, when a system which is in equilibrium is disturbed, it will respond in such a way as to _____ the disturbance. An increase in pressure [de/in]creases the crowding of gaseous molecules. The system will respond by [de/in]creasing their crowding. Crowding is decreased in gases when [fewer/more] molecules are formed. In the Haber Process the [forward/reverse] reaction makes fewer molecules than the [forward/reverse] reaction. In the forward reaction _____ molecules of ammonia are made from every _____ molecules of reactants (_____ N_2 and _____ H_2 molecules). Consequently, an increase in pressure _____ equilibrium for a while by making the [forward/reverse] reaction occur at a higher rate than the [forward/reverse] reaction. This causes [more/less] ammonia to be formed and [more/less] nitrogen and hydrogen. After a while a new dynamic equilibrium is reached. The rates of forward and reverse reactions are again _____ to one another, and the amounts of reactants and products will [change/remain constant]. However, compared to before the pressure was applied, there will now be [more/less] ammonia present at equilibrium. The equilibrium constant value, Kc, however, will be [higher than/lower than/the same as] it was in the original equilibrium.

Decreased pressure



Decreasing pressure [de/in]creases the crowding of gaseous molecules. The system will respond by [de/in]creasing their crowding. Crowding can be increased by forming [fewer/more] molecules. In the Haber Process, that means that for a while the [forward/reverse] reaction will occur at a higher rate than the [forward/reverse] reaction. The reverse reaction changes every _____ molecules of ammonia into _____ molecules (_____ nitrogen and _____ hydrogen molecules). This causes the amount of ammonia present to [de/in]crease and the amount of nitrogen and hydrogen to [de/in]crease. While this is happening the system [is/is not] in equilibrium. After a while a new dynamic equilibrium will be reached, in which the rates of both forward and reverse reactions will _____ one another, and the amounts of reactants and products will remain _____. However, compared to before the pressure was decreased, there will now be [more/less] ammonia present at equilibrium. The equilibrium constant value, Kc, however, will be [higher than/lower than/the same as] it was in the original equilibrium.

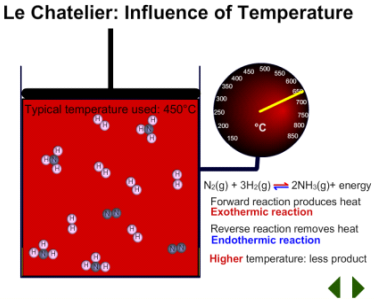
Optimum pressure



In the Haber Process, we want to make as much _____ as possible. We want the dynamic equilibrium to be such that a lot of [reactant/product] is formed. A(n) [de/in]crease in pressure will cause more products to form. We need as [low/high] a pressure as it is safe and economical to use. We say we need to use an _____ pressure: the pressure for which we get a good yield for a reasonable price while still being safe. Pressures between 200 and 300 atmospheres are typically used in the Haber Process.

Le Chatelier: Effect of temperature

13 Complete the explanation by filling the gaps or choosing from the options. Do this before, or after, but not during, watching the animations.
Mark during re-watching.



Heating

Heating a reaction up increases the _____ energy of the particles, and so causes them to react more [slowly/rapidly] with one another. Additionally, heat can have an effect on disturbing the _____ of a reaction. In the Haber Process the forward reaction is [exo/endo]thermic and the reverse is [exo/endo]thermic. This means that as nitrogen and hydrogen react with one another to form ammonia, heat is [absorbed/released], but as ammonia breaks up into hydrogen and nitrogen, heat is [absorbed/released]. According to Le Chatelier's principle, when a system which is in equilibrium is disturbed, it will respond in such a way as to counteract the disturbance. So if heat is added to a system in the Haber Process, the [exo/endo]thermic [forward/reverse] reaction is favoured to [absorb/release] some of that heat and so [cool the system back down/heat the system back up]. Both the forward and reverse reactions occur at [lower/higher] rates than before the heat was added, due to the additional kinetic energy of all the particles, but the [forward/reverse] reaction will have been speeded up to a greater extent than the [forward/reverse] reaction. So for a while, the system will not be in _____

as the [forward/reverse] reaction occurs more rapidly than the [forward/reverse] reaction. This will [in/de]crease the amount of ammonia present, and [in/de]crease the amount of hydrogen and nitrogen. After a while a new dynamic equilibrium is reached. The rates of forward and reverse reactions are again _____ to one another, and the amounts of reactants and products will remain _____. However, compared to before the heat was added, there will now be [less/more] ammonia present at equilibrium. A new equilibrium constant, Kc, [higher than/lower than/the same as] that of the original equilibrium, is reached.

Cooling

Cooling a system that is in equilibrium has two effects. Firstly, by [de/in]creasing the kinetic energy of all the molecules, it [reduces/increases] the rates of both the forward and reverse reactions. Secondly, it has the effect of disturbing the _____ by favouring the [exo/endo]thermic reaction until a new equilibrium is reached with [the same/a different] equilibrium constant.

If heat is removed from a system in the Haber Process, the [exo/endo]thermic [forward/reverse] reaction is favoured to [cool the system back down/heat the system back up]. For a while, the system will not be in _____ as the [forward/reverse] reaction occurs more rapidly than the [forward/reverse] reaction. This will [in/de]crease the amount of ammonia present, and [in/de]crease the amount of hydrogen and nitrogen. After a while a new dynamic equilibrium is reached. The rates of forward and reverse reactions are again _____ to one another, and the amounts of reactants and products will remain _____. However, compared to before the system was cooled, there will now be [less/more] ammonia present at equilibrium. A new equilibrium constant, Kc, [higher than/lower than/the same as] that of the original equilibrium, is reached.

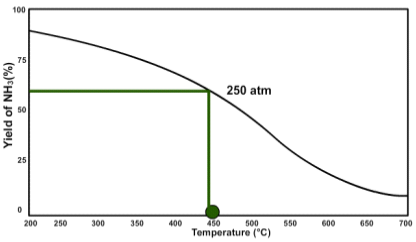
Optimum temperature

In the Haber Process, we want to get a high ammonia yield. We want a dynamic equilibrium which makes as much ammonia product as possible. Consequently, we need to use a fairly [high/low] temperature. However, this causes a problem, namely _____

_____.

Therefore, a compromise is made, and a temperature of approximately 450°C is often used.

Influence of temperature on NH_3 yield
Typical operating conditions: 450°C and 250 atm



An increase in temperature decreases the NH_3 yield

Units of pressure and temperature

14 Complete for units of pressure.

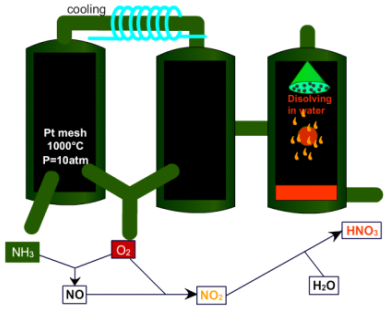
Unit		Pressure at sea level at 0°C
Name	**Symbol**	

15 Kelvin is the SI (Standard International) unit for temperature. Complete for conversions.

Temperature in degrees Celsius (°C)	Temperature in Kelvin (K)
0	
	0
100	
	200
25	

Ostwald Process

Oswald Process to produce HNO_3



16 What is the purpose of the Ostwald Process?

To produce _____ from _____.

17 How is the product of the Ostwald Process useful for the fertiliser industry?

_____

_____

18 Why doesn't it matter that the platinum catalyst used is very expensive?

_____

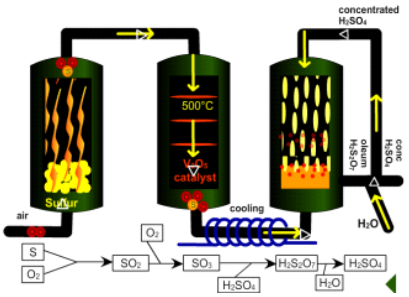
_____

19 Complete.

Step 1	Step 2	Step 3
_____ + _____ → (catalyst) _____	_____ + _____ → _____	_____ + _____ → _____

Contact Process

Contact Process to produce H_2SO_4



20 What is the purpose of the Contact Process?

To produce _____ from _____.

21 Name some uses of sulfuric acid.

_____

_____

22 Complete.

Step 1	Step 2	Step 3	Step 4
_____ + _____ → _____	_____ + _____ → (catalyst) _____	_____ + _____ → _____	_____ + _____ → _____