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|  | Making ammonia – the Haber process | |
|  | Why do we need plants? | For food and to maintain oxygen levels in the air |
| Why do we need to assist plants in getting nitrogen when the air contains 80% nitrogen? | Most plants cannot absorb nitrogen directly from the air. |
| How do most plants absorb nitrogen? | In the form of nitrates from the soil through their roots |
| Why does the nitrogen in plants not find its way back to the soil? | Because the plants are often harvested before the plant decomposes and replenishes the soil |
| What do we generally use to replenish the nitrogen in the soil? | Nitrate fertilisers |
| The Haber process | What is the Haber process? | A way of turning nitrogen in the air into ammonia |
| What raw materials are needed for making ammonia? | Nitrogen (from the air) and hydrogen (from natural gas) |
| What conditions are required for the Haber process? | Pure nitrogen and hydrogen  Iron catalyst  High temperature (~450°C)  High pressures (~200 atmospheres) |
| How is the ammonia gas separated from the reactants in this reversible reaction? | The gases are cooled, ammonia liquefies before nitrogen and hydrogen, allowing it to be collected and separated. |
| What happens to the unreacted nitrogen and hydrogen? | They are recycled back into the reaction mixture. |
| What is a huge commercial benefit of removing the ammonia as it is produced? | It keeps the equilibrium to the right so the forward reaction (making ammonia) is favoured. |
| What are the benefits and costs of the special conditions needed for the Haber process? | **Benefits**: *Give a reasonable yield of ammonia as quickly as possible*  **Costs**: *Expensive to heat and apply pressure*  *a* |

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|  | The economics of the Haber process (HIGHER) | |
| The effect of pressure | Which direction of reaction is favoured by increasing the pressure during the Haber process? | The forward reaction (making products) |
| Why does the Haber process use 200 atmospheres pressure when a higher pressure would produce more products? | It is a compromise between yield and cost, very high pressure requires a lot of energy and very expensive equipment. |
| The effect of temperature | What **two** factors of the reaction are affected by temperature? How are they affected? | 1. Amount of ammonia at equilibrium – lower temperatures increase the amount of ammonia at equilibrium as forward reaction is exothermic |
| 2. Rate of reaction – higher temperatures increase the number of collisions of molecules and the energy each molecule has, therefore increasing the rate |
| Give **two** reasons why 450°C is used when a lower temperature would produce a higher yield? | 1. The ammonia would be produced too slowly to be economically viable. |
| 2. Lower temperatures reduce the effectiveness of the catalyst. |
| The effect of a catalyst? | What effect does the catalyst have on yield? Why? | None, as it increases the rate of both the forward and reverse reaction the same amount |
| Why is a catalyst used? | It increases the speed that ammonia is produced. |