The content on this sheet is assessed on paper 1 only.

Obtaining Metals and Equilibria

* Indicates knowledge which is not, strictly speaking, covered until topic 7.

5.19—The Haber process

The Haber process is a reversible reaction between nitrogen gas (fractionally distilled from air) and hydrogen gas (made from natural gas) to produce ammonia gas.

5.20—Rate of attainment of equilibrium (HT only)

5.20a—Change in temperature

Increasing the temperature will lead to all molecules having more energy, and so they will collide more frequently. Both the forward **and** backward reactions will occur faster, and therefore equilibrium will be reached faster.

5.20b—Change in pressure

Increasing the pressure will lead to all gaseous molecules being closer together, and so they will collide more frequently. Both the forward **and** backward reactions will occur faster (if there are gases on both sides), and therefore equilibrium will be reached faster.

5.20c—Change in concentration

Increasing the concentration will lead to there being more particles per litre, and so they will collide more frequently. Both the forward **and** backward reactions will occur faster, and therefore equilibrium will be reached faster.

5.20a—Use of a catalyst

Adding a catalyst reduces the activation energy of both the forward **and** backward reactions, which will therefore occur faster, and therefore equilibrium will be reached faster.

5.22—Fertilisers

Fertilisers are chemicals which promote plant growth. They contain significant quantities of the elements nitrogen, phosphorus and potassium. The elements aren't soluble for the roots to absorb, so fertilisers tend to contain salts, especially ammonium (NH_4^+), phosphate (PO_4^{3-}) and nitrate (NO_3^-) salts.

5.21—Managing industrial reactions

5.21a—Raw materials and energy

The cost and availability of raw materials determines whether a process is feasible. The process used will depend on these factors. Generally, processes are preferred where the energy costs are lower, and raw materials are renewable.

5.21b—Compromise conditions*

Increasing the temperature or pressure (of a reaction involving gases) will increase the rate of the reaction. However, they also affect the position of equilibrium. Where this 'shifts left', reducing the quantity of products made, a compromise must be reached.

For example, if the forward reaction of a dynamic equilibrium is exothermic (gives out energy), increasing temperature will reduce the yield of product. A compromise between rate and yield must be reached, so enough product is made quickly enough.

Increasing pressure will shift the equilibrium to the side with fewer moles of gas. There is also the consideration of the costs of using high pressure—both in terms of the initial cost of the reaction vessel and generating the pressures. The pressure used is determined by these factors.

Using a catalyst has no downsides, as the rate is increased whilst the yield is unaffected.

5.23—Making ammonium nitrate (a very useful fertiliser)

ammonia	+	nitric acid	→	ammonium nitrate
NH_3	+	HNO_3	→	NH_4NO_3

5.24—Making ammonium sulfate (another useful fertiliser)

5.24a—Making ammonium sulfate on a small scale (in a laboratory)

In a laboratory, ammonia solution is reacted with dilute sulfuric acid (via a titration reaction). The neutral salt solution ($(NH_4)_2SO_4$) is then left to crystallise.

This is a batch process, meaning small amounts are made relatively small.

5.24b—Making ammonium sulfate in industry

In industry, ammonium sulfate is made in several stages. The ammonia and sulfuric acid are manufactured in situ, from the raw materials, rather than purchasing ammonia and sulfuric acid in. This process is continuous, meaning $(NH_4)_2SO_4$ can always be made if the raw materials are available.