Unit 12: Equilibria

Recommended prior knowledge

Students should have good breadth of chemical knowledge, in particular concerning reaction rates and calculations involving moles.

Context

This unit brings together ideas from several earlier units.

Outline

This unit begins with the introduction the concept of equilibrium and its importance to industry [the Haber Process and the Contact Process] and the world economy. These industrial processes enable vital chemicals such as ammonia and sulfuric acid to be produced, which are needed for the production of fertilisers and other important industrial chemicals. This unit sets the scene for a consideration of how socioeconomic and environmental factors are important in choosing a site for an industrial process. There are numerous opportunities to link to Units already covered. This unit is cross-referenced to assessment objectives A1–5, B1–6, C1–3 and Unit 5.

(Please note: **(S)** in **bold** denotes material in the Supplement (Extended syllabus) only)

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
7.2	Describe the idea that some chemical reactions can be reversed by changing the reaction conditions (Limited to the effects of heat on hydrated salts, including hydrated copper(II) sulfate and hydrated cobalt(II) chloride) (Concept of equilibrium is **not** required.)	Some reactions can be classified as reversible and students should be introduced to the reversible sign ⇌. Experimental work can involve students heating hydrated copper(II) sulfate and adding water to anhydrous copper(II) sulfate as an illustration. Extension – students to determine the amount of water removed on heating and calculate the formula of hydrated copper(II) sulfate [link to Unit 6 – Amount of Substance].	www.chalkbored.com/lessons/chemistry-11/hydrate-lab.pdf

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
7.2(S)	**Concept of equilibrium**	This could be introduced using the escalator analogy and by demonstrating the effect of acid and alkali on: • Methyl orange indicator • Sodium chromate/dichromate equilibrium • Iodide/iodine equilibrium	Interactive tool to introduce equilibrium: www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/chemreac/reversiblereacrev1.shtml

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
7.2(S)	**Predict the effect of changing the conditions (concentration, temperature and pressure) on other reversible reactions**	Students in groups can analyse yield data comparing rate and yield with varying conditions and extend this to predicting reaction conditions used for equilibrium reactions to produce the most efficient reaction. The effect of concentration can be demonstrated using the chlorine/iodine monochloride equilibrium. Care and use of a fume cupboard are essential. Illustrate how changing the temperature, pressure and the introduction of a catalyst in effect the yield and rate [link with Unit 4] in the Haber and Contact processes (below). Important issues to consider include: • Raising the temperature, increases the rate and the energy demand and hence economic cost. However, lowers the yield for exothermic but increases the yield in endothermic reactions; • Increasing the pressure, increases the rate and the energy demand and hence economic/equipment costs. The yield changes depends on the number of moles of gas reactants to products; • Introduction of a catalyst leads can lead to a lower energy demand (lower temperature for an equivalent rate) and hence economic cost and saving fossil fuel resources; • Considerations of increased yield against increased cost are balanced to give 'optimum conditions'. It is important to distinguish the effect of changing a condition on the reaction rate and equilibrium. Summarise in a table to avoid confusion.	*R. Norris & R. Stanbridge. Chemistry for IGCSE*, Nelson Thornes, 2009, ISBN 9781408500187, p112.

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
11(S)	**Describe the essential conditions for the manufacture of ammonia by the Haber process including the sources of the hydrogen and nitrogen, i.e. hydrocarbons or steam and air**	Nitrogen from the air (link with Unit 1 - Periodic Table 1). Hydrogen from natural gas [link with Unit 4]. Opportunity for group work where students can produce a series of flash cards to produce a flowchart of this process or question loop activity to sequence the process. The importance of recycling unreacted nitrogen and hydrogen needs to be mentioned. The effect of the variation of values of temperature and pressure can be studied by advanced students. Awareness of the economic and environmental advantages of placement of a manufacturing site can be investigated by students. Opportunities for reacting masses and volume calculations [link with Unit 6 – Amount of Substance].	www.chemguide.co.uk/physical/equilibria/haber.html Video clip of the process: www.bbc.co.uk/learningzone/clips/formation-of-ammonia-in-the-haber-process/4432.html Video clip on ammonia: www.rsc.org/Education/Teachers/Resources/Alchemy/
11	Describe the need for nitrogen-, phosphorus- and potassium-containing fertilisers	Links to biology and practical involving plant growth under controlled conditions.	
12(S)	**Name some sources of sulfur**	Sulfur is found uncombined or combined with metals as zinc blende (ZnS) or galena (PbS). Allotropes of sulfur could also be mentioned here Note, however that the concept of allotropes is not on the syllabus.	
12(S)	**Name the use of sulfur in the manufacture of sulfuric acid**	90% of the extracted sulfur is converted to sulfuric acid.	

Syllabus ref	Learning objectives	Suggested teaching activities	Learning resources
12(S)	**Name the uses of sulfur dioxide as a bleach in the manufacture of wood pulp for paper and as a food preservative (by killing bacteria)**	Emphasise the uses of sulfur dioxide as a bleaching agent (paper manufacture) and in killing bacteria (to preserve food). Look at food labels to see if sulfites (which release sulfur dioxide in acidic conditions) are present.	
12(S)	**Describe the manufacture of sulfuric acid by the Contact process, including essential conditions**	Mention specific temperature, pressure and catalyst information. Students can practise using flow diagrams to represent the process. Economic issues relating to temperature and catalyst use could be discussed here, as with the Haber Process. Opportunity for group work as the Haber process. As with the Haber process, more advanced students could study the effect of variation of temperature and pressure on the yield of sulfuric acid. Stress that the industrial process does not use high pressure even though it would be theoretically beneficial – it is not cost effective for the mediocre increase in yield. Opportunities for reacting masses and volume calculations [link with Unit 6].	www.chemguide.co.uk/physical/equilibria/contact.html Video clip on the Contact Process: www.rsc.org/Education/Teachers/Resources/Alchemy/ www.greener-industry.org.uk/pages/sulphuric_acid/9SulphuricAcidManu.htm
12(S)	**Describe the properties of dilute sulfuric acid as a typical acid**	Link to the reactions in Unit 1 and Acids, Bases and Salts [Unit 3].	