Typical problems

Inorganic chemistry

The yellow binary compound X1 was dissolved in concentrated nitric acid by heating, the gas evolved is 1.586 times denser than air. Upon the addition of the excess of barium chloride to the solution formed a white solid X2 precipitates. The filtrate reacts with an excess of silver sulfate solution forming a precipitate X3, also separated by filtration. To a new filtrate the solution of sodium hydroxide was being added drop-wise unless the solution became nearly neutral. At this time a yellow powder X4 crystallized from the solution. The mass of X4 is nearly 2.4 times larger than that of X2.

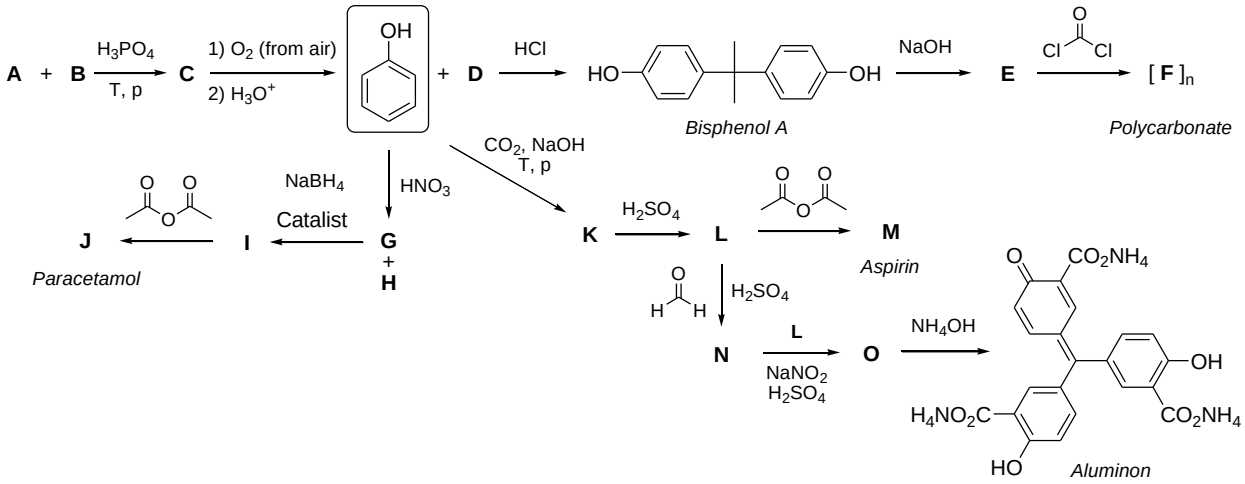
1. Determine the chemical formulae of X1 – X4.
2. Write down all reaction equations.
3. The compound X1 is composed of molecules. Draw the structural formula of its molecule.

Organic chemistry

Phenol is a valuable industrial commodity for the synthesis of various materials and compounds with useful properties. Therefore, its annual production totals several million tons. The classical industrial method of phenol production is a two-stage process developed by the Soviet chemist R. Udris in 1942. First, the mixture of benzene **A** and propene **B** is compressed under heating in the presence of an acid as a catalyst. Interaction of equal amounts of **A** and **B** leads to compound **C** which is then oxidized with air followed by acidification, which finally results in two products: phenol and compound **D** also widely used in industry.

High potential of phenol in the synthesis of polymers, drugs, and dyes can be illustrated by the hereunder examples.
The reaction of phenol with **D** in the presence of an acid gives *bisphenol A*, which was for the first time synthesized by the Russian chemist A. Dianin in 1891. The treatment of *bisphenol A* with NaOH leads to **E**, which reacts with phosgene affording *polycarbonate* with a monomeric unit **F**.
The treatment of phenol with diluted nitric acid results in isomeric compounds **G** and **H**, which can be separated by steam distillation. The molecule of **G** has two planes of symmetry (that of the molecule and an orthogonal one), while the plane of the molecule is the only element of symmetry for **H**. Starting with **G**, one can obtain *paracetamol* **J** via a two-stage process.

Aspirin **M** can be obtained from phenol in three steps. First, phenol is treated with NaOH and CO_2 under heating and high pressure. This reaction gives compound **K**, which has only one element of symmetry (plane of the molecule). Two equivalents of an acid are required for acidification of **K** to form compound **L**. Further acetylation of **L** affords *aspirin* **M**.
Moreover, **L** is a precursor of a dye *Aluminon* used for quantitative determination of aluminum and some other metals. Reaction of two equivalents of **L** with formaldehyde under acidic conditions affords **N**. Addition of one more equivalent of **L** to **N** in the presence of $NaNO_2$ and sulfuric acid yields **O**, which finally gives *Aluminon* upon treatment with ammonia.



Write down the structural formulae of **A**-**E** and **G**-**O**.
Write down the structure of monomeric unit **F**.

Theoretical chemistry

The gaseous substances A_2 and B_2 were mixed in a molar ratio 2:1 in a closed vessel at a temperature T_1. When the equilibrium $A_2(g) + B_2(g) = 2AB(g)$ was established the number of heteronuclear molecules in a gas phase became equal to the total number of homonuclear molecules.

1. Determine the equilibrium constant K_1 for the above reaction.
2. Find the ratio of heteronuclear to homonuclear molecules at equilibrium if the substances are mixed in a ratio 1:1 at the temperature T_1?

The equilibrium mixture obtained from the initial mixture $A_2 : B_2 = 2 : 1$ was heated so that equilibrium constant became $K_2 = K_1 / 2$.

3. How much substance B_2 (in percent to the initial amount) should be added to the vessel in order to keep the same equilibrium amounts of A_2 and AB as at the temperature T_1?

Multiple-choice question (one correct answer)

The presence of hydrogen sulfide in aqueous solution can be determined by adding

* 1) led nitrate
2) strong acid
3) phenolphthalein
4) sodium chloride

Fixed-answer question

Given the thermochemical equation $3C_2H_2(g) = C_6H_6(g) + 600$ kJ determine how many kilojoules will be released if 117 g of acetylene is converted to benzene? Give the integer answer
(900)