How was the first artificial dye made? Answers

Perkin's patent

1. For example:
- Mix aniline and another organic substance, *eg* toluidine.
- Add bichromate.
- Leave to stand.
- Filter.
- Dry the residue.
- Extract the residue with coal tar naphtha.
- Evaporate off the naphtha.
- Dissolve the residue in methylated spirits.

2. See text - aniline, sulfate of toluidine, solution of xylidine, bichromate, coal-tar naphtha, methylated spirit
3. aniline - phenylamine; toluidine – 1-amino-2-methylbenzene or 2-amino-1-methylbenzene; xylidine - dimethylaminobenzene; coal tar naphtha - the same name is used today. Coal tar naphtha is a mixture of varying percentages of aromatic hydrocarbons including toluene, xylene and benzene; methylated spirit - 95% ethanol, 5% methanol; by 'bichromate' Perkin probably meant sodium (or potassium) dichromate ($Na_2Cr_2O_7$ or $K_2Cr_2O_7$).
4.
   a. Black powder – a compound produced between the oxidised aniline and oxidised other organic material
   b. brown substance - this is most likely mauveine sulfate
   c. mauveine sulfate + ethanol → mauveine ethanoate + sulfate ions
5. Potential difficulties to solve include: obtaining and transporting the raw materials; transferring large quantities of liquids between vessels; checking temperatures; filtering large quantities of liquids; health and safety hazards, such as flammability and toxicity.

The modern process

1. For example:
- Add reagents to a conical vial with a spin vane in place.
- Add 30 mg of potassium dichromate in 160 cm^3 of water.
- Stir for 2 hours.
- Draw off the liquid.
- Place the solid on filter paper.
- Apply suction filtration.
- Wash with distilled water.
- Dry at 110 ^oC for 30 minutes.
- Wash with petroleum ether.
- Dry at 110 ^oC for 10 minutes
- Wash with 25% methanol / water solution.
- Evaporate to 5 cm^3 volume.
- Transfer to a conical flask.
- Add 300 mm^3 of methanol to the solid.
- Draw off the liquid into a 3 cm^3 flask.
- Evaporate liquid to 30 mm^3 volume.

2. See text
3. Aniline - phenylamine; o-toluidine – 1-amino-2-methylbenzene or 2-amino-1-methylbenzene; p-toluidine – 1-amino-4-methylbenzene or 1-methyl-4-aminobenzene; petroleum ether is a general organic solvent comprising a mixture of hydrocarbons with M_r values between 87-114, including benzene. It is also called 'petroleum naphtha' or 'petroleum spirits' and is similar to the 'coal tar naphtha' described in the Perkin instructions.

4.
   a. '2N' = 2 mol dm^{-3} in modern units
   b. 0.052 ml
   c. a microscale version of a magnetic stirrer
   d. The black solid is the organic product generated between the oxidised aniline and oxidised toluidine.
   e. The raw product is being 'cleaned' of reagent molecules that have not reacted.
5. Measuring small quantities of chemicals accurately.

Compare the procedures

1. The modern procedure is longer with more washings of the product; the modern procedure names discrete chemicals; the amounts are more accurate; wider range of techniques.
2. Suction filtration; spin vane (stirring and heating of small quantities); measuring small quantities
3. The modern process: the greater precision and more extensive washings will contribute to this.
4. Examples - Periodic Table exists now, also naming of chemicals, understanding of structures and reaction processes; safety procedures, waste disposal, new techniques, better measurement. Essentially, Perkin knew the process but not the chemistry behind it.