Year 13 Science: Substitution reactions: from haloalkanes to amides

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. Name the organic product when 2-bromobutane is heated with KOH(aq).

2. Name the organic product when propanoic acid reacts with $SOCl_2$.

3. Name the organic product when ethanoyl chloride reacts with propan-1-ol.

4. Give the organic products when propanamide is heated with NaOH(aq).

5. What is seen when water is added to ethanoyl chloride, and why?

Exam-style question: a family of propyl compounds

1-bromopropane is heated with concentrated NH_3 to give compound A. 1-bromopropane is also heated with KOH(aq) to give compound B. Propanoic acid reacts with $SOCl_2$ to give compound C.

6. Name compound A, and say what it does to damp red litmus paper.

7. Name compound B.

8. Compound C reacts with A. Name the organic product and the type of link it contains.

9. Compound C reacts with B. Name the organic product.

10. The product from part 3 is heated under reflux with dilute HCl. Give the two organic products and explain why one of them is an ion.

Fix the mistake

11. Correct this statement: "1-bromopropane with KOH always gives propan-1-ol."

12. Correct this statement: "Hydrolysing an amide in acid gives the carboxylic acid and ammonia."

13. Correct this statement: "The ester from propanoic acid and methanol is propyl methanoate."

14. Correct this statement: "An acyl chloride dissolves in water to give a solution of the acyl chloride."

Answer key (for parents and tutors)

1. Name the organic product when 2-bromobutane is heated with KOH(aq).
   Butan-2-ol: OH^- replaces Br.
2. Name the organic product when propanoic acid reacts with $SOCl_2$.
   Propanoyl chloride, CH_3CH_2COCl, with SO_2 and HCl.
3. Name the organic product when ethanoyl chloride reacts with propan-1-ol.
   Propyl ethanoate, $CH_3COOCH_2CH_2CH_3$, with HCl.
4. Give the organic products when propanamide is heated with NaOH(aq).
   The propanoate ion, $CH_3CH_2COO^-$, and ammonia, NH_3.
5. What is seen when water is added to ethanoyl chloride, and why?
   Steamy fumes: the acyl chloride is hydrolysed to ethanoic acid and HCl gas, which forms droplets with moisture in the air.
6. Name compound A, and say what it does to damp red litmus paper.
   A is propan-1-amine, $CH_3CH_2CH_2NH_2$; it turns damp red litmus blue because its N lone pair accepts a proton from water, releasing OH^- (Achieved; Merit with the reason).
7. Name compound B.
   B is propan-1-ol (Achieved).
8. Compound C reacts with A. Name the organic product and the type of link it contains.
   $CH_3CH_2COCl + CH_3CH_2CH_2NH_2 \rightarrow CH_3CH_2CONHCH_2CH_2CH_3 + HCl$: N-propylpropanamide, which contains an amide (peptide-type) link (Achieved for the name, Merit with the equation).
9. Compound C reacts with B. Name the organic product.
   Propyl propanoate, $CH_3CH_2COOCH_2CH_2CH_3$ (Achieved).
10. The product from part 3 is heated under reflux with dilute HCl. Give the two organic products and explain why one of them is an ion.
    Propanoic acid, CH_3CH_2COOH, and the propylammonium ion, $CH_3CH_2CH_2NH_3^+$. Water breaks the C-N bond, and the propan-1-amine released is a base, so it accepts a proton from the excess acid and ends up as its ammonium ion (Merit; Excellence also contrasts the products in NaOH, propanoate ion and propan-1-amine, and explains the difference).
11. Correct this statement: "1-bromopropane with KOH always gives propan-1-ol."
    Only KOH(aq) gives the alcohol; KOH in alcohol mostly gives propene by elimination.
12. Correct this statement: "Hydrolysing an amide in acid gives the carboxylic acid and ammonia."
    In acid the NH_3 is protonated, so the products are the carboxylic acid and NH_4^+.
13. Correct this statement: "The ester from propanoic acid and methanol is propyl methanoate."
    The alcohol gives the first word and the acid the second: methyl propanoate.
14. Correct this statement: "An acyl chloride dissolves in water to give a solution of the acyl chloride."
    It reacts with the water, giving the carboxylic acid and HCl, seen as steamy fumes.