WJEC (Wales) Chemistry A-level

SP 4.8a - Synthesis of a Liquid Organic Product

Flashcards

Give the chemical equation for the reaction between 2-methylpropan-2-ol and concentrated hydrochloric acid

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2-methylpropan-2-ol + hydrochloric acid → 2-chloro-2-methylpropane + water

$$(CH_3)_3COH + HCl \rightarrow (CH_3)_3CCl + H_2O$$

Name the mechanism of the reaction which takes place between 2-methylpropan-2-ol and hydrochloric acid

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Nucleophilic substitution

What apparatus is required to synthesise 2-chloro-2-methylpropane from 2-methylpropan-2-ol?

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- Digital mass balance
- 100 cm^3 round bottom flask
- 100 cm^3 conical flask with stopper
- 10 cm^3 measuring cylinder
- 50 cm^3 measuring cylinder
- 50 cm^3 separating funnel
- Reflux condenser
- Thermometer
- Sample vial
- Water bath
- Bunsen burner
- Clamp stand
- Filter funnel with cotton wool

Outline the experimental procedure to produce 2-chloro-2-methylpropane from 2-methylpropan-2-ol

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1. Add 30 cm^3 of concentrated HCl solution to a stoppered conical flask. This should be done in a fume cupboard.
2. Cool the HCl solution in the ice bath.
3. When the HCl solution has cooled add 2.5 g anhydrous $CaCl_2$ to the solution.
4. Add 10 cm^3 of $(CH_3)_3COH$ to the reaction mixture. Mix thoroughly.
5. Remove the mixture from the ice bath and allow it to slowly warm up to room temperature. Note that gaseous side products can be formed at this stage and so the stopper should be released periodically.

Why should the hydrochloric acid be handled in a fume cupboard?

Why should the hydrochloric acid be handled in a fume cupboard?

Concentrated hydrochloric acid is toxic if breathed in. It is also corrosive. The fume cupboard helps to remove the vapours from the air.

What is the purpose of $CaCl_2$?

What is the purpose of $CaCl_2$?

$CaCl_2$ is a drying agent which removes water from the organic solution.

Why is it important that the stopper on the conical flask is released periodically after the reaction?

Why is it important that the stopper on the conical flask is released periodically after the reaction?

The gaseous side products will cause the pressure of the flask to increase. If the gases are not released, the build up of pressure could cause the flask to explode.

Why is it important that the conical flask containing hydrochloric acid is stoppered?

Why is it important that the conical flask containing hydrochloric acid is stoppered?

Hydrochloric acid is very volatile so the stopper prevents vapour escaping from the flask.

Outline the experimental procedure to purify 2-chloro-2-methylpropane from the synthesis reaction

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1. Transfer the reaction mixture to a separating funnel.
2. Stopper the funnel and invert it a few times to mix. Alleviate the pressure by opening the tap upside down.
3. Run off and discard the aqueous layer. Add 10 cm^3 of saturated $NaHCO_3$ solution to the organic layer and mix thoroughly in the separating funnel. Alleviate the pressure in the funnel periodically.
4. Run off and discard the aqueous layer.
5. Repeat steps 3-4 to wash the product for the second time.
6. Repeat steps 3-4 using 15 cm^3 of deionised water to wash the product for a third time.
7. Place the product in a conical flask. Add anhydrous $MgSO_4$ until it no longer clumps together.
8. Transfer the organic product to a round bottomed flask, filtering off the $MgSO_4$.
9. Distil off the $(CH_3)_3CCl$ produced and collect in a clean, dry, pre weighed 100 cm^3 conical flask.
10. Record the temperature at which the liquid product is collected.
11. Calculate the mass of the product and calculate the product yield.

How can you identify which is the aqueous layer in the separating funnel?

How can you identify which is the aqueous layer in the separating funnel?

Add deionised water to the separating funnel. The layer which increases in volume is the aqueous layer.

Why is $NaHCO_3$ added to the organic layer?

Why is $NaHCO_3$ added to the organic layer?

$NaHCO_3$ reacts with any excess acid. This allows it to then be easily removed from the organic product.

Give the chemical equation for the reaction between $NaHCO_3$ and HCl

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$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$

After the $NaHCO_3$ is added to the separating funnel, why is it important that the tap is periodically opened upside down?

After the $NaHCO_3$ is added to the separating funnel, why is it important that the tap is periodically opened upside down?

The $NaHCO_3$ reacts with the acid and produces CO_2 gas. The pressure caused by the gas needs to be alleviated by opening the tap. This should be done upside down so no solution is lost.

Why is $MgSO_4$ added to the organic product?

Why is $MgSO_4$ added to the organic product?

$MgSO_4$ is a drying agent which will remove any water from solution, leaving the organic liquid product.

Why is the organic product distilled in a round bottom flask?

Why is the organic product distilled in a round bottom flask?

The round bottom flask allows the reaction mixture to be evenly heated.

What is the purpose of anti bumping granules?

What is the purpose of anti bumping granules?

Anti bumping granules prevent the sudden production of large gas bubbles which can lead to 'bumping'. They encourage ‘smooth boiling’, preventing the liquid from splashing into the condenser.

How do you calculate percentage yield?

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$$\text{Percentage yield} = \frac{\text{Actual mass of product}}{\text{Theoretical mass of product}} \times 100$$

Why might the product yield be lower than expected for the synthesis of 2-chloro-2-methylpropane?

Why might the product yield be lower than expected for the synthesis of 2-chloro-2-methylpropane?

- The system is in equilibrium so some of the products may have reacted together to form the original reactants.
- Some of the product may have been lost during the purification process.