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methaneic magnesiumate + hydrogen gas ==================================== Footnotes: (1) For this tutorial, we will only be concerned with examples where R is an alkyl group (that is a group derived from the alkane series). And, we only be dealing with esters derived from straight chain carboxylic acids, so the name of the ester will be two words. It should be noted that the names of more complex esters will be made up of more than 2 words. If more than organyl group (alkyl, aryl etc) is present, they are cited in alphabetical order. (2) During the esterification reaction, the C-O bond in the carboxylic acid is broken. Evidence for this comes from experiments using isotopically labeled reactants. If some of the alcohol used contains the 18O isotope, the atoms of this isotope are all found in the ester product and NOT in the water. (3) There are other ways to produce esters besides the direct (Fischer) esterfication of a carboxylic acid with an alcohol. (a) Alcoholysis of acid chlorides, anhydrides, or nitriles, produces esters. (b) Reaction of the salt of a carboxylic acid with an alkyl halide or sulfate will produce an ester. (c) Trans-esterification of an ester produces a new ester. (4) If a liquid is largely free of air, and the glass flask is clean and very smooth, the liquid may superheat, a condition in which the temperature of the liquid rises above its boiling point. In a superheated liquid it is hard to form vapour bubbles resulting in irregular expulsion of bubbles of vapour, or, bumping. Boiling chips (pieces of porous pot) provide an additional source of minute air bubbles which act as a nucleus for building bubbles of vapour in the liquid, allowing the liquid to boil quietly. (5) An even better way to improve ester yield is to use anhydrides in the synthesis instead of carboxylic acids. For example, the reaction between ethanol and acetic anhydride is irreversible, and goes to completion within minutes. acetic anhydride + ethanol → ethyl acetate + acetic acid (6) Although sulfuric acid plays a vital role in the esterification reaction mechanism, it is beyond the scope of this tutorial. Suffice it to say that since the sulfuric acid that is used during in the reaction is re-produced at the end of the reaction mechanism, sulfuric acid is acting as a catalyst for the reaction. (7) For a saturated sodium carbonate solution, dissolve 4.5 g sodium carbonate in 15 mL of distilled water. (8) If you are an organic chemist you will name HO-CO-O-Na+ as sodium hydrogen carbonate, but if you are an inorganic chemist you will probably name it sodium hydrogencarbonate. Another common name for the same compound is sodium bicarbonate. (9) Anhydrous magnesium sulfate is used as a drying agent in preference to fused or "anhydrous" calcium chloride which can combine with some esters. Note the use of the term "drying agent". No chemical change is involved in using a drying agent, the drying agent is used to remove excess water molecules from the mixture. In a dehydration reaction, however, there is a chemical change. Atoms of hydrogen and oxygen are removed from reactant molecules and produce water as product.The neutralisation reaction between a carboxylic acid and a hydroxide yields salt and water. For instance, potassium hydroxide reacts with ethanoic acid to form potassium ethanoate and water: CH3COOH + KOH → CH3COOK + H2O. In another example, the reaction of a carboxylic acid with a carbonate results in the production of a metal salt, water, and carbon dioxide. For instance, potassium carbonate reacts with ethanoic acid to yield potassium ethanoate, water, and carbon dioxide: 2CH3COOH + K2CO3 → 2CH3COOK + H2O + CO2. The process of making an ester involves several stages, each requiring careful attention to detail. The first stage is neutralizing any acids present in the mixture using sodium carbonate solution. After adding the solution and replacing the stopper, the separating funnel is shaken to ensure complete removal of the acid. However, this process creates carbon dioxide, which needs to be released periodically by inverting the funnel, opening the tap, and allowing the gas to escape. Once there's no more effervescence or gas pressure, the mixture can settle, and when the two layers are fully separated, the stopper is removed, and the lower aqueous layer is carefully run off without losing any of the ester. To remove impurities, particularly acidic ones, concentrated calcium chloride solution is added to the still-impure ester in the separating funnel. The mixture is shaken again, allowing the aqueous calcium chloride to absorb any remaining unreacted alcohol. After tapping off the lower aqueous layer, only the ester layer remains, which may contain some water. The final step involves drying the product. The still-pure ester is run off from the separating funnel into a small conical flask and mixed with granules of anhydrous calcium chloride. The mixture is then stoppered and shaken to allow the calcium chloride to absorb any remaining moisture in the ester. Once the pure ester can be filtered off, it's ready for use. This reaction follows an equilibrium process, where starting with pure acid and alcohol yields about 2/3rds conversion to the ester. The preparation is catalyzed by a few drops of concentrated sulphuric acid, but due to losses in each step, the theoretical maximum reaction yield is only about 67%.The molecules that can overcome attractive forces in liquids and escape into the air have higher kinetic energy. These escaped molecules diffuse through the air to reach receptor cells in the nose, triggering the sense of smell. Perfume molecules must be volatile but not too volatile for their effect to last long. When heated, particles gain kinetic energy and move faster, overcoming intermolecular forces. Therefore, perfumes should smell stronger in warmer rooms theoretically. Esters are ideal for cosmetic perfumes due to their volatility and pleasant scent. However, esters are also used in air fresheners, such as jasmine's flowery smell. Due to limited fruit sources, many esters are now synthesized. This means that flavorings and derived tastes in fruit drinks, sweets, and cakes may come from manufactured esters. Esters are used in pharmaceuticals and household products, like ointments and washing-up liquids, for their pleasant odor. Designing a perfume requires several factors, including the use of esters. The chemicals must have certain properties, such as evaporation rate, to be effective. They should not react with water or be soluble in it. Esters must also be non-toxic and harmless to the skin. Cosmetic companies develop new products based on consumer demand. However, testing these products involves animal trials. Opinions are divided between using animal testing for safety reasons versus believing it's morally wrong. The European Union has banned most animal test procedures due to concerns about animal welfare. ester fumes, or indeed their use as food additives. Why does a substance dissolve in one liquid solvent but not another? There are three particle interactions going on if you mix one substance with another e.g. a liquid solvent that may or may not dissolve a solid. The three possible attractions are (i) solid ... solid, (ii) solid ... liquid and (iii) liquid ... liquid. The relative strength of these attractive intermolecular forces decides whether e.g. a solid will dissolve in a particular solvent. For example, nail varnish will not dissolve in water, but will dissolve in organic solvents like an ester, alcohol or acetone. Nail varnish is insoluble in water because the intermolecular forces between the nail varnish molecules themselves, and between the water molecules themselves are much stronger than the attraction between water and the nail varnish molecules, so the nail varnish cannot possibly dissolve in water. Forces (i) and (iii) override force (ii) However, nail varnish will dissolve in organic solvents like butyl ethanoate or ethyl ethanoate (esters, old names butyl acetate and ethyl acetate), ethanol ('alcohol') and propanone (old name acetone) solvents. Here the organic solvent intermolecular attraction to the nail varnish molecules can override the nail varnish ... nail varnish and the solvent ... solvent intermolecular forces and the nail varnish will dissolve. In this case attractive force (ii) overrides both attractive forces (i) and (iii). Since different solvents are different molecular affinities for different substances, the solubility of a solute in a solvent can vary quite considerably from one solvent to another. The question of which solvent you choose to use to dissolve a substance depends on two main factors .. (a) How soluble is the substance in the solvent? (b) How safe is to use the solvent? e.g. in terms of inhaling vapour or spillage on the skin (gloves!), is it harmful?, irritating?, even toxic?, and is it highly flammable, so more dangerous to use. Chlorinated organic solvents e.g. trichloromethane ('chloroform') tend to be harmful, alcohols and esters are safer but are more flammable. This section is repeated in alcohols Other natural esters - triglycerides Esters from the 'triol' alcohol glycerol , which has three C-O-H groups, is the alcohol plants and animals use to make oils and fats - which are esters we use in food and soaps. Animals and plants combine glycerol and long chain fatty acids to make triglyceride esters - fats from animals and oils from plants. For more details on fatty acids, oil and fat esters see Oils, fats, margarine and soaps Polymers - polyesters like Terylene (diagram above) The diagram above shows part of structure of Terylene, a very useful polymer used for making plastic objects and also manufactured as fibres for use in fabrics for the clothing industry. You don't have to know any detailed molecular structure at GCSE/IGCSE level, but I have highlighted the -COOC- ester linkage, which is the same functional group structure as in the 'little' esters described on the page above. The most common use of polyester today is called PET (for short!) and is used to make the plastic bottles for storing liquids in like soft drinks, PET is very useful because it is transparent, shatterproof and cheap! Fine polyester fibres can be made into a variety of articles of clothing which are lighter and cheaper than traditional materials like wool. Plastic bottles made from polyester can recycled and turned into fibres again and reused in clothing. For more see section 11. Condensation polymers including Terylene INDEX of Advanced A Level revision notes on the chemistry of CARBOXYLIC ACIDS and DERIVATIVES Multiple Choice Quizzes and Worksheets KS4 Science GCSE/IGCSE m/c QUIZ on Oil Products (easier–foundation–level) KS4 Science GCSE/IGCSE m/c QUIZ on Oil Products (harder–higher–level) KS4 Science GCSE/IGCSE m/c QUIZ on other aspects of Organic Chemistry and 3 linked easy Oil Products gap–fill quiz worksheets ALSO gap–fill ('word–fill') exercises originally written for ... ... AQA GCSE Science Useful products from crude oil AND Oil, Hydrocarbons & Cracking etc. ... OCR 21st C GCSE Science Worksheet gap–fill C1.1c Air pollutants etc ... ... Edexcel GCSE Science Crude Oil and its Fractional distillation etc ... ... each set are interlinked, so clicking on one of the above leads to a sequence of several quizzesThe process of esterification, which involves the combination of an organic acid (RCOOH) with an alcohol (ROH) to form an ester (RCOOR) and water, is a fundamental concept in organic chemistry. This reaction is crucial for various applications, including the production of medicines, paints, and fragrances. Esterification can occur through three main methods: acid anhydride and alcohol, acid chloride and alcohol, and carboxylic acid and alcohol. The choice of method depends on the desired outcome and the reactants involved. In the first method, esterification occurs between an alcohol and an acid anhydride, resulting in a slower reaction rate compared to the second method. To obtain multiple esters, the mixture is warmed, as seen in the example with 2,6-diiodophenol reacting with an acid anhydride. The second method involves esterification between an alcohol and an acid chloride, which can be performed at room temperature. This reaction produces an ester with steamy acidic fumes of hydrogen chloride, such as benzoyl chloride reacting with alcohol to form an ester. In the third method, esterification occurs when carboxylic acid and alcohol are heated in the presence of an acid catalyst like sulphuric acid (H2SO4). For instance, the reaction between ethanoic acid and propanol produces propyl-ethanoate and water. Esters possess distinct characteristics, including a pleasant smell and wide applications in perfumes, food flavorings, and cosmetics. These compounds are also used as organic solvents and have various industrial uses.Esterification reaction involves a chemical equation that explains how carboxylic acid reacts with alcohol to form an ester. For instance, ethanol combines with ethanoic acid in the presence of an acid catalyst to produce a sweet-smelling substance, which is ethylethanoate. The process of forming an ester can be demonstrated through an activity: Take 1 ml of ethanol and 1 ml of glacial acetic acid in a boiling tube, mix well, add a few drops of concentrated H2SO4, warm for a few minutes, then pour the solution into a beaker containing water. Observe the sweet-fruity smell indicating ester formation. During the reaction, ethanoic acid takes a proton from concentrated sulphuric acid, which gets attached to one of the oxygen atoms with double bonds to carbon. This process involves electron pair shifting, resulting in delocalised structures known as resonance forms or canonical structures. These structures contribute to the real structure of the ion formed. In the lab, carboxylic acids and alcohols are often warmed together with a few drops of concentrated sulphuric acid to observe the smell of esters produced. However, this method is slow and reversible, resulting in limited ester production. A better approach involves pouring the mixture into water, where excess acid and alcohol dissolve while the ester layer forms on the surface. For larger-scale synthesis, methods depend on ester size, with smaller esters formed faster than bigger ones. One technique involves gently heating a mixture of ethanoic acid and ethanol in the presence of sulphuric acid, then distilling off the ester as soon as it's formed to prevent reverse reactions. Esterification is a chemical reaction between an alcohol and a carboxylic acid, often requiring an acid catalyst. This process produces esters, valuable compounds used in fragrances, flavors, and industrial applications. Esters are typically volatile, with pleasant sweet or fruity odors.Esters are versatile compounds used in various industries, including perfumery, food flavoring, plastics, solvents, and medicine. They possess distinct characteristics that set them apart from their parent carboxylic acids and alcohols. For instance, esters have lower polarity, leading to lower boiling points compared to their parent compounds. Furthermore, esters are generally soluble in organic solvents but tend to be less soluble in water. The molecular structure of esters is characterized by an ester group (-COO-), formed through the reaction between a carboxylic acid and an alcohol. This can be seen in examples such as: 1. Acetic acid (CH_3COOH) reacting with ethanol (C_2H_5OH) to form ethyl acetate ($CH_3COOC_2H_5$) 2. Methanol (CH_3OH) combining with acetyl chloride (CH_3COCl) to produce methyl acetate (CH_3COOCH_3) and hydrochloric acid (HCl) 3. Butanol (C_4H_9OH) reacting with acetic anhydride ($(CH_3CO)_2O$) to form butyl acetate ($(CH_3CO)_2C_4H_9$) and acetic acid (CH_3COOH) The Fischer esterification mechanism involves several steps, including protonation of the carbonyl oxygen in the carboxylic acid, nucleophilic attack by the alcohol, formation of a tetrahedral intermediate, and finally, elimination of water to form the ester. Esters are crucial in various applications: * Fragrances: Esters like isoamyl acetate (banana scent) and ethyl butanoate (pineapple scent) are used in perfumes. * Food Flavorings: Esters such as ethyl acetate (pear flavor) and methyl butanoate (apple flavor) mimic natural fruit flavors. * Plastics and Polymers: Esters serve as building blocks for synthetic materials like polyesters, which are used in fabrics and packaging materials. * Solvents: Esters like ethyl acetate and butyl acetate are effective solvents for paints, coatings, adhesives, and nail polish removers. * Medicinal Applications: Certain esters have therapeutic properties and are used in pharmaceuticals. In the laboratory, esterification reactions can be carried out to test equilibrium positions at different temperatures using ethanoic acid and ethanol. When conducting this experiment, safety precautions should be taken to prevent accidental contact with chemicals and ensure a well-ventilated area is maintained.