

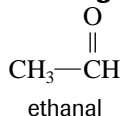
1.6 ALDEHYDES AND KETONES

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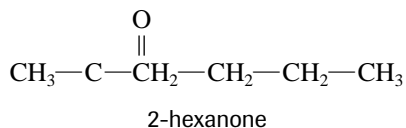
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Understanding Concepts

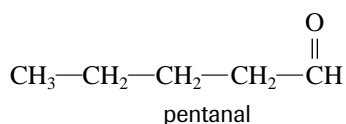
1. (a)



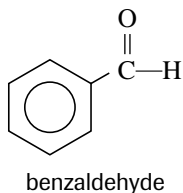
(b)



(c)



(d)



2. (a) 2-heptanone, 3-heptanone, 4-heptanone

(b) heptanal

3. (a) pentanal

(b) 3-hexanone

(c) methanal

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4. (a) propanone

(b) methanal

(c) ethanal

5. In order of increasing boiling points: propane (b); 1-propanone (a); 1-propanol (c). This order is predicted because (a) contains a carbonyl group (with a polar double bond), making it more polar than (b), which gives 1-propanone a higher boiling point than propane. 1-propanol contains a hydroxyl group, which can hydrogen bond with other molecules, giving (c) a higher boiling point than (a) or (b).

Try This Activity: How Many Can You Build?

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(a) ethanol (hydroxyl group), methoxymethane (oxygen atom bonded to two alkyl groups, an ether)

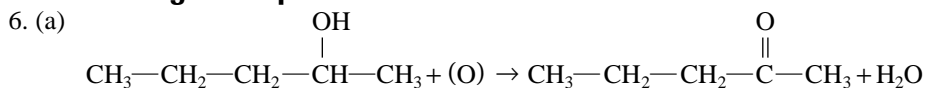
(b) 1-hydroxy-1-propene, 3-hydroxy-1-propene, propanal, propanone

(c) The two compounds in (a) are structural isomers; the four compounds in (b) are structural isomers; 1-hydroxy-1-propene has *cis*- and *trans*- isomers.

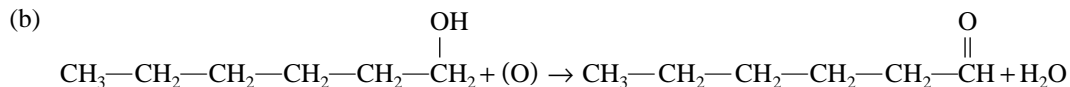
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2-pentanol + (controlled oxidation) → 2-pentanone + water



1-hexanol + (controlled oxidation) → hexanal + water

7. In increasing order of solubility: butane (c), 2-butanone (a), 1-butanol (b). Butane is a nonpolar hydrocarbon and is less soluble in water than the ketone (a) and the alcohol (b). The ketone (a) has a polar carbonyl group, making it more soluble in water than (c), but it is less soluble than the alcohol (b), which has a hydroxyl group that allows it to hydrogen bond.
8. Generally, the term “oxidation” means a reaction in which a substance gains oxygen atoms or loses hydrogen atoms. Further definitions of oxidation also include reactions that do not involve oxygen or hydrogen atoms.

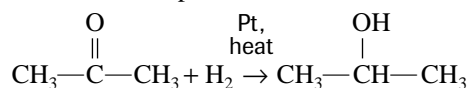
Applying Inquiry Skills

9. Experimental Design

Acetone (propanone) is hydrogenated, at high temperatures and in the presence of a catalyst, to produce 2-propanol.

Procedure

1. Set up equipment for heating acetone and condensing the product.
2. Insert a catalyst (e.g., Pt) where the hot acetone will circulate.
3. Heat the acetone carefully.
4. Condense and collect the product.



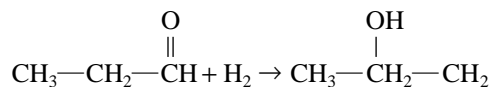
propanone (acetone) + hydrogen → 2-propanol (*i*-propyl alcohol)

SECTION 1.6 QUESTIONS

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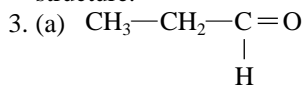
Understanding Concepts

1. (Sample answer)



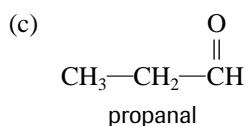
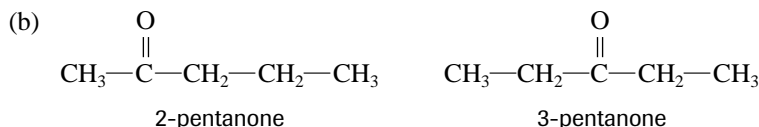
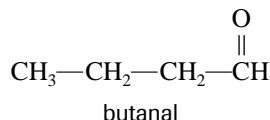
propanal + hydrogen → 1-propanol

2. The carbonyl group in butanal must be at the end of the 4-carbon chain; only one structure is possible. The carbonyl group in butanone must be either carbon-2 or carbon-3, not at an end carbon atom; either position results in the same structure.



propanal

- (b) $\text{O}=\text{C}=\text{O}$ and $\text{H}-\text{O}-\text{H}$
carbon dioxide and water
4. (a) The ether ethoxypropane will evaporate at a lower temperature because it is less polar than the pentanal which contains a polar carbonyl group.
- (b) The ether ethoxypropane has higher solubility in nonpolar solvents because it does not contain any carbonyl groups and is less polar than the pentanal.
- (c) The pentanal can undergo an addition reaction with hydrogen at its carbonyl group, but the ether cannot.
5. (a) (Sample answer)



Applying Inquiry Skills

6. Experimental Design

The tertiary alcohol does not undergo controlled oxidation to aldehydes or ketones; each alcohol is allowed to react with sodium dichromate and the alcohol that does not cause a colour change in the dichromate solution is the tertiary alcohol. (Primary alcohols are oxidized to aldehydes, and secondary alcohols are oxidized to ketones.)

Procedure

- Set up three separate test tubes containing each of the alcohols.
- Add the sodium dichromate solution, in the presence of H_2SO_4 .

Safety Precautions:

Do not use open flames. Sulfuric acid is corrosive; avoid contact with skin or clothing. Wear eye protection and a lab apron.

7. Experimental Design

1-butene is hydrolyzed with water, in the presence of acid, to produce 2-butanol. 2-butanol is then made to undergo controlled oxidation (e.g., in KMnO_4) to produce butanone.

Procedure

- Place 1-butene in a container and add sulfuric acid.
- Add $\text{KMnO}_{4(\text{aq})}$ to the mixture.

Safety Precautions:

Do not use open flames. Sulfuric acid is corrosive; avoid contact with skin or clothing. Wear eye protection and a lab apron. Work in a well-ventilated area. Dispose of organic materials in designated containers for collection.

Making Connections

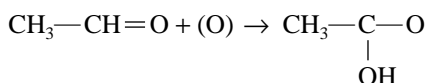
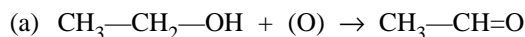
8. Examples include acetone, wood alcohol, rubbing alcohol, formaldehyde, natural gas, barbecue gas, lighter fluid, and glycerin.
9. (a) methanal
- (b) Formaldehyde is a flammable, poisonous, colourless gas with a suffocating odour. It readily polymerizes into paraformaldehyde, a white solid that can be formed into candles and used for fumigating rooms. Formalin, the preservative used in biological materials, is a solution of formaldehyde in water, with a small amount of methanol added.
- Other fluids used as preservatives include alcohol (the standard is 70–75% ethanol, or 40–50% 2-propanol); Zenker's fluid (containing mercury(II) chloride, glacial acetic acid, potassium dichromate, and sodium sulfate in water).

10. (a) Acetone contains a carbonyl group that is polar and makes it soluble in aqueous solutions.
- (b) $c = 20 \text{ mg}/100 \text{ mL}$
 $c = 200 \text{ mg/L}$
 $M_{\text{CH}_3\text{C(O)CH}_3} = 58.09 \text{ g/mol}$
 $n = \frac{200 \text{ mg}}{58.09 \text{ g/mol}}$
 $n = 0.003 \text{ mol}$
 $c = 0.003 \text{ mol/L}$
- (c) People who are severely starved or dieting do not have a ready supply of sugars in their bodies and are breaking down fats for energy. The acetone produced in the process is exhaled with the breath.
- (d) Diabetic ketoacidosis (DKA) is a condition that occurs when blood sugar levels get too high. The signs of DKA include nausea and vomiting (which can lead to dehydration), stomach pain, and deep and rapid breathing. Other symptoms include a flushed face, dry skin and mouth, a fruity odour to the breath, a rapid and weak pulse, and low blood pressure. DKA may be avoided by taking the correct amount of insulin, or exercise. In emergency situations, the person must be given fluids and insulin right away, or ketoacidosis can lead to coma and even death.

1.7 CARBOXYLIC ACIDS AND ESTERS

Try This Activity: Making Flavoured Vinegar

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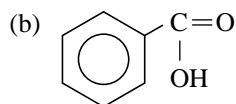
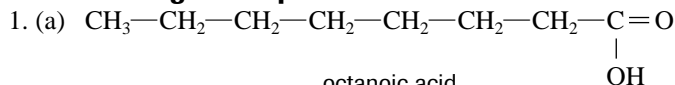


- (b) To test for acid, use pH meter or pH paper; or mix with baking soda and look for bubbles of CO_2 formed.
- (c) Heating the jars of vinegar has the effect of stopping further reaction by the yeast; the high temperature kills the yeast.

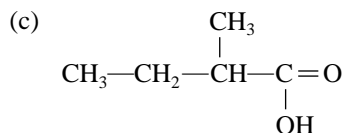
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Understanding Concepts



benzoic acid



2-methylbutanoic acid

2. (a) methanoic (formic) acid
 (b) 3-ethylpentanoic acid
 (c) 2,3-diethylhexanoic acid