RoshChem

Carbon based fuels

Part 1 Solutions

Chemistry

Units 3&4

Dr. Roshani Peiris

PhD (Monash University), Grad. Chem. (1st class Hons.)

1.

a. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

b. $C(s) +)O_2(g) \rightarrow CO_2(g)$

c. $2C_8H_{18}(l) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(l)$

d. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

2. $C_2H_5OH(l) + 2O_2(g) \rightarrow 2CO\ (g) + 3H_2O(l)$

3.

Similarity

- Methane produced from both biogas and natural gas produces carbon dioxide when combusted.
- Methane produced from both biogas and natural gas contains small amounts of nitrogen and sulfur. And the combustion produces oxides of nitrogen and sulfur.

Difference

- Methane from landfills is more carbon neutral. Methane from natural gas increases atmospheric CO_2 levels.
- Landfill gases contain less methane and release more CO_2 for the same amount of energy generated. Natural gas has more methane and releases less CO_2 for the same amount of energy generated.
- Methane is 21 times more effective as a greenhouse gas than carbon dioxide. So, it is better to burn methane present in biogas to release carbon dioxide than to release methane into the atmosphere. Therefore, the collection of biogas can minimise emissions.

4. They are made from primitive plants and animals. The formation of fossil fuels takes millions of years, and they are used at a faster rate than they can be replaced.

5.

Biogas - It can be used for heating to power homes and farms.
biodiesel – as a fuel for transportation
bioethanol - as a fuel for transportation

6. Fuels are considered to be renewable if they can be replaced at a sustainable rate.
A renewable resource is one that can be used repeatedly and does not run out because it is naturally replaced.
Eg: solar power, biochemical fuels

Non-renewable energy resources
Resources that are used at a faster rate than they can be replaced
Eg: fossil fuels take millions of years to form and cannot be replaced in a shorter period.

7.
   a. Land Use and Deforestation: Biodiesel production often relies on the cultivation of crops such as soybean, palm oil, and canola. Large-scale monoculture farming for biodiesel feedstocks can lead to deforestation and the displacement of natural ecosystems, which can have negative environmental consequences.
   b. Food vs. Fuel: The use of food crops like corn and soybeans for biodiesel can lead to competition for land and resources with food production. This can potentially drive up food prices.
   c. Greenhouse Gas Emissions: While carbon dioxide released during the combustion of biodiesel is absorbed by the plants used to make biodiesel, its production and transportation can still generate greenhouse gas emissions.
   d. Land and Water Resource Consumption: Biodiesel crops require significant amounts of land, water, and fertilisers for cultivation. This can strain local resources, lead to water pollution from runoff, and negatively impact soil health.
   e. Biodiversity Loss: The expansion of biodiesel crop plantations can threaten local biodiversity and disrupt ecosystems.
   f. Energy-Intensive Production: The production process of biodiesel, particularly through transesterification, can be energy-intensive. The energy required for processing and transporting feedstocks and the final product can offset some of the environmental benefits of biodiesel.
   g. Cannot be used in cold climates- due to the presence of polar ester molecules, biodiesel has stronger intermolecular forces and can solidify in cold climates.

8.

	Advantages	Disadvantages
Bioethanol	Renewable CO_2 absorbed by plants Fewer particulate emissions than Petrol Burns smoothly It can be made from waste	Lower energy content than Petrol Limited supply of raw materials Growing crops can cause land degradation and erosion. The cost of some food, such as corn, can increase.

9. Higher Sugar Content: Sugarcane is a high-sugar crop, and molasses is a byproduct of sugar extraction. Molasses contains a high concentration of fermentable sugars, primarily sucrose, making it a rich source of feedstock for bioethanol production. Forest waste, on the other hand, contains much lower sugar content, primarily in the form of cellulose.

Simpler Preprocessing: Sugarcane and molasses are relatively easy to process (sucrose is a small and soluble molecule). The sugar content is readily accessible and can be easily extracted. In contrast, forest waste, such as wood or plant residues, typically requires more complex and energy-intensive preprocessing steps like pretreatment and enzymatic hydrolysis to break down cellulose into fermentable sugars. This is because, in cellulose, there are strong hydrogen bonds holding the polymer chains.

10. Bioethanol: Bioethanol is an alcohol produced through the fermentation of sugars by yeast or other microorganisms. Ethanol is soluble in water as it can form hydrogen bonds with water. Therefore, ethanol solution produced by fermentation have a larger amount of water in it. Ethanol has a lower boiling point than water, which makes it possible to separate ethanol from the water and other components using distillation. Ethanol used as a biofuel or for various industrial applications needs to be relatively pure and highly concentrated. Distillation is essential for achieving the desired ethanol concentration (usually above 95%) and removing impurities.

Biodiesel: Biodiesel is typically produced through a chemical reaction called transesterification, which converts vegetable oils or animal fats into biodiesel. This reaction does not require distillation because the products have different chemical properties, and they naturally separate after the reaction. The glycerol layer settles at the bottom, and the biodiesel settles at the top.

Biogas: Biogas is mainly composed of methane, carbon dioxide, and small amounts of other gases. Separating methane from other gases in biogas can be done without distillation through processes like compression, adsorption, or membrane separation. For example, to remove the CO_2, the industry often uses membranes. These membranes function as molecular sieves that separate the methane and the CO_2.