The following questions assume knowledge of molecular structure, bonding and the ideal gas law (PV=NRT)

Note PV=nRT is not on the 2024-2027 course but is included here as knowledge of units 1 and 2 is always assumed.

1. The term 'clean coal' is increasingly being used to describe black coal. On the other hand, brown coal is described as a dirty alternative to black coal. Terms such as “clean or dirty” tend to muddy the argument in the use of coal as a fuel.
   a. Can coal, in all its forms, ever be a clean fuel alternative? Explain.

   b. Explain why is black coal given the term “clean coal” over the alternative brown coal?

2. Hydrogen and methane are common fuels. Even though hydrogen has a higher energy density than methane
   a. Draw the molecule of:

methane	hydrogen

   b. Describe the intermolecular bonds found amongst the molecules of methane and hydrogen.

   c. Explain why methane is currently more widely used as a fuel than hydrogen. In your answer show an understanding of the role intermolecular forces play in the storage and usage of each gas.

3. Liquefied ammonia and hydrogen can be transported via huge sea-going vessels. The cost of shipping hydrogen, however, is much greater than shipping ammonia. Given the boiling temperatures of hydrogen and ammonia are -253^{O}C and -33^{o}C respectively and that hydrogen is an odourless gas compared to the distinct and noticeable odour of ammonia, answer the following questions.

   a. Explain why, with reference to molecular structure of each molecule, transporting ammonia is a lot cheaper than the same mass of hydrogen gas.

   b. Why is it safer to transport ammonia than it is to transport pure hydrogen gas?

   c. "A greater mass of hydrogen can be transported in a given storage tank, under identical conditions, in the form of ammonia gas than as pure hydrogen gas" Justify this comment.

   d. Calculate the mass of hydrogen present in a 300.0 litre storage tank at 30^{o}C and 400 kPa pressure containing:
      i. pure hydrogen gas.

      ii. pure ammonia gas.

Step 1	fermentation	$C_6H_{12}O_6(aq) \rightarrow 2CH_3CH_2OH(aq) + 2CO_2(g)$
Step 2	oxidation	$CH_3CH_2OH(aq) + O_2(aq) \rightarrow CH_3COOH(aq) + H_2O(l)$
Step 3	neutralisation	$2CH_3COOH(aq) + CaCO_3(s) \rightarrow Ca(CH_3COO)_2(aq) + CO_2(g) + H_2O(l)$
Step 4	bacterial conversion	$Ca(CH_3COO)_2(aq) + H_2O(l) \rightarrow 2CH_4(g) + CO_2(g) + CaCO_3(s)$

4. Biogas can be produced from waste water and organic material where sugars are present. A 4 step process is used and pictured above.

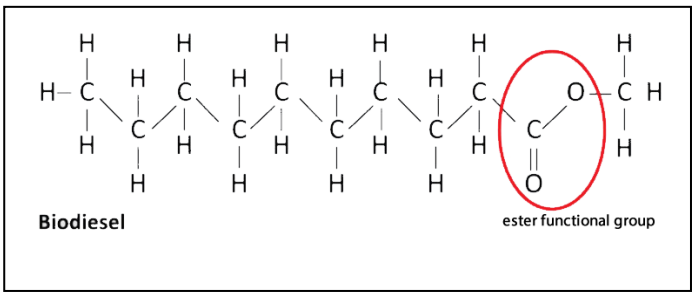
   a. Assuming ten molecules of glucose reacted, under identical conditions, in step 1 what is the value of the expression shown on the right?

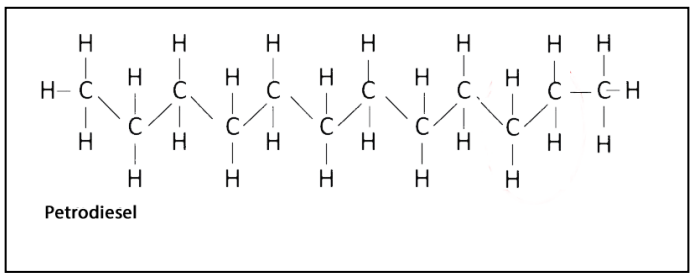
$$\frac{\text{Final volume of } CH_4 \text{ formed in step 4}}{\text{Final volume of } CO_2 \text{ formed in step 4}}$$

   b. Explain with reference to the reactions above why biogas, formed in this way, is renewable and environmentally friendly.

5. On the right are two molecules that are typical of biodiesel and petrodiesel.

   a. Which one of these two molecules would you expect to form flammable vapours at the lowest temperature? Explain.



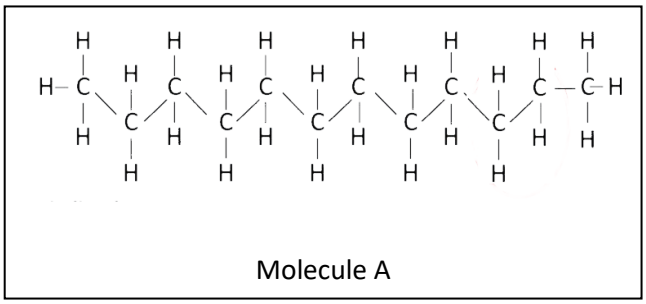


   b. Write the balanced chemical equations for the complete combustion reaction for each molecule. States not included.

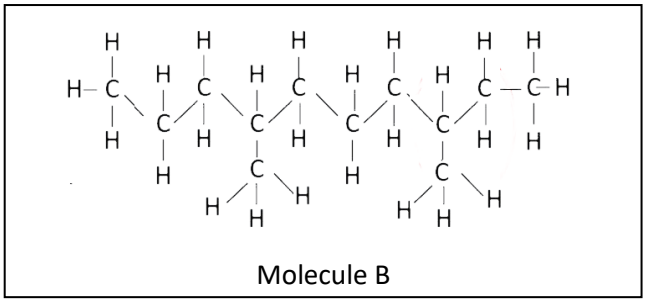
c. Which one of these two molecules is likely to burn completely in a low oxygen environment and produce less energy than the other? Explain.

6. Calculate the mass, in grams, of methane gas needed to be burnt completely in order to raise the temperature of 200 mL of water from 25.0 °C to 55.0°C. Assume 100% of the heat energy is absorbed by the water sample.

7. Consider the two hydrocarbons shown on the right. These molecules are considered as fuels in a town high in the mountains where the temperature can drop to below zero for several months of the year. Which molecule is best suited as a fuel under such conditions? Explain.



Molecule A



Molecule B

8. Climate change has been identified as a threat to the environment. Fossil fuels are recognised as a significant contributor to the rise in carbon dioxide levels in the atmosphere. The replacement of fossil fuels as an energy source represents a challenge and has been the focus of research for a number of years. However, there are different opinions/views about the suitability of using a biofuel, such as biodiesel,

and bioethanol as a replacement for fossil fuels.
Using the chemistry that you studied, discuss the **carbon neutrality** and the **sustainability** of using biodiesel or bioethanol as a fuel for transport.

a. Carbon neutrality.
   i. For

   ii. Against

b. Sustainability
   i. For

   ii. Against