**SECTION A: Multiple-choice questions (1 mark each)**

**Question 1**

*Answer:* C

*Explanation:*

A fuel needs to release significant energy and it needs to be released relatively simply.

**Question 2**

*Answer:* A

*Explanation:*

 In 2023, fossil fuels accounted for over 60 % of our electricity. Wind/solar and hydro combine for most of the remainder.

**Question 3**

*Answer:* B

*Explanation:*

Rotting biomass produces biogas which is being collected in the bags.

**Question 4**

*Answer:* D

*Explanation:*

 The per mole is incorrect in the other options.

**Question 5**

*Answer:* A

*Explanation:*

 This is an exothermic reaction. Energy is released to the surroundings.

**Question 6**

*Answer:* D

*Explanation:*

 The higher value per gram for fats leads to option D providing the highest total. (37 x 12kJ)

**Question 7**

*Answer:* A

*Explanation:*

Heats of combustion and amounts of energy released are represented as positive values.

**Question 8**

*Answer:* C

*Explanation:*

 Bioethanol converts glucose to an ethanol solution. The %ethanol is unlikely to be above 15%. The presence of oxygen would lead to oxidation of ethanol to ethanoic acid.

**Question 9**

*Answer:* B

*Explanation:*

The polarity of ethanol leads to a greater likelihood of water being absorbed by the fuel.

**Question 10**

*Answer:* C

*Explanation:*

Option A will not be as high as it is incomplete combustion. Option D will also be less as the methane is starting as a liquid. Option B will be less as the water is in a gaseous state.

**SECTION B: Short-answer questions**

**Question 1** (15 marks)

**a. i**. C2H6O(l) + 3O2(g) 🡪 2CO2(g) + 3H2O(l) ∆H= -1360 kJ 1 mark

 **ii**. 92 g = 2 mol => 2720 kJ 2 marks

 **ii**. C2H6O(l) + 2O2(g) 🡪 2CO(g) + 3H2O(l) 1 mark



**b**.  **i**. 1 mark

 **ii**. Synthetic ethanol is the same molecule as bioethanol. If both samples are purified the properties should be

 the same. 2 marks

**c**. **i**. Fermentation requires smaller saccharides, such as glucose. Pretreatment involves pulping the timber to a solution and allowing enzymes to break the cellulose molecules to glucose. 2 marks

 **ii**. Glucose is a ‘hexose’ type of sugar as it has 6 carbon atoms. Although you have not met pentose you can conclude it is a small sugar and that it ferments to ethanol under the same conditions as glucose. 2 marks

**d**. **i**. 2C2H6O(aq) 🡪 2C2H6O(aq) + 2CO2(g) 1 mark

 **ii.** Fermentation produces an ethanol solution. It needs to be distilled in the columns to remove the water. The column separates water and ethanol on the basis of ethanol having a lower boiling point. Ethanol will come off the top of the tower and water the bottom. 3 marks

**Question 2** (6 marks)

**a**. **i**. The bonds broken are the covalent bonds in P4 and the double covalent bond in oxygen molecules.

 1 mark

 **ii**. The bonds formed are the covalent bonds in P4O10. 1 mark

 **iii**. The temperature of the surroundings will rise 1 mark

 **iv**. The activation energy is 400 kJ 1 mark

**b**. P4(s) + 5O2(g) 🡪 P4O10(s) ∆H = -600 kJ 2 marks

**Question 3** (8 marks)

**a. i.** 6CO2(g) + 6H2O(l) 🡪 C6H12O6(aq) + 6O2(g) 1 mark

  **ii**. light energy 🡪 chemical potential energy 1 mark

 **iii**. energy, make glycogen or other polysaccharides 2 marks

**b**. **i**. C6H12O6(aq) + 6O2(g) 🡪 6CO2(g) + 6H2O(l) . 1 mark

 **ii**. chemical potential energy 🡪 kinetic energy 1 mark

 **iii**. 4 x 2803 = 11200 kJ 1 mark

**c**. Carbohydrates contain a significant number of oxygen atoms. They are already ‘partially’ oxidised, unlike fats. 1 mark

**Question 4** (11 marks)

**a**. **i**. Farm animal waste. The waste is added to anerobic digestor where bacteria can produce biogas.

 2 marks

 **ii**. CH4 65%, CO2 30%, water 5% 2 marks

 **iii**. biogas can be burnt in a generator to produce electrical energy – usually done on site 1 mark

**b**. **i**. Lipids are triglycerides. They have three long hydrocarbon chains that each forms an ester bond with a glycerol molecule. 2 marks

 **ii**. Plant oil is reacted with methanol in concentrated KOH. The ester bonds in the triglyceride are broken and new ester bonds form between methanol and each hydrocarbon. Three biodiesel molecules are formed from each triglyceride. 2 marks

 **iii**. Biodiesel produces emissions but it is a renewable fuel – it can be replenished. The growing of the crops used absorbs CO2 so the net impact on CO2 levels is less than when fossil fuels are used.

 2 marks