Version 1.1

General Certificate of Education
Advanced Subsidiary Examination
Specimen paper for examinations in June 2010 onwards

General Studies (Specification A)

GENA2

Unit 2 AS Science and Society

Source Booklet

Source for use with **Questions 1.1** to **1.30**

Source for Questions 1.1 to 1.30

Consider the following passage, including **Figures 1** to **3** and then answer **Questions 1.1** to **1.30**.

Ethanol – The Long Haul

(1) At an airport in South Dakota there is a green and white 'Indy'-style racing car covered with stickers indicating that it runs on ethanol. Approach the rent-a-car booths and you will see a sign reminding the customers NOT to pump E85, the ultraethanol blend sold locally, into the rental cars because they are not designed for it and it will ruin their engines.

(2) This is ethanol country and is the centre of the national push in the United States to use carbohydrates to produce a fuel to replace hydrocarbons. In 2005, Congress passed an energy bill calling for an increase in the production of ethanol from 4 billion to 7.5 billion gallons of ethanol a year by 2012 to help displace imported fuel. 7.5 billion gallons is small compared to the annual consumption of diesel and gasoline of about 140 billion gallons but it has already increased by 50% in one year. Developers are scrambling to build ethanol plants and there is an ethanol boom.

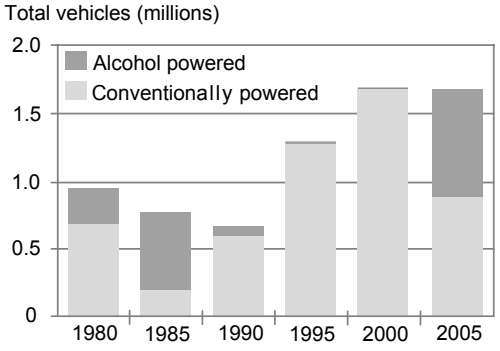
(3) At present the conversion of corn into ethanol makes little energy sense. It requires copious amounts of fossil fuels and even if 100% of the United States' corn supply was distilled into ethanol it would only supply a small fraction of the fuel consumed by the nation's vehicles. The use of ethanol will only make economic sense when refineries perfect a method to derive the fuel from cellulose, not corn. Cellulose is the woody material that forms the stalk of a corn plant and the bodies of trees and other plants such as grasses, which require less energy to tend and harvest.

(4) Although scientists understand the biology-based processes that convert the sugars tied up in cellulose, companies trying to make ethanol from these sources have not reached commercial viability. Sugar-cane is the ultimate plant source, far richer in ethanol-producing sugars than cornstalks and grasses, but the United States and Europe lack the climate or cheap labour to exploit this crop. Where sugar-cane is abundant, ethanol is widely and economically used as a fuel, reducing the need for such high imports of oil and also reducing the quantity of carbon emissions.

(5) Most ethanol in the United States is sold as an additive. It is also added to fuel in Europe ('bio-fuel') and can constitute up to 10% of the blend, which is the greatest amount which conventional engines can accommodate without damage. In the US, drivers can find the E85 blend which is 85% ethanol and 15% unleaded regular fuel. This mixture, however, requires specially equipped engines designed to tolerate it. The use of this fuel is expanding because advocates argue that ethanol is renewable since corn can be grown year after year.

(6) In Brazil, the state-run alcohol fuel programme paid farmers generous subsidies to grow sugar-cane from which the ethanol was produced. Consequently, in 1985 and 1986, more than 75% of all motor vehicles produced in Brazil – and more than 90% of cars – were designed for alcohol consumption.

Figure 1: Production of vehicles in Brazil



(7) After this time the tide turned to some extent against ethanol in Brazil. Reasons for this included:

- a fall in oil prices,
- a rise in sugar prices, making the ethanol subsidy too costly,
- the discovery of oil offshore, making Brazil more self-sufficient in oil,
- the newly restored civilian government being less concerned about promoting the fuel for national security reasons.

(8) But there is less to ethanol than meets the eye. The first problem is that a standard 42 gallon barrel of ethanol is worth only about 28 gallons of gasoline. This is because a gallon of ethanol contains only 80 000 British Thermal Units (Btu) of energy compared to about 119 000 Btu for regular fuel. Thus if your car is filled with E85 the tank will run dry about 33% sooner. Even if a gallon of ethanol were cheaper at the pump, drivers would have to buy more gallons to do the same distance.

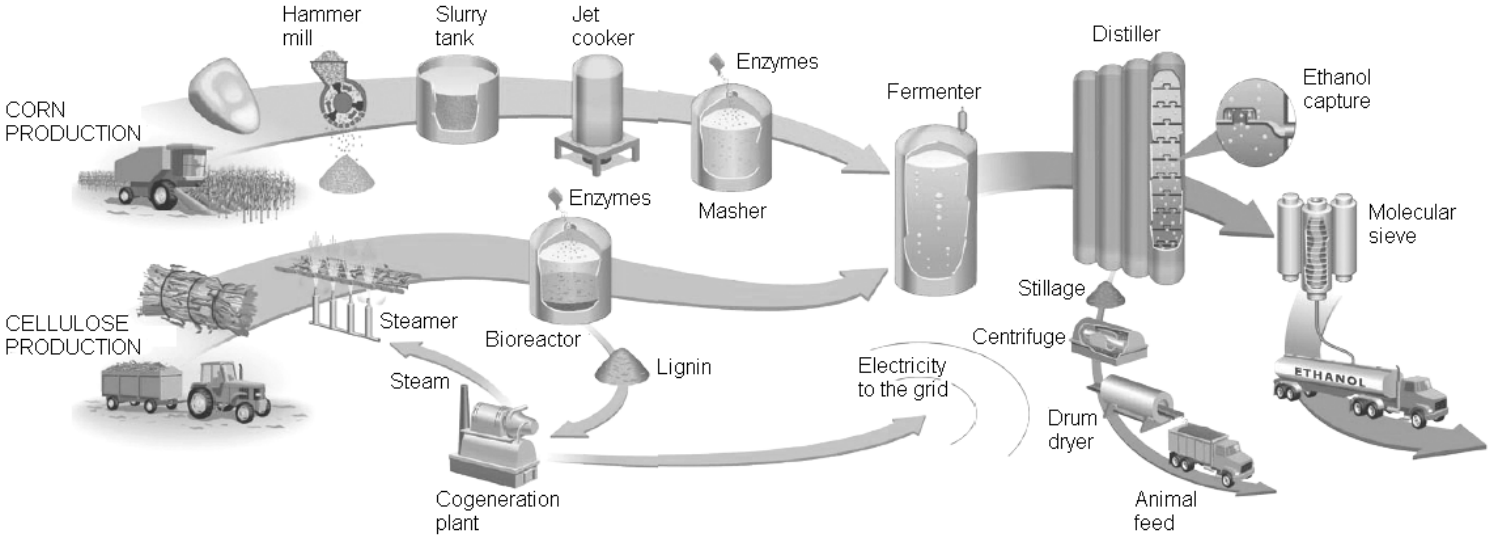
(9) The second problem is the difficulty and cost of producing the ethanol. Manufacturing ethanol requires copious amounts of natural gas for heating. Basically ethanol for fuel is produced in the same way as ethanol for spirits and drinking. The enzymes in yeast convert sugar into ethanol and give off carbon dioxide. The output then has to be distilled and natural gas is used to supply the energy for this. Producing a gallon of ethanol with its 80 000 Btu of energy currently requires about 36 000 Btu of natural gas. Alternatively some ethanol producers are burning coal which fits nobody's definition of clean and renewable.

(10) Ethanol requires other forms of energy too. One is the need for diesel fuel for the trucks to haul the corn to the factories and to fuel the combines which harvest the corn. These considerations are key to the calculation of 'net energy balance' and it can be argued that it takes more energy to make a gallon of ethanol than the fuel produces when burned. The generally accepted conclusion is that producing energy from corn yields about 10% more than was required to produce it. The effectiveness of the production of ethanol from sugar-cane is in stark contrast to this low percentage and in Brazil it is calculated that the energy yield from that source is 370%.

(11) The greenhouse benefit of ethanol is even smaller. A University of California report declared that the effect on greenhouse gases was "ambiguous". It was concluded that ethanol made using natural gas produces marginally fewer global-warming pollutants than gasoline production, but ethanol made using coal is worse. Burning a gallon of gasoline releases about 20 pounds of carbon dioxide, counting the contributions of the car engine as well as the refinery. The comparable figure for ethanol varies depending on how the ethanol is made but can be slightly better or worse.

(12) The initial steps in converting corn or cellulose to ethanol vary significantly. Corn is ground, cooked and mashed before entering a fermenter. Cellulose is steamed to expose fibres that enzymes convert into sugars in a bioreactor. Companies are still looking for bioreactors which are efficient on a large scale. One bonus from the use of cellulose is the lignin which is left behind and which can be burned to generate steam and electricity. The distillation of raw material from both corn and cellulose creates stillage, a valuable by-product which can be processed into animal feed.

Figure 2: Production processes for ethanol



(13) For the future, the use of corn is not a practical solution. Although there is currently a corn surplus in the United States, using the entire crop to produce ethanol would only meet 7% of the demand now met by gasoline. The long term production of energy-positive ethanol will need the processes using cellulose to be fully operational. The cellulose could come from the stalk of a corn plant, the straw of grains and the body of other plants not typically thought of as crops, such as some fast-growing grasses.

(14) The main problem is the taming of the natural processes for breaking down cellulose; the sugars locked in the fibre cannot be distilled into ethanol until they are removed from the lignin. Bacteria or fungi must produce enzymes to do this and these bacteria are found in inconvenient places in nature, proving much more difficult to use on an industrial scale than yeast. However, it is expected that a commercially viable process will be in operation in five years.

(15) In addition to the possible use of ethanol there has been a significant development in the production of biodiesel for use mostly in motor vehicles. Brazil is now also developing this technology but the biodiesel production in the European Union is also increasing rapidly.

Figure 3: Biodiesel production in EU countries in 1000 metric tonnes

Country	**2002**	**2003**
Germany	450	715
France	366	357
Italy	210	273
Austria	25	32
Denmark	10	41
United Kingdom	3	9
Spain	0	6
Sweden	1	1
Total	**1065**	**1434**

Source: Adapted from MATTHEW L WARD, 'Ethanol - The Long Haul', *Scientific American*, January 2007
Additional material from: www.fas.usda.gov/pecad2/highlights/204/07/WorldBiodiesel
www.news.bbc.co.uk./1/hi/business/4581955.stm

END OF PASSAGE