REVISION – ENERGY/FUELS

1. Glucose is a renewable energy source derived from the photosynthesis of plants. Many countries cultivate vast amounts of land for the growth of corn from which glucose is ultimately derived for the purpose of generating bioethanol, a renewable fuel. Below, in diagram 1, is a graph showing the amount of corn produced in the US from 1986 to 2020 in bushels. One bushel being equivalent to 25 kg of corn.

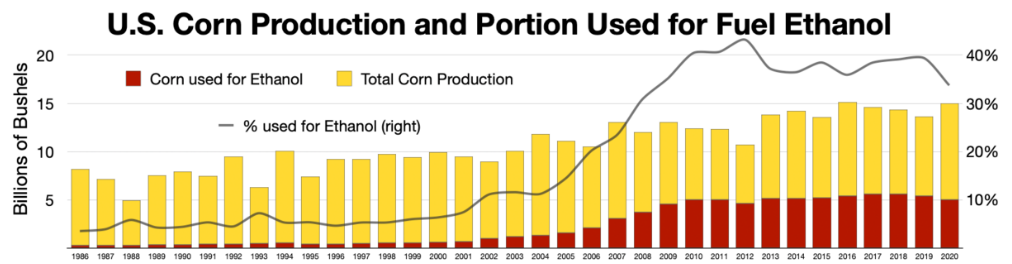

Diagram 1

a. Given that the molar heat of combustion of glucose is 2800 kJ/mol, write balanced thermochemical equations, states included, for:

i. Cellular respiration

____ *3 marks*

ii. Photosynthesis

____ *3 marks*

b. Write the balanced chemical equation, states included, for the anaerobic respiration known as alcohol fermentation and using oxidation numbers suggest why it is an incomplete or complete oxidation reaction.

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____ *3 marks*

c. Renewable and sustainable are sometimes used by non-chemists interchangeably to describe fuels.

i. Define each term

Renewable:____

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____ *1 mark*

ii. Sustainable:____

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____ *1 mark*

iii. Using bioethanol as an example and the information given in the stem of the question in diagram 1, label bioethanol as either renewable or non-renewable, sustainable or unsustainable**.** Explain your reasoning.

4 marks

2. A food label for a plant based energy bar clearly states that 100 g of the food contains:

12.0 grams of total carbohydrates
- 4.0 grams of fibre
8.2 grams of fat/oil
9.0 grams of protein

a. What is the mass of available carbohydrate that can be used as an energy source if the athlete consumed 225 grams of the energy bar. Explain how you derived your answer.

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____ *3 marks*

b. Calculate the total energy available to the athlete when consuming 100 grams of the energy bar. *3 marks*

3. A known mass of butane gas was burnt completely in pure oxygen at SLC. When all the mass of butane had finally reacted with the oxygen, 37.2 litres of a gaseous product was collected and its mass measured at 42.0 grams.

   a. Identify the gaseous product. Show all working out. *3 marks*

   b. Write a balanced chemical equation, states included, for the combustion reaction between butane and oxygen gas.

____ *3 marks*

   c. Using your answer to b. above:

      i. Identify the type of reaction taking place between the butane and oxygen gases at SLC.

____ *1 mark*

      ii. Describe the conditions under which the type of reaction you specified in i. above takes place.

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____ *1 mark*

   d. Calculate the mass, in grams, of butane that was consumed during this reaction? Give your answer to the right number of significant figures. *3 marks*

4. A mass of 4.65 grams of octane is mixed with 8.54 grams of oxygen at SLC and ignited. An exothermic reaction took place to produce a major greenhouse gas.
   a. Write the balanced thermochemical equation, states included, for the reaction taking place.

____ *3 marks*

   b. Calculate the amount of energy, in kJ, that was released from the combustion of octane in oxygen gas. *4 marks*

   c. The energy released from this reaction was used to heat a mass of water by 20.0°C. Calculate the mass of water in kg. *2 marks*

   d. The energy profile in figure 2 is of the reaction whose chemical equation is shown below.
   A(g) + B(g) → AB(g).
   600 kJ of energy was used to break bonds and whilst 500 kJ of energy was released during bond formation.

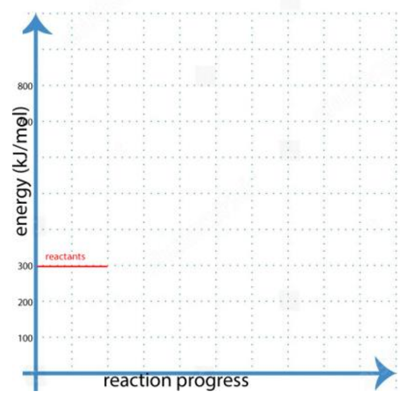

Figure 1

   i. Complete the energy profile shown in figure 2. Give the ΔH *2 marks*

   ii. What type of thermochemical reaction is this?

______________________________ *1 mark*

   iii. Write the thermochemical equation for the reaction above.

____ *2 marks*

   iv. Write the balanced thermochemical equation for the reaction
   2AB(g) → 2A(g) + 2B(g)

____ 2 marks

   v. Consider the reaction A(g) + B(g) → AB(l). It is the same type of reaction as A(g) + B(g) → AB(g). How might the thermochemical equation for A(g) + B(g) → AB(l) differ from that of A(g) + B(g) → AB(g)? Explain.

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____ *2 marks*

5. A student used the setup shown in fig 2. to heat 500 mL of pure water, at SLC, using a spirit burner filled with ethanol. The temperature of the water increased by 40.0 °C.
Below is part of the method from the student's experimental report.

Weigh the spirit burner ------------ 110.24 g
Record the temperature of the water --- 25.0 °C
Light the spirit burner and heat the water for 10 minutes.
Put the flame out and record the:
- final temperature of the water ---- 50.0°C
- the mass of the spirit burner ----- 106.75 g

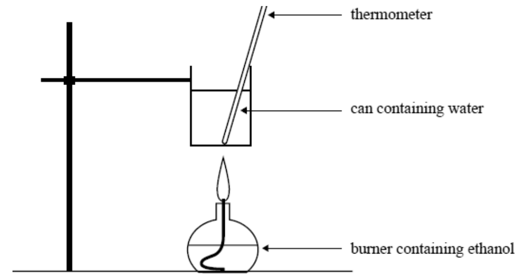

Figure 2

a. Calculate the amount of energy, in kJ, absorbed by the water, to the right number of significant figures. *3 marks*

b. Calculate total energy, in kJ, produced by the combustion of the ethanol in the spirit burner to the right number of significant figures. *2 marks*

c. Black soot was seen to form on the outside of the beaker, diagram 1, as the flame heated the water.

i. What can be deduced from this observation?

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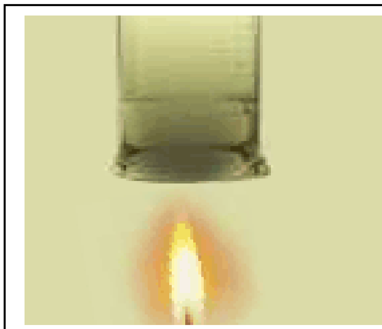
Diagram 1

ii. How significant is this observation to the calculation of the answer to b. above. Explain.

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______________________________ *2 marks*

d. Calculate the energy transformation efficiency of this method of heating. *2 marks*

6. A current of 5.00 amps at 6.00 volts was passed through the heating coil of a solution calorimeter with 50 mL of distilled water. The current was allowed to flow for 1.00 minute and the temperature of the water was recorded every few seconds and the results presented as a graph, figure 3.

a. From the graph, figure 2, obtain a value for the change in temperature in °C. *1 mark*

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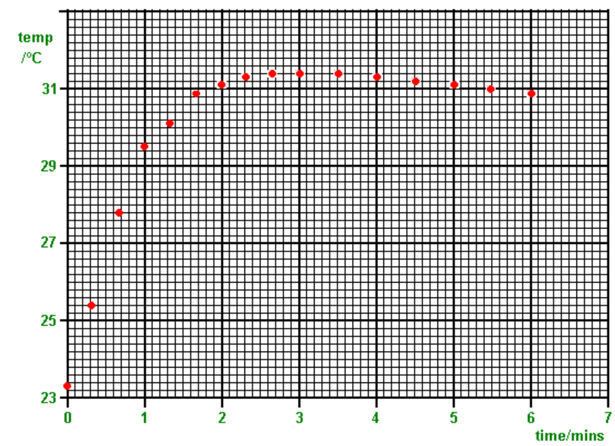

Temperature vs time graph

Figure 3

b. Calculate the calibration factor, in kJ/°C, of the calorimeter to the correct number of significant figures. *3 marks*

c. An investigation was conducted to workout the thermochemical equation for the reaction shown below.

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq) \quad \Delta H = ?$$

An amount of 0.875 grams of calcium oxide was placed in the 50 mL of water and stirred. The water, originally at 25.00 °C reached a maximum of 32.20 °C.

i. Calculate the value of the ΔH for the above reaction and give its appropriate sign *4 marks*

ii. The literature indicates that the magnitude of the ΔH for the above reaction is 89 kJ. Compare your result with the literature value and suggest a reason for the discrepancy.

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7. Lithium-ion batteries work poorly in extreme cold because the movement of lithium ions between the anode and cathode during discharge and recharge is severely hampered.

   To make a rechargeable battery that would operate safely and maintain performance in the extreme cold, a physical chemist at Fudan University, selected ethyl acetate as a cold-tolerant electrolyte solvent. Ethyl acetate's freezing point is –84 °C, and it doesn't become viscous when it's cold. When combined with organic electrodes, the battery performed well at a temperature range from
   50°C to -70°C. At -70°C the battery maintained 70% of its normal storage capacity.

   The battery is shown in figure 1.

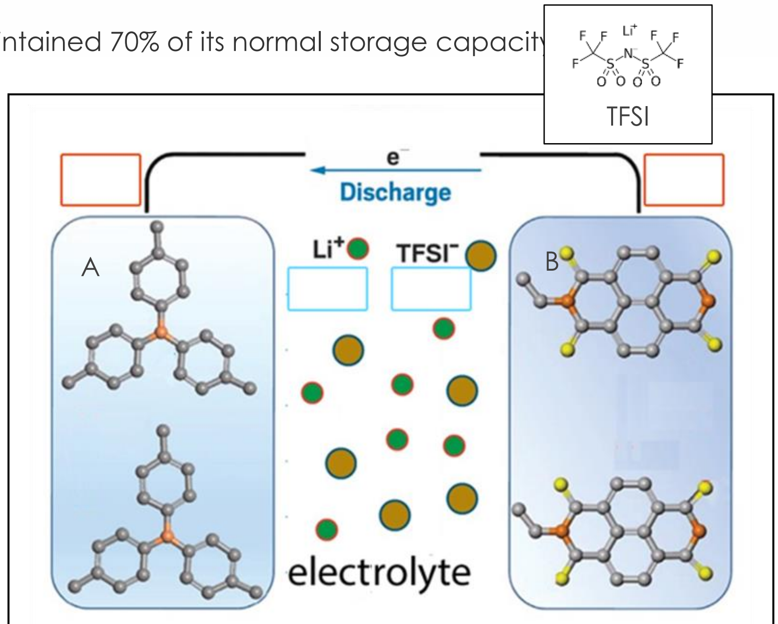

Figure 4

a. Indicate, in the red boxes, the polarity of each electrode.

b. Indicate in the blue boxes the direction of the ion movement.

c. Which electrode is the:

   i. Anode _______

   ii. Cathode _____

3 marks

d. Explain why ethyl acetate was chosen as the electrolyte and not a water based solution?

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____ *2 marks*

e. As the temperature decreases the amount of electrical energy a battery can store and subsequently release is severely limited at low temperatures. Explain why in terms of collision theory and activation energy.

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____ *2 marks*

f. Below is the same cell as above (fig 4) but in recharge mode.

i. Indicate, in the red boxes, the polarity of each electrode.
ii. Indicate, in the blue boxes the direction of the ion movement.
Iii. Which electrode is the:

Anode _______

Cathode _____

3 marks

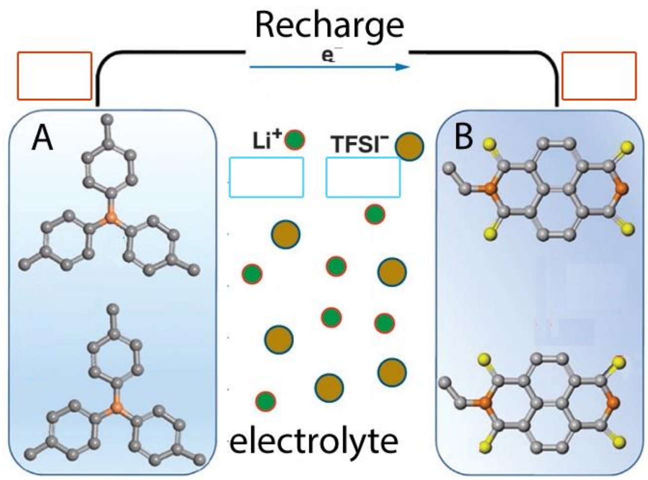

Figure 5