Revision Fuels, thermochemical equations, galvanic and electrolytic cells.

1. Write the thermochemical equation for the complete combustion of methane gas at SLC. States include.

2. Using the thermochemical equation derived in question 1. above derive the ΔH for the following equations.
   i. $2CH_4(g) + 4O_2(g) \rightarrow 4H_2O(l) + 2CO_2(g)$ ΔH =

   ii. $2H_2O(l) + CO_2(g) \rightarrow CH_4(g) + 2O_2(g)$ ΔH =

   iii. $H_2O(l) + ½\ CO(g) \rightarrow ½\ CH_4(g) + O_2(g)$ ΔH =

3. Given the thermochemical equation for the complete combustion of butane, shown below,

   $2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$ ΔH = *-5760 kJ mol*

   i. calculate the amount of heat energy, in kJ, produced from the burning of 0.232 kg of butane gas using only the information provided.

   ii. calculate the mass of CO_2 produced in the release of 1440 kJ of heat energy

   iii. calculate the volume of O_2 gas needed for the complete combustion of butane gas in order to release 720 kJ of energy at 60.0°C and 100 kPa pressure. Give the answer to the right number of significant figures.

4. The energy released from the complete combustion of 0.2600 grams of ethyne (C_2H_2) gas in pure oxygen gas was used to heat 39.9 grams of water from 20.0°C to 26.0°C.
Write the thermochemical equation, states included, for the complete combustion of ethyne.

5. Consider the galvanic cell shown in diagram 1.

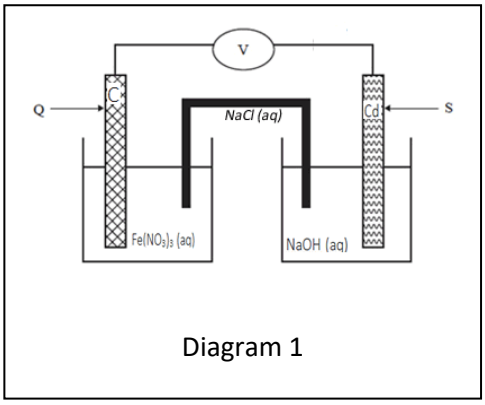

Diagram 1

   a. Predict whether a spontaneous reaction is likely to take place and if so what is the dominant type of energy that will be produced. Justify your answer.

   b. On the diagram, identify the anode and cathode and indicate the polarity of each electrode.

   c. Write the balanced half-equation for the reactions taking place at the anode and cathode.

      Anode: _____

      Cathode _____

   d. Indicate, with a clearly labelled arrow, the direction of negative ion flow from the salt bridge.

   e. Instead of NaCl a solution of $SnCl_2$ was used in the making of the salt bridge. Explain the impact this will have on the performance of the cell in producing electrical energy.

6. An experimental solid oxide fuel cell, that uses liquid ammonia as a fuel, is known as a direct ammonia fuel cell (DAFC). The overall reaction taking place is shown below.

$$4NH_3(l) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(g)$$

This type of fuel is showing great promise in producing electrical energy at temperatures around 800°C. A simplified diagram of the cell is shown in diagram 2, on the right. This type of fuel cell, however, is not appropriate for passenger vehicles where frequent stop-starts are necessary.

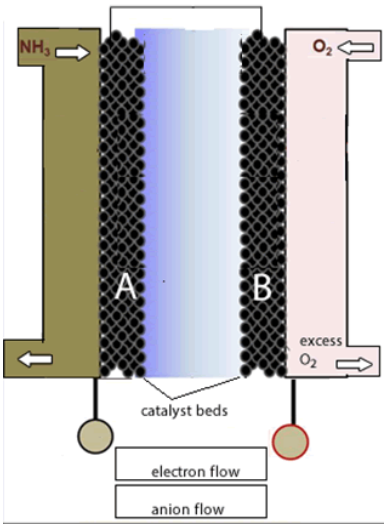

Diagram 2

a. Write the reaction taking place at electrode "B". States not required.

b. Write the reaction taking place at electrode "A". States not required.

c. Indicate on the diagram the direction of electron and anion flow.

d. How does this cell differ from a secondary cell? Answer this question by circling the correct options below.

i. Secondary cells and fuel cells can be recharged using an external power source.

ii. Both secondary cells and fuel cells operate at very high temperatures.

iii. The voltage output of a secondary cell declines during discharge whereas the voltage of a fuel cell remains constant during discharge.

iv. Both types of cells are very expensive as they both use expensive catalysts as electrodes.

v. In both fuel cells and secondary cells chemical energy is converted to electrical energy as well as heat energy through exothermic reactions.

7. The unbalanced, overall equation, states not included, for the complete combustion of ethane is given below.

$$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$$

Complete the table below by writing the half-equations, states not included, for the reactions taking place at the anode and cathode for each type of fuel cell.

Fuel cell	Anode	Cathode
Solid oxide fuel cell (SOFC)		
Molten carbonate fuel cell (MCFC)		
Phosphoric acid fuel cell (PAFC)		
Alkaline fuel cell		

8. Consider the electrolytic cell shown on the right in diagram 3. Nickel metal is deposited on one of the electrodes as the cell operates at5.0 volts.
a. How is the mass of each electrode changed after the cell is allowed to operate for several minutes? Justify your answer with reference to the electrochemical series.

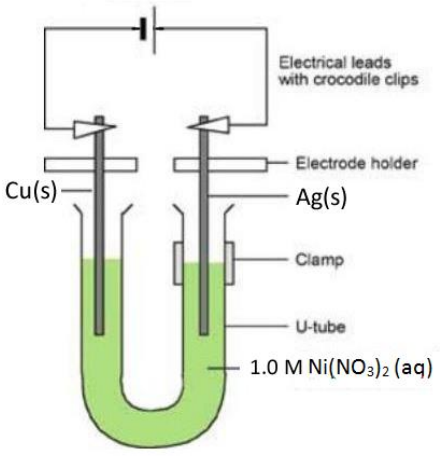

Diagram 3

b. What will be the impact to the amount and type of product formed at each electrode when the following changes to the cell are made? Justify your answer.

i. The electrolyte concentration was replaced with 0.5 M $NiCl_2$.

ii. The silver electrode was replaced with a copper electrode.

iii. 0.1 M HCl was added to the electrolyte.

iv. 1.0 M NaOH was added to the electrolyte.

9. Consider the two molecules shown in diagram 4.
   a. Which image represents an average molecule found in petrodiesel? Explain your choice.

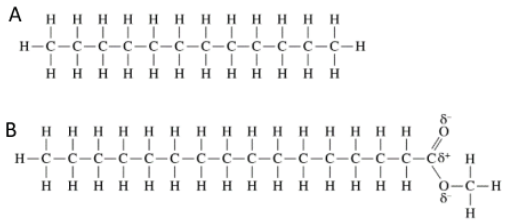

Diagram 4

   b. Predict, with reasons, which molecule will have the lowest:

      i. Flash point

      ii. Cloud point

      iii. Viscosity

   c. Which molecule Is hygroscopic? Explain.