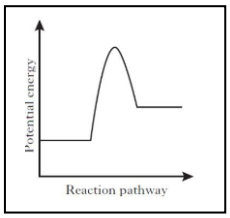
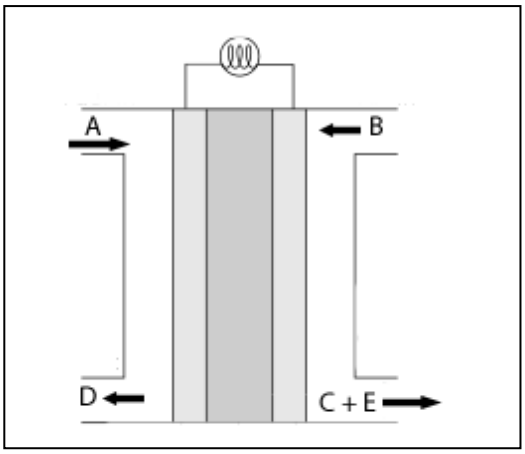
Revision (electrochemical cells, rates and investigation)

	Fuel Cells	Secondary Cells	Primary Cells	Electrolytic cells
Rechargeable				
Relatively inexpensive				
Electrodes				
- Porous				
- Act as catalysts				
- Separate reactant from electrolyte				
- Are inert				
- May act as reductants				
Produce heat energy				
Efficient energy production when compared to coal fired power stations				
Maintains constant voltage and current throughout extended operation				
Store a finite amount of chemical energy .				
Can operate at very high temperatures.				
Usually used for small scale energy production				
Negative ions migrate to the anode via an electrolyte.				
Anode always has a positive polarity				
The anode is the electrode where oxidation always takes place.				
Concentration of the electrolyte does not change during the course of operation				
Primary function is to convert chemical energy into electrical energy.				
Is capable of converting electrical energy into chemical energy.				
Spontaneous redox reactions are the only type of reaction taking place during the life of the cell.				
Electrons always travel from the anode to the cathode				
Has an external, electrical power source central to its operation throughout the life of the cell.				
Involves predominantly combustion reactions for the production of electrical energy.				
The following energy profile diagram may apply at some stage during the life of the cell. 				

2) An innovative CO_2/H_2 fuel cell can convert CO_2 into methane (CH_4) while generating electricity instead of consuming it. In this new cell, H_2 is oxidized, while CO_2 forms CH_4. This cell uses a proton exchange membrane as the electrolyte.



a. Give the balanced half reactions, sates not required, that occur at the:

anode _____

cathode _____

b. Give the balanced equation for the overall cell reaction.

c. Identify the oxidizing agent _____

d. Identify the reducing agent _____

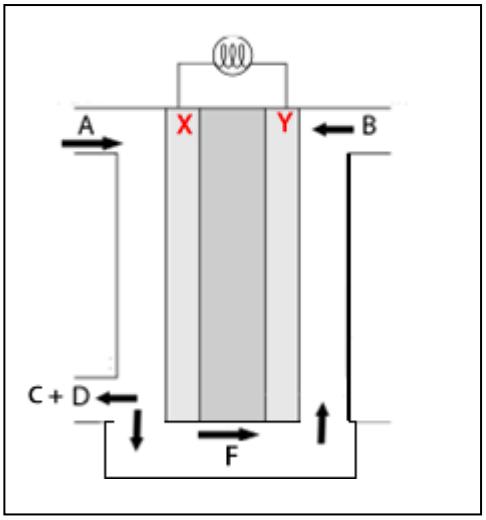
e. Consider the image above of a fuel cell. Label the:

- direction of electron flow.
- anode
- cathode

f. Identify the ions flowing through the membrane and indicate their direction.

g. Identify substances:

- A -
- B -
- C –
- D –
- E –



h. The methane produced is then used in a methane/oxygen molten carbonate fuel cell, shown on the right.

i. Identify A, B, D, C and F

ii. Give the balanced equation to the reaction taking place at the :

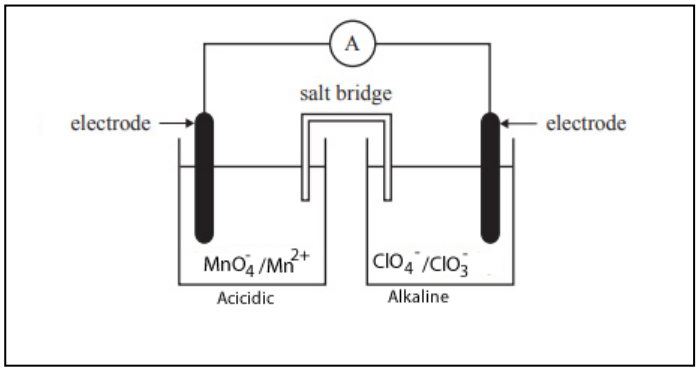
- anode. _____
- cathode _____

iii. What is the role substance “F” plays in the operation of this cell?

iv. Identify the reducing agent _____

v. What ions move through the electrolyte and in what direction?

3) Consider the galvanic cell shown on the right. It is constructed using 1M solutions at 25^{O}C



The following unbalanced half-cell reactions occur in this cell

$ClO_4^-(aq) \rightarrow ClO_3^-(aq)$ +0.36 V

$MnO_4^-(aq) \rightarrow Mn^{2+}(aq)$ +1.28 V

a. Will a spontaneous reaction occur when both electrodes are connected? Explain your reasoning.

b. Give the balanced half-cell equations, no states required, for the reactions taking place at the:

- cathode
- anode

c. How does the pH of each half-cell change as the cell discharges? Explain.

d. Write the balanced overall equation, with states.

e. In the diagram above label the:

- anode and its polarity
- direction of negative ion flow
- direction of electron flow

f. Calculate the cell EMF.

g. Can this cell be recharged and if so what is the voltage that should be supplied? Explain

h. Which of the following is the reducing agent? Circle your answer and give an explanation. MnO_4^-, Mn^{2+}, ClO_4^-, ClO_3^-, H_2O , H^+, Mn^{+7}, Cl^{+5}, O^{-2}.

i. Offer a possible material that each electrode should be made from and the properties that each electrode should possess. Explain

4) Ethane undergoes complete combustion in a fuel cell with oxygen gas to produce electrical energy and two products, one of which is a liquid. The fuel cell is 65% efficient.

a. Write a balanced thermochemical equation for the overall reaction occurring in the fuel cell

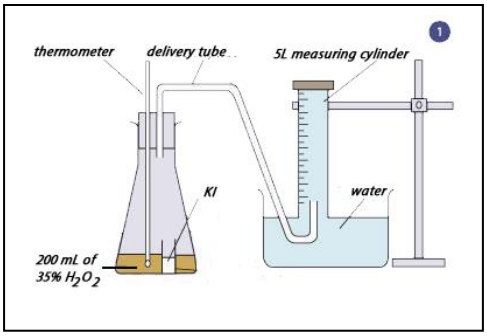
b) Calculate, to the right number of significant figures, the amount of ethane, in kilograms, used to produce 3.132×10^4 kJ of electrical energy.

c) A student argued that a hydrogen-oxygen fuel cell is better for the environment as it produces zero greenhouse emissions. Is the student correct? Explain.

5) Consider the data below collected by a student.

	Volume of gas evolved seconds after decomposition reaction of H_2O_2 starts *(mL)* $2H_2O_2 \xrightarrow[\text{Catalyst}]{KI(s)} 2H_2O + O_2 \quad \Delta H = \text{negative}$								
Time after reaction starts(s)	*5*	*10*	*15*	*20*	*30*	*35*	*40*	*50*	*60*
Potassium iodide. (1.00 g) in large crystals.	*12.0*	*24.1*	*48.8*	*98.1*	*394*	*1,200*	*1,450*	*1,550*	*1,600*
Potassium iodide. (1.00 g) in finely crushed powder	*50.0*	*203*	*820.0*	*1,701*	*1,710*	*1,735*	*1,738*	*1,740*	*1,735*

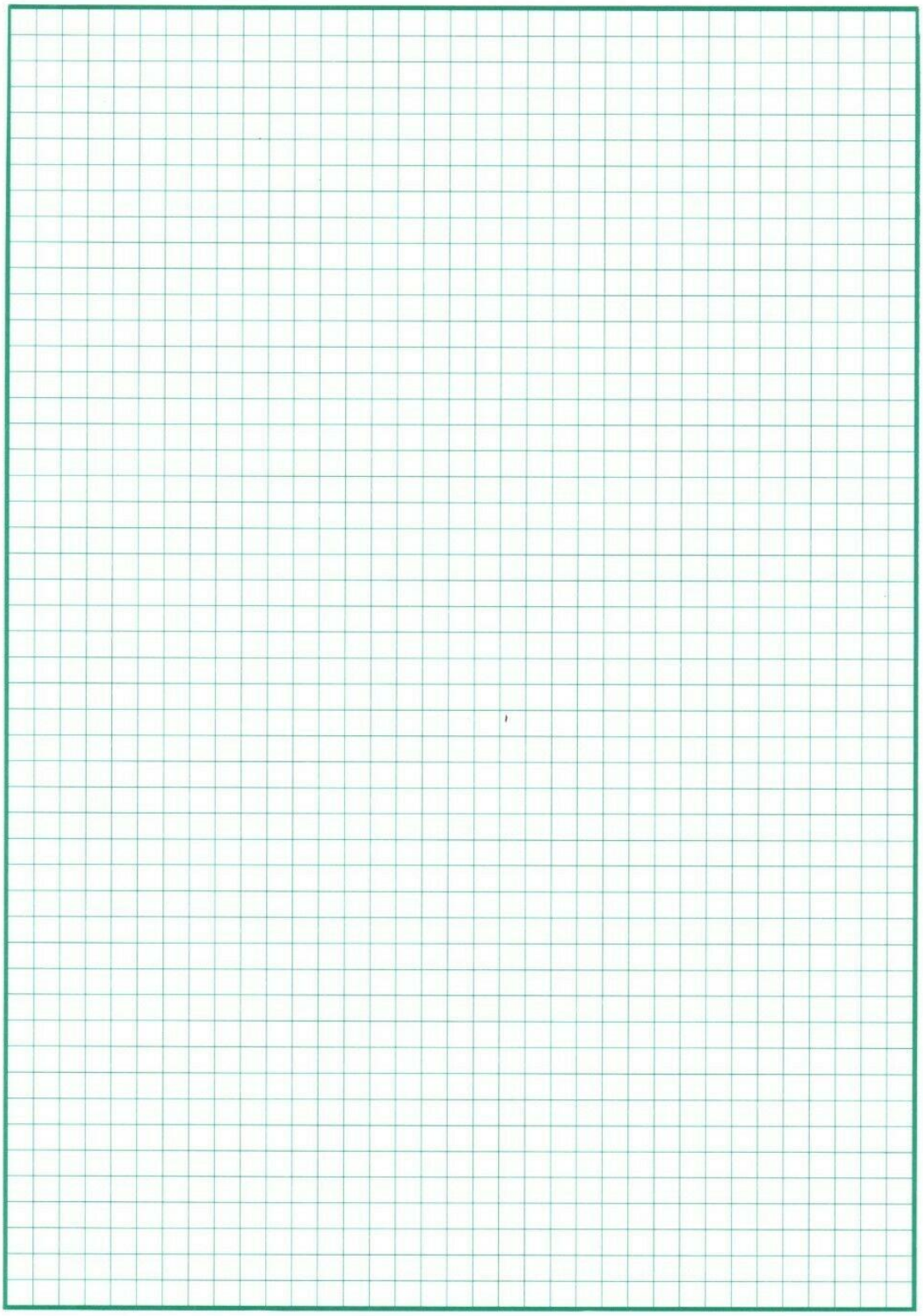
A student set up the experiment shown in the diagram on the right. Data collected was then presented as a table, shown above.



As part of the student's practical report the following set of steps were included in dot point form.

1. Set up the apparatus as shown on the diagram
2. Measure 200mL of a 35% v/v H_2O_2 solution and place it in the flask as shown in the diagram.
3. Using an electronic balance measure 1.00 g of KI in large crystal form.
4. Place the KI crystal into a small crucible inside the flask and seal the flask with the stopper, thermometer and delivery tube as shown in the diagram.
5. Shake the flask until the KI crystals are totally immersed in the H_2O_2 solution.
6. Start measuring the volume of gas produced over time until no more gas is formed
7. Using an electronic balance measure 1.00 g of KI in large crystal form.
8. Use a mortar and pestle to finely crush the 1.00 gram of crystals into a fine powder.
9. Repeat steps 4-6.

a. Use the graph paper provided on the next page to construct a detailed and properly labelled graph of the results from the table above.



b. What is the independent variable?

c. What is the dependent variable and how is it measured?

d. Name a controlled variable and explain how it should be controlled and its impact on the results if it's not controlled.

e. What is the student testing for and are the results valid?

f. What is a possible systematic error? What can be done to account for this error?

g. Describe a possible random error that may have occurred and indicate a solution that would minimise the impact of random errors on the results.

h. Without reference to the data collected during the investigation, predict the relationship between the independent variable and the dependent variable prior to the investigation being conducted. Explain your prediction

i. Analyse the graph of the student's results. Does it support your prediction in h. above? Give your reasoning.

j. Offer one suggestion for improvement to this investigation and mention how the improvement will impact the data.

6) Consider the following 6 options.

i. Heating the reaction vessel.

ii. Increasing the concentration of the reactants.

iii. Increasing the pressure of gaseous reactants.

iv. Introducing a catalyst.

v. Mixing the reactants thoroughly.

vi. Crushing solid reactants into a powder.

vii. Increasing the volume of the reaction vessel.

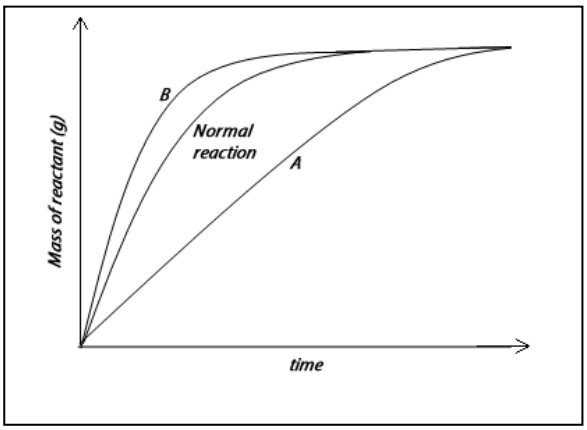
a. Which option/s listed will result in an increase in the rate of a chemical reaction? Explain

b. Which option/s will increase the rate of a reaction without increasing the number of collisions per second of the reactant particles? Explain

c. Which option/s will reduce the activation energy of the reaction? Explain

d. Which option/s will increase the average speed of the reactant particles? Explain

e. Consider the graph shown on the right. Each reaction involves the exact same amount of reactants. Which option/s could have changed the graph of the normal reaction to the one represented by "A"? Explain



f. Which options will increase the rate of a reaction at a particular temperature? Explain