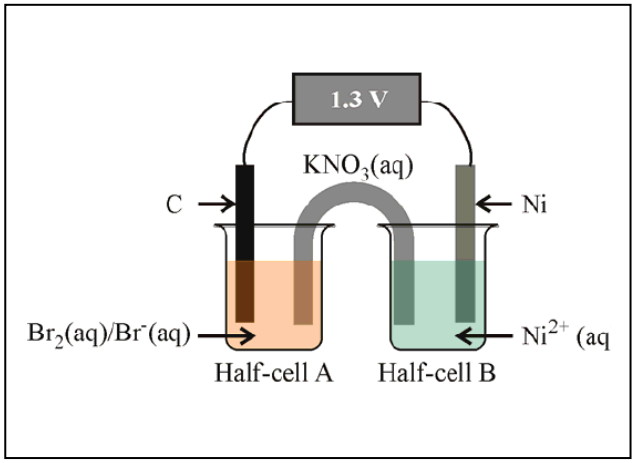
Question 1
The maximum voltage produced when standard Fe^{3+}(aq)/Fe^{2+} (aq) and Fe^{2+} (aq)/Fe(s) half-cells are combined to produce a galvanic cell, will be
A. 1.98 V
B. 1.21 V
C. 1.10 V
D. 0.33 V

Question 2
The spontaneous reaction that occurs when a piece of zinc metal is placed in an aqueous solution of copper(II) sulfate can be represented by the thermochemical equation
$Cu^{2+}(aq) + Zn(s) \rightarrow Cu(s) + Zn^{2+}(aq)$ $\Delta H = -218$ kJ mol^{-1}
The same chemical reaction occurs when the Cu^{2+} (aq)/Cu(s) and Zn^{2+} (aq)/Zn(s) standard half-cells are combined to form a galvanic cell. Compared to the total energy produced when the materials are mixed directly, the total amount of energy produced from the galvanic cell will be
A. larger because of the more efficient conversion of chemical energy into electrical energy.
B. smaller because in the galvanic cell the process can take longer.
C. the same because the reactants and products are the same.
D. smaller because the electrons have to travel from the anode to the cathode through the external circuit.

Question 3
A galvanic cell was constructed by combining the Br_2 (aq) / Br-(aq) and Ni^{2+}(aq) / Ni(s) half-cells as shown in the diagram.



For the cell pictured above which option below is correct.

	Positive electrode	Oxidant	Potassium ions will flow into
A	Nickel	Bromine, Br_2 (aq)	Half-cell B
B	Carbon	Bromide ion, Br-(aq)	Half-cell A
C	Nickel	Nickel ions (Ni^{2+} (aq))	Half-cell B
D	Carbon	Bromine, Br_2(aq)	Half-cell A

Question 4
When comparing a fuel cell with a galvanic cell, one major difference is that in fuel cells
A. the charge on the cathode is the opposite of that on a galvanic cell**.**
B. the energy conversion is more efficient.
C. the potential difference will always be about 2V.

D. the oxidant and reductant are continually being replaced.

Question 5

The salt bridge and connecting wire are removed from an operating galvanic cell and discarded. If the contents of the two half-cells are placed in one container, what will be the likely outcome?

A. The reaction will continue as electrons can move through the liquid in the container.
B. The reaction will continue as heat energy rather than electrical energy is produced.
C. The reaction will stop as there is no salt bridge to transport the anions and cations.
D. The reaction will stop as there is no connecting wire allowing electrons to travel.

Question 6

The following equation shows the chemical reaction which occurs in a galvanic cell.

$2Cd(s) + 2OH^-(aq) + Ni_2O_3(s) + 3H_2O(l) \rightarrow 2Cd(OH)_2(s) + 2Ni(OH)_2(s)$

Statements I to IV relate to the above chemical reaction.

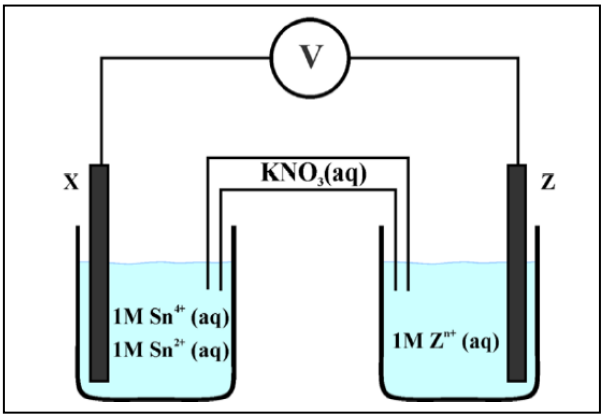
I Cd undergoes oxidation.
II OH^- is the reducing agent.
III The oxidation number of nickel changes from +3 to +2.
IV The nickel ion undergoes reduction and so it is the oxidising agent.

Which of these statements are correct?

A. I and II only
B. II and III only
C. I, III and IV only
D. I, II, III and IV

The information below applies to Questions 7 and 8.

The diagram below represents a simple galvanic cell assembled in a laboratory.



Question 7

Which of the following elements would be **<u>least</u>** suitable for electrode X?

A. Carbon (graphite).
B. Silver.
C. Platinum.
D. Tin.

Question 8

If the galvanic cell has a potential difference of 1.53 V at SLC,

A. the half-equation for the reaction at electrode Z is $Z(s) \rightarrow Zn^+(aq) + ne^-$.
B. $K^+(aq)$ ions are moving towards electrode Z.
C. the cathode is electrode X.
D. number of tin(IV) ions in the cell is decreasing.

1. A lead-acid battery is made up of six cells connected in series. When the battery is providing energy, the reactions occurring at the electrodes of a single cell are:
$Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e-$
$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e- \rightarrow PbSO_4(s) + 2H_2O(l)$
a. i. Give an equation for the net reaction that occurs while a lead-acid battery is providing energy. 1 mark

ii. Give the formula of the oxidant and the formula of the reductant in the above reaction.
oxidant _____
reductant _____ 2 marks

b. What happens to the pH when the battery is being recharged? Explain 2 marks

c. Write the equation occurring at the negative terminal when the battery is being recharged. 1 mark

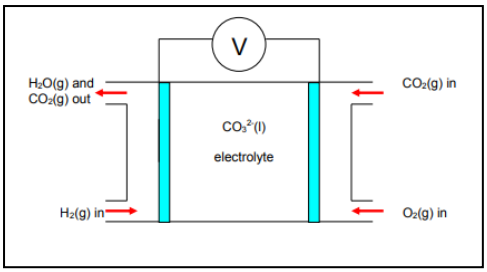
2. NiCad batteries are secondary cells. The chemical reaction that occurs when a NiCad cell is being recharged can be represented by the chemical equation below
$Cd(OH)_2(s) + 2\ Ni(OH)_2(s) \rightarrow Ni_2O_3(s) + Cd(s) + 3\ H_2O(l)$

i. What is the reductant when the NiCad cell is discharging? 1 mark

ii. When a NiCad cell is being recharged what terminal of the external power supply must be attached to the cadmium electrode? 1 mark

iii. Write a balanced chemical reaction, with states, that occurs at the cathode during recharge. 2 marks

3. A molten carbonate fuel cell (MCFC) uses a molten mixture of lithium carbonate, Li_2CO_3 and sodium carbonate,



Na_2CO_3 as the electrolyte. Hydrogen gas is passed over one electrode and a combination of oxygen gas and carbon dioxide gas is passed over the other electrode, as shown in the diagram below. The net overall reaction is H_2 (g) + O_2 (g) -> H_2O (g). There is no net gain or loss of the electrolyte.

a. Write a half equation for the overall cell reaction at the anode.

_____ 1 mark

b. Write a half equation for the overall cell reaction at the cathode.

_____ 1 mark

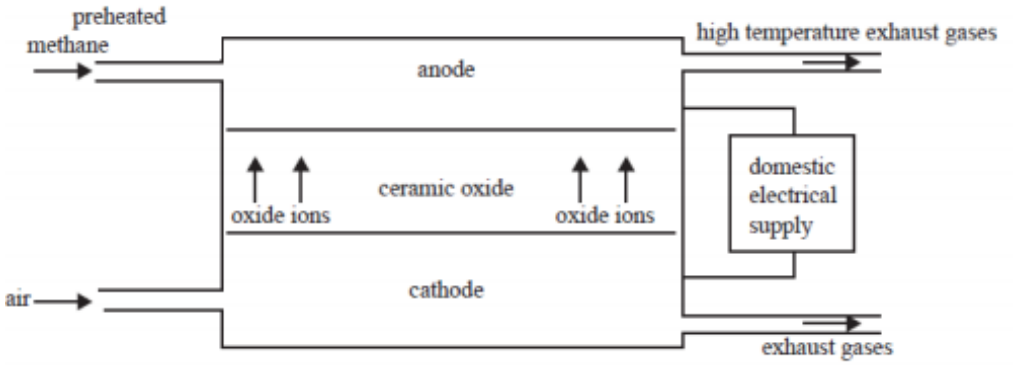
c. On the diagram above, label

i. the anode and its polarity.

ii. the direction of electron flow. 2 marks

d. What is the net overall effect on the molten carbonate electrolyte as the cell produces energy?

4. A Victorian company produces solid oxide fuel cells for use in the home. These fuel cells use natural gas to produce electricity through an electrochemical process summarized in the diagram below.



They operate at temperatures in excess of 500^{O}C.

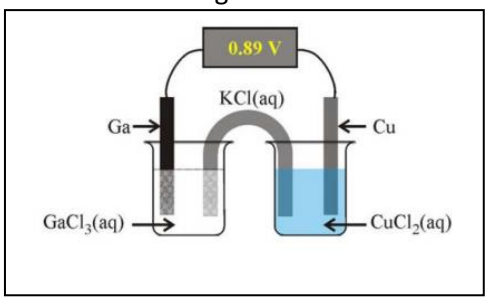
a. What are the exhaust gases produced from this fuel cell? 2 marks

b. Write the overall cell reaction from this fuel cell including states. 2 marks

c. Give one advantage of this type of electricity production over a coal fired power station. 1 mark

d. How could the high temperature waste exhaust gases produced from this reaction best be utilised? 1 mark

5. a. A galvanic cell was assembled by combining the Cu^{2+}(aq)/Cu(s) and Ga^{3+}(aq)/Ga(s) standard half-cells as shown in the diagram below.



The cell potential was measured at 0.89 V, with the copper electrode gaining mass when the cell was discharging.

i. Write an appropriate half-equation for the process that would be occurring at the gallium electrode when the cell is discharging. 1 mark

ii. Write an appropriate chemical equation for the overall reaction that would occur in this cell when it is discharging. 1 mark

iii. Determine the standard electrode potential (E^o) for the Ga^{3+}(aq)/Ga(s) standard half-cell. 1 mark

iv. On the diagram above clearly label the direction of flow of the potassium ions in the salt bridge 1 mark

b. When students conducting an experiment mixed aqueous solutions of potassium iodide and iron(III) sulfate in a test tube, they observed that a reaction had occurred.

i. Identify the oxidant in this reaction. 1 mark

ii. Write an appropriate chemical equation, with states, to describe the reaction that has occurred. 1 mark

6. A hydrogen-oxygen proton exchange membrane fuel cell operates at 65% efficiency.

a. Write appropriate chemical half-equations for the reaction occurring at the cathode
1 mark

b. Calculate the volume of hydrogen gas, at 75°C and 120 kPa, that would be required for the fuel cell to produce 400 MJ of electrical energy. Be sure your answer is to the correct number of significant figures. 3 marks

c. Explain one major issue associated with the use of hydrogen as a fuel. 1 mark

7. An experimental rechargeable galvanic cell is being trialled that uses lithium metal and sulphur as reactants. The overall equation, states not shown, for this cell is shown below.

$$16Li + S_8 \rightarrow 8Li_2S$$

A polymer electrolyte is used rather than an aqueous electrolyte. This cell produces 2.4 volts, is relatively cheap and is light in weight.

a) Give an explanation as to why an aqueous solution is not used in this cell. Provide a chemical equation to support your explanation. 2 marks

b) Write balanced half-equations for the reactions occurring at the cell is discharging:

i. Anode
ii. Cathode 2 marks

c) Write the balanced half-equation of the reaction occurring at the cathode during recharging (States not required) 1 mark.