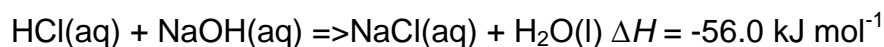


# Energy

42

## Question 1

The reaction between solutions of hydrochloric acid and sodium hydroxide can be represented by the following equation.



80.0 mL of 2.00 M HCl, at 21.0 °C, is mixed with 20.0 mL of 2.50 M NaOH, also at 21.0 °C, in a well-insulated calorimeter. The calibration factor for the calorimeter and contents is 420 J °C<sup>-1</sup>

What is the final temperature, in °C, of the resultant solution in the calorimeter?

3 marks

## Question 2

a) Which one of the following would be predicted to spontaneously oxidise aqueous iodide ions but not aqueous chloride ions? Explain

- A. Au<sup>+</sup>(aq)
- B. Sn<sup>2+</sup>(aq)
- C. Fe<sup>2+</sup>(aq)
- D. Br<sub>2</sub>(l)

2 marks

b) Two carbon electrodes are inserted into a solution of MgCl<sub>2</sub> and Fe(NO<sub>3</sub>)<sub>2</sub>. The electrodes are connected to the positive and negative terminals of an external power source.

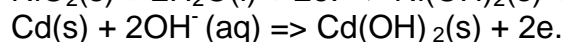
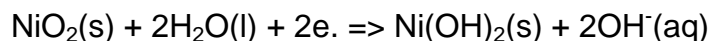
- i) Write the half cell reaction occurring at the anode.
- ii) Write the half cell reaction occurring at the cathode.
- iii) Explain how the pH of the solution changes as the power source is switched on?

3 marks

8

### Question 3

The rechargeable nickel-cadmium cell is used to power small appliances such as portable computers. When the cell is being used, the electrode reactions are represented by the following equations.



a) When the cell is being **recharged** give the reaction that occurs at the:

- Anode

- Cathode

b) What happens to the pH of the electrolyte?

c) When the cell is being used what is the reaction occurring at the:

- anode.

- cathode

4 marks

### Question 4

A galvanic cell consists of one half cell that is made up of an inert graphite electrode in a solution containing 1.0 M  $\text{Fe}^{2+}(\text{aq})$  and 1.0 M  $\text{Fe}^{3+}(\text{aq})$  at 25°C.

a) Select, from the electrochemical series provided, a second half cell so that when connected will provide approximately 1.2 V ;

1 mark

b) Draw the galvanic cell. Label the following.

i) anode and cathode

ii) polarity of each electrode

iii) oxidation and reduction reactions

iv) an appropriate electrolyte for the salt bridge

v) direction of electron flow

vi) direction of ion flow from salt bridge

6 marks

**Question 5**

A copper disc is to be silver-plated in an electrolytic cell. The disc forms one electrode and a silver rod the other electrode. The electrolyte provides a source of  $\text{Ag}^+(\text{aq})$ . The mass of silver to be deposited is 0.150 g.

- a) If the current is held steady at 1.50 amps, calculate the time, in seconds, that it takes to complete the plating

*2 marks*

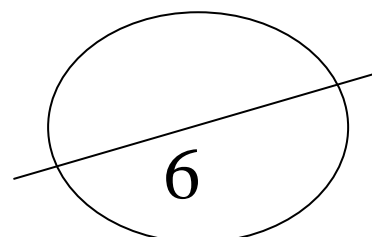
- b) Write the equation to the reaction occurring at the:

- Anode
- Cathode

*2 marks*

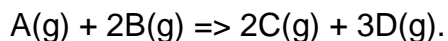
- c) An identical disc is to be zinc-plated with a solution containing  $\text{Zn}^{2+}(\text{aq})$  as the electrolyte using a current of 1.50 amps. Calculate the ratio of the time that is needed to plate the disc with 0.150 g of zinc to the time needed to plate the disc with 0.150 g of silver.

*2 marks*



**Question 6**

Two reactants "A" and "B" react according the equation shown below



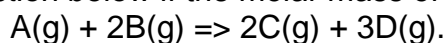
A calorimeter was used to record the energy given out when 6.00 grams of "B" reacts completely with excess "A".

A bomb calorimeter was calibrated by passing a current of 1.20 amps at 2.31 volts for 2.50 minutes through 100 mL of water at 25.2 °C. The temperature of the water increased to a maximum of 31.2 °C.

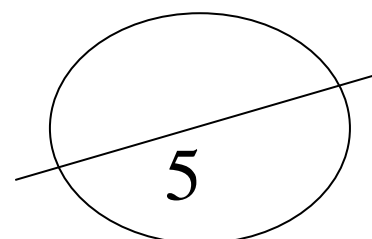
a) Calculate the calibration factor of the calorimeter.

*2 marks*

b) If the temperature of the water increased from 25.2 °C to 29.3 °C when 6.00g of reactant "B" reacted completely, find the  $\Delta H$  of the reaction below if the molar mass of "B" is 46.3 g/mol..

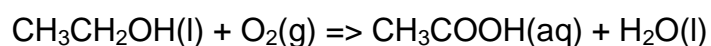


*3 marks*



### Question 7

- a) Fuel cell is constructed using ethanol and oxygen as the main reactants. Ethanol and oxygen react to form acetic acid according to the chemical equation below.



- i) Give the half equation that occurs at the anode

*1 mark*

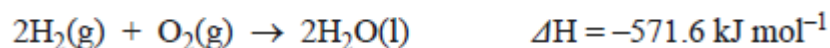
- ii) Give the half equation that occurs at the cathode

*1 mark*

- iii) A set of fuel cells produce 230.0 grams of acetic acid every minute.  
What charge is produced by the fuel cells over a 24 hour period?

*3 marks*

8) The reaction between hydrogen and oxygen is the basis of energy production in a number of fuel cells



An alkaline electrolyte is used in a particular hydrogen/oxygen fuel cell.

b) Write a balanced half-equation for the reaction occurring at the

i. cathode

1 mark

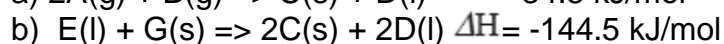
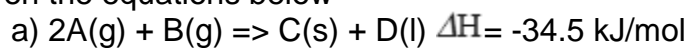
ii. anode.

1 mark

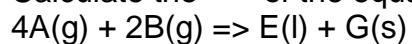
iii. 16.00 grams of oxygen reacted with excess hydrogen and the energy generated was used to heat 80.00 grams of water at 1.20 °C. Assuming no energy is lost what is the final temperature of the water.

3 marks

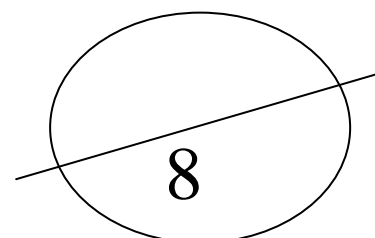
iv. Given the equations below



Calculate the  $\Delta\text{H}$  of the equation below



3 marks



**Physical constants**

$$F = 96\,500 \text{ C mol}^{-1}$$

$$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$1 \text{ atm} = 101\,325 \text{ Pa} = 760 \text{ mmHg}$$

$$0^\circ\text{C} = 273 \text{ K}$$

$$\text{Molar volume at STP} = 22.4 \text{ L mol}^{-1}$$

$$\text{Avogadro constant} = 6.02 \times 10^{23} \text{ mol}^{-1}$$

**Ideal gas equation**

$$pV = nRT$$

**The electrochemical series**

	$E^\circ$ in volt
$\text{F}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{F}^-(\text{aq})$	+2.87
$\text{H}_2\text{O}_2(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$	+1.77
$\text{Au}^+(\text{aq}) + \text{e}^- \rightarrow \text{Au}(\text{s})$	+1.68
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$	+1.36
$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$	+1.23
$\text{Br}_2(\text{l}) + 2\text{e}^- \rightarrow 2\text{Br}^-(\text{aq})$	+1.09
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$	+0.80
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{I}_2(\text{s}) + 2\text{e}^- \rightarrow 2\text{I}^-(\text{aq})$	+0.54
$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq})$	+0.40
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.34
$\text{S}(\text{s}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2\text{S}(\text{g})$	+0.14
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$	0.00
$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$	-0.13
$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}(\text{s})$	-0.14
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$	-0.23
$\text{Co}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Co}(\text{s})$	-0.28
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.44
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$	-0.76
$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$	-0.83
$\text{Mn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mn}(\text{s})$	-1.03
$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Al}(\text{s})$	-1.67
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$	-2.34
$\text{Na}^+(\text{aq}) + \text{e}^- \rightarrow \text{Na}(\text{s})$	-2.71
$\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ca}(\text{s})$	-2.87
$\text{K}^+(\text{aq}) + \text{e}^- \rightarrow \text{K}(\text{s})$	-2.93
$\text{Li}^+(\text{aq}) + \text{e}^- \rightarrow \text{Li}(\text{s})$	-3.02