Lisachem Materials

Chemistry Physics Biology
Psychology

VCE CHEMISTRY 2005 SUPPLYING AND USING ENERGY TEST UNIT 4

Time allowed: 50 minutes
Total marks: 40

SECTION A
Contains 12 multiple choice questions

SECTION B
4 Extended response questions

A data sheet and multiple choice answer sheet are provided. Answer extended response questions in the space provided. Use the marks and time allowed as a guide to how much time you should spend answering each question.

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PERIODIC TABLE

						relative atomic number symbol name relative atomic mass	1 H Hydrogen 1.0										2 He Helium 4.0
3 Li Lithium 6.9	4 Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0	8 O Oxygen 16.0	9 F Fluorine 19.0	10 Ne Neon 20.2
11 Na Sodium 23.0	12 Mg Magnesium 24.3											13 Al Aluminium 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulfur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 39.9
19 K Potassium 39.1	20 Ca Calcium 40.1	21 Sc Scandium 44.9	22 Ti Titanium 47.9	23 V Vanadium 50.9	24 Cr Chromium 52.0	25 Mn Manganese 54.9	26 Fe Iron 55.9	27 Co Cobalt 58.9	28 Ni Nickel 58.7	29 Cu Copper 63.6	30 Zn Zinc 65.4	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
37 Rb Rubidium 85.5	38 Sr Strontium 87.6	39 Y Yttrium 88.9	40 Zr Zirconium 91.2	41 Nb Niobium 92.9	42 Mo Molybdenum 95.9	43 Tc Technetium 98.1	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Caesium 132.9	56 Ba Barium 137.3	57 La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Ha Hahnium (262)	106 Sg Seaborgium (266)	107 Ns Neilsbohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Uun Ununnilium (272)	111 Uuu Unununium (272)	112 Uub Ununbium (277)		114 Uuq Ununquadium (289)				

Lanthanide series	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.3	63 Eu Europium 152.0	64 Gd Gadolinium 157.2	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0
Actinide series	90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium 237.1	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (255)	103 Lr Lawrencium (256)

DATA SHEET

Physical Constants

F = 96 500 C mol^{-1}

R = 8.31 JK^{-1} mol^{-1}

V_m (STP) = 22.4 L mol^{-1}

V_m (SLC) = 24.5 L mol^{-1}

Ideal gas equation

$pV = nRT$

The Electrochemical Series

		E° in volt
$F_2(g) + 2e^-$	$\rightarrow 2F^-(aq)$	+ 2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^-$	$\rightarrow 2H_2O(l)$	+ 1.77
$Au^+(aq) + e^-$	$\rightarrow Au(s)$	+ 1.68
$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$\rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+ 1.50
$Cl_2(g) + 2e^-$	$\rightarrow 2Cl^-(aq)$	+ 1.36
$O_2(g) + 4H^+(aq) + 4e^-$	$\rightarrow 2H_2O(l)$	+ 1.23
$Br_2(l) + 2e^-$	$\rightarrow 2Br^-(aq)$	+.1.09
$Ag^+(aq) + e^-$	$\rightarrow Ag(s)$	+ 0.80
$Fe^{3+}(aq) + e^-$	$\rightarrow Fe^{2+}(aq)$	+ 0.77
$I_2(s) + 2e^-$	$\rightarrow 2I^-(aq)$	+ 0.54
$O_2(g) + 2H_2O(l) + 4e^-$	$\rightarrow 4OH^-(aq)$	+ 0.40
$Cu^{2+}(aq) + 2e^-$	$\rightarrow Cu(s)$	+ 0.34
$CO_2(g) + 8H^+(aq) + 8e^-$	$\rightarrow CH_4(g) + 2H_2O(l)$	+ 0.17
$S(s) + 2H^+(aq) + 2e^-$	$\rightarrow H_2S(g)$	+ 0.14
$2H^+(aq) + 2e^-$	$\rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^-$	$\rightarrow Pb(s)$	- 0.13
$Sn^{2+}(aq) + 2e^-$	$\rightarrow Sn(s)$	- 0.14
$Ni^{2+}(aq) + 2e^-$	$\rightarrow Ni(s)$	- 0.23
$Co^{2+}(aq) + 2e^-$	$\rightarrow Co(s)$	- 0.28
$Fe^{2+}(aq) + 2e^-$	$\rightarrow Fe(s)$	- 0.44
$Zn^{2+}(aq) + 2e^-$	$\rightarrow Zn(s)$	- 0.76
$2H_2O(l) + 2e^-$	$\rightarrow H_2(g) + 2OH^-(aq)$	- 0.83
$Mn^{2+}(aq) + 2e^-$	$\rightarrow Mn(s)$	- 1.03
$Al^{3+}(aq) + 3e^-$	$\rightarrow Al(s)$	- 1.67
$Mg^{2+}(aq) + 2e^-$	$\rightarrow Mg(s)$	- 2.34
$Na^+(aq) + e^-$	$\rightarrow Na(s)$	- 2.71
$Ca^{2+}(aq) + 2e^-$	$\rightarrow Ca(s)$	- 2.87
$K^+(aq) + e^-$	$\rightarrow K(s)$	- 2.93
$Li^+(aq) + e$	$\rightarrow Li(s)$	- 3.02

VCE Chemistry 2005 Supplying and Using Energy Unit 4

SECTION A

MULTIPLE CHOICE ANSWER SHEET

Instructions:

For each question choose the response that is correct or best answers the question.
Circle the chosen response on this answer sheet.
Only circle **one** response for each question.

Question 1.	A	B	C	D
Question 2.	A	B	C	D
Question 3.	A	B	C	D
Question 4.	A	B	C	D
Question 5.	A	B	C	D
Question 6.	A	B	C	D
Question 7.	A	B	C	D
Question 8.	A	B	C	D
Question 9.	A	B	C	D
Question 10.	A	B	C	D
Question 11.	A	B	C	D
Question 12.	A	B	C	D

VCE Chemistry 2005 Supplying and Using Energy Unit 4

SECTION A - [12 marks, 15 minutes]

This section contains 12 multiple choice questions.
For each question choose the response that is correct or best answers the question.
Indicate your answer on the answer sheet provided.
*(Choose only **one** answer for each question.)*

Question 1

The combustion of butane can be described by the chemical equation,

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$$

When a 2.00 g of butane was burnt it released 99.0 kJ of energy. The change in enthalpy, ΔH, for this reaction would be

A. -5740 kJ mol^{-1}.
B. -2870 kJ mol^{-1}.
C. 2870 kJ mol^{-1}.
D. 5740 kJ mol^{-1}.

Question 2

Pieces of lead metal are placed into separate test tubes containing $Cu^{2+}(aq)$, $Fe^{2+}(aq)$, $Ni^{2+}(aq)$ and $Zn^{2+}(aq)$ respectively. A chemical reaction

A. would be expected to occur with all of the ions.
B. would be expected to occur with the $Fe^{2+}(aq)$, $Ni^{2+}(aq)$ and $Zn^{2+}(aq)$ ions.
C. would only be expected to occur with the $Cu^{2+}(aq)$ ions.
D. would be not expected to occur with any of the ions.

Question 3

One significant difference between a fuel cell and a secondary cell, is that in a fuel cell

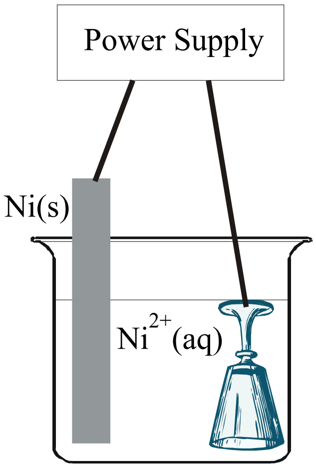
A. the reactants are continually being replaced.
B. the products of the reaction remain near the electrodes.
C. the reaction cannot be reversed by the application of an external energy source.
D. the chemical energy is released at a faster rate.

Question 4

The combination of which of the following standard half-cells would produce a galvanic cell with the highest voltage?

A. $Cu^{2+}(aq)/Cu(s)$ and $Ni^{2+}(aq)/Ni(s)$.
B. $Fe^{2+}(aq)/Fe(s)$ and $Cu^{2+}(aq)/Cu(s)$.
C. $Zn^{2+}(aq)/Zn(s)$ and $Pb^{2+}(aq)/Pb(s)$.
D. $Ni^{2+}(aq)/Ni(s)$ and $Zn^{2+}(aq)/Zn(s)$.

Questions 5 and 6 refer to the following information.
The diagram below shows a cell that was constructed to electroplate an object with nickel.



Question 5
For this cell to function as desired the nickel plate needs to be

A. negatively charged and act as the anode.
B. positively charged and act as the anode.
C. negatively charged and act as the cathode.
D. positively charged and act as the cathode.

Question 6
What current would be required to plate an object with 1.80 g of nickel over a 2.00 hour period?

A. 0.82 A.
B. 0.41 A.
C. 1.6 A
D. 25 A

Question 7
The temperature of a calorimeter and its contents increased by 2.82 °C when it was electrically calibrated using a current of 2.50 A and a voltage of 6.50 V for 4.00 minutes. What is the calibration factor for this calorimeter and its contents?

A. 23.0 J $°C^{-1}$.
B. 213 J $°C^{-1}$.
C. 1380 J $°C^{-1}$.
D. 3900 J $°C^{-1}$.

Question 8
What is the specific heat capacity for a substance?

A. The amount of energy required to change 1.00 g of the material from the liquid phase to gas phase.
B. The amount of energy required to change 1.00 mole of the material from the liquid phase to the gas phase.
C. The amount of energy required to raise the temperature of 1.00 g of the material by 1 °C without changing its state.
D. The amount of energy required to raise the temperature of 1.00 mole of the material by 1 °C without changing its state.

Question 9

A large percentage of Australia's electrical energy is generated by coal-fired power stations. Which of the following shows the basic energy changes that occur in these power stations?

A. Chemical energy → mechanical energy → electrical energy.
B. Chemical energy → thermal energy → mechanical energy → electrical energy
C. Thermal energy → mechanical energy → electrical energy.
D. Chemical energy → thermal energy → electrical energy.

Question 10

Which one of the following statements best explains why a primary cell is not able to be recharged?

A. The amount of reductant is limited by the size of the cell.
B. The electrolyte in the cell is a solid that keeps the products formed during discharge near the electrodes.
C. The products formed during discharge move slowly away from the electrodes.
D. One of electrodes is consumed during the discharge of the cell reducing the efficiency that is required for successful recharging.

Question 11

When a galvanic cell is discharging

A. the electrons flow from the anode to the cathode and the positive ions in the salt bridge flow into the half-cell containing the anode.
B. the electrons flow from the cathode to the anode and the negative ions in the salt bridge flow into the half-cell containing the anode.
C. the electrons flow from the cathode to the anode and the positive ions in the salt bridge flow into the half-cell containing the anode.
D. the electrons flow from the anode to the cathode and the negative ions in the salt bridge flow into the half-cell containing the anode.

Question 12

Which one of the following is **not** correct regarding the operation of the Down's cell during the production of sodium?

A. The electrolyte is a molten mixture of sodium and calcium chlorides.
B. The anode can be made from iron.
C. Another product from the Down's cell is chlorine.
D. The high temperature of the cell is maintained by the high currents used during the electrolysis.

End of Section A

SECTION B - [28 marks, 35 minutes]

This section contains four questions, numbered 1 to 4.
All questions should be answered in the spaces provided.
The mark allocation and approximate time that should be spent on each question are given.

Question 1 - [11 marks, 14 minutes]

a. Calorimeters are used to measure the energy changes that occur as the result of a chemical reaction, by measuring the change in temperature of the calorimeter and its contents that takes place.

i. What absorbs most of the energy released when a bomb calorimeter is used to measure the energy change for a combustion reaction?

1 mark

ii. Why should a bomb calorimeter be calibrated just prior to or just after use if accurate measurements of the energy released are to be made?

1 mark

iii. Why is it necessary for the calorimeter to be well insulated?

1 mark

b. A bomb calorimeter was used to determine the heat of combustion for liquid ethanol, CH_3CH_2OH.

When a 1.618 g sample of liquid ethanol was ignited in the calorimeter the temperature increased from 21.275 °C to 30.566 °C. The calorimeter was then electrically calibrated by passing a current of 2.743 A at 5.886 V through the heater for 5 minutes and this further increased the temperature to 31.504 °C.

i. Determine the calibration factor for this calorimeter.

2 marks

ii. What amount of energy in kJ was released when this sample of ethanol was burnt?

1 mark

iii. Write an appropriate chemical equation to describe the combustion of ethanol.

1 mark

iv. Calculate the enthalpy change, ΔH, - for this combustion reaction.

1 mark

c. The combustion of methane can be described by the following chemical equation,

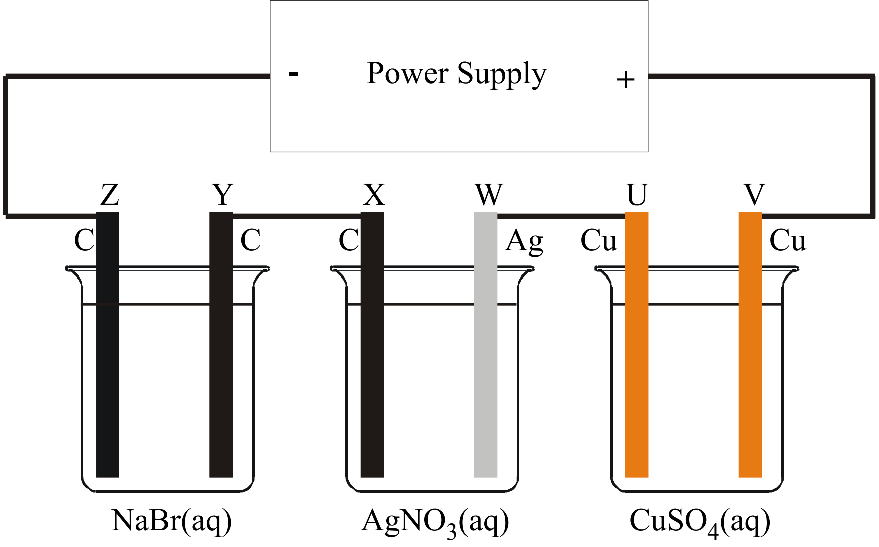
$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad \Delta H = -889 \text{ kJ mol}^{-1}$$

A 10.0 L gas cylinder contained methane at a pressure of 7450 kPa at 14.2 °C.
How much useful energy could be obtained if all of the methane in the cylinder was used to fuel a furnace that operated with an 80% efficiency?

3 marks

Question 2 - [7 marks, 9 minutes]

Three electrochemical cells with different electrolytes and electrodes were set up, in series, as shown in the diagram below.



a. Write appropriate chemical half-equations for the reactions occurring at;

i. Electrode V

ii. Electrode X

iii. Electrode Y

iv. Electrode Z

4 × 1 = 4 marks

b. The mass of electrode V changed by 0.833 g during the time that the cells were operating. The initial mass of electrode X was 5.173 g. What would be the mass of electrode X after the same time period?

3 marks

Question 3 - [5 marks, 6 minutes]
Recently there has been some discussion in the media that Australia should consider the development of water desalination plants powered by nuclear energy.

a. What are two advantages of using nuclear energy in preference to fossil fuels to provide the energy requirements for these desalination plants?

2 marks

b. What are two issues that can be raised against the use of nuclear energy to provide the energy required?

2 marks

c. What type of nuclear process is currently used to provide nuclear energy?

1 mark

Question 4 - [5 marks, 6 minutes]
The batteries currently used in motor vehicles are based on the lead-acid accumulator that was first built in the nineteenth century. The battery consists of lead plates in approximately 4 M sulfuric acid solution and each cell produces about 2 volts. The overall reaction that occurs during the discharge of the cell can be represented by the chemical equation,

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

a. Write an appropriate chemical half-equation for the reaction that would occur at the anode while the cell is discharging.

1 mark

b. How would the pH of the electrolyte in the cell change while the cell is being recharged?

1 mark

c. What is one disadvantage of the lead-acid battery as an energy storage device?

1 mark

d. What is one advantage that the lead-acid battery has over other currently available batteries for storing electrical energy?

1 mark

e. Car batteries have a life of about 4 – 5 years. What is one factor that limits the life of the lead-acid battery?

1 mark

End of Task

Suggested Answers VCE Chemistry 2005 Supplying and Using Energy Unit 4

SECTION A [1 mark per question.]

Q1 A The combustion of butane is described by the chemical equation,

$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$

$M(C_4H_{10}) = 4\times12.0 + 10\times1.0 = 58.0$ g mol^{-1}

$n(C_4H_{10}) = m(C_4H_{10})/M(C_4H_{10}) = 2.00/58.0 =$ **3.45×10^{-3} mol**

3.45×10^{-3} mol of C_4H_{10} releases 99.0 kJ of energy.

1 mole of C_4H_{10} will release $99.0/3.45\times10^{-3} = 2.87\times10^{3}$ kJ of energy.

The chemical equation is for 2 mole of C_4H_{10} therefore the energy released will be; $2 \times 2.87\times10^{3} = 5.74\times10^{3}$ kJ

Energy is released therefore the reaction is exothermic and the value for the enthalpy change, **$\Delta H < 0$**

$\Delta H = -5740$ kJ mol^{-1}.

Q2 C For a reaction to occur between the lead and the ions dissolved in solution, the ions must be stronger oxidants than the lead(II) ion. Referring to the electrochemical series on the data sheet the only ion to fulfil this criterion is the **$Cu^{2+}(aq)$ ion**.

The chemical reaction that would occur between the lead and the $Cu^{2+}(aq)$ ion can be described by the chemical equation: $Cu^{2+}(aq) + Pb(s) \rightarrow Cu(s) + Pb^{2+}(aq)$

Q3 A In a **fuel cell the reactants are being continually replaced as they are consumed** in the redox processes, whereas in a secondary cell the amount of materials remains constant and only the oxidation states of the materials changes depending on whether the cell is discharging or being recharged.

Q4 B The voltage produced by the combination of the two standard half-cells can be calculated from the difference between the two standard electrode potentials, E°. The E° values can be obtained from the electrochemical series on the data sheet.

Cell A:	0.34 – (-0.23) = 0.57 V
Cell B:	0.34 – (-0.44) = 0.78 V
Cell C:	-0.13 – (-0.76) = 0.63 V
Cell D:	-0.23 – (-0.76) = 0.53 V

Therefore **cell B** produces the highest voltage.

Q5 B The function of the nickel plate in the electrolytic cell is to help maintain the concentration of the $Ni^{2+}(aq)$ ions in solution as constant as possible so that the object will be evenly plated with nickel. Therefore the **nickel** must be **oxidised** to form $Ni^{2+}(aq)$ ions, for this to occur the nickel plate must be the **anode** (oxidation always occurs at the anode). In an electrolytic cell the charge on the **anode** has to be **positive**.

Q6 A $n(Ni) = m(Ni)/M(Ni) = 1.80/58.7 = 3.07\times10^{-2}$ mol

$Ni^{2+}(aq) + 2e^{-} \rightarrow Ni(s)$

$n(e^{-}) = 2 \times n(Ni) = 2 \times 3.07\times10^{-2} = 6.14\times10^{-3}$ mol

$Q = n(e^{-}) \times F = 6.14\times10^{-2} \times 96500 = 5920$ C

$Q = I \times t$ where t is in seconds $\Rightarrow I = Q / t$

$I = 5920 /(2.00 \times 60 \times 60) =$ **0.82 A**

Q7 C The calibration factor for a calorimeter and its contents is the amount of energy required to raise the temperature by 1 °C.

The electrical energy put into the system can be calculated using;

$E = V \times I \times t$ where V, I and t are the voltage, current and time in seconds.

E = 6.50 × 2.50 × (4.00 × 60) = 3900 J
CF = E/ΔT = 3900/2.82 = **1380 J °C^{-1}.**

Q8 C The **specific heat capacity** for a substance is defined as the **energy required to increase the temperature of 1.00 g of the material by 1.00 °C** without changing the state of the material.

Q9 B In a coal-fired power station the **chemical** energy from the coal is released by burning it to form **thermal** energy. This thermal energy is used to heat steam thereby increasing its thermal energy. The **thermal** energy of the steam is used to drive a turbine converting the energy into **mechanical** energy. The **mechanical** energy is then used to drive a turbine which turns a generator to produce **electrical** energy. Therefore the basic energy transformations that occur are:
Chemical → Thermal → Mechanical → Electrical

Q10 C In a primary cell the **products produced during the discharge of the cell are free to move away from the electrodes** therefore are not available at these should an external electrical energy supply be applied to recharge the cell. Some of the reaction products **can also react in other reactions that take place in the cell further reducing their availability**.

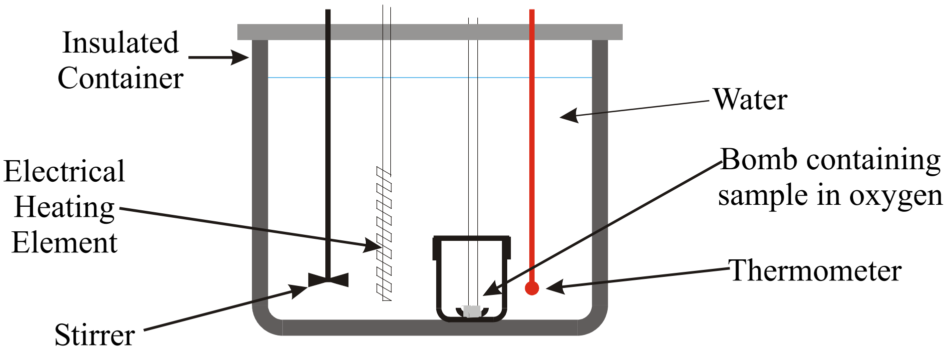
Q11 D In electrochemical cells oxidation occurs at the anode. In a **galvanic cell electrons** are **released at the anode and travel through the external circuit to the cathode**. The oxidation reaction half-cell, containing the anode, will produce substances that will have a higher positive charge, therefore negative ions from the salt-bridge will need to flow into this half-cell to balance its electrical neutrality.

Q12 B The Down's cell is used to produce sodium metal and uses a molten electrolyte consisting of sodium and calcium chlorides. The calcium ions are not reduced because they are weaker oxidants than the sodium ions. The half-reactions that take place in the cell are:
Cathode (reduction): $Na^+(l) + e^- \rightarrow Na(l)$
Anode (oxidation): $2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$
The anode therefore must be made from a material that cannot itself be oxidised or attacked by chlorine gas produced. Usually the anode in the Down's cell is made from carbon. **An iron electrode would be oxidised**, as iron is a stronger reductant than the chloride ions and would also oxidised by any chlorine produced.

SECTION B

Question 1 - [11 marks, 14 minutes]

a. i. Most of the heat released in a bomb calorimeter is absorbed by **the water** in the calorimeter. **[1 mark]** The diagram below shows the components of a bomb calorimeter.



ii. For accurate results the calorimeter should be calibrated just prior to or just after use because the **calibration factor**, which is used to determine the energy change by measuring the temperature, **is a measure of how much energy is required to change the calorimeter and its contents by 1 °C**. **[1 mark]** As the water absorbs most of the energy any change in the volume of water in the calorimeter will alter the calibration factor.

iii. If the **calorimeter were not insulated then energy could be either lost to or absorbed from the surroundings** thereby making it difficult to determine an accurate energy change for the reaction being investigated. **[1 mark]**

b. i. The temperature change for the calibration: $\Delta T = 31.504 - 30.566 = 0.938$ °C
The electrical energy supplied to the heater is given by the equation:
$E = V \times I \times t$ where the time, t, must be in seconds.
$E = 5.886 \times 2.743 \times (5 \times 60) = 4844$ J **[1 mark]**
$CF = E / \Delta T = 4844 / 0.938 =$ **5164 J °C^{-1}** **[1 mark]**

ii. The temperature change for the combustion reaction:
$\Delta T = 30.566 - 21.275 = 9.291$ °C
$E = CF \times \Delta T = 5164 \times 9.291 = 4.798\times10^4$ J
1 kJ = 1000 J
$E = 4.798\times10^4/1000 =$ **47.98 kJ** **[1 mark]**

iii. The chemical equation can be developed in steps.
Ethanol: $CH_3CH_2OH = C_2H_6O$

1. Write the formulae for the reactants and products.
   $C_2H_6O + O_2 \rightarrow CO_2 + H_2O$
2. Balance the number of carbon atoms: $C_2 \Rightarrow 2CO_2$
   $C_2H_6O + O_2 \rightarrow 2CO_2 + H_2O$
3. Balance the number of hydrogen atoms: $H_6 \Rightarrow 3H_2O$
   $C_2H_6O + O_2 \rightarrow 2CO_2 + 3H_2O$
4. Balance the number of oxygen atoms:
   In the products the number of oxygen atoms is $2\times2 + 3 = 7$ O atoms
   There is an O atoms in the ethanol therefore need $7 - 1 = 6$ O atoms
   Since oxygen is a diatomic molecule, O_2 then ${}^6/_2 = 3$ molecules
   $C_2H_6O + 3O_2 \rightarrow 2CO_2 + 3H_2O$
5. Add states and multiply through by 2 to remove half oxygen molecules.
   $C_2H_6O(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ [1 mark]

iv. $M(C_2H_6O) = 2\times12.0 + 6\times1.0 + 16.0 = 46.0$ g mol^{-1}
$n(C_2H_6O) = m(C_2H_6O) / M(C_2H_6O) = 1.618 / 46.0 = 3.517\times10^{-2}$ mol.
3.517×10^{-2} mol. of ethanol releases 47.98 kJ
1 mole of ethanol will release $47.98/3.517\times10^{-2} = 1364$ kJ
Energy is release in the reaction therefore it is exothermic and $\Delta H<0$
$\Delta H = -1364$ kJ mol^{-1} [1 mark]

c. Since this is a gas the number of mole of methane can be determined using the general gas equation: PV = nRT where T is in Kelvin

T = 273 + 14.2 = 287.2 K

$n(CH_4) = \frac{PV}{RT} = \frac{7450 \times 10.0}{8.31 \times 287.2} = 31.2$ mol **[1 mark]**

For 100% efficiency, the energy release by 1 mol of CH_4 is 889 kJ.

Assuming 100% efficiency, E = 31.2 × 889 = 2.78×10^4 kJ **[1 mark]**

At 80% efficiency the energy available will be:

E = $2.77 \times 10^4 \times (80/100) =$ **2.2×10^4 kJ** **[1 mark]**

Question 2 - [7 marks, 9 minutes]

a. These are **electrolytic cells** therefore **oxidation will occur at the anode which will be positively** charged and **reduction will occur at the cathode which will be negatively** charged.

i. Electrode V – Positively charged therefore oxidation will occur at this anode. Two possible reactions are the oxidation of water or the copper electrode. From the electrochemical series copper is a stronger reductant than water therefore it will be oxidised.

$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ [1 mark]

ii. Electrode X – Negatively charged therefore reduction will occur at this cathode. Two possible reactions are the reduction of water or silver ions. From the electrochemical series the silver ions are stronger oxidants than water therefore these will be reduced.

$Ag^+(aq) + e^- \rightarrow Ag(s)$ [1 mark]

iii. Electrode Y – Positively charged therefore oxidation will occur at this anode. Since the electrode is made from carbon it will not react, the two possible reactions will be the oxidation of water or bromide ions. From the electrochemical series the bromide ions are stronger reductants than water therefore these will be oxidised.

$2Br^-(aq) \rightarrow Br_2(aq) + 2e^-$ [1 mark]

iv. Electrode Z – Negatively charged therefore reduction will occur at this cathode. Since the electrode is made from carbon it will not react, the two possible reactions will be the reduction of water or sodium ions. From the electrochemical series the water is a stronger oxidant than the sodium ions therefore this will be reduced.

$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ [1 mark]

b. The half-equation for the reaction occurring at electrode V is:

$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

Therefore the mass of this electrode will decrease.

n(Cu) = m(Cu) / M(Cu) = 0.833 / 63.5 = 1.31×10^{-2} mol

As the three cells are in series the same current flows through all three and hence the number of mole of electrons flowing through all three will be the same.

$n(e^-) = 2 \times n(Cu) = 2 \times 1.31 \times 10^{-2} = 2.62 \times 10^{-2}$ mol **[1 mark]**

The half-equation for the reaction occurring at electrode X is:

$Ag^+(aq) + e^- \rightarrow Ag(s)$

$n(Ag) = n(e^-) = 2.62 \times 10^{-2}$ mol

$m(Ag) = n(Ag) \times M(Ag) = 2.62 \times 10^{-2} \times 107.9 = 2.83$ g **[1 mark]**

As the silver is deposited on electrode X its mass will increase, therefore

m(Electrode X) = 5.173 + 2.83 = **8.00 g** **[1 mark]**

Question 3 - [5 marks, 6 minutes]

a. Possible answers include:

[Total marks allocated = 2 marks: 1 mark for each correct answer]

Nuclear energy would not add any additional greenhouse gases to the atmosphere whereas fossil fuels would add significant amounts of these gases.

The use of fossil fuels for desalination would deplete the reserves of these more rapidly.

Nuclear energy significantly provides more energy for a given amount of fuel than fossil fuels.

Nuclear energy would produce less pollution in the form of smoke and other gas emissions than fossil fuels.

Australia has large nuclear energy resources that could be readily developed to provide the energy without affecting the current fossil fuel usage.

b. Possible answers include:

[Total marks allocated = 2 marks: 1 mark for each correct answer]

The problems associated with the disposal of radioactive waste.

The potential for an accident that could have a significant impact on the environment and the population.

The problems associated with the increased availability of nuclear materials that could fall into the hands of terrorists.

The potential for the site to be a terrorist target.

c. **Nuclear fission** involves splitting large nuclei, such as uranium, to form smaller nuclei and release energy in the process. **[1 mark]**

e.g.: ${}^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{93}_{36}\text{Kr} + {}^{140}_{56}\text{Ba} + 3\,{}^{1}_{0}\text{n} +$ energy

Question 4 - [5 marks, 6 minutes]

a. During discharge the battery is acting as a galvanic cell. Oxidation occurs at the anode therefore the Pb is being oxidised to Pb^{2+}.

$\mathbf{Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-}$ **[1 mark]**

b. The reaction that occurs during recharging is the reverse of the discharge reaction.

$2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 2H_2SO_4(aq)$

This reaction leads to the formation of sulfuric acid which will increase the concentration of the $H^+(aq)$ ion in solution, therefore the **pH will decrease**. **[1 mark]**

c. Possible answers include:

[1 mark for a correct answer.]

Lead is a toxic element and the disposal of the batteries when they have finished their life can be an environmental problem.

The batteries are heavy because of the high density of lead.

If a battery is damaged a relatively concentrated solution of sulfuric acid can leak and this can cause problems.

Because the batteries have a liquid electrolyte they have limited applications for where they can be used.

d. Possible answers include:

[1 mark for a correct answer.]

The batteries are relatively cheap to manufacture.

The technology required to manufacture the batteries is relatively simple and well developed.

The batteries can be used to store high current densities.

The batteries can supply relatively high currents.

The equipment required to recharge the batteries is not complicated and readily available.

e. Possible answers include:

[1 mark for a correct answer.]

The lead sulfate, $PbSO_4$, formed on the electrodes during discharge crumbles and falls off the electrodes and this reduces the amount of material available for recharging.

The lead metal is slowly corroded by the sulfuric acid solution.

The lead sulfate crystals can change into a less reactive form if the cell is not kept charged.

Internal short circuits can occur in the cell causing problems during charging and discharging.

As the cells are connected in series to make a 12 volt battery, if one cell becomes non-functional then the battery will not function.