Lisachem Materials

Chemistry Physics Biology Psychology

VCE CHEMISTRY 2006 SUPPLYING AND USING ENERGY 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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relative atomic number
symbol
name
relative atomic mass

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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 Yittrium 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 Ds Darmstadtium (272)	111 Rg Roentgenium (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}

Specific heat of water = 4.184 J mL^{-1} ^{o}C^{-1}

Ideal gas equation

p*V* = 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 2006 Supplying & Using Energy Test 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

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
Which one of the following groups of energy sources only contains renewable sources?
A. Geothermal, wind, solar and tidal.
B. Hydroelectricity, solar, nuclear fission and wind.
C. Wind, solar, coal and oil.
D. Tidal, geothermal, solar and nuclear fission.

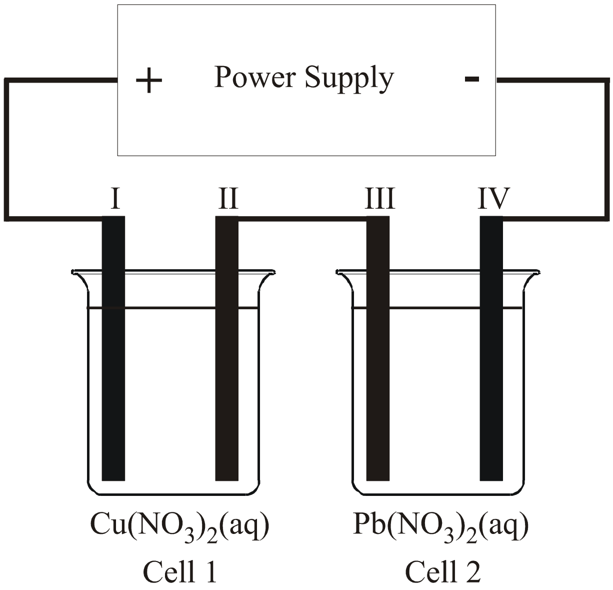
Question 2
The specific heat capacity of a substance is
A. the energy required to change the state of the substance from a liquid to a gas at its boiling temperature.
B. the energy required to raise the temperature of one gram of the substance by 1 ºC without changing the state.
C. the energy required to change the state of the substance from a solid to a liquid at its melting temperature.
D. the energy released by one mole of the substance when it is burnt in excess oxygen.

Question 3
In a galvanic cell
A. reduction will occur at the positive cathode.
B. reduction will occur at the negative cathode.
C. the electrons flow through the external circuit from the cathode to the anode.
D. the negative ions flow from the salt-bridge into the half-cell containing the cathode.

Question 4
Which one of the following would **not** be characteristic required of the material used to construct the negative electrode in a hydrogen/oxygen fuel cell?
A. To be the reductant in the overall reaction.
B. To be an electrical conductor.
C. To be unreactive.
D. To be able to catalyse electron transfer reactions.

Question 5
To plate an iron object with a thin layer of manganese
A. the object is made the positive electrode of an electrolytic cell containing an aqueous solution of manganese(II), $Mn^{2+}(aq)$, ions.
B. the object is made the negative electrode of an electrolytic cell containing an aqueous solution of manganese(II), $Mn^{2+}(aq)$, ions.
C. the object can be dipped in an aqueous solution of manganese(II), $Mn^{2+}(aq)$, ions.
D. an aqueous solution of manganese(II), $Mn^{2+}(aq)$, ions cannot be used.

Questions 6, 7 & 8 refer to the following information.
Two electrolytic cells were set up in series as shown in the diagram below.
A current of 2.00 A was passed through the system for 5.0 minutes.



Question 6
At which electrodes would reduction occur?

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

Question 7
What mass of copper would be deposited on the electrode where reduction occurs in cell 1?

A. 0.40 g.
B. 0.79 g.
C. 0.20 g.
D. 0.0062 g

Question 8
How would the mass of lead deposited in cell 2 compare with the mass of copper deposited in cell 1?

A. It would be about 3.3 times the mass of the copper.
B. It would be about 0.3 times the mass of the copper.
C. It would be about twice the mass of the copper.
D. It would be about 1.6 times the mass of the copper.

Questions 9 & 10 refer to the following information.
A group of students carried out the electrical calibration of a solution calorimeter using a 6.00 V power supply. After passing a current of 1.20 A through the heater for 10.0 minutes the temperature changed from 21.92 ºC to 28.85 ºC.

Question 9
What is the calibration factor for this calorimeter?

A. 10.4 J $ºC^{-1}$.
B. 623 J $ºC^{-1}$.
C. 104 J $ºC^{-1}$.
D. 519 J $ºC^{-1}$.

Question 10
When repeating the calibration using the same electrical conditions the students found that there was a smaller temperature change.
Which one of the following could explain this observation?

A. The thermometer was placed closer to the heater while the solution was stirred normally.
B. The thermometer was placed closer to the heater and the solution was not stirred during the calibration.
C. A smaller volume of solution was added to the calorimeter than was previously used.
D. A larger volume of solution was added to the calorimeter than was previously used.

Question 11
The combustion of butane can be represented by the chemical equation;

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l) \quad \Delta H = -5772 \text{ kJ mol}^{-1}$$

What amount of energy will be released when 1.00 kg of butane is completely burnt?

A. 99500 kJ.
B. 199000 kJ.
C. 4980 kJ.
D. 49800 kJ.

Question 12
In a typical Down's cell used to produce sodium the anode and cathode are respectively

A. both made of iron.
B. made of iron and carbon.
C. made of carbon and iron.
D. both made of iron.

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 - [8 marks, 10 minutes]
Biodiesel is a fuel, considered as a greener alternative to diesel obtained from crude oil, that can be made from various vegetable oils.

a. In an experiment to determine the heat of combustion for biodiesel, a 5.00 mL sample of the fuel was burnt in a bomb calorimeter with a calibration factor of 5438 J $^{\circ}C^{-1}$. The temperature of the calorimeter and its contents changed from 24.17 ºC to 55.11 ºC during the experiment.

   i. Calculate the amount of energy released when this biodiesel sample was burnt.

   ii. Determine the heat of combustion for biodiesel and express it in kJ mL^{-1}.

1 + 1 = 2 marks

b. Why is it necessary to express the heat of combustion in kJ mL^{-1} rather than in kJ mol^{-1}?

1 mark

c. When burnt in an engine the thermal energy obtained from the biodiesel was less than that determined using the calorimeter. What would be one reason why there is a difference in the energies obtained?

1 mark

d. The energy available from the engine was significantly less than the heat of combustion. Give one reason for this observation.

1 mark

e. Why would biodiesel be considered as a renewable fuel?

1 mark

f. Considering the environmental and/or the economic impact of using biodiesel to replace diesel obtained from crude oil as a fuel.

i. What would be one advantage, other than it is a renewable fuel, of using biodiesel?

ii. What would be one disadvantage of using biodiesel?

1 + 1 = 2 marks

Question 2 - [9 marks, 11 minutes]

a. The chemical equation below describes the reaction that occurs during the discharge of a rechargeable cell, with a potential of 1.9 V, that was used for some specialist applications.

$$Ag_2O(s) + Zn(s) + H_2O(l) \rightarrow 2Ag(s) + Zn(OH)_2(s)$$

The cell used an alkaline electrolyte.

i. Write an appropriate chemical half-equation to describe the half-reaction that would occur at the cathode when the cell was being recharged.

ii. Write an appropriate chemical half-equation to describe the half-reaction that would occur at the anode when the cell was being recharged.

iii. What would be the minimum mass of silver that a cell would need to contain if it were to be able to produce a continuous current of 0.050 A for 24 hours?

iv. Give one reason why this cell was only used for specialist applications.

1 + 1 + 3 + 1 = 6 marks

b. The NiMH batteries that are extensively used in mobile phones also use an alkaline electrolyte and the discharge reaction can be described by the chemical equation;

$$NiO(OH)(s) + MH(s) \rightarrow Ni(OH)_2(s) + M(s)$$

In this equation M is a mischmetal, a form of alloy, that acts as a hydrogen carrier.

i. What is the oxidant in this reaction?

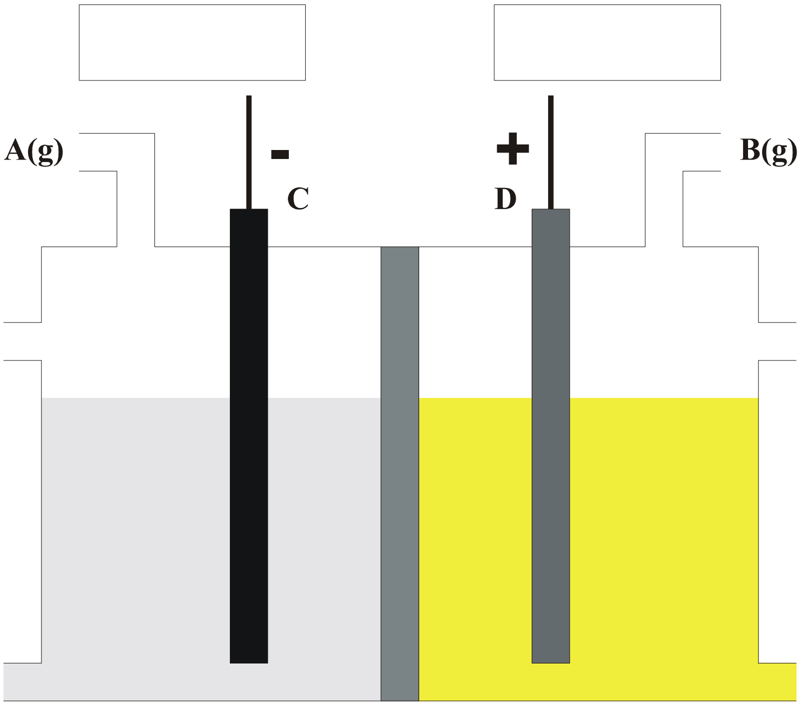
ii. Write an appropriate chemical half-equation to describe the half-reaction that would occur at the cathode when this cell is discharging.

1 + 1 = 2 marks

c. What characteristic does a galvanic cell require for it to be viable as a rechargeable cell?

1 mark

Question 3 - [7 marks, 9 minutes]
The diagram below shows a semipermeable membrane cell that can be used to produce sodium hydroxide.



a. On the diagram mark which electrode is the anode and which is the cathode.

1 mark

b. Identify the following:
   i. The gas A produced

   ii. The gas B produced

   iii. The material used to construct electrode C.

   iv. What properties does the material used to construct electrode D need to have?

1 + 1 + 1 + 1 = 4 marks

c. Write appropriate chemical half-equations to describe the half-reactions that occur at;

i. the anode

ii. the cathode.

1 + 1 = 2 marks

Question 4 - [4 marks, 5 minutes]

Write appropriate chemical equations for the following reactions.

a. A piece of calcium metal is placed in water.

1 mark

b. A piece of tin metal is placed in an aqueous solution of iron(III) nitrate.

1 mark

c. The complete combustion of liquid propanol, C_3H_7OH, at SLC.

1 mark

d. The electrolysis of an aqueous solution of sulfuric acid using platinum electrodes.

1 mark

END OF TASK

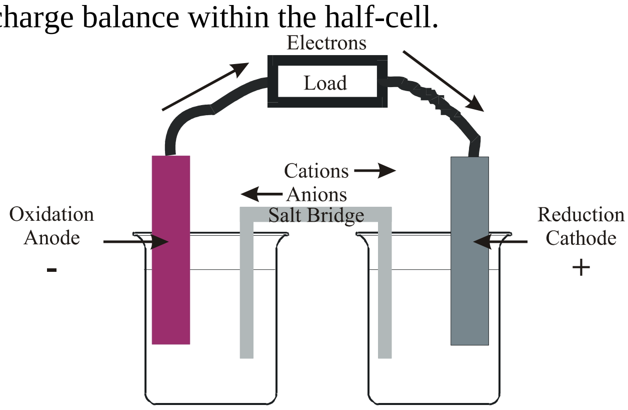
Suggested Answers VCE Chemistry 2006 Supplying and Using Energy Test Unit 4

SECTION A [1 mark per question.]

Q1 A A renewable energy source is one that does not use or consume a finite resource, this would include; geothermal, hydroelectricity, solar, tidal and wind. Nuclear fission uses uranium, and coal and oil are a finite resources.

Q2 B The specific heat, or heat capacity, of a substance is the energy required to raise the temperature of one gram of the substance by 1 ºC without changing the state. The specific heat for water is 4.18 J $^{\circ}C^{-1}$ g^{-1}.

Q3 A In all electrochemical cells oxidation occurs at the anode and reduction occurs at the cathode. Oxidation involves the loss of electrons, therefore the anode gains these electrons and becomes negatively charged. Reduction involves gain of electrons therefore electrons leave the cathode making it positively charged. The electrons flow from the anode to the cathode through the external circuit. Since the species being reduced at the cathode are becoming less positive then cations from the salt-bridge will need to flow into this half-cell to maintain electrical charge balance within the half-cell.



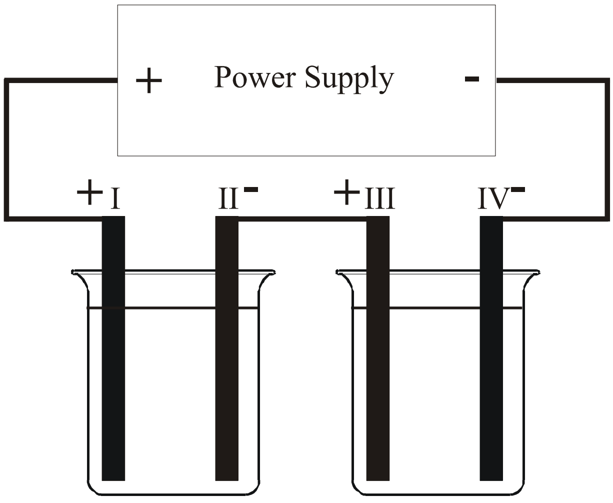
Q4 A In a fuel cell the oxidant and reductant are being continually added to the cell, therefore the negative electrode, anode, should not be acting as the reductant in the cell and needs to be unreactive. In all electrochemical cells the electrodes need to be electrical conductors and able to catalyse the electron transfer reactions.

Q5 D From the electrochemical series the reduction half-equation for manganese(II) ions is given as;

$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s)$ $E^o = -1.03$

This reduction potential is more negative than the reduction potential for water, therefore manganese(II) ions are poorer oxidants than water and can not be reduced from an aqueous solution of manganese(II) ions. In any electrolytic reaction the water will be reduced in preference to the manganese(II) ions. Adding iron to an aqueous solution of manganese(II) ions will not result in a chemical reaction because iron is a poorer reductant than manganese.

Q6 C This is an electrolytic cell since an external power supply is present. As reduction involves the gain of electrons, therefore this will occur at the negative electrodes in the cells. Electrode IV is negative because it is attached to the negative terminal of the power supply. Electrode I is positive, so electrode II is negative since the cells are in series.



Q7 C The half-equation for the reduction reaction occurring in cell 1 is

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

Q = I × t where I is the current in amps and t is the time in seconds.

Q = 2.0 × 5.0 × 60 = 600 C

$n(e^{-}) = Q/F = 600/96500 = 6.2\times10^{-3}$ mol

From the half-equation:

$n(Cu) = ½\ n(e^{-}) = ½ \times 6.2\times10^{-3} = 3.1\times10^{-3}$ mol

$m(Cu) = n \times M = 3.1\times10^{-3} \times 63.6 =$ **0.20 g**

Q8 A The half-equation for the reduction reaction occurring in cell 2 is

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

Since the current passing through both half-cells and the number of electrons being consumed are both the same then the number of mole of copper and lead deposited will be the same. Therefore the ratio of the masses of the two metals will depend on the molar masses of the metals.

M(Cu) : M(Pb) = 63.6 : 207.2 divide both by the smaller number 63.6

M(Cu) : M(Pb) = **1 : 3.26**

Q9 B The calibration factor is the energy required to change the temperature of the calorimeter and its contents by 1 ºC.

E = V × I × t = 6.0 × 1.2 × (10 × 60) = 4320 J

ΔT = 28.85 – 21.92 = 6.93 ºC

CF = E / ΔT = 4320 / 6.93 = **623 J ºC^{-1}.**

Q10 D If the volume of solution that is added to the calorimeter was larger than that used previously then the **same amount of energy will give a smaller temperature rise**.

Not stirring the solution during the calibration will result in a larger temperature rise of the solution near the heater.

Q11 D The combustion of butane is described by the chemical equation,

$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$ ΔH = -5772 kJ mol^{-1}

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

1.00 kg = 1000 g

$n(C_4H_{10}) = m(C_4H_{10})/M(C_4H_{10}) = 1000/58.0 =$ **17.2 mol**

2 mol of C_4H_{10} releases 5772 kJ of energy.

17.2 mole of C_4H_{10} will release (17.2/2) × 5772 = **49800 kJ of energy**.

Q12 C In the Down's cell molten sodium chloride is electrolysed to produce chlorine at the anode and sodium metal at the cathode. The anode needs to be unreactive and not attacked by the corrosive chlorine so carbon is used. An iron cathode is used in the Down's cell.

SECTION B

Question 1 - [8 marks, 10 minutes]

a. i. CF = 5438 J $^{\circ}C^{-1}$

$\Delta T = 55.11 - 24.17 = 30.94$ ºC

E = CF × ΔT = 5438 × 30.94 = **1.683×10^5 J [1 mark]**

ii. 1 kJ = 1000 J

E = 1.683×10^5 / 1000 = 168.3 kJ

Heat of Combustion = 168.3 / 5.00 = **33.7 kJ mL^{-1}. [1 mark]**

b. The heat of combustion needs to be expressed in kJ mL^{-1} rather than in kJ mol^{-1} because the original vegetable oil would contain a mixture of compounds and the molar mass could not be determined. **[1 mark]**

c. When the biodiesel is burnt in the calorimeter it reacts with pure oxygen and is burnt completely to yield carbon dioxide and water, whereas when it burns in the engine, with air, incomplete combustion occurs to yield other products, such as carbon monoxide and carbon, and this would lower the energy released by the fuel. **[1 mark]**

d. The energy available from the engine is significantly less than the energy of the fuel due to losses as heat through the various energy conversions.
(Chemical → thermal → mechanical). **[1 mark]**

e. Biodiesel is considered as a renewable fuel because it is made from a resource that can be replaced over a short time scale unlike crude oil which takes millions of years to form. **[1 mark]**

f. i. Possible answers include: **[Total marks allocated = 1 marks]**

The carbon dioxide released when the fuel is burnt would be reabsorbed by the plants that are grown to make the fuel, unlike diesel made from crude oil.

The energy requirements for the production of biodiesel are comparable with those used to produce diesel from crude oil.

Growing the source crops would provide an alternative income for farmers and their employees.

Can generally be used in existing engines without modification.

ii. Possible answers include: **[Total marks allocated = 1 marks]**

The use of land for growing the plants required to make the biodiesel could impact on the production of crops for food.

Growing more crops to produce vegetable oils to make biodiesel from would require more water for irrigation.

Growing the crops to produce biodiesel could involve the usage of more fertilisers that could lead to pollution of waterways.

Could result in a glut/famine situation due to growing conditions that could make the price highly variable.

Question 2 - [9 marks, 11 minutes]

In all electrochemical reactions, oxidation occurs at the anode and reduction at the cathode.

a. i. Cathode reaction = reduction

$Zn(OH)_2(s) + 2e^- \rightarrow Zn(s) + 2OH^-(aq)$ [1 mark]

Since students may not be familiar with redox reactions in an alkaline solution accept: $Zn(OH)_2(s) + 2H^+(aq) + 2e^- \rightarrow Zn(s) + 2H_2O(l)$

ii. Anode reaction = oxidation:

$2Ag(s) + 2OH^-(aq) \rightarrow Ag_2O(s) + H_2O(l)$ [1 mark]

Since students may not be familiar with redox reactions in an alkaline solution accept: $2Ag(s) + H_2O(l) \rightarrow Ag_2O(s) + 2H^+(l) + 2e^-$

iii. I = 0.050 A, t = 24 hours = 24 × 60 × 60 = 86400 s.

Q = I × t = 0.050 × 86400 = 4320 C **[1 mark]**

$n(e^-) = Q / F = 4320 / 96500 = 4.5 \times 10^{-2}$ mol **[1 mark]**

From the chemical half-equation in ii. above:

$n(Ag) = n(e^-) = 4.5 \times 10^{-2}$ mol.

$m(Ag) = n \times M = 4.5 \times 10^{-2} \times 107.9 =$ **4.9 g [1 mark]**

Accept 4.8 if no rounding off is used for $n(e^-)$

iv. The main reason why this cell was only used for specialist applications was the **cost of the silver used in the cell**. **[1 mark]**

b. i. In a redox reaction the oxidant is reduced. In this reaction the oxidation numbers for the Ni in NiO(OH) and $Ni(OH)_2$ are +3 and +2 respectively. Therefore the **NiO(OH) is the oxidant**. **[1 mark]**

ii. Cathode reaction = reduction.

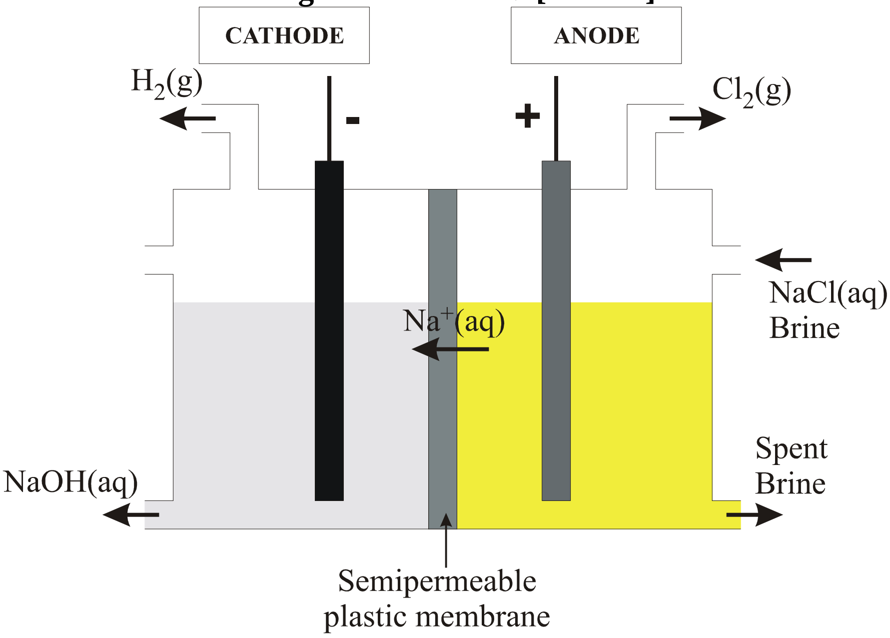
$NiO(OH) + H_2O(l) + e^- \rightarrow Ni(OH)_2(s) + OH^-(aq)$ [1 mark]

Since students may not be familiar with redox reactions in an alkaline solution accept: $NiO(OH) + H^+(aq) + e^- \rightarrow Ni(OH)_2(s)$.

c. For a cell to be rechargeable the products from the discharge reaction must remain in contact with the electrodes and be in a form that will allow them to be converted back to the original reactions when an external electrical energy source (charger) is applied. **[1 mark]**

Question 3 - [7 marks, 9 minutes]

a. This is an electrolytic cell, therefore the **anode will be positively charged** and the **cathode will be the negative electrode**. **[1 mark]**



b. i. Gas A is produced at the negative electrode, cathode, will involve a reduction reaction. The species present in the cell that can undergo reduction are Na^+(aq) and H_2O(l). From the electrochemical series water is the stronger oxidant which will be reduced to produce **hydrogen gas, H_2(g)**. **[1 mark]**

ii. Gas B is produced at the negative electrode, anode, will involve an oxidation reaction. In this cell the electrolyte is brine, which is a concentrated sodium chloride solution. The reaction that takes place is the oxidation of the chloride ion to produce **chlorine gas, Cl_2(g)**. **[1 mark]**

iii. Electrode C is usually made from a **steel mesh or nickel**. **[1 mark]**

iv. The material used to construct electrode D needs to be an **electric conductor**, not **oxidised during the electrolysis** and **not react with the chlorine gas** produced. **[1 mark]** Some cells use a titanium coated anode.

c. i. Oxidation occurs at the anode:

$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ [1 mark]

ii. Reduction occurs at the cathode.

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

Question 4 - [4 marks, 5 minutes]

a. Calcium is a strong reductant and can be oxidised by water. The chemical half-reactions are:

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

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

The overall reaction can be determined by adding the two half-equations since both contain $2e^-$.

$Ca(s) + 2H_2O(l) \rightarrow Ca^{2+}(aq) + H_2(g) + 2OH^-(aq)$ [1 mark]

or $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$

b. Tin will act as a reductant which will be oxidised by the iron(III) ions. The chemical half-equations are:

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

$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$

The second half-equation must be multiplied by 2 before the two half-equations are added.

$Sn(s) + 2Fe^{3+}(aq) \rightarrow Sn^{2+}(aq) + 2Fe^{2+}(aq)$ [1 mark]

or $Sn(s) + 2Fe(NO_3)_3(aq) \rightarrow Sn(NO_3)_2(aq) + 2Fe(NO_3)_2(aq)$

c. The complete combustion involves the reaction between the propanol and oxygen that will produce carbon dioxide, CO_2, and water, H_2O.

Build the chemical equation in steps:

1. Write down the reactants and products.
   $C_3H_7OH + O_2 \rightarrow CO_2 + H_2O$
2. Balance the number of carbon atoms.
   $C_3H_7OH + O_2 \rightarrow \mathbf{3}CO_2 + H_2O$
3. Balance the number of hydrogen atoms
   $C_3H_7OH + O_2 \rightarrow 3CO_2 + \mathbf{4}H_2O$
4. Balance the number of oxygen atoms.
   $C_3H_7OH + {}^{\mathbf{9}}/_{\mathbf{2}}O_2 \rightarrow 3CO_2 + 4H_2O$
   If the number of oxygen molecule is a fraction multiply the equation by 2.
   $\mathbf{2}C_3H_7OH + \mathbf{9}O_2 \rightarrow \mathbf{3}CO_2 + \mathbf{4}H_2O$
5. Add appropriate states.
   $2C_3H_7OH(l) + 9O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ [1 mark]

d. The platinum electrodes are unreactive.

The appropriate chemical half-equations are:

The oxidation of water: $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

The reduction of hydrogen ions: $2H^+(aq) + 2e^- \rightarrow H_2(g)$

The overall equation can be determined by multiplying the reduction half-equation by 2 and adding the two half-equations.

$2H_2O(l) + 4H^+(aq) \rightarrow O_2(g) + 2H_2(g) + 4H^+(aq)$

Since there are $4H^+$ on each side of the equation these can be cancelled.

$2H_2O(l) \rightarrow O_2(g) + 2H_2(g)$ [1 mark]