Chemistry Physics Biology
Psychology

VCE CHEMISTRY 2005
TRIAL EXAM UNIT 4

Time allowed: 90 minutes
Total marks: 76

SECTION A
Contains 20 multiple choice questions
24 minutes, 20 marks

SECTION B
5 Extended response questions
66 minutes, 56 marks

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}	**Ideal gas equation**
R	= 8.31 JK^{-1} mol^{-1}	pV = nRT
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}

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

Student Name...

VCE Chemistry 2005 Year 12 Trial Exam 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.

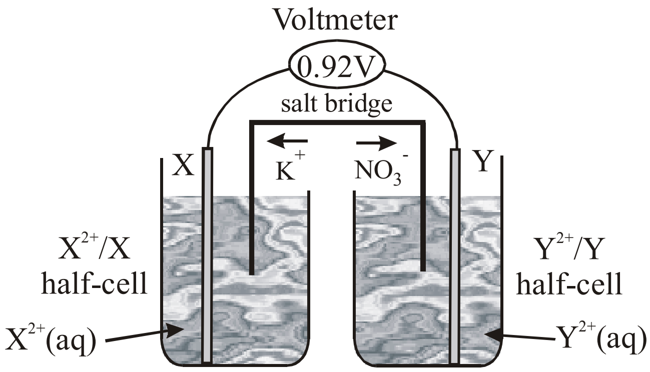
Question 1.	A	B	C	D
Question 2.	A	B	C	D
Question 3.	A	B	C	D
Question 4.	A	B	C	D
Question 5.	A	B	C	D
Question 6.	A	B	C	D
Question 7.	A	B	C	D
Question 8.	A	B	C	D
Question 9.	A	B	C	D
Question 10.	A	B	C	D
Question 11.	A	B	C	D
Question 12.	A	B	C	D
Question 13.	A	B	C	D
Question 14.	A	B	C	D
Question 15.	A	B	C	D
Question 16.	A	B	C	D
Question 17.	A	B	C	D
Question 18.	A	B	C	D
Question 19.	A	B	C	D
Question 20.	A	B	C	D

VCE Chemistry 2005 Year 12 Trial Exam Unit 4

Section A

Section A consists of 20 multiple-choice questions.
Section A is worth approximately 26 per cent of the marks available.
You should spend approximately ***24 minutes*** *on this section.*
Choose the response that is ***correct*** *or* ***best answers*** *the question.*
Indicate your choice on the answer sheet provided.

Question 1.
Consider the galvanic cell represented below



In this cell
A. K^+ ions are moving towards the negative electrode X
B. NO_3^- ions are moving towards the cathode Y
C. oxidation is occurring at electrode X
D. oxidation is occurring at electrode Y

Question 2.
The 12-volt battery used in motor vehicles consists of six lead-acid cells connected in series. When current is being delivered by the battery, the overall redox reaction is described by the equation

$$PbO_2(s) + Pb(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

When each cell in this battery is being recharged, the oxidation number of Pb
A. increases at the positive electrode
B. increases at the negative electrode
C. increases as Pb is converted to $PbSO_4$
D. increases as $PbSO_4$ is converted to Pb

Question 3.
An aqueous solution of nickel II chloride is green. Ammonia is a weak base, which ionises in aqueous solution, according to

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

If concentrated ammonia solution is added to an aqueous solution of nickel II chloride the solution changes from green to blue. The most likely cause of this colour change would be
A. the oxidation of $Ni^{2+}(aq)$ to $Ni^{3+}(aq)$ by ammonia
B. the conversion of $Ni(H_2O)_6^{2+}(aq)$ ions to $Ni(NH_3)_6^{2+}(aq)$ ions
C. the precipitation of nickel (II) hydroxide, $Ni(OH)_2$
D. the movement of an electron from the 4s subshell to the 3d subshell.

Question 4.
The energies, in kJ mol^{-1}, required to successively remove the first 8 electrons from an atom of an element X are shown below:

Electron	1	2	3	4	5	6	7	8
Energy	1020	1910	2920	4960	6270	21300	25400	29900

A. oxygen
B. neon
C. nitrogen
D. phosphorus

Question 5.
Hydrogen reacts with oxygen to from water vapour according to the thermochemical equation

$$H_2(g) + ½O_2(g) \rightarrow H_2O(g); \quad \Delta H = -242 \text{ kJ mol}^{-1}$$

The amount of thermal energy produced for each mole of H_2 reacting according to the equation

$$H_2(g) + ½O_2(g) \rightarrow H_2O(l)$$

will be
A. less than 242 kJ
B. 242 kJ
C. more than 242 kJ
D. dependant on the temperature of the water

Question 6.
Consider the following description of the operation of a mass spectrometer

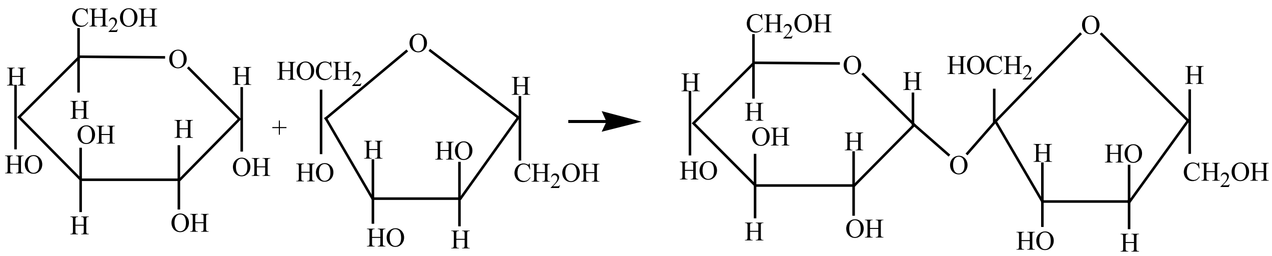
When a gaseous sample of an element is injected into a mass spectrometer, the individual atoms assume a positive charge as they pass the ____________________. As the ions pass through the ____________ they are _______________ and then separated in the __________________.

Which of the following does not correctly fit one of the gaps in the description?
A. electron beam
B. accelerated
C. magnetic field
D. detector

Question 7.
On June 28, 2005, an international consortium announced that Cadarache in Southern France would be the site of the world's first large-scale, sustainable nuclear fusion reactor. Nuclear fusion reactors are not currently a viable energy source because
A. the required fuels are very difficult to obtain
B. the radioactive products of the process have a long half-life
C. it is extremely difficult to generate the required operating temperature
D. they are not as efficient as coal-fired power stations

Question 8.
Which of the following elements would, in its ground state, have its highest energy electrons in a 5d subshell?
A. Mercury – $_{80}Hg$
B. Plutonium – $_{94}Pu$
C. Molybdenum– $_{42}Mo$
D. Strontium – $_{38}Sr$

Question 9.
The formation of a common disaccharide may be represented by the reaction shown below



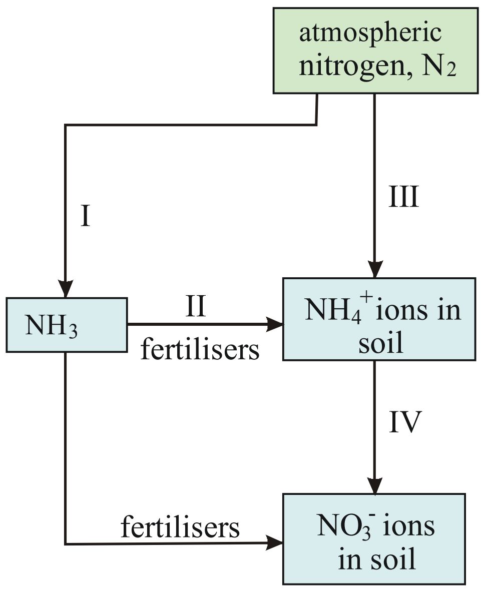
The percentage, by mass of carbon in the product shown will be approximately

A. the same as in the reactants
B. less than in the reactants
C. 40 %
D. 42 %

Question 10.
The diagram below shows a segment of the nitrogen cycle:

Which section does not involve a change in the oxidation number of nitrogen?

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



Question 11.
Which of the following statements about the trends in properties of elements down a group of the periodic table is **correc**t?

A. atomic radius decreases
B. oxidising strength decreases
C. electronegativity increases
D. first ionisation energy increases

Question 12.
Yttrium-90 is a radioactive which may have potential in the radiotherapy treatment of some cancers. It forms Y^{3+} ions which would be expected to each have

A. 39 neutrons.
B. their highest energy electrons in the 4p subshell
C. 39 electrons
D. 36 protons

Question 13.
The emission of visible and ultraviolet radiation from atoms is due to

A. the movement of electrons from higher energy levels to lower energy levels
B. the movement of electrons from the 4s subshell to the 3d subshell
C. the movement of electrons between orbitals in a d subshell
D. the movement of electrons from the ground state to an excited state.

Question 14.
Lithium-ion batteries are excellent power sources for high drain devices such as portable computers and mobile phones. These consist of an anode of lithium metal absorbed into graphite, a solid metal oxide cathode such as CoO_2, and a polymer electrolyte containing a dissolved metal salt. The reactions occurring at the electrodes during the operation of these batteries may be simplified to:

Anode $Li \rightarrow Li^+ + e^-$
Cathode $CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$

A lithium-ion battery operating at of 3.7 volt delivers a current of 4.0 A for 3.0 hours, what mass of Li will be consumed at the anode?

A. 3.1 g
B. 0.45 g
C. 0.051 g
D. 11.4 g

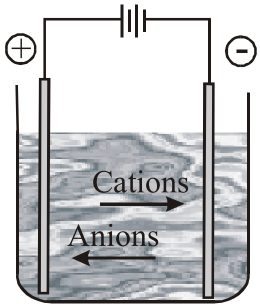
Question 15.
Which of the following reactions involves an oxide which does not display acidic properties under any circumstances?

A. $MgO(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2O(l)$
B. $CO_2(g) + 2NaOH(aq) \rightarrow Na_2CO_3(aq) + H_2O(l)$
C. $SO_3(s) + 2OH^-(aq) \rightarrow SO_4^{2-}(aq) + H_2O(l)$
D. $Al_2O_3(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2O(l)$

Question 16.
The Pauli principle is associated with the limitations on

A. the number of electron shells in an atom
B. the number of orbitals in a subshell
C. the number of electrons in an orbital
D. the number of subshells in shell

Question 17.
The diagram below represents the general structure of an electroplating cell.



In this cell

A. the object to be plated is at the positive electrode
B. the object to be plated is at the negative electrode
C. the electrolyte contains anions of the plating metal
D. oxygen gas is produced as water is oxidised at the anode.

Question 18.
When a current of 1.40 A was passed through the electric heater of a bomb calorimeter for 54.5 seconds at a potential difference 6.00 volts, the temperature of the calorimeter rose by 0.390°C.
When 9.50×10^{-4} mol of methane gas underwent combustion in the calorimeter, the temperature rose from 21.45 to 22.17°C.
How much energy, in kJ was released for each 1 mol CH_4 reacting?

A. 1174
B. 845
C. 890
D. 55.6

Question 19.
The membrane cell is used to produce a number of chemicals by electrolysis of a concentrated aqueous solution of sodium chloride, i.e. NaCl(aq).
Which of the following statements does **not** apply to the membrane cell?

A. Chlorine gas is produced at the anode
B. The pH increases around the cathode
C. Cl^- ions move towards the positive electrode.
D. The semipermeable membrane allows the transfer of Cl^- ions but not Na^+ ions.

Question 20.
Naturally occurring copper consists of two isotopes: ^{63}Cu and ^{65}Cu.
The relative isotopic masses of theses isotopes are 62.93 and 64.93 respectively.
The percentage abundance of copper-63 in a naturally occurring sample of copper would be closest to

A. 33.5 %
B. 50.0 %
C. 66.5 %
D. 87.5 %

Section B

Section B consists of 5 short answer questions.You should answer all of these questions.
This section is worth approximately 74 per cent of the total marks available.
You should spend approximately 66 minutes on this section of the examination.
The marks allotted are shown at the end of each part of each question.

Questions should be answered in the spaces provided.

Question 1

Olive oil is considered to be beneficial to health due to its high content of monounsaturated fatty acids and antioxidants. Studies have shown that olive oil may offer protection against heart disease by controlling LDL - "bad" - cholesterol levels while raising HDL - "good" - cholesterol levels.

(a) Olive oil usually contains two polyunsaturated fatty acids:
Linoleic acid which is approximately 9 % by mass of the oil and has the structural formula $CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$
Linolenic acid which is approximately 1 % by mass of the oil and has the structural formula $CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$.
Linolenic acid is classified as an omega-3 fatty acid because the first C=C double bond begins on the third carbon from the end of the hydrocarbon chain. On this basis, linoleic acid is classified as an omega-6 fatty acid.
Oleic acid, the main monounsaturated fatty acid in olive oil – making up between 60 and 85 % by mass, has the same number of carbon atoms as linoleic acid and linolenic acid and is classified as an omega-9 fatty acid.

(i) How does a polyunsaturated fatty acid differ from a monounsaturated fatty acid?

(ii) Write the molecular formula of oleic acid.

(iii) Give the structural formula of oleic acid.

[1 + 1 + 2 = 4 marks]

(b) Some olive oils contain small amounts of saturated fatty acids. Give the structural formula of stearic acid, a fatty acid with molecules containing 18 carbon atoms.

[1 mark]

(c) Fatty acids are converted into fats by reaction with a compound characterised by molecules with three carbon atoms and three hydroxy functional groups.
(i) Give the name and molecular formula of this compound.

(ii) Explain how fats are converted into fatty acids during digestion.

[1 + 2 = 3 marks]

(d) When a 5.00 mL sample of 'olive oil' was completely burnt in a bomb calorimeter with calibration factor 5.95×10^3 J °C^{-1}, the temperature increased from 24.6°C to 53.2°C.
Calculate the energy content of the 'Olive Oil' in kJ per 100 mL

[3 marks]

(e) The main antioxidant present in olive oil is Vitamin E. What structural aspect of the molecules in olive oil does the vitamin protect and how does it provide that necessary protection?

[2 marks]

Total 13 marks

Question 2.

Methanol, CH_3OH, also known as wood alcohol, may be used as a petrol additive to improve combustion and is used as a fuel in its own right in some racing cars.
The combustion of methanol occurs according to the equation.

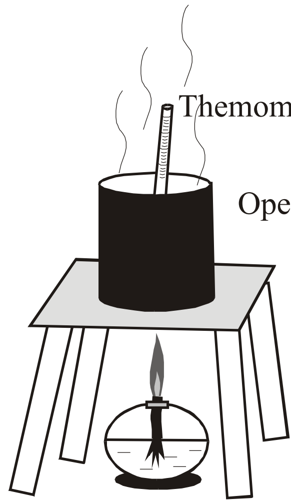
$$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l); \quad \Delta H = -1506 \text{ kJ mol}^{-1}$$

(a) Determine the heat of combustion of methanol in kJ g^{-1}

[2 marks]

(b) A laboratory experiment is set up to determine the heat of combustion of methanol. Methanol is burned in a 'spirit burner' and heat released is used to heat 200 mL of water. The apparatus was set up as shown below.

The following data was recorded:
Mass of spirit burner before heating: 125.62 g
Mass of spirit burner after heating: 117.23 g
Temperature of water before heating: 23.5°C
Temperature of water after heating: 87.9°C



(i) Determine the amount of energy, in kJ, added to the water during heating.

(ii) Determine the amount of energy released by the combustion of the methanol.

(iii) What percentage of the energy released from the methanol was transferred to the water?

(iv) Suggest how the experimental setup could be modified to increases the efficiency of the energy transfer to the water.

[2 + 2 + 1 + 1 = 6 marks]

(c) Methanol can also be used as the 'fuel' in a fuel cell using hydrochloric acid as an electrolyte.

(i) What is the main energy transformation occurring in a fuel cell?

(ii) Using the electrochemical series write the half-equation for the reaction occurring at the positive electrode.

(iii) CO_2 is produced at the negative electrode. Write a half-equation describing the production of CO_2 from methanol in the fuel cell.

(iv) State three properties usually associated with the electrodes in a fuel cell.

[1 + 1 + 1 + 2 = 5marks]

Total 13 marks

Question 3.

Stars may be described as giant 'nuclear powerhouses' that are continuously producing atoms. On Earth nuclear reactors are a significant source of electrical energy.

(a) A nuclear reactor used in the generation of electricity may be powered by the reaction

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{x}_{36}Kr + 3^{1}_{0}n$$

(i) State the type of reaction represented by this equation and give the value of '***x***'.

(ii) State one way in which such reactions differ from chemical reactions.

(iii) State one environmental issue associated with such reactions.

[2 + 1 + 1 = 4 marks]

(b) (i) Write an equation describing the main reaction occurring in the Sun.

(ii) What type of reaction is represented by this equation?

(ii) Justify the claim that the Sun is becoming less heavy as a result of this reaction.

[1 + 1 + 1 = 3 marks]

(c) Solar energy is an important part of the operation of many Remote Area Power Supplies (RAPS). Energy is stored by using photovoltaic cells to charge batteries. What are the energy transformations associated with this 'storage of solar energy'?

[1 mark]

(d) Energy from the Sun is essential for the process of photosynthesis. Write a balanced equation for photosynthesis.

[1 mark]

Total 9 marks

Question 4.

In 1886, the French chemist Moissans wrote about the preparation of fluorine.

"I obtained the fluorine from a fluorine compound that had been added to a mineral having a low melting point and in which the fluorine compound dissolved readily. The use of electricity produced the fluorine at the positive terminal. Difficulty was experienced in getting any material for that terminal that would resist the chemical action of the gas."

(a) How is the reactivity of fluorine related to its position in (i) the electrochemical series and (ii) the periodic table?

[2 marks]

(b) Write the half-equations for the electrode reactions which occur during the electrolysis of molten potassium fluoride.

(+) electrode

(-) electrode

[2 marks]

(c) Explain why fluorine, F_2, is not produced during the electrolysis of a dilute aqueous solution of potassium fluoride, and give the half-equations for the reactions occurring at the anode and cathode during this electrolysis.

[3 marks]

(d) A description of the production of aluminium by electrolysis may refer to '*the dissolving of an aluminium compound in a lower melting temperature compound'* and '*the gradual decrease in size of the positive electrode'*.

(i) Give the names of the '*aluminium compound*' and the '*lower melting temperature compound*'.

(ii) Give the equation(s) for the reaction(s) occurring at the positive electrodes during the production of aluminium, and explain why these electrodes decrease in size.

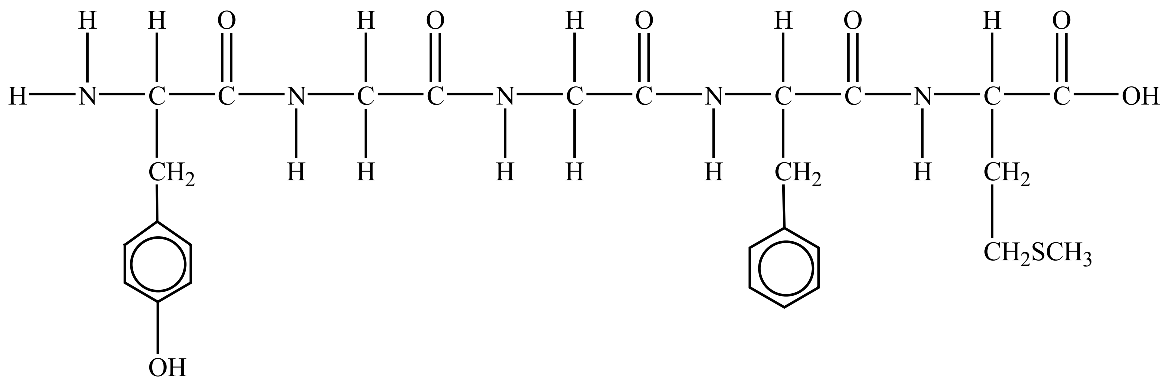
(iii) Explain why aluminium is not produced by the electrolysis of a dilute aqueous solution of Al^{3+} ions.

[1 + 2 + 1 = 4 marks]

Total 11 marks

Question 5.

(a) The human brain synthesises small polypeptides called enkephalins, part of the endorphin group, which play a role in controlling pain. The structure of one of these enkephalins is given below.



(i) How many different amino acids are present in this polypeptide?

(ii) Describe the functional group changes which occurred as this polypeptide was produced from its amino acids.

(iii) Indicate, on the diagram above, one hydrogen atom that would be involved in hydrogen bonding maintaining the secondary structure of a polypeptide.

(iv) Give the structural formula of the simplest amino acid which would be released during the digestion of this polypeptide

[1 + 1 + 1 + 1 = 4 marks]

(b) Amino acids may studied using a process known as electrophoresis, which involves passing an electric current through a gel containing the amino acids. An experimental investigation of the electrophoresis of amino acids showed that the direction of movement of the amino acids depends on the pH of the gel. Amino acids moved towards the negative electrode when the pH of the gel was 2 but towards the positive electrode when the pH was 12.

(i) Explain why the direction of movement of amino acids is dependent on the pH of the gel.

(ii) If an amino acid does **not** move towards either electrode during electrophoresis what does that suggest about its structure?

[3 + 1 = 4 marks]

(c) In a simple taste test a student places a small amount of starch on her tongue. After a few minutes she notices a sweet taste. However when she repeats the exercise with a small amount of cellulose no sweet taste results.
Explain the link between these observations and proteins.

[2 marks]
Total 10 marks

Suggested Answers VCE Chemistry 2005 Year 12 Exam Unit 4

Section A.

Q1. D The key to this question was the direction of movement of the ions in the salt-bridge.
Anions – NO_3^- – always move towards the anode, which is the site of oxidation, i.e. Y
Cations – Na^+ – always move towards the cathode, which is the site of reduction, i.e. X
Hence, reduction is occurring at electrode X, and **oxidation is occurring at electrode Y.**
In galvanic cells, electrons move spontaneously from the (-) electrode to the (+) electrode.

Q2. A Since the discharge reaction is
$PbO_2(s) + Pb(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$
then the recharge reaction is
$2\overset{+2}{Pb}SO_4(s) + 2H_2O(l) \rightarrow \overset{+4}{Pb}O_2(s) + \overset{0}{Pb}(s) + 4H^+(aq) + 2SO_4^{2-}(aq)$
The oxidation number of Pb is reduced from +2 to 0 ($PbSO_4 \rightarrow Pb$) at the cathode which, in electrolysis, is the (-) electrode.
The **oxidation number of Pb** is **increased from +2 to +4** ($PbSO_4$ to PbO_2) at the **anode** which, in electrolysis is the (+) electrode.
Alternative C may have been tempting. However, it is during discharge that the oxidation number of Pb increases as Pb is converted to $PbSO_4$.

Q3. B As nickel is a transition element **the colour change could be due to a change in its oxidation number or the formation of a complex ion.**
In NH_3 N is at its lowest oxidation state of -3. Hence it will **not** oxidise Ni^{2+}.
NH_3 is a stronger complexing agent or ligand than H_2O. Therefore, NH_3 will take the place of H_2O as a ligand around Ni^{2+}, according to the equilibrium
$Ni(H_2O)_6^{2+}(aq) + 6NH_3(aq) \rightleftharpoons Ni(NH_3)_6^{2+}(aq) + 6H_2O(l)$
As this equilibrium moves to the right, the **solution colour changes from the green of $Ni(H_2O)_6^{2+}(aq)$ to the blue of $Ni(NH_3)_6^{2+}(aq)$**
A precipitate of $Ni(OH)_2$ would be expected to be green, the same colour as $Ni^{2+}(aq)$.
The colours of different complex ions of a particular transition metal are associated with electron movement between different orbitals in the d-subshell.

Q4. D The ionisation energy is the minimum amount of energy required to remove the highest energy electron from an atom.
The first five ionisation energies increase gradually but there is a big jump from the fifth to the sixth. As each electron is removed from the outer shell, the core charge is acting on fewer electrons which become progressively harder to remove hence the increase in ionisation energy. There are **5 electrons in the outer shell**.
The big jump from the fifth to the sixth ionisation energy indicates that the **sixth electron is removed from a shell closer to the nucleus**. The increase from the sixth to seventh to eighth ionisation energies indicates there are **more than two electrons in that shell**.
Both N: 2, 5 and P: 2, 8, 5 atoms have 5 outershell electrons, but the ionisation energy data **cannot be** that of **nitrogen**, which has only seven electrons in its atoms.

Q5. C According to $H_2(g) + ½O_2(g) \rightarrow H_2O(g)$; $\Delta H = -242$ kJ mol^{-1}, for each 1 mol H_2 reacting 242 kJ of energy is released.
The link between
$H_2(g) + ½O_2(g) \rightarrow H_2O(g)$; $\Delta H = -242$ kJ mol^{-1}
and **$H_2(g) + ½O_2(g) \rightarrow H_2O(l)$**
is $H_2O(g) \rightarrow H_2O(l)$
Energy is released when water condenses, so **for each mole of $H_2(g)$ reacting in $H_2(g) + ½O_2(g) \rightarrow H_2O(l)$ more than 242 kJ of energy is released**

Q6. D *When a gaseous sample of an element is injected into a mass spectrometer, the individual atoms assume a positive charge as they pass the* **electron beam**. *As the ions pass through the* **electric field,** *they are* **accelerated** *and then separated in the* **magnetic field**.

Q7. C The fusion of hydrogen to helium in the Sun occurs at **temperatures well in excess of 10 million degrees**. Such **temperatures have proved very difficult to achieve on Earth**.
The fuels used will be deuterium and tritium, which are isotopes of hydrogen that can be extracted from water.
Fusion does not produce radioactive products.
In terms of generating electricity, a nuclear fusion power station would differ from a coal-fired power station only in the initial reaction – nuclear fusion rather than combustion. However, the energy released per gram of nuclear fuel would be many magnitudes greater than the energy released per gram of coal.

Q8. A The element with its highest energy electrons in a d-subshell will be in the d-block on the Periodic Table, i.e. it is a transition element. If the highest energy electrons are in the 5d-subshell, the element is the third transition series, i.e. the third row in the d-block.
$_{80}$**Hg** – third row, d-block; highest energy electrons in **5d subshell**
$_{94}$Pu – second row, f-block; actinide; highest energy electrons in 5f subshell
$_{42}$Mo - second row, d-block; highest energy electrons in 4d subshell
$_{38}$Sr – fifth row, s-block; highest energy electrons in 5s subshell.

Q9 D Using molecular formulae, the equation for the reaction is
$\mathbf{C_6H_{12}O_6(aq) + C_6H_{12}O_6(aq) \rightarrow C_{12}H_{22}O_{11}(aq)}$ [+ $H_2O(l)$]
Because water is condensed out as the monosaccharides react to produce the disaccharide, the **% by mass of carbon** will be **greater in the disaccharide**.
$C_6H_{12}O_6$: % C = $[6 \times M(C) / M(C_6H_{12}O_6)] \times 100$
= $[6 \times 12.0 / 180] \times 100$
= 40 %
$C_{12}H_{22}O_{11}$: % C = $[12 \times M(C) / M(C_{12}H_{22}O_{11})]$ x 100
= $[12 \times 12.0 / 342] \times 100$
= 42 %

Q10. B Consider the steps shown
I $N_2 \rightarrow NH_3$; this is reduction as oxidation number of N decreases from 0 to -3
II $NH_3 \rightarrow NH_4^+$; this shows **NH_3 acting as a base** (accepting H^+). The **oxidation number of N does not change**. It is -3 in both NH_3 and NH_4^+.
III $N_2 \rightarrow NH_4^+$; this is reduction as oxidation number of N decreases from 0 to -3
IV $NH_4^+ \rightarrow NO_3^-$; this is oxidation as oxidation number of N increases from -3 to +5

Q11. B Trends in properties down a group can all be related to the distance of the outershell electrons from the nucleus. All atoms in a group have the same core charge but its effect, and the atoms hold on its outershell electrons, decreases down the group as the outershell electrons are progressively further from the nucleus. Consequently, down a group:
Atomic radius increases as the number of occupied electron shells **increases**
Electronegativity – electron attracting ability – **decreases**.
Ionisation energy – energy needed to remove highest energy electron – **decreases**.
Reducing strength – ability to give up electrons to other species – **increases**.
Oxidising strength – ability to force other species to give up electrons – **decreases.**

Q12. B Yttrium is located under scandium, Sc, on the Periodic Table.
Since the atomic number of yttrium is 39, Yttrium-90 has the isotopic symbol $^{90}_{39}Y$.
Each atom contains 39 protons, 39 electrons and 90-39 = 51 neutrons.
A Y^{3+} ion contains 39 protons, 36 electrons and 51 neutrons.
With **36 electrons** in its nucleus, a Y^{3+} ion, has the **same electron arrangement as $_{36}$Kr**, which means its **highest energy electrons are in the 4p subshell.**

Q13. A **Atoms emit energy** when **electrons** that have been excited to higher energy levels **return to lower energy levels**. The wavelength **of the light emitted depends on the energy difference between the levels between which the electrons move**.
When electrons move from the ground state – where all electrons are in the lowest possible energy levels – to an excited state energy is absorbed. This energy is emitted when electrons return to their ground states.
With respect to the 4s and 3d subshells, atoms of the transition elements have electrons of similar energy in both the 4s and 3d subshells. This is why multiple oxidation states are possible for most transition elements.
The movement of electrons between orbitals in a d-subshell is associated with the colours of transition metal complex ions.

Q14. A The mass of Li consumed can be determined from the $n(e^-)$ transferred from the anode to the cathode.
The relationships $Q = It$ and $Q = n(e^-) \times F$ enable the calculation of the $n(e^-)$

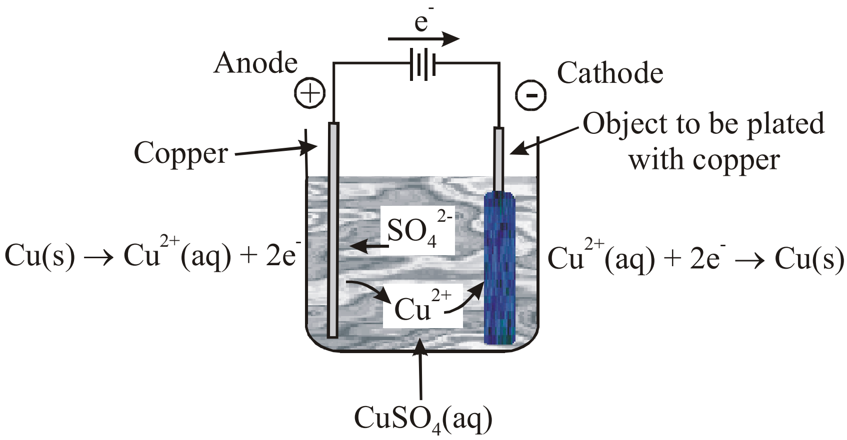
$Q = It = 4.0 \times 3 \times 60 \times 60$
$= 4.32 \times 10^4$ C
$n(e^-) = Q / F$
$= 4.32 \times 10^4$ C / 96500 C mol^{-1}
$= 0.448$ mol

Since the anode reaction is $Li \rightarrow Li^+ + e^-$
$n(Li) = n(e^-) = 0.448$ mol
$m(Li) = n(Li) \times M(Li)$
$= 0.448 \times 6.9$
= **3.1 g**

Q15. A The reaction of $CO_2(g)$ with $OH^-(aq)$ shows that **CO_2** is clearly an **acidic oxide**.
The other three oxides, MgO, SO_3 and Al_2O_3 are all oxides of period 3 elements. Across period 3, the oxides change from basic to acidic.
Na_2O and **MgO** are **basic oxide**s, meaning they react (i) with water to produce $OH^-(aq)$ ions, and (ii) with acidic solutions, i.e. with $H^+(aq)$
Oxides of P, S and Cl are acidic oxides, meaning they react (i) with water to produce acids, and (ii) with basic solutions, i.e. with $OH^-(aq)$. **SO_3** is an **acidic oxide.**
Al_2O_3 is an **amphoteric oxide**. It will react with both acidic and basic solutions.
$Al_2O_3(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2O(l)$
$Al_2O_3(s) + 2OH^-(aq) + 3H_2O(l) \rightarrow 2Al(OH)_4^-(aq)$.
The only oxide listed which does not display acidic properties was **MgO.**

Q16. C The electron content of an orbital is limited. According to the Pauli principle, **an orbital may contain 0, 1 or 2 electrons**, but never more than two.
The number of electron shells is the same for all atoms. However chemical properties are based on ‘occupied’ shells, hence the importance of electron arrangements.
The number of orbitals in each subshell follows the pattern s-1, p-3, d-5, f-7.
The number of subshells in a shell is the same as the shell number, eg the third shell has three subshells. The lowest energy subshell in a shell is always an s-subshell.

Q17. B Consider the electroplating of copper as an example



The **object to be plated is always at the cathode**, where the metal cations are reduced to the plating metal. The anode is a strip or ingot of the plating metal, which is oxidised to the cations. The electrolyte is an aqueous solution of the cations of the plating metal. The complementary oxidation and reduction process keep the cation concentration constant.

Q18. C Calibration Factor $= \text{Energy added during heating} / \Delta T_c$
$= VIt / \Delta T_c$
$= 6.00 \times 1.40 \times 54.5 / 0.390$
$= 457.8 / 0.390$
$= 1174 \text{ J °C}^{-1}$

Energy released by CH_4 $= CF \times \Delta T_r$
$= 1174 \times (22.17 - 21.45)$
$= 1174 \text{ J °C}^{-1} \times 0.72 \text{ °C}$
$= 845 \text{ J}$

Energy per mol CH_4 $= 845 \text{ J} / 9.50 \times 10^{-4} \text{ mol}$
$= 8.90 \times 10^{5} \text{ J}$
$= 8.90 \times 10^{2} \text{ kJ}$
= 890 kJ

Q19. D The half-equations relevant to the electrolysis of concentrated NaCl(aq) are

$Cl_2 + 2e^-$	→	$2\mathbf{Cl^-}$	1.36 V
$O_2 + 4H^+ + 4e^-$	→	$2\mathbf{H_2O}$	1.23 V
$2\mathbf{H_2O} + 2e^-$	→	$H_2 + 2OH^-$	-0.83V
$\mathbf{Na^+} + e^-$	→	Na	-2.76 V

The stronger oxidant, **H_2O(l) is reduced at the cathode**, which is the (-) electrode in the electrolysis cell. The pH around the cathode increases due the increasing $[OH^-]$
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
At the **anode**, which is the (+) electrode, whilst H_2O is the stronger reductant, in high concentrations of NaCl(aq), 5 to 10 M, **Cl^-(aq) is preferentially oxidised** to **Cl_2**
$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$.
Cl^-(aq) ions move towards the anode – anions move towards the anode.
The **semipermeable membrane allows Na^+(aq) ions to migrate to the cathode**, where they combine with OH^-(aq) to produce NaOH (aq). So that the NaOH produced is not contaminated with NaCl, the **membrane does <u>not</u> allow the passage of Cl^-(aq) ions**.

Q20. C To calculate the percentage abundance of ^{63}Cu you also need the relative atomic mass of Cu which, according to the supplied data table, is 63.6

$$\text{Since } A_r(\text{Cu}) = \frac{\Sigma(\text{isotopic mass x \% abundance})}{100}$$

If the % abundance ^{63}Cu is ***y***, then the % abundance of ^{65}Cu is ***100 - y***

$$\text{So} \quad 63.6 = \frac{62.93 \times y + 64.93 \times (100 - y)}{100}$$

$$6360 = 62.93y + 6493 - 64.93y$$

$$6360 - 6493 = 62.93y - 64.93y$$

$$-133 = -2y$$

$$y = 133 / 2$$

$$= \mathbf{66.5\ \%}$$

Section B

Question 1

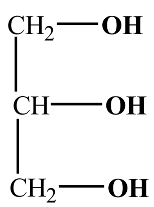
(a) (i) A **monounsaturated** fatty acid has only **one carbon-carbon double bond**, C=C, in each molecule
A **polyunsaturated** fatty acid has **two or more carbon-carbon double bonds**, C=C, in each molecule. ❶

(ii) linolenic acid; $CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$ – $C_{18}H_{30}O_2$
linoleic acid; $CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$ – $C_{18}H_{32}O_2$
Since each oleic acid molecule has one less C=C double bond, and hence 2 more H atoms, than a linoleic acid molecule, its molecular formula is $\mathbf{C_{18}H_{34}O_2}$ ❶

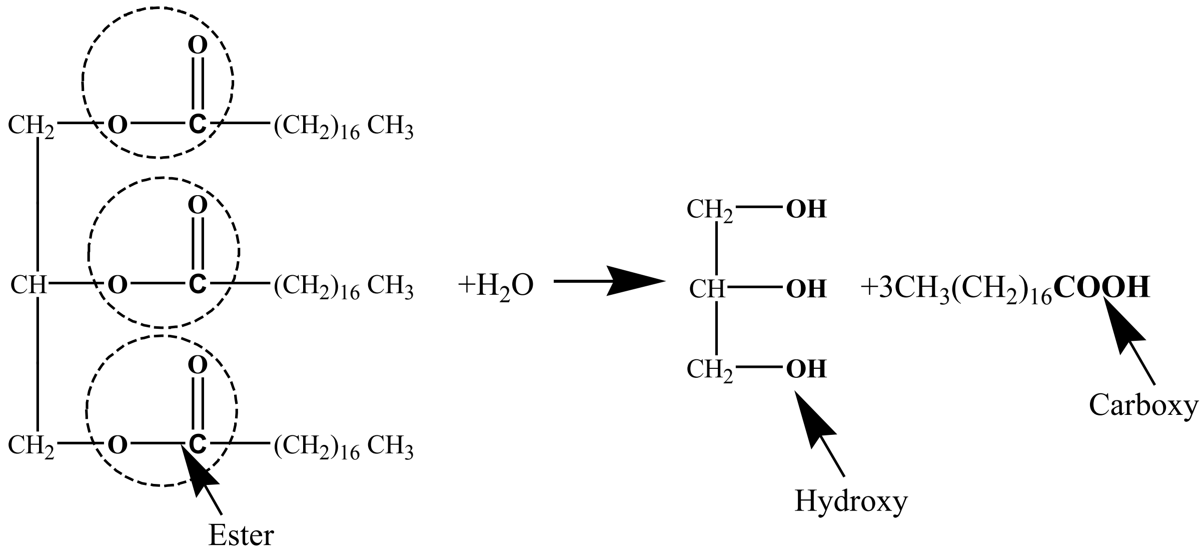
(iii) Oleic acid molecules have 18 C atoms and one C=C double bond, which begins on the ninth carbon atom in the hydrocarbon chain. The structural formula is
$\mathbf{CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH{=}CHCH_2CH_2CH_2CH_2CH_2CH_2CH_2COOH}$ *or*
$\mathbf{CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH}$ ❶ ❶

(b) Since stearic acid is saturated its molecules do not contain any C=C double bonds.
The structural formula is
$\mathbf{CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2COOH}$ ❶

(c) (i) **Glycerol, $\mathbf{C_3H_8O_3}$** ❶
Glycerol is more commonly recognised by the structural formula



(ii) During digestion of fats **water acts across the ester functional groups** ❶ which are **converted into carboxy and hydroxy functional groups**. ❶



(d) Energy released by 5 mL olive oil $= CF \times \Delta T$
$= 5.95\text{x}10^3 \times (53.2\text{-}24.6)$ ❶
$= 5.95\text{x}10^3 \times 28.6$
$= 1.70\text{x}10^5$ J ❶
Energy released by 100 mL olive oil $= (1.70\text{x}10^5 / 5) \times 100$
$= 3.40 \times 10^6$ J
= **$3.40\text{x}10^3$ kJ** ❶

(e) Vitamin E protects the **C=C double bonds** ❶ in the unsaturated fats / oils from reaction with atmospheric oxygen. As an antioxidant it **reacts preferentially with atmospheric oxygen.** ❶
Antioxidants are good reductants

Question 2.

(a) According to $2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$; $\Delta H = -1506$ kJ mol^{-1}
Combustion of 2 mol CH_3OH releases 1506 kJ of energy
$\therefore$ 1 mol $CH_3OH \rightarrow 1506 / 2 = 753$ kJ ❶
Since $M(CH_3OH) = 32.0$ g mol^{-1}
32 g $CH_3OH \rightarrow 753$ kJ
1 g $CH_3OH \rightarrow 753 / 32 = 23.5$ kJ ❶
Heat of combustion of methanol is **23.5 kJ g^{-1}**

(b) (i) Energy added to water $= 4.184$ J mL^{-1} °C^{-1} $\times V(H_2O) \times \Delta T$
$= 4.184 \times 200 \times (87.9\text{-}23.5)$ ❶
$= 4.184 \times 200 \times 64.4$
$= 5.39 \times 10^4$ J
= **53.9 kJ** ❶

(ii) $m(CH_3OH)$ used $= 125.62 - 117.23$
$= 8.39$ g ❶
Energy released by CH_3OH $= m(CH_3OH) \times$ Energy released per gram CH_3OH
$= 8.39$ g $\times 23.5$ kJ g^{-1}
= **197 kJ** ❶

(iii) % energy transferred to water = (energy added to water / energy released by CH_3OH) $\times$ 100
$= (53.9 / 197) \times 100$
= **27.4 %** ❶

(iv) Most of energy released form the combustion of CH_3OH escapes to the surrounding atmosphere. The amount transferred to the water could be increased by **providing a shield around the burner** and/or **placing a lid or cover on the can**. ❶

(c) (i) In a fuel cell **chemical energy** is converted directly **to electrical energy**.❶

(ii) The fuel is oxidised at the negative electrode and oxygen is reduced at the positive electrode. Since the electrolyte is acid, the reduction half-equation is obtained from the electrochemical series by looking for O_2 – the oxidant – in a half-equation with $H^+(aq)$

$\mathbf{O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)}$ ❶

(iii) CH_3OH oxidised to CO_2

$CH_3OH(l) \rightarrow CO_2(g)$

$\mathbf{CH_3OH(l) + H_2O(l) \rightarrow CO_2(g) + 6H^+(aq) + 6e^-}$ ❶

(iv) Electrodes in a fuel cell must:

- conduct electricity
- not react with the fuel, oxygen or electrolyte
- be porous to allow contact between the oxidant / fuel and the electrolyte

❶ *for two*; ❶ ❶ *for three.*

Electrodes may also be impregnated with catalyst.

Question 3.

(a) (i) $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{x}_{36}Kr + 3^{1}_{0}n$

This is a '**nuclear fission**' reaction. ❶

A large nucleus is split into two smaller nuclei by the impact of a neutron.

Nuclear equations are balanced according to atomic numbers and mass numbers.

Left hand side: mass number = 235 + 1 = 236

Right hand side: mass number = 141 + '$\boldsymbol{x}$' + 3 × 1

'$\boldsymbol{x}$' + 144 = 236 → '$\boldsymbol{x}$' = 236 – 144

= **92** ❶

(ii) In nuclear reactions, **'different' atoms / elements are produced**, whereas in chemical reactions atoms are rearranged but no 'different' atoms / elements are produced. *or*

In nuclear reactions a **small amount of mass is converted into energy according to $\boldsymbol{E = mc^2}$**, whereas in chemical reactions mass is conserved. ❶

(iii) The main environmental issues associated with nuclear fission are:

- exposure to harmful **radiation**, especially gamma-rays
- storage and disposal of **radioactive waste**. ❶

(b) (i) $4^{1}_{1}H^+ \rightarrow ^{4}_{2}He^{2+} + 2^{0}_{1}e^+$ or $4^{1}_{1}H \rightarrow ^{4}_{2}He + 2^{0}_{1}e$ ❶

(ii) This is a **nuclear fusion** reaction. ❶ Small nuclei combine to form larger nuclei.

(iii) During the conversion of hydrogen nuclei to helium nuclei by nuclear fusion there is a **decrease in mass consistent with mass to energy conversion in line with Einstein's $\boldsymbol{E = mc^2}$.** ❶

Consequently the total mass of the Sun is decreasing, as is the total number of nuclei present.

(c) **Light energy** from the Sun is **transformed into electrical energy** in photovoltaic cells. This electrical energy is used to '*re*charge' the batteries and **is transformed into chemical energy.** ❶

(d) $\mathbf{6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6H_2O(l)}$ ❶

Question 4.

(a) In the **electrochemical series** fluorine, F_2, is clearly the **strongest oxidant**. This means it readily causes reductants to give up electrons. ❶
In the **periodic table** fluorine is the **most electronegative element.** This means it has the strongest attraction for electrons. ❶
So strong is fluorine's attraction for electrons that it is better than any other element at causing other species to be oxidised.

(b) During electrolysis electrons are dragged off the (+) electrode and forced onto the (-) electrode. Therefore, **oxidation occurs at the (+) electrode** and **reduction occurs at the (-) electrode**.
(+) electrode $\mathbf{2F^-(l) \rightarrow F_2(g) + 2e^-}$ ❶
(-) electrode $\mathbf{K^+(l) + e \rightarrow K(l)}$ ❶

(c) The oxidants and reductants present in dilute KF(aq) are included in the half-equations

$F_2(g) + 2e^-$	$\rightarrow \mathbf{2F^-(aq)}$	+2.87 V
$O_2(g) + 4H^+(aq) + 4e^-$	$\rightarrow \mathbf{2H_2O(l)}$	+1.77 V
$\mathbf{2H_2O(l)} + 2e^-$	$\rightarrow H_2(g) + 2OH^-(aq)$	-0.83 V
$\mathbf{K^+(aq)} + e^-$	$\rightarrow K(s)$	-2.93 V

The general principle of reactions in electrochemical cells is that reaction occurs between the strongest oxidant and strongest reductant.
In KF(aq) there are two oxidants - $K^+(aq)$ and $H_2O(l)$, and two reductants - $F^-(aq)$ and $H_2O(l)$
H_2O is the stronger reductant – stronger than $F^-(aq)$. Hence H_2O will be oxidised at the anode, rather than $F^-(aq)$. Consequently O_2 will be produced rather than F_2. ❶
Anode half-equation: $\mathbf{2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-}$ ❶
H_2O is the stronger oxidant, hence the cathode half-equation will be
$\mathbf{2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)}$ ❶

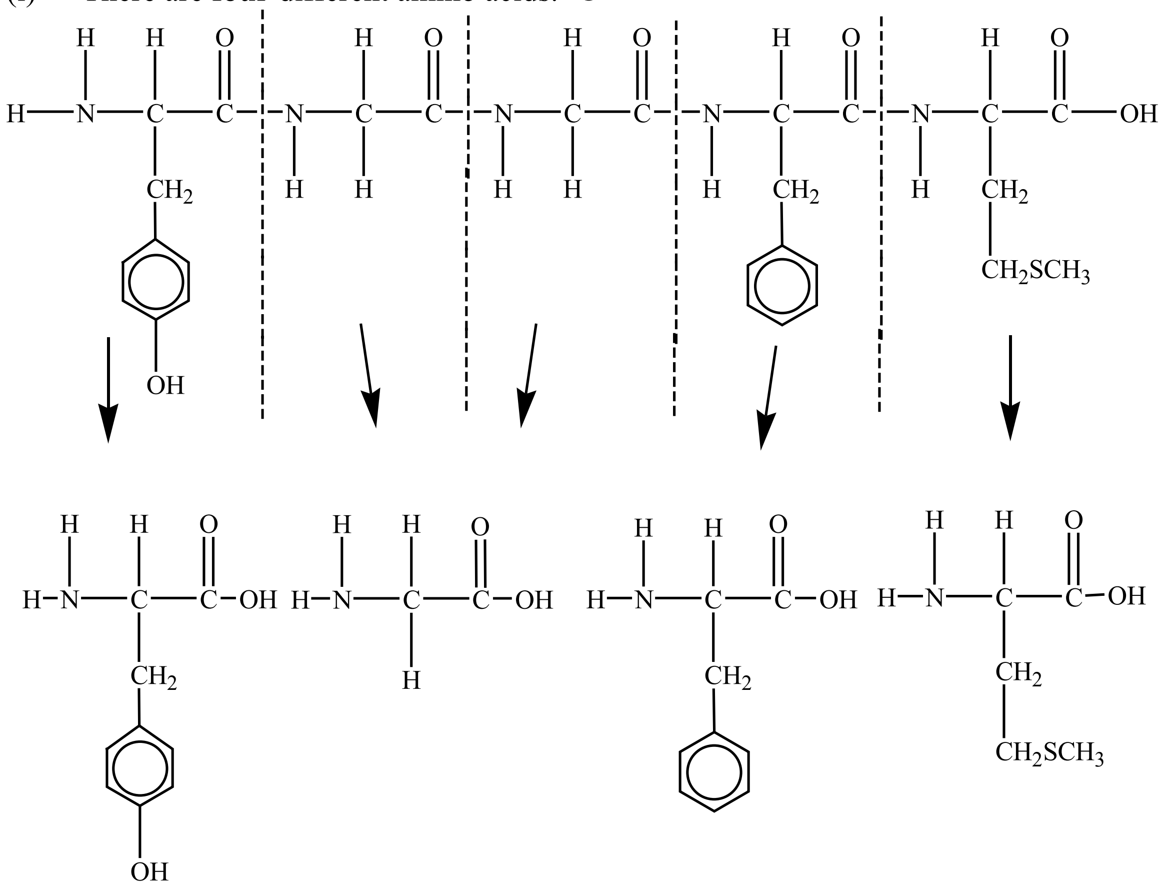
(d) (i) '*aluminium compound*' is **alumina** or **aluminium oxide**
'*lower melting temperature compound*' is **cryolite** ❶

(ii) In electrolysis, oxidation occurs at the positive electrode. The oxidation half-equation is
$\mathbf{2O^{2-}(l) \rightarrow O_2(g) + 4e^-}$ ❶
However at the high operating temperature of the Hall Cell, the **carbon anodes react with the oxygen** according to $\mathbf{C(s) + O_2(g) \rightarrow CO_2(g).}$ ❶ The **carbon anodes are gradually consumed** and are replaced every few weeks.
The changes occurring at the anode may be described by the overall half-equation
$\mathbf{C(s) + 2O^{2-}(l) \rightarrow CO_2(g) + 4e^-}$

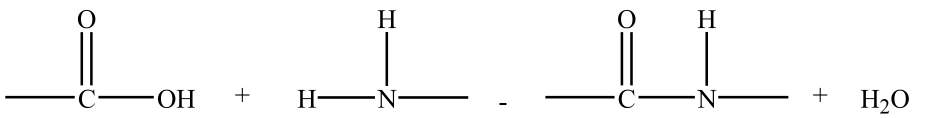
(iii) In an aqueous solution of Al^{3+} there are two oxidants – $H_2O(l)$ and $Al^{3+}(aq)$.
According to the electrochemical series, **$H_2O(l)$ is a stronger oxidant that $Al^{3+}(aq)$, so $H_2O(l)$ will be preferentially reduced**. ❶
The half-equation for the reaction occurring at the cathode will be:
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

Question 5.

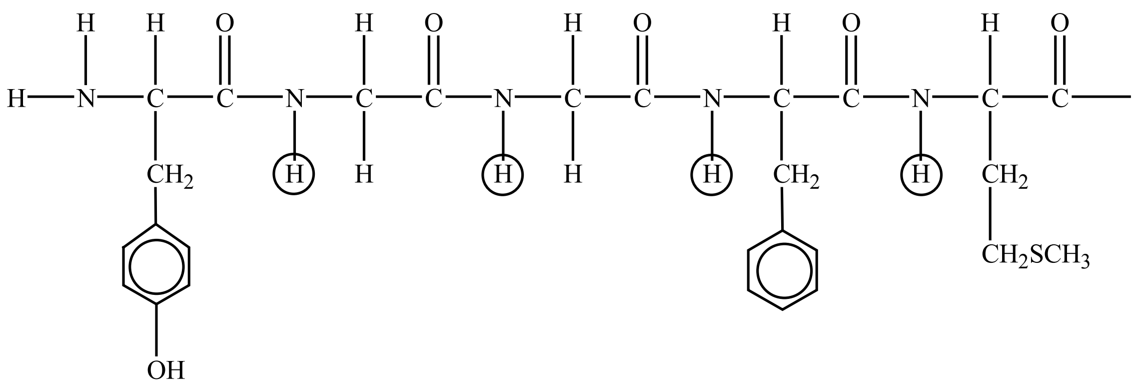
(a) (i) There are **four** different amino acids. ❶



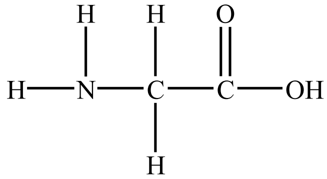
(ii) The **peptide group CONH** is produced when the **carboxy group, -COOH, reacts with the amino group, $-NH_2$**, in a condensation reaction. ❶



(iii) The **H atom in a peptide group** ❶



(iv)



or NH_2CH_2COOH ❶

(b) (i) Because amino acids have both acidic and basic functional groups their molecular structures are different at pH < 7 and pH > 7.
At **pH 2,** an amino acid molecule will act as a base and **accept a proton**, according to
$NH_2CH\mathbf{Z}COOH(aq) + H_3O^+(aq) \rightarrow {}^+NH_3CH\mathbf{Z}COOH(aq) + H_2O(l)$ ❶
At **pH 12**, an amino acid molecule will act as an acid and **donate a proton**, according to
$NH_2CH\mathbf{Z}COOH(aq) + OH^-(aq) \rightarrow NH_3CH\mathbf{Z}COO^-(aq) + H_2O(l)$ ❶
Hence the **positively charged molecules migrate to the negative electrode at pH 2**, whilst **at pH 12 the negatively charge molecules migrate to the positive electrode**. ❶

(ii) If the amino acid molecules do not move to either electrode, then the pH of the gel is such that the amino acid is present as its zwitterion, ${}^+NH_3CH\mathbf{Z}COO^-$. ❶

(c) The **digestion of starch begins in the mouth due to the presence of the enzyme amylase** in saliva. The starch is hydrolysed to the sweet tasting disaccharide, maltose. **Enzymes are proteins**. ❶
There is **no sweet taste** resulting **from cellulose** because **humans do not produce the enzyme necessary for its digestion.** ❶