VCE CHEMISTRY
CAT 3 1994

"ANALYSIS AND EVALUATION"

DETAILED SUGGESTED SOLUTIONS

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For the convenience of teachers, the questions have been included.

Chemistry CAT 3

Data Sheet

Physical constants

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

The electrochemical series

	E° in volt
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightarrow Au(s)$	+1.68
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(1)$	+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
$S(s) + 2H^+(aq) + 2e^- \rightarrow H_2S(g)$	+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

Periodic table of the elements

1 H 1.0																	2 He 4.0
3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.1
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 44.9	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27 Co 58.9	28 Ni 58.7	29 Cu 63.6	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc 98.1	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 197.0	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)															

Lanthanides

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.3	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0

Actinides

90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.1	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (255)	103 Lr (256)

Instructions for students

There are 7 questions. Answer all questions.
To obtain full credit for your responses, you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full credit.
- show all working in your answers to numerical questions. No credit can be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include indications of state, for example H2(g); NaCl(s).

Some of the questions in this examination require comparison between elements in the periodic table and a knowledge of atomic numbers or relative atomic masses. A periodic table showing atomic numbers and relative atomic masses is given on the data sheet.

Question 1

a. **i.** State the similarity in electronic configuration of the following elements:
O, S, Se (1 mark)

These three elements belong to group VI in the periodic table. Each has atoms with six electrons in the outershell. That is, the outershell electronic configuration is ns^2np^4 where n = 2, 3 or 4.

ii. State the similarity in electronic configuration of the following elements:
Fe, Co, Ni (1 mark)

These three elements are successive members of the first transition series of elements with atomic numbers 26, 27 and 28 respectively. In each case, there is a partially filled 3d subshell.
The outershell electronic configurations are respectively, $3d^6\ 4s^2$; $3d^7\ 4s^2$; $3d^8\ 4s^2$;

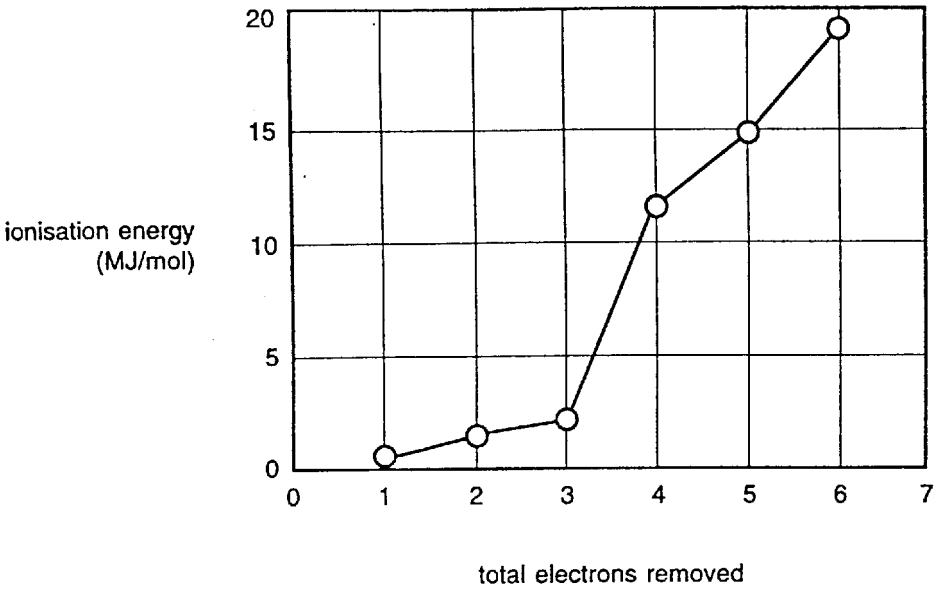
b. What is the expected trend in the atomic radii of the elements Mg, Ca and Sr?
Briefly explain this trend. (2 marks)

Mg, Ca and Sr are successive members of group II in the periodic table. The outershell electronic configuration is ns^2 where n = 3, 4 or 5. As we move down the group an extra shell of electrons is added to the atom. Hence, the expected trend in atomic radii (treating the atoms as spheres) is an **increase**.

c. The symbol for the most common atom of carbon may be written in the form $^{12}C_6$.
Use this notation to give the chemical symbol for the atom or ion which contains 12 protons, 12 neutrons and 10 electrons. (1 mark)

This is an ion because it has different numbers of protons and electrons. This ion has an atomic number of 12 (it is the element magnesium), a mass number of 24 (total number of protons and neutrons) and a charge of +2. The symbol is $^{24}Mg_{12}{}^{2+}$.

d. Ionisation energy is the energy necessary to remove an electron from an atom or ion. The diagram below shows the ionisation energies as the first six electrons are successively removed from an aluminium atom.



i. Using subshell notation, write the electronic configuration of an atom of aluminium. (1 mark)

Aluminium atom (atomic number = 13) : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

ii. Relate the trend in the ionisation energies for the first six electrons of aluminium to its electronic configuration. (3 marks)

The first three ionisation energies involve the removal of the three electrons in the third energy level. It is progressively more difficult to remove each of these electrons because the core charge of the ion is increasing as shown by the equations:

$Al(g) \rightarrow Al^{+}(g)$ ionisation energy ≈ 1 MJ/mol

$Al^{+}(g) \rightarrow Al^{2+}(g)$ ionisation energy ≈ 2 MJ/mol

$Al^{2+}(g) \rightarrow Al^{3+}(g)$ ionisation energy ≈ 3 MJ/mol

It takes approximately four times as much energy (12 MJ/mol) to remove the fourth electron because this involves the removal of an electron from a full second energy level ($2s^2\ 2p^6$) which is a particularly stable arrangement of electrons. It is them progressively more difficult to remove the fifth and sixth electrons as the core charge continues to increase as shown by the equations:

$Al^{3+}(g) \rightarrow Al^{4+}(g)$ ionisation energy ≈ 12 MJ/mol

$Al^{4+}(g) \rightarrow Al^{5+}(g)$ ionisation energy ≈ 15 MJ/mol

$Al^{5+}(g) \rightarrow Al^{6+}(g)$ ionisation energy ≈ 18 MJ/mol

It should be noted that these experimental results provide evidence for the electronic energy levels in atoms.

Question 2
This question refers to the transition elements of the periodic table.

a. **i.** Explain why a transition series is made up of 10 elements. (1 mark)

A transition series corresponds to the filling of a 'd' subshell. A 'd' subshell can contain a maximum of 10 electrons. Hence, there are 10 elements in each transition series as the atomic number increases and the electronic configuration changes from d^1 to d^{10}.

ii. Give the symbol of one element from **each** of the transition element series. (1 mark)

There are many possible answers. For example, Cu(29), Ag(47), Au(79)

b. **i.** In different compounds, the one transition element may occur in different oxidation states. Give the formulas of two different compounds of the **same** transition metal which show this property. (2 marks)

There are many possible answers.
For example, MnO_2 (Mn oxidation state = +4) , $KMnO_4$ (Mn oxidation state = +7)

Question 2 (continued)

b. **ii.** Describe, with an example, one other property which separates the transition metals or their ions from the metallic elements in groups I and II of the periodic table.

(2 marks)

There are many possible answers. For example, the transition metal ions give coloured aqueous solutions ($Cr_2O_7^{2-}$(aq) is orange) while the group I and II metal ions form colourless solutions.

Question 3

a. A healthy adult person has approximately 15 kg of fatty tissue. When extra energy is required, some of the fat is converted to fatty acids which are then oxidised as in the following equation.

$$CH_3(CH_2)_{14}COOH(aq) + 23O_2(g) \rightarrow 16CO_2(g) + 16H_2O(l) \quad \Delta H = -10\,035 \text{ kJ mol}^{-1}$$

i. What kind of reaction is involved in the conversion of the fat to fatty acids? (1 mark)

The fatty tissue is adipose tissue and the fat is present as triglycerides. These triglycerides are hydrolysed (reaction with water catalysed by enzymes) to produce fatty acids.
A general equation for this reaction is (where R = C_nH_{2n+1}

$$\underset{\text{a triglyceride}}{CH_2COOR.CHCOOR.CH_2COOR} + 3H_2O \rightarrow \underset{\text{a fatty acid}}{3RCOOH} + \underset{\text{glycerol}}{C_3H_5(OH)_3}$$

ii. What is the total amount of energy released by the oxidation of 150 g of fatty acid?

(3 marks)

Relative molecular mass of the fatty acid = (16x12) + (32x1) + (2x16) = 256.
From the equation, 1 mole of fatty acid produces 10 035 kJ.
Hence, 150 g produces $10\,035 \times \frac{150}{256} = 5880$ kJ **ANS**

b. The oxidation of carbohydrates also provides the body with energy. Glucose circulates in the blood, but in what form are carbohydrates **stored** in the human body?

(1 mark)

Glycogen (a polymer of glucose) is stored in the human body as a future source of energy.

Question 3 (continued)

c. The label on a packet of "KORN CHIPS' gives the following information about 100g of the product.

Available energy in 100 g KORN CHIPS	2060 kJ
Composition of 100 g KORN CHIPS	
Protein	7.3 g
Fat	25.4 g
Carbohydrate	62.1 g
Sodium	600 mg
Potassium	190 mg
Water	4.4 g

i. Using the following heats of combustion, calculate the total energy that would be released from the combustion of the contents of a 100 g packet of KORN CHIPS.

Protein 24 kJ g^{-1}

Fat 39 kJ g^{-1}

Carbohydrates 17 kJ g^{-1}

(3 marks)

Total energy released = (24 x 7.3) + (39 x 25.4) + (17 x 62.1)
= 175.2 + 990.6 + 1055.7
= 2221.5 kJ **ANS**

ii. Give **two** reasons for the difference between the result in part **c.i.** and the energy available from 100 g of KORN CHIPS (2060 kJ) as printed on the label.

(2 marks)

The calculation in **c.i.** assumes that

(1) each and every gram of the protein, fat and carbohydrates is oxidised to produce energy.

and

(2) each and every gram of the protein, fat and carbohydrates is **completely** oxidised. That is, no partial oxidation occurs.

The experimentally determined value of 2060 kJ indicates that either or both of these assumptions may not be valid since the calculated value is approximately 8% greater than this.

iii. Processed food, such as KORN CHIPS, often contain food additives. Give **two** reasons why additives might be used in food.

(2 marks)

Additives are used in food to improve the colour, to improve the flavour, to prevent food spoilage by bacteria growth, to prevent oxidation, to improve the consistency and to improve the nutritional value.

d. Digestion of the fat in food occurs in the small intestine and is helped by the action of bile. How does bile help in the digestion of fat?

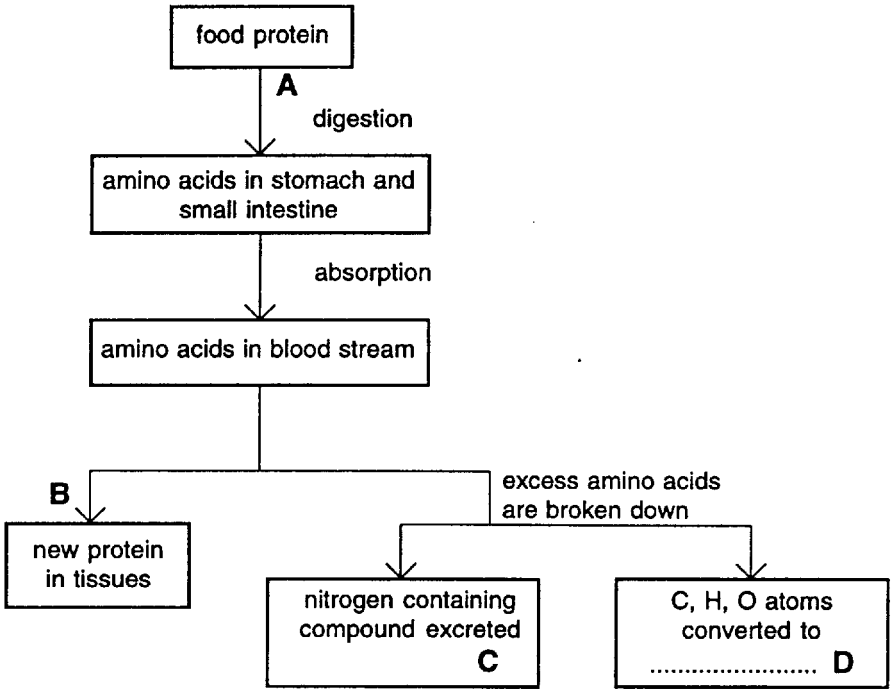
(2 marks)

Bile contains surface active molecules which convert fat into an emulsion. The surface area of the fat is thereby increased which allows it to be digested more rapidly.

Question 4

Proteins are one of the three major food groups

a. The following flow chart shows the digestion of proteins and the absorption and use of the products of protein digestion.



Use the flow chart to answer the following questions.

i. Give an example of a food which is high in protein.

(1 mark)

Meat is a food which is high in protein.

ii. Digestion of food occurs at **A**. What type of chemical reaction takes place when food is digested?

(1 mark)

When proteins break down into amino acids, the chemical reaction is the enzyme catalysed reaction with water called **hydrolysis**. A simple general equation for this (where R and R' can be a wide variety of groups of atoms) is

$$NH_2\text{-R-CO-NH-R'-COOH} + H_2O = NH_2\text{-R-COOH} + NH_2\text{-R'-COOH}$$

iii. What type of chemical reaction takes place at **B**?

(1 mark)

When amino acids combine to form proteins, the chemical reaction is the enzyme catalysed elimination of water called **condensation**. A simple general equation for this (where R and R' can be a wide variety of groups of atoms) is

$$NH_2\text{-R-COOH} + NH_2\text{-R'-COOH} = NH_2\text{-R-CO-NH-R'-COOH} + H_2O$$

Question 4 (continued)

iv. What is the name of the nitrogen containing compound formed at **C**?

(1 mark)

The nitrogen containing compound that is produced initially is ammonia, NH_3, but this is converted into urea, $CO(NH_2)_2$ which is excreted.

v. What compound is formed at D ?

(1 mark)

Amino acids are converted into either glucose ($C_6H_{12}O_6$) which is used to produce energy, or fat.

b. Some of the amino acids, from the digestion of protein in food, are classified as **essential** while others are **non essential**. Explain the difference between **essential** and **non essential** amino acids.

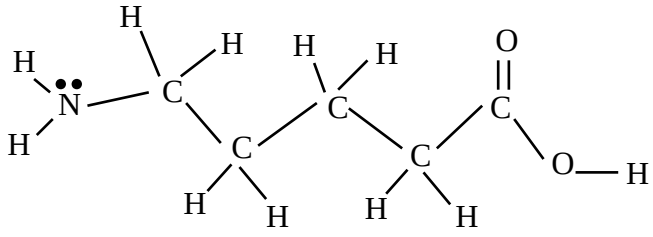
(1 mark)

The nine essential amino acids are amino acids that must be supplied in the diet since the human body is not capable of manufacturing them. The eleven non-essential amino acids are amino acids that can be manufactured by the human body.

c. Valine is one of the amino acids in food protein. It has a molecular formula of $C_5H_{11}0_2N$. Deduce and draw a possible structural formula for valine.

(3 marks)

The extended molecular formula for valine is $NH_2(CH_2)_4COOH$. The structural formula is



d. Enzymes belong to an important group of proteins. Fresh pineapple contains an enzyme which stops jelly from setting. However, if the pineapple is boiled first, it can be added to jelly and the jelly will set. Suggest a reason why boiling the pineapple changes the way it acts.

(1 mark)

When the pineapple is boiled (100^oC), the bonds holding the enzyme (protein) in its three-dimensional structure are broken and the protein chain unravels. The biological activity of the enzyme is destroyed. This is called denaturation. Hence, the jelly is able to set.

Question 5
An article is plated with the metal chromium by electrolysis of an aqueous solution of a salt of chromium. The half equation for the reaction is

$$Cr^{n+}(aq) + ne^- \rightarrow Cr\ (s)$$

a. In the electroplating process, is the item to be plated attached to the positive or the negative electrode? Give a reason for your answer.

(1 mark)

The item to be plated is attached to the negative electrode. The negative electrode is the source of electrons to be accepted by the chromium ions which are then reduced to the metal chromium.

b. The following data are relevant to this process

mass of article before plating	=	32.26 grams
mass of article after plating	=	36.60 grams
current used	=	2.24 amperes
time taken	=	3.00 hours

i. Calculate the amount, in mole, of electrons that pass through the cell in this period of time.

(3 marks)

The quantity of electricity used = current x time
= 2.24 x 3.00 x 60 x 60
= 24192 coulombs.

Hence, the number of mole of electrons $= \dfrac{\text{number of coulombs}}{\text{number of coulombs in 1 mole of electrons}}$

$= \dfrac{24192\ \text{C}}{96500\ \text{C mol}^{-1}}$

= 0.25 mol **ANS**

ii. Using the mass of the article before and after plating, calculate the amount, in mole, of chromium deposited.

(2 marks)

The number of mole of chromium deposited

$= \dfrac{\text{mass deposited}}{\text{relative atomic mass}}$

$= \dfrac{36.60 - 32.26}{52.0}$

$= \dfrac{4.34}{52.0}$

= 0.08(3) mol **ANS**

Question 5 (continued)

iii. From your calculations in **i.** and **ii.** calculate the charge on the chromium ion used in this electroplating process.
(You **must** show your working in order to gain credit for this part.)

(2 marks)

Charge on the chromium ion $= \dfrac{\text{number of mole of electrons}}{\text{number of mole of chromium}}$
$= \dfrac{0.25}{0.083}$
$= 2.995$
$= 3+$ **ANS**

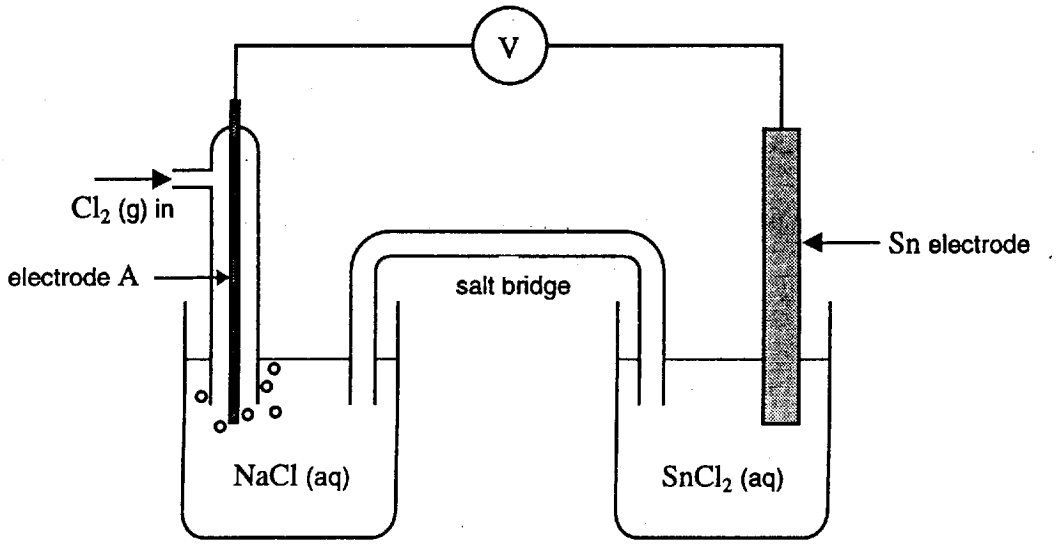
c. Explain why it would not be possible to electroplate the article with aluminium from an aqueous solution of a salt of aluminium.

(2 marks)

From the Data Sheet, the E^o value for the reduction of the aluminium ion to aluminium metal in aqueous solution is -1.67 V. The E^o value for the reduction of water to hydrogen gas is -0.83. Hence, hydrogen gas would be produced at the negative electrode in the electrolysis of an aqueous aluminium salt.

Question 6

a. The following diagram represents a galvanic cell.



i. Name a suitable material for electrode **A**.

(1 mark)

Electrode A is an inert electrode. It acts as a surface for the reaction. A suitable material would be platinum (Pt).

Question 6 (continued)

ii. State whether electrode **A** is positive or negative when the cell is working.

(1 mark)

The relevant half-equations in this galvanic cell are
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$ ($E^o = +1.36$ V) and $Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$ ($E^o = -0.14$ V). Hence, chlorine gas is the oxidant and is reduced to chloride ions.
Hence, electrons are consumed at electrode A. Hence, electrode A is positive.

iii. Give the formula of an ionic compound that can be used in the salt bridge.

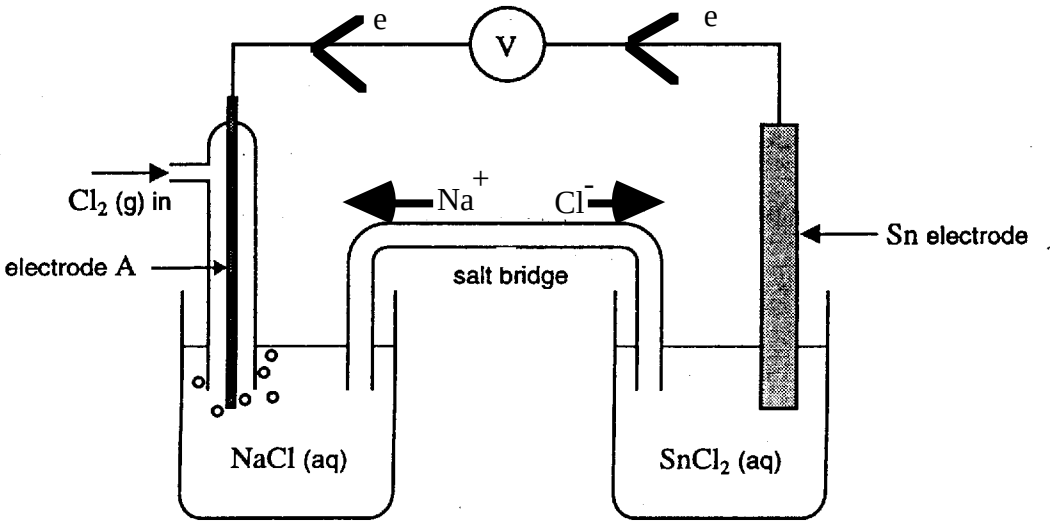
(1 mark)

Any ionic compound that does not react with any of the chemicals in either of the half-cells could be used. For example, NaCl.

iv. **On the diagram itself,** show

- the direction of flow of electrons in the external circuit.
- the direction in which the anions and cations of your selected compound move in the salt bridge.

(2 marks)



Na^+ is a cation

Cl^- is an anion

Question 6 (continued)

v. for this galvanic cell, write equations for the

oxidation half reaction (1 mark)

$$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$$

reduction half reaction (1 mark)

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

overall cell redox reaction (1 mark)

$$Cl_2(g) + Sn(s) \rightarrow 2Cl^-(aq) + Sn^{2+}(aq)$$

vi. The galvanic cell above is a **primary cell**. How does a primary cell differ from a secondary cell?

(2 marks)

A primary cell cannot be recharged because the products at the electrodes gradually move away from the electrodes and are used up in other chemical reactions. A secondary cell such as the lead-acid accumulator (car battery) can be recharged.

b. Bubbling hydrogen gas through a solution containing metal ions may cause a reduction reaction of the type

$$M^{x+}(aq) + xe^- \rightarrow M(s)$$

i. Use the electrochemical series to choose **two** metal ions which would be expected to react in this way. Write balanced equations for these reductions.

(2 marks)

The ions chosen must have E^o values greater than 0.00.
For example, $Au^+(aq)$ $E^o = +1.68$ V; $Ag^+(aq)$ $E^o = +0.80$ V; $Cu^{2+}(aq)$ $E^o = +0.34$ V.
The balanced equations for these reductions are:

$$2Au^+(aq) + H_2(g) \rightarrow 2Au(s) + 2H^+(aq)$$

$$2Ag^+(aq) + H_2(g) \rightarrow 2Ag(s) + 2H^+(aq)$$

$$Cu^{2+}(aq) + H_2(g) \rightarrow Cu(s) + 2H^+(aq)$$

Question 6 (continued)

ii. It sometimes happens that the reaction expected on the basis of the electrochemical series is not, in fact, observed. Give **two** reasons for this.

(2 marks)

The E^o values give no information about the rate of reaction. It may be that a reaction is occurring so slowly that it is not observed. The E^o values in the electrochemical series are based on solutions with a concentration of 1mol L^{-1}. When the concentrations change, the potentials change. The E^o values are also defined for a temperature of 298K and a pressure of 1 atm. When the temperature and pressure change, the potentials change. Also, the build up of deposits on an electrode (gaseous or solid) can change the potential of a half-cell.

Question 7
A number of scientists have helped our understanding of atomic theory and the periodic table. Some examples are described below. Use the information given to answer the questions in each section.

1 Democritus (460-357 BC)

Democritus first suggested that matter was not continuous but made up of pieces which he called atoms. His model of matter stated:

- all matter is made up of tiny particles called atoms.
- atoms are solid.
- atoms are indivisible.
- atoms of different substances differ in size.

a. **i.** List the parts of Democritus' theory of matter which are thought to be correct today.

(2 marks)

- all matter is made up of tiny particles called atoms.
- atoms of different substances differ in size.

ii. Explain why the other parts of Democritus' theory are no longer thought to be correct.

(2 marks)

• atoms are solid.	Experiments show that the atom is mainly empty space through which tiny electrons move
• atoms are indivisible.	Experiments show that the atom is composed of protons, neutrons and electrons.

Question 7 (continued)

2 Lothar Meyer (1830-1895)

The periodic table provides a useful framework for the study of chemistry. One of the early tables was by Lothar Meyer who wrote that:

- if elements are arranged in order of increasing atomic mass, their properties vary periodically.

b. i. How does the way in which the elements were ordered by Meyer differ from that used today?

(1 mark)

The Periodic Law to-day is "If elements are arranged in order of increasing atomic **number**, their properties vary periodically".

ii. Suggest one reason why Meyer would have been unable to organise the elements as we do today.

(1 mark)

There are pairs of elements which are out of order in the Periodic Table if they are arranged in order of increasing atomic mass. For example, elements 52 and 53. Meyer had no knowledge of the electronic configurations of the elements since the electron was not discovered until 1897. Meyer had no knowledge of the nuclear structure of the atom since the nucleus was not discovered until 1911.

3 Ernest Rutherford (1871-1937)

As a result of experiments involving the firing of high energy, positively charged particles at a piece of gold foil, Rutherford put forward the theory that:

- all the positive charge and almost all the mass of the atom is concentrated in a very small nucleus.
- most of the volume of the atom is occupied by the electrons of which there are enough to make the atom neutral.

c. Give **two further** pieces of information which we now know about the electrons around the nucleus of the atom.

(2 marks)

(1) an electron in an atom can only have certain discrete energies.

(2) the electrons are arranged in shells or energy levels around the nucleus.

(3) the number of electrons that can occupy a given shell = $2n^2$ where n is the number of the shell.

(4) the shells are further divided into subshells.

Question 7 (continued)

4 Lise Meitner (1878-1968)

In the 1930s, experiments were being performed in which a sample of uranium was bombarded with neutrons. When the uranium target was analysed at the end of the experiment, traces of barium (an element with atomic mass about half that of uranium) were found. Lise Meitner and her colleagues called this type of reaction nuclear fission.

An equation for such a fission reaction is given below.

$$^{1}n_{0} + {}^{235}U_{92} \rightarrow {}^{141}Ba_{56} + \mathbf{X} + 3\ {}^{1}n_{0}$$

d. i. Give the symbol, including the mass number and atomic number, of particle **X**.

(2 marks)

The positive charges and the mass numbers must be balanced on both sides of the equation. Hence, atomic number of **X** = 92 - 56 = 36. Mass number of **X** = 236 - 144 = 92.
Hence, the isotope is $_{36}Kr^{92}$.

ii. Another kind of nuclear reaction is nuclear fusion. How does nuclear fusion differ from nuclear fission?

(1 mark)

In nuclear fusion, two or more nuclei combine to form a larger nucleus.

iii. What is the source of the energy released in nuclear fusion reactions?

(1 mark)

The source of the energy released in nuclear fusion reactions is the mass lost in the reaction. Note that energy is produced by the nuclear fission of heavy elements (eg. U) and the nuclear fusion of light elements (eg. H).

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