VCE CHEMISTRY
CAT 3 1992
VBOS SAMPLE QUESTIONS

"ANALYSIS AND EVALUATION"

DETAILED SUGGESTED SOLUTIONS

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Area of Study: Periodic Table

Question 1

(a) The Periodic Table is outlined below.

1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	104 Rt	105 Hn													

Lanthanides *	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides **	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lw

(1) Four elements from Group VII could be F, Cl, Br and I.
(2) Four elements in Period 3 could be Na, Mg, Al and Si.
(3) Four elements from the first transition series could be Cr, Mn, Fe and Co.

(b) Properties and Position in the Periodic Table

A fundamental explanation of the similar properties of certain elements is found in the electronic structure of these elements. The number of electrons in an atom is equal to the number of protons, and these electrons are arranged in shells (energy levels) around the atom. Each shell is made up of one or more subshells (divisions of the main energy level). The shells are numbered 1, 2, 3, 4 . . . and the subshells are labelled
s, p, d, f . . . The subshells are filled with electrons in a specific order, namely *s* before *p* before *d* before *f,* and each subshell can only hold a certain number of electrons: *s* - 2; *p* - 6; *d* - 10; *f* - 14. Elements have similar chemical properties when they have the same outer shell electronic configuration.

(1) Fluorine, chlorine, bromine and iodine occupy Group VII in the Periodic Table because they each have seven electrons in their outermost shell. The outershell electronic configuration in each case is s^2p^5. Collectively, they are known as the halogens. They are extremely reactive diatomic molecules. They act as oxidants and form stable halide ions or covalent molecules with a single covalent bond.

(2) Sodium, magnesium, aluminium and silicon are the first four elements in Period 3 of the Periodic Table. They have the outershell electronic configurations $3s^1$, $3s^2$, $3s^23p^1$ and $3s^23p^2$ respectively. Sodium, magnesium and aluminium are known as main group metals with properties such as low melting temperatures, one particular oxidation state per metal, form white compounds and strong reducing ability. In contrast to these, silicon has a high melting temperature.Sodium, magnesium and aluminium form mainly ionic compounds unlike silicon which forms mainly covalent compounds. e.g SiO_2.

Question 1(continued)

(3) Chromium, manganese, iron and cobalt are members of the first series of transition metals. Each has an unfilled 3d subshell of electrons. Cr $3d^54s^1$, Mn $3d^54s^2$, Fe $3d^64s^2$ and Co $3d^74s^2$. Chromium, manganese, iron and cobalt are known as transition metals with properties such as higher melting temperatures, more than one oxidation state per metal, form coloured compounds, form complex ions. Fe is easily magnetized.

(c)

(1) R.A.M. of Mg $= (\frac{78.7}{100} \times 23.985) + (\frac{10.13}{100} \times 24.986) + (\frac{11.17}{100} \times 25.983)$

$= 18.88 + 2.531 + 2.902$

$= 24.31$ **ANS**

(2)

^{24}Mg	12 protons, 12 neutrons, 12 electrons
$^{25}Mg^{2+}$	12 protons, 13 neutrons, 10 electrons
^{26}Mg	12 protons, 14 neutrons, 12 electrons

(d) The elements in the modern Periodic Table are arranged in order of increasing atomic number; that is, in order of the number of protons in the nucleus. When this is done, it is found that elements which exhibit similar chemical properties are in the same group of the Table. It should be noted that historically, elements were placed in groups showing similar chemical properties before anything was known about the internal structure of the atom.

Area of Study: Periodic Table

Question 2

(a) The modern view of the Periodic Table is that the chemical properties of the elements are a periodic function of the outer shell electronic configuration of the atoms of the elements. There are no gaps in the Periodic Table because there must be an integer number of protons. However, it is possible that there are other elements either stable or unstable beyond those presently known.It is important to remember that just as modifications were needed to Mendeleev's Periodic Table in order to bring it into line with experimental evidence, so too the modern Periodic Table will have to change as new experimental data comes to light.

(b) It is likely that any more elements produced in the immediate future will form part of the transition series that starts with Period 7.

(c) These new elements may be produced by bombarding the nuclei of heavy elements with particles such as protons, neutrons and alpha particles with the hope that extra protons can be put into the nucleus. Many of these new elements will be extremely unstable with very short half-lives.

Area of Study: Energy

Question 3
(a) From TOP LEFT in the diagram in a clockwise direction, the labelling is
INERT ELECTRODE e.g. platinum; ZINC ELECTRODE; $Zn^{2+}(aq)$;
POROUS PARTITION; $Br^-(aq)$ and $Br_2(aq)$. The zinc electrode is negative and the inert electrode (platinum) is positive.

(b) **(NB The data should read $Br_2(aq)$ <u>not</u> $Br_2(l)$)**
Since $Br_2(aq)$ (E^o = +1.09) is a stronger oxidant than $Zn^{2+}(aq)$ (E^o = -0.76), the spontaneous electrode reactions will be
$Br_2(aq) + 2e^- = 2Br^-(aq)$ and $Zn(s) = Zn^{2+}(aq) + 2e^-$
The overall reaction is: $Br_2(aq) + Zn(s) = Zn^{2+}(aq) + 2Br^-(aq)$

(c) The cell can be recharged by attaching an external power source. Reactions must be made to go in reverse so pump electrons into the zinc electrode and take them out at the inert (platinum) electrode. That is, attach the negative terminal of the external power source to the zinc electrode and the positive terminal to the inert electrode. A potential greater than 1.85V must be used.

(d) Since there is not so much stopping and starting of the car in the country, less energy is consumed per kilometre. City driving has to work harder against friction. More energy is consumed.

(e) I = 10A and m(Zn) = 1000 g. Hence, $n(Zn) = \frac{1000}{65.4}$.
From the equation $Zn(s) = Zn^{2+}(aq) + 2e^-$, $n(e^-) = 2 \times \frac{1000}{65.4}$
The amount of electricity = Q = current x time = $n(e^-) \times F$.
Therefore, $t = 2 \times \frac{1000}{65.4} \times \frac{96500}{10} \times \frac{1}{3600}$ = 82 hours **ANS**

Area of Study: Food

Question 4
(a) Proteins are formed by condensation polymerisation from amino acids. In the process, water is also formed. In general, the equation for the most simple polymerisation of two amino acids is
$NH_2R_1COOH + NH_2R_2COOH = NH_2R_1CONHR_2COOH + H_2O$

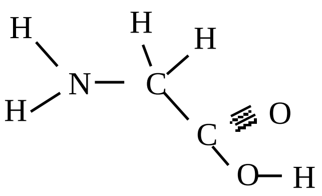
(b) The peptide link is highlighted in the structure below.

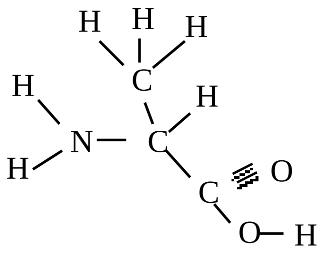
$NH_2CH_2\mathbf{CONH}CHCO_2H$
|
CH_3

Area of Study: Food

Question 4 (continued)

(c) The structures of two possible amino acids are given below





(d) One possible condensation would be

$NH_2CH_2CO_2H + NH_2CH_2CONHCHCO_2H$

$|$

CH_3

$= NH_2CH_2CONHCH_2CONHCHCO_2H + H_2O$

$|$

CH_3

(e) Of the twenty amino acids required by humans, only eleven can be manufactured in the body. The other nine must be provided in the diet. These are called essential amino acids. Hence, a healthy diet must contain the proteins which themselves contain these essential amino acids. Two sources of protein are (1) animal protein which contains all the essential amino acids and (2) a combination of vegetable sources such as rice and lentils which are complementary in their protein content.

Question 5

(a) Mass (Palm Oil) = 2.0 g. Relative molecular mass (Palm Oil) = 806.

Hence, n(Palm Oil) = $\frac{2.0}{806}$

From the balanced equation, the oxidation of 1 mole of Palm Oil produces 31500 kJ. Hence, the energy released = $\frac{2.0}{806} \times 31500 = 78.2$ kJ **ANS**

(b) Relative molecular mass (Glucose) = 180. Let m = mass of glucose required.

Therefore, $\frac{m}{180} \times 2800 = 78.2$. Hence, $m = \frac{78.2 \times 180}{2800} = 5.0$ g **ANS**

Area of Study: Food

Question 5 (continued)

(c) The energy content of a solid food can be determined in a bomb calorimeter. First, obtain the mass of the food sample and the calibration factor of the calorimeter (this is the calorimeter constant and gives the energy required to raise the temperature of the calorimeter and its contents by $1^{o}C$.). Burn the food sample inside the calorimeter in an atmosphere of oxygen (this is equivalent to the process of respiration in the body). Note the temperature rise of the calorimeter and its contents. Multiply this temperature rise by the calorimeter constant to obtain the total amount of energy released in burning the food sample. Divide this energy by the mass of the food sample to obtain the energy content of the food in $kJ\ g^{-1}$.

Area of Study: Energy

Question 6

(a) **One** possible flowchart for the experimental procedure would be

I. Add the potassium silver dicyanide solution to the bath.
E. Clean the tray by dipping it briefly in dilute nitric acid.
D. Rinse the tray with clean water.
H. Connect a copper rod to the tray and dip the tray in the plating solution.
A. Connect copper rod to the silver metal strip and dip the strip in the plating solution.
J. Connect silver metal strip and copper tray to the power source with copper rods.
G. Turn on the electric power source.
B. Adjust the current through the solution to 0.05A.
F. Allow current to flow for 30 minutes.
C. Turn off the current, remove the tray from the bath and wash it thoroughly.

(many of these steps can be interchanged and the procedure is still valid.
e.g. place **I** *after* **E** *and* **D**.)

(b) The silver is to be deposited onto the tray by the reaction $Ag^{+}(aq) + e^{-} = Ag(s)$ so there must be a supply of electrons to the copper tray. Hence, connect the tray to the negative terminal of the power source.

(c) If the tray is connected to the positive terminal by mistake, the copper will go into solution according to the equation $Cu(s) = Cu^{2+}(aq) + 2e^{-}$. At the negative silver electrode, more silver will be deposited according to the equation
$Ag^{+}(aq) + e^{-} = Ag(s)$.

Area of Study: Energy

Question 7

(a)
(i)This chemical reaction is photosynthesis.
(ii)Photosynthesis takes place in plants.
(iii)The chemical pigment that is an essential part of this process is chlorophyll.
(iv)The reaction is endothermic since energy is stored in the complex glucose molecule.

Area of Study: Energy

Question 7 (continued)

(b)

(i) The change from liquid water to gaseous water occurs in the boiler.

(ii) The process is endothermic since the gaseous water contains more energy than the liquid water.

(iii) The gaseous water is used to spin the turbine at high speed to generate the electrical energy.

(c)

(i) The nuclear fusion of hydrogen into helium occurs in the sun.

(ii) The nuclear fusion of light elements such as hydrogen is exothermic since, although the reaction requires energy to start, there is a net release of energy.

(d)

(i) The oxidation of sulfur-containing compounds to sulfur dioxide takes place in the furnace when the coal is burned.

(ii) Sulfur dioxide is a serious pollutant since it attacks the respiratory system in humans, causes damage to plants and through the production of more acidic rainfall, damages structures containing metals or calcium carbonate. For example:

$SO_2(g) + H_2O(l) = H_2SO_3(aq)$.

$CaCO_3(s) + 2H^+(aq) = Ca^{2+}(aq) + H_2O(l) + CO_2(g)$.

$Zn(s) + 2H^+(aq) = Zn^{2+}(aq) + H_2(g)$

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