THE SCHOOL FOR EXCELLENCE
UNIT 4 CHEMISTRY 2006
COMPLIMENTARY WRITTEN EXAMINATION 2 - SOLUTIONS

SECTION A: MULTIPLE CHOICE QUESTIONS

QUESTION 1 Answer is B

2 × $C_2H_5O_2N$ + $C_6H_{14}O_2N_2$ and subtract $2H_2O$ for the 2 peptide links = $C_{10}H_{20}N_4O_4$.
The corresponding molar mass is (10x12)+20+(4x14)+(4x16)= 260 $gmol^{-1}$

QUESTION 2 Answer is A

The oxidation of carbohydrates is the respiration reaction in which glucose is converted to CO_2 and H_2O. Energy is released in the process.

QUESTION 3 Answer is D

Carbohydrate hydrolysis begins in the mouth and finishes in the small intestine, both of which are alkaline. Since reactions are occurring in the body, the optimal temperature for activity would be 37°C.

QUESTION 4 Answer is B

Solubility of disaccharides is a result of exposed hydroxyl (OH) groups.

QUESTION 5 Answer is D

Lise Meitner proposed that after two new products were formed from the bombardment of uranium that nuclear fission had occurred.

QUESTION 6 Answer is C

Moving down a group, the atomic radius increases, which means it becomes easier to lose electrons (undergo oxidation). Hence the reducing strength increases as we move down a group.

QUESTION 7 Answer is C

Al_2O_3 is a metallic oxide which behaves as an acidic oxide when reacted with H_2O and OH^- to produce $Al(OH)_4^-$.

QUESTION 8 Answer is D

Oxidation number of N_2 in Equation D is 0 .
Oxidation number of NH_3 in Equation D is $^-3$.

Equation D therefore represents reduction.

QUESTION 9 Answer is A

n(palmitic acid) = mass/$\mathcal{M}$ = 200/256 = 0.78125 mol

1 mole → 10035 kJ
0.78125 mol → x kJ

x = 7840 kJ

QUESTION 10 Answer is B

Derive a half-equation for CH_3OH/CO_2:

$CH_3OH + H_2O \rightarrow CO_2 + 6H^+ + 6e^-$ Then convert to alkaline electrolyte

$+ 6OH^-$ $+6OH^-$ to form

$CH_3OH + 6OH^- \rightarrow CO_2 + 5H_2O + 6e^-$

QUESTION 11 Answer is A

During discharge the cadmium is oxidised at the anode. Recharging will therefore involve reduction at the cathode (which has a negative polarity).

$Cd(OH)_{2(s)} + 2e^- \rightarrow Cd_{(s)} + 2OH^-_{(aq)}$

QUESTION 12 Answer is B

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4\ 4p^1$ represents the manganese ion in an excited state. When this ion returns to the ground state (which is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$) it becomes more stable. In the process, energy is released.

QUESTION 13 Answer is C

Total protons on Left Hand Side is 98 + 5 = 103
Total protons on Right Hand Side is 0

Unknown element must therefore display an atomic number of 103 i.e. A or C.

Total mass number on Left Hand Side is 252 + 10 = 262
Total mass number on Right Hand Side is 3(1) = 3

Unknown element must therefore display a mass number of 262 – 3 = 259 i.e. A or C.

As process is a fusion reaction that results in the formation of a less stable nucleus (larger than Fe), the reaction is endothermic.

QUESTION 14 Answer is A

The emission of an electron from the nucleus turns a neutron into a proton, which leaves the mass number unchanged. However, the atomic number increases as the new nucleus is formed.

QUESTION 15 Answer is C

As electrons are present in excess, the mole of metal produced depends on the mole of metal ions. Ca^{2+} is a weaker oxidant than H_2O and hence will not be reduced at the cathode. No calcium metal would be deposited.

QUESTION 16 Answer is D

The primary structure is the order and sequence of amino acids, which are joined by peptide links. These links are covalent bonds.

QUESTION 17 Answer is D

Ascorbic acid prevents oxidation and is therefore classified as an antioxidant.

QUESTION 18 Answer is C

Glycerol ($C_3H_8O_3$) is always a product of the hydrolysis of any fat. The other product would be the polyunsaturated fatty acid; $C_{15}H_{27}COOH$.

QUESTION 19 Answer is C

Nitrogen is eliminated from the body as urea, $CO(NH_2)_2$

QUESTION 20 Answer is A

Rancidity is caused by the oxidation of unsaturated fats. The least susceptible fats are those which contain no double bonds i.e. the saturated fats. $C_{16}H_{32}O_2$ is a saturated fatty acid.

SECTION B: SHORT ANSWER QUESTIONS

QUESTION 1

a. Substance A: Carbon Rods
Substance B: Molten alumina (Al_2O_3) in cryolite (Na_3AlF_6)
Substance C: Molten aluminium metal

b. Anode: $C(s) + 2O^{2-}(l) \rightarrow CO_2(g) + 4e^-$

Cathode: $Al^{3+}(l) + 3e^- \rightarrow Al(l)$

c. Al^{3+} is a weaker oxidant than H_2O and hence H_2O would be preferentially reduced at the cathode if an aqueous solution was used.

d. $n(e^-) = 4 \times n(C) = 4 \times 20{,}000/12 = 6666.67$mol

$t = (n(e^-) \times F)/I = (6666.67 \times 96500)/180{,}000 = 3574.1$ s $= 59.57$ min $= 1.0$ hr

e. Photosynthesis: $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$ or
Calcium carbonate formation: $Ca^{2+}(aq) + 2OH^-(aq) + CO_2(aq) \rightarrow CaCO_3(s) + H_2O(l)$

QUESTION 2

a. Condensation reaction.

b. n(dipeptide) = n(H_20) = 2.5/222 = 0.01126 mol

Mass(H_2O) = 0.01126 × 18 = 0.20 g

c. Acidic pH, hence it behaves as base and is positively charged.

d. An essential amino acid is one which the body cannot synthesise itself, and therefore. must be obtained through the diet. A non-essential amino acid is one which the body can synthesise itself.

e. Dipeptide + Lactic Acid $\rightarrow$ Ester Linkage

Lactic Acid + Dipeptide $\rightarrow$ Peptide Linkage

QUESTION 3

a. (i) $E = m \times c \times \Delta T = 500 \times 4.184 \times 52.8 = 110457.6$ J = 110 kJ

(ii) Energy is lost as heat to the surroundings.

(iii) mass(C_2H_5OH) = d × V = 0.789 × 5.00 = 3.945 g

n(C_2H_5OH) = mass/$\mathcal{M}$ = 3.945/46 = 0.08576 mol

0.08576 mol → 110 kJ then 1 mole → 110/0.08576 = 1282.6 kJ

$C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(g)}$ $\Delta H = -1283\ kJmol^{-1}$

b. (i) Calibration factor = Energy/ ΔT = 110/52.8 = 2.08 kJ°C^{-1} = 2.08 kJ°K^{-1}

(ii) Energy (kJ) = 505/15 × 2.50 = 84.2 kJ
ΔT = Energy/CF = 84.2/2.08 = 40.5°C

c. (i) Monounsaturated.

(ii) Stearic acid is saturated. If it was the main component of olive oil then the oil would be more solid.

QUESTION 4

a. (i) The effective nuclear charge is increasing across the period, hence the outer shell electrons experience a greater degree of attraction to the nucleus, which makes it harder for them to be removed. Hence first ionization energies increase across a period.

(ii) Electronegativity
Oxidising Strength

b. (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

(ii) The electron configuration of magnesium is $1s^2\ 2s^2\ 2p^6\ 3s^2$ whilst the electron configuration of aluminium is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$. It is easier to remove the $3p^1$ electron from alumiuium as it is the only electron in the subshell as opposed to the removal of an electron from the $3s^2$ of magnesium as this subshell is full (and hence more stable). Therefore, the first ionisation energy of magnesium is slightly higher than that of aluminium.

(iii) $SO_{3(l)} + H_2O_{(l)} \rightarrow H_2SO_{4(l)}$

c. (i) Separation is based on the mass to charge ratio of each particle.

(ii) Ar = {(94.93 × 31.97)+(0.760 × 32.97)+(4.29 × 33.97)+(0.0200 × 35.97)}/100
= 32.06 g/mol

QUESTION 5

a. (i) Ni(s) as it is the Cathode where Ni^{2+} ions are reduced to Ni.

(ii) Negative (Cathode).

(iii) To separate the two half cells and hence force the electrons produced at the anode to move through the external wire and produce an electric current that can be harnessed.

(iv) $E°_{cell} = E°_{cathode} - E°_{anode} = {}^{-}0.23 - {}^{-}0.76 = 0.53$ V

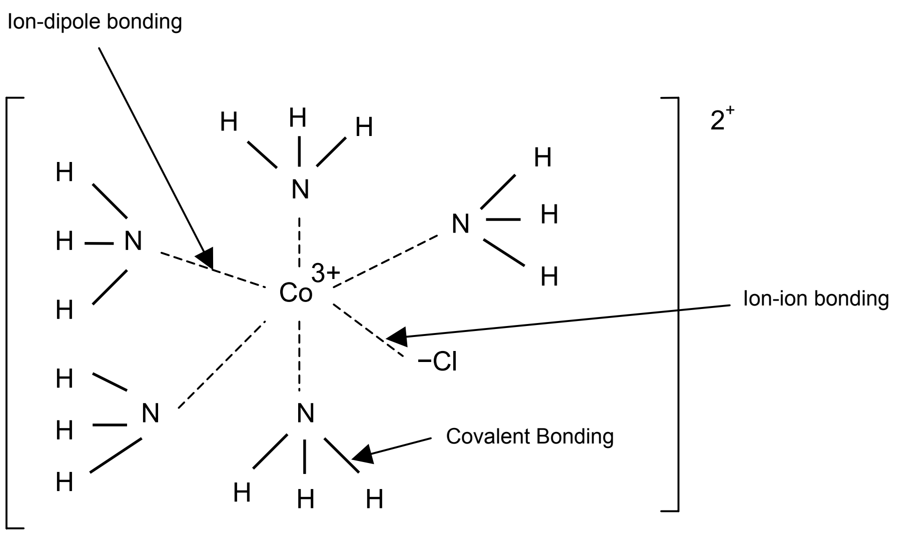
(v) $Ni^{2+}(aq) + Zn(s) \rightarrow Ni(s) + Zn^{2+}(aq)$

b. $n(e^-) = n(Au) = \text{mass}/\mathcal{M} = 10.0/196.97 = 0.0508$ mol

$t = (n(e^-) \times F)/I = (0.0508 \times 96500)/2.50 = 1968.6$ secs = 32.8 mins

QUESTION 6

a.



b. The ligand must have a negative end, either a dipole or charge, that will be attracted to the positive transition metal ion.

c. (i) Scandium (Sc).

(ii) Although the 4s level has a slightly lower energy than the 3d in neutral atoms, the 3d level develops a slightly lower energy than the 4s when the corresponding ion forms. Therefore, transition metals form ions by losing the s electrons first.

(ii) Ability to form coloured compounds.
Ability to form complex ions.
Catalytic properties.

QUESTION 7

a. The biological activity of an enzyme is directly related to its 3-dimensional shape, which is the result of its secondary and tertiary structures. The bonds maintaining these structures are disrupted by heat, resulting in a loss of shape, and consequently loss of activity.

b. $NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$ or
$NH_3(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq)$

c. $Cu^{2+}_{(aq)} + 2e^{-} \rightarrow Cu_{(s)}$

$H_{2(g)} + 2OH^{-}_{(aq)} \rightarrow 2H_2O_{(l)} + 2e^{-}$

Overall equation: $Cu^{2+}_{(aq)} + H_{2(g)} + 2OH^{-}_{(aq)} \rightarrow Cu_{(s)} + 2H_2O_{(l)}$

d. Energy of reactants and activated complex will be unchanged.

To evaporate 2 mole of H_2O, $88\ kJ$ of energy are required. Hence the ΔH for the second reaction will be $88\ kJ$ lower (as energy is used up to evaporate the water).

Hence enthalpy of products will be $-(890 - 88) = -802\ kJ/mol$