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M02/420/S(3)M+

MARKSCHEME

May 2002

CHEMISTRY

Standard Level

Paper 3

12 pages

Subject Details: Chemistry SL Paper 3 Markscheme

General

- Each marking point is usually shown on a separate line or lines.
- Alternative answers are separated by a slash (/) – this means that either answer is acceptable.
- Words underlined are essential for the mark.
- Material in brackets (…) is not needed for the mark.
- The order in which candidates score marks does not matter (unless stated otherwise).
- The use of **OWTTE** in a markscheme (the abbreviation for "or words to that effect") means that if a candidate's answer contains words different to those in the markscheme, but which can be interpreted as having the same meaning, then the mark should be awarded.
- Please remember that many candidates are writing in a second language, and that effective communication is more important than grammatical accuracy.
- In some cases there may be more acceptable ways of scoring marks than the total mark for the question part. In these cases, tick each correct point, and if the total number of ticks is greater than the maximum possible total then write the maximum total followed by **MAX**.
- In some questions an answer to a question part has to be used in later parts. If an error is made in the first part then it should be penalised. However, if the incorrect answer is used correctly in later parts then "follow through" marks can be scored. Show this by writing **ECF** (error carried forward). This situation often occurs in calculations but may do so in other questions.
- Units for quantities should always be given where appropriate. In some cases a mark is available in the markscheme for writing the correct unit. In other cases the markscheme may state that units are to be ignored. Where this is not the case, penalise the omission of units, or the use of incorrect units, once only in the paper, and show this by writing **–1(U)** at the first point at which it occurs.
- Do not penalise candidates for using too many significant figures in answers to calculations, unless the question specifically states the number of significant figures required. If a candidate gives an answer to fewer significant figures than the answer shown in the markscheme, penalise this once only in the paper, and show this by writing **–1(SF)** at the first point at which this occurs.
- If a question specifically asks for the name of a substance, do not award a mark for a correct formula; similarly, if the formula is specifically asked for, do not award a mark for a correct name.
- If a question asks for an equation for a reaction, a balanced symbol equation is usually expected. Do not award a mark for a word equation or an unbalanced equation unless the question specifically asks for this. In some cases, where more complicated equations are to be written, more than one mark may be available for an equation – in these cases follow the instructions in the mark scheme.
- Ignore missing or incorrect state symbols in an equation unless these are specifically asked for in the question.
- Mark positively. Give candidates credit for what they have got correct, rather than penalising them for what they have got wrong.
- If candidates answer a question correctly, but by using a method different from that shown in the markscheme, then award marks; if in doubt consult your Team Leader.

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OPTION A – HIGHER ORGANIC CHEMISTRY

A1. (a) **A** is $CH_3CH_2CH_2OH$ ***[1]***

B is CH_3CHCH_2 ***[1]***

C is $CH_3CH_2CH_2OCH_2CH_2CH_3$ ***[1]***

If full structural formulas are given, but the H atoms attached to the C– bonds are omitted, penalize first time only.

Dehydration ***[1]*** ***[4]***

(b) (i) Oxidation/redox ***[1]***

D is CH_3CH_2CHO ***[1]***

E is CH_3CH_2COOH ***[1]*** ***[3]***

(ii) $LiAlH_4$ (*allow H_2 and $NaBH_4$*). ***[1]***

(iii) greater dissociation / more H^+ formed ***[1]***
C ═ O increases bond polarity / stability of (carboxylate) ion. ***[1]*** ***[2]***

A2. (a) Distance between atomic centres / nuclei. ***[1]***
(Use table to indicate that) bond lengths decrease as number of bonds increases. ***[1]***
Two e-pairs draw nuclei closer together */ OWTTE.* ***[1]*** ***[3]***

(b) Oxygen double bond, nitrogen triple bond. ***[1]***
(Accept O=O, N≡N / nitrogen has extra bond.)
Bond in nitrogen harder to break / needs more energy to break. ***[1]*** ***[2]***

OPTION B – HIGHER PHYSICAL CHEMISTRY

B1. (a) (Weak acid) is one that partially ionises/dissociates (in water). ***[1]***
(Reference to H^+ ions is not needed, but mention of OH^- scores zero.)

(b) $CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$ *(do not accept →)* ***[1]***

(c) $\dfrac{[H^+][CH_3COO^-]}{[CH_3COOH]}$ ***[1]***
(Accept H_3O^+ instead of H^+, but $[H_2O]$ in denominator scores zero.)

(d) $K_a = 1.74\times10^{-5}$ ***[1]*** mol dm^{-3} ***[1]*** ***[2]***

(e) Concentration of solution is 0.01 mol dm^{-3} ***[1]***

$1.74\times10^{-5} = \dfrac{x^2}{0.01}$
(Mark is for realising $[H^+] = [CH_3COO^-]$) ***[1]***

$[H^+] = 4.17\times10^{-4}$ (mol dm^{-3}) ***[1]***

pH = 3.38 (*accept 3.3–3.4*) ***[1]*** ***[4]***

B2. (a) $H_2O \rightarrow H^+ + OH^-$ / $2H_2O \rightarrow H_3O^+ + OH^-$ *(allow ⇌)* ***[1]***

(b) (i) $K_w = [H^+][OH^-]$ *(Accept H_3O^+ instead of H^+)* ***[1]***

(ii) $[H^+] = 1.21\times10^{-7}$ ***[1]***

pH = 6.92 ***[1]*** ***[2]***

(iii) As temperature increases the pH decreases. ***[1]***
reaction is endothermic so more $[H^+]$ formed / forward reaction favoured / *OWTTE.* ***[1]*** ***[2]***

OPTION C – HUMAN BIOCHEMISTRY

C1. W and Z. (*Award **[1]** for each.*) ***[2]***

W contains several alkanol / alcohol / hydroxyl / OH groups ***[1]***
Therefore is able to hydrogen bond with water ***[1]*** ***[2]***

OR
Z contains charged group / ionic group ***[1]***
Forms a strong interaction with polar water molecules ***[1]***

OR
Z contains several alkanol / alcohol / hydroxyl / OH groups ***[1]***
which can hydrogen bond with water ***[1]***

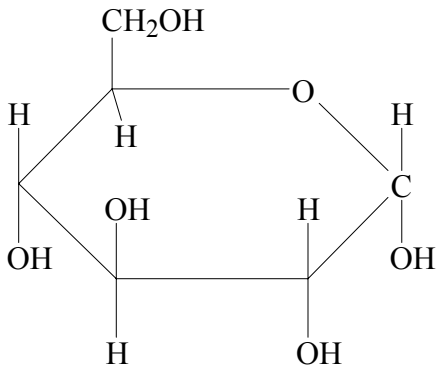
C2. (a) Soluble in water. ***[1]***
Oxidation (of vitamin C is accelerated by heating) ***[1]*** ***[2]***

(b) Production of collagen / connective tissue / regenerate tissue / *OWTTE* ***[1]***
Scurvy / scorbutus ***[1]*** ***[2]***

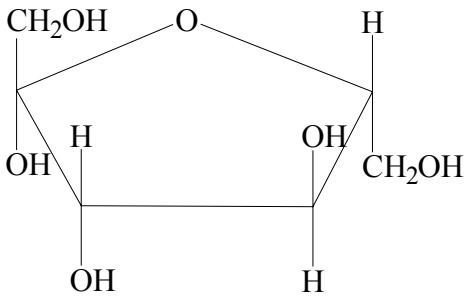
C3. (a) *(Award **[1]** each for any two of the following:)*

One carbonyl group
and at least 2 OH/hydroxyl groups
empirical formula CH_2O ***[2]***

(b) (i)



[1]



[1] ***[2]***

(ii) Water ***[1]***
Condensation ***[1]*** ***[2]***

(c) Fructose / β-fructose / β-D-fructose ***[1]***

OPTION D – ENVIRONMENTAL CHEMISTRY

D1. (a) Carbon dioxide dissolves in / reacts with rain. ***[1]***

$CO_2 + H_2O \rightarrow H_2CO_3 / H^+ + HCO_3^- / 2H^+ + CO_3^{2-}$ *(accept ⇌)* ***[1]*** ***[2]***

(b) (i) Nitrogen oxide(s) / NO_x / NO / NO_2 *(do not accept N_2O)* ***[1]***
burning/combustion of fuel/petrol/gasoline (in car engines) / reference to correct chemical reaction (*e.g.* $N_2 + O_2 \rightarrow 2NO$) (*do not accept car / car engine / car exhaust*) ***[1]***
sulfur oxide(s) / SO_x / SO_2 / SO_3 ***[1]***
combustion of fossil fuels / roasting sulfide ores ***[1]*** ***[4]***

(ii) Nitrogen oxides, (*award **[1]** each for any two from the following*):

- modify internal combustion engines to function at lower temperature
- increase fuel : air ratio
- use catalytic converters
- use public transport / *OWTTE*
- use vehicles powered by fuel cells / electricity

Sulfur oxides, (*award **[1]** each for any two from the following*):

- use fossil fuels with lower S content
- remove S before burning
- remove SO_2 from emissions / scrubbing / limestone fluidised beds
- use specified alternative power *e.g.* nuclear / geothermal / hydroelectric ***[4]***

D2. (a) *(Award **[1]** each for any two formulas or names from the following:)*

CO_2, CH_4, N_2O, H_2O, O_3, CFCs. ***[2]***

(b) Radiation from Earth is IR / lower energy / longer wavelength ***[1]***
Greenhouse gases absorb / trap this radiation ***[1]***
Radiation absorbed by bonds in molecule / bond vibration ***[1]*** ***[3]***

OPTION E – CHEMICAL INDUSTRIES

E1. (a) Bauxite. ***[1]***

(b) Silicon(IV) oxide / SiO_2 / silicon dioxide / sand. ***[1]***
OR iron(III) oxide / Fe_2O_3 / Fe_3O_4 / Fe
OR titanium dioxide / TiO_2 / Ti

(c) Aluminium has high affinity for oxygen compared to carbon / aluminium is more reactive than carbon / Al has more negative $E^{\ominus}$ value / correct reference to Ellingham diagram or ΔG values. ***[1]***

(d) Anode: $2O^{2-} \rightarrow O_2 + 4e^-$ / $O^{2-} \rightarrow \frac{1}{2} O_2 + 2e^-$ ***[1]***

Cathode: $Al^{3+} + 3e^- \rightarrow Al$ ***[1]***

(e) (i) *(Award **[1]** for any two of the following.)*

Good conductor of heat / unreactive / low density / malleable / high m.pt. ***[1]***

(ii) *(Award **[1]** for any two of the following.)*

Low density / corrosion resistant / good electrical conductor / low electrical resistance / ductile. ***[1]***

(f) Al is covered in an oxide layer that prevents further reaction. ***[1]***

E2. (a) $S + O_2 \rightarrow SO_2$ / $S_8 + 8O_2 \rightarrow 8SO_2$ ***[1]***

(b) (i) Yield decreases / equilibrium shifts to left as the reaction is exothermic. ***[1]***

(ii) Yield increases / equilibrium shifts to right as there are less moles of gas on right hand side / number of moles of gas decreases from left to right. ***[1]***

(c) The temperature gives a reasonable yield at a reasonable rate. ***[1]***
Yield is high at just above 1 atm ***[1]*** ***[2]***

(d) Manufacture of fertilisers / soaps and detergents / paints and pigments / dyestuffs / fibres *e.g.* rayon / petroleum refining / in batteries / cleaning of steels and metals / manufacture of plastics *etc.*
*(Award **[2]** for any four, **[1]** for any two or three.)* ***[2]***

OPTION F – FUELS AND ENERGY

F1. (a) (i)

Radiation	Name	Charge
α	alpha	+2
β	beta	–1
γ	gamma	0

[3]

(ii) α, β, γ. ***[1]***

(b) (i)

$$\underset{100\ \% \rightarrow}{27y} \quad \underset{50\ \% \rightarrow}{27y} \quad \underset{25\ \% \rightarrow}{27y} \quad = \quad \underset{12.5\ \%}{81 \text{ years}}$$

*(Award **[1]** for indication of three half-lives and **[1]** for answer.)* ***[2]***

(ii) $^{90}_{38}\text{Sr} \rightarrow {}^{90}_{39}\text{Y} + {}^{0}_{-1}\text{e}$ ***[1]***

(iii) decay could take place at any time / random / *OWTTE* ***[1]***

F2. (a) *(Award **[1]** for any of the following:)*

Air – does not freeze/boil at temperatures involved / is not corrosive / can circulate directly to different parts / no problems with leakage. ***[1]***

*(Award **[1]** for any of the following:)*

Water – transfers heat more efficiently / higher specific heat capacity / easy to fit piping and plumbing after building constructed. ***[1]***

(b) Passive: no use of fans / pumps / moving parts
Or
Active: use of fans / pumps / moving parts ***[1]***

(c) *(Award **[1]** for any one of the following:)*

- Relatively low running cost.
- Renewable / unlimited source
- Low maintenance.
- Reliability/long life.
- Does not deplete non-renewable source
- Non-polluting ***[1]***

(d) (i) $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

*(Award **[1]** for formulas and **[1]** for correct balancing.)* ***[2]***

(ii) Chlorophyll ***[1]***