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M02/420/H(3)M

MARKSCHEME

May 2002

CHEMISTRY

Higher Level

Paper 3

18 pages

Subject Details: Chemistry HL 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

OPTION C – HUMAN BIOCHEMISTRY

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

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

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

OR
Z contains NH group ***[1]***
which can hydrogen bond with water ***[1]***

*(Award **[1]** for group and **[1]** for explanation.)*

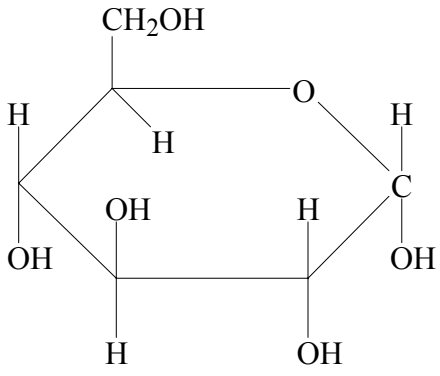
C2. (a) Soluble in water. ***[1]***
Oxidation of vitamin C is accelerated by heating (*owtte*). ***[1]*** ***[2]***

(b) Essential in production of collagen / connective tissue ***[1]***
Scurvy / scorbutus ***[1]*** ***[2]***

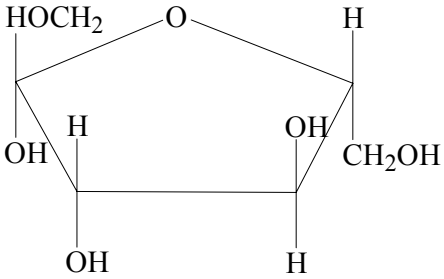
C3. (a) *(Award **[1]** each for any two of the following:)*

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

(b) (i)



[1]



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

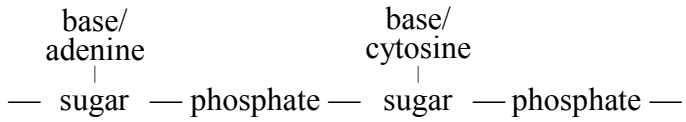
(ii) Water ***[1]***
Condensation ***[1]*** ***[2]***

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

C4. Increase in temperature results in increase in reaction rate ***[1]***
due to increase in kinetic energy ***[1]***
larger fraction of molecules with sufficient energy to react / $E > E_a$ ***[1]***
Boiling results in denaturation of the enzyme ***[1]***
The structure of the active site is altered, resulting in a loss of enzyme activity ***[1]*** ***[5]***

C5. Nucleotide consists of a pentose sugar, an organic base and a phosphate group ***[1]***
base is attached to each sugar ***[1]***
nucleotides are linked through their sugars and a phosphate group to form a dinucleotide ***[1]***

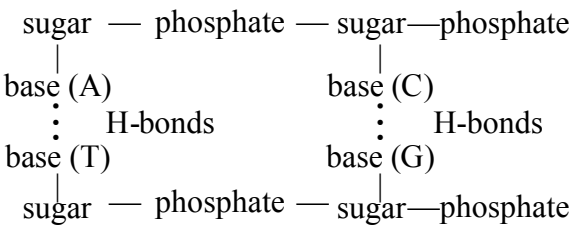
(This may be shown diagramatically:)



- sugar–phosphate backbone ***[1]***;
- base / named base attached to sugar ***[1]***;
- must show **two** repeating units ***[1]***;

A pairs with **T** and **C** with **G** (*allow names*) ***[1]***;
hydrogen bonds between the bases hold chains together ***[1]***.

(This may be shown diagramatically:)



*(Must show **A** with **T** and **C** with **G** in diagram, and correct position of H bonds.)* ***[5]***

OPTION D – ENVIRONMENTAL CHEMISTRY

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

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

(b) (i) Nitrogen oxides ***[1]***
internal combustion engine ***[1]***
sulfur oxides ***[1]***
industrial combustion of fossil fuels ***[1]*** ***[4]***

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

- modify internal combustion engines to function at lower temperature, reducing formation of nitrogen oxides
- use catalytic converters in exhaust system / lean-burn engines
- encourage driving less
- alternative transport system *e.g.* use public transport
- use vehicles powered by alternative fuels *e.g.* H_2 powered or electric cars

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

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

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

Carbon dioxide, methane, N_2O, water vapour, O_3, CFCs. ***[2]***

(b) Radiation from sun is shorter wavelength/higher energy than that radiating from earth ***[1]***
OR
Radiation from sun is UV/visible light, but that from earth is IR.

Greenhouse gases absorb radiation from earth / longer wavelength radiation / IR radiation. ***[1]***

More heat / increase in temperature in atmosphere/at earth's surface. ***[1]***

D3. (a) O_2 molecules that absorb UV photons break into O atoms. ***[1]***
When ozone molecules break up, UV light of larger wavelength needed. ***[1]***

(Must show that UV light needed to break up O_2 is shorter wavelength / higher energy.)

$O_2 \rightarrow 2O$ ***[1]***
$O + O_2 \rightarrow O_3$ ***[1]***
$O_3 + O \rightarrow 2O_2$ ***[1]*** ***[5]***

(b) Chlorine atom released from CFC ***[1]***
by bombardment with photons. ***[1]***

Chlorine atom catalyses the decomposition of O_3 ***[1]***
chlorine atoms not used up in decomposition ***[1]***

OR
$Cl(g) + O_3(g) \rightarrow ClO(g) + O_2(g)$
$ClO(g) + O_3(g) \rightarrow Cl(g) + 2O_2(g)$

One chlorine atom decomposes **many O_3** molecules. ***[1]*** ***[5]***

OPTION E – CHEMICAL INDUSTRIES

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

(b) Silicon(IV) oxide / silicon dioxide / sand. ***[1]***
OR iron(III) oxide
OR titanium dioxide.

(c) Aluminium has high affinity for oxygen compared to carbon / aluminium is more reactive than carbon. ***[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 heat plus one other property.)*

Good conductor of heat / unreactive / light / low density. ***[1]***

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

Low density / corrosion resistant / good electrical conductor / low electrical resistance. (*Insist on electrical – 'good conductor'* or *'low resistance' is not sufficient.*) ***[1]***

(f) Al is covered in inert oxide layer (preventing further reaction). ***[1]***

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

(b) (i) Yield decreases as the reaction is exothermic. ***[1]***

(ii) Yield increases, there are less moles of gas on right hand side / number of moles of gas decreases from left to right.

*(Need **what** it does and **why** for **[1]**.)* ***[1]***

(c) High temperature gives a reasonable/high rate of reaction. ***[1]***
Generation of high pressure is expensive (*any reference to economic considerations*). ***[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]***

E3. *(Award **[1]** for any ten of the following:)*

Diaphragm cell and mercury cathode cell ***[1]***

Diaphragm cell:
advantage: relatively cheap to build; ***[1]***
disadvantage: lower purity product / lower concentration of product. ***[1]***

Mercury cathode cell:
advantage: higher product purity / high concentration of product; ***[1]***
disadvantage: toxic mercury must be removed from effluent / very expensive to build. ***[1]***

$2H^+ + 2e^- \rightarrow H_2$ ***[1]***
$2Cl^- - 2e^- \rightarrow Cl_2$ / $2Cl^- \rightarrow Cl_2 + 2e^-$ ***[1]***

Sodium hydroxide – *two named uses, for example:* ***[1]***
- production of paper products;
- manufacture of organic chemicals;
- manufacture of inorganic chemicals;
- manufacture of soaps and detergents;
- oil refining;
- aluminium industry.

Chlorine – *two named uses, for example:* ***[1]***
- manufacture of solvents;
- manufacture of PVC;
- manufacture of chloromethane or chloroethane;
- manufacture of inorganic chemicals;
- water purification;
- disinfecting swimming pools.

Hydrogen – *two named uses, for example:* ***[1]***
- manufacture of ammonia;
- manufacture of methanol;
- refinery processes / cracking oil / reforming;
- hydrogenation of fats and oils;
- reduction of metallic ores;
- production of HCl. ***[10]***

OPTION F – FUELS AND ENERGY

F1. (a) (i)

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

*(Award **[1]** for each radiation type that has two correct answers.)* ***[3]***

(ii) α, β, γ. ***[1]***

(b) (i)

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

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

OR

$N = N^0\left(\frac{1}{2}\right)^n$ where n = the number of half-lives, thus n + 3

$12.3 = 100\left(\frac{1}{2}\right)^n$ so $\frac{12.5}{100} = \left(\frac{1}{2}\right)^n$ or $\frac{1}{8} = \left(\frac{1}{2}\right)^n$, thus $n = 3$.

Time since explosion $= 27 \times 3 = 81$ years

(ii) decay could take place at any time / random therefore, the term half-life is meaningless. ***[1]***

(c) $n : p = 52 : 38 = 1.37 : 1$ (*accept* 1.4:1) ***[1]***

Number of neutrons higher than protons, therefore beta emitter ***[1]***
(Reason needs to be given for mark.)

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

Mass of products less than that of ^{90}Sr ***[1]***
Mass converted to energy ***[1]***. ***[5]***

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. ***[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.
Active: use of fans/pumps. ***[1]***

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

- Relatively low cost.
- No moving parts.
- Low maintenance.
- Reliability/long life. ***[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) Chloroplasts/chlorophyll. ***[1]***

F3. Material with conductivity intermediate between conductor and insulator. ***[1]***

Examples: germanium or silicon. ***[1]***

One layer doped with group (V) element / arsenic / phosphorus ***[1]***
the other layer doped with group (III) element / gallium / indium ***[1]***

Group V doping gives n-type / provides extra electrons ***[1]***
Group III doping gives p-type / introduces holes in crystal ***[1]*** ***[6]***

OPTION G – MODERN ANALYTICAL CHEMISTRY

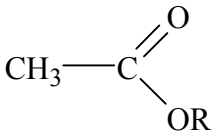
G1. (a) Tetramethylsilane / TMS ***[1]***
Used as reference standard ***[1]*** ***[2]***

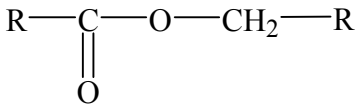
(b) (i) (three) different chemical environments ***[1]***

(ii) ratio of hydrogen atoms in each environment ***[1]***

(iii) the number of hydrogens on adjacent carbon atoms ***[1]***

(c) 1.3 ppm $R-CH_2-R$ ***[1]***

2.0 ppm  ***[1]***

4.1 ppm  ***[1]*** ***[3]***

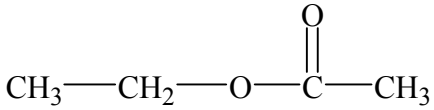
Candidates who correctly identify the structure of ethyl ethanoate may give the following answer for shift of 1.3 ppm:

CH_3-CH_2-R (i.e. CH_3 next to CH_2)

*This answer should be awarded **[1]**.*

(d) A C—H ***[1]***
B C=O ***[1]***
C C—O ***[1]*** ***[3]***

(e) Ethyl ethanoate ***[1]***

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

(f) MRI / magnetic resonance imaging / nuclear magnetic resonance / NMR. ***[1]***

(g) Non-invasive / radiation is not harmful / distinguishes between different types of soft tissue. ***[1]***

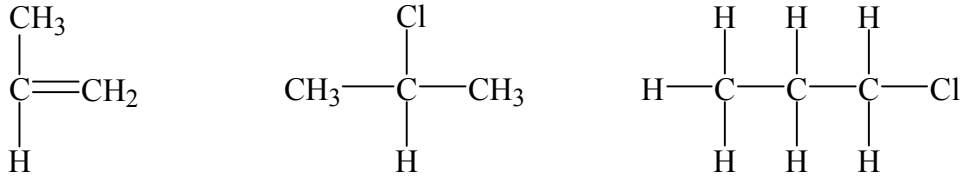
G2. (a) Stationary phase and a mobile phase ***[1]***;
Components dissolve / absorb / partition to differing extents between the two phases ***[1]***. ***[2]***

(b) Gas-liquid chromatography / GLC; ***[1]***
Hydrocarbons are volatile; ***[1]***
Mobile phase is a gas; ***[1]***
Stationary phase is a liquid; ***[1]***
Sample is vaporised; ***[1]***
Components separated and detected. ***[1]*** ***[6]***

(c) Molecular mass; ***[1]***
Molecular formula. ***[1]*** ***[2]***

OPTION H – FURTHER ORGANIC CHEMISTRY

H1. (a) *(Award **[1]** for each correct structure.)*

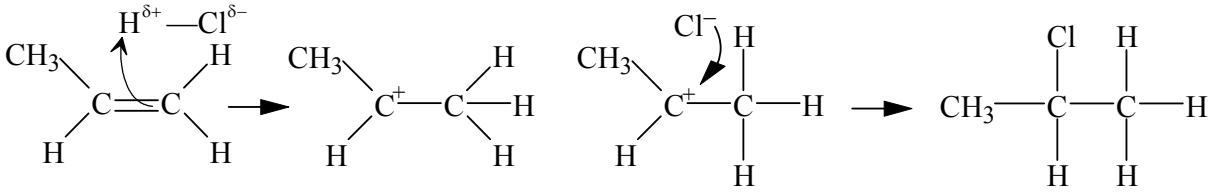


A **B** **C** ***[3]***

(b) Electrophilic addition. ***[1]***

Mechanism:

- step to form carbocation; ***[1]***
- correct structure of carbocation; ***[1]***
- step to convert carbocation to product. ***[1]***

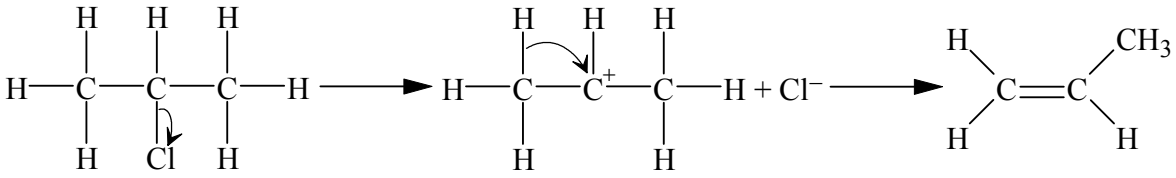


Carbocation in B is more stable ***[1]***.
Inductive effect of methyl groups / 2° carbocation in B more stable than 1° carbocation in C ***[1]***. ***[6]***

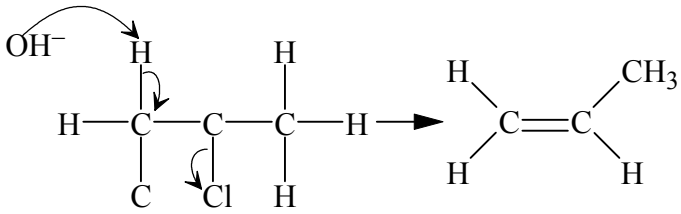
(c) (i) Elimination ***[1]***
Heat/hot and alcoholic/ethanolic solution ***[1]***. (*Both needed for the mark.*)
NaOH or KOH ***[1]*** ***[3]***

(ii) If E1 drawn:

- correct structure for carbocation; ***[1]***
- curly arrow shown correctly in 1st step; ***[1]***
- curly arrow shown correctly in 2nd step. ***[1]*** ***[3]***



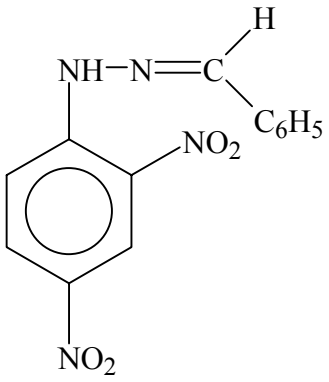
If E2 drawn, award ***[1]*** for each **correctly** positioned curly arrow.



H2. (a) (i) Reaction X: addition – elimination (*allow condensation*) ***[1]***.

Reaction Y: nucleophilic addition. ***[1]*** ***[2]***

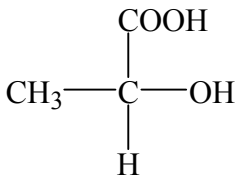
(ii)



[1]

(b) 2,4-dinitrophenylhydrazine ***[1]***
products are solids/precipitates ***[1]***
melting points can be measured ***[1]***
compared with data / literature values ***[1]*** ***[4]***

(c) Useful as it can be used to introduce another C atom into a carbon chain. ***[1]***



[1]

chiral centre / optical isomerism ***[1]*** ***[3]***