M08/4/CHEMI/HP3/ENG/TZ2/XX/M+

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MARKSCHEME

May 2008

CHEMISTRY

Higher Level

Paper 3

19 pages

Subject Details: Chemistry HL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the options **[2 × 25 marks]**. Maximum total = **[50 marks]**

1. A markscheme often has more marking points than the total allows. This is intentional. Do not award more than the maximum marks allowed for part of a question.

2. Each marking point has a separate line and the end is signified by means of a semicolon (;).

3. An alternative answer or wording is indicated in the markscheme by a slash (/) – either wording can be accepted.

4. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

5. Words that are underlined are essential for the mark.

6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by writing ***OWTTE*** (or words to that effect).

8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

9. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. Indicate this with **ECF** (error carried forward).

10. Only consider units at the end of a calculation. Unless directed otherwise in the mark scheme, unit errors should only be penalized once in the paper. Indicate this by writing **–1(U)** at the first point it occurs and **U** on the cover page.

11. Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits** unless directed otherwise in the markscheme.

e.g. if the answer is 1.63:

2	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

Indicate the mark deduction by writing **–1(SD)** at the first point it occurs and **SD** on the cover page.

12. 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.

13. 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 directed otherwise in the markscheme.

14. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

Option B – Medicines and drugs

B1. (a) esterification / condensation / acetylation; ***[1]***

(b) OH/hydroxyl group replaced by OCH_3 /ether group / H replaced by CH_3 / *OWTTE*; ***[1]***

(c) *advantage*
strong analgesic/pain killer;
No mark for just pain killer

disadvantage
dependence / addictive / tolerance can lead to taking dangerously high doses / constipation; ***[2]***

(d) spread of AIDS/hepatitis / dangerous infectious diseases
increased crime/theft
loss of jobs/diversion of money
prostitution
family disintegration ***[2 max]***
*Award **[1]** each for any two.*

B2. (a) (i) stimulant(s); ***[1]***

(ii) copies/mimics stimulation of the nervous system / action of adrenaline / *OWTTE*; ***[1]***

(b) nicotine;

short-term
addiction
increase heart rate
increase blood pressure / constricts blood vessels
reduction of urine output
*Award **[1]** for any two.*

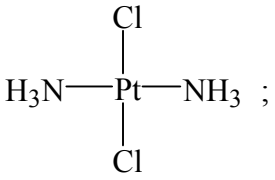
long-term
heart disease
peptic ulcers
lung cancer
emphysema
coronary thrombosis / clot inside blood vessel / heart attack
pregnancy problems
addiction ***[3 max]***
*Award **[1]** for any two.*
Addiction can score only once in either short or long term.

(c) amphetamine is a primary amine and adrenaline is a secondary amine;
only adrenaline has an –OH/hydroxyl group / is a phenol / is an alcohol; ***[2]***

(d) (i) diuretic / frequent urination; ***[1]***

(ii) (tertiary) amine; ***[1]***

B3. (a) cis-platin;
cancer/tumours;



;

[3]

No mark for stating trans isomer

(b) chiral/asymmetric/stereo centre;
forms two enantiomers / optical isomers / d/dextro and l/levo forms;
drug given as a racemic mixture;
each form causes one effect; ***[4]***

(c) *Any three of the following.*
process used to synthesize a large number of compounds / *OWTTE;*
compounds are structurally related;
repetitive/computerized technique;
screen them for biological activity / *OWTTE;*
produces a library/database of different compounds / *OWTTE;* ***[3 max]***

Option C – Human biochemistry

C1. (a) ester / triglyceride; ***[1]***
No mark for water/H_2O.

(b) (i) linoleic acid is unsaturated / contains C=C double bonds / linoleic has a kink/bend/120° bond angle within the molecule / *OWTTE*; ***[1]***

(ii) C=C double bonds stop molecules packing closely together;
resulting in weaker van der Waals'/London/dispersion forces of attraction / *OWTTE*; ***[2]***
No mark for intermolecular forces.

(c) 2 C=C double bonds require 2 moles of iodine / *OWTTE*;
Accept molecular formula or chemical equation.
507.6 g; ***[2]***
Accept 507–508, units required for second mark.
*Correct answer with units scores **[2]**.*
*253.8 / 254 score, **[1 max]**.*

C2. (a) alcohol/hydroxyl/OH;
alkene/C=C; ***[2]***
Accept –OH but not OH^- / hydroxide.

(b) fat-soluble because long hydrocarbon chain/non-polar hydrophobic chain;
so cannot form hydrogen bonds with water / *OWTTE*; ***[2]***

(c) (i) rhodopsin;
converts light energy/signals into electrical energy/signals/light converts trans to cis (isomer) / *OWTTE*;
(messages) travel along optic nerve / to the brain; ***[3]***

(ii) night blindness / nyctanopia / nyctalopia;
Xerophthalmia/(chronic) conjunctivitis / eyes fail to produce tears; ***[2]***
No mark for saying just eye problems.

C3. (a) they prevent substrate reacting with the enzyme;
by occupying/blocking/binding to active sites on the enzyme;
they slow down the rate of reaction;

increased substrate concentration reduces the effect / increases the rate of reaction / *OWTTE*;
because there is more competition for active sites by the substrate / *OWTTE*; ***[5]***

(b) Hg replaces H in the –SH groups of the enzyme / reacts with cysteine in enzyme;
alters the tertiary structure/shape of the molecule/denatured;
inhibits enzyme activity; ***[3]***

(c) proteases;
breaks down proteins; ***[2]***

Option D – Environmental chemistry

D1. (a) *natural:*
respiration / forest fires / decay of plants/animals / oxidation of soil humus / volcanoes;

CO_2:
man-made:
combustion of fossil/hydrocarbon fuels / combustion of biomass;

N_2O:
man-made:
combustion of biomass / (artificial/nitrogen based) fertilizers;

natural:
bacterial decomposition of nitrogen-containing compounds / lighting; ***[4]***
Do not accept just a reference to cars or factories.
*If unclear whether natural or man-made source award **[2 max]**.*

(b) CO_2 is less effective at trapping heat than N_2O / N_2O heat trapping effectiveness is much greater than CO_2;
CO_2 contributes more to the greenhouse effect because there is more of it in the atmosphere / N_2O contributes less to the greenhouse effect because there is less of it in the atmosphere; ***[2]***
*Accept CO_2 more abundant and N_2O more effective for **[2]**.*

(c) *Discussion of any three of the following:*
stated climate change (e.g. drought / increased rainfall / desertification);
rising of sea-levels / thermal expansion of oceans / coastal flooding;
melting of the polar ice caps and glaciers;
stated changes in agriculture (e.g. crop yields reduced/increased);
stated changes in biodistribution/biodiversity (e.g. loss of cold water fish habitat, loss of habitat for polar bears, desertification);
stated effect on forests (e.g. more forest fires, forests grow rapidly); ***[3 max]***

D2. (a) H_2SO_3 / sulfurous acid / H_2SO_4 / sulfuric acid; ***[1]***

(b) $S + O_2 \rightarrow SO_2 / SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$;
$SO_2 + H_2O \rightarrow H_2SO_3 / SO_3 + H_2O \rightarrow H_2SO_4 / SO_2 + H_2O + ½O_2 \rightarrow H_2SO_4$; ***[2]***

*Award **[1]** for $S + O_2 + H_2O \rightarrow H_2SO_3 / S + 1½O_2 + H_2O \rightarrow H_2SO_4$*

(c) *Any two of the following:*
alkaline scrubbing;
remove sulfur from coal;
using limestone-based fluidized beds; ***[2 max]***

D3. (a) *Any three of the following **[2]**, any two of the following **[1]**.*
*One of the following receives **[0]**.*
heavy metals
pesticides
polychlorinated biphenyls
dioxins ***[2 max]***

(b) use of artificial fertilizers / intensive farming;
acid rain;

cancer;
methaemoglobinaemia / blue baby; ***[4]***

D4. surrounding hills;
lack of wind;
warmer air above cooler air;
smog / pollutants trapped;
breathing problems / exacerbates bronchitis / emphysema / *OWTTE*; ***[5]***

Option E – Chemical industries

E1. (a) (limestone) reacts with silica/acidic impurities;
$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$ /
$CaCO_3 \rightarrow CaO + CO_2$ and $CaO + SiO_2 \rightarrow CaSiO_3$;
(coke) heats furnace / acts as a reducing agent / forms a reducing agent / forms CO;
$C + O_2 \rightarrow CO_2$ / $2C + O_2 \rightarrow 2CO$ /
$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$ / $C + CO_2 \rightarrow 2CO$ / $FeO + CO \rightarrow Fe + CO_2$ /
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$; ***[4]***

(b) oxygen added;
lime/limestone/calcium oxide/calcium carbonate added;
carbon/impurities react with oxygen / are oxidized;
impurities react with (the lime) to form a slag; ***[4]***
Accept relevant equations.

E2. (a) air is blown through during the condensation of the polymer;

*properties award **[1]** for any two*.
insulation
flexible
compressible
soft
low density ***[2 max]***

(b) *Accept two of the following:*
produces toxic vapour in fire / produces carbon dioxide / a greenhouse gas on combustion;
non-biodegradable/non-recyclable;
production of polymer depletes natural resources; ***[2 max]***

E3. *Any four of the following:*
silica is reduced using carbon / $SiO_2 + 2C \rightarrow Si + 2CO$ / $SiO_2 + C \rightarrow Si + CO_2$;
silicon is converted to silicon tetrachloride by heating in chlorine / $Si + 2Cl_2 \rightarrow SiCl_4$;
silicon tetrachloride is then purified by distillation;
(and) reduced to silicon by heating with hydrogen or magnesium /
$SiCl_4 + 2H_2 \rightarrow Si + 4HCl$ / $SiCl_4 + 2Mg \rightarrow Si + 2MgCl_2$;
silicon is further refined by zone refining; ***[4 max]***

E4. *Thermal cracking: free radical mechanism* ***[5 max]***
initiation step / the formation of the free radicals / homolytic fission;
$C_2H_6 + \text{heat} \rightarrow 2{\bullet}CH_3$;
propagation step / one free radical is used, but another produced in its place;
$C_2H_6 + {\bullet}CH_3 \rightarrow CH_4 + {\bullet}C_2H_5$ / ${\bullet}C_2H_5 + C_2H_4 + {\bullet}H$ / $C_2H_6 + {\bullet}H \rightarrow {\bullet}C_2H_5 + H_2$;
termination step / free radicals combine;
${\bullet}H + {\bullet}CH_3 \rightarrow CH_4$;
Accept free radicals without dots.
steam;
1000 – 1150 K;

Catalytic cracking: ionic mechanism ***[5 max]***
the ionic mechanism results in the formation of carbocations / heterolytic fission;
this is followed by rearrangement since a tertiary carbocation is more stable than a secondary or primary one;
branched chains are formed;
structure of carbocation given;
alumina / silica;
700 – 800 K; ***[9 max]***
Accept a series of reactions to illustrate this.
If temperatures not given, award ***[1]*** *for lower temperature in ionic mechanism.*

Option F – Fuels and energy

F1. abundant/renewable;
easily ignited;
safe storage/transport;
(energy source should have) a high heat of combustion;
cheap;
easily accessed;
release energy at a reasonable rate;
use should cause minimal environmental problems/non-polluting; ***[2 max]***
Any two of the above.

F2. (a) negative electrode (anode): $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$;
positive electrode (cathode): $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$;
*Award **[1]** if equations are interchanged.*
Accept e instead of e–

overall reaction: $2H_2 + O_2 \rightarrow 2H_2O$; ***[3]***

(b) (i) negative electrode (anode): $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$;
positive electrode (cathode): $PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$; ***[2]***
*Award **[1]** if equations are interchanged.*
Accept e instead of e–

(ii) water is electrolysed during charging / evaporation; ***[1]***

F3. (a) heat from sun is concentrated/focussed/collected using parabolic mirrors / heat is used to heat oil/liquid sodium;
heated liquid pumped into heat exchanger / used to produce steam;
steam → turbine → generator; ***[3]***

(b) *Two of the following disadvantages*
large area required (for mirrors);
mirrors need to be constantly cleaned;
mirror surface needs to withstand extreme temperature;
loss of energy during conversion/transmission; ***[2 max]***

(c) $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$;
food/energy source / converted into other fuel/raw material; ***[2]***
*Two of these needed for the **[1]**.*

F4. (a) $^{67}_{29}\text{Cu} - \beta$ emission;
$^{67}_{29}\text{Cu} \rightarrow ^{67}_{30}\text{Zn} + ^{0}_{-1}\text{e}$;

$^{147}_{62}\text{Sm} - \alpha$ emission;
$^{147}_{62}\text{Sm} \rightarrow ^{143}_{60}\text{Nd} + ^{4}_{2}\text{He}$;
Accept these alternatives for the final ***[2]*** *marks.*

positron emission;
$^{147}_{62}\text{Sm} \rightarrow ^{147}_{61}\text{Pm} + ^{0}_{+1}\text{e}$;

OR

electron capture;
$^{147}_{62}\text{Sm} + ^{0}_{-1}\text{e} \rightarrow ^{147}_{61}\text{Pm}$; ***[4]***

(b) $k = 0.693 / 4.47 \times 10^{9} \text{ year}^{-1} = 1.55 \times 10^{-10} \text{ year}^{-1}$;

$$t = \frac{\ln(\frac{100}{15})}{1.55 \times 10^{-10}} = 1.22 \times 10^{10} \text{ years};$$ ***[2]***

F5. *High level*
Source: spent fuel / nuclear industry/reprocessing of spent fuel;

Low level
Source: protective clothing / coolant from nuclear power plants / radioisotopes from hospitals;

high level longer half-life / low level short half-life;
high level (radio) activity level high / low level (radio) activity low; ***[4]***

Option G – Modern analytical chemistry

G1. (a) (i) UV – Visible spectroscopy / colorimetry / atomic absorption spectroscopy/AAS; ***[1]***

(ii) IR spectroscopy / iodine titration; ***[1]***

(iii) gas-liquid chromatography/GLC / gas chromatography/GC / UV – visible spectroscopy; ***[1]***
No mark just for chromatography.

(b) *Any two of the following.*
protons/hydrogen atoms in water, lipids (etc) in body can be detected by magnetic resonance imaging/MRI;
different water-lipid ratios / hydrogen atoms in different chemical environments absorb different (radio) frequencies;
giving a two/three dimensional view of body organs; ***[2 max]***

(c) *absorption spectra*:
the absorption of a photon/quantum of energy by an atom/molecule / absorption of specific frequencies/wavelength of light;
(to achieve an) excited state/electrons move from lower to higher energy level;

emission spectra:
energy is emitted by an excited atom/molecule / emission of specific frequencies/wavelength of light;
as it returns to its lower/ground state / electrons move from higher to lower energy level; ***[4]***
No mark for stating Balmer or Lyman series.

G2. (a) 2; ***[1]***

(b) (i) CH_3 0.9 (ppm);
CH_2 3.8 (ppm); ***[2]***
Units are not required for mark.

(ii) 3 : 2 / 6 : 4; ***[1]***

(iii) CH_3 triplet;
CH_2 quartet/quadruplet; ***[2]***

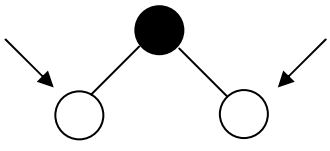
(c) ^1H NMR of butan-2-one will have 3 peaks (whereas ethoxyethane has 2);
ratio of peaks for butan-2-one 3 : 2 : 3 (ethoxyethane 3 : 2 / 6 : 4);
butan-2-one has a singlet peak;
butan-2-one has a peak at $\delta = 2.1$ ppm; ***[1 max]***
*Award **[1]** for any above.*

(d) tetramethylsilane / TMS;
to calibrate the instrument / as a reference / standard; ***[2]***

(e) ethoxyethane will have an absorption between 1000 to 1300 cm^{-1} for the C–O–C;
butan-2-one will have an absorption between 1680 to 1750 cm^{-1} for the C=O; ***[2]***

G3. (a) bending and stretching of bonds;
for absorption to occur there must be a change in dipole moment / polarity of the molecule;
diagram of H_2O demonstrating asymmetric / symmetric stretching;
e.g.

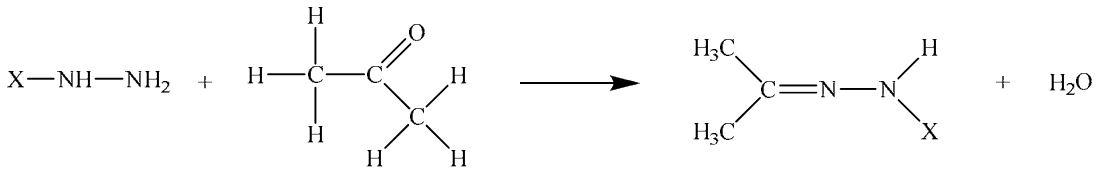
diagram of H_2O demonstrating bending; ***[4]***
e.g.



(b) inverse/reciprocal relationship / inversely proportional / wavelength $= \frac{1}{\text{wavenumber}}$; ***[1]***

Option H – Further organic chemistry

H1. (a) *Reaction of 2,4 – dinitrophenylhydrazine and propanone to produce corresponding 2,4 – dinitrophenyhydrazone and water.*



[2]

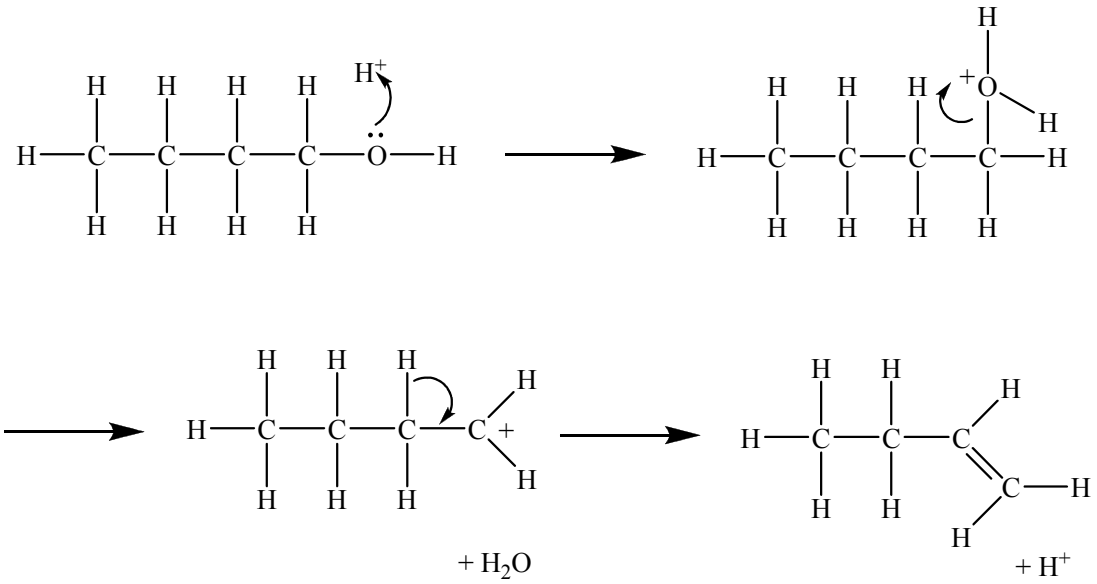
*Award **[1]** for the reactants and **[1]** for the organic product.*

(b) addition-elimination reaction / condensation reaction; ***[1]***

(c) ketone and aldelyde derivatives of 2,4- dinitrophenylhydrazine have different melting points; ***[1]***

H2. (a) <u>concentrated</u> acid / H_2SO_4 / H_3PO_4 and heat / high temperatures /150°C – 200°C; ***[1]***
*Both a reference to the acid and temperature are needed for **[1]**.*

(b) *Mechanism of dehydration of butan-1-ol to produce but-1-ene.*



lone pair on O and curly arrow to proton;
curly arrow from C–O bond to O (to form water);
curly arrow from C–H bond to C–C bond (to form double bond);
carbocation intermediate;
correct organic product; ***[5]***

(c) tertiary intermediate carbocation is more stable;
due to the positive inductive effect / electron releasing alkyl groups / *OWTTE*; ***[2]***

H3. (a) 2-chloro-methylpropane > 1-chorobutane > chlorobenzene;
tertiary halogenoalkanes react faster than primary halogenoalkanes;
chlorobenzene reacts the slowest because non-bonded/lone pairs of electrons on the chlorine delocalize with the electrons in the benzene ring / delocalized electrons from the benzene ring repel nucleophiles; ***[3]***

(b) the rate of reaction would decrease;
OH^- has a greater electron density than NH_3 / ammonia is a poorer nucleophile / OH^- has a negative/anoinic charge while NH_3 is neutral / NH_3 is a weak base so $[OH^-]$ would be lower; ***[2]***

(c) there is not enough room for five bulky groups around the central atom in the transition state / steric hindrance/crowding; ***[1]***

H4. UV radiation breaks the C–Cl bond in chloroalkanes;

Resultant chain reaction:
$RCH_2Cl(g) \rightarrow RCH_2\bullet + Cl\bullet$ (initiation);
$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2 / ClO\bullet + O_3 \rightarrow Cl\bullet + 2O_2$ (propagation);
$2O_3 \rightarrow 3O_2$ / a termination step; ***[4]***
Accept radicals without dots.
No mark just for ozone concentration decreases.

H5. A. chloroethanoic acid is more acidic / lower pK_a due to the (negative) inductive effect of chlorine / chlorine is more electronegative / anion is more stable;
B. trichloroethanoic acid has three chlorine atoms increasing the (negative) inductive effect;
C. iodine is less electronegative reducing the (negative) inductive effect; ***[3]***

Or accept converse arguments.