M10/4/CHEMI/SP3/ENG/TZ1/XX/M+

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MARKSCHEME

May 2010

CHEMISTRY

Standard Level

Paper 3

18 pages

Subject Details: Chemistry SL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the options **[2 × 20 marks]**. Maximum total = **[40 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 markscheme, 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 A — Modern analytical chemistry

A1. (a) (i) (2-)methylpropan-2-ol;
the (H atoms in the three) $–CH_3$ groups are responsible for the peak at 1.3 ppm;
the –O**H** hydrogen atom is responsible for the peak at 2.0 ppm; ***[3]***
Accept explanations with suitable diagram.

(ii) (2-)methylpropan-1-ol;
the first peak (at 0.9 ppm) is due to the (H atoms in the) two $–CH_3$ groups (bonded to the second carbon atom) / $(C\mathbf{H_3})_2CHCH_2OH$;
the peak at 3.4 ppm is due to the (H atoms in the) $–CH_2–$ group / $(CH_3)_2CHC\mathbf{H}_2OH$; ***[3]***
Accept explanations with suitable diagram.

(b) (i) butan-1-ol and butan-2-ol;

74: M^+ / $C_4H_{10}O^+$ / $CH_3CH_2CH_2CH_2OH^+$ **and** $CH_3CH_2CH(OH)CH_3^+$;

59: $C_3H_7O^+$ / $(M – CH_3)^+$ / $CH_2CH_2CH_2OH^+$ **and** $CH_2CH(OH)CH_3^+$/$CH_3CH_2CH(OH)^+$;

45: $C_2H_5O^+$ / $(M – C_2H_5)^+$ / $CH_2CH_2OH^+$ **and** $CH(OH)CH_3^+$; ***[4]***
Accept explained answers instead of formulas.

(ii) butan-1-ol;
CH_2OH^+ / $(M – C_3H_7)^+$; ***[2]***
Penalize missing + signs once only in parts (b) (i) and (ii).

(c) they all contain O–H;
they all contain C–H;
they all contain C–O; ***[2 max]***
*Award **[1 max]** for same functional groups/bonds.*

A2. (a) identification of (named) metal in blood/soil/food; ***[1]***

(b) *The fuel*
to form a combustion mixture / to produce heat;

The atomizer
turns all the ions in the sample into atoms / *OWTTE*;

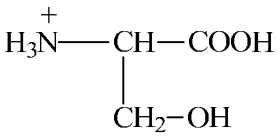
The monochromatic light source
provides light that is absorbed by the lead/metal to be detected / provides light from excited atoms of lead/metal being detected; ***[3]***

(c) concentration of Pb^{2+} from graph = 1.15 (mg dm^{-3});
Allow between 1.13 and 1.17 mg dm^{-3}.

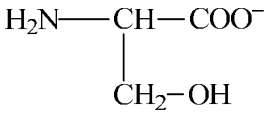
original concentration $= 1.15 \times \frac{7.5}{100} = 8.63 \times 10^{-2}$ (mg dm^{-3}); ***[2]***

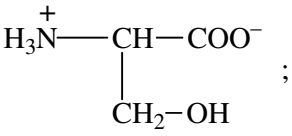
Allow ECF from $[Pb^{2+}]$.

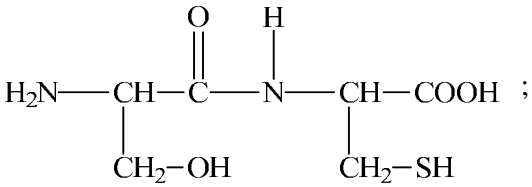
Option B — Human biochemistry

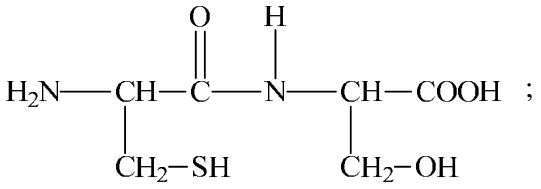
B1. (a) (i)  ; ***[1]***

If R– used or incorrect amino acid structure chosen from data booklet apply ECF for subsequent answers.

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

(b)  ; ***[1]***

(c)  ;

 ; ***[2]***

Accept –CO–NH–/–CO–HN– for peptide linkage.

(d) van der Waals attraction between non polar groups;
ionic bonding between charged groups/NH_3^+ and COO^-;
hydrogen bonding between H bonded to O or N with another O or N;
disulfide bridges/bonds between two S atoms (in cysteine);
peptide linkages/bonds between –COOH and $–NH_2$ groups; ***[5]***
*If no examples given, award **[2 max]** for 4 or 5 interactions and **[1 max]** for 2 or 3 interactions.*

B2. (a) *Beriberi*
lack/deficiency of vitamin B_1/thiamine;

Goitre
lack/deficiency of iodine;

Pellagra
lack/deficiency of vitamin B_3/niacin; ***[3]***

(b) providing food rations containing fresh foods rich in vitamins and minerals;
providing nutrient supplements;
genetic modification of food;
adding nutrients missing to commonly consumed foods;
educating the population in healthy eating; ***[3 max]***

B3. (a) the number of grams/mass of iodine that add to/react with 100 g of the fat/lipid/oil; ***[1]***

(b) amount of linoleic acid $= \frac{1}{281} = 0.00356$ (mol);
amount of I_2 required $= 2 \times 0.00356 = 0.00712$ (mol);
volume of 1.00 mol dm^{-3} solution = 7.12 cm^3/0.00712 dm^3;

OR

281 g of acid require 507.6 g of iodine;
1 g of acid requires 1.806 g/0.00712 mol of iodine;
volume of 1.00 mol dm^{-3} solution = 7.12 cm^3/0.00712 dm^3; ***[3 max]***

*Award **[3]** for correct final answer.*

Option C — Chemistry in industry and technology

C1. (a) Al is more reactive than Fe / Al is higher than Fe in the reactivity series;
it is harder to reduce aluminium ores compared to iron ores / Fe^{3+} is a better oxidizing agent than Al^{3+} / *OWTTE*; ***[2]***

(b) (i) $Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$; ***[1]***

(ii) $Fe_3O_4 + 4H_2 \rightarrow 3Fe + 4H_2O$; ***[1]***

(c) steel has more desirable (physical) characteristics than iron / steel is stronger than iron / *OWTTE*;
by adjusting the composition of steel it can be given specific properties / *OWTTE*; ***[2]***

(d) *Positive electrode*
graphite/carbon;

Negative electrode
graphite/carbon (on a steel liner); ***[2]***

(e) much less energy required to recycle than to produce Al from ore / *OWTTE*;
less production of CO_2/greenhouse gases (graphite used in the electrolysis is converted into CO_2) / the more that is recycled the less there will be in landfill sites / *OWTTE*; ***[2]***

C2. (a) in HDPE there is little branching / in LDPE there is branching/side chains;
long chains can pack closely together/have greater forces of attraction so (HDPE) is more dense/more rigid/stronger;
side chains make (LDPE) more flexible/ideal for film products (such as food wrapping); ***[3]***
Accept opposite statements for marking points 2 and 3.

(b) makes the polymer low density/good thermal insulator/expanded/softer/better shock absorber;
packaging/insulation; ***[2]***
*Award **[1 max]** if thermal insulation given for both answers.*

C3. (a) homogeneous catalysts are in the same phase/state as the reactants and heterogeneous catalysts are in a different phase/state to the reactants; ***[1]***

(b) *Advantage*
often works faster / all the catalyst is exposed to the reactants / *OWTTE*;

Disadvantage
difficult to remove the catalyst from the products / more limited range of acceptable catalysts; ***[2]***

(c) efficiency;
ability to work under a variety of conditions;
environmental impact;
problems with the catalyst becoming poisoned (by impurities); ***[2 max]***

Option D — Medicines and drugs

D1. (a) prostaglandins are involved in the transmission of pain impulses (to the brain) / *OWTTE*; ***[1]***

(b) morphine (temporarily) bonds to/inhibits receptor sites in the brain (without depressing central nervous system) / *OWTTE*; ***[1]***

(c) causes blood disorders;
causes damage to kidney;
causes damage to liver;
causes damage to brain; ***[2 max]***

(d) preventing (recurrence of) heart attacks/strokes / reduces blood clotting / thins the blood / anti-inflammatory; ***[1]***

(e) (i) phenol / alcohol / hydroxyl; ***[1]***

(ii) ester; ***[1]***

(f) *tolerance:* more of the drug needs to be taken to achieve the initial effect / *OWTTE*;
in order to achieve the desired effect heroin users may reach/exceed the lethal dose / heroin users are more likely to commit crimes to pay for gradually increasing doses of the drug / *OWTTE*; ***[2]***

D2. (a) penicillins interfere with the enzymes that bacteria need to make cell walls / interfere with formation of bacterial cell wall / *OWTTE*;
the increased osmotic pressure causes the bacterium to die / the bacterial cells absorb too much water and burst / *OWTTE*; ***[2]***

(b) resistant to penicillinase enzyme / more resistant to bacteria breaking it down / effective against bacteria which are resistant (to penicillin G);
resistance to breakdown by stomach acid (so can be taken orally) / *OWTTE*; ***[2]***

(c) bacteria which cause TB are extremely resistant to penicillins so a mixture of different antibacterials is used / *OWTTE*; ***[1]***

D3. (a) (i) $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$;
Accept H_2CO_3 instead of H_2O and CO_2.

$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$; ***[2]***

(ii) $n(NaHCO_3) = 1.19 \times 10^{-2}$ mol;
$n(Mg(OH)_2) = 8.57 \times 10^{-3}$ mol;
$Mg(OH)_2$ reacts with twice the number of moles of acid / is more effective than $NaHCO_3$ / *OWTTE*; ***[3]***

(b) produce a neutralizing layer/(foam) barrier which prevents heartburn/acid rising into the esophagus; ***[1]***

Option E — Environmental chemistry

E1. (a) *Carbon monoxide*
incomplete combustion of fossil fuels;

Oxides of nitrogen
combination of nitrogen and oxygen at high temperatures (inside an internal combustion engine); ***[2]***

(b) hot gases passed over a catalyst of Pt/Rh/Pd / gases adsorbed onto surface of metal;
$2CO + 2NO \rightarrow 2CO_2 + N_2$; ***[3]***
*Award **[1]** for correct reactants and products and **[1]** for correctly balancing.*

(c) volatile organic compounds/VOCs; ***[1]***

(d) electrostatic precipitation;
charged particles attracted to electrodes which are periodically shaken / *OWTTE*;

OR

wet scrubbers;
water spray washes particulates from exhaust gases;

OR

cyclone extractors;
particulates removed by spinning/vortex of air; ***[2]***

E2. (a) *Advantage*
reduce volume / stable odour-free residue / source of energy;

Disadvantage
expensive to build and operate / can form dioxins/toxic gases / requires energy / adds to greenhouse effect; ***[2]***

(b) low activity **and** short half-life;
materials (*e.g.* gloves, paper towels, clothes) that have been in proximity to radioactivity / any named source (such as smoke detectors); ***[2]***

(c) *methods:*
vitrification / encasing in concrete / burying in <u>deep</u> places;

problems: [2 max]
may leak into water table;
remains active for a very long time;
geological instability (*e.g.* earthquakes);
potential weapon for terrorists; ***[3 max]***

E3. (a) *Formation*
$O_2 \rightarrow 2O\bullet$ **and** $O_2 + O\bullet \rightarrow O_3$;

Depletion
$O_3 \rightarrow O_2 + O\bullet$ **and** $O_3 + O\bullet \rightarrow 2O_2$; ***[2]***

(b) *advantage:*
do not contain a C–Cl bond / do not form radicals in ultraviolet light / do not react with ozone;

disadvantages:
flammable / less efficient solvent than CFCs;
contribute to global warming/greenhouse gas/absorb infrared radiation; ***[3]***

Option F — Food chemistry

F1. (a) a food is a substance intended for (human) consumption;
a nutrient is obtained from food **and** used by the body to provide energy/regulate growth/maintain and repair body tissues; ***[2]***

(b) they have the empirical formula CH_2O;
they contain <u>one</u> carbonyl/C=O group;
they contain at least two hydroxy/–OH groups; ***[3]***

(c) condensation reaction;
(NH_2 of) amino acid/protein/peptide;
(CHO of) reducing sugar/glucose/lactose;
presence of lysine gives the most brown colour;
presence of cysteine gives the least brown colour; ***[3 max]***

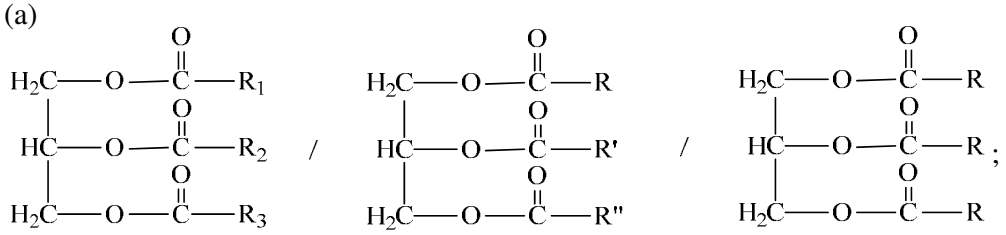
F2. (a) pigments absorb visible light;
and scatter/reflect/transmit the remaining light; ***[2]***

(b) (i) no effect as it lies outside the visible region/is in the UV / *OWTTE*; ***[1]***

(ii) the colour will be the complementary colour to the colour absorbing at 530 nm / it will be red as 530 nm is blue-green / *OWTTE*; ***[1]***

(c) oxidation;
temperature;
pH/acidity/basicity;
presence of metal ions; ***[2 max]***

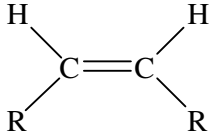
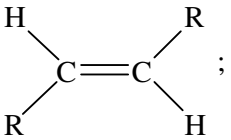
F3. (a)



saturated fatty acids contain only single bonds between carbon atoms/C–C whereas unsaturated fatty acids contain at least one double bond between carbon atoms/C=C / *OWTTE*; ***[2]***

(b) the double (C=C) bond in unsaturated fats causes a "kink" so the molecules cannot pack so closely / *OWTTE*;
the weaker van der Waals/intermolecular forces between the molecules cause unsaturated fats to have lower melting points; ***[2]***

(c) *Difference*
in *cis* the R groups on either side of the C=C point in the same direction **and** in *trans* the R groups point in opposite directions / *OWTTE* /

cis  **and** *trans*  ;

Disadvantage
hard to metabolize;
accumulate in fatty tissue;
difficult to excrete;
increase levels of LDL;
not a good source of energy; ***[2 max]***
*Award **[1]** for any one of the above points.*

Option G — Further organic chemistry

G1. (a) $C_2H_5MgBr + H_2O \rightarrow C_2H_6 + Mg(OH)Br$ ***[2]***

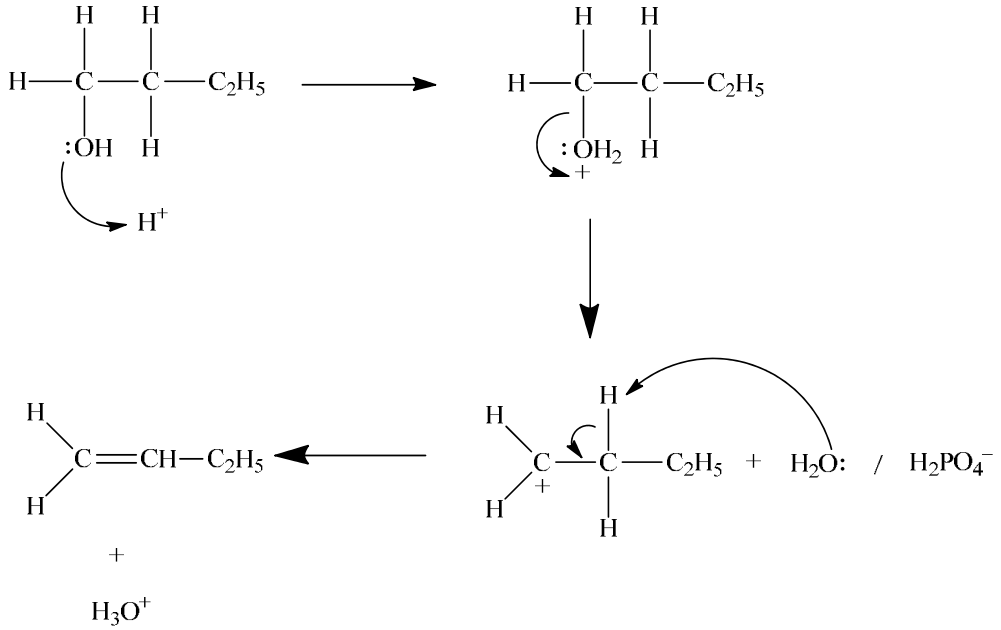
*Award **[1]** for C_2H_6 and **[1]** for correct equation.*

(b) (i) butan-2-ol/2-butanol;
$CH_3CH_2CH(OH)CH_3$; ***[2]***

(ii) 2-methylbutan-2-ol;
$C_2H_5C(CH_3)_2OH$; ***[2]***

(c) (i) but-1-ene/1-butene; ***[1]***

(ii)



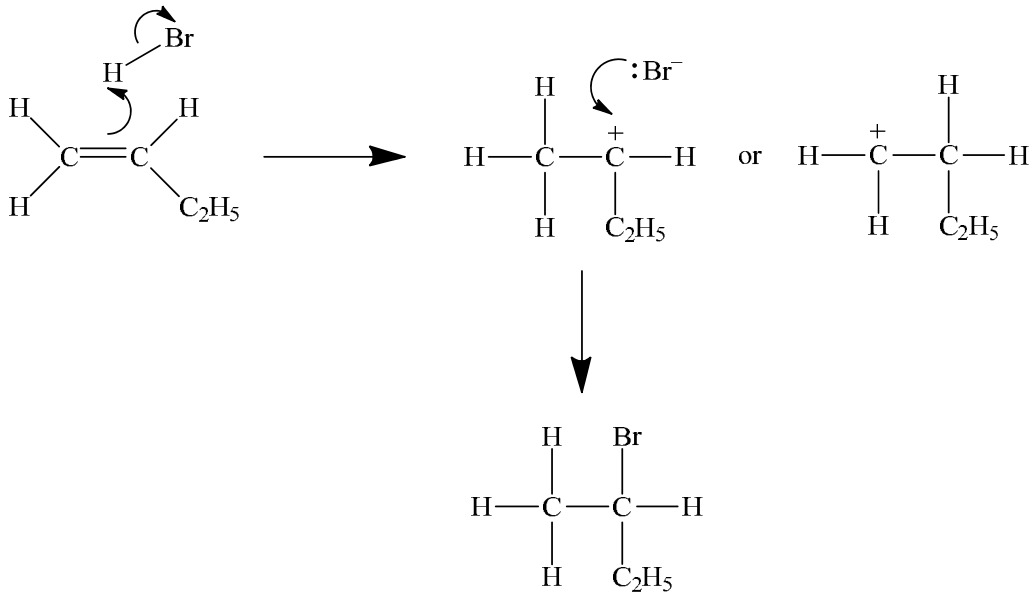
curly arrow going from lone pair on O to H^+;
representation of positively charged O intermediate **and** curly arrow showing H_2O leaving;
curly arrow going from lone pair on O of $H_2O/H_2PO_4^-$ to H **and** curly arrow going from CH bond to C–C^+ to form C=C; ***[3]***
No mark awarded if C^+ is not represented.

G2. (a) as the bromine approaches the alkene an induced dipole is formed / *OWTTE*; ***[1]***

(b) (i) 2,3-dibromobutane; ***[1]***

(ii) 2-bromobutane; ***[1]***

(c)



showing curly arrow from double bond to H (in H–Br) **and** curly arrow from bond in H–Br to Br;
showing the curly arrow from the lone pair/negative charge on Br^- to the secondary carbocation **and** 2-bromobutane as correct product;
stating that the secondary carbocation will be formed in preference to the primary carbocation;
the two positive/electron releasing inductive effects due to the two R– groups on the secondary carbocation make it more stable; ***[4]***

G3. (a) the C–C bond lengths are all the same;
IR absorption of C–C bonds in benzene is different to that of both C–C single bonds and C=C double bonds;
chemical shift of protons in benzene is different to that of protons in alkenes;
only one isomer exists for 1,2-disubstituted benzene compounds; ***[2 max]***
Do not accept average bond enthalpy in benzene is between that of C–C and C=C.

(b) substitution rather than addition occurs / bromine is not decolourized (without a catalyst) *OWTTE*; ***[1]***