IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
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N06/4/CHEMI/HP3/ENG/TZ0/XX/M+

MARKSCHEME

November 2006

CHEMISTRY

Higher Level

Paper 3

19 pages

Subject Details: Chemistry HL Paper 3 Markscheme

General

- Each marking point has a separate line and the end is signified by means of a semicolon (;).
- 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 penalized. 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, penalize 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 penalize 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, penalize 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 penalizing 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 B – Medicines and drugs

B1. (a) (tertiary) amine; ***[1]***

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

(c) basic;
N atoms can accept H^+ ions from water / forms OH^- ions in the solution; ***[2]***

(d) anxiety;
irritability;
sleeplessness; ***[1 max]***
increase in urine output;
*Award **[1]** for any two.*

(e) increased heart rate;
increased blood pressure;
reduction in urine output; ***[1 max]***
*Award **[1]** mark for any two.*

(f) symphathomimetic drug mimics the effect of adrenaline / stimulates the sympathetic nervous system;
amphetamine/methamphetamine/speed/ecstasy; ***[2]***

B2. (a) $C_{16}H_{18}O_4N_2S$; ***[1]***
Accept elements in any order

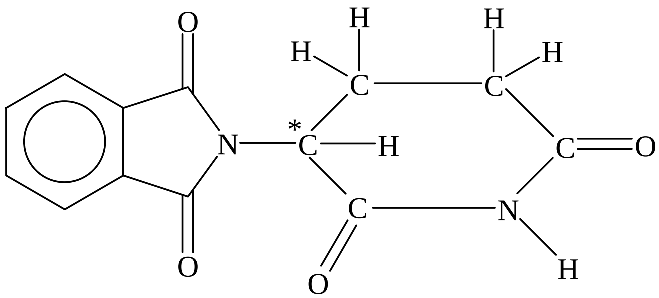
(b) prevents deactivation by stomach acid / more resistant to stomach acid;
prevents deactivation by the enzyme penicillinase (produced by bacteria) / increases resistance/tolerance to penicillinase; ***[2]***

(c) broad spectrum – effective against many types/strains of bacteria
and
narrow spectrum – effective only for certain type of bacteria; ***[1]***

(d) penicillin interferes with the cell wall formation;
cells can expand/burst/disintegrate / bacteria die; ***[2]***

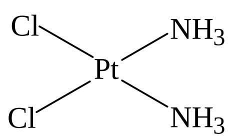
(e) makes penicillin less effective;
destroys useful/beneficial bacteria;
allows resistant population to build up; ***[2 max]***
*Award **[1]** each for any two.*

B3. (a) (i) correct identification of chiral carbon atom; ***[1]***

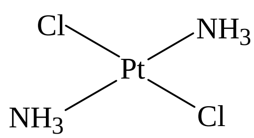


(ii) alleviates morning sickness in pregnant women;
causes deformities in the limbs of the fetus/birth defects/inhibits fetal growth; ***[2]***

(b) (i)



cisplatin



transplatin/isomer

; ***[1]***

*Award **[1]** for both structures.*
Do not award mark if labelled incorrectly.

(ii) geometrical isomerism because it exist as cis-trans forms / atoms/groups next to or opposite each other /*OWTTE*; ***[1]***

(iii) cisplatin and cancer; ***[1]***
Ignore type of cancer.

(c) (i) secondary; ***[1]***

(ii) LSD and psilocybin; ***[1]***

(d) tetrahydrocannabinol / THC; ***[1]***

Option C – Human biochemistry

C1. (a) *low pH*
C;
high pH
A; ***[2]***

(b) (i) place sample on gel;
with (buffer) solution of known pH;
apply voltage/potential difference;
Do not accept current applied.
develop / spray with ninhydrin;
measure distance moved / compare with known iso-electric point / compare with standards; ***[3 max]***
Award ***[1]*** *each for any three.*

(ii) *positive electrode*
glutamic acid;

negative electrode
arginine; ***[2]***

C2. 761.7 g of I_2 / 274÷253.8 = 1.08 mol;
3 mol of I_2 / 6 mol of I atoms / 100÷278 = 0.360 mol;
(1.08÷0.360 =) 3 double bonds; ***[3]***
Some correct working must be shown.
Allow ecf if M_r *of iodine used as 126.9 instead of 253.8.*
Accept correct alternative methods.

C3. (a) recovery from injury/surgery/starvation/illness/disease;
increased rate of protein synthesis / tissue/muscle building / increase in muscle mass; ***[2]***

(b) enhances performance/strength unfairly; ***[1]***

(c) mimics the action of progesterone in pregnancy;
prevents release of the egg / no ovulation;
prevents release of FSH and LH by the pituitary gland; ***[2 max]***
Award ***[1]*** *each for any two.*

C4. (a) (i) substrate concentration at which the reaction rate is one half the maximum rate ($1/2\ V_{max}$);
higher the value of K_m, lower the activity of enzyme / lower the value of K_m, higher the activity of enzyme/*OWTTE*; ***[2]***

(ii) 5/5.1 ($mmol\ dm^{-3}$); ***[1]***

(iii) *competitive* K_m increases;
more substrate needed to reach $1/2\ V_{max}$ so K_m is higher / reaction is slower due to active sites being occupied by inhibitor/OWTTE;

non- competitive K_m remains the same;
no effect on the way the substrate interacts with uninhibited enzyme / increasing substrate concentration has no effect on inhibited enzyme / inhibitor changes enzyme shape, so although V_{max} decreased K_m is still based on half of new V_{max} / OWTTE; ***[4]***

(b) (i) glucose – oxidation;
oxygen – reduction; ***[2]***

(ii) $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$; ***[1]***
Accept $Cu^{2+} + e \rightarrow Cu^+$ *or* $Fe^{3+} + e \rightarrow Fe^{2+}$.

Option D – Environmental chemistry

D1. (a) rain with pH less than 5.6; ***[1]***

(b) HNO_3 /HNO_2/ nitric acid/nitrous acid;
H_2SO_4 / H_2SO_3 / sulfuric acid / sulfurous acid;
(NO) high temperature in internal combustion/jet engine / reaction between N_2 and O_2 at high temperature;
(SO_2) from burning of coal / smelting plants / sulfuric acid plants; ***[4]***
Do not accept combustion of fossil fuels.

(c) $SO_2 + H_2O \rightarrow H_2SO_3$ / $SO_3 + H_2O \rightarrow H_2SO_4$ / $2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$ /
$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$; ***[1]***

D2. (a) earths temperature may be increased / global warming / thermal expansion of ocean / melting of polar icecaps / coastal flooding; ***[1]***
Do not accept greenhouse effect but increased greenhouse effect is acceptable.

(b) dissolving in H_2O / photosynthesis / absorbed by green plants;
$CO_2 + H_2O \rightarrow H_2CO_3$ / $H^+ + HCO_3^-$ / $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$; ***[2]***

D3. (a) aeration / adding O_2 /air;
bacteria / microbes; ***[2]***

(b) detergents / washing powder; ***[1]***

(c) precipitation;
$Pb^{2+}(aq) + H_2S(aq) \rightarrow PbS(s) + 2H^+(aq)$;
$PO_4^{3-}(aq) + Al^{3+}(aq) \rightarrow AlPO_4(s)$ / $2PO_4^{3-}(aq) + 3Ca^{2+}(aq) \rightarrow Ca_3(PO_4)_2(s)$; ***[3]***
Ignore state symbols.
Accept ionic equation for the first marking point.

D4. (a) oxides of nitrogen/ NO/NO_x ;
hydrocarbons/HCs;
(NO) high temperature in the internal combustion/jet engine / (HCs) evaporation / incomplete combustion; ***[3]***
Do not accept NO_2.

(b) R–CHO/aldehyde;
$R{-}CO_3NO_2$ /PANs;
$R{-}CH_2O + O_2 \rightarrow R{-}CHO + HO_2$ / $R{-}CH_2 + O_3 \rightarrow R{-}CHO + HO_2$ /
$R{-}CO_3 + NO_2 \rightarrow R{-}CO_3NO_2$; ***[3]***
Accept any other correct equation.

(c) mercury – batteries/seed dressing to prevent mould/mercury cell in chlor-alkali industry;
Minamata disease / mental disorder/paralysis;

nitrates – leaching of nitrate fertilizers into water/animal waste from intensive farming;
forms carcinogens / blue baby syndrome/methaemoglobinaemia; ***[4]***

Option E – Chemical industries

E1. (a) $H_2S(g) + CO_3^{2-}(aq) \rightleftharpoons HS^-(aq) + HCO_3^-(aq)$; ***[1]***

Ignore state symbols and reversible sign.

(b) (i) (crude oil) vaporized/heated;
rises up a column/tower;
temperature gradient;
lighter fractions/smaller molecules condense higher up / heavier fractions condense lower down;
mixture separated due to difference in boiling points;
vapour phase is always richer in the more volatile component; ***[4 max]***
*Award **[1]** each for any four.*

(ii) (non polar molecules with) only weak van der Waals/London/dispersion/ intermolecular forces; ***[1]***

(c) $C_{16}H_{34} \rightarrow C_8H_{18} + C_8H_{16}$; ***[1]***

E2. (a) HDPE;
no/very few branches;
chains pack closer together;
stronger intermolecular forces; ***[4]***
Allow converse argument e.g. LDPE has more branches, so its chains are further apart and the intermolecular forces are weaker.

(b) *named polymer 1*
plasticizers added to polyvinyl chloride;
polymer chains become more flexible;

named polymer 2
volatile hydrocarbons in the formation of expanded polystyrene;
reduced density / light, very good thermal insulator;

named polymer 3
air in the manufacture of polyurethane foams;
low-density foam; ***[4 max]***
*Award **[2]** each for any two polymers.*

E3. (a) LDP
high temperature / high pressure;
peroxide / O_2;
free radical mechanism;

HDP
low temperature / low pressure;
Ziegler-Natta catalyst / $TiCl_4$ / $TiCl_3$;
ionic mechanism;
*Award **[4]** for 6 correct, **[3]** for 4,5 correct, **[2]** for 2,3 correct, **[1]** for 1 correct.* ***[4 max]***

(b) (i) **positive electrode**
diaphragm cell $2Cl^- \rightarrow Cl_2 + 2e^-$ and mercury cell $2Cl^- \rightarrow Cl_2 + 2e^-$;

negative electrode
diaphragm cell $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$;
mercury cell $Na^+ + e^- + Hg \rightarrow Na/Hg$; ***[3]***
*Award **[1]** only for both equations at positive electrode.*
Ignore Hg in the equation.
Accept e instead of e^-.

(ii) asbestos;
allows (sodium chloride) solution ions to flow between the electrodes;
keeps Cl_2 and H_2 separated/stops OH^- ions being attracted to positive electrode; ***[3]***

Option F – Fuels and energy

F1. (a) atomic number 88;
mass number 222; ***[2]***

(b) 5 half-lives;
250 dpm; ***[2]***
*Award **[2]** for correct final answer.*

F2. (a) *disadvantages*
requires very high temperature / containment of reaction very expensive;

advantages
fuel deuterium is abundant and cheap;
small amount of radioactive waste; ***[3]***

(b) *advantages*
produces large amounts of energy;
consumes small amount of fuel;
produces little/no CO_2;
*Award **[2 max]** for advantages.*

disadvantages
production/storage of radioactive waste;
meltdown / loss of control / explosion;
high capital costs;
weapons of mass destruction; ***[4 max]***
*Award **[2 max]** for disadvantages.*

F3. (a) methane / CH_4;
anaerobic/bacterial decay of organic matter; ***[2]***

(b) enzyme (present in yeast);
absence of air/O_2; ***[2]***

(c) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$; ***[1]***

F4. (a) group 3 element/Ga/In has three outer electrons;
p type semi conductor / forms electron holes;
group 5 element/As/P has five outer electrons;
n type semi conductor / forms mobile electron;
sunlight interacts with the semiconductors to release electrons; ***[5]***

(b) (low level waste) short half-life / (high level waste) long half-life;
gloves / clothing and spent fuel rods; ***[2]***

(c) $K = 8.7 \times 10^{-4}$;
$t = 2.9 \times 10^{3}$ years; ***[2]***

Option G – Modern analytical chemistry

G1. (a) $C_3H_6O_2$; ***[1]***

(b) $C_3H_6O_2$ peak at 74 due to molecular ion/molar mass 74; ***[1]***

(c) 57 $CH_3CH_2CO^+/C_3H_5O^+$;
45 $COOH^+$ / $HCOO^+$ / $C_2H_5O^+$;
29 $C_2H_5^+/COH^+$; ***[3]***
Penalize once only if + charge is missing.

(d) A O–H;
B C=O;
C C–O; ***[2 max]***
Award ***[2]*** *for three correct,* ***[1]*** *for two correct and* ***[0]*** *for one correct answer.*

(e) $CH_3 — CH_2 — COOH$;
triplet, quartet, singlet;
$H — COO — CH_2 — CH_3$;
singlet, quartet, triplet;
$CH_3 — COO — CH_3$;
singlet, singlet; ***[6]***
Do not accept ratio of peak areas.
Accept other possible structures with correct splitting pattern.

(f) the acid / CH_3CH_2COOH ;
presence of –OH in the infrared spectrum; ***[2]***

G2. (a) (i) benzene-UV;
nitrobenzene-visible/UV of longer wavelength; ***[2]***

(ii) conjugated double bonds increases the delocalisation;
less energy needed / lower frequency of light absorbed; ***[2]***

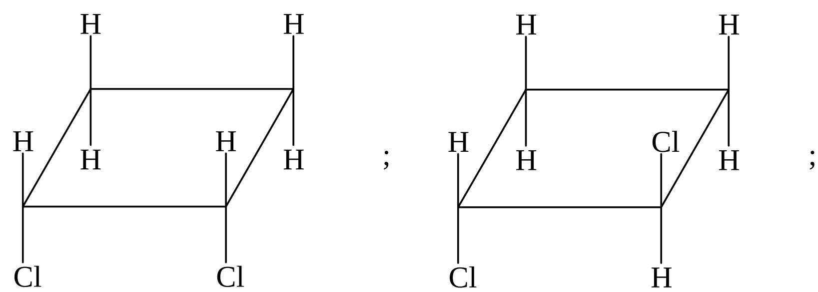
(iii) both have full d subshell of electrons /[Ar]$3d^{10}$;
no unpaired electrons / no splitting of d sublevel; ***[2]***

(b) (i) $[Cu(H_2O)_6]^{2+}$ / $[Cu(H_2O)_4]^{2+}$;
$[Cu(NH_3)_4(H_2O)_2]^{2+}$ / $[Cu(NH_3)_4]^{2+}$; ***[2]***
Do not penalize if square brackets missing.

(ii) Colour depends on energy difference/ΔE between split levels;
ammonia ligands produce greater ΔE than water ligands /
ammonia has a greater ability to split the d sub-level/different ligands cause the d sublevel to split by different amounts; ***[2]***

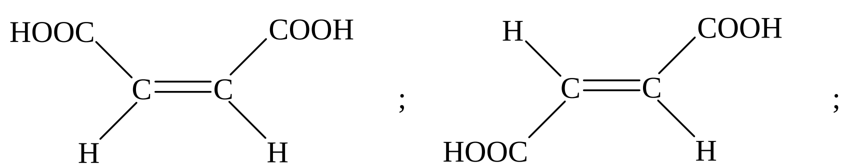
Option H – Further organic chemistry

H1. (a) restricted rotation because C–C bond is now part of a cyclic system; ***[3]***



*Award **[1]** for each correct 3D structure.*
*If correct structure, but not 3D, or wrongly labelled award **[1]** only.*
Accept 1,3-disubstituted cyclo compound, or any other correct isomer.

(b) (i)

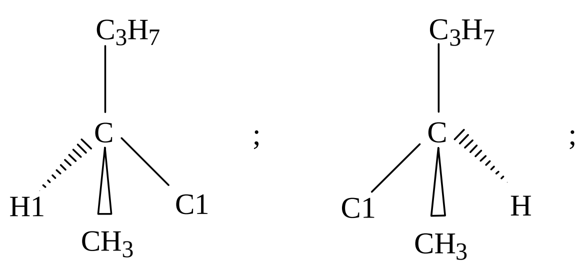


[2]

(ii) cis isomer (has lower melting point than the trans-isomer);
intramolecular hydrogen bonds / weaker intermolecular forces / less close packing; ***[2]***

(iii) (gentle) heating of a sample of each isomer;
cis isomer readily releases water vapour (forming a cyclic anhydride); ***[2]***

(c) (i) 2-chloropentane;



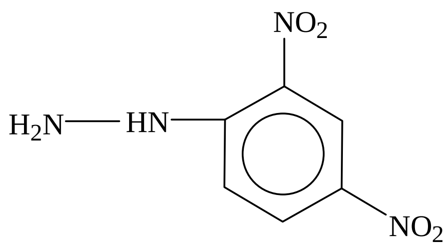
[3]

*Award **[1]** for each correct 3D structure.*
*If correct structures, but not 3D, award **[1]** only.*

(ii) rotation of the plane polarized light in opposite directions; ***[1]***

H2. (a) (i) react with 2,4-dinitrophenylhydrazine solution;
determine the melting points of the product; ***[2]***

(ii)



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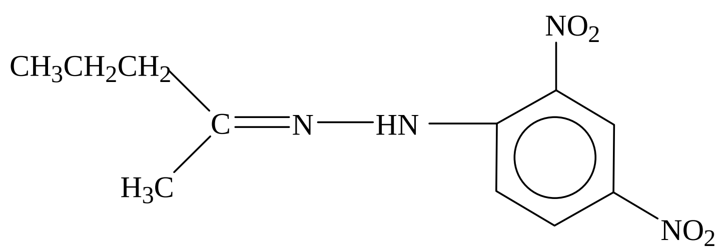
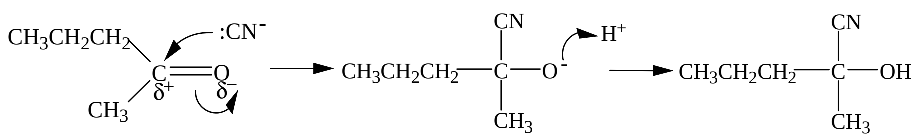


; ***[2]***

(b)



[4]

*Award **[1]** for each curly arrow and **[1]** for the final product.*

curly arrow from C of cyanide ion to C of carbonyl group;
curly arrow from C=O bond to O;
curly arrow from O to H^+;

H3. *2,2-dimethylpropanoic acid*
less acidic;
due to positive inductive effect of alkyl group / electron releasing alkyl group;

trichloroethanoic acid
more acidic;
due to negative inductive effect of Cl / electron withdrawing effect of Cl atom; ***[4]***