IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

M07/4/CHEMI/HP3/ENG/TZ0/XX/M

MARKSCHEME

May 2007

CHEMISTRY

Higher Level

Paper 3

21 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 that are <u>underlined</u> 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) (acidified)potassium dichromate(VI)/$K_2Cr_2O_7$ / $Cr_2O_7^{2-}$ is used which is reduced by/oxidises ethanol;
orange to green; ***[2]***

(b) infrared radiation is passed through breath (and reference sample);
(C–H bond in) ethanol causes radiation to be absorbed at a specific wavelength;
amount of absorption depends upon the amount of ethanol in the breath;
*Award **[1]** each for any two.*

OR

fuel cell;
ethanol is oxidised to produce electricity; ***[2 max]***

B2. (a) (both) contain <u>tertiary</u> amine;
(both) contain pyrole/ring structures with nitrogen atoms / heterocyclic ring;
both contain alkene group;
(only) caffeine has carbonyl/amide groups; ***[2 max]***
Do not accept ketone in place of carbonyl.
Do not accept different numbers of methyl groups.
*Award **[1]** each for any two.*

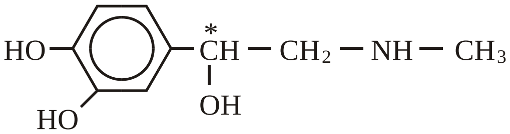
(b) both contain alkene group;
increased heart rate;
increased blood pressure/ restriction of blood vessels/ vascoconstrictor;
reduced urine output/ acts as an anti-diuretic;
increased concentration/alertness; ***[2 max]***
*Award **[1]** each for any two.*
Do not accept ketone in place of carbonyl.
Do not accept different numbers of methyl groups.

B3. (a) bacteria multiply by cell division/binary fission/mitosis;
viruses insert DNA/RNA/genetic material into cells; ***[2]***
*For "bacteria multiply by themselves but viruses require a host cell" / OWTTE award **[1]**.*

(b) block enzyme activity within host cell/block reverse transcriptase;
alter host cell's genetic material;
prevent virus from multiplying/replicating;
alter virus's binding site on cell wall / prevent virus binding with cell wall;
prevent virus from entering/leaving cell; ***[2 max]***
*Award **[1]** each for any two.*

(c) HIV virus mutates rapidly;
HIV metabolism linked to that of host cell/HIV uses host cell;
Drugs harm host cell as well as HIV/ difficult to target HIV without damaging host cell;
[2 max]

B4. (a) asymmetric/chiral carbon atom / 4 different groups around carbon atom/

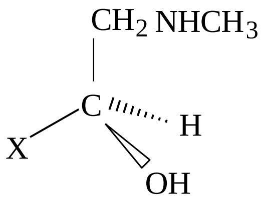


;

[1]

(b) one correct 3-D structure;
second structure clearly shown as correct isomer; **[2]**

e.g.



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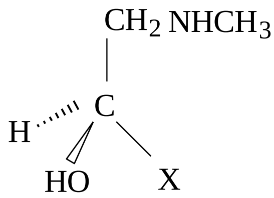
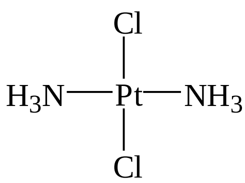


Accept diagrams that make it clear they are mirror images even though not perfect 3-D representations but must have the chiral carbon at the centre of the molecule.

(c) (i) covalent and coordinate/dative (covalent);
square planar;
90°; **[3]**

(ii)



;

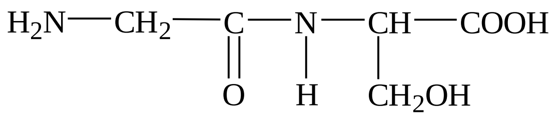
[1]

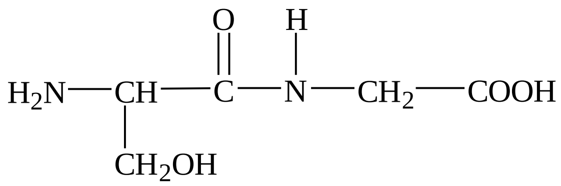
B5. (a) (local) block pain at site/in a particular area/where applied/injected / prevent formation of prostogladins;
(general) cause unconsciousness / block central nervous system / act on pain receptors in brain; **[2]**

(b) $(0.15 \times 105) \div (0.15+1.10)$;
= 12.6 (kPa); **[2]**
Units not needed, but penalise incorrect units –1(U).

Option C – Human biochemistry

C1. (a)





OR

[2]

*Award **[1]** for peptide bonds correctly shown in full and a further **[1]** if rest of structure correct.*
*If peptide bond abbreviated, eg –CO–NH– but structure otherwise correct, award **[1]**.*

(b) (i) (warm with dilute) hydrochloric acid;
to hydrolyse protein / to break it down into amino acids / to break the peptide bonds; ***[2]***

(ii) (mixture of) amino acids spotted on paper (and known amino acids spotted on paper);
water/solvent/eluent flows up/down paper;
amino acids separate because they have different solubilities in water/solvent/eluent and/or different adsorption on paper;
amino acid positions identified / sprayed with ninhydrin/locating agent;
locations compared with known amino acids /R_f values compared; ***[4 max]***

C2. (a) saturated have only single carbon to carbon/C–C bonds / unsaturated have double carbon to carbon /C=C bonds;
Do not award mark if no reference to carbon-carbon bonds.
saturated have a straight hydrocarbon chain / unsaturated have a kinked hydrocarbon chain / *OWTTE*; ***[2]***
Accept bond angle of 109(.5)° in saturated and 120° in unsaturated.

(b) chains pack closer together;
stronger intermolecular forces / van der Waals' forces; ***[2]***
Accept London forces and dispersion forces in place of van der Waals' forces.
Do not accept stronger hydrogen bonding.
Award [0] if any reference to breaking carbon-carbon bonds.

C3. (a) (testosterone)
testes;
development of male sex organs/characteristics / tissue/muscle/bone growth/ anabolic effect;

OR

(oestradiol)
ovaries;
ovulation / development of female sexual characteristics;

OR

(progesterone)
ovaries;
prepares uterus for fertilized egg; ***[2]***

(b) (adrenaline / epinephrine)
adrenal glands;
regulates body's preparation for stress / *OWTTE*;

OR

(thyroxine)
thyroid gland;
regulates body's metabolism;

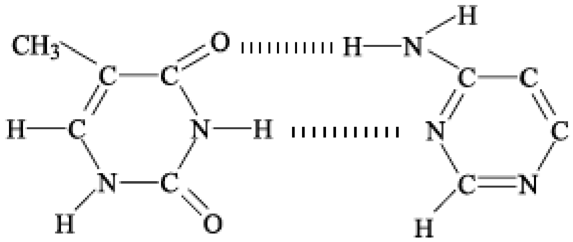
OR
(Insulin)
pancreas / Islets of Langerhans;
Regulation of glucose concentration in bloodstream/ regulates blood sugar levels; ***[2]***

C4. (a) enzyme has an active site that substrates bind to;
substrate reacts (to form products);
products leave active site;
provides an alternative pathway with a lower activation energy;
explanation of lock and key hypothesis / induced fit hypothesis; ***[3 max]***

(b) rate increases at first/up to maximum;
more reactant molecules have energy greater than E_a / more frequent collisions;
rate decreases after maximum / optimum temperature;
enzyme becomes denatured / 3-D/tertiary structure breaks down/ quaternary structure changes/ active site affected;

[4]

C5.



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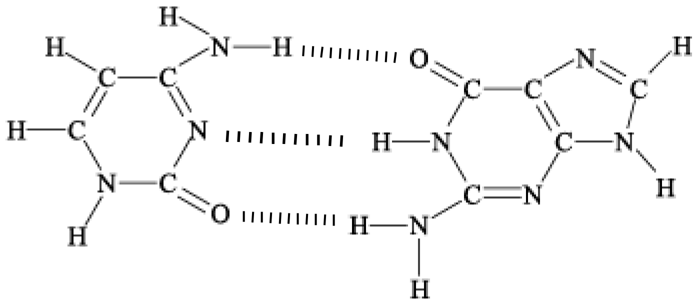


;

[2]

Option D – Environmental chemistry

D1. (a) (i) visible; ***[1]***
Ignore references to ultraviolet and infrared.

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

(iii) bonds in molecule/gas stretch/bend/vibrate/change in bond angle; ***[1]***

(iv) more carbon dioxide in step III;
Accept CH_4, CFCs, H_2O, N_2O or SF_6.

because of large scale/increase in burning fossil fuels;
so more infrared radiation/heat radiated back to earth's surface;
If gas other then CO_2 identified accept correct reason for its increase. ***[2 max]***
Accept either of above for 2^{nd} mark.

(b) carbon dioxide is more abundant (than methane);
methane (molecule) is better/more effective at absorbing/reradiating (infrared) radiation; ***[2]***

D2. (a) 4.2 **and** 5.2; ***[1]***

(b) SO_2 / SO_3 / NO_2;
Accept names, do not accept NO or NO_x.
$SO_2 + H_2O \rightarrow H_2SO_3$ / $SO_3 + H_2O \rightarrow H_2SO_4$ / $2SO_2 + O_2 + 2H_2O \rightarrow 2H_2SO_4$ /
$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$ /$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$; ***[2]***

(c) (SO_2/SO_3)
alkaline scrubbing;
removal of sulfur from coal before burning;
use of limestone to react with SO_2/SO_3;
fluidized bed combustion of coal;
less energy wastage/ use of alternative /renewable energy sources;
Do not accept washing or filtering.
*Award **[1]** each for any two.*

OR

(NO_2)
catalytic converter;
exhaust gas recirculation/ thermal exhaust reactor;
lean-burn engine / increase air:fuel ratio;
use of electric cars/greater use of public transport; ***[2 max]***
*Award **[1]** each for any two.*

If CO_2 identified in part b) ECF cannot be applied

D3. (a) amount of oxygen needed to decompose organic matter/waste;
in specified time/5 days/at a specified temperature/20°C; ***[2]***

(b) (i) B because the amount/concentration (of oxygen) is less; ***[1]***

(ii) addition of sewage/organic waste / increase in temperature; ***[1]***

D4. (a) nitrogen monoxide/nitrogen(II) oxide/nitric oxide **and** primary;
high temperature in the internal combustion / jet engine / lightening; ***[2]***

(b) ethanal **and** secondary;
(free) radical;
unpaired (outer) electron; ***[3]***

D5. $CCl_3F \rightarrow CCl_2F\bullet + Cl\bullet$;
$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$;
$ClO\bullet + O\bullet \rightarrow O_2 + Cl\bullet$;
$Cl\bullet$ (from CFC) used in step 2 regenerated in step 3 / OWTTE; ***[4]***
Accept equations without $\bullet$ *symbol.*
Do not accept $ClO\bullet + O_3 \rightarrow 2O_2 + Cl\bullet$.

Option E – Chemical industries

E1. coke/carbon/C **and** limestone/calcium carbonate/$CaCO_3$;

(coke)
to produce heat;
$C + O_2 \rightarrow CO_2$;

OR

to act as a reducing agent / to produce carbon monoxide;
$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$ / $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$ / $C + CO_2 \rightarrow 2CO$;

(limestone)
to remove impurities/silica;
$CaCO_3 \rightarrow CaO + CO_2$ **and** $CaO + SiO_2 \rightarrow CaSiO_3$ / $CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$; ***[5]***

E2. (a) 90%-to burn / produce energy/heat / as fuels;
10%-main source of organic chemicals / produce useful or valuable substances / make plastics/polymers/chemical feedstock /cracked to make alkenes;
Only award 1 mark if % stated incorrectly, if % not mentioned 2 marks can be awarded. ***[2]***

(b) $C_8H_{18} \rightarrow 2C_2H_4 + C_4H_{10}$ / $2C_3H_6 + C_2H_6$; ***[1]***

(c) burning would form sulfur dioxide/SO_2/acid rain/ S is removed is because it poisons the catalysts used in the refining processes;
manufacture of sulfuric acid/H_2SO_4 / contact process / H_2S obtained is used in the tertiary treatment of sewage to precipitate heavy metal ions; ***[2]***

E3. (a) (i) melting point;
Do not accept boiling point
softness/hardness/flexibility/strength/rigidity/density; ***[2]***

(ii) atactic;
methyl groups arranged randomly /*OWTTE*; ***[2]***

(b) (metal)
does not rust/corrode;
low density;
thermal insulator / poor conductor of heat;
electrical insulator / poor conductor of electricity;
*Accept any answer above for **[1]***.

(wood)
easily moulded;
non biodegradable / does not rot;
low density; ***[2 max]***
*Accept any answer above for **[1]***.
Do not accept reference to cost.

E4. (a) 2200 – 2300 K ;
ΔG must be positive / greater than zero for the (decomposition) reaction to occur / *OWTTE*;
[2]

(b) 1200 – 1300 K; ***[1]***

E5. (a) (electrolysis of) brine / sodium chloride solution / NaCl (aq);
sodium hydroxide **and** chlorine **and** hydrogen / correct formulas;
$2Cl^- \rightarrow Cl_2 + 2e^-$; ***[3]***
Accept $-2e^-$ *on left and e instead of* e^-.

(b) (i) toxic to fish/humans / builds up in food chain / causes birth defects / minemata disease;
Accept any correct effect, but not just toxic or poisonous. ***[1]***

(ii) (asbestos) diaphragm / (polymer) membrane;
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ / $2H^+ + 2e^- \rightarrow H_2$; ***[2]***

Option F – Fuels and energy

F1. (a) (i) $(\frac{802}{16.05}) = 50.0$;
Ignore + and – signs.
No penalty for the use of 16. ***[1]***

(ii) $(\frac{610}{20.0}) = 30.5$;
Units not needed ***[1]***

(iii) produces less sulfur dioxide / particulates / carbon dioxide;
easier to transport / easier to ignite / easier to store;
Do not accept cleaner. ***[2]***

(iv) abundant / larger reserves; ***[1]***
Do not accept widely distributed.

(b) $C + H_2O \rightarrow CO + H_2$; ***[1]***

F2. (a) (i) ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$; ***[1]***

(ii) ${}^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{145}_{57}\text{La} + {}^{88}_{35}\text{Br} + 3{}^{1}_{0}\text{n}$; ***[1]***

(iii) ${}^{1}_{1}\text{H} + {}^{2}_{1}\text{H} \rightarrow {}^{3}_{2}\text{He}$; ***[1]***
*If atomic numbers missing throughout but everything else correct, award **[2]**.*

(b) alpha and beta particles are deflected in opposite directions;
alpha particles travel shorter distances;
alpha particles are deflected less than beta particles; ***[2 max]***
Accept corresponding statements for beta particles.
*Award **[1]** each for any two.*

F3. passive heating uses the sun's energy to warm a home by using well placed windows or glass roofs;
active heating uses pumps/fans to distribute heat;
direct conversion uses photovoltaic cells;
indirect conversion uses (parabolic) mirrors to boil water/produces steam; ***[4]***

F4. (a) difference in/loss of mass when comparing atom/nucleus with particles it is made of / OWTTE;
helium atom's 2p + 2n + 2e have less mass together than separately; ***[2]***
Accept helium nucleus 2p + 2n have less mass together than separately.

(b) 1 more p and 1 more e and 1 less n / 82p + 127n + 82e on left and 83p + 126n + 83e on right;
mass change/decrease = 8.46×10^{-7} (kg mol^{-1});
energy released (=mc^2) = $7.61(4) \times 10^{10}$ J / $7.61(4) \times 10^{7}$ kJ; ***[3]***
Apply ECF from mass decrease to energy release but not from wrong number of particles to mass decrease.
Do not award final mark without units.

F5. Si has lower ionization energy (than P or S) so electrons can flow through material;
(p-type) has small amount of/is doped with group 3 element/B/Ga/In;
which produces electron holes/positive holes;
sun/photons cause release of electrons;
electrons move from n-type to p-type material; ***[5]***

Option G – Modern analytical chemistry

G1. (a) electrons move to higher (energy) levels; ***[1]***

(b) (i) d orbitals/levels split (into two);
electrons on lower energy level absorb radiation from visible spectrum to move to higher energy level;
leaving complementary colour transmitted / OWTTE; ***[3]***

(ii) (different ligands have) different electron densities;
so causing different amounts of splitting of d orbitals/levels;
so absorbing radiation from different part of the spectrum; ***[2 max]***
*Any two for **[1]** each.*

(c) (i) II and IV; ***[1]***

(ii) (IV)
it has two double bonds/conjugated double bonds;
less energy needed to excite delocalised electrons / delocalised electrons absorb energy more easily; ***[2]***
*Award **[0]** if wrong compound chosen.*

G2. (a) molecules vibrate;
bonds stretch;
bond angle changes;
dipole moment alters; ***[2]***
*Any two for **[1]** each.*

(b) (i) 1050 is C–O and 1700 is C=O; ***[1]***

(ii) CH_3CH_2COOH;
(only) spectrum A has broad absorption due to O–H in (acids); ***[2]***

(iii) they have the same functional groups; ***[1]***

(c) (i) singlet indicates no hydrogens/protons on neighbouring carbon;
triplet indicates 2 hydrogens/protons on neighbouring carbon;
quartet indicates 3 hydrogens/protons on neighbouring carbon;
both compounds contain a C_2H_5- group (as they both have a triplet and a quartet); ***[3max]***

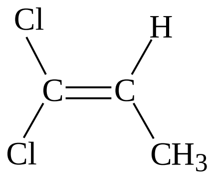
(ii) C is $HCOOCH_2CH_3$ (because it has CH_2 between COO and R);
D is CH_3CH_2COOH (because it has H next to COO); ***[2]***

G3. (paper) water in fibres of paper;
Do not accept just paper.
(column) silica (gel) / alumina;
capillary action in paper;
gravity in column;
column because larger quantities obtained; ***[5]***

Option H – Further organic chemistry

H1. (a) restricted/no rotation around double bond/pi bond; ***[1]***

(b) Accept either of these structures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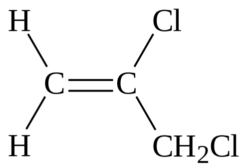
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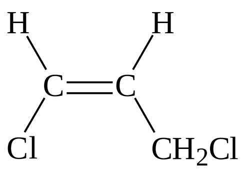
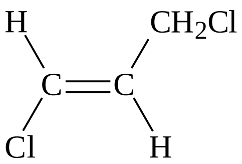
two identical atoms on one side of double bond / interchanging CH_3 and H/ Cl and CH_2Cl makes no difference; ***[2]***

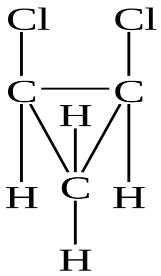
(c)


cis;


trans;

*Award **[0]** if structure of another isomer drawn.*
*Award **[1]** if both structures correct but unlabelled or wrongly labelled.*
*Award **[1]** for each correctly drawn and labelled structure.* ***[2]***

(d)



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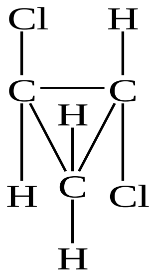


; **[2]**

Award ***[0]*** *if structure of another isomer drawn.*

H2. (a) ultraviolet light causes Cl–Cl bond to split;

$Cl_2 \rightarrow 2Cl\bullet$;

$Cl\bullet + CH_3CH_3 \rightarrow CH_3CH_2\bullet + HCl$;

$CH_3CH_2\bullet + Cl_2 \rightarrow CH_3CH_2Cl + Cl\bullet$

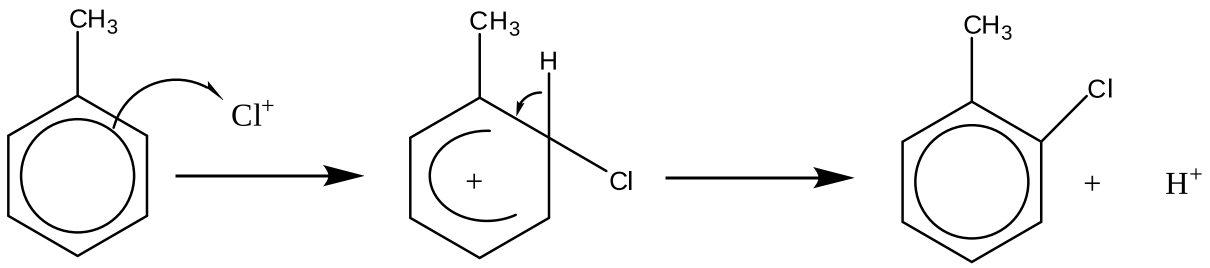
$CH_3CH_2\bullet + Cl\bullet \rightarrow CH_3CH_2Cl$ / other correct termination step; **[5]**

Penalize missing $\bullet$ *symbol once only.*
If different alkane used, then deduct ***[1]****.*
No penalty for not labelling steps, but deduct ***[1]*** *if any wrongly labelled.*

(b) $C_6H_5CH_2Cl$/ $C_6H_5CHCl_2$/ $C_6H_5CCl_3$; **[1]**

H3. (a) electrophilic substitution;
$FeCl_3 + Cl_2 \rightarrow FeCl_4^- + Cl^+$; ***[2]***

(b) (mechanism showing)
curly arrow from circle in benzene ring to attacking Cl^+ / curly arrow from one of the three double bonds in the Kekule structure;
intermediate showing $\frac{2}{3}$ - $\frac{5}{6}$ of circle and + charge;
curly arrow from C–H bond into benzene ring;
correct organic product and H^+; ***[4]***
Deduct ***[1]*** *if benzene used instead of methylbenzene.*
Deduct ***[1]*** *if meta-isomer product formed.*



H4. (a) $O_2NC_6H_4OH \rightleftharpoons O_2NC_6H_4O^- + H^+$ / $O_2NC_6H_4OH + H_2O \rightleftharpoons O_2NC_6H_4O^- + H_3O^+$;
Accept more detailed correct structures.

NO_2 is electron-withdrawing group;
attracts electrons from O–H bond/ weakens O-H bond;
more H^+ released;
Any two of last three for ***[1]*** *each.*

OR

electron withdrawing nitro group further reduces the charge on the O of the anion through increased delocalisation;
so it does not attract a proton so readily (i.e. is a weaker base); ***[3 max]***

(b) $CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$;

CH_3 is electron-releasing group / positive inductive effect of methyl group;
increases electron density on N;
more H^+/H_2O attracted; ***[3max]***
Any two of last three for ***[1]*** *each.*

Penalise incorrect arrows once for H4. (a) and (b).