N08/4/CHEMI/HP3/ENG/TZ0/XX/M+

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MARKSCHEME

November 2008

CHEMISTRY

Higher Level

Paper 3

18 pages

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) by e-mail (or telephone) – if by e-mail, please reply to confirm that you have downloaded the markscheme from EXAMNET. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the mark scheme and its interpretation. AEs should contact their team leader by e-mail at any time if they have any problems/queries during the marking process.

Note:

The DHL courier service must be used to send assessment material to your team leader/senior moderator and to IB Cardiff. (However, this service is not available in every country.) The cost is met directly by the IBO. It is vitally important that the correct DHL account number is used.

If you have any queries on **administration** please contact:

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1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases write a brief annotation to explain your decision. You are encouraged to write comments where it helps clarity, especially for moderation and re-marking. It should be remembered that the script may be returned to the candidate.

4. Unexplained symbols or personal codes/notations are unacceptable.

5. Record marks in the right-hand margin against each mark allocation shown in square brackets *e.g.* ***[2]***. The total mark for a question must equal the number of ticks for the question.

6. Do **not** circle sub-totals. **Circle the total mark** for the question in the right-hand margin **at the end of the question.**

7. Where an answer to a part question is worth no marks, put a zero in the right-hand margin next to the square bracket.

8. Where work is submitted on additional sheets the marks awarded should be shown as ticks and a note made to show that these marks have been transferred to the appropriate square bracket in the body of the script.

9. For each option: Add the totals for each question in the option and write it in the Examiner column on the front cover.
Total: Add the marks awarded and enter this in the box marked TOTAL in the Examiner column on the cover sheet.

10. After entering the marks on the front cover check your addition to ensure that you have not made an error. Check also that you have transferred the marks correctly to the cover sheet. **All scripts are checked and a note of all clerical errors will be given in feedback to examiners.**

11. If an answer extends over more than one page and no marks have been awarded on a section draw a diagonal line through that section to indicate that it has been marked.

12. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers and use the marks of those answers that have the highest mark, **unless the candidate has indicated the question(s) to be marked on the front cover**.

13. A mark should not be awarded where there is contradiction within an answer. Make a comment to this effect in the left hand margin.

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) they both contain (at least one) $-\overset{\overset{O}{\|}}{C}-O-CH_3$ / $-\overset{\overset{O}{\|}}{C}-O-R$ group; ***[1]***
Do not accept –COO without the carbon attached or RCOO.

(b) *aspirin*:
prevents the formation of prostaglandin synthase/other pain producing substances at source;
stops transmission of pain from source to brain;

heroin:
interacts with receptor sites within brain/spinal cord;
blocks pain signals within brain/spinal cord; ***[4]***

(c) causes bleeding/ulcers in stomach / Reye's disease / asthma / deafness; ***[1]***

(d) larger and larger doses needed to achieve original effect / *OWTTE*;
danger of exceeding the lethal dose / *OWTTE*; ***[2]***

B2. (a) (i) $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$;
$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$ / $NaCl + H_2CO_3$; ***[2]***

(ii) magnesium hydroxide because it neutralizes twice as much HCl / *OWTTE*; ***[1]***
Do not accept just "more HCl".

(b) *alginates*:
produce neutralizing layer/coating (over stomach contents) / prevent heartburn / prevent stomach contents/acid rising up oesophagus / prevents acid reflux;

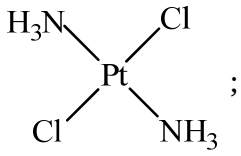
anti-foaming agents:
prevent bloating/flatulence; ***[2]***

B3. (a) overcame the problems associated with isolating/concentrating penicillin;
showed that penicillin is harmless and effective on mice;
developed techniques to purify penicillin (to eliminate many side effects) / prepared it in crystal form / *OWTTE*;
first to use penicillin on a policeman/human (dying of septicaemia);
grew penicillin in bulk;
grew strains of penicillin in corn-steep liquor; ***[3 max]***

(b) they are resistant to stomach acid / *OWTTE*;
they are effective against bacteria resistant to penicillin G / not deactivated by penicillinase / *OWTTE*; ***[2]***

B4. (a) A = amide;
B = alkene; ***[2]***
Accept cycloalkene, halogenoalkene or fluoroalkene

(b) (it cannot exhibit geometrical isomerism) as the ring prevents the possibility of *cis*- and *trans*- isomers / *OWTTE*; ***[1]***

(c) 

; ***[1]***
Accept Pt bonded to the H of the NH_3 groups

(d) the DNA in the cancer cell is not able to bond to the nitrogen in two adjacent positions / the N atoms involved in bonding are too far apart / transplatin does not bond to 3D receptor site / *OWTTE*; ***[1]***

(e) ibuprofen;
amphetamine; ***[2]***
*If three answers given **[1 max]**, if four or more given no marks.*

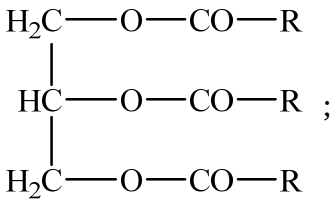
Option C – Human biochemistry

C1. (a) (i) heat produced by $2.19\,\text{g} = 600 \times 4.18 \times 11.2 = 2.81 \times 10^4\,\text{(J)} / 28.1\text{(kJ)}$;

heat produced by $45.0\,\text{g} = \dfrac{45.0 \times 28.1}{2.19} = 577\,\text{kJ}$; ***[2]***

*Correct final answer scores **[2]**.*

(ii) not all the heat was transferred to the water;
food was not completely combusted;
heat capacity of stirrer/thermometer/calorimeter was not taken into account;
heat was lost to the surroundings; ***[2 max]***
*Any two for **[1]** each.*

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

(ii) unsaturated fats contain a carbon to carbon double bond, in saturated fats all the carbon to carbon bonds are single; ***[1]***

(iii) 7.61 g of $I_2 = \dfrac{7.61}{254} = 0.0300$ mol of I_2;
the fat contains three C=C bonds in each molecule; ***[2]***
*Correct final answer scores **[2]**.*
Accept 0.03 mol of I_2.

C2. (a) one of the four steroid rings is not complete / the steroid backbone is not present / *OWTTE*; ***[1]***

(b) because of the long non polar (hydrocarbon) part of the molecule / can form van der Waals' forces with fat molecules; ***[1]***

(c) malformed bones / deformed skeleton / bow legs / rickets;
uptake of calcium (and phosphate) from food hindered / *OWTTE*; ***[2]***

C3. (a) chemicals produced in glands which are transported through the blood to the site of action / chemical messengers; ***[1]***

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

(c) (i) phenyl (group) / benzene ring / phenol; ***[1]***
Accept aromatic ring

(ii) ketone / alkanone / carbonyl **and** alkene; ***[1]***
Accept cycloalkene

C4. (a) cell protein synthesis requires a high potassium concentration;
nerve impulses require a high concentration gradient (between inside and outside of nerve cell); ***[1 max]***

(b) potassium ion is larger so has lower charge density than sodium ion;
so it can pass through a medium of lower polarity / so it can diffuse through the membrane;
because of size three Na^+ ions can bind to pump but only two K^+ ions; ***[2 max]***

C5. (a) V_{max} is the maximum rate of the reaction reached when the active sites on the enzyme are saturated;
K_m is the substrate concentration when the rate is equal to $\frac{1}{2}$ V_{max}; ***[2]***

(b) V_{max} is lower;
K_m stays the same;
non-competitive inhibitors bind to the enzyme but not the active site;
the enzyme's shape is altered so increasing the substrate has no effect; ***[4]***

Option D – Environmental chemistry

D1. (a) both gases allow radiation from the sun to pass through;
carbon dioxide absorbs the longer wavelength/lower energy/heat/IR radiation from the Earth (whereas nitrogen does not);
bonds in carbon dioxide stretch/bend/vibrate;
C=O bonds are polar / N_2 bonds are non-polar;
heat is re-radiated back to earth; ***[3 max]***

(b) the decomposition is anaerobic / decomposes in the absence of oxygen / not enough oxygen present; ***[1]***

(c) *Any **two** from*: H_2O, N_2O, O_3, CFCs, SF_6; ***[1]***
Accept names or formulas including NO_x.
Penalize extra incorrect answers.

(d) particulates cool the earth / opposite effect to greenhouse gases;
scatter radiation from the sun / reflect radiation back into space / prevent radiation from the sun reaching the Earth; ***[2]***

D2. (a) carbonic acid is a weak acid / only partially dissociated / low solubility;
the pH must be lower than 5.6 for acid rain / *OWTTE*; ***[2]***

(b) H_2SO_4 / H_2SO_3 **and** burning coal/sulfur-containing fuels/fossil fuels / smelting of sulfide ores;
HNO_3 / HNO_2 **and** reaction (between N_2 and O_2) in internal combustion/jet engine; ***[2]***
*If both acids correct but sources incorrect award **[1]** mark.*
*If SOx / NOx given with two correct sources award **[1 max]**.*
Accept names or formulas of acids.

(c) $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O / H_2CO_3$; ***[1]***

(d) plant growth is reduced;
nutrients (Ca^{2+}, Mg^{2+}, K^+) are leached from the soil / *OWTTE*;
reduction in Mg^{2+} reduces chlorophyll (so affects photosynthesis);
Al^{3+} leached from rocks damages roots (by preventing them from taking up water); ***[2 max]***

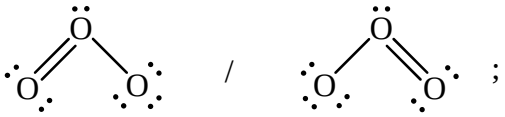
D3. (a) polychlorinated/polychloro biphenyl(s); ***[1]***

(b) metal plating
(rechargeable) batteries
pigments/paint
run-off from zinc mining areas ***[1 max]***
*Any two for **[1]***

(c) (i) the dose required to kill fifty percent of the population (the toxin is tested on); ***[1]***

(ii) the tests can only be done on animals (not humans);
it can be considered unethical to kill animals for research purposes;
the LD_{50} for animals may be very different for humans/or other animals / *OWTTE*;
very large doses of relatively non toxic substances required; ***[2 max]***
*Award **[1]** each for any two correct*

D4. (a) ultraviolet; ***[1]***

(b)  ;

Accept dots/crosses in place of lines

it requires less energy to break the O–O bond in ozone;
because bonds (in ozone) are weaker than double bonds in oxygen; ***[3]***

(c) $NO_2(g) \rightarrow NO(g) + O(g)$;
$O(g) + O_3(g) \rightarrow 2O_2(g)$;
Ignore state symbols
Accept O• instead of O

Accept any mechanism that adds up to the overall equation, e.g.
$O_3 \rightarrow O_2 + O$;
$O + NO_2 \rightarrow O_2 + NO$; ***[2 max]***

Option E – Chemical industries

E1. (a) $2C + O_2 \rightarrow 2CO$;
$C + O_2 \rightarrow CO_2 / CaCO_3 \rightarrow CaO + CO_2$;
$CO_2 + C \rightarrow 2CO$; ***[3]***
Also accept equations showing the formation of CO during reduction of oxides of iron with carbon.

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

(c) calcium carbonate/limestone is added / $CaCO_3 \rightarrow CaO + CO_2$;
the product is calcium silicate/slag / $CaO + SiO_2 \rightarrow CaSiO_3$;
this sinks to the bottom of the furnace and is (periodically) tapped off; ***[2 max]***

(d) carbon; ***[1]***

(e) use a magnet; ***[1]***
Accept any other simple method based on the different properties of iron and aluminium.

E2. (a) it poisons the catalyst(s) (used in refining);
to prevent the release of SO_2 / formation of acid rain (when it is combusted); ***[2]***

(b) used as raw material for Contact process / sulfuric acid production; ***[1]***

(c) mix with hydrogen;
high pressure / between 50 and 100 atmospheres;
catalyst of silica/ SiO_2 /alumina/ Al_2O_3 /aluminosilicate/(finely divided) platinum; ***[2 max]***
Catalyst must be identified.
No credit for reference to high temperature

(d) $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$;
polymers / plastics / ethanol / polythene / <u>feedstock</u> for other chemicals; ***[2]***

E3. (a) $SiO_2(s) + C(s) \rightarrow Si(s) + CO_2(g)$; ***[1]***

Accept $SiO_2(s) + 2C(s) \rightarrow Si(s) + 2CO(g)$

States not necessary for mark.

(b) $SiCl_4$ has a low boiling point so can be distilled;
this removes involatile impurities / *OWTTE*; ***[2]***

(c) a heater is passed along a rod of impure silicon which melts the silicon;
after the heater has passed the silicon resolidifies;
impurities dissolve better in molten silicon so are transferred to the end of the rod; ***[2 max]***
OWTTE for each of the above.
Accept a suitably labelled diagram.

(d) electrons in silicon are in fixed positions / not delocalized;
energy required to excite an electron is obtained from sunlight;
electron is then free to move through crystal lattice; ***[2 max]***

(e) group 3 element has fewer electrons which form a "hole" / *OWTTE*;
electrons can move into this hole creating a new hole / known as a p-type semiconductor; ***[2]***

(f) n-type semiconductor; ***[1]***

Option F – Fuels and energy

F1. (a) $^{235}_{92}\text{U} \rightarrow {}^{4}_{2}\text{He} + {}^{231}_{90}\text{Th}$ ***[2]***

*Award **[1]** for correctly identifying $^{231}_{90}Th$, **[1]** for correct equation.*
Accept α in place of $^{4}_{2}He$.

(b) 7 alpha emissions;
4 beta emissions; ***[2]***

(c) six half-lives;
mass = 0.0375 kg; ***[2]***
*Correct final answer scores **[2]**.*

(d) *Moderator*

made from:
water / heavy water / graphite;

function:
to slow down neutrons / to increase the number of collisions that lead to fission between neutrons and nuclei / *OWTTE*;

Control rods

made from:
cadmium / boron;

function:
to absorb (excess) neutrons; ***[4]***

(e) mass defect $= [235.0439 + 1.0087] - [89.9470 + 143.8810 + 2.0174]$
$= 0.2072\,(\text{g}) / 2.072 \times 10^{-4}\,(\text{kg})$;
energy $= 2.072 \times 10^{-4} \times (3.00 \times 10^{8})^2 = 1.86 \times 10^{13}$ J / 1.86×10^{10} kJ; ***[2]***
*Correct final answer scores **[2]**.*

F2. (a) $M_r(CH_4) = 16$ so energy evolved $= \frac{890 \times 1000}{16} = 5.56 \times 10^4$ kJ;

$M_r(C_8H_{18}) = 114$ so energy evolved $= \frac{5510 \times 1000}{114} = 4.83 \times 10^4$ kJ;

(so methane gives out the most energy) ***[2]***

Penalize once only if 1.00 used instead of 1000.
*Award **[2]** if a comparison is made between 890/16 and 5510/114 and it is stated that the mass is the same.*

(b) *positive electrode:*
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$;

negative electrode:
$H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$; ***[2]***

*If equations correct but at wrong electrodes award **[1]**.*
Accept correct equations for acidic conditions
Positive: $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$
Negative: $H_2 \rightarrow 2H^+ + 2e^-$

F3. (a) energy (capable of doing work) is always lost when it is converted from one form to another; ***[1]***

(b) *Pumping water*

Advantages:
makes use of cheap "off peak" electricity / when demand is low;
rapid response to increase demand;
relatively efficient;

Disadvantages:
high initial cost;
damage to environment / ecosystems;
limited to suitable locations;

Hydrogen

Advantages:
produces a large amount of heat per kilogram of fuel;
relatively easy to achieve (by electrolysis of water);

Disadvantages
not very efficient;
Do not award this mark if relatively efficient awarded above.

occupies a large volume;
cannot easily be liquefied;
costly to transport (as bulky containers required);
potentially explosive with air; ***[8 max]***
*Award **[1]** each for any two correct advantages and disadvantages for each method.*

Option G – Modern analytical chemistry

G1. (a) (i) 74: M^+ / molecular ion / $HCOOC_2H_5^+$;
45: $HCOO^+$ / $C_2H_5O^+$;
29: $C_2H_5^+$ / HCO^+; ***[3]***
[2 max] *if positive sign missing.*

(ii) (peak at 75) due to presence of carbon-13; ***[1]***

(b) The vibration must involve a change in dipole moment/bond polarity; ***[1]***

(c) The precise value of the absorption depends on the groups/atoms attached to the C=O / *OWTTE*; ***[1]***

(d) $-CH_3$ (of the ethyl group – CH_2CH_3); ***[1]***

(e) (the three hydrogen atoms of the methyl group are) split by/spin spin coupling with the two hydrogen atoms on the adjacent $-CH_2-$ group; ***[1]***

(f) integration pattern: only one hydrogen atom in that environment;
splitting: not split so no H atoms on adjacent carbon atoms;
the absorption is due to the H of $HCOOC_2H_5$; ***[3]***

(g) (i) no change / still at *m/z* of 74; ***[1]***

(ii) only two absorptions (not three);
two equal areas/heights (three protons for each absorption); ***[2]***

(iii) there will just be two singlets / there is no splitting; ***[1]***

(h) a different fingerprint region;
a (broad) absorption in range 2500–3300 cm^{-1}; ***[2]***

G2. (a) sample is vaporized/heated;
mobile phase is inert/nitrogen/helium gas;
stationary phase is a liquid/long chain alkane/grease on a solid support;
less volatile components have longer retention time / *OWTTE*;
components detected by flame ionizer;
converted to electrical current / connected to chart recorder; ***[5 max]***

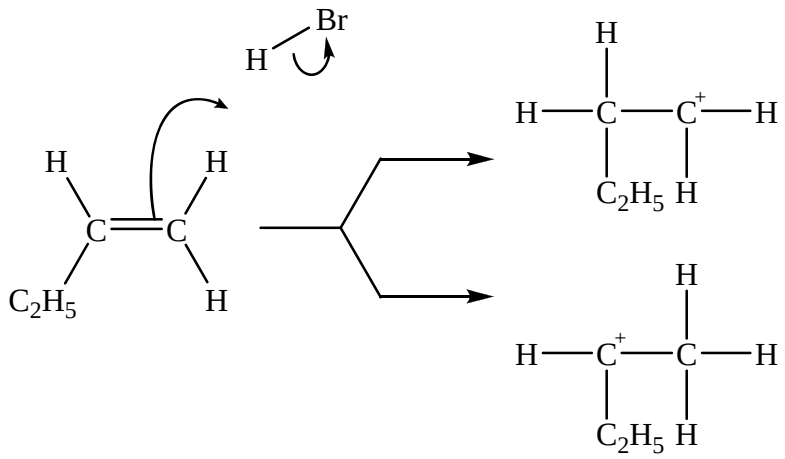
(b) (i) high pressure/performance liquid chromatography / HPLC; ***[1]***

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

(iii) paper chromatography / thin layer chromatography / TLC; ***[1]***

Option H – Further organic chemistry

H1. (a)



curly arrow from double bond to H (of H–Br) shown correctly;
curly arrow to Br (from H–Br bond);
two carbocation intermediates drawn correctly; ***[3]***

(b) 2-bromobutane;
the secondary carbocation is more stable (than the primary carbocation) / the positive inductive effect of two R– groups is greater (than one); ***[2]***

(c) (2-bromobutane) lower;
2-bromobutane (is more spherical) and there is less surface area (for contact between two molecules)/weaker intermolecular forces/smaller dipole moment; ***[2]***

(d) only 2-bromobutane has enantiomers;
it contains an asymmetric/chiral carbon atom / four different groups on C; ***[2]***

(e) <u>rotate the plane</u> of (plane-)polarized light;
Accept "rotates plane-polarised light" but do not accept "rotates polarised light".

one rotates it clockwise/to the right and the other anticlockwise/to the left (by the same amount) / in opposite directions; ***[2]***

H2. (a) 2-chloromethylbenzene **and** 4-chloromethylbenzene; ***[1]***
Accept ortho– and para– in place of 2– and 4–.
Accept correct structural formulas.

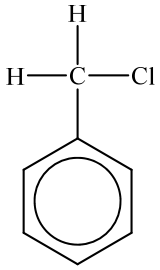
(b) to produce Cl^+/the electrophile / act as a catalyst / halogen carrier / Lewis acid;
$AlCl_3 + Cl_2 \rightarrow AlCl_4^- + Cl^+$; ***[2]***

(c) the methyl group has a positive inductive effect / *OWTTE*;
this increases the electron density of the benzene ring/pi electrons / makes the ring more attractive to electrophiles; ***[2]***

(d) there is a change in oxidation numbers / Cl oxidation number changes from zero to –1 / both oxidation and reduction occur; ***[1]***

(e) a pair of electrons is donated / according to Lewis theory;

acid is $AlCl_3$ **and** base is Cl_2;
acid is Cl^+ **and** base is $C_6H_5CH_3$; ***[2 max]***
Accept either answer for second mark.

(f) 
/ $C_6H_5CH_2Cl$; ***[1]***
Accept $C_6H_5CHCl_2$ or $C_6H_5CCl_3$.

(g) free radical substitution;
breaks the Cl–Cl bond <u>homolytically</u> / forms Cl•/Cl radical; ***[2]***

H3. (a) it forms an ionic salt/ $C_6H_5NH_3^+$; ***[1]***

(b) the non-bonding/lone pair of electrons on the N delocalize with the (pi) electrons from the benzene ring (so they are less able to attract a proton); ***[1]***

(c) the $–NO_2$ group draws electrons from the ring (making the lone/non-bonding pair of electrons on the N atom less able to attract a proton); ***[1]***