



MARKSCHEME

November 2013

CHEMISTRY

Standard Level

Paper 3

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Subject Details: Chemistry SL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the options [**2 x 20 marks**]. Maximum total = [**40 marks**].

1. A markscheme often has more marking points than the total allows. This is intentional.
2. Each marking point has a separate line and the end is shown 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 **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. When marking, indicate this by adding **ECF** (error carried forward) on the script.
10. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.
11. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the markscheme. Similarly if the formula is specifically asked for, unless directed otherwise in the markscheme, do not award a mark for a correct name.
12. 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.
13. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

Option A — Modern analytical chemistry

1. (a) spin / magnetic moment; [1]
- (b) MRI can detect soft tissues/body organs / different properties of (soft) tissue (and bone);
Accept “contrast can be a problem in X-ray”. [1]
Accept three-dimensional image.
2. (a) (i) 90; [2]
 $C_3H_6O_3^+$;
Penalize missing positive charge of ion only once in (a).
- (ii) $COOH^+$;
Accept $C_2H_5O^+$. [1]
Penalize missing positive charge of ion only once in (a).
- (iii) CHO^+ / COH^+ ; [1]
Accept $C_2H_5^+$ / $CH_3CH_2^+$.
Penalize missing positive charge of ion only once in (a).
- (b) (i) CH_3 / methyl; [1]
- (ii) $CH_3CH(OH)COOH$; [1]
Allow full or condensed structural formula.
- (c) change in bond length / bond stretching / asymmetric stretch / change in bond angle / bending (of molecule/bond) / molecule vibrates more; [2]
causes a change in molecular polarity/dipole moment / *OWTTE*;

3. (a)

	Partition/adsorption	Mobile phase	Stationary phase
Paper	partition	solvent <i>Accept water or alcohol as an example of a solvent.</i>	water in (cellulose/fibres of) paper; <i>Accept hydroxyl group in cellulose/water. Do not accept just paper or liquid.</i>
TLC	adsorption	solvent; <i>Accept water or alcohol as an example of a solvent.</i>	silica (gel)/SiO ₂ / alumina/ Al ₂ O ₃ ;

[3]

Award [1] for partition/adsorption and mobile phase correct for both techniques. Award [1] each for correct stationary phase.

- (b) takes less time;
results more reproducible;
Accept (same results) repeatable.

separation more efficient;
useful for small samples;
components when separated can be obtained in pure form / *OWTTE*;

[1 max]

- (c) 0.6;
Allow $\frac{3}{5}$.

[1]

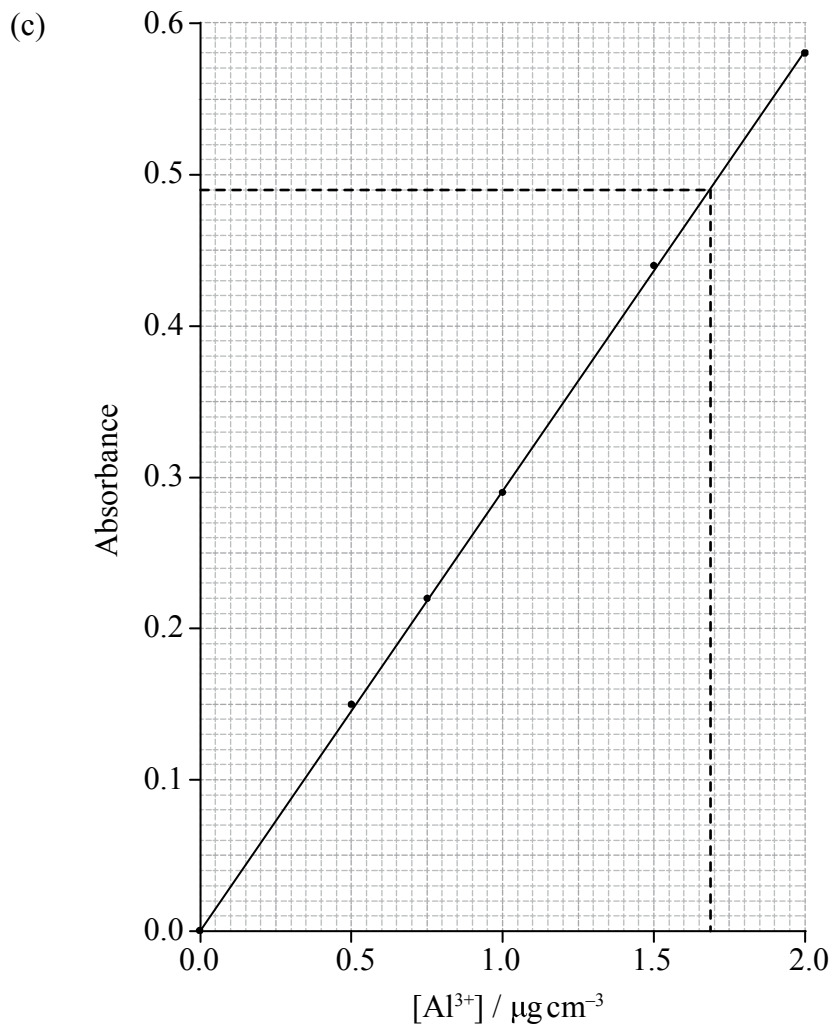
4. (a) light source emits wavelength of light that is absorbed by the element/Al atoms / must be an Al lamp/hollow cathode Al lamp;

[1]

- (b) **Y**:
(sample) dehydrated/vaporized/atomized / solvent/water evaporated;

Z:
absorbs/re-emits radiation / (electromagnetic radiation) excites electrons to higher energy levels/states;

[2]



line graph based on all six points plotted **and** connected;
Points should be plotted closest to within a half of a small square and extended to the origin.

(concentration =) 1.68 (μg cm⁻³);
 Allow in range 1.65–1.70 (μg cm⁻³).

[2]

Option B — Human biochemistry

5. (a) alcohol/hydroxyl group **and** alkene; [1]
Accept carbon-carbon double bond.
Do not accept just double bond.
Do not accept hydroxide.
- (b) (i) vitamin C / ascorbic acid; [1]
- (ii) several OH groups / polar molecule;
 able to form hydrogen bonds with water; [2]
- (c) (i) softening/malfunctioning of bones / causes low/deficiency in calcium;
Accept rickets. [1]
- (ii) less time outdoors / skin not exposed due to clothing/sunscreen / *OWTTE*;
Accept answers that show link with outdoors/sunlight. [1]
6. (a)
$$\begin{array}{c} \text{H}_3\text{N}^+ - \text{CH} - \text{COO}^- \\ | \\ \text{CH}_2 - \text{SH} \end{array} ;$$
 [1]
Accept full or condensed structural formulas as long as correct charges on N/NH₃ and O are represented.
Accept NH₃⁺ for H₃N⁺ in the diagram.
- (b) (i) any value or range below 5.1; [1]
- (ii) any value or range from 5.1 – 6.0 ;
 alanine positive **and** cysteine negative; [2]
Accept biggest charge difference/opposite charges between isoelectric points so move in opposite directions.
Need reference to charges to score M2.
- (c) disulfide bridge;
Accept S–S.
- covalent / strongest bond; [2]

(d)

<i>Function</i>	<i>Named example</i>
structural	collagen / keratin / myosin / elastin
hormone	insulin*
enzyme / catalyse reactions	lysozyme
defence / protective mechanisms	immunoproteins /antibodies
transport	hemoglobin
movement / contractile	actin / myosin
energy (storage/source)	casein / ovalbumin
lubrication	mucoprotein

[3 max]

Need function with valid example for each mark.

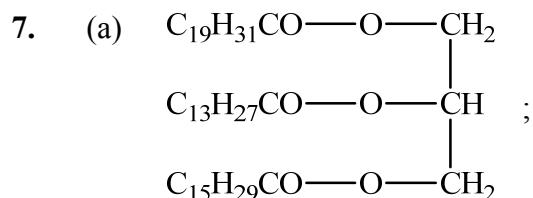
Award [1 max] for three correct functions or three named examples.

Accept other correct examples.

Do not apply list principle.

* Other protein hormones include human growth hormone, follicle stimulating hormone (FSH), adrenocorticotrophic hormone (corticotropin or ACTH), thyroid stimulating hormone (TSH).

* Do **not** accept steroids, sex hormones, testosterone, progesterone, estrogen, adrenalin.



[1]

Accept alternative orders for the hydrocarbon tails.

- (b) water/H₂O **and** enzyme/biological catalyst/lipase;
Accept acidic/alkaline/basic condition instead of water.
Do not award mark for lipase alone without water/ H₂O.

[1]

- (c) C₁₉H₃₁COOH;
 they lower level of LDL cholesterol/low-density lipoproteins / reduce (the risk of) heart disease;
Allow comparison with saturated fats with explanation.

[2]

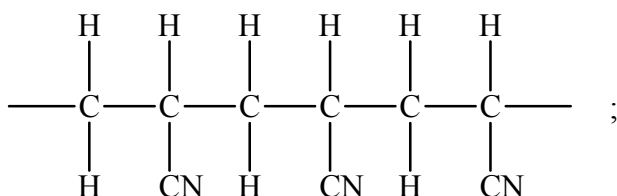
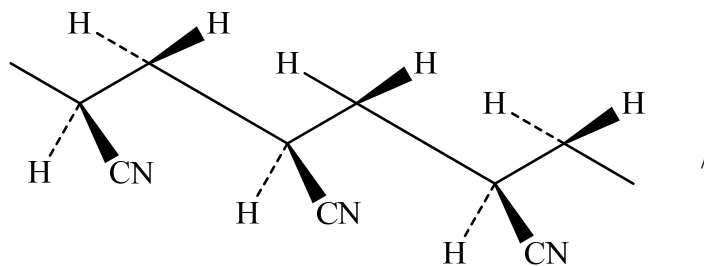
- (d) fats provide more energy (per kg) than carbohydrates;
Do not allow "fat is an insulator".

[1]

Option C — Chemistry in industry and technology

8. (a) (i) hematite/magnetite/limonite **and** added at P; [1]
Allow P to be indicated on diagram.
- (ii) *Any two for [1]:*
 limestone/calcium carbonate;
 coke;
 air; [1]
- (b) $C(s) + O_2(g) \rightarrow CO_2(g)$;
Note: state symbols must be correct. [1]
- (c) (i) slag / calcium silicate / calcium aluminate; [1]
- (ii) $CaCO_3(s) + SiO_2(s) \rightarrow CaSiO_3(s) + CO_2(g)$ /
 $CaCO_3(s) + Al_2O_3(s) \rightarrow CaAl_2O_4(s) + CO_2(g)$; [1]
Accept $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ and $CaO(s) + SiO_2(s) \rightarrow CaSiO_3(s)$.
Accept $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ and $CaO(s) + Al_2O_3(s) \rightarrow CaAl_2O_4(s)$.
Ignore state symbols.
- (d) reacts with oxygen/O₂ / is oxidized (and carbon dioxide/CO₂ formed); [1]
Accept equation.
- (e) (i) (alloying element(s)) atoms/ions have different size;
Allow suitable diagram.
 disrupts regular/repeating (metal) lattice;
 difficult for one layer to slide over another / added atoms/ions smaller than
 metal atoms/ions can fit into the (holes of) metal lattice disrupting bonding; [2 max]
If “particles” is penalised in M1, allow “particles” in M3.
Do not award mark for different or unique properties of alloys.
- (ii) makes steel less brittle/more malleable/softer/less hard/more ductile; [1]

9. (a) (i)



[2]

Continuation bonds at end of structure needed.

Hydrogen atoms must be included.

Award [1] for chain with CN groups on alternate carbons.

Award [2] for correct chain with CN on alternate carbons with same orientation.

(ii) chains pack together better;
 strong intermolecular/attractive forces between chains;
 chains do not move past each other easily (so fibre strong/rigid); [2 max]

(b) (i) catalyst; [1]

(ii) (selective) because of dimensions/shape/size (of cage); [1]
Accept "large surface area".

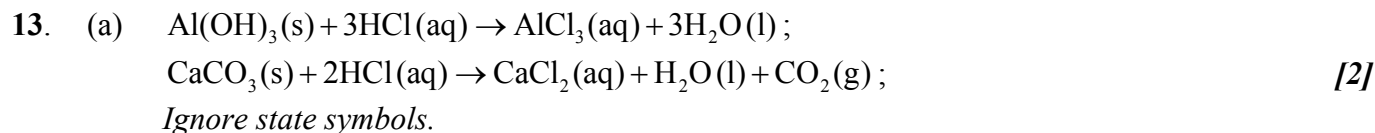
(c) (i) cylinder with hexagons of carbon (atoms); [1]
Accept suitable diagram.
Do not award mark if pentagons are also mentioned.

(ii) (electrical) conductor; [1]
Accept low density.
Do not accept light.

10. rod shape / rigid;
 chemically stable (due to hydrocarbon rings and chain);
 polar (due to the presence of F) / OWTTE;
 can change orientation / rapid switching in electric field/when voltage is applied; [3 max]

Option D — Medicines and drugs

11. (a) (i) 2850–3100(cm^{-1}); [1]
- (ii) (OH absorption present) in water/air/water vapour; [1]
- (b) transmittance decreases / absorbance increasing (with increasing concentration); [1]
No mark for: transmittance/absorbance changes.
- (c) (i) has synergistic effect (with other drugs) / alcohol can change effectiveness of some drugs; [1]
- (ii) heavy sedation/coma with sleeping pills/barbiturates/tranquilizers; increased risk of stomach bleeding/ulcers with aspirin; *Accept "greater risk of cancer with tobacco" / OWTTE.* [1 max]
12. (a) (i) paracetamol/acetaminophen; [1]
- (ii) phenyl **and** (secondary) amide; [1]
Accept benzene ring for phenyl.
Do not allow just benzene or arene instead of phenyl.
- (b) antipyretic/fever reducer / analgesic/pain reducer/killer; [1]
Accept "reduces/inhibits synthesis of (enzyme that produces) prostaglandins".
Allow ECF from incorrect answer given in (a) (i).
- (c) range of dosages/concentrations of drug able to treat disease successfully staying within safety limit/between therapeutic and toxic levels / OWTTE; [1]
Accept LD_{50} over ED_{50} .



- (b) Al(OH)_3 has smaller molar mass (so more moles per tablet);
 one mole of Al(OH)_3 neutralizes more moles of acid;

OR

$$(\text{for } \text{Al(OH)}_3) \quad n_{\text{HCl}} = \frac{3}{78}(\text{mol}) ;$$

$$(\text{for } \text{CaCO}_3) \quad n_{\text{HCl}} = \frac{2}{100}(\text{mol}) ; \quad [2]$$

- (c) strong (soluble) base/alkali;
 damage to/corrosive to body/tissue; [2]

- (d) body's natural healing process due to individual expectation/desire / power of suggestion / body fooled into healing itself naturally / *OWTTE*;
 used in double blind trials in drug development / (pharmacologically) inert substance used as a control / placebo given to some patients in a drug trial so that effects on other patients who have been given the real drug can be compared / *OWTTE*; [2]

14. viruses mutate quickly so adapt to drugs/evade immune system response / *OWTTE*;

bacteria are more complex and thus can be targeted in more ways / viruses lack sub-units/functions targeted by antibacterials / *OWTTE*;

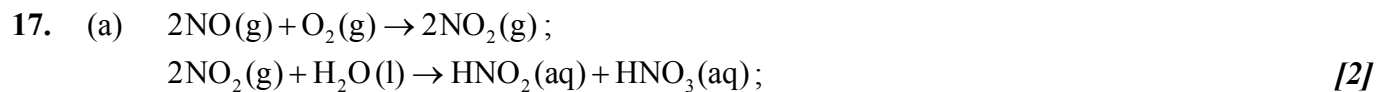
different types of bacteria employ similar metabolic processes and thus can be targeted by common antibacterials / each kind of virus usually requires special drugs/approaches / *OWTTE*;

bacteria can be killed by interfering with cell wall production without attacking host cell / difficult to attack the virus without attacking host cell;

[3 max]

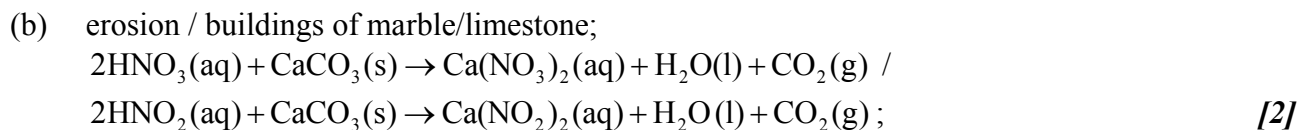
Option E — Environmental chemistry

15. (a) amount of oxygen needed to decompose/oxidize organic/biological matter/waste; in specified time/5 days / at specified temperature/ 20 °C ; [2]
Award [1] for “measure of the organic matter in water” / OWTTE
- (b) (i) oxidizable pollutant / organic material/waste / sewage; [1]
Accept any specific example.
- (ii) O₂ used in aerobic respiration / by aerobic bacteria / breakdown of X uses O₂; [1]
- (iii) O₂ dissolving from air; oxygen consumption for decomposition/oxidation of X is decreased/completed; [2]
- (iv) days 9/10 – 12/13; [1]
- (c) line/curve with negative gradient; [1]
16. (a) (i) (salt build-up/accumulation) from excess irrigation; [1]
- (ii) soil fertility is reduced / plants do not grow; plants lose water (by osmosis)/become dehydrated (in salty soil); [2]
- (b) *Physical [1 max]:*
 improves structural stability;
 influences water retention properties;
 increases cation exchange capacity (due to presence of humus);
 thermal properties / absorbs heat;
- Biological [1 max]:*
 source of nutrients (for stronger plant growth);
 chelates to nutrient ions (preventing these from precipitating out);
 behaves as a buffer/controls pH;
 reduces/limits absorption of pesticides/heavy metal ions (through its chelating ability);
 provides source of heat; [2 max]
- (c) (switch from inorganic to) organic fertilizers / reduce inorganic/increase organic additives/manure/compost; [1]
Accept any other valid suggestions.
Do not accept “crop rotation”.



Ignore state symbols.

Award [1 max] for $4\text{NO}_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g}) \rightarrow 4\text{HNO}_3(\text{aq})$.



Ignore state symbols.

18. *Source:*
protective clothing/gloves / plastic bags / paper towels;

Storage/disposal method:

storage in (cooled) water/ponds / buried underground/in dedicated landfills/
shallow-lined trenches/steel/metal containers; [2]

Option F — Food chemistry

19. (a) substance that delays onset/slows rate of oxidation; [1]
Do not allow "prevents oxidation".
- (b) (i) alcohol/hydroxyl **and** phenyl; [1]
Accept benzene ring in place of phenyl.
Do not allow hydroxide or just benzene or arene.
- (ii) tertiary carbon (atom)/butyl group / C bonded directly to 3 methyl groups/
3 carbon (atoms); [1]
- (iii) $C_{15}H_{24}O$; [1]
- (c) (i) *Any two for [1]:*
carrot, squash, broccoli, sweet potato, tomato, kale, peach, apricot,
cantaloupe, mango, papaya, yam; [1 max]
Do not allow just melon.
- (ii) *Any two for [1]:*
vitamin C/ascorbic acid, vitamin E, selenium; [1 max]
- (d) may be less safe because not naturally occurring / *OWTTE*;
need to be regulated by policies and legislation / *OWTTE*;
difficulties in monitoring and implementing safe use / *OWTTE*;
may have a negative effect on human health; [1 max]
Accept any other valid argument.

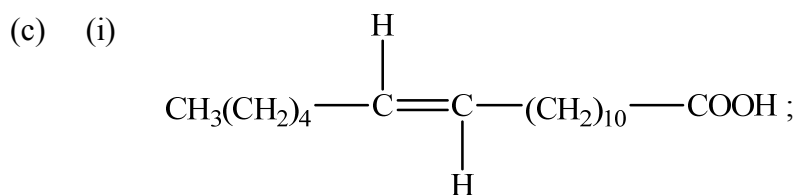
20. (a) stearic acid;
saturated molecule / more closely packed / greater surface area (of contact) / not "kinked";
more/stronger van der Waals' forces; [3]
Accept intermolecular/London/dispersion forces instead of van der Waals' forces.

- (b) $C_{17}H_{29}COOH(l) + 3H_2(g) \rightarrow C_{17}H_{35}COOH(l)$;
Ignore state symbols.
Accept either condensed structural formulas or molecular formulas.

Any two correct conditions for second mark:
high temperature/heat;
Accept any temperature value/range greater than 100 °C.

- (high) pressure;
(finely divided catalyst) Zn / Cu / Ni / Pt / Pd; [2 max]
Accept room temperature only if Pt or Pd is given as catalyst.

Note to examiners: it is very easy in Scoris to give one mark before two conditions are given.



Award mark for structures showing one or two double bonds with trans arrangement correctly shown.
Accept R as long as the trans arrangement is clear.
Ignore errors in hydrocarbon chain/position of double bonds so long as trans arrangement is clear. [1]

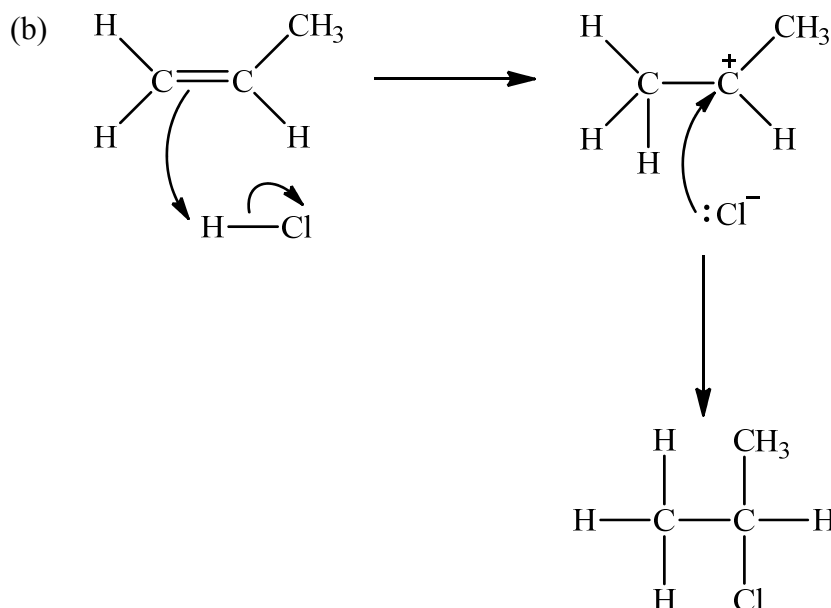
- (ii) *trans* fats harder to metabolize / accumulate in tissue;
increase levels of LDL cholesterol/low-density lipoprotein / increase risk of heart disease;
low-quality energy source; [2 max]

21. (a) kinetically stable mixture of one phase in another largely immiscible phase; [1]
- (b) (i) *Emulsion*: liquid in liquid **and** *Foam*: gas in liquid/solid; [1]
- (ii) *Emulsion*: unwhipped cream / butter **and** *Foam*: whipped cream;
Accept beer as example of foam. [1]
- (c) (i) emulsifier helps the mixing of the two phases whereas stabilizer prevents separation of the phases; [1]
- (ii) polar/hydrophilic/dissolves in water **and** non-polar/hydrophobic/dissolves in oil/fat; [1]

Option G — Further organic chemistry

22. (a) (i) (experimental) C–C bonds in benzene are all 0.140(nm)/the same length;
Kekulé structure would have C–C bond lengths of 0.154 and 0.134 (nm)/
benzene does not have C–C bond lengths of 0.154 or 0.134 (nm)/different
bond lengths; [2]
Award [1 max] if no reference to carbon-carbon bonds.
- (ii) $-360(\text{kJ mol}^{-1})$; [1]
- (b) (i) (circle represents six) delocalized electrons (over 6 C–C bonds); [1]
Allow “delocalized pi-bonds”.
Accept “resonance”.
- (ii) C–C/bond length/order is intermediate between double and single/1.5; [1]
- (c) (i) conjugate base/ion more stable as negative charge spread out/delocalized on
the ring;
lone/non-bonding pair on oxygen can interact with delocalized electrons of
benzene/aromatic ring / orbital overlap between non-bonding pair and
aromatic system; [2]
- (ii) NO_2 group is electron withdrawing/negative inductive effect / more
delocalization (over more atoms);
Do not just accept “NO₂ deactivating”.
- negative charge delocalized on the ring **and** NO_2 group / negative charge
on oxygen/conjugate base decreases more (because of the presence of
the NO_2 group, thus easier for H^+ to leave); [2]

23. (a) electrophilic addition; [1]



curly arrow going from C=C to H of HCl **and** curly arrow showing Cl leaving;
representation of carbocation;

curly arrow going from lone pair/negative charge on Cl to C⁺;
formation of CH₃CHClCH₃; [4]

(c) secondary carbocations are more stable (than primary);
positive inductive/electron pushing of methyl groups; [2]

24. (a) (i) C₂H₅MgBr / CH₃CH₂MgBr; [1]

(ii) Grignard reagents are basic/remove H⁺ from water to form alkane;
Accept "reacts with water". [1]

(b) (i) carbon dioxide/ CO₂ **and** water/ H₂O;
Accept dilute HCl(aq) instead of water/H₂O. [1]

(ii) propanone/acetone/(CH₃)₂CO **and** water/H₂O;
Accept dilute HCl(aq) instead of water/H₂O. [1]

Only penalize missing H₂O once in (b).