

MARKSCHEME

November 2003

CHEMISTRY

Higher Level

Paper 3

1. Follow the markscheme provided, do **not** use decimals or fractions and mark in **RED**.
2. Where a mark is awarded, a tick (✓) should be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark.
3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases write a brief annotation in the **left hand margin** to explain your decision. This is useful for moderation and re-marking.
4. Unexplained symbols or personal codes/notations on their own are unacceptable.
5. Record subtotals (where applicable) in the right-hand margin against the part of the answer to which they refer next to the mark allocation. Do **not** circle subtotals. **Circle the total mark for the question in the right-hand margin opposite the last line of the answer.**
6. Where an answer to a part question is worth no marks, put a zero in the right-hand margin.
7. For each Option: Add the totals for each question in the Option and write it in the Examiner column on the cover sheet.
Total: Add the marks awarded and enter this in the box marked TOTAL in the Examiner column.
8. After entering the marks on the cover sheet, 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. **We have script checking and a note of all clerical errors may be given in feedback to examiners.**
9. Every page and every question must have an indication that you have marked it. Do this by **writing your initials** on each page where you have made no other mark.
10. If a candidate has attempted more than the required number of Options within the paper, mark only the required number of Options in the order in which they are presented in the paper, **unless the candidate has indicated the Options s/he wants to be marked, on the cover sheet.**
11. A candidate can be penalized if s/he clearly contradicts him/herself within an answer.

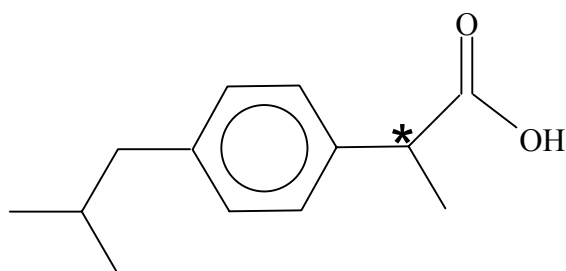
Subject Details: Chemistry HL Paper 3 Markscheme**General**

- Each marking point is usually shown on a separate line or lines.
- 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) intramuscular / into muscles ;
 intravenous / into veins
 subcutaneous / into fat (*Award [2] for three correct , [1] for two or one correct*;
 accept parenteral (other than by mouth).
 intravenous;
 the drug is circulated / transported quickly via the blood stream (to various parts of
 the body); [4]
- (b) more and more of the drug needs to be taken to achieve the original effect;
 it may get close to / exceed the lethal dose; [2]
- B2.** (a) the dichromate(VI) ion is reduced / forms the Cr^{3+} ion;
 the ethanol is oxidized / forms ethanal / ethanoic acid; [2]
- (b) ethanol absorbs infrared radiation at a particular wavelength / due to –OH bond;
 sample of breath compared with a reference sample containing no breath;
 intensity of emerging beam converted into alcohol concentration; [3]
- (c) alcohol has a synergistic effect / *OWTTE* with other drugs;
 alcohol depresses central nervous system which enhances the effect of other drugs
 which have a sedative effect on CNS / increased risk of stomach bleeding with aspirin;
 alcohol can reduce the effectiveness of some drugs; [2 max]
- B3.** (a)
- The diagram shows the chemical structure of 4-methylamphetamine (4-MTA). It features a benzene ring on the left, connected to a methylene group (CH₂). This methylene group is bonded to a methine group (CH), which is also bonded to a methyl group (CH₃) below it. The methine group is further bonded to a nitrogen atom (N). The nitrogen atom is bonded to a hydrogen atom (H) above it and another methyl group (CH₃) to its right.
- the ring must circle the N atom to gain the mark;*
 secondary; [2]
- (b) the amine in 4-MTA is a primary amine [1]
- (c) (i) they all contain the phenylethylamine structure / contain a benzene ring linked to
 two carbon atoms attached to an amine group [1]
- (ii) sympathomimetic drugs mimic the effect of adrenaline / stimulate the sympathetic
 nervous system;
 speed up the heart / increase sweat production / increase rate of breathing; [2]

B4. (a)



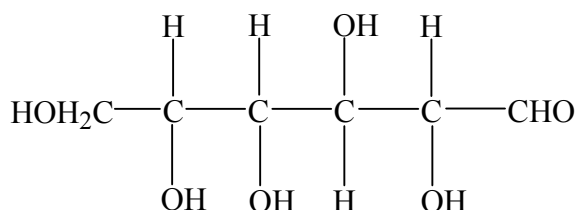
[1]

- (b) a chiral auxiliary is itself an enantiomer;
it is bonded to the reacting molecule to create the stereochemical conditions necessary to follow a certain pathway;
once the desired enantiomer is formed the auxiliary is removed;
different enantiomers may have different biological effects, some of which may be harmful;
genetic defects / deformities / other suitable example;

[5]

Option C – Human biochemistry

C1. (a)



[1]

(b) the -OH group on the first carbon atom is inverted in β -glucose

[1]

(c) one (amylose) is a straight chain polymer whereas the other (amylopectin) is branched; one (amylose) has only 1,4 bonds (between the monomers) whereas the other (amylopectin) has 1,4 and 1,6 bonds;

[2]

(d) M_r for sucrose = 342;

$$\text{heat evolved} = 0.631 \text{ (kg)} \times 4.18 \text{ (kJ kg}^{-1} \text{ K}^{-1}) \times 6.22 \text{ (K)} = 16.4 \text{ kJ};$$

$$\text{calorific value} = \frac{16.4 \times 342}{1.00} = 5.61 \times 10^3 \text{ kJ mol}^{-1};$$

[3]

C2. (a) stearic acid is saturated, linoleic acid is unsaturated / contains C=C double bonds; regular tetrahedral arrangement in stearic acid / they can pack closer together (so van der Waals' forces are stronger) / *OWTTE*;

C=C causes a change in bond angle so unsaturated acids are unable to pack so closely (so van der Waals' forces are weaker hence m.pt. lower) / *OWTTE*;

[3]

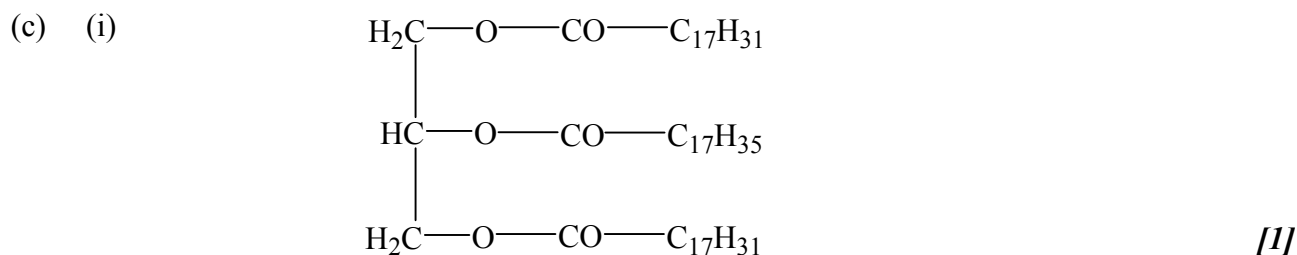
(b) (i) zero (it is saturated so iodine cannot add)

[1]

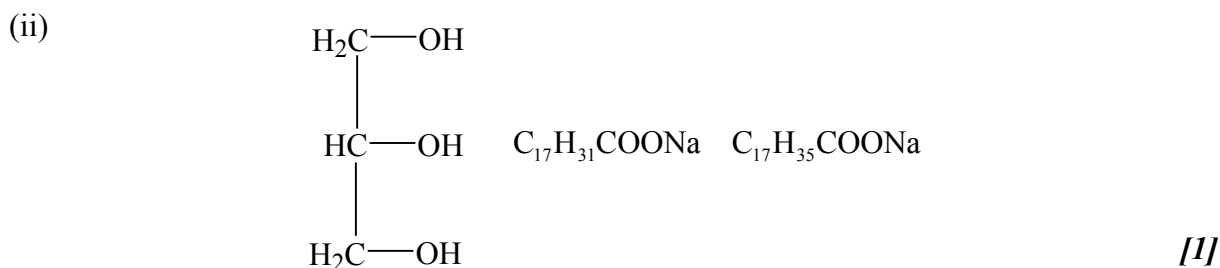
(ii) amount = $\frac{100}{280} = 0.357 \text{ mol};$

mass of I₂ = 2 × 0.357 × 254 = 181 g;

[2]



Accept acid residues in a different order.



Allow for ECF if structure in (c) is incorrect. Accept any two correct formulas for [1].

C3. (a) (i) the nucleotides condense / form a phosphodiester bond;
between the C₃ of the sugar and a neighbouring phosphate group; [2]

(ii) hydrogen bonds formed between the different strands;
thymine/T bonds to adenine/A and cytosine/C bonds to guanine/G; [2]

(b) the coded information lies in the sequence of triplets of bases / codons;
each codon / triplet represents an amino acid (or a terminator); [2]

(c) *Award [1] for any three of following.*
DNA extracted from blood / sample;
cut into mini-satellites using restriction enzymes;
fragments separated by gel electrophoresis;
some mention of method of detecting the pattern e.g. labelling with ³²P and using X-ray film / staining with fluorescent dye;

DNA profile taken from child should be similar to adult's DNA if the adult is the parent;

The last point stands in its own right.

[4 max]

Option D – Environmental chemistry

- D1.** (a) catalytic converter / lean burn engine / thermal exhaust reactor;
 $2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$ (for catalytic converter also accept $2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2$); [2]
- (b) catalytic converter;
 $2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2$; [2]
- (c) (alkaline) scrubbing / fluidized bed combustion;
 $\text{CaCO}_3 + \text{SO}_2 \rightarrow \text{CaSO}_3 + \text{CO}_2$ / $\text{CaO} + \text{SO}_2 \rightarrow \text{CaSO}_3$; [2]
- (d) catalytic converter;
 Accept thermal exhaust reactor but not lean burn. [2]
 $2\text{C}_8\text{H}_{18} + 25\text{O}_2 \rightarrow 16\text{CO}_2 + 18\text{H}_2\text{O}$;
- D2.** (a) it contains dissolved carbon dioxide;
 $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ / $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{HCO}_3^-$; [2]
- (b) coal contains sulfur (which burns to form SO_2);
 $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$ (accept equation for formation of H_2SO_3 or H_2SO_4); [2]
- (c) (i) it leaches nutrients (Ca^{2+} , Mg^{2+} , K^+) from the soil;
OR it lowers the concentration of Mg^{2+} so reduces the amount of chlorophyll / photosynthesis;
OR it increases the concentration of Al^{3+} (from rocks) which damages roots; [1 max]
- (ii) $\text{CaCO}_3 + 2\text{H}^+ \rightarrow \text{Ca}^{2+} + \text{CO}_2 + \text{H}_2\text{O}$ [1]
 Accept full equations with HNO_3 , H_2SO_3 or H_2SO_4 .
- (d) CaO is a basic oxide / CaO neutralises the acid in the lake / equation to represent this [1]

- D3.** (a) LD_{50} : the dose required to kill 50 % of the population (upon which the toxin is tested);
 maximum daily tolerance: a measure of the level of toxin that a person can be exposed to without being harmed;

Disadvantage of LD_{50} :

tests done on animals not people;
 different species react differently to different poisons;
 very large doses of relatively non-toxic substances required to kill 50 % of population;
Award [1] each for any two disadvantages in list.

Disadvantage of maximum daily tolerance:

imprecise as people differ in the amount they can tolerate;
 long term effect(s) may not be immediately apparent;
 impossible to define safe / sometimes multiplied by an extra safety factor;
Award [1] each for any two disadvantages in list.

[6 max]

- (b) M_r of $\text{NO}_3^- = 62.01$ M_r of $\text{NaNO}_3 = 85.00$;

mass of NaNO_3 in $1.00 \text{ dm}^{-3} = 50 \times \frac{85.00}{62.01} = 68.5 \text{ mg}$ ($6.85 \times 10^{-2} \text{ g}$); **[2]**

- (c) nitrates are converted into nitrosamines;
 which are carcinogenic / *OWTTE*;

[2]

Option E – Chemical industries

- E1.** (a) (i) *Award [1] each for any three of the following.*
 availability of investment and or incentives / ready market for product / available labour / suitably skilled workforce / minimal pollution to local area; **[3 max]**
- (ii) intermediate product: used to make another chemical *e.g.* H_2SO_4 , NH_3 *etc.*;
 consumer product: end product *e.g.* pharmaceuticals / silicon chips / dyes *etc.*; **[2]**
Both definition and a suitable example must be given to gain mark.
- (b) enzymes to make ethanol / fructose syrup / proteases in biological detergents / insulin production / vitamin synthesis / other suitable example **[1]**
- E2.** (a) peroxide / oxygen acts as an initiator / to form free radicals;
 radical mechanism;
Award [1] for any correct equation e.g.
 $\text{R-O-O-R} \rightarrow 2 \text{RO}\cdot$
 $\text{RO}\cdot + \text{H}_2\text{C}=\text{CH}_2 \rightarrow \text{R-O-CH}_2\text{-CH}\cdot$
 $\text{R-O-CH}_2\text{-CH}_2\cdot + \text{H}_2\text{C}=\text{CH}_2 \rightarrow \text{R-O-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\cdot$ *etc.*; **[3]**
- (b) Ziegler-Natta catalyst / titanium(III) or titanium(IV) chloride (together with an alkyl-aluminium compound *e.g.* triethylaluminium $\text{Al}(\text{C}_2\text{H}_5)_3$);
 the titanium atom can utilize its empty d orbitals; **[2]**

- E3. (a)** Fe downwards because
 the reduction of FeO is an endothermic process so (ΔH^\ominus) is positive;
 ΔS^\ominus is positive as the system is becoming more disordered;
 $\Delta G^\ominus = \Delta H^\ominus - T\Delta S^\ominus$ so at lower temperatures the value for ΔG^\ominus becomes more positive
 (as the factor $-T\Delta S^\ominus$ becomes less negative);
 CO upwards because
 two moles of gas are being converted into one mole of gas so the system is becoming more
 ordered (*i.e.* the factor $-T\Delta S^\ominus$ becomes more positive with decreasing temperature); **[4]**
- (b) for reduction to occur ΔG^\ominus for the reducing system must be more negative than ΔG^\ominus
 for the formation of the metal oxide;
 so the overall value of ΔG^\ominus for the redox reaction will be negative;
OR $\text{FeO} + \text{C} \rightarrow \text{Fe} + \text{CO}$ ΔG^\ominus negative above 1000 K;
 $\text{FeO} + \text{CO} \rightarrow \text{Fe} + \text{CO}_2$ ΔG^\ominus positive above 1000 K / *OWTTE*; **[3]**
- (c) $\text{Fe}_3\text{O}_4 + 4\text{H}_2 \rightarrow 3\text{Fe} + 4\text{H}_2\text{O}$ **[1]**
- (d) preheated oxygen is injected;
 at (high) pressure;
 this oxidise the impurities;
one equation from: $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ / $\text{P}_4 + 5\text{O}_2 \rightarrow \text{P}_4\text{O}_{10}$ / $\text{Si} + \text{O}_2 \rightarrow \text{SiO}_2$;
 lime / CaO / CaCO_3 is also added to form slag / CaSiO_3 ;
 reaction is exothermic so temperature controlled by adding scrap steel; **[6]**

Option F – Fuels and energy

- F1.** (a) *Any two of the following:*
 fission involves the breakdown of the nucleus, chemical bond breaking involves the rearrangement of electrons;
 no new elements are formed in chemical fission, they are in nuclear fission;
 mass is lost in nuclear fission and retained in chemical fission;
 a large change in energy for nuclear fission compared to chemical bond breaking;
 chemical bond breaking is endothermic, nuclear fission may be exothermic or **[2 max]** endothermic;
- (b) (i) neutron / ${}_0^1\text{n}$ **[1]**
- (ii) $2.072 \times 10^{-4} \text{ kg} \times (3.00 \text{ m}^2 \text{ s}^{-2} \times 10^8)^2 = 1.86 \times 10^{13} \text{ J}$ (or $1.862 \times 10^{10} \text{ kJ}$) **[1]**
- (c) 1.35×10^{10} years **[1]**
- (d) (i) control rods absorb excess neutrons;
 moderators slow down neutrons (making them more likely to collide with fissionable nuclei); **[2]**
- (ii) cadmium / boron **[1]**
- (e) to avoid the transfer of radioactivity to the water / escape of radioactivity **[1]**
- F2.** (a) the mixture burns as efficiently as a mixture of 2% heptane and 98% 2,2,4-trimethylpentane / an isomer of octane **[1]**
- (b) $2\text{C}_8\text{H}_{18} + 25\text{O}_2 \rightarrow 16\text{CO}_2 + 18\text{H}_2\text{O}$ (accept $\text{C}_8\text{H}_{18} + 12.5\text{O}_2$ etc.) **[1]**
- (c) $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2$ **[1]**
- (d) (i) $\frac{1000}{114} \times 5512 = 4.83 \times 10^4 \text{ kJ}$ **[1]**
- (ii) $\left(\frac{800}{114} \times 5512\right) + \left(\frac{200}{46} \times 1371\right)$;
 $= 4.46 \times 10^4 \text{ kJ}$; **[2]**

F3. *Advantages:*

water is abundant;
burning H_2 to recover the energy is non polluting;
energy is released quickly from H_2 compared to H_2O ;

Award [1] each for any two.

Disadvantages:

inefficient (as energy lost when changing from one form to another)/ expensive;
hydrogen potentially explosive / flammable gas;
must be stored and transported in large / heavy containers (as cannot be easily liquefied); **[4 max]**

F4. photovoltaic cell converts light into electricity;

light stimulates flow of electrons in Si or Ge / *OWTTE*;
doping with Group 5 element / As *etc.*;
produces an electron rich layer / n-type semiconductor;
doping with Group 3 element / Ga *etc.*;
produces an electron deficient layer / p-type semiconductor;

[6]

Option G – Modern analytical chemistry

- G1.** (a) ^1H NMR absorptions are due to transitions between different energy states in the nucleus (when an external magnetic field is applied);
IR absorptions are due to bond vibrations;
nuclear transitions are at a much lower energy than bond vibrations; [3]
- (b) the bond in both molecules vibrates / stretches;
only the stretching in H—I causes a change in dipole moment; [2]
- (c) phenolphthalein in alkaline solution is more conjugated than it is in acidic solution;
the more conjugation / delocalization of electrons the less energy is required to excite the electrons; [2]
- G2.** (a) (i) $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ is pink / colourless and $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ is green / the colours they show are complementary to the colours they absorb;
colour is caused by transitions between the d orbitals;
different metals cause the d orbitals to split differently (due mainly to the different number of protons in the nucleus); [3]
- (ii) the oxidation state affects the size of the d orbital splitting due to the different number of electrons present [1]
- (iii) the more electron-dense the ligand the greater the splitting of the d orbitals [1]
- (b) determine λ_{max} ;
make up different solutions of known concentrations from the standard;
measure the absorbance for each concentration at λ_{max} ;
plot a calibration curve and read off value of unknown concentration from its absorbance;
at a fixed wavelength the absorption is directly proportional to the concentration provided the same pathlength is used / Beer-Lambert law only works for dilute solutions; [5]
- G3.** IR:
both have (sharp) C=O absorption at about 1680 – 1750 cm^{-1} 1610 – 1680 cm^{-1} ;
and C—H absorptions at about 2840 – 3095 cm^{-1} ;
only obvious difference will be in the “fingerprint region”;
- ^1H NMR :
propanal will show three separate absorptions;
a triplet at 0.9 ppm, a quartet at 1.3 ppm (*accept 1.1 – 1.6 ppm*) and a singlet at 9.7 ppm;
in the ratio of 3:2:1;
propanone will show one absorption;
a singlet at 2.1 ppm; [8]

Option H – Further organic chemistry

H1. (a) Similarities:

both double bonds are made up of one σ bond and one π bond;

the electrons are at 120° to the two other bonds attached to the C atom(s) / the carbon atom is sp^2 hybridized in both bonds;

Do not award a mark for simply stating that both are covalent.

Differences:

the (shared) electrons are closer to the O atom in propanal / the bond in propanal is polar / *OWTTE*;

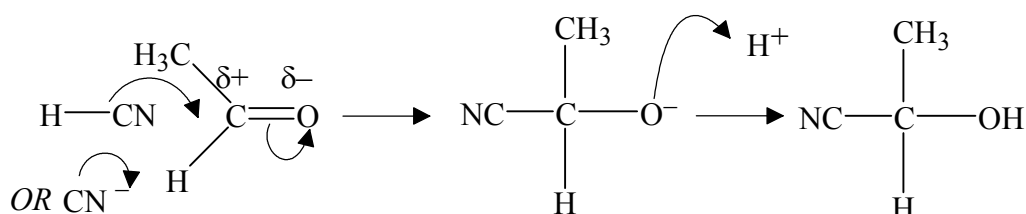
the $C=O$ bond is shorter / stronger than the $C=C$ bond (*this data is available from the Data Booklet*);

[4]

- (b) propene: electrophilic (addition);
propanal: nucleophilic (addition);

[2]

- (c)



[1]

[1]

[1]

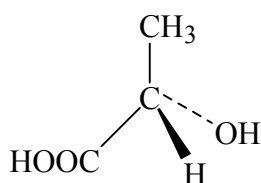
[1]

[4]

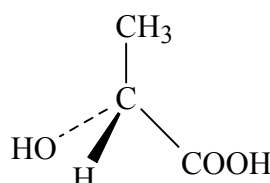
Mark for intermediate.

Do not penalize if CN is the wrong way round.

- (d) (i)



[1]



[1]

[2]

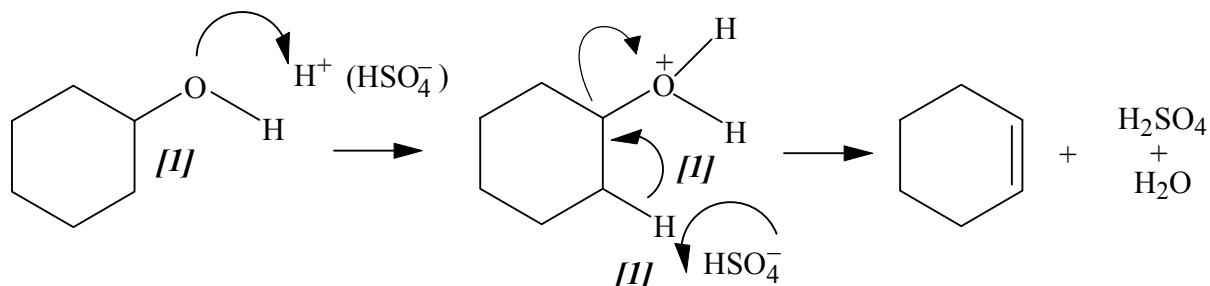
Allow [1] if the structures are correct but it is not clear that they are mirror images.

- (ii) (identical) except with other optically active compounds;
(identical) except that they rotate the plane of plane polarised light in opposite directions;

[2]

H2. (a) reduction (*accept redox*) [1]

(b)



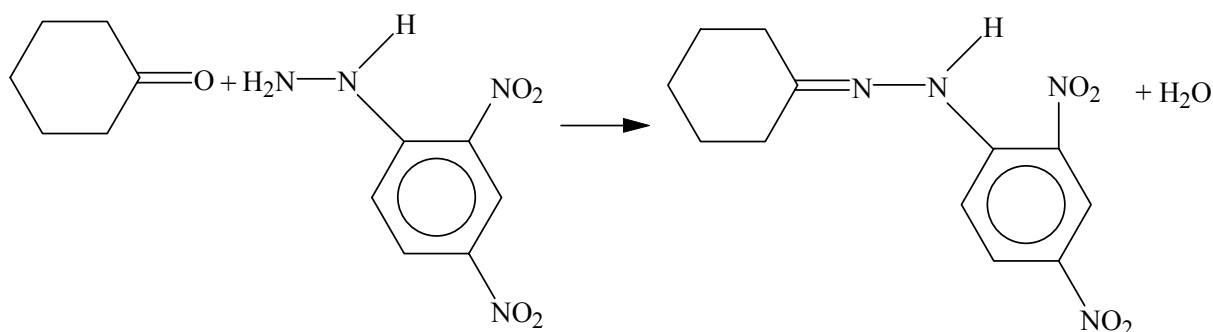
H_2SO_4 acts as an acid by protonating the O atom of the alcohol group / HSO_4^- acts as a base to remove the proton in the intermediate;

H_2SO_4 acts as a dehydrating agent removing the water formed / moving the position of equilibrium towards the right / increasing the yield of the alkene; [5]

(c) H_3PO_4 does not react with the product / less side reactions / not an oxidizing agent [1]

(d) (i) addition-elimination / condensation [1]

(ii)



Award [1] for correct structural formula of the organic product and [1] for including water in the equation. [2]

(iii) the (crystalline) solid has a characteristic melting point [1]