



# **MARKSCHEME**

**November 2001**

**CHEMISTRY**

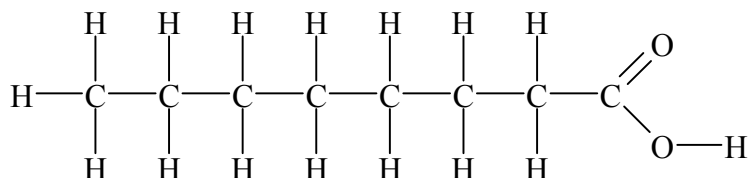
**Higher Level**

**Paper 3**

**OPTION C – HUMAN BIOCHEMISTRY**

**C1.** (a)  $\text{CH}_2\text{OH}-\text{CHOH}-\text{CH}_2\text{OH}$  [1]

(b)  $-\text{COOH}$  [1]



(Accept  $\text{CH}_3(\text{CH}_2)_6\text{COOH}$  or any correct alternative, including branched structures or alkenoic acids.) [1]

(c) Molecules of saturated fats contain only single C—C bonds in the carbon chains / contain no double bonds. [1]

Molecules of unsaturated fats contain at least one C=C double bond. [1]

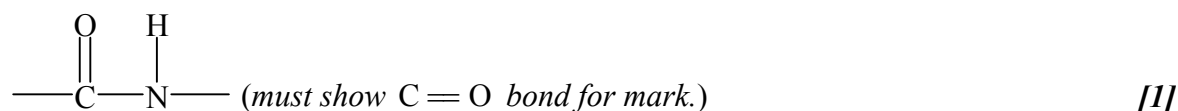
The degree of unsaturation can be found by determining the number of moles of iodine that react with one mole (or a stated mass) of fat. [1]

Iodine adds across the C=C double bond in a 1:1 stoichiometric ratio. [1]

**Total [7 marks]**

**C2.** (a)  $-\text{NH}_2$  / amino group / amine. [1]

(b) Peptide bond (accept amide bond) [1]



(c) First hydrolyse the peptide bonds to release individual amino acids then use chromatography (comparison of  $R_f$  values) (accept electrophoresis / mass spectrometry). [1]

(Award both marks if X-ray crystallography is given.) [1]

(d) The secondary structure describes the type of coil or sheet / folding of polypeptide /  $\alpha$ -helix and  $\beta$ -pleated sheet. [1]

Tertiary structure describes the interactions between the R groups of the amino acid residues. [1]

(e) Hydrogen bond. [1]

**Total [8 marks]**

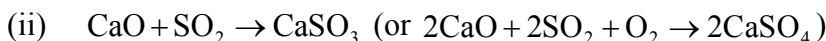
- C3. (a)** Enzymes provide an alternative pathway with a lower activation energy. [1]  
 Enzymes possess an active site where the substrate binds to the enzyme. [1]  
 Mention of 'lock and key' and/or induced fit hypothesis. [1]
- Competitive inhibitors (resemble the substrate in shape) compete with the substrate for the active site (and therefore slow the rate of reaction). [1]  
 Non-competitive inhibitors bind to the enzyme away from the active site. [1]
- (b)**  $K_m$  for uninhibited enzyme  $\left(= \frac{1}{2} V_{\max}\right) = 7 \pm 1 \mu\text{mol dm}^{-3}$  [1]
- With a competitive inhibitor  $K_m$  is higher,  $V_{\max}$  is the same. [1]  
 At high [S] effect of inhibitor is negligible so no change to  $V_{\max}$  but more substrate needed to reach  $\frac{1}{2} V_{\max}$  so  $K_m$  is higher. [1]
- With a non-competitive inhibitor  $K_m$  is the same but  $V_{\max}$  is lower. [1]  
 Adding a non-competitive inhibitor has the same effect as lowering [enzyme] (hence  $V_{\max}$  is lower), but does not affect the way the substrate interacts with those enzyme molecules that are uninhibited (hence  $K_m$  is unchanged). [1]

**Total [10 marks]**

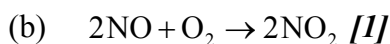
**OPTION D – ENVIRONMENTAL CHEMISTRY**



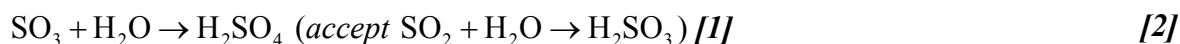
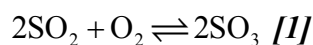
*(Award [1] for correct products and [1] for balanced equation.)* [2]



*(Award [1] for reactants and [1] for product.)* [2]



**OR**



- (c) Irritation of the mucous membranes / fatigue / weakness / confusion (e.g. from exposure to  $\text{C}_6\text{H}_5\text{CH}_3$ ) / cancer forming / respiratory problems. [1]

**Total [7 marks]**

**D2.** (a) Polychlorinated biphenyls [1]

- (b) (i)  $\text{LD}_{50}$  – lethal dose in 50 % of the population (the amount of poison that kills half the organisms in a randomly chosen batch of a named species). [1]

Maximum daily tolerance – the highest amount or concentration that has ‘no effect’ on any of the organisms in a specified batch. [1]

- (ii)  $\text{LD}_{50}$ :

Advantage: clearly measurable value. [1]

Disadvantage: not done on human population so effect on humans ‘unknown’. [1]

**OR**

Maximum daily tolerance value:

Advantage: gives idea of ‘safe amount’. [1]

Disadvantage: same as for  $\text{LD}_{50}$  so has to be divided by ‘safety factor’. [1]

- (c) (i) Batteries / seed dressings to prevent mould / chlor-alkali process (do not accept “mercury fillings in teeth”). [1]

- (ii) *(Award [1] for any of the following:)*

inflammation of the mouth / muscle spasms / nausea / diarrhoea / kidney damage / blindness / deafness / damage to CNS / personality change. [1]

- (iii) The  $\text{Hg}^+$  ions interfere with the normal functioning of enzymes (e.g. by replacing the  $\text{Ca}^{2+}$  or  $\text{Mg}^{2+}$  ions). [1]

**Total [10 marks]**

- D3.** Water is a highly polar substance (due to shape and high electronegativity of oxygen). [1]  
Capable of hydrogen bonding (that allows it to dissolve many chemicals). [1]

Fresh water not available uniformly around the world / 'locked up' in glaciers and icebergs. [1]

Where the consumption is necessarily high it is easily contaminated with water borne diseases / by micro-organisms from human waste / from flooding / due to inadequate chemical treatment of water supplies. [1]

Reverse osmosis:

Uses high pressure [1]  
to force water from salt-water through partially- (semi)-permeable membrane; [1]  
the partially-permeable membrane does not allow the passage of dissolved ions. [1]

**OR** Osmosis is the net movement of water molecules from a region of high concentration, *i.e.* pure water to one of lower concentration, *i.e.* less pure water through a partially-permeable membrane / osmosis is the tendency to equalise concentrations. [1]

Due to osmosis, pure water will move through a partially-permeable membrane into salt water, thus diluting it. [1]

If pressure greater than osmotic pressure is applied, the flow of solvent takes place in the opposite direction, called reverse osmosis. [1]

Ion exchange:

Requires the use of both a positive ion exchange (which can replace metal ions in sea water with  $H^+$  ions) [1]

and a negative ion exchange (which can replace anions with  $OH^-$  ions). [1]

The  $H^+$  and  $OH^-$  ions combine to form fresh/pure water. [1]

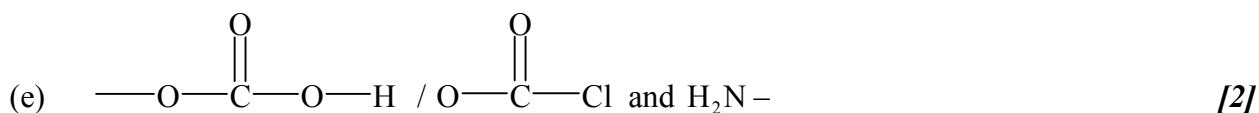
**Total [10 marks]**

**OPTION E – CHEMICAL INDUSTRIES**

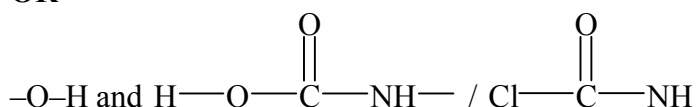
- E1.** (a) (i)  $\text{N}_2$  obtained from the fractional distillation of liquid air. [1]  
*(Not enough to just state 'from air'.)*
- (ii)  $\text{H}_2$  obtained from cracking of petroleum products / from water using reduction with methane / from water using reduction with naphtha / catalytic reforming / electrolysis of sodium chloride solution. [1]
- (b) There are four volumes (moles) of gas on LHS and only two on RHS [1]  
 so increasing the pressure will move the position of equilibrium to the right [1]  
 Increasing the pressure increases the concentration of the gases [1]  
 So reaction rate increases. [1]
- (c) The yield of ammonia is low [1]  
 so most of the  $\text{N}_2$  and  $\text{H}_2$  needs to go round again (to save waste/cost). [1]

**Total [8 marks]**

- E2.** (a) The free radical electron ( $\text{HO}-\text{CH}_2-\text{CH}_2\cdot$ ) attacks one of the C atoms in  $\text{H}_2\text{C}=\text{CH}_2$ . [1]  
 An electron from one of the bonds in the double bond joins this electron to form a single C–C bond. [1]  
 The double bond is now a single bond with the electron on the end carbon. [1]
- (b)  $\text{HO}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2\cdot + \text{H}_2\text{C}=\text{CH}_2 \rightarrow \text{HO}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2\cdot$  [1]
- (c) High density is ionic. [1]
- (d) *(Award [1] each for two conditions from the following:)*  
 • Temperature about  $60^\circ\text{C}$ ;  
 • Pressure 2–6 atmospheres;  
 • Ziegler (Natta) catalyst/triethylaluminium with titanium(IV) chloride. [2]



**OR**



**Total [9 marks]**

**E3.** Tabulated form of answer.

(For each, give [1] for the process, [1] for the reactants, [1] for the products, and [1] for explaining the conditions.)

Choose from the following:

Temperature	
Thermal cracking / coking	Thermal decomposition of <b>very heavy fractions</b> to give mainly lower alkanes and alkenes <b>and a high coke yield</b> .
Steam cracking	Thermal cracking of <b>C<sub>2</sub>+ hydrocarbons (C<sub>4</sub>–C<sub>12</sub>)</b> to <b>alkenes (ethene, 1,3-butadiene, etc.)</b> in the presence of steam. Temperature around 800 °C.
Catalyst	
Catalytic cracking	Accelerated decomposition, with some aromatisation, of <b>middle/higher fractions</b> over <b>solid acidic catalysts/zeolites</b> . Gives <b>lower alkanes, alkenes, aromatics</b> .
Hydrocracking	Accelerated hydrogenolysis / decomposition of <b>heavy fractions</b> to <b>naphtha</b> over <b>metal/acid catalysts e.g. palladium on zeolite</b> .
Catalytic reforming (platforming etc.)	<b>Metal/acid-catalysed e.g. platinum on acidic alumina rearrangement / cyclisation and dehydrogenisation of alkanes and aromatisation of naphthas</b> .
Thermal / autothermal	More general term, including methane to ethene – cracking autothermal, with partial combustion.

[8]

By choosing a suitable catalyst, the temperature required is lower which makes it more efficient (and less costly) / helps to give the desired products by dictating the mechanism.

**Total [8 marks]**

**OPTION F – FUELS AND ENERGY**

- F1.** (a) Anode: zinc [1]  
 Cathode: graphite (carbon) [1]  
 Electrolyte: ammonium chloride **OR** zinc chloride and ammonium chloride and water. [1]
- (b) Anode:  $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$  [1]  
 Cathode:  $2\text{NH}_4^+ + 2\text{e}^- \rightarrow 2\text{NH}_3 + \text{H}_2$  [1]  
**OR**  $2\text{MnO}_2 + 2\text{NH}_4^+ + 2\text{e}^- \rightarrow \text{Mn}_2\text{O}_3 + 2\text{NH}_3 + \text{H}_2\text{O}$   
*(State symbols are not required.)*
- (c) *(Award [1] each for any **two** from the following:)*  
 No decline in performance under high loads / no gases formed at cathode / longer shelf life / able to produce more current for a longer time / good for emergency lighting. [2]
- (d) Voltage does not change [1]  
 voltage depends primarily on materials used. [1]

**Total [9 marks]**

- F2.** (a) (i)  ${}_0^1\text{n} + {}_{92}^{235}\text{U} \rightarrow {}_{37}^{90}\text{Rb} + {}_{55}^{144}\text{Cs} + 2{}_0^1\text{n}$  [2]  
*(Give [1] for correct isotopes and [1] for two neutrons.)*
- (ii)  $E = mc^2 = 1 \times 0.001 \times (3.0 \times 10^8)^2$  [1]  
 $= 9.0 \times 10^{13} \text{ J } (9.0 \times 10^{10} \text{ kJ})$  [1]
- (b) Four half-lives [1]  
 so  $t_{1/2} = \frac{57.2}{4} = 14.3 \text{ days}$  [1]

**Total [6 marks]**



- F3. (a)** The crude oil is heated; [1]  
 Fed into the base of a fractionating column; [1]  
 Temperature gradient across column / lower boiling fractions distil first; [1]  
 Fractions emerging in boiling range **not** pure compounds. [1]

*(Award [1] each for any three correct fractions from: (any two from number of C atoms, boiling range, and uses must be correct for each mark).)* [3]

Fraction	Number of C atoms	Boiling range / °C	Uses
Gases	1–4	0–200	cooking, heating
Naptha	5–7	20–100	solvents
Gasoline (petrol)	5–12	40–175	motor car fuel
Kerosene	12–18	175–300	jets / diesel
Gas oil	18–24	300–400	diesel fuel
Lubricating oil	20–30	non volatile	lubricants
Paraffin wax	25–40	solid	candles
Bitumen / tar	> 30	solid	road surfaces

- (b)  $C_{12}H_{26} \rightarrow C_8H_{18} + 2C_2H_4$  (or  $C_4H_8$ ) [1]  
*(must show an alkene for mark).*  
 Octane for car engines and alkenes for polymers. [2]

**Total [10 marks]**

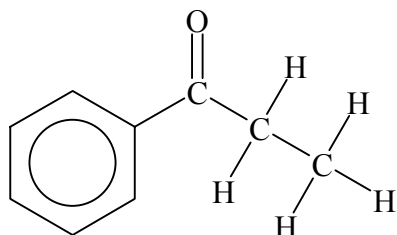
**OPTION G – MODERN ANALYTICAL CHEMISTRY**

- G1.** (a) (i) The positive molecular ion or  $M^+$  / parent ion. [1]  
 The molecular formula of compound A is  $C_9H_{10}O$  [1]  
 (Accept “the relative molecular mass of compound A is 134”.)
- (ii) Due to the presence of  $^{13}C$  isotopes in the compound. [1]
- (iii) 105 due to  $(M-C_2H_5)^+ / (C_7H_5O^+)$  [1]  
 (also accept  $(M-CHO)^+ / (C_8H_9^+)$ )  
 77 due to  $(M-C_3H_5O)^+ / C_6H_5^+$  [1]  
 (must have + sign to gain mark, but only penalize once if omitted)
- (b) (i) It contains a carbonyl / either alkanal or alkanone /  $C=O$  group. [1]  
 (Do not accept acid or ester.)
- (ii) C–H bond vibration (in alkanes, alkenes, arenes) [1]
- (iii) It does not contain an alkanol or phenol group / no –OH group present. [1]
- (c) (i) Molecular formula:  $SiC_4H_{12}$  (accept  $Si(CH_3)_4$ ) [1]  
 (Award [1] each for any two from the following:)  
 • Gives a sharp single peak;  
 • Strong peak as 12 protons in identical environment;  
 • Volatile so can be easily removed from the sample afterwards;  
 • Occurs well away from other peaks (which are shifted downfield from it). [2]
- (ii) They are in the ratio 3 : 2 : 5 (since there are only 10 protons this is the actual number). [1]
- (iii) It contains  $(-C_2H_5)$  group / a  $-CH_3$  group next to a  $-CH_2-$  group [1]  
 The  $-C_2H_5-$  group is attached to a C atom containing no other H atoms bonded to it. [1]
- (iv) It contains an aromatic (benzene) ring. [1]

*continued...*

*Question G1 continued*

(d)



(Give [1] for correctly showing aromatic ring and [1] for  $\text{—}\overset{\text{O}}{\parallel}{\text{C}}\text{—C}_2\text{H}_5$  group.) [2]

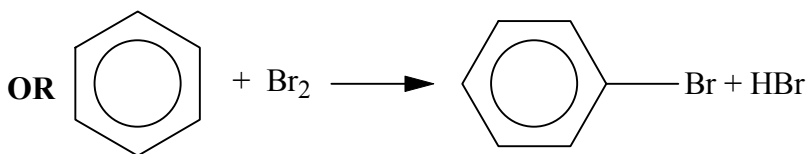
**Total [17 marks]**

- G2.** (a) The five d orbitals are split into different levels. [1]  
 When an electron is excited from a lower to a higher level it absorbs light/energy. [1]  
 The wavelength of the transmitted light / complementary colour lies in the visible region of the spectrum. [1]
- (b) A spectrum is run with the copper(II) sulfate solution to determine the wavelength of maximum absorption /  $\lambda_{\text{max}}$ . [1]  
 The standard solution is diluted to give several solutions of different known concentrations. [1]  
 The absorbance for each of these solutions at a fixed wavelength /  $\lambda_{\text{max}}$  is recorded. [1]  
 A calibration curve of absorption versus concentration is plotted. [1]  
 The absorption of the unknown solution is recorded at the same wavelength and the concentration obtained from the graph. [1]

**Total [8 marks]**

**OPTION H – FURTHER ORGANIC CHEMISTRY**

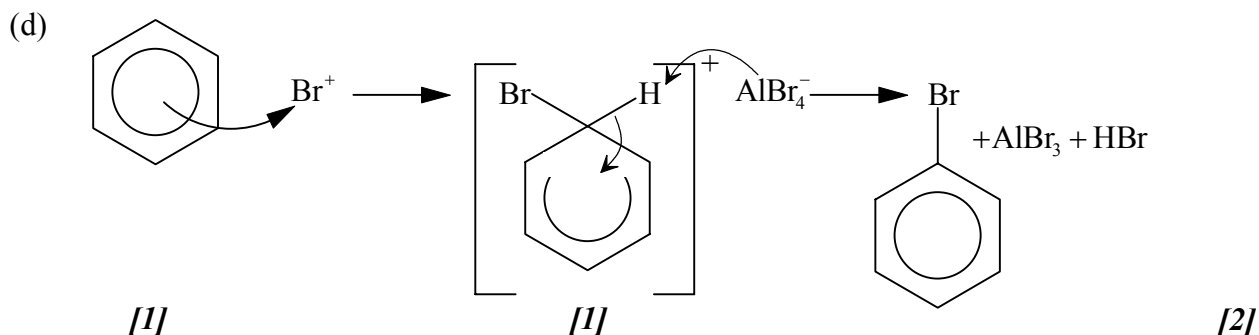
**H1.** (a)  $C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr$  [1]



(b) Addition of a halogen carrier /  $AlBr_3$  /  $Fe$  /  $FeBr_3$  [1]

Heat / reflux [1]

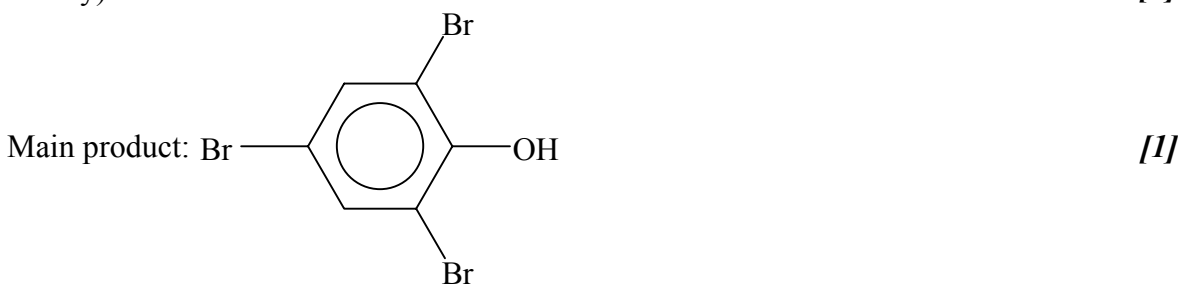
(c) Electrophile:  $Br^+$  [1]



(e) Phenol is more reactive than benzene. [1]

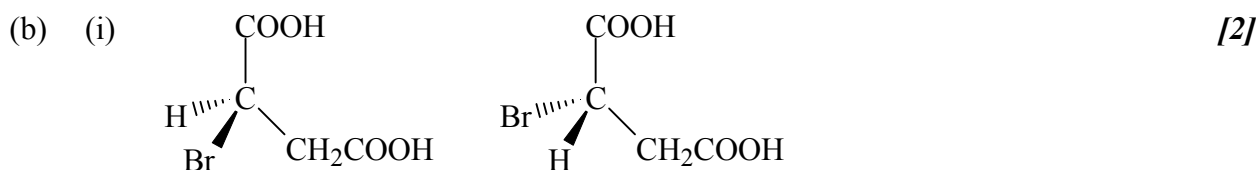
No halogen carrier necessary for the reaction to proceed. [1]

A pair of electrons on the oxygen atom delocalises with the  $\pi$  electrons in the ring (thus attracting electrophiles more readily). [1]



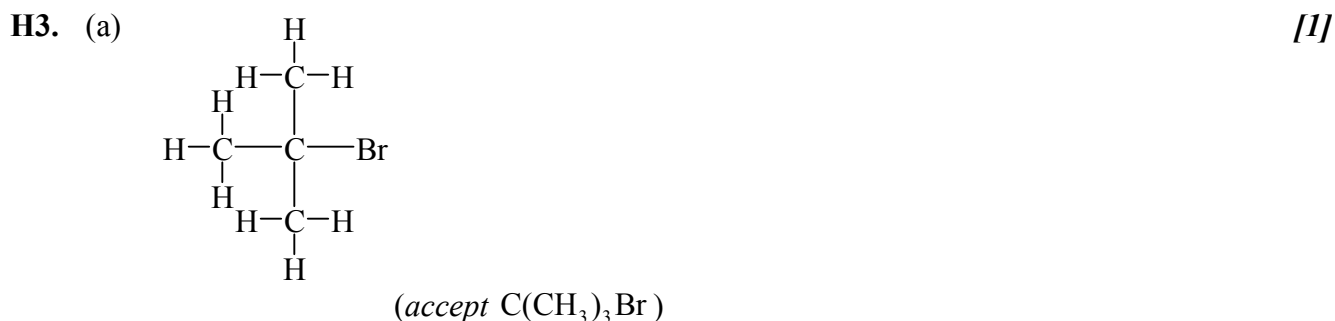
**Total [11 marks]**

- H2.** (a) The  $\pi$  bond prevents the double bond from rotating in both cases. [1]  
In but-2-ene the atoms in the two isomers are arranged differently in space / contain two different groups attached to each carbon atom. [1]

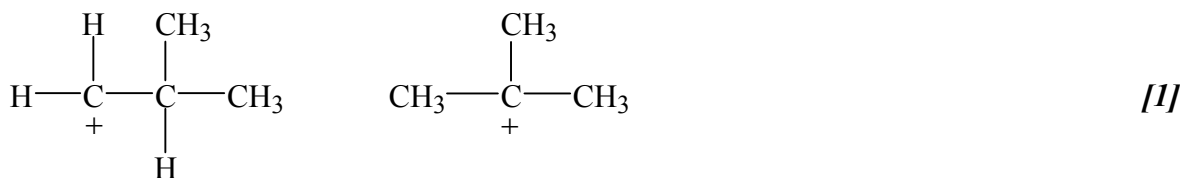
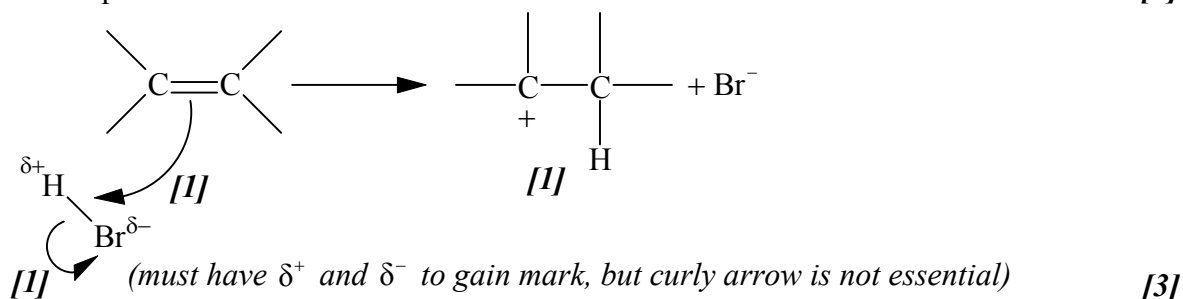


- (ii) They rotate the plane of polarised light in opposite directions. [1]  
Due to the presence of an asymmetric carbon atom / enantiomers / chirality. [1]

**Total [6 marks]**

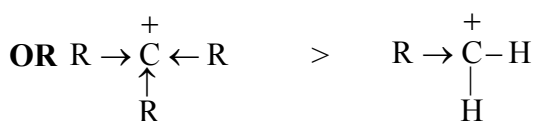


- (b) Electrophilic addition [1]



**OR** primary carbocation tertiary carbocation

Tertiary more stable [1]  
due to electron donating / positive inductive effect of the alkyl group. [1]



**Total [8 marks]**