1)

C

2)

B

3)

(a) A
(b) A
(c) D

4)

B

5)

D

6)

C

7)

C

8)

B

9)

B

10)

B

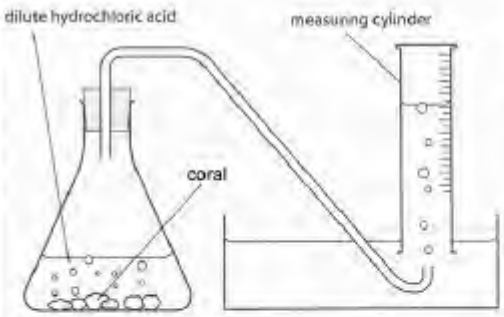
11)

A

12)

(a) (i)	$H_2O + CO_2 \rightarrow H_2CO_3$ (Allow atoms in H_2CO_3 in any order) Or $H_2O + CO_2 \rightarrow H^+ + HCO_3^-$ Or $H_2O + CO_2 \rightarrow 2H^+ + CO_3^{2-}$ Or H_3O^+ in place of H^+ *IGNORE STATE SYMBOLS EVEN IF INCORRECT*		1

estion mber	Acceptable Answers	Reject	Mar
(a) (ii)	$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$ LHS (1) RHS (1) OR $2H_3O^+ + CO_3^{2-} \rightarrow 3H_2O + CO_2$ LHS (1) RHS (1) *IGNORE STATE SYMBOLS, EVEN IF INCORRECT* *IGNORE* = arrows	H_2CO_3 as a product $H^+ + CO_3^{2-} \rightarrow HCO_3^-$ Any other ions including spectator ions (e.g. Ca^{2+}, Cl^-) in the equation scores zero	2

estion mber	Acceptable Answers	Reject	Mar
(b) (i)	 Conical flask and a delivery tube leaving the conical flask (1) *IGNORE* "heat" beneath conical flask Inverted measuring cylinder with collection over water shown and cylinder above mouth of delivery tube (1) *ALLOW* collection over water to be shown/implied in the diagram without labels or	If collection over water is not somehow evident	2

(b) (ii)	Any method which is likely to bring the reactants into contact after the apparatus is sealed	Method suggesting mixing the reactants and then putting bung in flask very quickly	1

estion nber	Acceptable Answers	Reject	Mari
(b) (iii)	(224 ÷ 24000 =) 0.009333/9.333 x 10^{-3} (mol) Ignore SF except 1 SF Ignore any incorrect units	"0.009" as answer	1

estion nber	Acceptable Answers	Reject	Mari
(b) (iv)	$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2$ (g/aq) ALL FOUR state symbols must be correct for this mark		1

estion nber	Acceptable Answers	Reject	Mari
(b) (v)	(Mass of 1 mol $CaCO_3$ = 40 + 12 + 3 x 16) = 100 g *ALLOW* just "100" *ALLOW* any incorrect units *ALLOW* "100.1 g " *OR* just "100.1" (Reason: this uses the Periodic Table value of A_r = 40.1 for Ca)		1
(b) (vi)	(Mass of $CaCO_3$ = 100 x 0.009333) = 0.9333 (g) **(1)** *IGNORE* sig figs including 1 sf here **NOTE:** Moles of $CaCO_3$ consequential on answers to (b)(iii) and (b)(v) [**NOTE:** if A_r = 40.1 used for Ca, then the answer = 0.9339 (g)] Percentage of $CaCO_3$ in the coral = 100 x 0.9333 /1.13 = 82.6% **(1)** **NOTE:** If mass $CaCO_3$ used is 0.93, final answer is 82.3% [**NOTE:** if A_r = 40.1 used for Ca, then the answers = 0.9339 (g) and **82.7%**]	Final % answer is **not given to 3 sf**	2
(b) (vii)	(Different samples of) coral have different amounts of $CaCO_3$ /different proportions of $CaCO_3$ / different "levels" of $CaCO_3$ *ALLOW* "calcium carbonate" for $CaCO_3$ OR Only one sample of coral (was) used	Answers that do not include any mention of $CaCO_3$ References to solubility of CO_2 in water References to repeating the experiment at a different temperature	1

13)

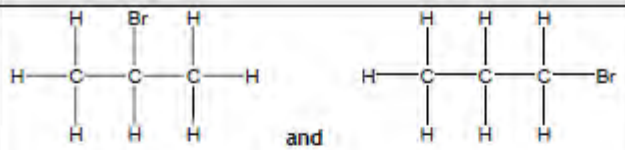
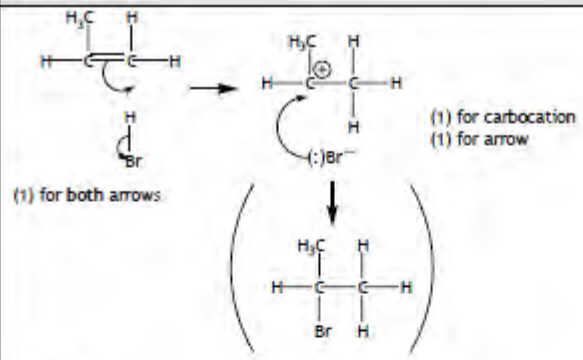
(c)	**First Mark:** *EITHER* Magnesium reacts with chlorine to form only magnesium chloride/ magnesium reacts with chlorine to form only one product / magnesium reacts with hydrochloric acid to form hydrogen (as well as magnesium chloride) / magnesium reacts with hydrochloric acid to form more than one product / magnesium reacts with hydrochloric acid to form a waste product *OR* **Both equations** $Mg + Cl_2 \rightarrow MgCl_2$ **and** $Mg + 2HCl \rightarrow MgCl_2 + H_2$ *IGNORE* state symbols, even if incorrect **(1)** **Second Mark:** *EITHER* The reaction with chlorine has an atom economy which is higher /100% ALLOW "high" *OR* Any mention of numbers comparing 100 % v. 97.9% **(1)** *IGNORE* any comments about **yield** **Mark the two points independently**		2

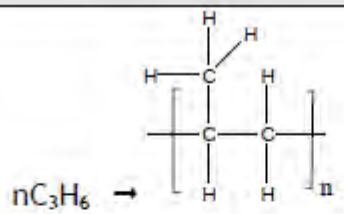
14)

(a)	$C_{10}H_{22} \rightarrow C_7H_{16} + C_3H_6$ *ALLOW* structural or displayed formulae instead of molecular formulae *IGNORE* any state symbols, even if incorrect		1

(b) (i)	diagram for the σ-bond e.g.  **First Mark:** *EITHER* Diagram shows overlap of any-shaped orbitals along the line between the two nuclei *OR* Mentions/implies rotation around a sigma/single bond **(1)** **Second Mark:** Any written mention, or clear evidence from the diagram (e.g. shading), of the resultant (high) electron density (along the line) between the two nuclei **(1)** diagram for the π-bond e.g. *EITHER*  *OR*  **Third Mark:** *EITHER* Diagram shows two dumb-bell shaped (p-) orbitals(these can be separate dumb-bells or the diagram can show the p-orbitals overlapping sideways) *OR* Restricted /lack of /no rotation about a pi/double bond **(1)** **Fourth Mark:** Any written mention, or clear evidence from the diagram (e.g. shading), of the resultant (high) electron density **above and below** (the line between) the two nuclei **(1)**	Just a line between the two nuclei Just curved lines above and below the two nuclei	4

(b) (ii)	Electrophilic addition *BOTH words needed* *ALLOW* "heterolytic" before electrophilic addition		1

(b) (iii)	π bond weaker than σ (bond) / less energy needed to break π bond *ALLOW* π bond weak(er) / π bond easy to break **(1)** π - electrons / π bonds (more) accessible (to electrophilic attack) *ALLOW* high/higher/more electron density in π bond (so alkenes more susceptible to electrophilic attack) **(1)** **Mark the two points independently**		2
(c) (i)	 and (main product) both DISPLAYED structures, with ALL bonds and atoms shown **(1)** major product identified or shown as product in (c)(ii) if NOT identified in (c)(i) **(1)** **NOTE:** if only one isomer of C_3H_7Br is named, assume this is the required "labelling" of the major product **Mark the two points independently**	CH_3 not fully displayed Incorrect name of isomer for 2nd mark	2
(c) (ii)	 (1) for both arrows (1) for carbocation (1) for arrow **1st mark:** Curly arrows must start from the bonds NOT the atoms **3rd mark:** Bromide ion must clearly have a 1^- charge to get this mark **NOTE:** The arrow from the bromide ion can start from anywhere on the Br^- ion (including the minus sign) or from a lone pair on Br^- if shown Curly arrow can go to the C or the + sign on the intermediate TE for mechanism on the isomer identified in (c)(i) or either mechanism if no major product has been identified in (c)(i) **Mark the three points independently**	**half** arrow-heads $Br^{\delta-}$	3

(c) (iii)	Secondary carbocation (named or described or drawn) **(1)** more stable (than primary) **(1)** **Mark the two points independently** **NOTE:** Zero awarded if primary carbocation thought to be more stable	Answers just in terms of Markownikoff's rule	2
(d) (i)	 $nC_3H_6 \rightarrow$ **Two "*n*'s" in the equation and a correct formula** (molecular or structural) for propene on left hand side of the equation **(1)** Correct repeating unit, with a methyl branch shown **(1)** *ALLOW* CH_3 fully displayed or just as CH_3 Continuation bond at each end (with or without bracket shown in equation) **(1)** Unsaturated polymer scores max **(1)** **Mark the three points independently**	"x" instead of "n"	3
(d) (ii)	**(Advantage):** polypropene will decompose (naturally) *ALLOW* "rot" or "break down" *OR* polypropene will not require landfill (as it can decompose in sunlight) *OR* no need to incinerate /burn *IGNORE* "good for environment" / "no pollution" **(1)** **(Disadvantage):** poly(propene) cannot be used when exposed to (bright) sunlight / UV / outdoors *OR* cannot be recycled / cannot be reused **(1)** **Mark the two points independently**	"Can be recycled" (0) for first scoring point Biodegradable for 1st mark Answers which do not imply exposure to UV/sunlight Biodegradable for 2nd mark	2

15)

(a) (i)	(q = 250 x (31.5 – 21.0) x 4.18 =) **10972.5** (J) *IGNORE* sf except 1 sf *IGNORE* units even if incorrect *IGNORE* any sign at this stage *ALLOW* 10.97 (kJ)	10000 (J)	1

estion mber	Acceptable Answers	Reject	Mar
(a) (ii)	(M_r ethanol) = 46 **(1)** (Mass ethanol burned = 63.21 – 62.47 =) 0.74 (g) *ALLOW* 63.21 – 62.47 as alternative to 0.74 **(1)** (Amount of ethanol = 0.74 ÷ 46 =) 0.0161 (mol) **(1)** **NOTE:** Moles of ethanol are CQ on molar mass and /or mass of ethanol burned *IGNORE* sf except 1 sf **NOTE:** Correct answer with no working /limited working scores **(3)** **Mark the three points independently**	0.02 (mol) ethanol	3

estion mber	Acceptable Answers	Reject	Mar
(a) (iii)	Answer (i) ÷ (1000 x answer (ii)) **(1)** **NOTE:** Be aware of numbers held in calculator not corresponding to what is written in answer Value and negative sign **(1)** *IGNORE* sf except 1 sf **NOTE:** Answer consistent with (a)(i) and (a)(ii) with no working scores **(2)** **E.g.** 10.9725 ÷ (0.74 ÷ 46) = – 682 (kJ mol^{-1}) *ALLOW* Just kJ as the units **NOTE:** If correct answer is given in J mol^{-1}, the units of J mol^{-1} must be clearly given for the second mark to be awarded.	Correct answer in J instead of J mol^{-1}	2
(b) (i)	100 x (1370 – Answer to (iii)) ÷ 1370 = value e.g. 100 x (1370 – 682) ÷ 1370 = 50.2 %	Incorrect rounding of final answer **(0)**	1

(b) (ii)	Any three from: Heat loss (from the beaker)/beaker not insulated/heat loss as no lid on beaker (containing the water) /no stirring **(1)** Incomplete combustion (of the alcohol)/formation of soot (on beaker) **(1)** Not all of the energy from the flame is used to heat the beaker and/or the water OR Too large a distance between flame and beaker / no draught excluder **(1)** Heat capacity of the beaker is neglected/beaker absorbs heat/glass absorbs heat **(1)** Evaporation of the (hot) alcohol **(1)** Evaporation of the (hot) water **(1)**	More accurate thermometer Just "experimental /human error" Experiment carried out at a different (laboratory) temperature	3

16)

(a) (i)	Moles N = $\frac{14.42}{14}$ = 1.03 Moles H = 3.09 Moles S= $\frac{33.06}{32.1}$ = 1.03 (1) ALLOW Moles S= $\frac{33.06}{32}$ = 1.03 Moles O = $\frac{49.43}{16}$ = 3.09 (1) (Ratio 1:3:1:3) IGNORE sf/rounding for moles NH_3SO_3 any order (1) Correct answer, no working (3) If O omitted, giving NH_3S (2)		3

estion mber	Acceptable Answers	Reject	Mar
(a) (ii)	NH_3SO_3 (any order) since molar mass = empirical formula mass/ since empirical formula mass =97/ with some other justification TE from (i) $N_2H_6S_2$, as empirical formula mass =49, approx half molecular mass		1

(b) (i)	Look for workable method. Don't penalise lack of labels on simple equipment eg test tubes. Workable way of making and collecting gas eg flask or tube + connection/ below inverted funnel with tube of water above Labelling of reactants not needed (1) Suitable (labelled) apparatus for measuring volume eg Gas syringe/ inverted burette or measuring cylinder containing water (1)	Uncalibrated tubes	2

estion mber	Acceptable Answers	Reject	Mark
(b) (ii)	$\frac{66}{24\,000} = 2.75 \times 10^{-3}$ / 0.00275 / 0.0028	0.003	1

estion mber	Acceptable Answers	Reject	Mark
(b) (iii)	1 mol sulfamic acid → 0.5 mol H_2 OR ratio sulfamic acid : hydrogen gas = 2:1 OR 5.5 (x 10^{-3})(moles) = (2 x 2.75 (x 10^{-3})) (moles) OR TE using ratio calculated from (ii) (1) Each H_2 comes from 2 H^+ (So 1 sulfamic acid → 1 H^+) (1)	ratio sulfamic acid : hydrogen ions = 2:1	2