1)

C

2)

C

3)

B

4)

A

5)

C

6)

C

7)

B

8)

A

9)

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

10)

B

11)

D

12)

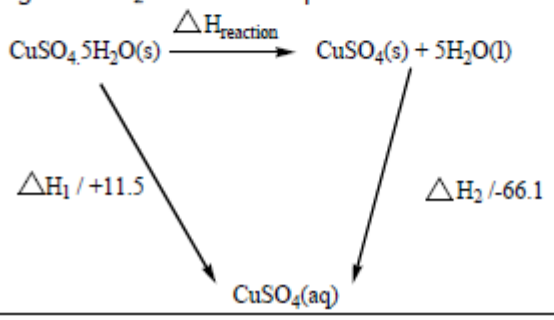
(a)	Do not penalize the use of A_r (Mg) = 24.3 at any stage in this question. Penalize SF errors (1 SF, incorrect SF (eg. 0.02) and incorrect rounding to 2 SF (e.g. 0.016)) only once in parts (a – d) Allow 0.0166 Allow fractions (e.g. 1/60) Amount Mg = (0.4 ÷ 24) = 0.016666 = 0.0167 (mol) Allow Amount Mg = (0.4 ÷ 24.3) = 0.016461 = 0.0165 (mol)		**1**

(b)	Amount HCl = 1.5 x 22.2/1000 = 0.033333 = 0.0333 (mol) Allow Amount HCl = 2 x answer in (a)		**1**

estion mber	Acceptable Answers	Reject	Mar
(c)	Amount of H_2 = 400 ÷ 24 000 = 0.016666 = 0.0167 (mol)		**1**

estion mber	Acceptable Answers	Reject	Mar
(d)	Ratio mol Mg:HCl:H_2 = 0.0167 (0.165) : 0.0333 : 0.0167 = 1:2:1 Allow answers in which the mole ratios of the reactant and products are compared separately	Just stating the molar ratio	**1**
(e)	M_r ($MgCl_2$) = 24 + 2 x 35.5 = 95 **(1)** Mol $MgCl_2$ = (mol Mg) = 0.0166666 (or 0.0167) **(1)** Mass $MgCl_2$ = 95 x 0.0166666 = 1.58 (g) **3 sf (1)** Or 95 x 0.0167 = 1.59 (g) 3sf Or 95.3 x 0.0166666 = 1.59 Or 95 x 0.0165 = 1.58 Or 95.3 x 0.0165 = 1.57 Correct answer with no working scores **(3)** TE on 17(a)		**3**

13)

(a)(i)	Product in box: $CuSO_4$**(aq) (1)** **Either** Mark the arrows and then the labels: Two downward arrows **(1)** labelled with symbols or values with or without units **(1)** **OR** Mark each arrow and label separately Downward arrow & ΔH_1 or value **(1)** Downward arrow & ΔH_2 or value **(1)** Allow reversed arrows **with** reversed signs on ΔH Ignore any other labels on the arrows. Ignore $5H_2O$ in bottom product  		**3**
(a)(ii)	**Route 1** **Mark the calculation based on their cycle** TE from (a)(i) ignoring incorrect bottom product **Route 2** **Mark a calculation which is independent of the cycle** $\Delta H_{reaction}$ = ΔH_1 - ΔH_2 stated or implied = +11.5 – (– 66.1) **(1)** = (+) 77.6 (kJ mol^{-1}) **(1)** Correct answer alone scores **(2)** −77.6 (kJ mol^{-1}) alone or from a correct addition scores **(1)**		

18 (b)	Dehydration reaction cannot be controlled OR temperature change (of dehydration reaction) cannot be measured OR $CuSO_4.5H_2O$ would need heating (so temperature change cannot be measured) OR impossible to add exact amount of water (to obtain value by reverse process) OR cannot mix solid with water to obtain perfect crystals	Temperature of solid / crystals cannot be measured	**1**

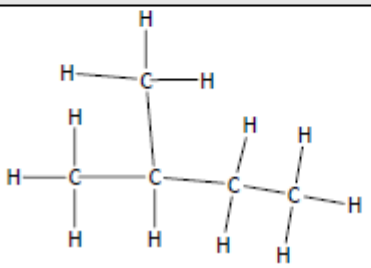
(c)(i)	First & second marks stand alone 1. Pipette/burette / measuring cylinder / balance to transfer (a known amount of) (water) **(1)** 2. to (expanded) polystyrene cup / calorimeter / any *insulated* container allow coffee / plastic cup **(1)** Third & fourth marks only awarded if correct chemicals **and** procedure used 3. add solid and **stir** (allow mix or shake) mixture **(1)** 4. measure initial **and** final temperature allow temperature change **(1)**	Just mass / volume measured Temperature **increase** unless exothermic penalised in (b)	**4**

Question Number	Acceptable Answers	Reject	Mar
18 (c)(ii)	Any three from: • heat transfer (from surroundings) (allow loss or gain) • approximation in (specific) heat capacity of solution • neglecting (specific) heat capacity of calorimeter/apparatus (allow energy absorbed by the apparatus) • reaction / dissolving may be incomplete/slow • temperature change is very small (and difficult to measure) • Density of solution is taken as the same as water • conditions not standard (allow)	Errors in calculation including adding mass of solid to mass of water loss of reagents / water incomplete combustion Just 'difficult to measure'	**3**

14)

Number			
(a)(i)	C_nH_{2n+2} or any symbol in place of n Ignore C_5H_{12}		**1**

Question Number	Acceptable Answers	Reject	Mar
(a)(ii)	(structural / chain) isomers		**1**

Question Number	Acceptable Answers	Reject	Mar
(a)(iii)	 (any orientation of this structure) Ignore non-displayed formulae	Structures in which **any** bonds or atoms are omitted Structures with CH_3 groups	**1**

Question Number	Acceptable Answers	Reject	Mar
(a)(iv)	2,2-dimethylpropane **(1)** Allow dimethylpropane, 2-dimethylpropane 2,2 dimethylpropane, 2 dimethylpropane Ignore hyphens, commas, spaces		**1**

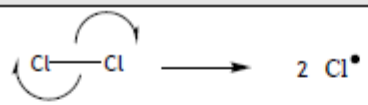
Question Number	Acceptable Answers	Reject	Mar
(b)(i)	$CH_4 + 1½O_2 \rightarrow CO + 2H_2O$ Formulae **(1)** balance **(1)** Or multiples Ignore state symbols No TE on **any** other species		**2**

Number			
(b)(ii)	Insufficient / not excess oxygen / air	Reactant does not react completely with oxygen Just 'methane in excess'	**1**

(b)(iii)	**Any two from** **CO** is toxic / poisonous (allow harmful) **(1)** Less energy is produced (allow (methane) becomes a less efficient fuel) **(1)** Unburned hydrocarbons react to form compounds which are toxic / harmful **(1)** Allow sooty deposits / carbon / particulates in atmosphere (ignore reference to global dimming) **(1)** Unburned hydrocarbons are toxic / harmful **(1)** If reference to damage to ozone layer, global warming and / or acid rain then max **(1)**	Explosive Reactants wasted Air pollution	**2**

(b)(iv)	Global warming / climate change **(1)** Due to (increase in concentration of) CO_2 in the atmosphere / CO_2 is a greenhouse gas **(1)** Traps the heat **from the earth** / IR radiation (re-radiating) **from the earth (1)** If reference to damage to ozone layer then max **(2)** Photochemical smog is formed **(0)** NO_x is produced (by reaction of nitrogen & oxygen) **(1)** and reacts with (volatile) organic compounds in sunlight **(1)** Ignore references to increase in (of concentration) of H_2O in the atmosphere Ignore references to the effects of climate change	(heat) from the sun Global dimming due to complete combustion of hydrocarbon fuels Effects (e.g. reactions of unburned hydrocarbons) due to *incomplete* combustion	**3**

Question Number	Acceptable Answers	Reject	Mar
(c)(i)	The arrows show the movement of electrons **(1)** Single-headed/I denotes 1 electron and Double-headed/II denotes a pair of / 2 electrons /allow lone pair **(1)** Allow Explanations just in terms of electron movement in bond fission	Just stating homolytic and heterolytic fission	**2**

(c)(ii)	 Equation **(1)** two arrows correctly showing a homolytic fission **(1)** Here and in subsequent mechanisms the covalent bonds may be shown as lines or electron pairs or both The mechanism arrows may be shown on the same side or on different sides of the bond The single electrons need not be shown		**2**

(c)(iii)	$CH_4 + Cl^{\bullet} \rightarrow CH_3^{\bullet} + HCl$ **(1)** $CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ **(1)** Ignore state symbols and curly arrows. Ignore order of equations so these marks may be scored if an initiation step with fission of C – H bond in methane is given in c(ii)		**2**

Question Number	Acceptable Answers	Reject	Ma
(c)(iv)	Because a (chlorine) radical is regenerated / reformed / reproduced / recycled (by the propagation reactions each time a molecule of product is formed) **(1)** Allow methyl radical regenerated if initiation step with fission of C – H bond in methane is given in c(ii) and propagation order reversed Ignore references to chain reaction	radical is regenerated by UV light (chlorine) radical is a catalyst	**1**
Number			
(c)(v)	$CH_3^{\bullet} + CH_3^{\bullet} \rightarrow C_2H_6$ / $2CH_3^{\bullet} \rightarrow C_2H_6$ Ignore state symbols The single electrons need not be shown		**1**

Question Number	Acceptable Answers	Reject	Ma
(d)	UV light does not have enough energy to (ALLOW 'cannot') break the C-H bond **(1)** So no H free radicals / atoms are formed (therefore cannot combine to form H_2) **(1)**	Just 'hydrogen' Just 'so no H_2 formed	**2**

15)

(a)	CO_2 has polar bonds / oxygen does not have polar bonds **(1)** Ignore O_2 is a non polar molecule (As it vibrates) polarity of CO_2 changes / dipole moment changes / shifts **(1)** Allow "Oxygen has no difference in electronegativity so polarity does not change" for 2 marks	CO_2 is a polar molecule	**2**

(b)(i)	Hydrogen bonds can form **with water** Allow full description of hydrogen bonds in absence of name. Ignore incorrect naming of functional groups in aminoethanol.	Just "it is polar"	**1**

estion mber	Acceptable Answers	Reject	M
(b)(ii)	Exothermic, with attempt at a reason OR reverse reaction is endothermic, with attempt at a reason **(1)** Reaction will go in the endothermic direction on heating / equilibrium moves to left to use up heat supplied **(1)** Second mark depends on the reaction being exothermic in first mark	Just "exothermic"	**2**

(c)(i)	 Electrons in double bond **(1)** Other electrons **(1)** Second mark dependent on first Only bonding electrons need be shown If inner shell electrons are included they must be correct. Electrons may be on circles, within circles or no circles may be shown.		**2**

estion mber	Acceptable Answers	Reject	Mar
(c)(ii)	Number of electrons (per molecule) is greater in CO_2 (than methane). If numbers are given must be correct. CO_2 has 22e$^-$, methane has 10e$^-$. Ignore CO_2 has larger surface area than methane	double bonds in CO_2 as the cause	**1**

estion mber	Acceptable Answers	Reject	Mar
(c)(iii)	Butane has a greater surface area / butane is less branched **(1)** so more contact between (neighbouring) molecules / (neighbouring) molecules pack better **(1)** OR Reverse argument for 2-methylpropane		**2**

estion mber	Acceptable Answers	Reject	Mar
(d)(i)	Mg – no colour in flame **(1)** Allow 'no flame visible' Ca brick red / red / yellow-red / red-orange	Mg: white flame Bright / white light Clear flame Just orange	**2**

(d)(ii)	**First mark:** Detect thermal decomposition by Passing gas into / reacting gas with lime water OR By collecting the gas evolved (in syringe or by displacement) OR By measuring change of mass **(1)** **Second mark:** Measure time for (same volume) of lime water to go milky OR Measure volume of gas produced in a measured time OR Measure time for a specified / same volume of gas to form OR Find loss of mass after heating samples for equal time **(1)** The mark for measurement should only be given if it matches the suggested method of detection. **Third and fourth marks:** For fair comparison Any **two** from: Keep strength of flame constant **(1)** Distance of flame from containing tube constant **(1)** Use carbonates with similar particle size **(1)** Same volume of lime water **(1)** Heat equal moles / same amount of each carbonate **(1)** Judge equal milkiness of lime water using a piece of paper marked with a cross **(1)** The marks for fair comparison should only be given if they match the suggested method of detection.	First mark: Combustion Heating carbonate solution Second mark: Just "measure volume of gas produced" Measure time for a specified change in mass to occur	**4**

	Ignore 'heat to same temperature' Ignore 'use same heat source' Ignore 'constant heat' These points could be shown on a diagram but marks are for the principles, not the detail of drawing a sketch diagram.		

stion nber	Acceptable Answers	Reject	Mar
d)(iii)	$CaCO_3$ more stable / $MgCO_3$ less stable **(1)** Mg^{2+} is smaller than Ca^{2+} / magnesium ions are smaller than calcium ions / charge density of Mg^{2+} is greater than Ca^{2+} / Ca^{2+} has more shells **(1)** EITHER Mg^{2+} causes more distortion of carbonate ion / more weakening of C-O / more polarisation of carbonate / more polarisation of anion / has more polarising power OR More energy is given out when MgO forms as the MgO lattice is stronger than CaO /as the 2+ ions can get closer to the 2^- ions on decomposition **(1)** Second and third marks can be scored if conclusion given in first mark is wrong	Mg is smaller "It" (unspecified) is smaller $MgCO_3$ is smaller More disruption of ion Polarisation of carbonate molecules CaO is less stable than MgO	**3**