OXFORD
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(9620)

CH02: Organic 1 and Physical 1
Mark Scheme

January 2018

Version: 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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A-level Chemistry
Mark Scheme Instructions for Examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information in the 'Comments' column is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

You should mark according to the contents of the mark scheme. If you are in any doubt about applying the mark scheme to a particular response, consult your Team Leader.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which might confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

The use of M1, M2, M3 etc in the right-hand column refers to the marking points in the order in which they appear in the mark scheme. So, M1 refers to the first marking point, M2 the second marking point etc.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **OR**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which students have provided extra responses. The general 'List' principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of error / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

For example, in a question requiring 2 answers for 2 marks:

Correct answers	Incorrect answers (i.e. incorrect rather than neutral)	Mark (2)	Comment
1	0	1	
1	1	1	They have not exceeded the maximum number of responses so there is no penalty.
1	2	0	They have exceeded the maximum number of responses so the extra incorrect response cancels the correct one.
2	0	2	
2	1	1	
2	2	0	
3	0	2	The maximum mark is 2
3	1	1	The incorrect response cancels out one of the two correct responses that gained credit.
3	2	0	Two incorrect responses cancel out the two marks gained.
3	3	0	

3.2 Marking procedure for calculations

Full marks should be awarded for a correct numerical answer, without any working shown, unless the question states 'Show your working' or 'justify your answer'. In this case, the mark scheme will clearly indicate what is required to gain full credit.

If an answer to a calculation is incorrect and working is shown, process mark(s) can usually be gained by correct substitution / working and this is shown in the 'Comments' column or by each stage of a longer calculation.

3.3 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are most likely to be restricted to calculation questions and should be shown by the abbreviation ECF or consequential in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.4 Equations

In questions requiring students to write equations, state symbols are generally ignored unless otherwise stated in the 'Comments' column.

Examiners should also credit correct equations using multiples and fractions unless otherwise stated in the 'Comments' column.

3.5 Oxidation states

In general, the sign for an oxidation state will be assumed to be positive unless specifically shown to be negative.

3.6 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.7 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited **unless** there is a possible confusion with another technical term or if the question requires correct IUPAC nomenclature.

3.8 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.9 Ignore / Insufficient / Do not allow

Ignore or insufficient is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

Do **not** allow means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.10 Marking crossed out work

Crossed out work that **has not been** replaced should be marked as if it were not crossed out, if possible. Where crossed out work **has been** replaced, the replacement work and not the crossed out work should be marked.

3.11 Reagents

The command word "Identify", allows the student to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when both the name and the formula are used. Specific details will be given in mark schemes.

The guiding principle is that a reagent is a chemical which can be taken out of a bottle or container. Failure to identify complete reagents **will be penalised**, but follow-on marks (e.g. for a subsequent equation or observation) can be scored from an incorrect attempt (possibly an incomplete reagent) at the correct reagent. Specific details will be given in mark schemes.

For example, **no credit** would be given for

- the cyanide ion or CN^- when the reagent should be potassium cyanide or KCN;
- the hydroxide ion or OH^- when the reagent should be sodium hydroxide or NaOH;
- the $Ag(NH_3)_2^+$ ion when the reagent should be Tollens' reagent (or ammoniacal silver nitrate). In this example, no credit is given for the ion, but credit could be given for a correct observation following on from the use of the ion. Specific details will be given in mark schemes.

In the event that a student provides, for example, **both** KCN and cyanide ion, it would be usual to ignore the reference to the cyanide ion (because this is not contradictory) and credit the KCN. Specific details will be given in mark schemes.

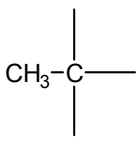
3.12 Organic structures

Where students are asked to draw organic structures, unless a specific type is required in the question and stated in the mark scheme, these may be given as displayed, structural or skeletal formulas or a combination of all three as long as the result is unambiguous.

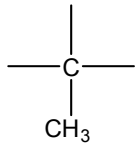
In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Skeletal formulae must show carbon atoms by an angle or suitable intersection in the skeleton chain. Functional groups must be shown and it is essential that all atoms other than C atoms are shown in these (except H atoms in the functional groups of aldehydes, secondary amines and N-substituted amides which do not need to be shown).
- Structures must not be ambiguous, e.g. 1-bromopropane should be shown as $CH_3CH_2CH_2Br$ and not as the molecular formula C_3H_7Br which could also represent the isomeric 2-bromopropane.
- Bonds should be drawn correctly between the relevant atoms. This principle applies in all cases where the attached functional group contains a carbon atom, e.g nitrile, carboxylic acid, aldehyde and acid chloride. The carbon-carbon bond should be clearly shown. Wrongly bonded atoms will be penalised **on every occasion**. (see the examples below)
- The same principle should also be applied to the structure of alcohols. For example, if students show the alcohol functional group as C ─ HO, they should be penalised **on every occasion**.
- Latitude should be given to the representation of C ─ C bonds in alkyl groups, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- Similar latitude should be given to the representation of amines where NH_2─ C will be allowed, although H_2N─ C would be preferred.
- Poor presentation of vertical C ─ CH_3 bonds or vertical C ─ NH_2 bonds should **not** be penalised. For other functional groups, such as ─ OH and ─ CN, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group.

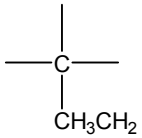
By way of illustration, the following would apply.



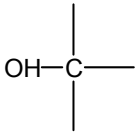
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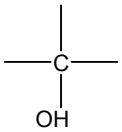
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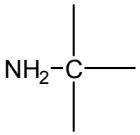
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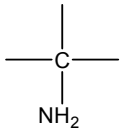
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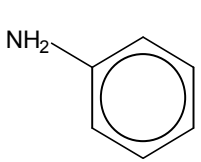
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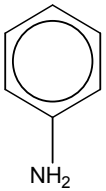
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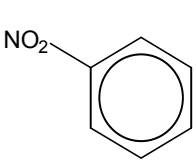
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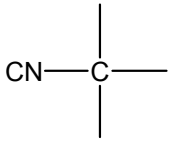
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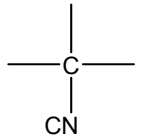
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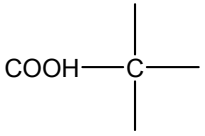
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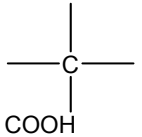
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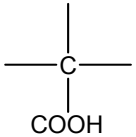
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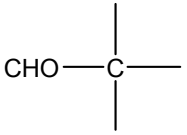
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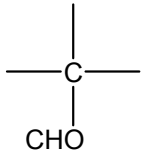
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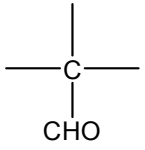
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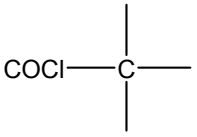
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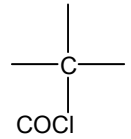
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- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations)

CH_3COH	for	ethanal
CH_3CH_2HO	for	ethanol
$OHCH_2CH_3$	for	ethanol
C_2H_6O	for	ethanol
CH_2CH_2	for	ethene
$CH_2.CH_2$	for	ethene
$CH_2:CH_2$	for	ethene

- Each of the following **should gain credit** as alternatives to correct representations of the structures.

$CH_2 = CH_2$	for	ethene, $H_2C=CH_2$
$CH_3CHOHCH_3$	for	propan-2-ol, $CH_3CH(OH)CH_3$

- In most cases, the use of “sticks” to represent C ─ H bonds in a structure should **not** be penalised. The exceptions to this when “sticks” will be penalised include
  - structures in mechanisms where the C ─ H bond is essential (e.g. elimination reactions in halogenoalkanes and alcohols)
  - when a displayed formula is required
  - when a skeletal structure is required or has been drawn by the candidate

3.13 Organic names

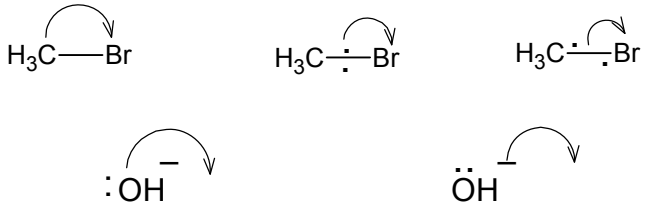
As a general principle, non-IUPAC names or incorrect spelling or incomplete names should **not** gain credit. Some illustrations are given here.

but-2-ol	should be **butan-2-ol**
2-hydroxybutane	should be **butan-2-ol**
butane-2-ol	should be **butan-2-ol**
2-butanol	should be **butan-2-ol**
ethan-1,2-diol	should be **ethane-1,2-diol**
2-methpropan-2-ol	should be **2-methylpropan-2-ol**
2-methylbutan-3-ol	should be **3-methylbutan-2-ol**
3-methylpentan	should be **3-methylpentane**
3-mythylpentane	should be **3-methylpentane**
3-methypentane	should be **3-methylpentane**
propanitrile	should be **propanenitrile**
aminethane	should be **ethylamine** (although aminoethane can gain credit)
2-methyl-3-bromobutane	should be **2-bromo-3-methylbutane**
3-bromo-2-methylbutane	should be **2-bromo-3-methylbutane**
3-methyl-2-bromobutane	should be **2-bromo-3-methylbutane**
2-methylbut-3-ene	should be **3-methylbut-1-ene**
difluorodichloromethane	should be **dichlorodifluoromethane**

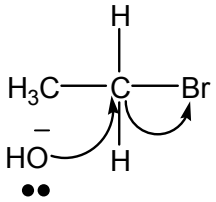
3.14 Organic reaction mechanisms

Curly arrows should originate either from a lone pair of electrons or from a bond.

The following representations should not gain credit **and will be penalised each time** within a clip.



For example, the following would score zero marks

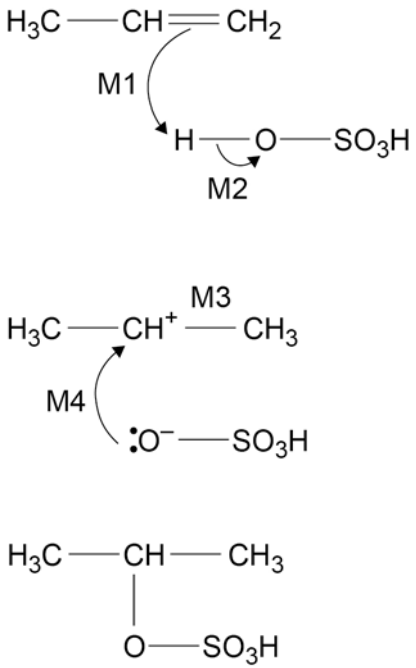


When the curly arrow is showing the formation of a bond to an atom, the arrow can go directly to the relevant atom, alongside the relevant atom or **more than half-way** towards the relevant atom.

In free-radical substitution

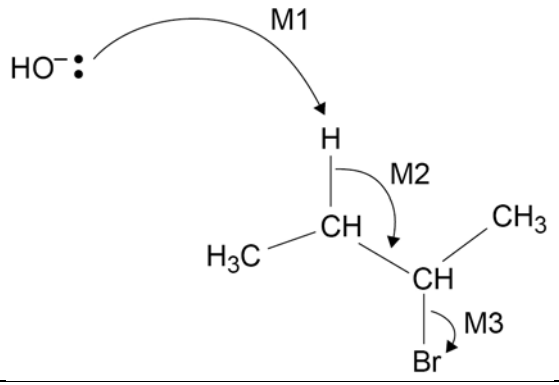
- the absence of a radical dot should be penalised **once only** within a clip.
- the use of half-headed arrows is not required, but the use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip

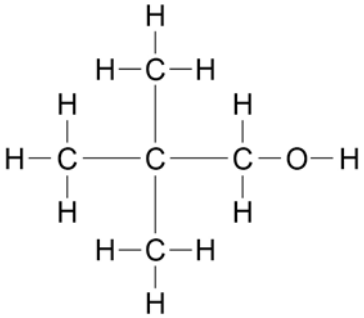
The correct use of skeletal formulae in mechanisms is acceptable, but where a C-H bond breaks both the bond and the H must be drawn to gain credit.

Question	Marking guidance	Mark	Comments
01.1	Electron pair acceptor	1	Not electron acceptor
01.2	C=C is area of high electron density / electron rich (π -)bond	1	
	(this) induces a dipole in the bromine molecule	1	Allow causes $Br^{\delta+}$–$Br^{\delta-}$ Mark independently
01.3		4	M1: Arrow from C=C to H–O in H_2SO_4 molecule M2: Arrow from H–O bond to the O M3: Structure of intermediate ion (must be major ion) M4: Attack of $^{-}OSO_3H$ (curly arrow from lp to C^{+}) If incorrect intermediate drawn, lose M3 Allow M4 for correct attack on primary carbocation

01.4	Formed via more stable carbocation / secondary carbocation more stable then primary Due to the electron-releasing character of the two/more alkyl groups / due to the positive inductive effect of the two/more alkyl groups	1 1	Do not allow M1 if tertiary carbocation discussed

Question	Marking guidance	Mark	Comments
02.1	$C_8H_{18} + 12½\ O_2 \rightarrow 8CO_2 + 9H_2O$	1	Ignore ss Accept multiple
02.2	CO_2/H_2O evolved contributes to/causes global warming The products formed contribute to global warming	1	Ignore climate change Accept CO_2/H_2O evolved is a greenhouse gas / The products formed are greenhouse gases
02.3	(2,2,3,3)- tetramethylbutane	1	
02.4	Because molecule is less polarisable / lower surface area / more spherical Weaker van der Waals forces <u>between molecules</u>	1 1	Allow molecule is smaller CE = 0 if bond breaking mentioned Allow converse answers which refer to straight chain isomers
02.5	Species with an unpaired electron	1	Do not allow ion; free electron; non bonded electron
02.6	Step 1: $C_6H_{14} + Cl^{\bullet} \rightarrow {}^{\bullet}C_6H_{13} + HCl$ Step 2: ${}^{\bullet}C_6H_{13} + Cl_2 \rightarrow C_6H_{13}Cl + Cl^{\bullet}$	1 1	Ignore ss Accept multiple Dot allowed anywhere on radical Allow skeletal formulae?
02.7	7 / tick in 4th box	1	Automarked

Question	Marking guidance	Mark	Comments
03.1	Reagent: NaOH / KOH	1	Not Al_2O_3
	Conditions: Ethanolic / Alcoholic	1	Penalise ethanoic Ignore hot
		3	One mark for each arrow If incorrect H removed then max = 1/3 for mechanism (loss of Br) Credit both E1 and E2 mechanisms Mark M3 independently
03.2	But-1-ene	1	Accept structural / skeletal formulae
	H can be removed from more than one carbon atom / can also be removed from C1 / If H removed from C1 then but-1-ene would be formed / the double bond would form in a different place / the double bond would form between C1 and C2	1	

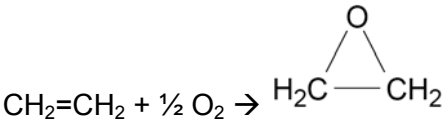
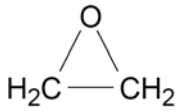
03.3	Concentrated H_2SO_4 / concentrated H_3PO_4	1	Allow aluminium oxide
03.4		1	Must show all bonds

Question	Marking guidance	Mark	Comments
04.1	Reagent: Bromine (water) / Br_2(aq)	1	If no/incorrect reagent, then CE=0 If incomplete reagent (e.g Br) do not award but mark on. Credit alternative reagents such as iodine / acidified $KMnO_4$
	Hexane: no visible change / no change / stays orange	1	Allow no reaction Do not allow none, nothing, clear, no observation Penalise ppt etc.
	Hex-2-ene: (bromine) turns colourless (from orange)	1	Allow decolourised
04.2	Reagent: Tollens' Reagent / ammoniacal silver nitrate	1	If no/ incorrect reagent, then CE=0 If incomplete reagent (e.g. formula of complex ion) do not award but mark on. Credit alternative reagents such as acidified $K_2Cr_2O_7$ / acidified $KMnO_4$ etc.
	Propanone: no visible change / no change	1	Allow no reaction Do not allow none, nothing, clear, no observation
	Propanal: silver mirror formed / grey solid / black ppt OR Reagent: Fehling's Solution / Benedict's Solution	1	
	Propanone: no visible change / no change / (solution) remains blue		Allow no reaction Do not allow none, nothing, clear
	Propanal: red ppt		Allow orange ppt

04.3	Reagent: acidified (dil H_2SO_4) $K_2Cr_2O_7$	1	If no/incorrect reagent, then CE=0 If incomplete reagent (such as ion or missing acid) do not award but mark on. Penalise ppt etc.
	Propan-2-ol: solution turns from orange to green	1	
	2-Methylpropan-2-ol: no visible change / solution remains orange	1	Allow no reaction Do not allow none, nothing, clear, no observation
	OR Reagent: acidified (dil H_2SO_4) $KMnO_4$		
	Propan-2-ol: solution turns from purple to colourless		
	2-Methylpropan-2-ol: no visible change / solution remains purple		Allow no reaction Do not allow none, nothing, clear

04.4	Reagent: $AgNO_3$	1	If no/incorrect reagent, then CE=0 If incomplete reagent (such as ion or missing acid) do not award but mark on.
	iodoethane: yellow ppt formed	1	Ignore rate of formation; Apply List
	Ethanoic acid: no visible change	1	Allow no reaction Do not allow none, nothing, clear
	OR Reagent: Na_2CO_3 / any named carbonate/hydrogencarbonate / any named reactive metal (e.g. Na)		
	Iodoethane; no visible change		Allow no reaction Do not allow none, nothing, clear
	Ethanoic acid: effervescence		Allow gas formed Penalise wrong gas

04.5	Relative molecular mass of pentane: 72.1416	1	2 d.p. or more
	Relative molecular mass of butanal: 72.1002	1	2 d.p. or more

Question	Marking guidance	Mark	Comments
05.1	Equation:  $CH_2=CH_2 + ½ O_2 \rightarrow$	1	Allow C_2H_4O etc Allow multiples / ignore ss
	Type of reaction: Oxidation	1	
05.2	Equation:  + $H_2O \rightarrow CH_2OHCH_2OH$	1	Allow C_2H_4O etc Allow multiples / ignore ss Do not allow $C_2H_6O_2$ for diol
	Use for ethane-1,2-diol: Antifreeze/Terylene/Polymers	1	
05.3	Reagent: NaOH/KOH	1	Do not allow hydroxide ions
	Type of reaction: Nucleophilic Substitution	1	Penalise “electrophilic”

Question	Marking guidance	Mark	Comments
06.1	Heat (energy) change measured at constant pressure	1	
06.2	Any one from: insulated container / polystyrene cup, pipette, burette	1	Not Bomb calorimeter / Cu calorimeter Allow Measuring cylinder.
06.3	To make sure all the solution/mixture/liquid is at the same temperature	1	
06.4	M1: $q = m c \Delta T$ or $50.0 \times 4.18 \times 7.0$ M2: 1.5 (kJ)	1 1	 Allow 1.463 (kJ) 2sf or more
06.5	$n = \frac{2.00}{111}$ = 0.018(0) (mol)	 1	 2sf or more
06.6	1.5 /0.018 or (ans 06.4 or 2.0 / ans 06.5 or 0.024) = 83.3 (kJ mol^{-1}) Enthalpy change has negative sign	 1 1	Mark M1 consequential to 06.4 and 06.5 or using data given Allow 81.3–83.3 Must have negative sign

06.7	<u>Standard Enthalpy of Formation</u> Enthalpy/ heat (energy) change when **one mole** of substance is formed from its constituent elements (with all substances) **in their standard states**. At **stated temperature & 100 kPa** <u>Hess's law</u> The enthalpy/ heat energy change (of a reaction) is independent of route taken	1 1 1	 Allow at 298 K and 100 kPa

06.8	M1: $\Delta_r H = \sum \Delta_f H^{\ominus}$(products) – $\sum \Delta_f H^{\ominus}$(reactants) or complete cycle which shows $2 \times \Delta_f H^{\ominus}NaCl + \Delta_f H^{\ominus}CaCO_3$ **and** $\Delta_f H^{\ominus}CaCl_2 + \Delta_f H^{\ominus}Na_2CO_3$ M2: $\Delta_r H = (\Delta_f H^{\ominus}CaCl_2 + \Delta_f H^{\ominus}Na_2CO_3) – (2 \times \Delta_f H^{\ominus}NaCl + \Delta_f H^{\ominus}CaCO_3)$ $= (-1926) – (–2029)$ M3: $\Delta_r H$ = 103 (kJ mol^{-1})	1 1 1	 Allow 1/3 for –103 (kJ mol^{-1})

Question	Marking guidance	Mark	Comments
07.1	$K_c = \frac{[D]\,[C]}{[A]\,[B]^2}$	1	Mark independently If K_c upside down then lose M1 and M2
	Units: $mol^{-1}\ dm^3$	1	
07.2	Increases	1	
	No effect	1	
	No effect	1	
07.3	M1: Expression for equilibrium constant: $K_c = \frac{[NH_3]^2}{[N_2]\,[H_2]^3}$	1	
	M2: correct rearrangement $[NH_3] = \sqrt{(K_c \times [N_2] \times [H_2]^3)}$ …	1	
	M3: divides moles by 1.50 in expression $[NH_3] = \sqrt{(9.60 \times (0.060/1.50) \times (0.975/1.50)^3)}$	1	If no division by volume, then loses M3 and M4.
	M4: answer $[NH_3] = 0.325\ (mol\ dm^{-3})$	1	If subsequent conversion to moles, lose M4