Pearson Edexcel

International A Level Science

Enhancing Teaching through Exam Insights in International A Level Chemistry

Pearson
Edexcel

Welcome to today's event

- Introduction to your trainer
- Housekeeping
- What's in your pack?

Getting to know you

Are you new to Pearson Edexcel IAL Chemistry?

OR

Have you been teaching the existing specification

1-2 years

3-5 years

more than 5 years?

Aims and objectives

- To introduce the writing process of the Pearson Edexcel examination papers and mark schemes
- To explain the training the examiners undertake in order the mark the exam papers
- Analyse the recent 2024 May/June Examination Papers and consider how questions have been answered by looking at Examiner Feedback
- Understand how to apply mark schemes to student answers in the 2024 May/June Examination series
- Review the support Pearson offers
- Discuss best practice and share ideas with other teachers

Today's Agenda

- How the exam papers are written
- Rules for writing exam papers
- Mark schemes
- Applying mark schemes to student answers
- Using student answers and examiner reports to enhance your teaching
- Support offered by Pearson

How exam papers are written

Overview of question writing process

There are nine stages involved in producing a question paper:

- Stage 1 – Preparation and writing

  The Principal Examiner (PE) produces the first draft of the question paper (QP), mark scheme (MS), assessment objective grid (AOG) and item category grid (ICAT)

- Stage 2 – Editing

  The Chair and Chief Examiner (CE) review the documents and the PE produces a second draft in the light of their comments

- Stage 3 – Revising

  A subject expert, known as a Reviser, reviews the documents and the PE produces a third draft in the light of their feedback

Overview of question writing process

- Stage 4 – QPEC meeting (Question Paper Evaluation Committee)

  The Chair, CE, PE and Revisers discuss and amend all the documents

- Stage 5 – Typesetting

  The typesetter produces the First Proof of the QP

- Stage 6 – Proofreader

  A professional proofreader checks all spelling, punctuation and grammar

  The Chair, CE and PE check the First Proof to make sure the typesetter has printed the QP as agreed at QPEC and that all diagrams, formulae, equations, etc. are correct

  The PE updates the other documents, if necessary

Overview of question writing process

- Stage 7 – Scrutiny

A subject specialist, known as a Scrutineer, works through the QP as a candidate would, without looking at the MS

They then check their answers against the MS and suggest amendments to the QP and MS, if necessary The Chair, CE and PE discuss these suggestions and amend the QP, if necessary The PE amends the MS, if necessary

- Stage 8 – Final proof

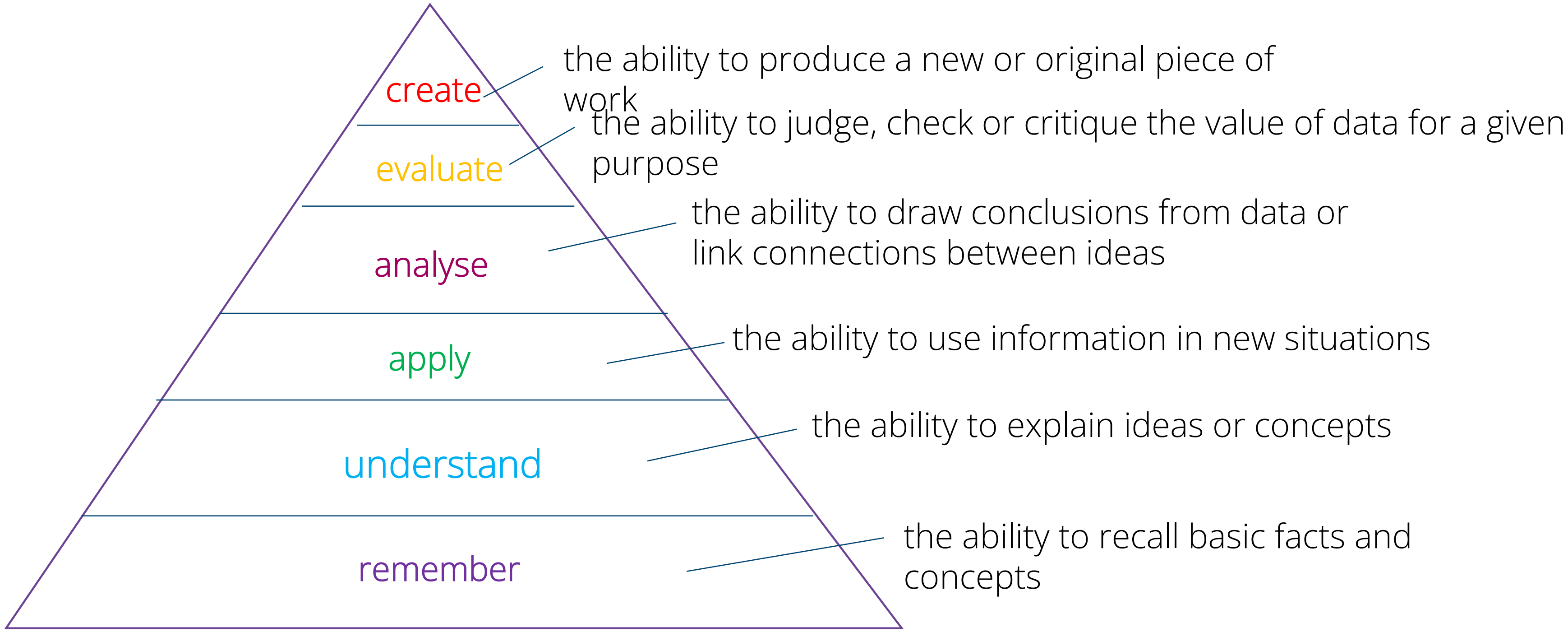
Once the changes have been made, the final proof is sent to the committee to complete the final check and sign-off the paper

- Stage 9 – Printing and ePEN set-up

The QP is printed and ePEN is set up ready for marking

Rules for writing exam papers

Bloom's Taxonomy



Assessment Objectives

Every question or part question is linked to a particular assessment objective (AO)

There are three assessment objectives labelled AO1, AO2 and AO3

AO2 is further subdivided into AO2(a) and AO2(b)

The assessment objectives are closely lined to Bloom's Taxonomy and are given different weightings in the exam papers

This is shown on the next slide

Definitions of AOs

		% in IAS	% in IA2	% in IAL
AO1	Demonstrate knowledge and understanding of science.	34–36	29–31	32–34
AO2 (a)	Application of knowledge and understanding of science in familiar and unfamiliar contexts.	34–36	33–36	33–36
(b)	Analysis and evaluation of scientific information to make judgements and reach conclusions.	9–11	14–16	11–14
AO3	Experimental skills in science, including analysis and evaluation of data and methods.	20	20	20

Specification p75

Linking AO1 to command words

- Demonstrate knowledge and understanding of science
- Recall facts and reasons

Example of command words:

Add/Label

Complete/Record

Describe (straightforward known ideas)

Explain (a simple idea or reason)

Give/State/Name

Write (a familiar equation)

Linking AO2(a) to command words

- Application of knowledge and understanding of science in familiar and unfamiliar contexts
- Apply facts and reasons to contexts

Example of command words:

Assess

Criticise

Deduce

Evaluate

Explain (for more complex ideas)

Suggest

Linking AO2(b) to command words

- Analysis and evaluation of scientific information to make judgements and reach conclusions
- Use information to explain facts and reasons or use information with facts and reasons to establish new ideas

Example of command words:

Assess

Criticise

Deduce

Evaluate

Explain (for more complex ideas)

Suggest

Linking AO3 to command words

- Experimental skills in science, including analysis and evaluation of data and methods
- Practical skills including recall of some key practical activities
- Explanation for the steps involved may be looked at in both familiar and unfamiliar contexts as will the evaluation of data and methods
- Any of the command words might be used

Why do we have assessment objectives?

- Help make exams fairer year on year
- Provide structure for question paper writers
- Make sure that exams are about skills, not just about knowledge
- Can provide students with some reassurance about the types of questions they will be asked

Command words

- All questions other than multiple choice questions, will be short open, open-response, calculations or extended writing questions
- All of these will only use the command words listed in Appendix 7 of the specification
- The depth of answer required will depend on the command word used and the number of marks available
- Command words also link to Bloom's taxonomy

Command words and Bloom's Taxonomy

Bloom's taxonomy	Command word(s)
Remember (Often AO1)	**Add** (e.g. units) **Complete** (e.g. a table or diagram) **Draw** (e.g. diagram of reflux apparatus) **Give** / **State** / **Name** (e.g. recall of one or more pieces of information) **Label** (e.g. a diagram) **State what is meant by** (i.e. the meaning of a term when there are different ways of expressing this)
Understand (Often AO1)	**Describe** (i.e. to give an account of something) **Explain** (i.e. the answer requires a point to be made **and** the reason(s) for it, this can include mathematical explanations) **Give a reason** / **reasons** (e.g. an explanation of a point that is given in the question – e.g. this happens because ....) **Show that** (i.e. verify a statement given in the question, this can include mathematical explanations – e.g. show that hydrochloric acid is in excess)

Command words and Bloom's Taxonomy

Bloom's taxonomy	Command word(s)
Apply (Often AO2)	**Calculate** (used for most calculations) **Determine** (used for some calculations) **Justify** (i.e. give evidence to prove a point made in a question or to prove a prediction that a candidate has made) **Plot** (used for graphs) **Sketch** (used for a freehand graph with axes and labels but no scale) **Write** (used for equations)
Analyse (AO2 or AO3)	**Compare and contrast** (i.e. looking for similarities **and** differences of two or more things) **Deduce** (i.e. use the information provided to draw or reach a conclusion) **Identify** (i.e. use the results of tests / spectra etc to identify an unknown substance) **Predict** (i.e. use the information given to give the expected result – e.g. looking at trends in data or the periodic table)

Command words and Bloom's Taxonomy

Bloom's taxonomy	Command word(s)
Evaluate (AO3)	Assess (i.e. consider all the factors that apply and identify which are the most important or relevant, make a judgement or come to a conclusion) Comment on (i.e. synthesise a number of variables from data / information to form a judgement) Criticise (i.e. inspect a set of data, an experimental plan or a scientific statement – look at the merits and faults of these and back judgements made by giving evidence) Discuss (i.e. identify the issue that is being assessed within the question or explore all aspects of it or investigate the issue by reasoning or argument) Evaluate (i.e. review information then bring it together to form a conclusion, drawing on evidence including strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to it's context.)
Create (AO3)	Devise (i.e. plan or invent a procedure from existing principles / ideas)

Activity 1

Activity 1 – Assigning command words and AOs

Your booklet contains some examples of questions

For each question/part question state that command word used and assign an assessment objective

Activity 1 – Assigning command words and AOs

Question 1

(a) (i) Define relative atomic mass. (2)

(ii) Calculate the relative atomic mass of a sample of silicon, using the isotopic abundance data provided.
Give your answer to 3 significant figures.

Isotope	Abundance (%)
^{28}Si	91.07
^{29}Si	4.62
^{30}Si	3.00
^{32}Si	1.31

(2)

(iii) In the mass spectrum of silicon, there is also a small peak at $m/z = 14$.
Deduce the formula of this particle. (1)

Activity 1 - Assigning command words and AOs

Question 2

Bromoethane was prepared from the reaction of ethanol with sulfuric acid and potassium bromide.

$$C_2H_5OH + H_2SO_4 + KBr \rightarrow C_2H_5Br + KHSO_4 + H_2O$$

Procedure

Step **1** 10.0 cm^3 of ethanol was placed in a round-bottomed flask.

Step **2** 10.0 cm^3 of concentrated sulfuric acid was added carefully and gradually to the ethanol in the flask.

Step **3** 12.0 g of potassium bromide was added to the reaction mixture in the flask.

Step **4** The flask was set up for distillation and heated gently.

Step **5** Water, ethanol and bromoethane were collected in a small beaker.

Step **6** The bromoethane was purified.

Step **7** The bromoethane was dried.

(a) Suggest why the flask in Step **2** was frequently placed in a stream of cold running water as the sulfuric acid was gradually added. **(1)**

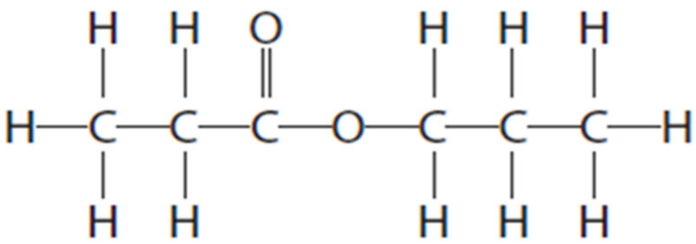
(b) The potassium bromide used in Step **3** was initially lumpy and not a fine powder. State the apparatus that would be suitable for breaking up the lumps of potassium bromide into a powder. **(1)**

(c) Explain why an orange colour was seen in the round-bottomed flask when it was first gently heated in Step **4**. **(2)**

Activity 1 - Assigning command words and AOs

Question 3

Propyl propanoate has the structure shown.



Devise a synthetic pathway to prepare propyl propanoate starting with 1-bromopropane as the **only** organic compound.

Include the reagents for each step in the synthesis, and the names or structures of the intermediate compounds.

Maths skills

- The set of three IAS and IA2 papers must include questions that target mathematics at Level 2 or above

- A minimum of 20% of the marks must be awarded for mathematics at Level 2 or above

- Individual steps in a calculation may not be at Level 2, for example, calculating a relative formula mass, but this may be acceptable if it is a complex formula and part of an unstructured question

- The details of the mathematical skills that will be tested are listed in Appendix 6 of the specification

Example of a maths question

A student was given 50.0 cm^3 of a solution of sodium hydroxide.

The pH of this solution was 12.43

The student was asked to adjust the pH to 12.00, by dilution with deionised water. The student did **not** have access to a pH meter.

Calculate the volume of deionised water, **in cm^3**, the student should add to the original solution.

(5)

M1	calculation of $[H^+]$ at both pH values	**(1)**
M2	calculation of $[OH^-]$ at both pH values	**(1)**
M3	calculation of moles of NaOH in 50.0 cm^3 at pH 12.43	**(1)**
M4	calculation of volume of NaOH required at pH 12.00	**(1)**
M5	volume of water required in cm^3	**(1)**

Mark Schemes

Mark Schemes

- Mark schemes (MS) are written at the same time as the questions
- They are related to the command word in the question
- Each bullet point in the MS shows what is needed for each mark
- The expected answer is in the left-hand column headed 'Acceptable Answers'
- There is more information for the examiners in the right-hand column headed 'Additional Guidance'
- The MS goes through the same checks as the question paper

Hierarchy for marking

The Chair or Chief Examiner overseas the paper and ensures that the mark scheme is of a similar standard to previous years

They also check the marking of the Principal Examiner

The Principal Examiner:

- contacts the team leaders and examiners,
- provides training for new examiners and team leaders,
- runs the pre-standardisation meeting,
- produces the final mark scheme,
- oversees the day-to-day running of the paper during the marking process, checks the marking of the TLs and/or examiners, and
- writes a final report that is posted on the Pearson website

Hierarchy for marking

Team Leaders:

- supervise a team of about 8 examiners and deal with all their initial queries,
- supervise the standardisation of the examiners in their team,
- check their marking, and
- write a report on each examiner

Examiners:

- carry out familiarisation marking,
- mark the practice and qualification items that they have been allocated,
- mark those items for which they have qualified, and
- write a report on those items

Familiarisation marking

- Once candidates have sat the exam paper and their responses have been scanned into ePEN, everyone involved in the marking of the paper (Chair or CE along with the PE, Team Leaders (TL) and examiners) provisionally mark about 15 responses for each item for which they are contracte

  This is called **'familiarisation marking'**

- The TL and examiners send their comments and questions on the mark scheme to the PE

- The PE amends the MS to give extra guidance to examiners

- The PE and TL select responses to be used in the Standardisation of examiners and for checking their marking after this

  These are called **'validity items'**

Mark schemes are amended

(e) Explain why the pH of a 1×10^{-8} mol dm^{-3} solution of nitric acid, HNO_3, is not 8.

[Ionic product of water, $K_w = 1.00 \times 10^{-14}$ mol^2 dm^{-6}]

(2)

The pre-standardisation mark scheme for this item was:

Question Number	Acceptable Answers	Additional Guidance	Mark
1(e)	An explanation that makes reference to the following points: • $[H^+]$/ $[H_3O^+]$/ concentration of hydrogen ions from water is $1(.0) \times 10^{-7}$ (mol dm^{-3}) **(1)** • so total $[H^+]$/ $[H_3O^+]$/ concentration of hydrogen ions is greater than $1(.0) \times 10^{-7}$ (mol dm^{-3}) / 1.1×10^{-7} (mol dm^{-3}) **or** the pH cannot be more than 7 **or** concentration of hydrogen ions from water is not negligible / cannot be ignored **(1)**	Allow is greater than 1×10^{-8} Allow pH is 6.96	**(2)**

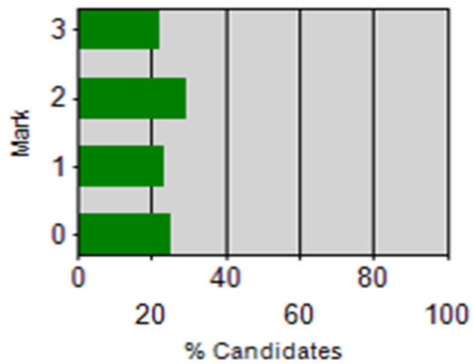
Mark schemes are amended

The final mark scheme was amended to:

Question Number	Acceptable Answers	Additional Guidance	Mark
1(e)	An explanation that makes reference to the following points: • $[H^+]$/ $[H_3O^+]$/ concentration of hydrogen ions from water is $1(.0) \times 10^{-7}$ (mol dm^{-3}) **(1)** • so total $[H^+]$ is greater than $1(.0) \times 10^{-7}$ (mol dm^{-3}) / is 1.1×10^{-7} (mol dm^{-3}) **or** the pH cannot be more than 7 / alkaline (for an acid) **or** concentration of hydrogen ions from water is not negligible / cannot be ignored **or** 10^{-8} is only the concentration of ions from the acid, it doesn't include those from the water **(1)**	Penalise reference to nitric acid as a weak acid in M2 only Allow $[H^+]$ from water = $\sqrt{1(.00) \times 10^{-14}}$ / $\sqrt{K_w}$ Allow this shown as part of a calculation Allow $[H_3O^+]$/ concentration of hydrogen ions for $[H^+]$ Allow $[H^+]$ is greater than 1×10^{-8} (mol dm^{-3}) Allow $[H^+]$ cannot be less than $[OH^-]$ / $[OH^-]$ cannot be more than $[H^+]$ Allow the addition of nitric acid to water decreases pH by increasing $[H^+]$ Allow pH is 6.96 Allow pH 8 / >7 is alkaline Allow acid must have pH below 7 Do not award $10^{-14}/10^{-8} = 10^{-6}$ so pH = 6 for M2 only Allow water also dissociates to form H^+ ions	**(2)**

Why are mark schemes so strict?

- The purpose of an exam is to separate students into different grades
- This can be done by having questions that are targeted at different levels and / or by mark schemes that differentiate
- A good 3-mark question, targeted at grade C, may well have a distribution similar to this:



- Mark schemes are also detailed and precise to ensure that all examiners mark to the same standard

Pre-standardisation meeting

- The Chair or Chief examiner, PE and TL meet to decide on the final MS based on the responses they have seen and the comments made by all examiners during familiarisation marking

- They check all the responses that have been proposed for the standardisation of examiners
This consists of:

    - 5 practice responses for each item

    - 10 qualification responses for each item

    - 10 validity responses for each item

- They check all the validity responses that have been proposed to make sure that the quality of examiners' marking does not vary throughout the marking period

- This may take 2 or 3 days, depending on the length of the exam paper and how many items there are

- After the pre-standardisation meeting, all the marks given during the familiarisation marking are removed from ePEN

Standardisation

- Examiners work through the 5 Practice sets for each of the items they are marking
- They contact their TL to discuss any queries they have
- They then work through the 10 Qualification sets by allocating a mark to each response, then they are told the agreed mark
- They need to get at least 8 correct in order to qualify to mark that item If they get less than 8 correct, the PE will produce a second set and they can have another try
- If they do not get at least 8 correct on the second set, they are stopped from marking that item. They can continue to mark the items for which they have qualified

Quality control

- After Qualification, examiners are allowed to do 'live marking'
- The ePEN system restricts them to marking about 10% of their allocation for each item at a time to ensure they mark evenly across all items
- Their TL has access to all the marking they do and does 'backreading' at regular intervals. If the TL disagrees with a mark that an examiner has awarded, they can change this mark and send a message to the examiner to explain why they have done this
- The validity responses occur randomly within the responses marked by the examiner. The examiner does not know they are there, but their marks are recorded against these.
- The TL and PE regularly check the examiner statistics for their progress and how many responses they have marked correctly.
- The examiner is contacted if their marking falls below a certain level, the TL will explain the MS again and monitor the marking closely.
- If the marking does not improve, the examiner will be stopped from marking that item.

Applying Mark Schemes

Understanding mark schemes

The expected answer is in the Answer column

- Sometimes there is more than one equivalent expected answer for a particular mark and these are shown by ‘or’ between them.
- If two points are needed for 1 mark, there is ‘and’ between them and both must be present

In the Notes column:

- ‘Allow’ indicates answers that are not quite as good as the expected answer, but they can still be given the mark
- ‘Ignore’ statements are other common answers the candidates may give. You just ignore them i.e. you do not award a mark for just that answer alone and you do not deduct a mark if the candidate has already scored that mark from an acceptable answer
- ‘Reject’ - if the candidate included any of those points as well as an acceptable answer, this negates the mark for the acceptable answer

Activity 2

Activity 2 - Your chance to qualify

Your pack contains 5 practice items for the following question taken from the Unit 1 Paper, May 2024

Assign a mark to each item

Pure silver cups are too soft so small amounts of copper are added to make an alloy.

Explain why copper makes the silver less malleable. **(2)**

Answer	Additional Guidance
An explanation that makes reference to the following points:	
• the layers / ions / atoms slide less well (over each other) **(1)**	Do not award layers can not slide (over each other)
• because copper ions / atoms are smaller than silver ions / atoms **(1)**	Allow copper ions and silver ions have different sizes Do not award just copper is smaller than silver Ignore comments about strength of metallic bonds or just copper ions disrupting the lattice

Activity 2 - Your chance to qualify

Practice Item 1

As copper is add, the layer
between the atom don't slip much
easily and therefore it becomes difficult
to break the intramolecular forces ~~bet~~ hence
it ~~makes s~~. and copper is an alloy which is
~~strong~~ difficult to break compared to the metals.

Activity 2 - Your chance to qualify

Practice Item 2

an alloy has different sizes of cations, which makes them harder to slide over each other, ~~and~~ ~~because~~ hence increases strength, which requires higher energy to break.

Activity 2 - Your chance to qualify

Practice Item 3

the size of copper is different
than~~g~~ silver. So the ~~&~~ copper ion
atoms stay between the layers
of silver, to avoid ~~the~~ the layers
from sliding pass eachothe~~ar~~r.

Activity 2 - Your chance to qualify

Practice Item 4

→ different types of atoms present in the structures.

→ so layers cannot slide pass over each other & making the electrostatic forces of attraction between the layers stronger due to TOf copper atoms. hence alloys is harder / brittle. & less malleable.

Activity 2 - Your chance to qualify

Practice Item 5

Copper breaks the alignment of the silver lattice.
Preventing the layers from sliding past each other.

Activity 2 - Your chance to qualify

Your pack contains 10 qualification items

Assign a mark to each one

Activity 2 - Your chance to qualify

Qualification Item 1

Copper and silver have different atomic
radii's therefore layers of silver can no
longer slide over each other as easily
therefore it becomes less malleable

Activity 2 - Your chance to qualify

Qualification Item 2

Adding copper distorts the regular lattice arrangement of silver metal as copper ions are smaller than silver ions hence lattice layers cannot slide past each other without breaking that easily.

Activity 2 - Your chance to qualify

Qualification Item 3

Silver is very malleable because it has free electrons that allow the structure to move without breaking the bonds. Adding copper gives the free electrons something to bond to, so they don't move ~~aroud~~ around as freely.

Activity 2 - Your chance to qualify

Qualification Item 4

This is because copper and silver ~~Positive~~ ~~ions~~ have different sizes of atoms so it is more difficult for layers of copper and silver to slide over each other

Activity 2 - Your chance to qualify

Qualification Item 5

Copper makes it more difficult for the layers of Ag to slide over each other, as it makes .

Activity 2 - Your chance to qualify

Qualification Item 6

Copper cations have different size than silver cations, break the arr~~ange-ment~~ arrangement, layers can not slide on each other easily, less malleable.

Activity 2 - Your chance to qualify

Qualification Item 7

Since ~~Cu have~~ Cu^{2+} ions have smaller radius, larger charge, more delocalized electron, the metallic bond of copper is stronger than ~~sti~~ silver. The attractions between Cu^{2+} ions and delocalized electrons ~~is~~ are greater. The sliding between layers becomes harder. Thus the alloy is not as malleable as pure silver.

Activity 2 - Your chance to qualify

Qualification Item 8

Because Cu have a stronger metallic bonding than Ag since it has smaller radius, larger charge so it will have ~~more attr~~ smaller sheilding effect and it will have a stronger attraction ~~of~~ than Ag and make Ag less malleable ~~and~~.

Activity 2 - Your chance to qualify

Qualification Item 9

Cu and Ag are in the same group.
but Cu has larger radius than Ag.
so the intermoleculur force between Cu^+ and
delocolized ions are greater, it is harder to
break the metalic bonding in Cu than Ag. so added Cu
can make Ag less malleable

Activity 2 - Your chance to qualify

Qualification Item 10

Because it prevents the layers of silver from sliding by increasing attraction between positive ions and the sea of delocalised electrons thus decreasing malleability

Student Answers & Examiner Reports

Activity 3

Activity 3 – Student answers and Examiner reports

Your pack contains questions from May/June 2024 Papers 1C and 2C, with mark schemes and student answers

Mark the questions using the scheme provided

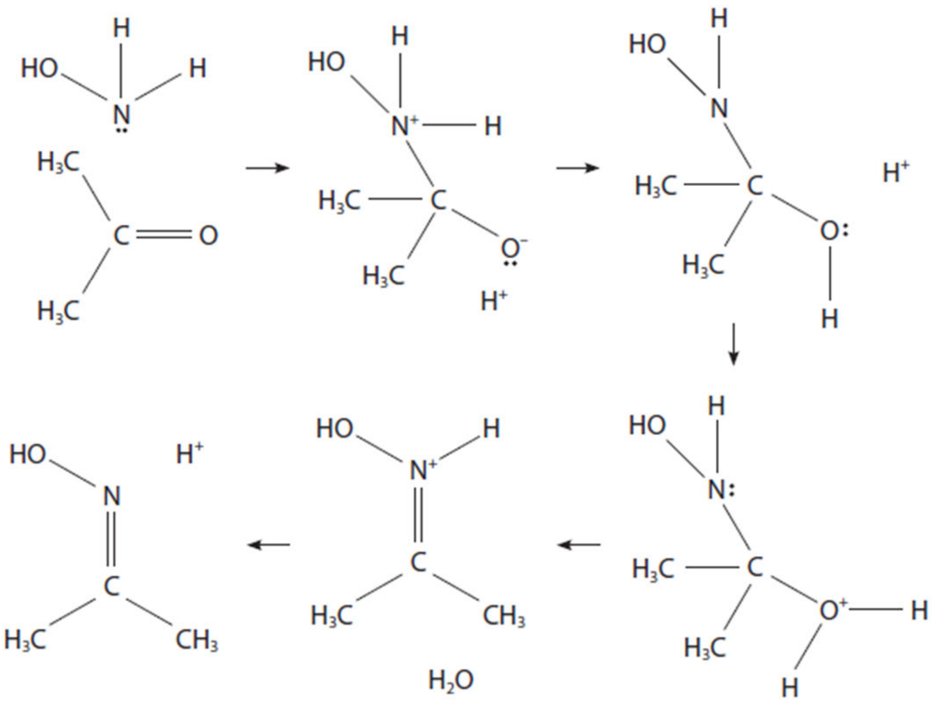
We will discuss the students answers to each question one by one, but don’t let that stop you working on the next question if you are waiting for others to finish

Activity 3 – Student answers and Examiner reports

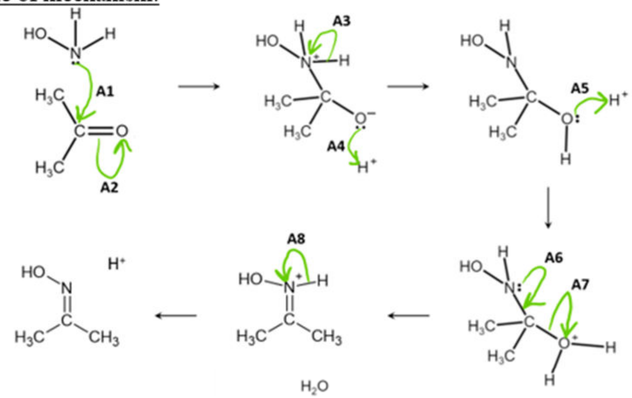
Question 1

Propanone, CH_3COCH_3, reacts with hydroxylamine, NH_2OH, under mildly acidic conditions.
The first stage of the reaction is a nucleophilic addition.

Add curly arrows to complete the mechanism for this reaction. **(4)**

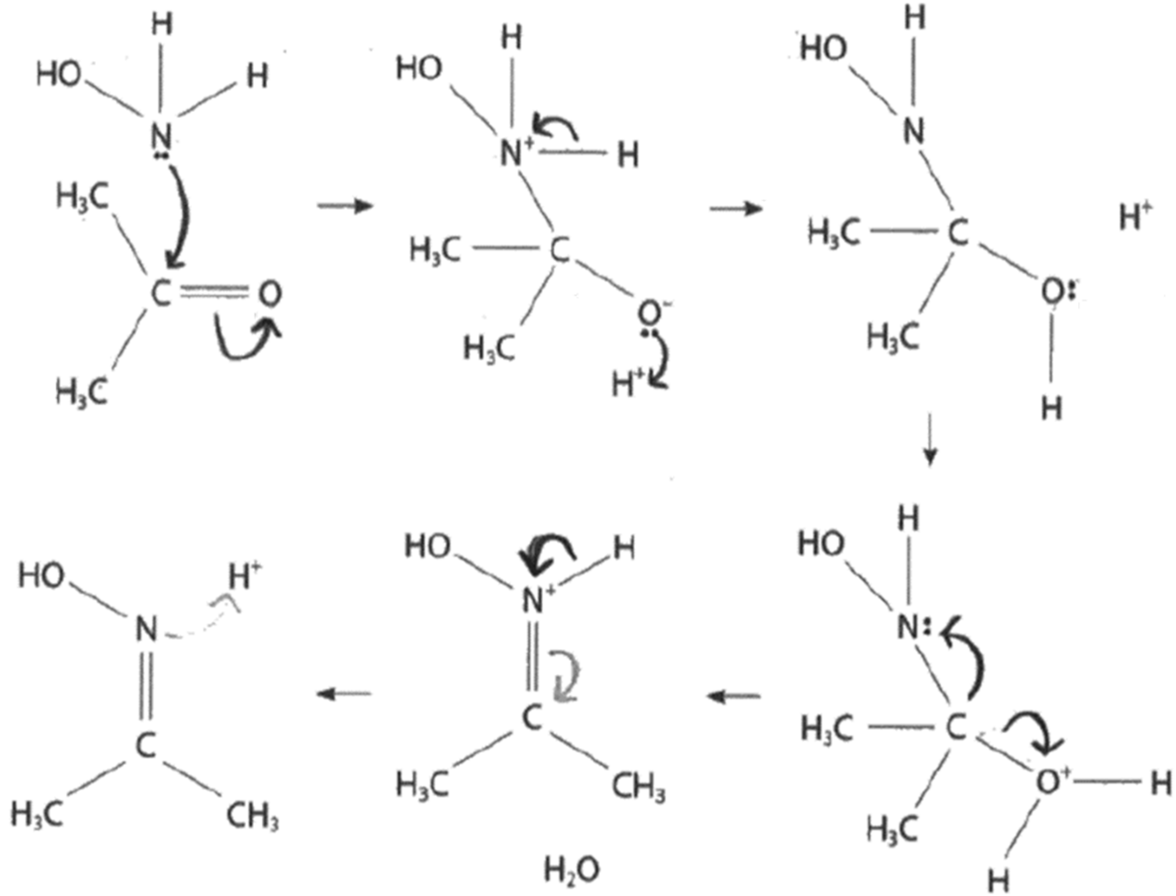


Activity 3 – Student answers and Examiner reports

Answer	Additional Guidance
An answer that makes reference to the following points: • 8 curly arrows **(4)** • 6 or 7 curly arrows **(3)** • 4 or 5 curly arrows **(2)** • 2 or 3 curly arrows **(1)**	Example of mechanism:  A1 and A6 curly arrows must start from N lone pairs Do not award A1 curly arrow if incorrect C=O dipole Ignore incorrect C=O dipole for A2 curly arrow Ignore N–H dipole for A3/A8 curly arrows Do not award A3/A8 curly arrows from N–H bond to H Allow curly arrow A4 from negative charge on O^- Do not award A4/A5 curly arrows starting at H^+ If more than 8 curly arrows shown, each incorrect arrow negates one correct arrow Comment Penalise use of half-headed arrows once only

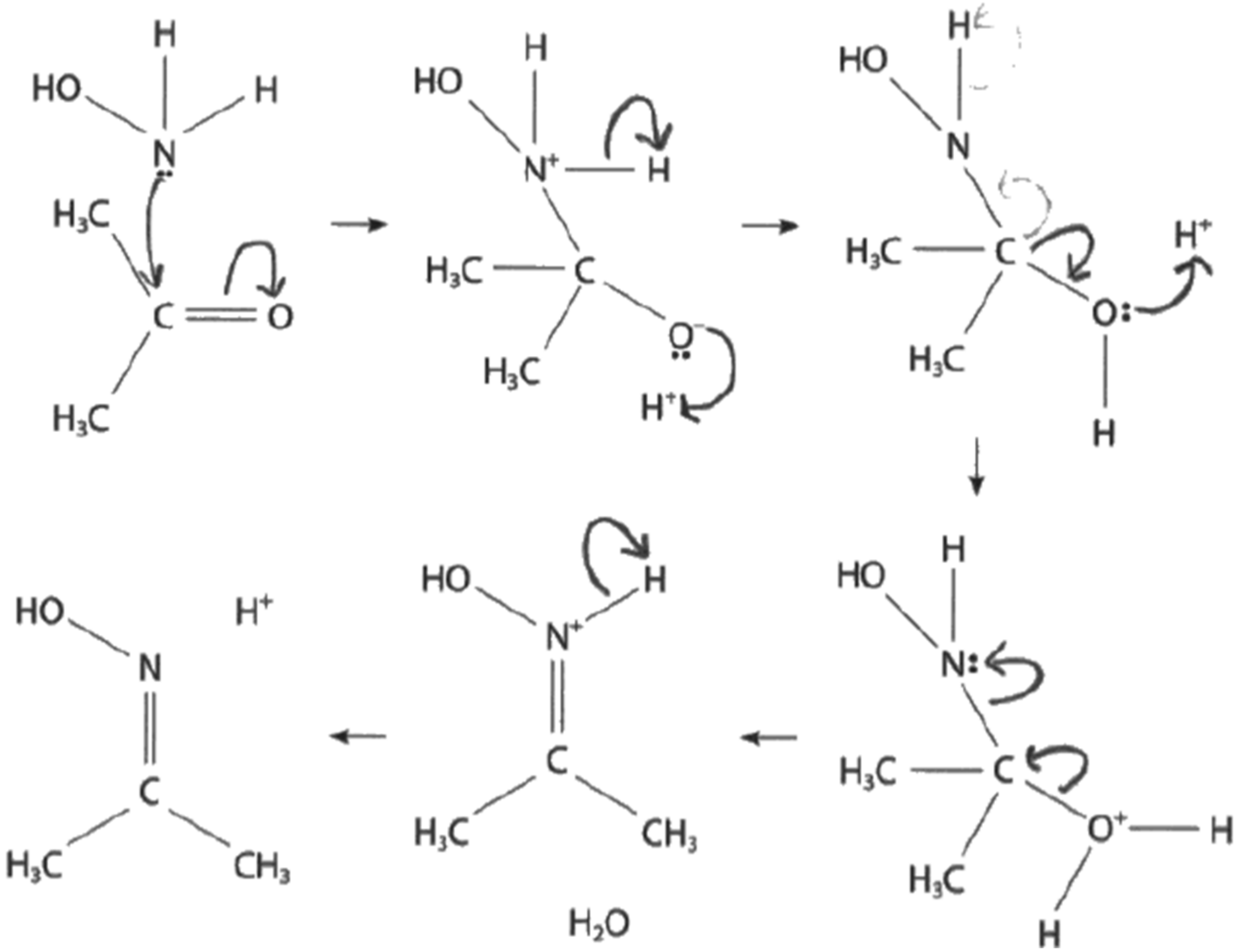
Activity 3 – Student answers and Examiner reports

Student 1



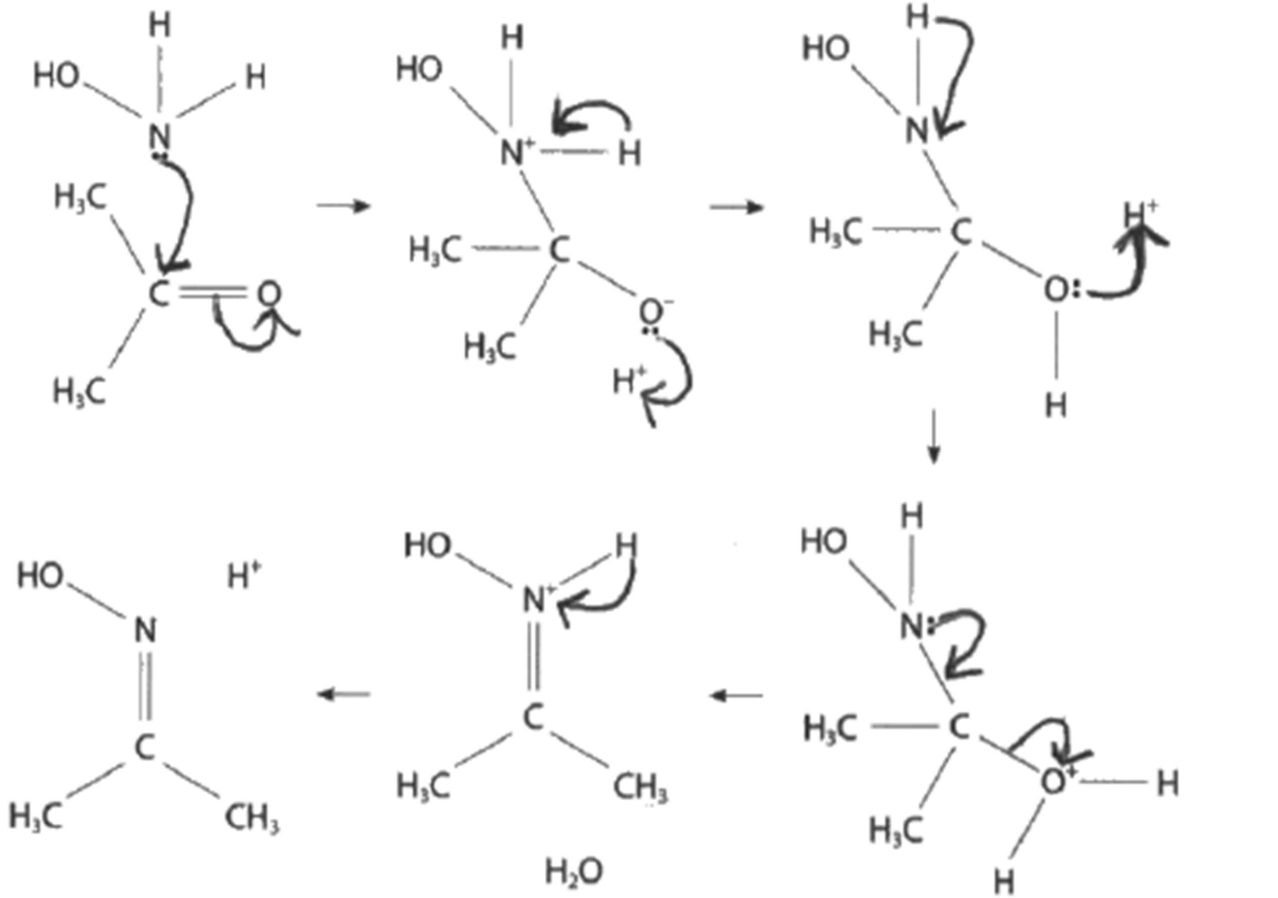
Activity 3 – Student answers and Examiner reports

Student 2



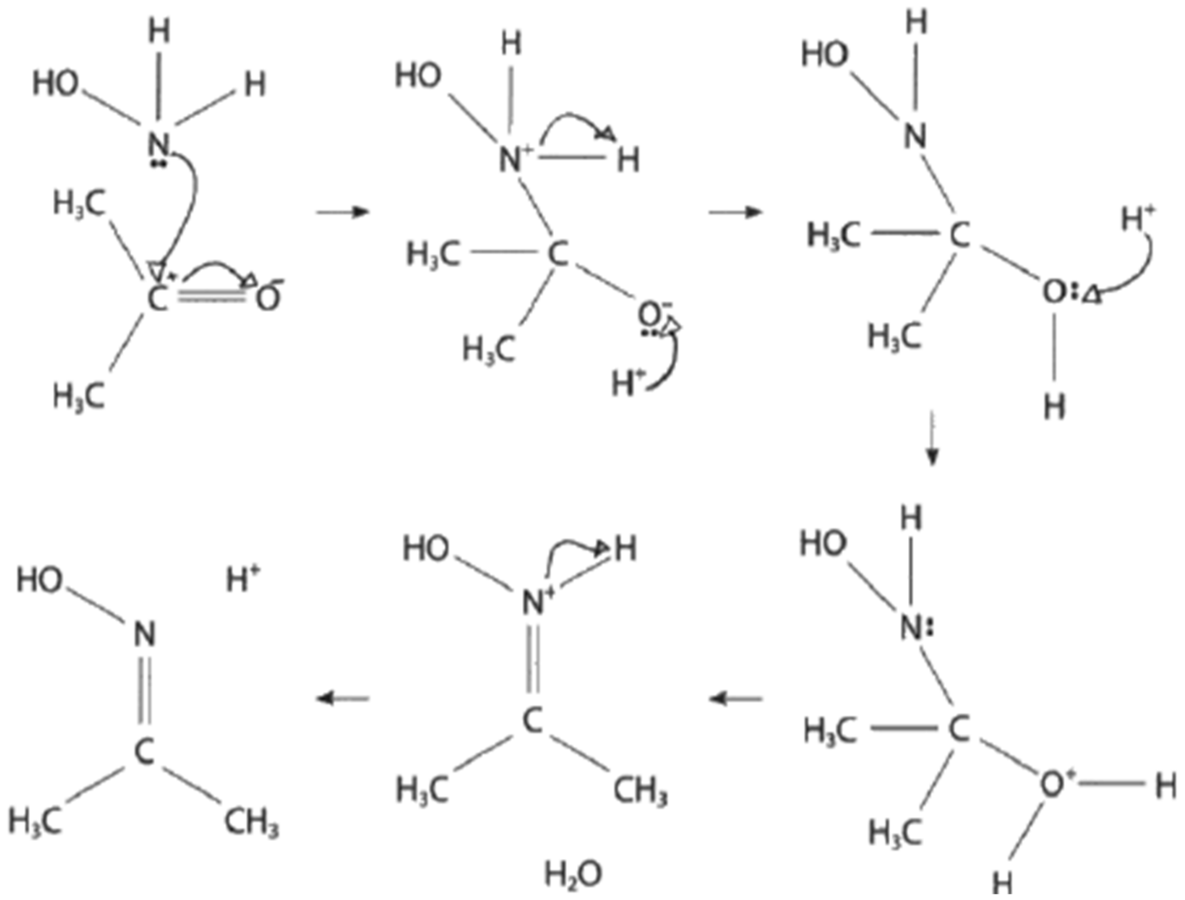
Activity 3 – Student answers and Examiner reports

Student 3



Activity 3 – Student answers and Examiner reports

Student 4



Activity 3 – Student answers and Examiner reports

Examiner's report

The key to scoring well in this question was to understand where bonds were forming and breaking and to consider how electron pairs needed to move to effect this.

Despite the instructions requiring the addition of curly arrows only, many candidates added incorrect charges and/or unnecessary dipoles.

It was commonplace for curly arrows to go in the wrong direction, for example from H^+ ions to O lone pairs or from N – H bonds to H atoms.

Candidates need to more carefully consider where electron pairs are located as well as the products that will be formed by their movement.

Organic Mechanisms – Suggestions to enhance teaching

Preliminary knowledge:

- Ability to translate between displayed, structural and skeletal formula
- Understanding of bonding pairs, lone pairs and unpaired electrons from bonding topics
- Understanding of bond polarity

Organic Mechanisms – Suggestions to enhance teaching

Before you add the curly arrows:

- make sure that the structures of the reactants are clearly shown

- focus on the key features of the reactants, for example:
  - functional groups
  - relevant dipoles
  - lone pairs

- encourage students to describe what they think might happen

Organic Mechanisms – Suggestions to enhance teaching

Now you are ready to add the curly arrows

- Use dual coding to emphasise understanding

- Consider using colours to emphasise different aspects of the mechanism

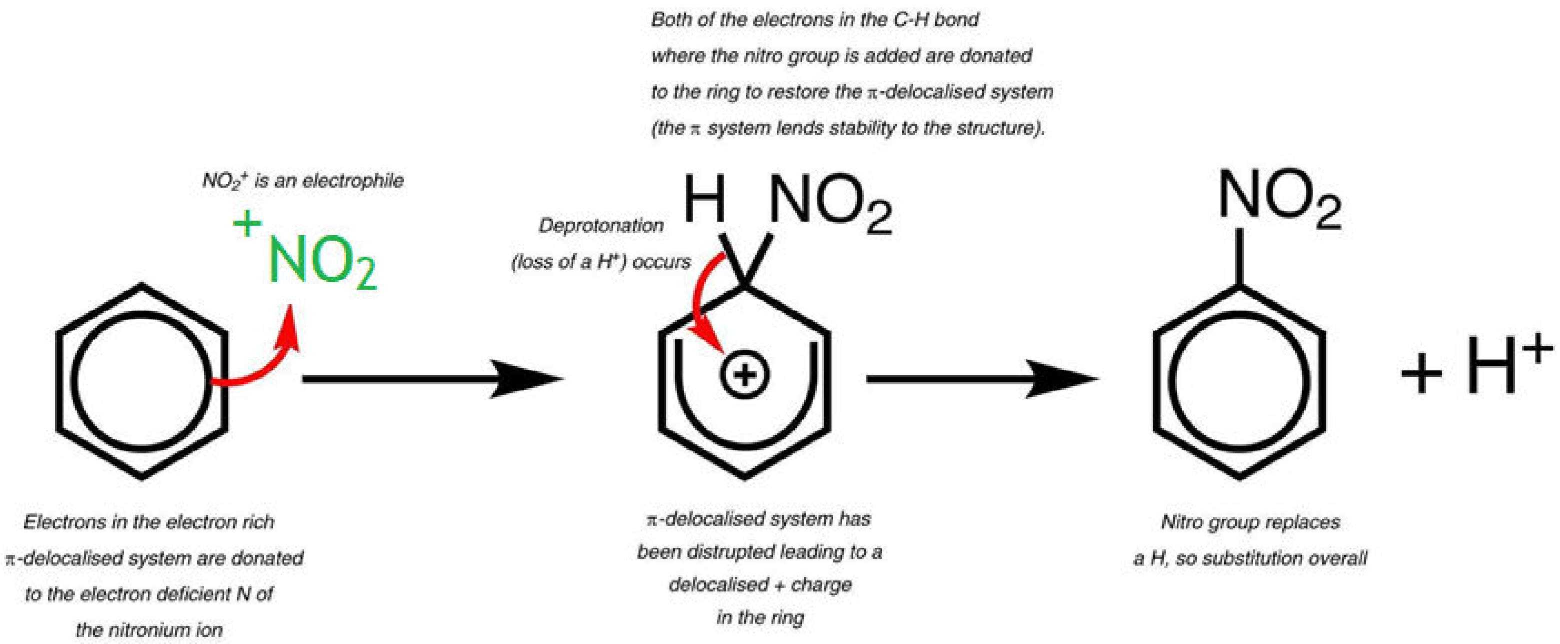
E.g. red for curly arrows

blue for nucleophiles

green for electrophiles

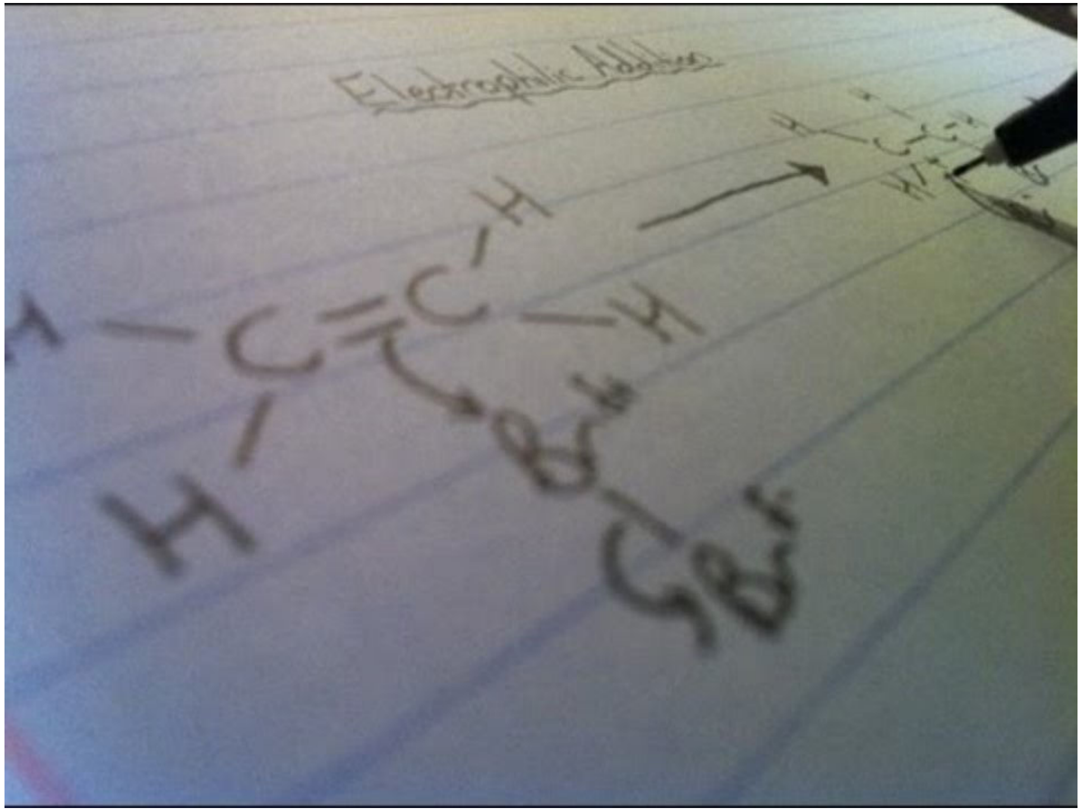
Organic Mechanisms – Suggestions to enhance teaching

Example of dual coding



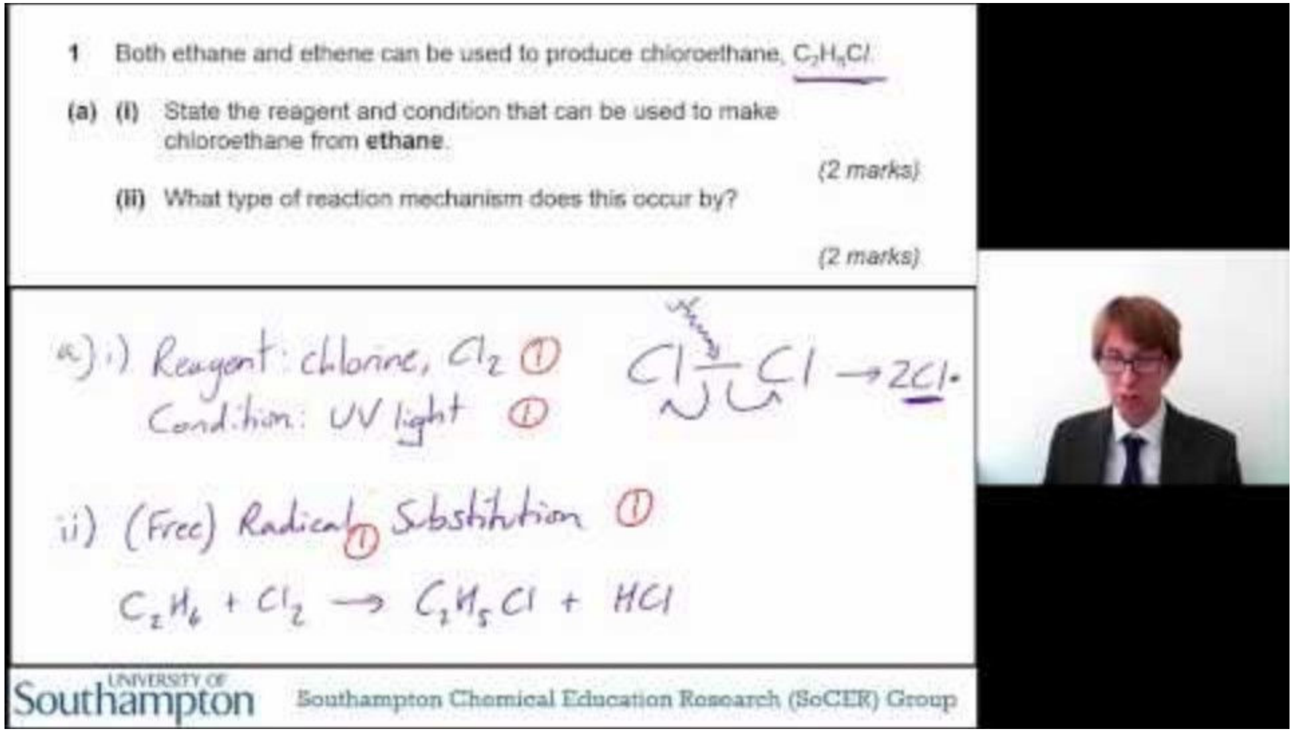
from https://edu.rsc.org/ideas/teaching-organic-mechanisms/3010691.article

Organic Mechanisms – Suggestions to enhance teaching



https://www.youtube.com/watch?v=haEL4F3cwf8

Organic Mechanisms – Suggestions to enhance teaching



https://www.youtube.com/watch?v=5BsNaaelmIQ&list=PLtvjIcjIrjjxFx-E_UKdqvk_rg0TiwpRP

Activity 3 – Student answers and Examiner reports

Question 2

A student measured the pH of separate 0.050 mol dm^{-3} solutions of $CH_2ClCOOH$ and of $CHCl_2COOH$, using a pH meter.

The student also calculated the pH of these solutions, making two assumptions:

- $[H^+] = [A^-]$
- $[HA]_{equilibrium} = [HA]_{initial}$

The measured and calculated pH values are shown.

	0.050 mol dm^{-3} $CH_2ClCOOH$	0.050 mol dm^{-3} $CHCl_2COOH$
Measured pH value	2.11	1.52
Calculated pH value	2.08	1.32

Discuss the differences between the student's measured and calculated pH values. (6)

In your answer, you should

- show how the student calculated their pH values
  [$K_a(CH_2ClCOOH) = 1.4 \times 10^{-3}$ mol dm^{-3};
  $K_a(CHCl_2COOH) = 4.5 \times 10^{-2}$ mol dm^{-3}]
- explain, with reference to the assumptions made, why there is a difference between the calculated and measured pH values
- suggest why the measured pH values are higher than the calculated pH values.

Activity 3 – Student answers and Examiner reports

Indicative points:	
• **IP1:** use of $[H^+] = \sqrt{(K_a \times [HA])}$	If calculations shown, pH values are 2.0775 and 1.3239
• **IP2:** use of $pH = -\log[H^+]$	
• **IP3:** indication that $[HA]_{equilibrium}$ is lower than $[HA]_{initial}$	Ignore $[H^+] = [A^-]$ assumption is not valid Ignore $[H^+] > [A^-]$ Do not award $[A^-] > [H^+]$
• **IP4:** (because) dissociation (of both acids) is significant	Allow dissociation is not negligible Allow dissociation occurs Do not award dissociation is negligible Do not award dissociation is complete
• **IP5:** (calculated pH values lower than measured pH values because) [HA] is overestimated in the **calculations**	Do not award $[H^+]$ overestimated in calculation due to dissociation of water
• **IP6:** (difference greatest for) $CHCl_2COOH$ (as is) stronger acid **or** two Cl atoms in $CHCl_2COOH$ are more electron withdrawing than one / stabilise anion more / weaken O–H bond more	Allow more dissociated for stronger Ignore strong acid for stronger acid Ignore $CHCl_2COOH$ has larger K_a / smaller pKa

Activity 3 – Student answers and Examiner reports

Student 1

For : 0.050 $mol dm^{-3}$ $CH_2ClCOOH$:

$Ka = \frac{[H^+]^2}{[CH_2ClCOOH]} \Rightarrow [H^+]^2 = \sqrt{1.4 \times 10^{-3} \times 0.050}$

$= 8.367 \times 10^{-3} mol dm^{-3}$

$pH = -\log_{10}[H^+] = -\log_{10}[8.367 \times 10^{-3}]$

pH = 2.077 ∴ pH = 2.08

For 0.050 $mol dm^{-3}$ $CHCl_2COOH$:

$Ka = \frac{[H^+]^2}{[CHCl_2COOH]} \Rightarrow H^+ = \sqrt{4.5 \times 10^{-2} \times 0.050}$

$pH = -\log_{10}[H^+] = -\log_{10}[0.04743]$

∴ pH = 1.32 .

For $CH_2ClCOOH$:

$[HA]_{equilibrium}$ is not equal to $[HA]_{initial}$.

$[HA]_{initial}$ must be greater than the $[HA]_{equilibrium}$.

For $CHCl_2COOH$:

$[HA]_{equilibrium}$ is not equal to $[HA]_{initial}$.

$[HA]_{initial}$ must be greater than the $[HA]_{equilibrium}$.

For both the $CH_2ClCOOH$ and $CHCl_2COOH$ there is a difference in Ka (acid dissociation). The Ka for $CH_2ClCOOH$ is smaller than the Ka of $CHCl_2COOH$. Therefore $CHCl_2COOH$ is stronger acid compared to $CH_2ClCOOH$. $CHCl_2COOH$ would dissociate fully but $CH_2ClCOOH$ would dissociate partially.

Activity 3 – Student answers and Examiner reports

Student 2

The student calculated the pH value of $CH_2ClCOOH$ by using $Ka = \frac{[H^+][CH_2ClCOO^-]}{CH_3ClCOOH}$ which rearranges to

$\sqrt{Ka \times 0.05} = \sqrt{1.4 \times 10^{-3} \times 0.05} = 8.37 \times 10^{-3}$

then the student did $-\log(8.37 \times 10^{-3})$ to get 2.08.

They did the same with the $CHCl_2COOH$ using $\sqrt{0.05 \times 4.3 \times 10^{-2}} = 0.047$ then did $-\log(0.047)$ which equals 1.32.

There is a difference between the calculated and measured values due to a variety of potential factors. Firstly, the dissociation of both $CH_2ClCOOH$ and $CHCl_2COOH$ are both negligible. Additionally, we assumed all H^+ is ~~from~~ not from ionisation of water and that the concentrations of the H^+ and its cojugate base are equal. These could have not been true in the student's experiment.

The measured pH values may be higher due to the equilibrium not reaching completion or the pH being measured too early.

Activity 3 – Student answers and Examiner reports

Examiner's report

Most were able to show how the pH values had been calculated but candidates found it much more challenging to use the assumptions to explain the differences between the measured and calculated values.

It was a common approach to simply restate the assumptions, rather than question their validity, and many thought that dissociation of water meant the first assumption was partly responsible for any differences.

A good proportion of candidates realised that the equilibrium concentration of the acids would be lower than the initial values, and that this was due to acid dissociation.

Far fewer were able to express that this meant the concentrations of the acids would be overestimated in the calculations, leading to erroneously high hydrogen ion concentrations and lower pH values.

Although not prompted to do so, it was expected that candidates would comment on the greater difference between measured and calculated pH values for dichloroethanoic acid but very few did this or attempted to compare the strength of the two acids.

Acid-Base Equilibria– Suggestions to enhance teaching

Misconceptions and difficulties

Some difficulties and misconceptions your students may have include:

- understanding the difference between the terms strong, weak, concentrated, and dilute
- all salts when dissolved in water have a pH of 7
- the pH scale is logarithmic: pH = – lg [H^+]. Understanding the maths is a common difficulty
- understanding the relationship between pK_a and Ka: pK_a = – lg [K_a]

Acid-Base Equilibria– Suggestions to enhance teaching

What students need to know

Students should understand there are several different theories of acids and bases (i.e., the Arrhenius, Brønsted-Lowry and Lewis theories)

Strong acids/bases are fully dissociated in aqueous solutions, while weak acids/bases are only partially dissociated

K_a is the acid dissociation constant

Acids and bases form conjugate acid–base pairs

The pH scale is a logarithmic scale used as a measure of H^+ concentration

Acid-Base Equilibria– Suggestions to enhance teaching

What students need to know

pH curves show how pH changes during an acid–base titration and can be used to determine the equivalence point

K_w is the ionic product of water and can be used to determine the pH of water at different temperatures

Indicators are weak acids that change colour when they donate H^+ ions

Buffers are solutions that minimise changes in pH when small amounts of acid/alkali are added and play an important role in biological (eg blood) and non-biological (eg shampoo) systems

Acid-Base Equilibria– Suggestions to enhance teaching

Acid and base strength

- Compare a strong and weak acid by carrying out a series of quick experiments
- For example, measure the pH and conductivity of 1 mol dm^{-3} HCl and 1mol dm^{-3} CH_3COOH, then observe how they each react with magnesium ribbon or marble chips
- Comparing the results will help students to understand the differences, especially if you ask them to interpret the reactions of the acids in terms of the number of H^+ ions present
- You could then go on to explore the equilibria involving carbon dioxide in an aqueous solution, which provides an opportunity to revisit the concept of equilibria before moving on to introduce the acid dissociation constant K_a, which is a mathematical relationship that indicates the degree of dissociation
- In this reaction there are several possible equilibria, which makes it quite complicated but allows for interesting discussions and practice writing expressions for K_a
- Follow up the theory by determining *K*a for a weak acid or base using pH measurements

Acid-Base Equilibria– Suggestions to enhance teaching

Real-life contexts

Relating the chemistry to real-life contexts adds extra interest for students. Examples include:

- household products such as cleaning products and food (citrus fruits, tomato-based products and processed grain are acidic, while nuts, legumes and vegetables are alkaline)
- neutralisation has a role to play within agriculture as many cultivated plants require a neutral soil to grow in, but soil pH varies from 3–10
- the environment – this topic links to air pollution, acid rain and ocean acidification, which many students are passionate about
- medicine, for example to diagnose and treat conditions such as heartburn, indigestion or respiratory alkalosis – a condition in which the pH of blood (around 7.4) is above normal, often caused by hyperventilation
- the three main buffer systems in the body (carbonic acid bicarbonate, phosphate and protein buffer systems), require pH to be controlled so that various biochemical processes can take place, and are especially relevant for those students also studying biology

Acid-Base Equilibria– Suggestions to enhance teaching

Take-home points

- Use diagnostic probes to promote discussion and find out what your students think
- At the start of the topic, make sure your students have a good understanding of the basics of equilibria before going further
- Use practical activities to promote thinking and to collect real data for use in calculations
- Provide lots of opportunities to practise calculations
  - Make sure students know how to use their calculators
- Simulations are great but do evaluate before use in the classroom
- Be careful with language
  - Incorrect use of the terms strong, weak, concentrated and dilute can lead to confusion
- Remember, putting the chemistry into real-life contexts can provide extra interest

Activity 3 – Student answers and Examiner reports
Question 3

Silicon dioxide and magnesium react when heated strongly.

Reaction **1** $SiO_2(s) + 4Mg(s) \rightarrow Mg_2Si(s) + 2MgO(s)$

The entropy change of the system, ΔS_{system}, for Reaction **1** is $-43.8\ J\ K^{-1}\ mol^{-1}$.

Suggest, with reference to the equation, why ΔS_{system} for this reaction is negative. **(2)**

Answer	Additional Guidance
An answer that makes reference to the following points:	Accept reverse arguments Allow particles or molecules for moles Ignore any reference to standard entropies of reactants and products
• (as) moles (decreases) from 5 to 3 **(1)**	Allow just number of moles decreases Do not award incorrect numbers of moles Do not award incorrect explanation relating to states
• decreases in disorder **(1)**	Accept fewer ways of distributing energy (in products) Accept fewer ways of arranging moles (in products) Ignore just less arranged for less disordered Ignore randomness for disorder Ignore just decreases in entropy

Activity 3 – Student answers and Examiner reports

Student 1

- There are more ~~particles~~ moles ~~on the~~ of reactants compared with the number of moles of products
- So the entropy change of products is less than the entropy change of reactants

Student 2

According to the equation, there is a decreasing number of moles as it goes from 5 total in the reactants to 3 in the products. A decrease in mole will generally lead to a negative Δsystem as its Σ products − Σ reactants.

Activity 3 – Student answers and Examiner reports

Student 3

There is a decrease in the entropy of the system because from 2 solids, 2 more ~~complex~~ ordered solids are created.

Student 4

The number of ~~molecules~~ moles in reactants side is 5 and number of moles for products is 3 so the decrease in moles mean decrease in disorder so entropy will decrease.

Activity 3 – Student answers and Examiner reports

Examiner's report

Most candidates recognised that entropy decreased due to a decrease in the number of moles but far fewer gave a satisfactory indication of the meaning of the term entropy.

A significant number tried to explain the change in terms of the entropies of the reactants and products but, as no data was provided, this was not a creditable approach.

Entropy – Suggestions to enhance teaching

What students need to know

- Entropy, S, is a measure of the number of ways of arranging particles and energy in a system
- The units are J mol^{-1} K^{-1}
- S (gas) > S (liquid) > S (solid)
- The entropies of more complex molecules are larger than those of simple molecules

Entropy – Suggestions to enhance teaching

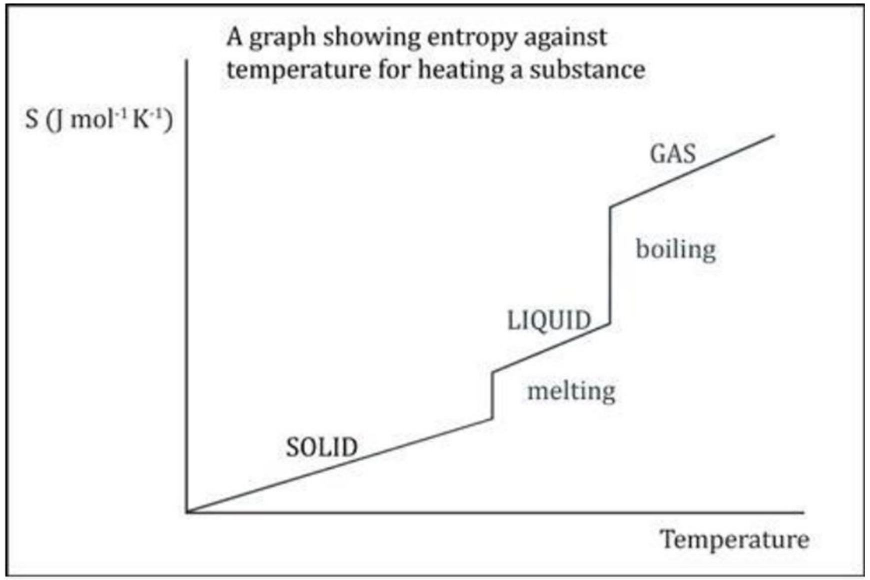
What students need to know

- A change in the number of particles as a result of a reaction will affect the entropy of the system
- The standard entropy change of a reaction can be calculated from the standard entropies of reactants and products
- Entropy calculations include:
  - $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$
  - $\Delta S_{surroundings} = -\Delta H/\mathrm{T}$
  - $\Delta S_{total} = \Delta S_{system} - \Delta H/\mathrm{T}$
- Spontaneous reactions occur when ΔS_{total} is positive

Entropy – Suggestions to enhance teaching

Common misconceptions and difficulties

- Learning about abstract concepts is challenging because students cannot see or measure any properties
- Ask students to complete a sketch graph of entropy against temperature will help to bolster the idea that entropy is a property and will reveal any underlying misconceptions
- Students often incorrectly draw horizontal lines to indicate entropy in the solid, liquid or gaseous state. If the temperature rises, then the vibration of the particles of the substance, and thus the entropy, will increase



Entropy – Suggestions to enhance teaching

Common misconceptions and difficulties

The terms enthalpy and entropy can at first seem similar but are, in fact, very different

Key difficulties are:

- using the correct equation
- recalling standard temperatures
- confusing units by failing to convert temperature into kelvin or using inconsistent energy units, particularly when calculating the entropy change of surroundings

$$\Delta S_{surroundings} = -\Delta H/T$$

Entropy – Suggestions to enhance teaching

Ideas for your classroom

- Before starting, ensure your students have a secure understanding of energy and change (https://edu.rsc.org/cpd/teaching-energy-and-change-post-16/4015925.article), including specialist language such as system and surroundings
- One way is to focus on order and disorder, starting with a familiar context
- A simple way of demonstrating this is by arranging marbles of two different colours in two layers in a large plastic beaker, and then shake it
- Ask students how likely it is that the system will return to the original ordered arrangement
- Next, move the conversation on to thinking about chemical events – for example, the odds of two chemicals mixing are very high if both have similar types of molecules

Entropy – Suggestions to enhance teaching

Ideas for your classroom

- Then explore why chemical reactions happen
  Introduce the idea that entropy can give accurate predictions about how a particular system will behave, but not what the individual atoms will do

- You can find more detailed explanations and further examples in ‘Chemistry is like a crowd’ (https://edu.rsc.org/opinion/chemistry-is-like--a-crowd/3007430.article)

- and these ‘Post-16 thermodynamic tutorials’ (https://edu.rsc.org/resources/post-16-thermodynamics-tutorials/922.article)

- The sequence of activities in this ‘Lesson plan looking at why chemical reactions happen’ (https://edu.rsc.org/lesson-plans/why-do-chemical-reactions-happen-16-18-years/128.article) provides a structured approach, through group discussions, demonstrations and role play, to understanding the question: why do chemical reactions occur?

Entropy – Suggestions to enhance teaching

Take-home points

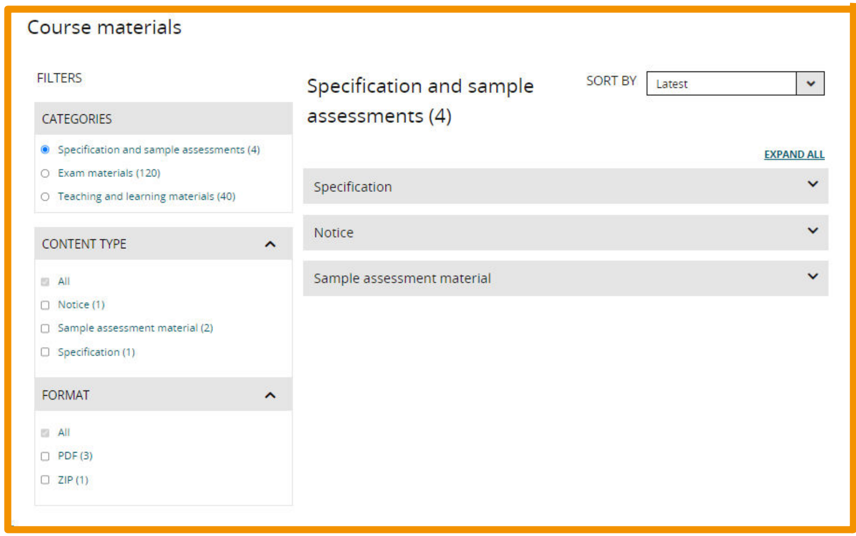
- Be upfront – entropy is a difficult concept due to its abstract nature
- Introduce the topic using everyday examples to get discussion started
- Carefully sequence learning to support conceptual understanding
- Make sure your students have a good qualitative understanding of entropy and can apply the ideas to a range of different systems before moving on to quantitative calculations
- Regularly use formative assessment to monitor progress and student understanding

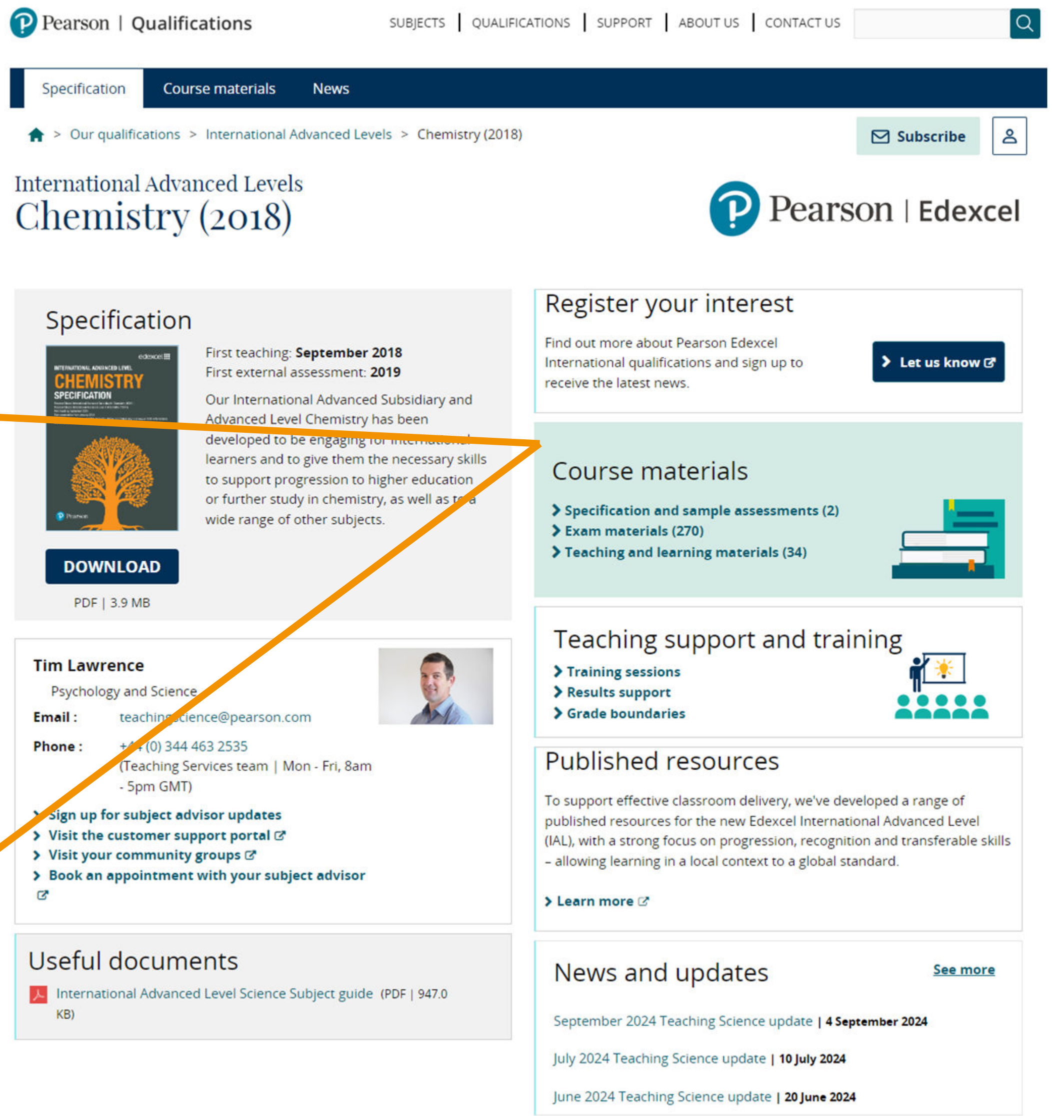
Support

Support for you at every stage

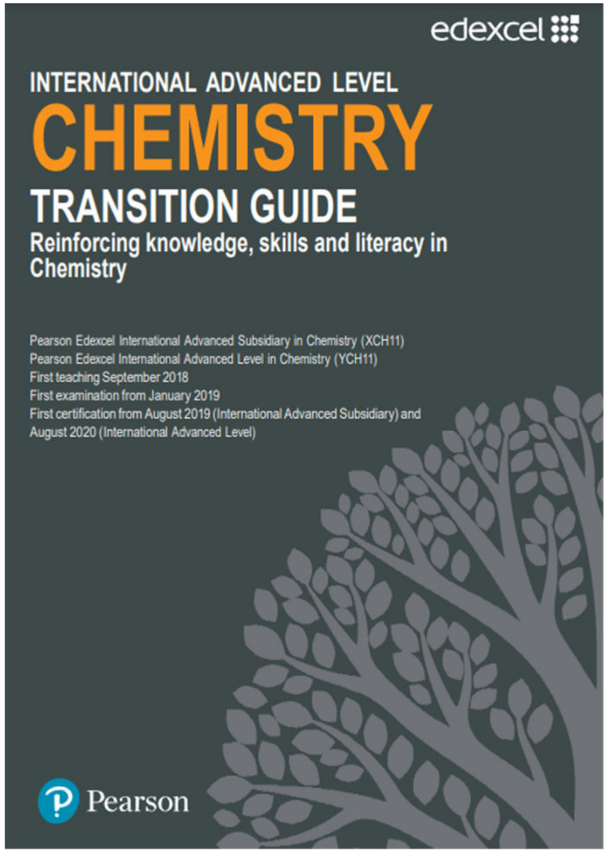
Free Resources and support	Planning, teaching and learning	Exam preparation and assessment	Results support
Getting Started Guide	✓		
Training Events (Face-to-Face & Online)	✓		
Subject Advisor Support	✓	✓	✓
Community Forums	✓	✓	✓
Schemes of Work	✓		
Skills Mapping	✓		
Sample Assessment Materials	✓	✓	
Examiner Reports	✓	✓	✓
Exemplar Marked Responses		✓	
Past Papers		✓	
examWizard		✓	
Mark Schemes		✓	
ResultsPlus Mock Exam Analysis		✓	
Results Plus		✓	✓
Access to Scripts Service (ATS)			✓

Teaching and Learning Materials online





Stepping up to A Level

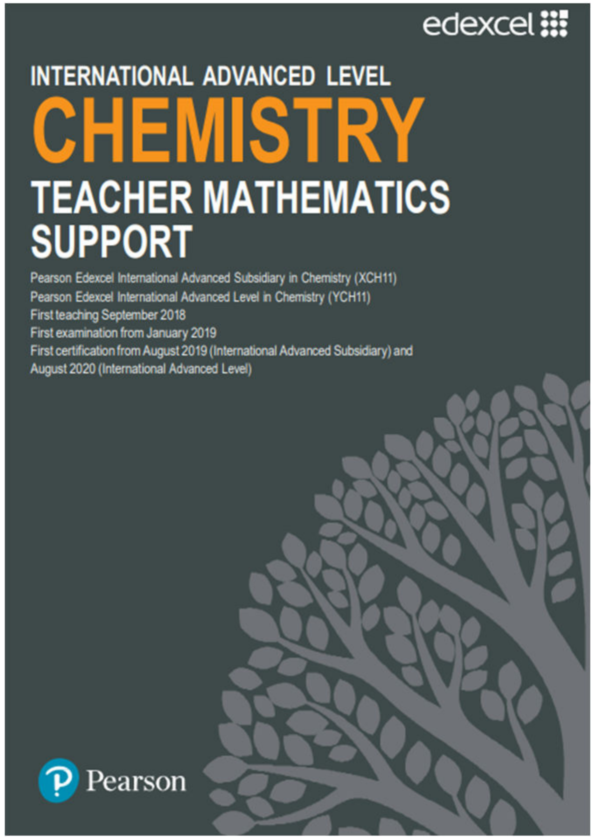


The transition materials include:

- mapping of Edexcel International GCSE(s) to the A Level Chemistry specification
- baseline assessments
- summary sheets
- student worksheets
- practice questions.

The teacher version also includes answers for assessments, worksheets and exam practice questions

Maths Support

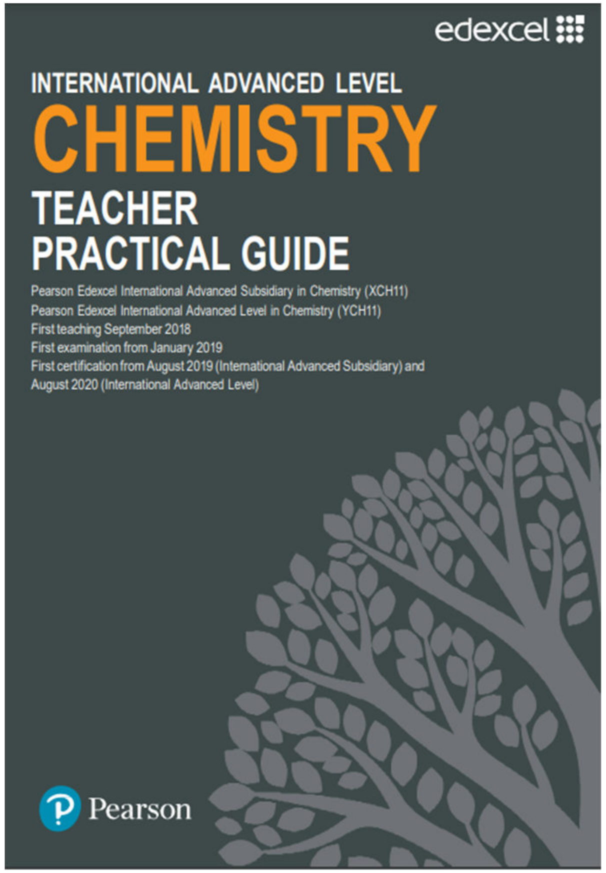


There is also a student guide that covers selected topics that students find difficult.

These are:

- Mole calculations
- Enthalpy changes
- Reaction rates
- Equilibrium calculations
- Acid base equilibria and pH calculations
- Electrode potentials

Practical Guide

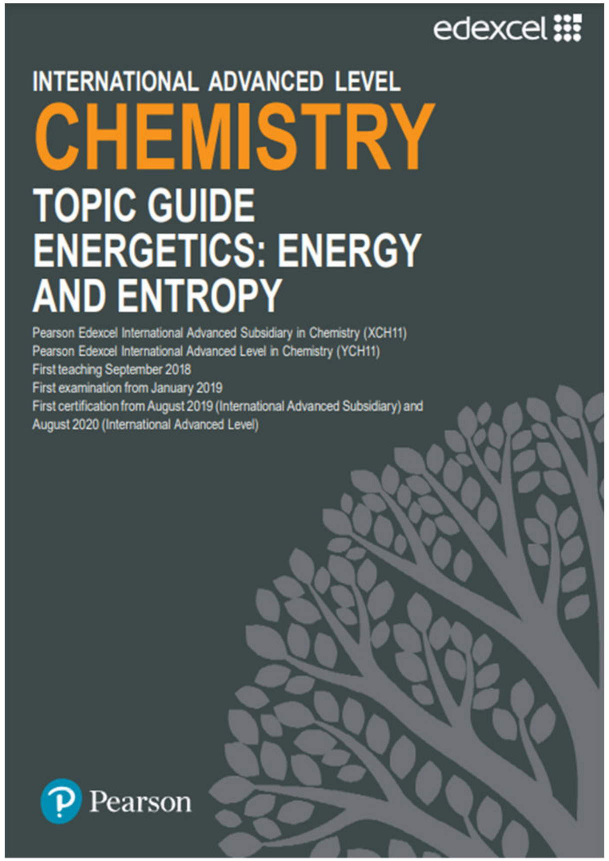


The guide is designed to:

1. support you and your students through all elements of practical work in the new International AS and A level specification. Although it will address assessment arrangements, its focus is to ensure good quality practical work is at the heart of teaching and learning in the subject, and

2. explain how the requirements for practical skills can be developed throughout the course using both core practicals and other specification content.

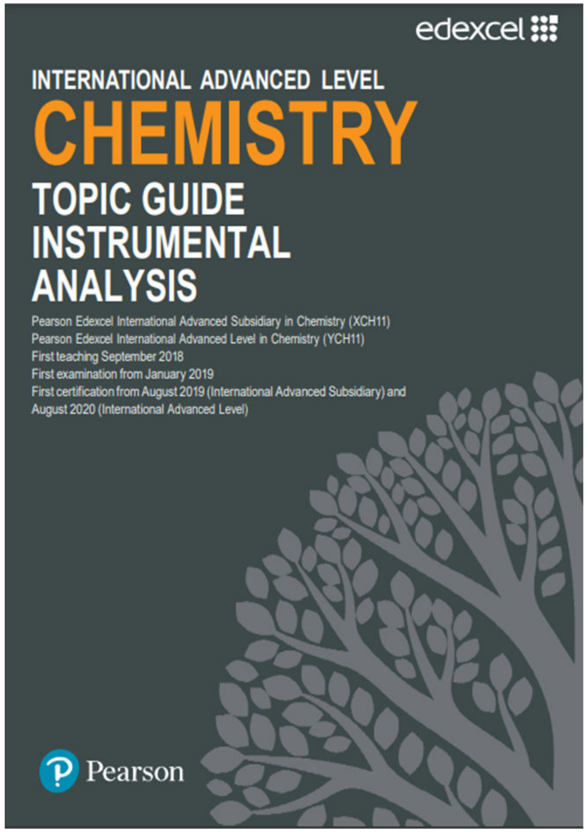
Topic Guide – Energetics: Energy and Entropy



Included in this guide are:

- some ideas on how to address common misconceptions in both new and previously included content
- possible teaching sequences for key specification points where there is new or challenging content
- worked examples that teachers could use to support students in developing their understanding.

Topic Guide – Instrumental Analysis



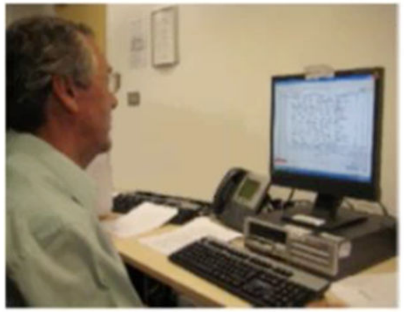
Included in this guide are:

- some ideas on how to address common misconceptions in both new and previously included content
- possible teaching sequences for key specification points where there is new or challenging content
- worked examples which teachers could use to support students in developing their problem-solving skills
- links to external websites which can be used to further students' understanding.

ResultsPlus

- Free online results analysis tool for teachers.
- Provides a detailed breakdown of student performance in Pearson Edexcel exams.
- Identify topics and questions where the student could benefit from further learning and inform teaching strategies and approaches.
- Benchmark your school's performance against other Pearson Edexcel schools in your country.
- Not just a post-results tool: Mock exam results can also be fed into the system to produce analysis.
- Find student results analysis from their previous Pearson Edexcel school.
- ResultsPlus Direct gives your students access to their final grades and performance breakdown, wherever they are.
- Schools can sign up for free ResultsPlus account in just a few quick and easy steps: https://qualifications.pearson.com/en/support/Services/ResultsPlus.html

ResultsPlus



1. Student takes exam on paper

2. Exam papers scanned

3. Examiners mark papers online

4. Performance reports shared

- A free tool for teachers which helps you make quick homework assignments, topic tests and mock exams.
- Questions tagged against unit, topic and assessment objective or simply choose a whole past paper.
- Use existing mark schemes for accurate marking.
- Use examiner report for insight.
- Most recent exam content available sooner.
- Use the results to understand where students need more support, informing teaching strategies.

Access to Script (ATS) Online Portal

Access to Scripts (ATS) is a free online portal which allows teachers to immediately access electronically marked exam papers

Provides enhanced transparency and

- Offers transparent approach to marking process
- Provides better understanding of marking before requests for enquiries about results are made
- Provides excellent aid for teaching and preparing other cohorts for examinations by helping you to evaluate a student's performance on particular questions in relation to what they have been taught.

Available instantly from results day for all our examination series, for a defined window, you can view and download scripts which have been marked online free of charge from our Self-Service Portal.

For more information on ATS, and the post results windows, visit our post-results pages.

Pearson published resources

Student Book
Edexcel International A Level: Chemistry Student Book 1

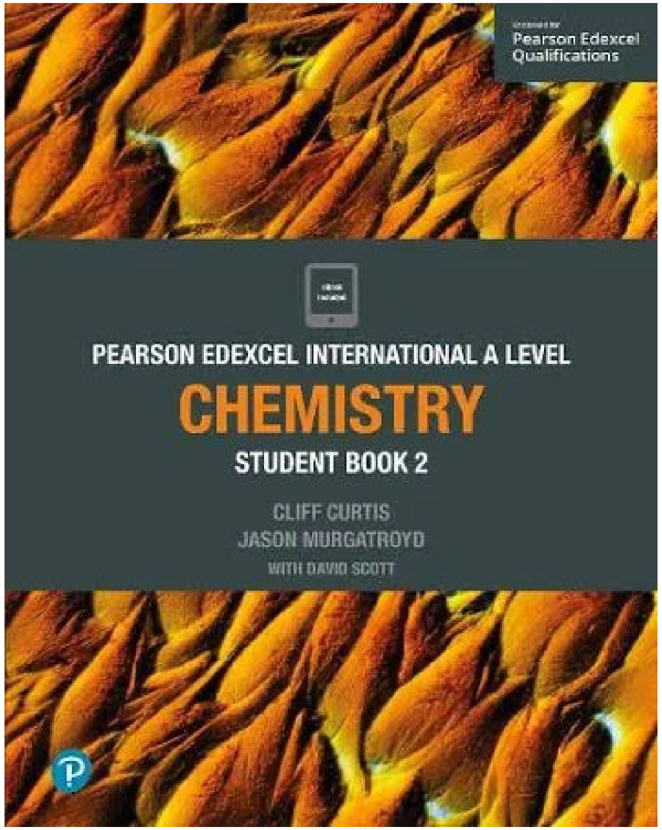
ISBN: 9781292244860

Edexcel International A Level: Chemistry Student Book 2

ISBN:9781292244723

For more information and access
to samples visit:

www.pearson.com/international-schools



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Questions