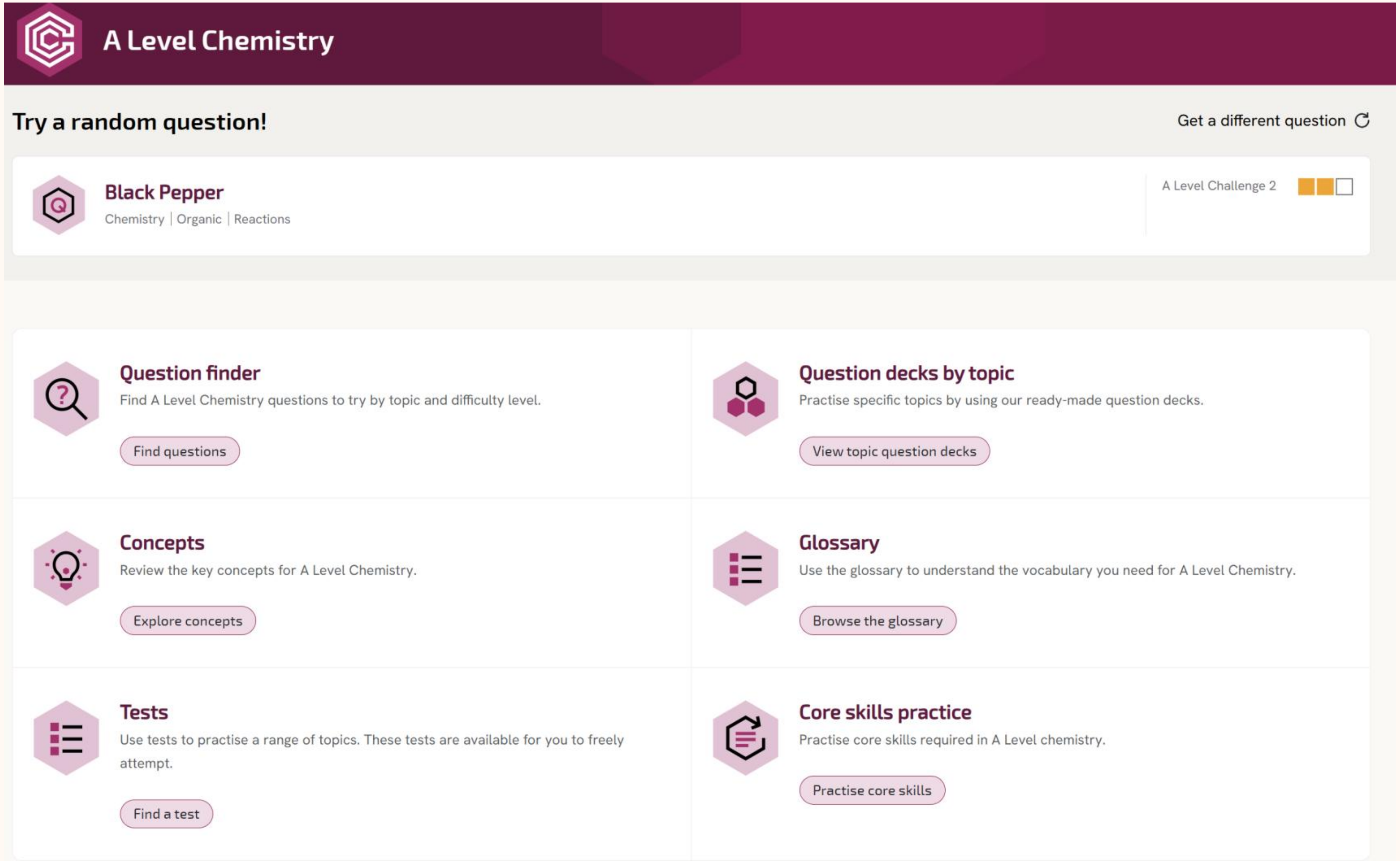
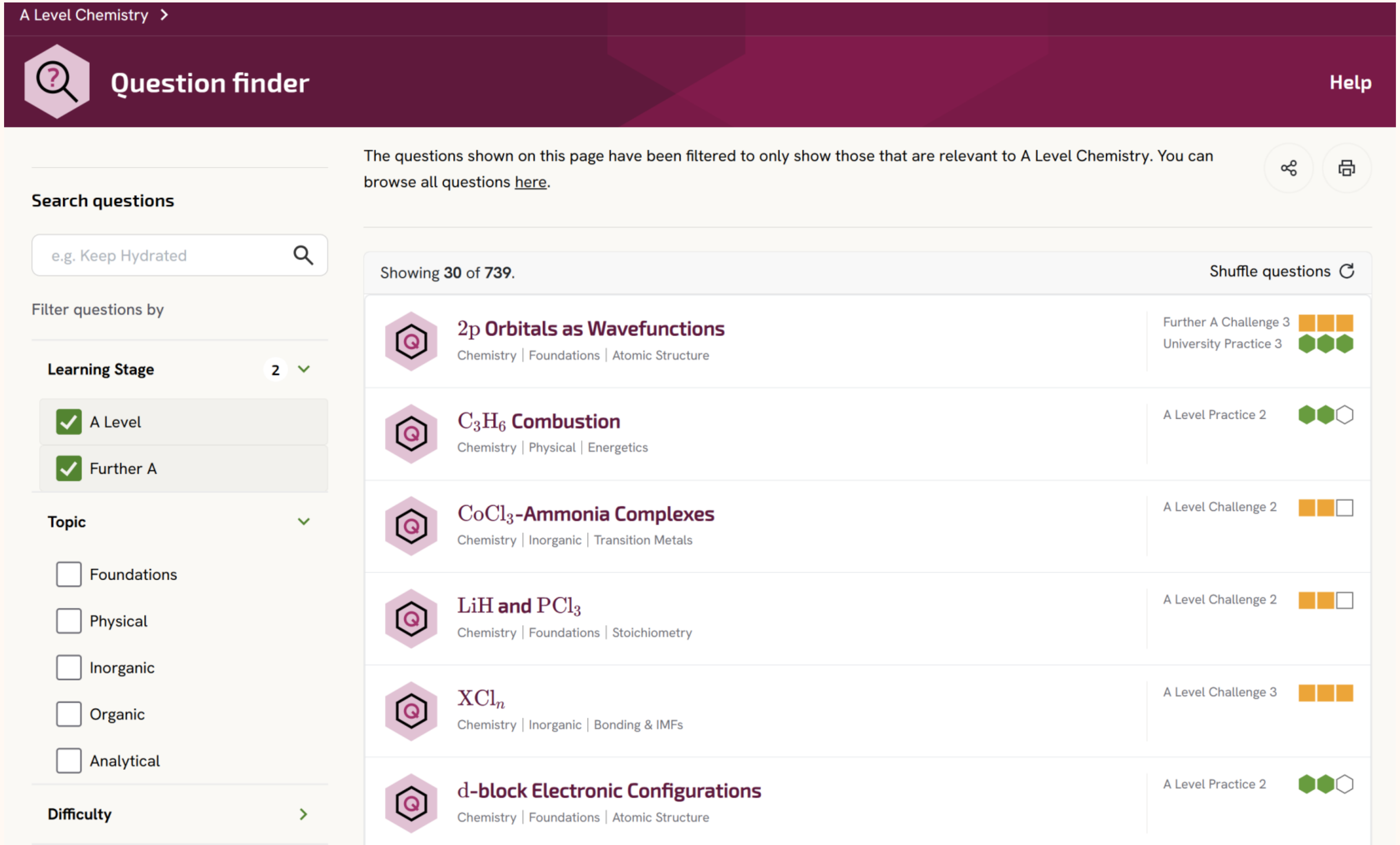
Isaac Chemistry

Andrea Chlebikova ac782@cam.ac.uk andrea.c@isaacscience.org

Isaac A Level Chemistry overview



Question finder



Questions: topics

- [x] Foundations
  - [ ] Numerical Skills
  - [ ] Atomic Structure
  - [ ] Stoichiometry
  - [ ] Gas Laws

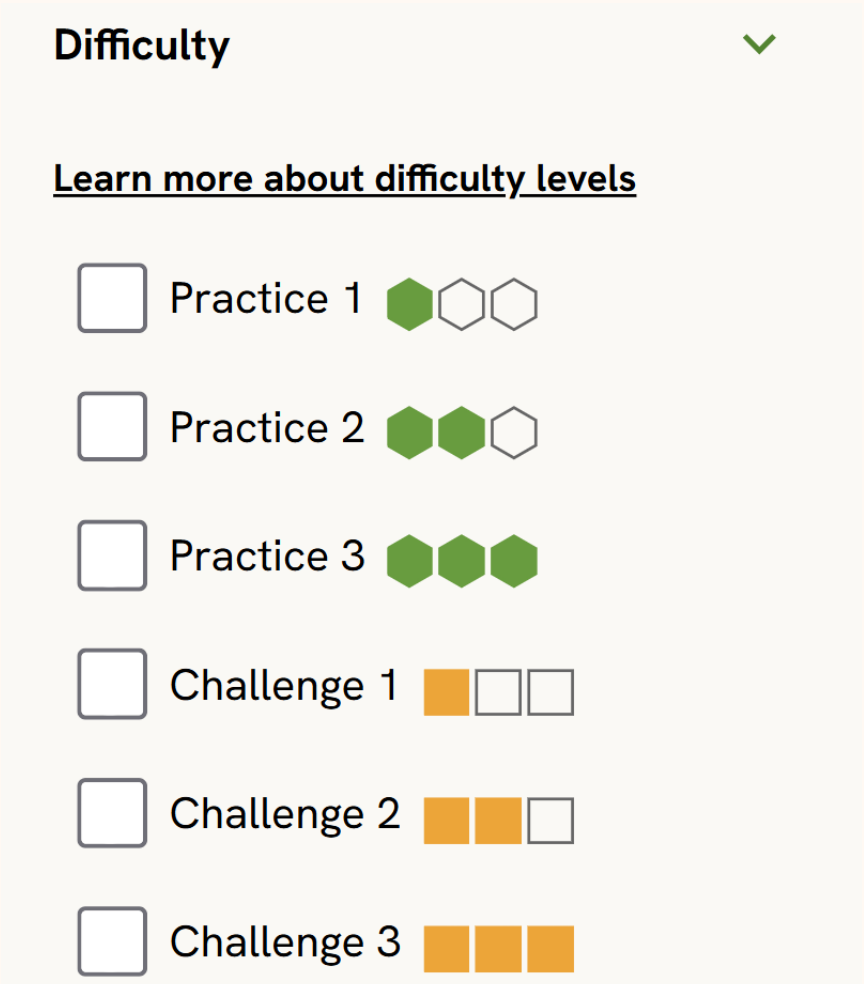
- [x] Inorganic
  - [ ] Periodic Table
  - [ ] Bonding & IMFs
  - [ ] Redox
  - [ ] Transition Metals

- [x] Analytical
  - [ ] Chromatography
  - [ ] Mass Spectrometry
  - [ ] IR Spectroscopy
  - [ ] NMR Spectroscopy
  - [ ] Electronic Spectroscopy

- [x] Physical
  - [ ] Kinetics
  - [ ] Energetics
  - [ ] Entropy
  - [ ] Equilibrium
  - [ ] Acids & Bases
  - [ ] Electrochemistry

- [x] Organic
  - [ ] Functional Groups
  - [ ] Isomerism
  - [ ] Reactions
  - [ ] Aromaticity
  - [ ] Reactions (aromatics)
  - [ ] Polymers

Questions: difficulty



- Practice questions are similar to what one would expect to see in an exam paper for the relevant stage (difficulty increasing P1 -> P3)

- Challenge questions require more problem solving/insights/… e.g. such as seen in C3L6 papers, Chemistry Olympiad, …

Question decks by topic

Question decks by topic

Decks by stage

- A Level

Decks by subject

- Physics
- Chemistry
- Maths
- Biology

The Chemistry topics below are ordered to allow for progression of ideas from one question deck to the next. To find a question deck on a specific topic, use `Ctrl+F` in your browser.

The "**What it contains**" column lists the difficulty levels of the questions and how many there are: for example, "7×P1" means seven questions of "Practice 1" difficulty. Generally, "Practice" questions are exam style, while "Challenge" questions use the same knowledge in a less familiar style and may require problem solving or combining of ideas. Some ratings are preliminary and subject to change, so feedback from teachers is very welcome. The table also shows which question types are used in each deck:

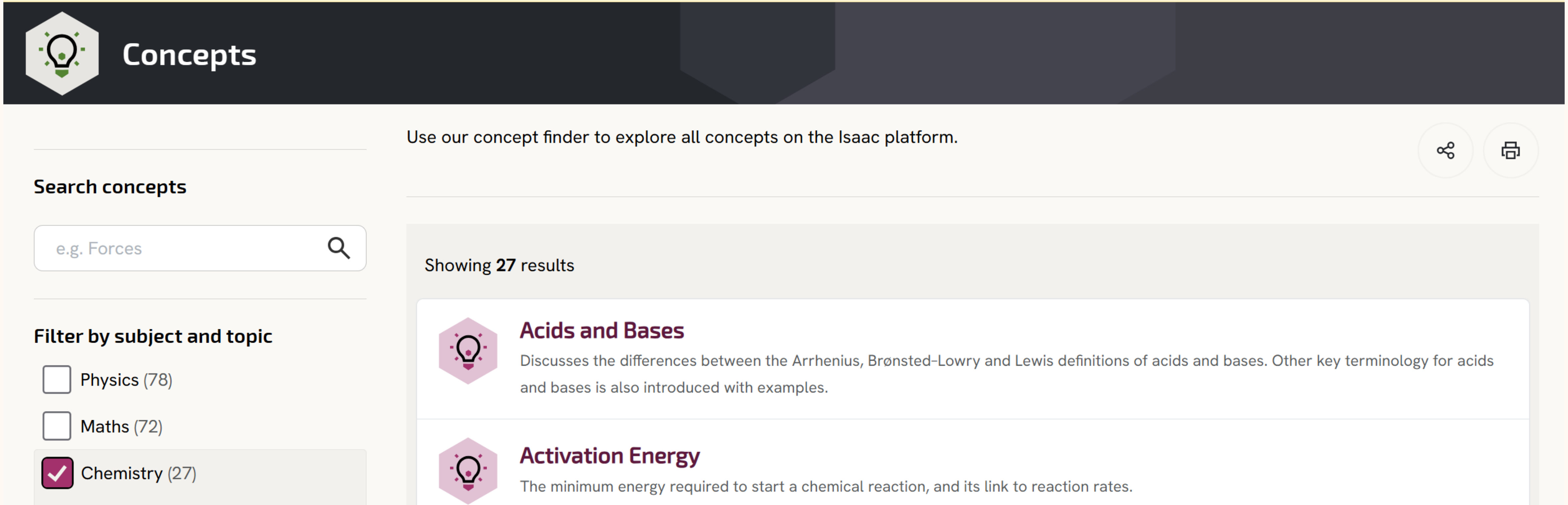
- **Quick**: show/hide the answer (not marked)
- **MCQ**: multiple-choice
- 1.2 **Numeric**: enter a number (with or without units)
- x^2 **Symbolic**: enter an algebraic expression
- OH^- **Chemistry**: enter a chemical formula or chemical equation
- abc **Short-answer**: type a word or combination of words
- **Organic**: use the external structure editor to draw a structure and generate a SMILES string, then copy into Isaac for checking
- **Drag-and-drop**: drag pre-loaded options into gaps in text or a table

Stoichiometry and Inorganic Chemistry >

Physical Chemistry >

Organic Chemistry and Spectroscopy >

Concept pages



Glossary

A Level Chemistry >

A Level Chemistry Glossary

Use our glossary to find definitions of important words and phrases.

Search glossary

e.g. Bond

Switch learning stage

GCSE

A Level

University

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

A	Addition	A reaction where two or more starting materials combine to form one larger product.
	Alicyclic	An organic compound containing at least one non-aromatic ring.
	Aliphatic	An organic compound containing no aromatic rings.
	Allotrope	A specific form of a chemical element, with atoms bonded together in a particular way. For example, graphite and diamond are two different allotropes of carbon.
	Aromatic	An organic compound containing at least one aromatic ring (often a benzene ring).

Tests

A Level Chemistry >

Practice tests

This page lists tests you can take whenever you'd like to practise your skills and check your understanding.

Search practice tests

e.g. Practice

You can see all of the tests that you have in progress or have completed in your My Isaac:

My tests →

- Chemistry Admissions Practice 1 — View test
- Chemistry Admissions Practice 2 — View test
- Chemistry Admissions Practice 3 — View test
- Chemistry Admissions Practice 4 — View test
- Chemistry Admissions Practice 5 — View test
- Chemistry Admissions Practice 6 — View test

Core skills practice tools

A Level Chemistry >

Core skills practice

Select stage

GCSE

A Level

These are new tools and are still under development. *We encourage you to try them out, and give us your feedback! However, please note that there may be bugs, and the difficulty levels of the questions may change before the final versions are released.*

Below you can see the list of tools available for practising different chemistry skills. Click on the buttons to access particular tools.

Atomic structure

Using the periodic table

Number of protons, neutrons and electrons

Calculations

Mole calculations

Titration calculations

Buffer calculations

Organic chemistry and spectroscopy

Functional group recognition

Counting environments in NMR

Atomic structure practice tool

Generate new question

Enter the integers missing in the table below as numbers:

isotope	number of protons	number of neutrons	number of electrons
${}^{75}_{33}As^{3-}$			

Check answers

Created by Andrea Chlebikova

Tools to practise chemistry calculations

Hide menu

- [x] include mass-based calculations
- [x] include solution calculations
- [x] include gas-phase calculations

Generate new question

What is the minimum mass, in grams, of $CaCO_3$ that needs to be used to produce 23 grams of CaO in the following reaction?

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

g

check

Created by Andrea Chlebikova

I would like some help

Show menu

Generate new question

A student uses the method of titration to measure the concentration of sulfuric acid. Using a volumetric pipette, the student transfers $25.0\ \mathrm{cm}^3$ of the acid solution to a conical flask containing an indicator, and fills a burette with a standard $0.187\ \mathrm{mol\ dm}^{-3}$ solution of sodium hydroxide.

The student adds the base from the burette until the end point is reached. After repeating the procedure to obtain concordant titres, the student calculates a mean titre of $43.45\ \mathrm{cm}^3$.

Calculate the concentration of the sulfuric acid solution.

$\mathrm{mol\ dm}^{-3}$

check

I would like some more help

Relevant formula: $n = cV$

Start by calculating the amount, in moles, of sodium hydroxide in the $43.45\ \mathrm{cm}^3$ titre.

Created by Andrea Chlebikova

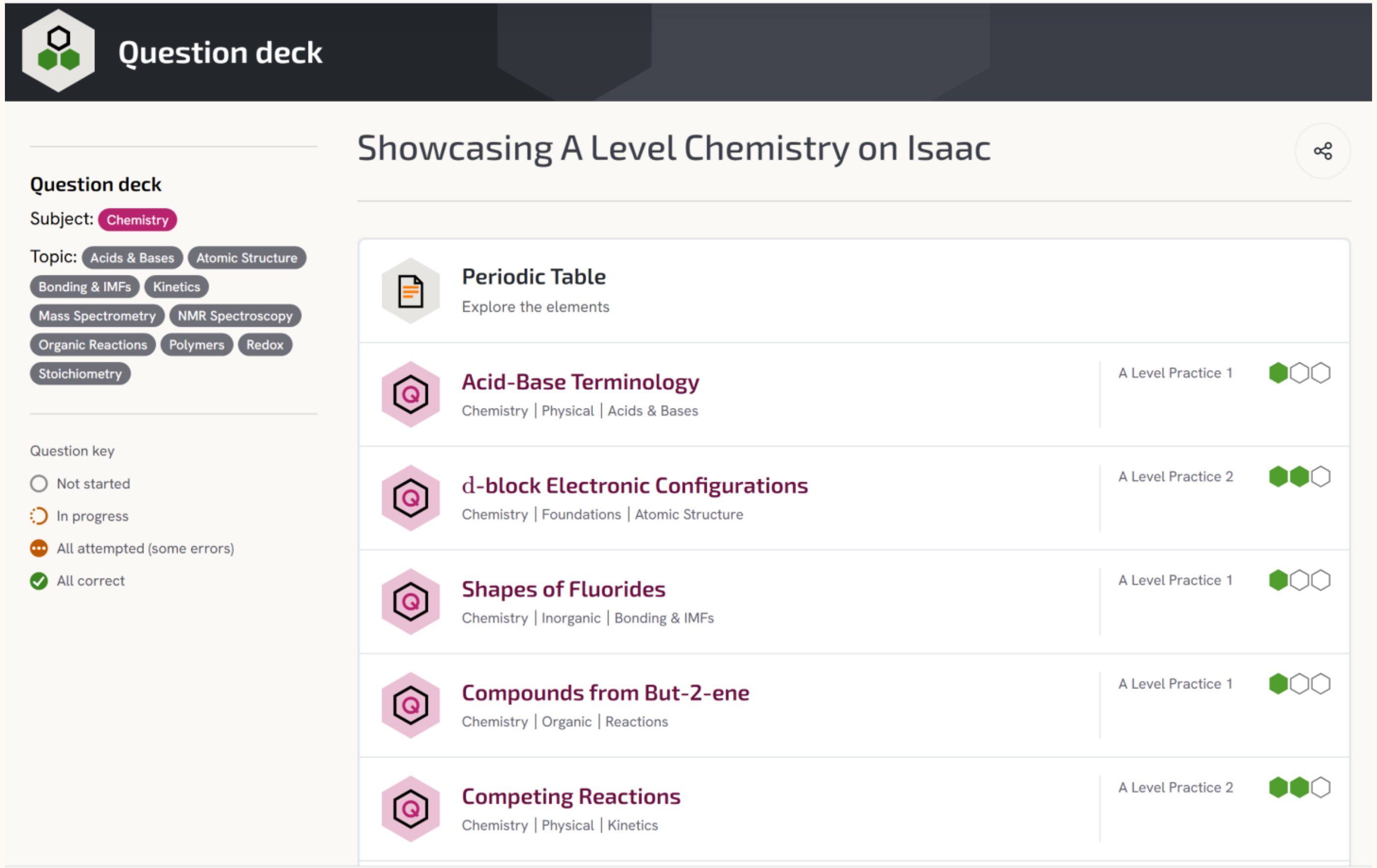
PART-CALCULATION QUESTION

mol

check

Looking at some questions

- Showcasing Isaac Chemistry: https://isaacscience.org/question_decks#isaac_chem_sample



Looking at some questions

Acid-Base Terminology

Subject & topics

Chemistry | Physical | Acids & Bases

Status

Not started

Stage & difficulty

A Level Practice 1

The terminology surrounding acids and bases can be a bit confusing. Answer the questions below to test your understanding of this topic.

Part A

Fully dissociated

What do we call an acid or base that fully dissociates in aqueous solution?

Type your answer here.

Check my answer

Part B

High $\mathrm{mol\,dm^{-3}}$

Part C

Low $\mathrm{mol\,dm^{-3}}$

Part D

Acidic solutions

An acid with a very high K_a value is a ____ acid, but it can still be ____ if we create a solution of it with large amounts of water. At the same concentration, a ____ acid will have a lower pH than a ____ acid.

Items:

strong | weak | concentrated | dilute

d-block Electronic Configurations

Subject & topics

Chemistry | Foundations | Atomic Structure

Status

Not started

Stage & difficulty

A Level Practice 2

Part A

$\mathrm{Cr^{3+}}$

Chromium (atomic number 24) is a d-block element. Its compounds are useful reagents in the laboratory.

Using s, p and d notation for electron energy levels, write the electronic configuration of the $\mathrm{Cr^{3+}}$ ion.

Items:

[Ne] [Ar] [Kr] s p d 1 2 3 ^{1} ^{2} ^{3} ^{4} ^{5} ^{6}

Check my answer

Need some help?

Periodic table

Part B

$\mathrm{V^{2+}}$

Which of the following electronic structures corresponds to the $\mathrm{V^{2+}}$ ion?

- $\mathrm{[Ar]\ 3d^3}$
- $\mathrm{[Ar]\ 3d^2\ 4s^1}$

Looking at some questions and concepts

Shapes of Fluorides

Subject & topics

Chemistry | Inorganic | Bonding & IMFs

Status

Not started

Stage & difficulty

A Level Practice 1

For each of the following, enter a one to two word answer, using appropriate shape of molecule terminology, e.g. "linear".

Part A

BF_3

Describe the shape of BF_3.

Type your answer here.

Check my answer

Need some help?

Hint 1

Concepts

Shapes of molecules

Part B

CF_4

Part C

NF_3

Part D

SF_6

Shapes of Molecules

Valence Shell Electron Pair Repulsion theory

The shapes of molecules can be determined using Valence Shell Electron Pair Repulsion (VSEPR) theory which states that pairs of electrons in the valence shell of the central atom will be arranged as far apart as possible to minimise repulsion between them.

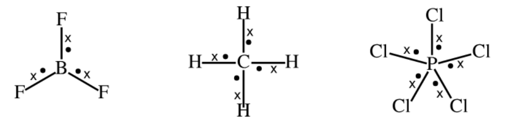
A Level

A Level

Step 1: determine number of electron pairs

First we need to find the number of electron pairs (or the number of areas of electron density) around the central atom, by accounting for all the valence electrons.

Each **single bond** from the central atom uses **one of its valence electrons**. The other electron in the bond is assumed to come from the atom it is bonded to. Therefore any **single bond** counts as **one electron pair**.



BF_3	CH_4	PCl_5
3 valence electrons from B	4 valence electrons from C	5 valence electrons from P
3 x B-F bonds	4 x C-H bonds	5 x P-Cl bonds
= 3 electron pairs	**= 4 electron pairs**	**= 5 electron pairs**

Figure 1: Structures of BF_3, CH_4 and PCl_5

Note that the **octet rule is not necessarily obeyed** in this model! Remember to include any contribution from overall charge on the molecule to the number of valence electrons.

Any unused electrons contribute to **non-bonding lone pairs**.

Looking at some questions

Shapes of Fluorides

Question

Subject & topics

Chemistry | Inorganic | Bonding & IMFs

Status

Not started

Stage & difficulty

A Level Practice 1

For each of the following, enter a one to two word answer, using appropriate shape of molecule terminology, e.g. "linear".

Part A

BF_3

Describe the shape of BF_3.

Type your answer here.

Check my answer

Need some help?

Hint 1

Concepts

Shapes of molecules

Part B

CF_4

Part C

NF_3

Part D

SF_6

Shapes of Molecules

Concept

Valence Shell Electron Pair Repulsion theory

The shapes of molecules can be determined using Valence Sh ... ates that pairs of electrons in the valence shell of the central atom will be arranged as far apart as possible to minimise repulsion between them.

A Level

A Level

Step 1: determine number of electron pairs

First we need to find the number of electron pairs (or the number of areas of electron density) around the central atom, by accounting for all the valence electrons.

Each **single bond** from the central atom uses **one of its valence electrons**. The other electron in the bond is assumed to come from the atom it is bonded to. Therefore any **single bond** counts as **one electron pair**.

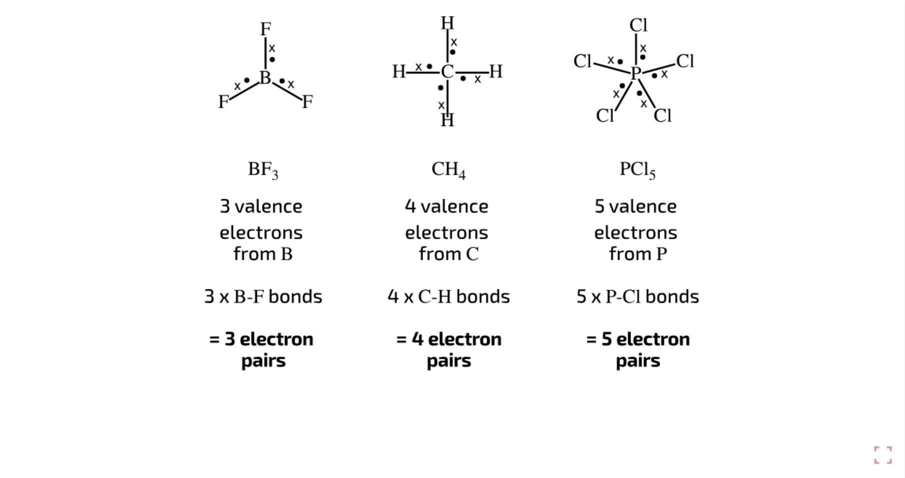


Figure 1: Structures of BF_3, CH_4 and PCl_5

Note that the **octet rule is not necessarily obeyed** in this model! Remember to include any contribution from overall charge on the molecule to the number of valence electrons.

Any unused electrons contribute to **non-bonding lone pairs**.

Looking at some organic questions

Compounds from But-2-ene

Subject & topics
Chemistry | Organic | Reactions

Status
Not started

Stage & difficulty
A Level Practice 1

Complete the reaction scheme shown below which starts with but-2-ene. In each of the boxes **A** to **D** give the principal organic product or intermediate compound.

Use the structure editor to generate a SMILES string.

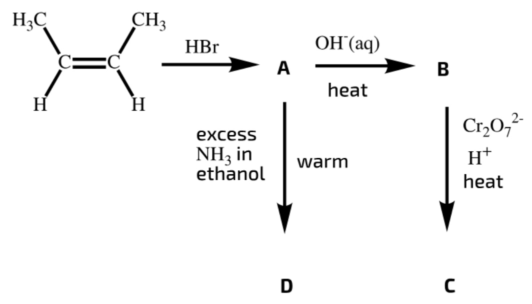


Figure 1: Compounds from but-2-ene

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

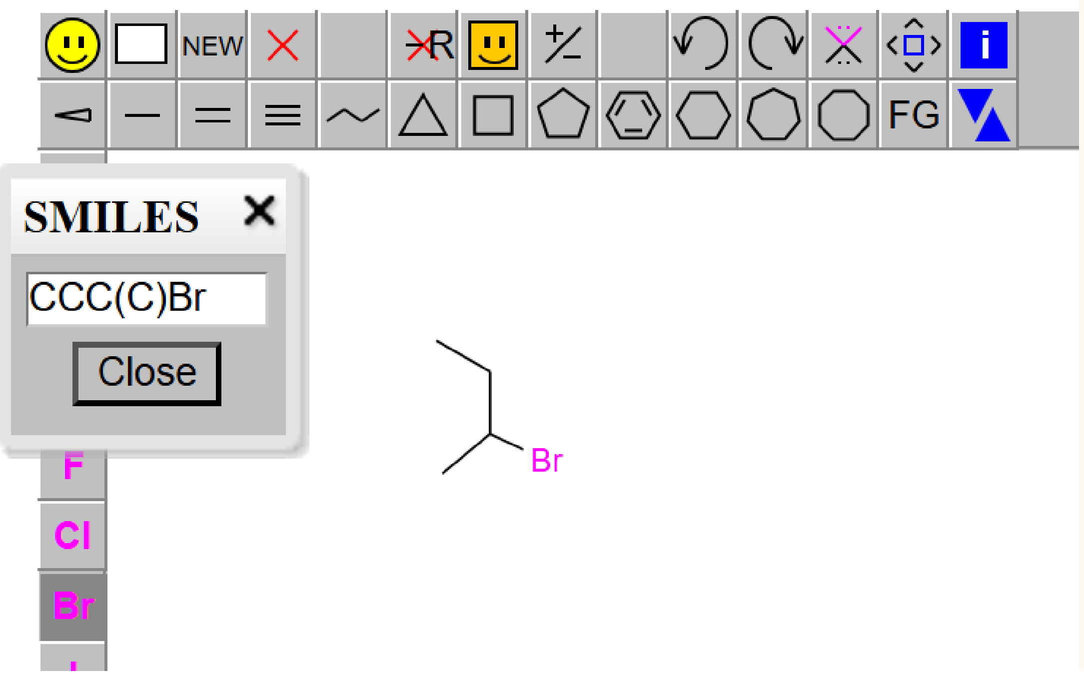
Using the structure editor

Part A
A

A is:

Type your answer here.

https://jsme-editor.github.io/dist/JSME_test.html



A is:

CCC(C)Br

Correct!

Looking at some more questions

Titrating Sulfur Dioxide

Subject & topics: Chemistry | Foundations | Stoichiometry

Status: Not started

Stage & difficulty: A Level Practice 2

Sulfur dioxide is a by-product of the combustion of coal in power stations. It can react with oxygen and water vapour in the air to form sulfuric acid, H_2SO_4. This is one of the causes of acid rain.

The amount of sulfur dioxide in the air may be determined by bubbling a sample of the air through sodium hydroxide solution, where it reacts according to the equation below:

$$SO_2\,(g) + 2\,NaOH\,(aq) \longrightarrow Na_2SO_3\,(aq) + H_2O\,(l)$$

The concentration of the unreacted sodium hydroxide can be determined by titration against a standard solution of hydrochloric acid.

$1000\ dm^3$ of air were bubbled through $200\ cm^3$ of a $1.00\ mol\,dm^{-3}$ solution of sodium hydroxide. The remaining solution was diluted to $1000\ cm^3$ with water, and $25.0\ cm^3$ of this solution was neutralised by $20.4\ cm^3$ of a $0.100\ mol\,dm^{-3}$ solution of hydrochloric acid.

Part A

H_2SO_4 formation

Construct an overall equation for the formation of sulfuric acid from sulfur dioxide (do not include state symbols). Balance it so as to use the smallest possible integer coefficients.

Click to enter your answer

Check my answer

Part B

Neutralisation reaction

Part C

Unreacted moles

Part C

Unreacted moles

Find the amount, in moles, of unreacted sodium hydroxide.

Value | Unit: mol

What can I type in this box?

Check my answer

Part D

Sulfur dioxide moles

Find the amount, in moles, of sulfur dioxide in $1000\ dm^3$ of air.

Value | Unit: mol

What can I type in this box?

Check my answer

Part E

Percentage by volume

Hence calculate the percentage by volume of sulfur dioxide in air. (You may assume $1\ mol$ of any gas occupies $24\ dm^3$ at this temperature and pressure.)

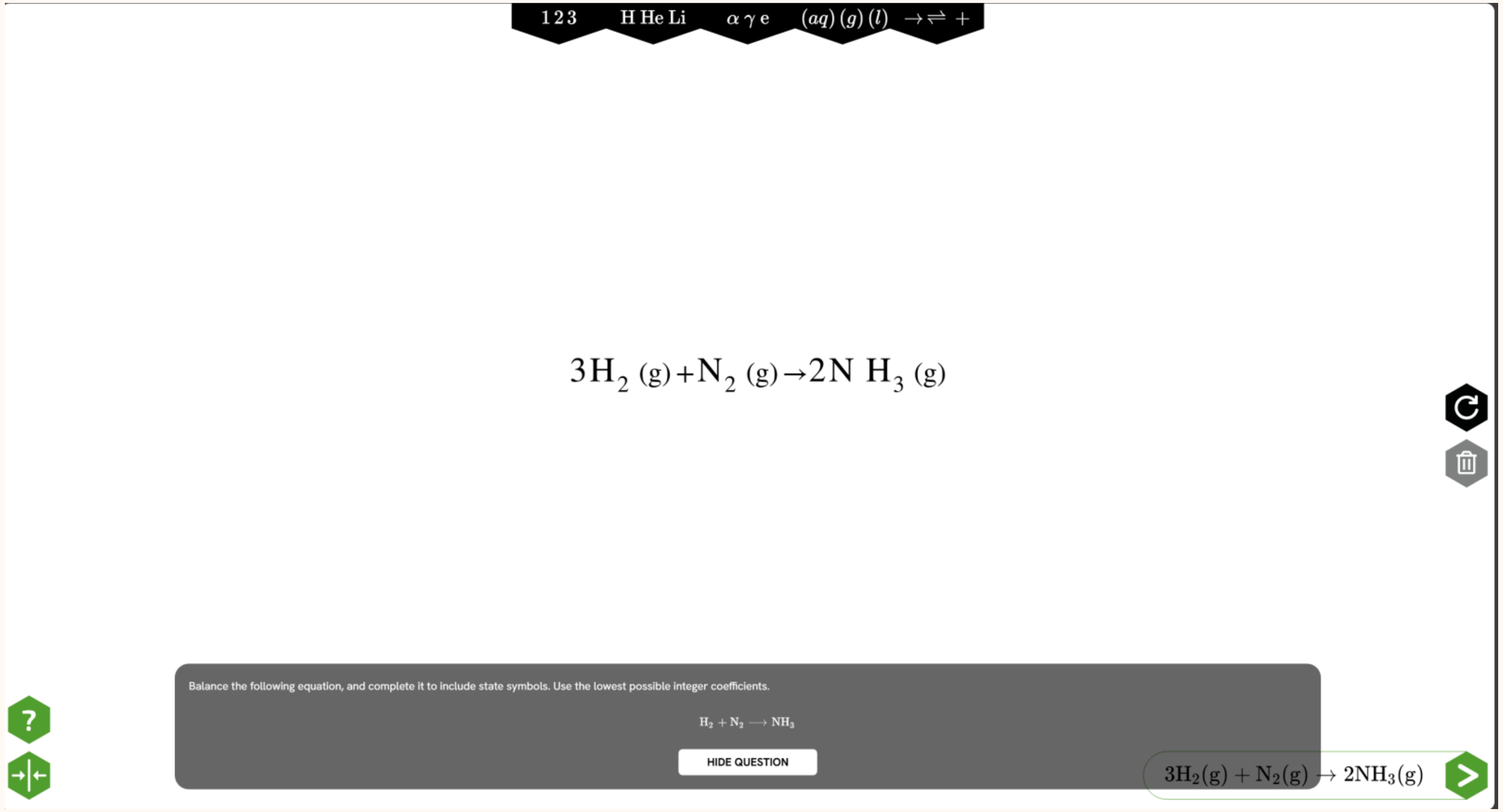
Value | Unit: %

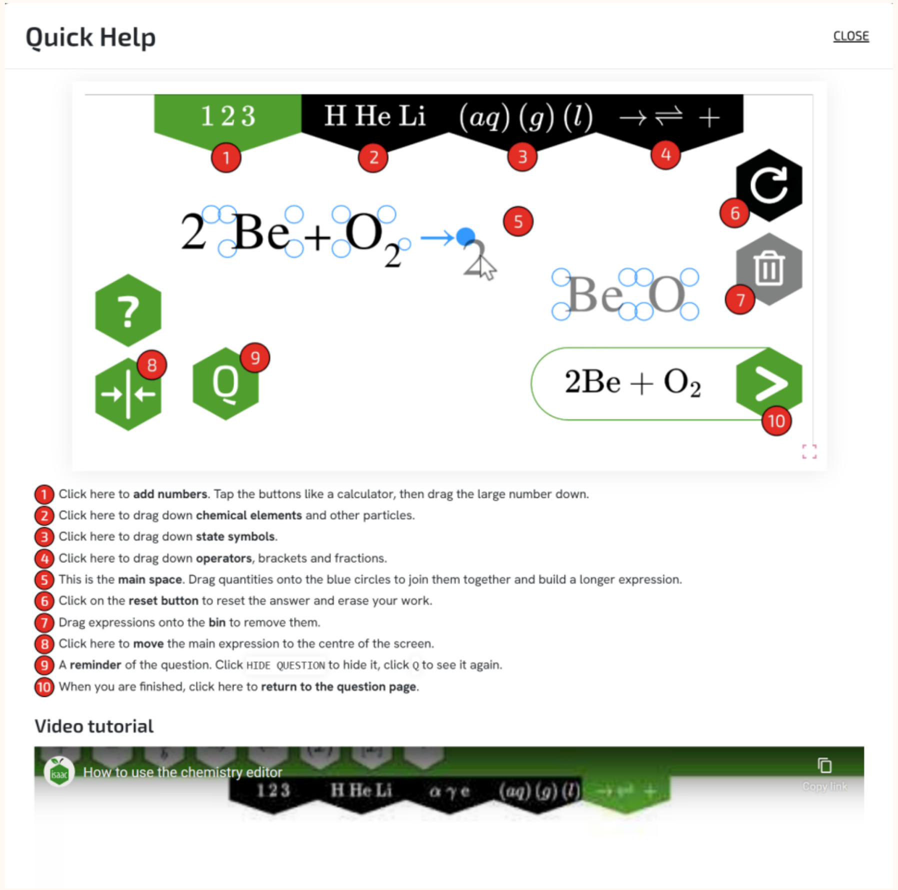
What can I type in this box?

Isaac Chemistry editor

https://isaacscience.org/questions/ch_editor_1

https://isaacscience.org/questions/ch_editor_2





Isaac Chemistry content is expanding

- More core skills practice tools, concept pages and glossary entries

A. Atomic Structure

Progress in our knowledge of atomic structure over the last two centuries has allowed us to explain chemical observations and understand the chemical behaviour of many substances from first principles.

When students are first introduced to the model of the atom, they will be thinking about the components as particles: **protons** and **neutrons** (together commonly known as **nucleons**) at the centre of the atom in the **nucleus**, with **electrons** around it. In a neutral atom, the number of protons matches the number of electrons, and ions are formed by the gain or loss of electrons, giving negatively-charged anions and positively-charged cations respectively.

In early models, the electrons are often presented as spheres orbiting the nucleus, and for some purposes this model is useful, but for a better understanding, **quantum mechanics** is required. Instead of orbiting the nucleus, electrons exist in electron clouds in the atom, and their behaviour cannot be fully understood by thinking of them as classical particles. They can be described by **wavefunctions**, which in this context are more commonly known as atomic **orbitals**. While at A Level, orbitals are often presented as regions of space, in fact these wavefunctions describe the probability distribution of electrons: where the magnitude of the wavefunction is higher, the probability density is higher. This wavefunction understanding is also useful for making sense of bonding: when atomic orbitals overlap, they give rise to molecular orbitals (see Bonding chapter).

Atomic orbitals for a hydrogen atom can be found mathematically in essentially exact form. For other atoms, we often think of the atomic orbitals as scaled versions of the hydrogen orbitals. In hydrogen itself, the energy of the orbitals only depends on the shell number or, as we should properly call it, the **principal quantum number**, n.

However, in other atoms, electrons repel one another, resulting in shielding. We introduce the idea of an **effective nuclear charge**, Z_{eff} which is experienced by an electron in an atom. It is calculated by subtracting a shielding term, s from the actual nuclear charge Z. Electrons close to the nucleus experience almost the full nuclear charge, while the outer electrons are quite effectively shielded by those in lower shells.

- GCSE content (also suitable for KS3)
- Book collating A Level questions
- What would you most like to see?