Multi-topic questions in GCSE Chemistry

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Questions covering material from more than one topic (teachers call them **synoptic** questions) are designed to truly stretch your knowledge and understanding of the GCSE course.

As these are tough questions, they will normally appear towards the end of the exam paper. Multi-topic questions may be challenging, but they **can** be done by following a few simple steps.

5-step method for multi-topic questions

Step 1 – read
Read the entire question carefully. Information that appears further down the page may give you a clue as to how best to tackle an earlier part of the question.

Step 2 – breathe
Take a moment to let your mind absorb the information which you've just read, and relax. You've watched My GCSE Science videos, completed the exam-style questions and tackled some past papers. You're in a strong position – this what you've prepared for.

Step 3 – highlight
Pay close attention to any key words and phrases which appear. Highlight them if you wish. Which topic(s) do they 'belong' to?

Step 4 – equations
If you've been asked to calculate something, which equations from the topics which you've just identified might you be able to use? Simply writing down the correct equation(s) could get you a mark or two, depending on the mark scheme.

Step 5 – attempt
Even if you're not sure how to answer the entire question, attempt as much of it as you can. As well as maximising your score, correctly answering part of the question may give you a clue how to deal with the rest of it.

EXAMPLE.

Titanium is a transition metal.
Titanium is extracted from titanium dioxide in a two stage industrial process.

Stage 1: $TiO_2 + 2\ C + 2\ Cl_2 \rightarrow TiCl_4 + 2\ CO$
Stage 2: $TiCl_4 + 4\ Na \rightarrow Ti + 4\ NaCl$

a) Suggest **one** hazard associated with **Stage 1**. [1]

b) Water must be kept away from the reaction in **Stage 2**.
Give **one** reason why it would be hazardous if water came into contact with sodium. [1]

c) Suggest why the reaction in **Stage 2** is carried out in an atmosphere of argon and **not** in air. [2]

d) Titanium chloride is a liquid at room temperature.
Explain why you would **not** expect titanium chloride to be a liquid at room temperature. [3]

e) In Stage 2, 40 kg of titanium chloride was added to 20 kg of sodium.
The equation for the reaction is:

$TiCl_4 + 4\ Na \rightarrow Ti + 4\ NaCl$

Relative atomic masses (Ar): Na = 23 Cl = 35.5 Ti = 48

Explain why titanium chloride is the limiting reactant.
You **must** show your working.

Use the 5-step method

Before you attempt this question, take another look through the 5-step method shown above. Have you read the entire question carefully and highlighted any key words or phrases? Do you know which topics the question is testing, and which equations you might have to use?

You'll have noticed that in Stage 1, one of the reactants (chlorine gas) is a toxic and one of the products (carbon monoxide gas) is also toxic. These gases are covered in the **Group 7 (Halogens)** and the **atmospheric pollutants** topics.

Either gas would be allowed as an answer:

a) Chlorine (Cl_2) or carbon monoxide (CO) is **toxic** or **poisonous** [1]

In the next part of the question, you are expected to recall the reactions of **Group 1 metals** with water. Any of the following would be accepted for one mark.

b) Very exothermic / explosive / violent reaction
Produces a corrosive solution
Produces hydrogen which is explosive / flammable

Part c) involves comparing an atmosphere of argon (a **noble gas** or **Group 0 element**) to an atmosphere of air. You have learned about this in the **Earth's atmosphere** topic.

c) Argon is unreactive / inert / will not react with the reactants or products [1]
Oxygen / water vapour (from the air) would react with sodium or titanium [1]

The next part of the question does not involve the reaction at all. So even if you don't understand the reaction taking place, or you didn't get the answers to the first three questions, there's still all to play for here. However, that's not to say part d) is easy. In fact, less than 8% of students got full marks on it in 2018!

The question states that the $TiCl_4$ is a liquid at room temperature, but asks you why you should **not** expect it to be a liquid. This was tricky and counter-intuitive to many students.

Part d) is a question about **structure and bonding**, and expects you to notice that titanium chloride is a compound made from a metal and a non-metal, and therefore ***should*** be an ionic compound [1], which ***should*** be a solid at room temperature (or have a high melting point) [1] as there are strong bonds between the ions [1].

An alternative approach (which is the flipside to the answer above) would be to say that if titanium chloride is a liquid at room temperature, it must be a small (covalent) molecule [1], with weak forces between molecules [1], but metal chlorides are usually ionic [1].

In the final part of the question, you are asked to carry out an **unstructured moles calculation** about **limiting reactants**. This was a new part of the 9-1 spec for 2018. Unstructured calculations are hard because you are expected to carry out several steps in order without being prompted. While you are often given full credit just for the correct answer, it's very important that you write down every step of your work so that you gain credit even if you miss a step or make a mistake with your calculator.

For any question about limiting reactants, the key is to find out how many moles are in the reaction from the masses given, and compare this to the moles ratio in the balanced equation. The limiting reactant is the one that would get completely used up: this means that there will be some of the other reactant left over.

e) (Mr of $TiCl_4$ =) **190**
(moles of Na = 20 000 / 23 =) **870** moles (0.870 if kg not converted to g)
(moles of $TiCl_4$ = 40 000 / 190 =) **211** moles (0.211 if kg not converted to g)

$TiCl_4 + 4\ Na \rightarrow Ti + 4\ NaCl$

The equation shows that TiCl4 reacts with Na in a 1:4 ratio, so there should be 4 times as many moles of Na as $TiCl_4$.

211 x 4 = 844 moles
870 moles of Na is more than the 844 needed to fully react with the $TiCl_4$.
Therefore the $TiCl_4$ is the limiting reactant.

or 870 / 4 = 217.5 moles
211 is less than 217.5 so there is not enough $TiCl_4$ to fully react with the sodium in the reaction.

Well done!

This is a really challenging question, covering different aspects of the course. But if you follow our 5-step method of approaching the question thoughtfully and then break the question down into smaller parts then **you *can* do it**!

Well done on getting this far. Take a quick break and then check through the specimen and past paper questions, available on the exam board's website. Can you spot any multi-topic questions? Give them a go, using the 5-step method above, before checking your answers using the mark scheme. Good luck!