**How to...survive a seemingly impossible OCR chemistry question in your exam.**

**Step 1: What topic is the question about? Scan the question and decide which topic area the question relates to. Here is the question.**

"The 'magic tang' in many sweets is obtained by use of acidic buffers. A sweet manufacturer carried out tasting tests with consumers and identified the acid taste that gives the 'magic tang' to a sweet. The manufacturer was convinced that the 'magic tang' would give the company a competitive edge and he asked the company's chemists to identify the chemicals needed to generate the required taste. The chemists' findings would be a key factor in the success of the sweets.”

**What have we learnt from scanning this paragraph?**

The question is about the topic “Acids, bases and buffers”. This is really all we have learned – the rest is just setting the scene for the question and is not really important.

**What do you do next?**

Think about the key equations you have learnt in this topic. Jot them down.

**pKa = -log10(Ka) so Ka = 10-pKa = [H+][A-]/[HA] pH = -log10 [H+] so [H+] = 10-pH**

**Now you’re well prepared, so let’s carry on reading the question. Underline the data needed to answer the question as you go along:**

“The team of chemists identified that a pH of 3.55 was required and they worked to develop a buffer at this pH. The chemists decided to use one of the acids in Table 4.1 below and a salt of the acid to prepare this buffer. “

|  |  |  |  |
| --- | --- | --- | --- |
| **Common name and source** | **systematic name**  | **Structural formula** | **pKa** |
| benzoic acid (from bark resin) | benzenecarboxylic acid | C6H5COOH | 4.19 |
| acetic acid (from vinegar) | ethanoic acid | CH3COOH | 4.76 |
| pyruvic acid (formed during metabolism) | 2-oxopropanoic acid | CH3COCOOH | 2.39 |
| lactic acid (from milk) | 2-hydroxypropanoic acid | CH3CH(OH)COOH | 3.86 |

**Write down the information you will definitely need:**

**pH = 3.55**

**pKa (C6H5COOH) = 4.19, pKa (CH3COOH) = 4.76, pKa (CH3COCOOH) = 2.39, pKa (CH3CH(OH)COOH) = 3.86**

**Can you use your equations to work out any more information?**

**Yes! You can work out the concentration of hydrogen ions in the buffer solution easily.**

**[H+] = 10-pH  and pH = 3.55 so [H+] = 10-3.55 = 0.000282 moldm-3**

**You can also easily calculate the Ka of each of the acids using Ka = 10-pKa**

## pKa (C6H5COOH) = 4.19 so Ka = 10-4.19 = 6.46 × 10-5

## pKa (CH3COOH) = 4.76 so Ka = 10-4.76 = 1.74 × 10-5

## pKa (CH3COCOOH) = 2.39 so Ka = 10-2.39 = 4.07 x 10-3

## pKa (CH3CH(OH)COOH) = 3.86 so Ka = 10-3.86 = 1.38 x 10-4

## You also have the equation: Ka = [H+][A-]/[HA] and you now know Ka and [H+] for all the acids.

## You just need to find [A-] and [HA].

**Read first part of the actual question.**

* Deduce the chemicals required by the chemists to prepare this buffer.

**The Answer**

You could technically use any of the acids in the table to prepare a buffer solution. You just need a solution of the acid and its salt e.g. benzoic acid (benzenecarboxylic acid) and sodium benzoate, acetic acid (ethanoic acid) and sodium acetate (sodium ethanoate), pyruvic acid (2-oxopropanoic acid) and sodium pyruvate (sodium 2-oxopropanoate) or lactic acid (2-hydroxypropanoic acid) and sodium lactate (sodium 2-hydroxypropanoate).

However, it is best to choose a buffer that has a pKa close to the pH of the buffer. Remember the pH of the buffer is 3.55 and there are other things to think about in real life, such as not being toxic. We can therefore assume that the question wants us to use lactic acid and sodium lactate to prepare the buffer as it fits both of these criteria.

**Read the second part of the actual question.**

* Calculate the relative concentrations of the acid and its salt needed by the chemist to make this buffer.

**The Answer**

As these are weak acids, we assume that the concentration of the acid is equal to [HA] as weak acids do not significantly dissociate into ions. The concentration of the salt is equal to [A-].

Use the equation Ka = [H+][A-]/[HA] rearrange to form Ka/[H+] = [A-]/[HA] and put in the values you know.

For lactic acid, Ka = 10-3.86 = 0.000138 and [H+] = 10-3.55 = 0.000282 moldm-3

## So [A-]/[HA] = 0.000138 / 0.000282 = 0.489

## Any sensible concentrations which give this ratio are acceptable e.g. 0.14 moldm-3 sodium lactate and 0.28 moldm-3 lactic acid, or indeed 1 moldm-3 sodium lactate and 2 moldm-3 lactic acid. Notice the underlined term “relative” in the question, which should have given you a clue! The mark scheme was generous with rounding errors and significant figures throughout.

**Read the third part of the actual question.**

* Comment on the validity of the prediction that the pH of the sweet would give the sweets the 'magic tang'.”

**The Answer**

This question, in my opinion, is not part of the chemistry course and is totally subjective, and has caused a bit of controversy on internet forums and many complaints to OCR. Nonetheless, a common sense approach is all that’s needed. It was worth only one mark.

The tang or taste of the sweet could come from the buffer, (so that the buffer would have the same tang as the sweet) or from other chemical in the sweet. We do not know the other ingredients so we cannot comment further on this.

**Further comments**

There were three pages of notes on the mark scheme on how to mark this question, with many possible alternatives. The error carried forward marks (4 marks out of 6) were for remembering the equations and putting in the values – which was actually a fairly simple process. A shame it was dressed up in so difficult a scenario!

Following the above approach can help you answer other odd questions in chemistry exams. To summarise:

Scan 🡪 Topic? 🡪 Equations known from this topic 🡪 Underline data relevant to question 🡪 Calculate other data using known equations 🡪 Read actual question 🡪 Use data to answer question 🡪 Write a common sense answer if the question requires it.

Good luck with your summer exams!