COLLATED QUESTIONS – ACIDS, BASES AND SALTS
ANSWERS

2014:1 BALLOONS

(c) Write a word equation AND a balanced symbol equation for the reaction between calcium carbonate and hydrochloric acid.
Word equation: Hydrochloric acid + calcium carbonate → calcium chloride + carbon dioxide + water.
Balanced symbol equation: $2HCl + CaCO_3 \rightarrow CaCl_2 + CO_2 + H_2O$

2014:3 Indicators and pH

A student has three unlabelled beakers each containing a colourless liquid. One contains **water**, one contains a solution of baking soda (**sodium hydrogen carbonate**), and one contains white vinegar (a solution of **ethanoic acid**).
To work out which liquid is which, the student put a drop from each beaker onto a piece of blue litmus paper and a piece of red litmus paper. She then added universal indicator to each beaker.
The following results were obtained:

	Colour of blue litmus paper	Colour of red litmus paper	Colour with universal indicator	Name of liquid
Beaker 1	stays blue	stays red	turns green	water
Beaker 2	turns red	stays red	turns orange	vinegar
Beaker 3	stays blue	turns blue	turns blue	baking soda

(a) Complete the last column of the table above to identify the three liquids.

(b) Use the information in the table to show how each of the liquids can be identified.
In your answer you should:
- use all of the observations for each beaker
- state the approximate pH from the colour of the universal indicator.

Beaker 1 = water. The green colour of the universal indicator indicates that this solution has a pH of 7 and therefore is neutral. The fact that both litmus papers stay the same colour also indicates that the liquid is neutral and has a pH of seven, and therefore Beaker 1 must be water.
Beaker 2 = vinegar. The orange colour of the universal indicator indicates that the solution is acidic and has a pH of 4–5. Because the blue litmus turns red, this also indicates that the solution is acidic, and therefore Beaker 2 must be vinegar (ethanoic acid)
Beaker 3 = baking soda. The blue colour of the universal indicator indicates that the liquid is basic and has a pH of 9–10. Because the red litmus turns blue, this also indicates that the liquid is basic, and therefore Beaker 3 must be basic, as baking soda (sodium hydrogen carbonate) is basic.

(c) Another student was given two beakers (Beaker 4 and Beaker 5) each containing different liquids. The liquid in Beaker 4 had a pH of 1. The liquid in Beaker 5 had a pH of 6. Discuss which liquid is more acidic and how you know this.
In your answer you should:
- use the pH to determine which liquid is more acidic
- compare the amount of hydrogen ions AND hydroxide ions in Beaker 4 (pH 1) with the amount of hydrogen ions AND hydroxide ions in Beaker 5 (pH 6).

Beaker with a pH of one is more acidic. In both solutions there are an excess of hydrogen ions compared to hydroxide ions, but in the solution with a lower pH the number of hydrogen ions is much more in excess compared to hydroxide ions; whereas when the pH is 6 the hydrogen ions are still in excess but not by as much.

2014: 4 ADDING SULFURIC ACID TO SODIUM HYDROXIDE

A beaker contains sodium hydroxide solution and 5 drops of universal indicator.
Sulfuric acid was added to the beaker until no more changes were observed.

(a) Write a word equation AND a balanced symbol equation for the reaction between sulfuric acid and sodium hydroxide.
Word equation: Sulfuric acid + sodium hydroxide → sodium sulfate + water
Balanced symbol equation: $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

(b) Describe how the indicator colour changes as the sulfuric acid is added to the beaker, AND explain what this tells you about the changing pH of this solution.

(c) Explain the relationship between the changing **pH** of the solution and the **ions** in the solution as the sulfuric acid is added to the beaker.

Explanations (b) and (c)
The solution would be purple to start with, as the pH would be 13–14. The pH would be high, as there are a high number of OH^- ions present. At this stage OH^- ions are in excess when compared to H^+ ions. As H_2SO_4 is added, the solution would go blue. At this stage the pH would be 8–12 and OH^- ions are still in excess of H^+ ions, but not by as much as when the solution was purple. When the solution becomes green, the amount of H^+ ions added (from the H_2SO_4) cancel out the OH^- ions from the sodium hydroxide and form water in a neutralisation reaction. At this stage the pH would be 7. As more H_2SO_4 is added, the solution then turns yellow, then orange, and then red. When the solution is yellow or orange, the pH is 3–6 as there are now more H^+ ions present than OH^- ions. When it becomes red, the pH is 1–2, as there are now many more H^+ ions present than OH^- ions.

2013: 2 ACIDS AND BASES

Potassium hydroxide (KOH) was added to a solution of sulfuric acid containing universal indicator until no further change was observed.
The experiment was repeated, but a piece of red litmus paper and a piece of blue litmus paper were each dipped into the solution after each 5 mL of potassium hydroxide was added.
The results of the experiments are shown in the table below.

Volume of KOH added (mL)	Colour of solution with universal indicator	Colour of red litmus paper	Colour of blue litmus paper
0	red	stays red	turns red
5	orange-yellow	stays red	turns red
10	green	stays red	stays blue
15	blue	turns blue	stays blue
20	purple	turns blue	stays blue

(a) Write a word equation AND a balanced symbol equation for the reaction between sulfuric acid and potassium hydroxide.
Sulfuric acid + potassium hydroxide → potassium sulfate + water
$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

(b) Discuss what happened in this reaction as the potassium hydroxide was added to the sulfuric acid.
In your answer you should:
- relate the colours of the solution observed to the acidity and pH of the solution
- explain why the different colours of the solution were produced AND link these colours to the ions present during the reaction.
- explain the advantages of using universal indicator compared to litmus paper.

As the KOH is added, the H_2SO_4 is being neutralised until water is formed, then after that the solution becomes more basic.
When no KOH has been added, the solution is red and has a pH of 1–2 and there is an excess of H^+ ions. As the solution becomes orange-yellow, the pH becomes 4–6. There is still an excess of H^+ ions but not as big an excess as when the pH was lower. When 10 ml has been added and the solution is green, the pH is 7, which is neutral. At this point, the number of H^+ and OH^- ions is equal and they cancel each other out to form water.
After 15 mL has been added and the solution is blue, the pH is 9–12 and there is now an excess of OH^- ions. When 20 mL have been added and the solution is purple, the pH is 13–14 and there is now a greater excess of OH^- ions than when the solution was blue.
Litmus paper is useful to tell us if a solution is acidic, basic or neutral. (When blue litmus turns red and red litmus stays red, this tells us the solution is acidic. When both blue and red litmus papers stay the same, this tells us the solution is neutral. When red turns blue, this tells the solution is basic.) UI however tells us more information and tells us how acidic, basic a solution is or if it is neutral. Litmus is limited as it only tells us if it is acid, basic, or neutral whereas UI tells us how acidic or basic it is.
You don't have to keep dipping / adding UI like you do litmus paper. (UI may be answered for solution or paper.)

2013:4 INVESTIGATING REACTIONS

Experiment One
A student carried out an experiment in the lab using the following method:
Step one: Universal indicator was added to a solution of hydrochloric acid in a beaker.
Step two: Calcium hydroxide was added slowly until the solution turned green.
Step three: The contents of the beaker were then poured into an evaporating dish and left in a sunny place for several days.

(a) Write a scientific aim for this experiment.
The purpose of Experiment 1 is to make the neutral salt, calcium chloride.

(b) Explain the purpose of each step in the method and how the equipment and chemicals used achieve that purpose.
Step one
- Purpose:
- Explanation:

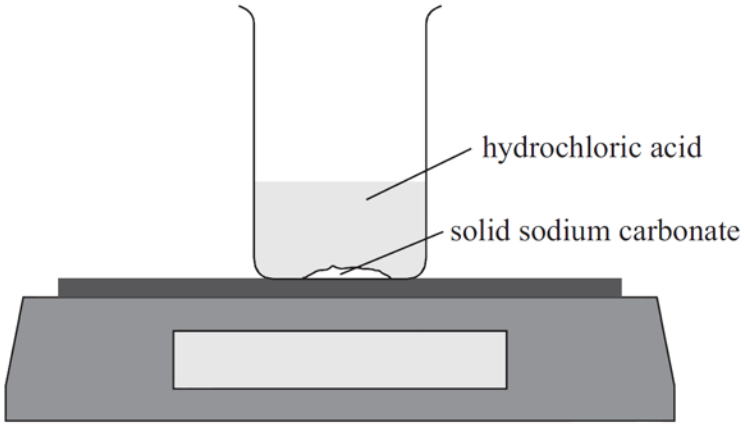
Step two
- Purpose:
- Explanation:

Step three
- Purpose:
- Explanation:

UI is used to check the pH of the solution. Calcium hydroxide is added so that it reacts with HCl to form calcium chloride. It is added until the solution is green so that the solution formed is neutral. The contents are put into an evaporating dish so that the water can evaporate to leave the salt calcium chloride. It is left for a few days to ensure that all the water has evaporated as this process takes time.

Experiment Two

In another experiment the following method was used:
Step one: A beaker was placed on a balance as shown in the diagram below.
Step two: Hydrochloric acid was added to solid sodium carbonate in the beaker.
Step three: The mass was recorded over time.



(c) Write a word equation AND a balanced symbol equation for the reaction between hydrochloric acid and sodium carbonate.

hydrochloric acid + sodium carbonate → sodium chloride + water + carbon dioxide

$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$

(d) Explain why the mass of the beaker and contents would decrease over time.
In your answer you should:

- state any other observations that would be made as hydrochloric acid reacts with the sodium carbonate
- explain how the products formed by the reaction lead to the decrease in mass of the beaker and contents. Fizzing would be observed.

The fizzing observed is due to carbon dioxide gas being released, and therefore because the carbon dioxide gas is leaving the beaker, there is less mass remaining in the beaker and therefore the balance measures less weight.

2012: 2 SALTS

A student wanted to make the neutral salt, sodium nitrate.

(a) Explain how to make sodium nitrate by mixing sodium carbonate and nitric acid solutions using school laboratory equipment (your explanation may use notes and diagrams).

(b) Explain how litmus paper could be used during the process described to show the salt being produced is **neutral**.

(c) Write a word equation AND a balanced symbol equation for the reaction between sodium carbonate and nitric acid.

How to make it

Mix the two solutions together, then take the resulting solution and put it in an evaporating dish. It could be heated using a Bunsen burner or left somewhere warm for a few days. The water would evaporate off leaving behind the neutral salt sodium nitrate.

The solution will be neutral when red and blue litmus papers both stay the same colour. When blue paper changes to red the solution is acidic. When red paper changes to blue the solution is basic.

Word Equation: nitric acid + sodium carbonate → sodium nitrate + water + carbon dioxide.

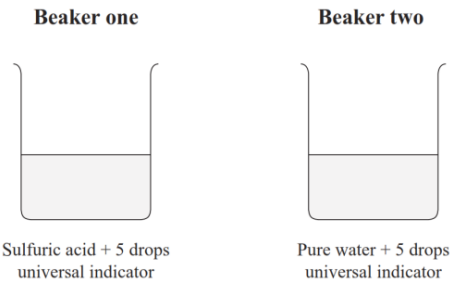
Balanced Equation: $2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$

2012:3 ACIDS AND BASES

Two beakers are shown below. Beaker one contains sulfuric acid solution and 5 drops of universal indicator.

Beaker two contains pure water and 5 drops of universal indicator.

Sodium hydroxide solution was added to both beakers until no more changes were observed.



(a) Write a word equation AND a balanced symbol equation for the reaction between sulfuric acid and sodium hydroxide.

Sulfuric acid + sodium hydroxide → sodium sulfate + water

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

(b) What is the colour of universal indicator in each solution at the start?

(c) Describe the colour changes as sodium hydroxide solution is added to each beaker, AND explain what this tells you about the changing pH of each solution.

(d) Explain the relationship between the pH of the solutions and the ions in the solutions, as the sodium hydroxide is added to each of the beakers.

Beaker one (acid): The solution would be red to start with as the pH would be 1–2. The ions present in solution would be H^+. The pH would be low as there is a high number of H^+ ions present.
As NaOH is added the solution would go orange, then yellow, then green. When the solution is orange and yellow the pH is still less than 7 as there are still more H^+ than OH^- ions. When the solution becomes green the amount of OH^- ions added (from the NaOH) cancel out the H^+ ions from the sulfuric acid and form water in a neutralisation reaction. At this stage the pH would be 7.
As more NaOH is added the solution then becomes blue and then purple. When the solution is blue the pH is 8 -11 as there are now more OH^- ions present than H^+ ions. When it becomes purple the pH is 13 – 14 as there are now many more OH^- ions present than H^+ ions.

Beaker two (water): The solution is green initially as water contains equal numbers of H^+ and OH^- ions and is pH 7. As NaOH is added, the solution would become blue (pH 8 - 11) and then purple (pH 13 – 14). Because the water was neutral to start with, as more OH^- ions are added, the solution becomes more basic as the OH^- ions are immediately in excess.

2011: 3 MAKING A SALT

A student wanted to make the salt, magnesium chloride.
Discuss how the student would make magnesium chloride salt from hydrochloric acid and magnesium oxide.
In your answer you should:

- state what type of reaction occurs
- write a word equation AND a balanced symbol equation for the reaction between hydrochloric acid and magnesium oxide
- explain how you would make magnesium chloride in a school lab from hydrochloric acid and solid magnesium oxide (this can be done by drawing labelled diagrams).
  - Type of reaction:
  - Word equation:
  - Balanced symbol equation
  - Diagrams

Type of reaction: Acid-Base reaction or neutralisation.
Word Equation: hydrochloric acid + magnesium oxide → magnesium chloride + water.
Balanced Equation: $2HCl + MgO \rightarrow MgCl_2 + H_2O$

How to make it
Add magnesium oxide to hydrochloric acid in a beaker. Heat slightly and pour this into an evaporating dish and leave somewhere warm (e.g. window sill) for a few days or heat over Bunsen to speed up the reaction, so that the water can evaporate, leaving magnesium chloride salt. Safe lab procedure would include dealing appropriately with chemicals such as HCl or the wearing of safety glasses.

2011: 4 pH AND INDICATORS

A student put 10 mL of dilute nitric acid in a boiling tube with five drops of universal indicator. Sodium hydroxide of the same concentration was then added. The following observations were recorded.

Amount of sodium hydroxide added (mL)	Colour of solution
0	red
10	green
20	purple

Discuss the reaction occurring as sodium hydroxide is added to the nitric acid.
In your answer you should:

- explain the relationship between the colours observed and the pH of the solution
- explain which ions cause the different colours of the solution
- write a word equation for the reaction AND a balanced symbol equation for the reaction.

Explanations
When the solution is red, the pH is 1–2. The colour is due to a high concentration of H^+ ions.
When the solution is green, the solution is neutral pH 7 and the hydroxide ions have reacted with the hydrogen ions, forming water.
When the solution is purple, the pH is 12–13 and there is a high concentration of hydroxide ions.
Word equation
Nitric acid + sodium hydroxide → sodium nitrate + water
Balanced equation
$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

2011: 3 ACID AND BASE REACTIONS (SAMPLE)

A student puts 5 mL of dilute hydrochloric acid into a boiling tube and adds five drops of universal indicator to the solution. The student then takes a solution of sodium hydroxide of the same concentration as the acid and adds it one drop at a time to the acid until the colour stops changing.

(a) (i) Describe the colour of the universal indicator solution:

- in the hydrochloric acid before any sodium hydroxide was added.
- when the sodium hydroxide was added and the colour of the solution **stopped changing**.

red / pink to start with
blue / purple / violet at end.

(ii) As the sodium hydroxide is added several colour changes occur.
Explain how the colour changes relate to pH AND what ions are present in the solution colour changes.

At the beginning the red indicated a low pH due to excess H^+ ions in the solution.
As the NaOH was added, a yellow/green colour indicates a pH of around 7, due to the OH^- ions combining with the H^+ ions to form a neutral solution.
As more NaOH is added the blue/purple indicated a pH of 11 plus, due to excess OH^- ions in the solution.

(b) The student combines **equal** volumes of nitric acid solution and sodium carbonate solution. Both solutions have the **same concentration**.
Discuss what happens in this reaction. In your answer, you should:

- name the type of reaction involved and the ions involved
- describe what the student would observe
- state the products of the reaction and link these to the observations made
- write a word equation for the reaction
- write a balanced symbol equation for the reaction.

Acid-base (or acid-carbonate) neutralisation (the carbonate ions react with the H^+ ions of the acidic solution and neutralise the solution).
Description of observations:
Bubbling in the solution / fizzing / effervescence / frothing / foaming $CaCO_3$ disappears.
Linking observations to products:
The products are CO_2, H_2O and a salt. The CO_2 gas causes the bubbles / fizzing / etc.
Writing a word equation:
Nitric acid + sodium carbonate → sodium nitrate + water + carbon dioxide
Writing a symbol equation: $2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$

2009: 3 BALANCING IT UP (expired AS90189)
A student reacted zinc oxide with sulfuric acid, and wrote the following incorrect equation to represent the reaction:

$$ZnO_2 + H_2SO_4 \rightarrow 2H_2O + ZnSO_4 + H_2$$

The equation contains THREE errors.
(a) Rewrite the equation so that it is a correctly balanced chemical equation.
$ZnO + H_2SO_4 \rightarrow H_2O + ZnSO_4$

(b) Discuss the reasons for the three changes made to correctly balance the chemical equation.

ZnO_2 changed to ZnO, as ZnO has a one to one ratio because Zn forms Zn^{2+} / ion and oxygen a O^{2-} / ion. H_2 was removed from the equation as hydrogen gas is not a product of an acid + base (metal oxide) reaction. Balanced equations show the same amount / number of atoms on each side so '2' is removed from $2H_2O$ as there are 2 H on the left.

2009: 4 BASE REACTIONS (expired AS90189)
A student carried out an experiment to neutralise sulfuric acid by adding sodium hydroxide to it.
Discuss how the student could have determined when the sulfuric acid had been neutralised and what effect adding the sodium hydroxide has on the pH of the solution.
In your answer include:

- an explanation of neutralisation in terms of an acid-base reaction
- the name of the indicator used
- observations that the student would make as the sodium hydroxide is added to the acid
- a word and balanced chemical equation for the reaction.

$2NaOH + H_2SO4 \rightarrow Na_2SO_4 + 2H_2O$
Neutralisation is when a salt and water are produced because the amount of acid = the amount of base. The NaOH increases the pH towards 7 by cancelling out the acid.
Neutralisation is when the products of the reaction are pH 7 and (as amount of H^+ = the amount of OH^-) the amount of acid equals the amount of base (when pH = 7 = $[H^+][OH^-]$).
At the beginning the solution is red due to the H_2SO_4. At neutralisation it is yellow-green / green due to the Na_2SO_4 and H_2O (no H_2SO_4) present.
Add a few drops of Universal Indicator solution. Monitor colour changes as reaction proceeds: red in acid → yellow-green / green when neutral.

2010: 4 ACID AND HYDROGEN CARBONATE (expired AS90189)
A student reacted dilute sulfuric acid solution with solid sodium hydrogen carbonate.
Discuss the reasons for any observations the student would make for this reaction.
In your answer you should:

- Describe any observations the student would make for this reaction.
- Write a word equation and balanced symbol equation for the reaction of sulfuric acid with sodium hydrogen carbonate.
- Explain how the observations link to the products formed.

Fizzing/ bubbling/gas given off. The fizzing (effervescence) is a result of carbon dioxide being formed.
Sodium hydrogen carbonate disappears / solution becomes clear or colourless. The Na_2SO_4 is soluble, so final solution is clear / colourless.
Sodium hydrogen carbonate + sulfuric acid → sodium sulfate + carbon dioxide + water
$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O + 2CO_2$

2008: 3 (expired AS90189)
An important part of keeping swimming pools safe is to keep the pH of the water balanced in the range 7.0 to 7.6.
Three chemicals used in pools are chlorine compounds (that react with water to produce hydrochloric acid), sodium hydrogen carbonate and aluminium sulfate.
(a) Complete the following table to show the characteristics of the solutions listed in the table below.

Solution	Estimated pH	Colour when tested with Universal indicator
Hydrochloric acid	1	(i)
Sodium hydrogen carbonate	(ii)	blue
Aluminium sulfate	5	(iii)
Water	(iv)	green

Solution	Estimated pH	Colour when tested with Universal indicator
Hydrochloric acid	1	(i) red
Sodium hydrogen carbonate	(ii) 8-12	blue
Aluminium sulfate	5	(iii) yellow / orange
Water	(iv) 7	green

(b) The pool was tested and found to have a pH of 6.5. Sodium hydrogen carbonate was used to raise the pH of the water.

Discuss how sodium hydrogen carbonate raised the pH of the water, and include in your answer a word equation **and** a symbol equation for the reaction of sodium hydrogen carbonate with hydrochloric acid.

Sodium hydrogen carbonate + hydrochloric acid → carbon dioxide + sodium chloride + water

$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

At pH 6.5 the pool water is too acidic so sodium hydrogen carbonate is added to raise the pH back to the ideal region of pH 7 to 7.6 as it is a base and it neutralises the acid.