AS CHEMISTRY

AQA 7404
Y12 Chemistry Course Preparation

Basic skills for the AS level Chemist

Name: ____

Complete this booklet and hand it in during the first Chemistry lesson in September

Chemistry – Y12 Induction

Objectives:

- To give you the skills needed for the successful study of Chemistry at AS and A level.
- To help you identify areas in which you might need help.

There are several areas in which students struggle as AS and A level:

- Use of formulae
- Balancing equations
- Decimal places, significant figures and standard form
- Quantitative and qualitative observations

When you have completed the exercises in this booklet, you need to:

- Correct your own work
- Reflect on your work and complete the following table:

Which exercises I found the easiest and why?
Which exercises I found the hardest and why?
Concerns I have about the AS Chemistry course in Year 12:

GCSE Chemistry Checker Task

You will need a periodic table and a calculator for this quiz:

1 The atomic number tells you the number of:
a) electrons
b) protons
c) neutrons

2 An ion is a particle containing:
a) a different number of neutrons
b) an even number of electrons
c) a charge

3 The nucleus contains:
a) protons and neutrons
b) protons and electrons
c) neutrons only

4 The number of electrons found in an element's outer shell is the same as it's:
a) atomic number
b) group number in the periodic table
c) row in the periodic table

5 A bond involving a shared pair of electrons is called:
a) covalent
b) ionic
c) metallic

6 Metals will bond with non-metals using:
a) metallic bonding
b) covalent bonding
c) ionic bonding

7 The relative formula mass of nitric acid, HNO_3, is:
a) 61
b) 62
c) 63

8 The formula for magnesium chloride is:
a) $MgCl$
b) Mg_2Cl
c) $MgCl_2$

9 In ionic equations, aluminium ions would be written as:
a) Al^{2+}
b) Al^{3+}
c) Al^{4+}

10 During an endothermic reaction the temperature:
a) decreases
b) increases
c) stays constant

11 The formula for limestone is:

a) CaO
b) $CaCO_3$
c) $Ca(OH)_2$

12 In terms of crude oil fractions, what effect will a longer carbon chain have on the boiling point?

a) increase the boiling point
b) decrease the boiling point
c) have no effect

13 As you move down group 7 from fluorine to iodine, the reactivity:

a) decreases
b) increases
c) stays the same

14 An alkali is a type of base that is:

a) insoluble in water
b) soluble in water
c) produces solutions above pH10

15 A catalyst increases the rate of reaction by:

a) providing energy
b) blocking reversible reactions
c) lowering the activation energy

Basic Skills for the A-level Chemist: Chemical Formulae

If you buy a piece of furniture that needs to be assembled, you are provided with a set of instructions to tell you the parts you need and how it fits together. A chemical formula is exactly that too – it tells you what elements are needed for a given compound or molecule and the ratios you need them in.

Chemical formulae are written in shorthand using the element symbols found on the periodic table. Most people know the formula for water is H2O, but what does that actually mean?

$$H_2O$$

- The symbol 'H' tells you water contains hydrogen
- The symbol 'O' tells you water contains oxygen
- The '2' to the right of the symbol for hydrogen tells you that one molecule of water contains two hydrogen atoms. (These number always refer to the element to the left of them in the formula.)
- There is no number after 'O'; this means there is only one oxygen atom in a molecule of water

Sometimes formulae contain brackets. These show groups of elements within compounds. Any number immediately outside the bracket tells you how man of these groups are present. For example, when magnesium reacts with water, one of the products is magnesium hydroxide, $Mg(OH)_2$.

$$Mg(OH)_2$$

- The brackets contain a group made from one oxygen atoms and one hydrogen atom
- The '2' to the right of the brackets tells you that two of these 'OH' groups are attached to magnesium

Simple chemical names can usually be worked out from looking at the formula. If a metal is present, it will come first in the compound name. Subsequent chemicals will come next and their name endings will change depending on the type of compound they form.

- The ending '-ide' tells you a compound has been formed from only two elements (it won't necessarily be just two atoms though), for example sodium chlor**ide**, NaCl
- The ending '-ate' tells you that the compound has been formed from for than two elements, one of them being oxygen, for example calcium carbon**ate**, $CaCO_3$

If a prefix is added to an element's name, this tells you not may of it's atoms are involved in the compound. (Some prefixes are different when naming hydrocarbon chains however.)

- 'Mono' (sometimes abbreviated to 'mon') means one; for example, carbon **mon**oxide, CO, contains one oxygen atom
- 'Di' means two; for example, carbon **di**oxide, CO_2, contains two oxygen atoms
- 'Tri' means three; for example, boron **tri**fluoride, BF_3, contains three fluorine atoms
- 'Tetra' means four; for example, **tetra**fluoride, CF_4, contains four fluorine atoms
- 'Hexa' means six; for example, **hexa**fluoride, SF_6, contains six fluorine atoms

HELPFUL TIP

You may be asked to predict the formulae of some simple compounds. Remember, an element's group number shows how many electrons it has in its outer shell. When elements bond, they usually bond with elements that can accept all their outer electrons or that can help them gain/share enough electrons to make a full outer shell with eight electrons in it. For example, chlorine (group 7) happily accepts sodium's electron (group 1), and magnesium (group 2) gives its two outer electrons to two chlorine atoms.

Questions

1. How many atoms of oxygen are represented in the formula for sulphuric acid, H_2SO_4?
2. How many atoms of silver are represented in the formula for silver nitrate, $AgNO_3$?
3. How many atoms of hydrogen are represented in the formula for calcium hydroxide, $Ca(OH)_2$?
4. How many atoms in total are represented in the formula for iron oxide, Fe_2O_3?
5. How many atoms in total are represented in the formula for manganese hydroxide, $Mn(OH)_2$?
6. What is the name of HF?
7. What is the name of MgO?
8. What is the name of $BaCO_3$?
9. What is the name of SO_2?
10. What is the name of CCl_4?
11. Predict the formula for calcium oxide.
12. Predict the formula for nitrogen monoxide.
13. Ammonia's formula is NH_3. What elements does it contain?
14. One beryllium atom can bond with two chlorine atoms. What would the name and formula of the product of this reaction be?
15. What is the name of I_2?

Basic Skills for the A-level Chemist: Balancing Chemical Equations

It is essential to be able to balance chemical equations, and as long as you follow some general rules and think logically about how to do this, it needn't cause you too much of a headache.

Chemical formulae tell you which elements are in compounds or molecules and the ratios they are in; these facts can't change, if they did, you would no longer have the same chemical. A simple analogy for this is a kitchen table and its component parts: a table top and four legs. Lets give the table top the symbol 'T' and the legs the symbol 'L'. If we wrote an equation for constructing the table it would be:

$$T + 4L \rightarrow TL_4$$

(*The table's formula is TL4 as it's made from one table top and four individual legs.)*

All individual formulae are fixed; all you are able to change is how many of each component you can sue up. You can't just change the table's formula to TL_2 because the table would fall over!

It's the same for chemicals: water is always H_2O, oxygen is always O_2, chlorine is always Cl_2, sulphuric acid is always H_2SO_4, and so on. You *cannot* and *must not* change the numbers within formulae when you balance equations, as that would change the chemical. And, equally as important, the parts you had at the beginning must all still be there are the end (that is, on either side of the arrow), just in different combinations.

Balancing equations can sometimes seems confusing when you have to consider how all the chemicals are typically found. Let's return to our table analogy. If table tops are always bought as packs of two, you can't just make a single table so you'd need more legs. The equation would now be:

$$T_2 + 8L \rightarrow 2TL_4$$

(Because 'T' is now found as a pair, we need twice the amount of 'L'. All the starting materials have to be used up, so we end up with two tables, $2TL_4$. Both sides of the equation have two T and eight L, so it's balanced.)

It's exactly the same with chemicals, we cannot change how the chemicals are found, so all we can do is change the amount of them we used, by changing the numbers *in front* of the formulae.

Consider sodium and chlorine reacting to form sodium chloride. First, **write out the element symbols**, showing how they are found naturally, with reactants on the left and products on the right, then count how many of each atom is present at the starts:

$$Na + Cl_2 \rightarrow NaCl$$

(The number of sodium remains constant, but here is one chlorine missing at the end.)

Now, **adjust the number in front of the formulae until the number of each atom match** at the beginning and end of the reactions. Is we make another NaCl (that is 2NaCl) and add another sodium at the start, it will balance:

$$2Na + Cl_2 \rightarrow 2NaCl$$

(Chlorine is always found in pairs of atoms, so we will need two individual sodium atoms. One sodium atom can only react with one of the chlorine atoms, hence the formula NaCl. So, we have to make two NaCl to use up all the starting atoms. So, on both sides of the equation we still have to Na and two Cl; it's balanced.)

Finally, remember that in a balanced equations each element symbol actually represents one **mole** of that elements, so it is possible to have half a mole of an element as it's actually 3.01 x 10^{23} atoms; this can somethings help balance the equation. For example, when carbon monoxide is formed as follows you could write the equations in either of these ways:

$$C + \frac{1}{2}O_2 \rightarrow CO$$

$$2C + O_2 \rightarrow 2CO$$

(For the purposes of balancing equations, half a mole of oxygen can be considered equivalent to a mole of oxygen atoms, as the same number of oxygen atoms are present.)

Questions

Balance the following equations.

1. $H_2 + Cl_2 \rightarrow HCl$
2. $Mg + HCl \rightarrow MgCl_2 + H_2$
3. $Cu + O_2 \rightarrow CuO$
4. $CH_4 + O_2 \rightarrow CO_2 + H_2O$
5. $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$
6. $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$
7. $N2 + H2 \rightarrow NH_3$
8. $Ca + HNO_3 \rightarrow Ca(NO_3)_2 + H_2$
9. $PbS + O_2 \rightarrow PbO + SO_2$
10. $Fe + Cl_2 \rightarrow FeCl_3$

Basic Skills for the A-level Chemist: Handling Numbers

The ability to work with numbers is essential for Chemistry, from working out how many moles of a substance you have produced to calculating an energy change for a reaction. Numbers you will encounter in Chemistry will range from incredibly small, for example the radium of an individual atoms, to the incredibly large, for example the number of atoms in a mole of an element. The following number-handling skills will be needed throughout your Chemistry studies.

Decimal place

Answers to calculations aren't always whole numbers. The calculator will show a 'decimal point' after the whole number and then one or more numbers, for example 12.5 – this is read as '12 point five' and means 12 and a half, or exactly half way between 12 and 13.

More usually calculators displace lots of numbers after the decimal point, and you will need to decide how manu of these numbers to use in each stahe of your calculations and how many to write down when you give in an answer. Each number after the decimal point is referred to as a 'decimal place'.

Decimal place is abbreviated to 'dp' and exam papers will often ask you to give answers to a certain number of decimal places, usually two. This is written as '2dp'. If this isn't the case, it's best to write down any answer will all the decimal places shown and then round up or down to the two decimal places. If a calculation gave an answer of 4.87509545, there are eight decimal places shown. This would be written as:

- 4.9 to 1dp
- 4.88 to 2dp
- 4.875 to 3dp
- 4.8751 to 4 dp , and so on

You may have noticed that the last decimal place often differs to the original number – if you aren't sure why, read the section below on rounding up or rounding down.

Rounding up and rounding down

Once you know how many numbers after the decimal point you need to include, you may need to 'round up' or 'round down'. This is because if the first number you are *not* including is closer to the next highest while number, it's too big to ignore.

If you were asked to quote 7.083754 to 1dp, it would become 7.1 – the eight that comes after the zero is too large to ignore, so you have to **round up** the preceding number (in this case the zero). If you had been asked to quote the same number to 2dp, however, it would be 7.08 – the eight wouldn't change because the three that comes after it is small enough to ignore, so you **round down** and keep the preceding number the same.
The general rule is: find the number that represents the last decimal place you need to quote. If the next number is small than five, round down (you won't change the last decimal place you quote). If it is five or more, round up (the last decimal place you quote will increase by one). You can only round up or down once. If you wounded 55.445 up to 55.45, you cannot then round this up to 55.5, as 55.445 to 1dp is 55.4.
When carrying out calculations, it is best to leave rounding up and down until you have your final answers. If you round up or down too early you may end up with the wrong figure at the end.

Significant figures
Significant figures are useful when quoting numbers to a certain number of decimal places isn't appropriate. If you quoted 0.0002 to 2dp, it would appear that you had a value of zero (0.00) but the two, which has been ignored, may be highly important (for example, the required concentration of a poison): it is **significant.**

Significant figures (sig. fig for SF for short) are number that tell you something about the magnitude (rough size) of a figure. You start counting significant figures as soon as you come across a non-zero number reading from left to right. Zeros netween other numbers and at the end of number are classed as significant also. Where the decimal place is has no bearing on whether a number id significant or not – all numbers are significant as soon as you encounter a number that isn't zero.

All of the following are quoted to three significant figures:

- 3.67
- 0.000000899
- 4.01
- 7.00

Scientific notation (standard form)
Some numbers in science are just so large that they would take too long to write out in their full form, so we use shorthand called 'scientific notation' or 'standard form'.

This shorthand way always takes the form of the number between 7.0 and 9.9 multiplied by 10 raised to a given power, for example 3.6×10^3 (this would be read as 'three point six times 10 to the power of three').

Consider the number 100,000. If we write this in scientific notation it becomes 1.0×10^5, because if we multiple 1.0 by 10^5, we get 100,000. A simple way to remember how to convert numbers into scientific notation is to imagine that the power the number 10 is raised to tells you have number that decimal place needs to 'leapfrog' over to get back to its place in the longhand answer.
It works for very small numbers too, except the decimal place has to leapfrog backwards, so the scientific notation shows a number between 1.0 and 9.9 multiplied by 10 raised to a negative power, for example 1.0×10^{-5} is 0.00001.

Questions

1. What is 0.867666 to 2dp?
2. What is 67.02887 to 3dp?
3. What is 489.0448 to 2dp?
4. What is 20.49 to the nearest whole number?
5. What is 0.0034577 to three significant figures?
6. What is 1.000642 to three significant figures?
7. What is 1.00546 to three significant figures?
8. How many significant figures are shown in 4000?
9. How many significant figures are shown in 9.000034?
10. What is 2000 is scientific notation?
11. What is 0.00067 in scientific notation?
12. What is 4570 in scientific notation?
13. What is 0.00000000044 in scientific notation?
14. Is 0.9×10^3 expressed in scientific notation?
15. What is 5.5×10^4 in longhand notation?
16. What is 2.7×10^7 in longhand notation?
17. What is 3.0×10^{-2} in longhand notation?
18. What is 2.5×10^{-5} in longhand notation?
19. What is 602000000000000000000000 in scientific notation?
20. What is 326700 in scientific notation, quoted to three significant figures?

Practical Skills for the A-level Chemist: Making Quantitative and Qualitative Observations

Throughout any investigation scientists will make observations. It is essential to observe experiments and scientific events to spot patterns or changes. Observations have led to some of the greatest scientific developments in history.
You will need to make two types of observations during your chemistry studies: quantitative observations and qualitative observations.

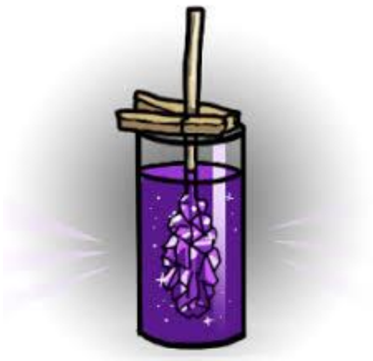
What is a quantitative observation?
If you take specific measurements or monitor changes in quantities, this is called quantitative observation – literally because it deals with quantities. When making quantitative observations it is important:

- To accurately record numerical values (for example, time, concentration, volume, mass)
- To record the units for each of your values (for example, seconds, mol dm^{-3}, dm^{3}, g)
- To be aware if you are working with units that you mat later need to covert to SI units
- To be careful not to write values down incorrectly (for example, 0.2 instead of 0.002…it does happen!)
- To use a table to record results where necessary, with the units recorded in the headings, not the body of the table
- To show all workings for calculations
- To not round figures up too early in calculations, as this can impact on the final result

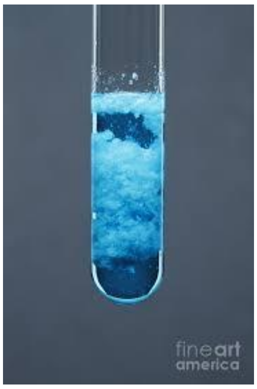
What is a qualitative observation?
Basically, any observation that doesn't involve numerical values is a qualitative observation. Qualitative observations are statements about what is notices about an event or experiment, using the senses (obviously not taste though!).

Qualitative observations may include:

- Colour changes (be specific with colours, for example don't say 'bluey, greeny, pinky with a touch of yellow')
- A reaction vessel (for example, a test tube) getting hotter or colder to the touch (using a thermometer to measure an actual temperature would be a quantitative observation)
- The appearance of a **precipitate** (solid particles suspended in a liquid produced from the reaction). If a liquid is opaque (you can't see through it) this generally means it contains a precipitate
- The appearance of **crystals** (solid particles with many faces, with an angular structure)



crystals



precipitate

- The disappearance of any substance (this is the one most students forget to write down), for example salt disappear when it is dissolved in water
- Bubbling/fizzing/effervescence (all ways of saying that a gas is being given off)
- Comparisons between different substances or reactions, foe example substance A fizzed for much longer than substance B

A very important point to remember about qualitative observations is that they should describe what can be seen, felt, heard or so on. Technically you don't need any knowledge of Chemistry to write qualitative observations; you need that when you go on to interpret what those observations mean.

If you wrote 'hydrogen is produced', that isn't actually a qualitative observation; you may have seen a gas but unless you test it further you can't confirm its identity.

Questions

Decide whether the following statements are true or false.

1. A qualitative observation involves numerical values.
2. Quantitative observations must always be recorded in tables.
3. Units should always be used when writing quantitative observations.
4. Quantitative observations must always be made in SI units.
5. The following statement is a good example of a qualitative observation: 'The white powder instantly reacted with the acid; it disappeared, and bubbles of gas were given off.'
6. The following is a good example of a quantitative observation: 'The first strip of magnesium was a bit smaller than the second. When it was added to the hydrochloric acid the temperatures went up by about 5°, but the second didn't go up this much.'
7. The following is an example of a qualitative observation: 'When the metal carbonate was heated, it decomposed into a metal oxide and carbon dioxide.'
8. If something changes from a solid to a liquid during a reaction, this means that its chemical identity has changed, and this should be mentioned in any qualitative observations.
9. When recording numerical values in a table of results, the units should be written alongside each individual value.
10. A precipitate is a solid particle that is suspended in a liquid after a reaction has occurred.

<u>Topic Builders: Moles</u>

GCSE: You may have met moles as a way of working out how many atoms there are in a certain mass of an element or compound, for example 12g of carbon would be 1 mole of carbon, or 2g of hydrogen would be 1 mole of hydrogen molecules.
You should remember that atoms are the smallest particles we can find that make up elements or compounds.

A-level: You will use moles calculations throughout A-level Chemistry. You will need to be able to find out how many moles are in given amounts of substances, included solutions and gases.
You will need to be able to convert the number of moles into masses and to link the number of moles to reacting amounts and to balanced equations.
Because atoms are so tiny, if we tried to use the number of atoms as a way of measuring things, we would end up working with huge numbers. For example, a small glass of water contains around 20,100,000,000,000,000,000,000,000 atoms. Imagine asking someone to measure that out every time you needed some water! It would take you ages to say that number.

Luckily in Chemistry we have a way of dealing with these larger n umbers. We use **moles**. Each 602,000,000,000,000,000,000,000 atoms (6.02×10^{23} atoms) is called **one mole**. It's a bit like saying 11 footballers is called a 'team', or 100 pence is called a 'pound'.
(6.02×10^{23} is called 'Avogadro's number' after the clever scientist who worked out that there were 6.02×10^{23} particles in a mole.)

How do we measure out a mole of something?
Conveniently, one mole of any elements will have the same mass in grams as the element's atomic mass number. So, of you want a mole of something, weigh out its atomic mass.

What about compounds – can we measure those in moles?
Yes, it's exactly the same as elements but one mole of a compound contains 6.02×10^{23} **molecules** instead of atoms. For example, a water molecule is H2O (two hydrogen atoms and one oxygen atoms bonded together). It isn't on the periodic table because it's not an element, so its won't have an atomic mass, but it does have a formula mass that can be worked out by adding up the atomic masses of the individual atoms in the compound.

One mole of a compound will have a mass in grams that is the same as its formula mass.
So:

- One mole of carbon would have a mass of 12g, and contain 6.02×10^{23} atoms of carbon
- Half a mole of carbon would have a mass of 6g, and contain 3.01×10^{23} atoms of carbon ($6.02 \times 10^{23} \div 2$)
- One mole of water as a mass of 18g and contains 6.02×10^{23} molecules
- Half a mole of water has a mass of 9g and contains 3.01×10^{23} molecules

The mass of a mole of anything is called the **molar mass.**

What if you have an amount of a substance that doesn't have the same mass as the atomic or formula mass? Can we still find out how many moles there are?
Yes, by using the formula:
No. of moles = mass of substance ÷ molar mass
(mol) (g) (g mol^{-1})
Sometimes you will want to weigh out a substance to use a specific number of moles, so you can rearrange this equation to find out the mass. Or sometimes you may want to calculate the molar mass of a substance – you can rearrange the equation to do this too.

Questions

Try these questions; always show you workings.

1. What mass would 1 mole of sodium (Na) have?

2. What mass would 0.5 moles of iodine (I) have?

3. What mass would 1 mole of carbon dioxide (CO_2) have?

4. What mass would 4 moles of copper sulphate ($CuSO_4$) have?

5. What mass would 0.2 moles of magnesium chloride ($MgCl_2$) have?

6. How many atoms are there in two moles of aluminium (Al)?

7. How many molecules are there in 0.5 moles of water (H_2O)?

8. How many moles are there in 3.01×10^{24} atoms of copper (Cu)?

9. How many moles are present in 90g of carbon (C)?

10. How many moles is 23g of nitrogen dioxide (NO_2)?

STARTER FOR 10

1.1.1. Moles and mass

Work out the answers to the following simple calculations
(1t = 1 tonne = 1,000kg):

1. No. of moles in 10.0g of O_2 + the mass in g of 2.41 moles of H_2O =
(2 marks)

2. Mass in g of 0.2 moles K_2CO_3 + mass in g of 0.5 moles of $MgCO_3$ =
(2 marks)

3. No. of moles in 12.4t of $NaNO_3$ ÷ no. of moles in 12.4t of NaCl =
(2 marks)

4. No. of moles in 25.9g of sodium – no. of moles in 25.9g of sodium chloride =
(2 marks)

5. ? x molar mass of in g mol^{-1} of calcium carbonate = no. of moles in 4.2kg of $SiCl_4$
(2 marks)

STARTER FOR 10

2.1 Development of theories about atomic structure

Our current understanding of atomic structure us a result of the discoveries of several scientists over many years, each scientist adding to the model.
Complete the table below by adding the name of the scientist and discovery made. Choose from the lists below the table. (9 marks)

Approx. year of discovery	Scientist	Addition made to our current understanding of atomic structure
1803	*John Dalton*	*Proposed that all matter is made up of tiny particles called atoms*
1897		
1911		
1915		
1924		
1932		

Scientists:
Ernest Rutherford; Wolfgang Pauli; J.J. Thomson;
James Chadwick; Niels Bohr

Discoveries:
Proposed that the electrons orbit around the nucleus in orbits with a set size and energy.
Discovered that atoms contain neutral particles called neutrons in their nucleus.
Realised that atoms are divisible and contain very tiny, negatively charged particles called electrons.
Discovered that an atom is made up of a nucleus and an extra-nuclear part. The central nucleus is positively charged, and the negative electrons revolve around this central nucleus.
Proposed the concept of electron spin.

BONUS MARK: Which of the scientists listed above was a famous football goalkeeper in his country?