Name……

HAUTLIEU SCHOOL CHEMISTRY
Pre A Level and IB Diploma Task 2023

Expectations

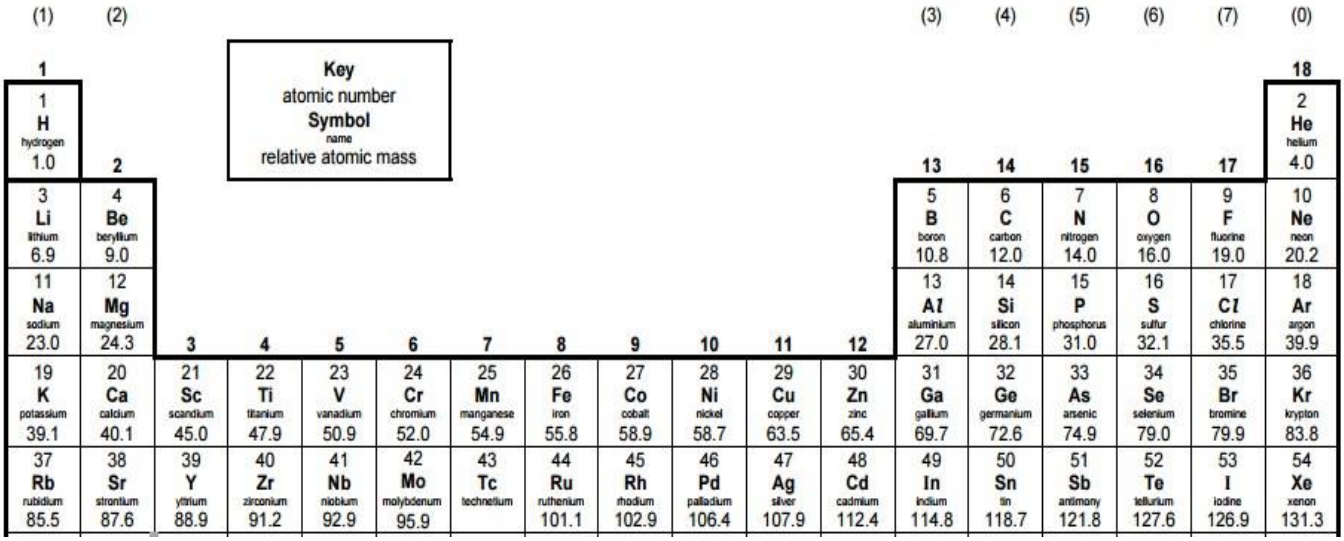
- All sections of the task will be attempted – please check you have answered **all** questions (10 pages)
- Answers should be presented in a **clear and well-structured** manner **on lined paper with pages numbered and your name on all pages (we can staple when you hand it in)**
- Answers should include an appropriate amount of relevant detail
- All parts of the task are to be **handed in at the start of your first A Level or IB lesson in September**
- **Extra credit will be given for more detailed responses, but use bullet points rather than prose**
- We have tried to use examples that will be used though the course so if there are names you are unsure about please look them up and try to remember them
- If you do not know something, please **make every effort to find out the answer** – doing this will help you to learn, this is not a test – use all the resources you can, it will help you to explore the available resources.

Content

- Revision of significant figures and standard form
- Naming compounds and writing formulae
- Writing equations
- Calculations from mass
- Bonding
- Qualitative analysis
- Groups in the periodic table
- States of matter and separation techniques
- Acids, bases and salts
- Rates of reaction

Requirements for the task and Chemistry lessons

- A scientific calculator (please buy one if you do not already own one)
- A copy of the Periodic Table (the one below should be sufficient)
- Access to Chemistry AS/IB textbooks (library) or internet articles – Chemguide is a good resource to start using early.



Significant Figures (sf) - General Rules – **read carefully!**

1. Any digit that is not zero is significant

- 86 has two sig figs
- 274.8 has four sig figs

2. A zero between non-zero digits are significant

- 806 has three sig figs
- 3001 has four sig figs

3. Zeroes to the left of the first non zero number are not significant. They just show the position of the decimal place.

- 002869 has four sig figs
- 0.000767 has three sig figs

4. If a number is greater than 1, then all the zeros to the left of the decimal point are significant as long as the decimal point is written. If the decimal point is not written, they are not significant. (The best way to avoid confusion is to use standard form.)

- 250 has two sig figs.
- In standard form this would be 2.5×10^2

5. For any numbers that contain a decimal, zeroes written to the right are significant.

- 6.7810 has 5 sig figs
- 0.00120 has 3 sig figs (the first three 0's are not significant, the last one is)]

6. For numbers written in standard form, all the digits written are significant.

- 1.23×10^{-4} has three sig figs
- 8.00×10^9 has three sig figs

Additional Guidance for numbers in chemistry

Expected precision is 3 sf unless M_r (1dp) or pH (2dp) (best practice is to keep numbers in your calculator and round numbers at the end of your working).

You will need to be fluent in the use of standard form.

Questions

1. Write the following numbers to the quoted number of significant figures.

a) 345789 **4 sig figs** ……

b) 297300 **3 sig figs** ……

c) 0.07896 **3 sig figs** ……

2. Complete the following calculations and give the answers to **3 significant figures**.

a) 6125 x 384 ……

b) 25.00 x 0.01 ……

c) 13.5 + 0.18 ……

3. Write the following numbers in **non-standard form**.

a) 1.5×10^{-3} ……

b) 0.046×10^{-2} ……

c) 3.575×10^5 ……

4. Write the following numbers in **standard form**.

a) 0.000167 ……

b) 0.0524 ……

c) 0.000000015 ……

5. Complete the following calculations and give the answers to **3 significant figures.**

a) $6.125 \times 10^{-3} \times 3.5$ ……

b) $4.0 \times 10^8 + 35000$ ……

c) $0.00156 + 2.4 \times 10^3$ ……

Naming Compounds – read carefully

When naming compounds there are two basic rules:

1. When a metal and a non-metal element combine the compound name is something **–ide** (the metal element is always named first)

   If sodium and chlorine combine you get sodium chloride
   If magnesium and oxygen combine you get magnesium oxide

2. When three or more different elements combine and one of them is oxygen the compound's name ends in **–ate**

   If copper, sulphur and oxygen combine you get copper sulphate
   If sodium, nitrogen and oxygen combine you get sodium nitrate

Finding Formulae

To work out the formula when chemicals react, you need to look at the ions that form

Positive Ions			Negative Ions		
1^+ ions	2^+ ions	3^+ ions	3^- ions	2^- ions	1^- ions
All group 1 metals:	All group 2 metals:	Aluminium – Al^{3+}	Phosphate – PO_4^{3-}	All group 6 elements:	All group 7 elements:
Lithium - Li^+	Magnesium - Mg^{2+}			Oxide – O^{2-}	Fluoride – F^-
Sodium – Na^+	Calcium – Ca^{2+}			Sulphide – S^{2-}	Chloride – Cl^-
Potassium – K^+					Bromide – Br^-
	Zinc – Zn^{2+}			Carbonate – CO_3^{2-}	Iodide – I^-
Ammonium – NH_4^+	Most transition metals have a 2+ ion			Sulphate – SO_4^{2-}	
					Hydroxide – OH^-
					Nitrate – NO_3^-

For assistance with writing formulae check out the following video:

http://www.youtube.com/watch?v=URc75hoKGLY

Questions

Give the formulae of the following compounds

1) potassium iodide ..... 6) potassium sulphate .....
2) sodium oxide ..... 7)aluminium hydroxide .....
3) calcium sulphide ..... 8) potassium nitrate .....
4) strontium chloride ..... 9) zinc carbonate .....
5) iron (III) oxide ..... 10)ammoniumsulphate .....

If you do not already know the formula of carbonate, sulphate, hydroxide, nitrate and ammonium ions, learn them – you WILL need them.

Equations

In Chemistry, one important skill is being able to write balanced chemical equations for reactions that have occurred.

These are some general equations you should be familiar with: **Learn them if you are not!**

Reaction	Examples
acid + alkali → salt + water	$HCl + NaOH \rightarrow NaCl + H_2O$ $H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$
Acid + base → salt + water	$H_2SO_4 + MgO \rightarrow MgSO_4 + H_2O$
Acid + carbonate → salt + carbon dioxide + water	$2HCl + MgCO_3 \rightarrow MgCl_2 + CO_2 + H_2O$
Acid + metal → salt + hydrogen	$H_2SO_4 + Ca \rightarrow CaSO_4 + H_2$
Substance + oxygen → oxides	$2Mg + O_2 \rightarrow 2MgO$ $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
Metal + water → metal hydroxide + hydrogen	$2Na + 2H_2O \rightarrow 2NaOH + H_2$
Metal carbonate → metal oxide + carbon dioxide (on heating)	$CaCO_3 \rightarrow CaO + CO_2$

Questions

Balance the following equations in the spaces underneath: **not all the gaps need to be filled**

a) _____Mg + _____HNO_3 → _____$Mg(NO_3)_2$ + _____H_2

b) _____Ca + _____H_2O → _____$Ca(OH)_2$ + _____H_2

c) _____H_3PO_4 + _____CaO → _____$Ca_3(PO_4)_2$ + _____H_2O

d) _____HNO_3 + _____Na_2CO_3 → _____$NaNO_3$ + _____CO_2 + _____H_2O

Give balanced equations for the following reactions (use the guidance on the previous page for help):

a) Strontium carbonate → strontium oxide + carbon dioxide

b) Aluminium + chlorine → aluminium chloride

c) Ammonia + sulphuric acid → ammonium sulfate

d) Lithium + water → lithium hydroxide + hydrogen

e) Cyclohexane (C_6H_{12}) + oxygen → carbon dioxide + water

f) Hydrochloric acid + barium carbonate → barium chloride + carbon dioxide + water

Relative formula mass

Remember that the relative atomic mass of an atom can be found by using the mass numbers of the periodic table. The relative formula mass of a compound is the sum of the relative atomic masses of the atoms involved. It is often given by the symbol M_r

Worked example 1:

What is the M_r of $CaCO_3$?

$CaCO_3$ has one calcium atom, one carbon atom and three oxygen atoms. The relative mass of calcium is 40, carbon is 12 and oxygen is 16. To calculate the total:

40 + 12 + (3 x 16) = 100

Worked example 2:

What is the Mr of $Ca(OH)_2$?

$Ca(OH)_2$ has one atom of calcium, two atoms of oxygen and two atoms of hydrogen (remember that everything in the brackets is multiplied by the little number. To calculate the total:

40 + (2 x 16) + (2 x 1) = 74

1. For each of the compounds below calculate their M_r

a. CO	d. Na_2O	g. $CuSO_4$
b. H_2O_2	e. $Al(OH)_3$	h. K_2SO_4
c. SO_2	f. $Mg(NO_3)_2$	i. $Al_2(SO_4)_3$

j. *A substance has an Mr of 180. A student knows that it has atoms of carbon, hydrogen and oxygen in it. What is its formula?*

The mole

In everyday life, there are some words we can use which represent a number. For example:

A score	= 20
A dozen	= 12
A baker's dozen	= 13

These words exist because in different contexts those words are more useful than the numbers they represent. Someone selling eggs will refer to them "by the dozen" as eggs come in containers of six or twelve. So "dozen" is more useful than "twelve."

In chemistry, we have a similar word called a "mole." A "mole" is a word which represents a number just like "dozen" represents "twelve." A mole represents the number 6.02×10^{23}. This number is called The Avogadro Constant. This helps us to work in uncomplicated numbers.

2. How many atoms are in:
    a. One mole of atoms
    b. Two moles of atoms
    c. Seven moles of atoms
    d. Half a mole of atoms
    e. A dozen moles of atoms

Worked example: Sodium has 11 electrons in each atom. How many electrons are in one mole of sodium atoms?

Answer: one mole of atoms is 6.02×10^{23}. If each atom has 11 electrons then there must be $11 \times 6.02 \times 10^{23}$ electrons in total which = 6.62×10^{24}

3. How many electrons are in:
    1. One mole of lithium atoms
    2. Two moles of carbon atoms
    3. One mole of carbon dioxide molecules
    4. Half a mole of methane molecules
    5. *Challenge: A sample of iron metal is found to have 4.85×10^{26} electrons in it. How many **moles** of iron atoms are present?*

Moles and relative formula mass

The M_r of a substance represents the **mass** of one mole of that substance.

For example: water has the formula H_2O. Each molecule of water has two hydrogen atoms and one oxygen atom. Its M_r is 18. This means that 18 grams of water, contains **one mole (6.02 x 10^{23})** of water molecules.

This leaves us with a formula relating moles, mass and M_r:

$$moles = \frac{mass}{Mr}$$

Worked example 3

How many moles are in 30g of CO_2?

The M_r of CO_2 is

12 + (16x2) = 44

Moles = 30/44 = ***0.68***

Worked example 4

How many moles are in 175g of Na_2CO_3?

M_r = (2 x 23) + 12 + (3 x 16) = 106

Moles = 175/106 = ***1.65***

4. How many moles are in:
   a. 198g CO_2
   b. 144g CH_4
   c. 102g NH_3
   d. 1kg NaF
   e. 1.2kg $Ca(OH)_2$

The equations can be rearranged to:

$$mass = moles \times Mr \qquad \text{and} \qquad Mr = \frac{mass}{moles}$$

5. What is the mass of:
   a. 5 moles of Cl_2
   b. 0.2 moles of Al_2O_3
   c. 0.01 moles of Ag
   d. 0.3 moles of Na_2CO_3
   e. An experiment was carried out to find the Mr of vitamin C (ascorbic acid). It was found that 1 g contains 0.00568 moles of Vitamin C molecules. Calculate the Mr of vitamin C.

<u>Reacting mass calculations.</u>

Worked example

Hydrogen and nitrogen react together to make ammonia (NH_3). Write a balanced symbol equation for this reaction and calculate how much nitrogen would be needed to react with 19.30 moles of hydrogen and how much ammonia would be produced.

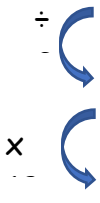
First, we write the equation:

$$H_2 + N_2 \rightarrow NH_3$$

Then balance:

$$3H_2 + N_2 \rightarrow 2NH_3$$

Then we calculate our ratio:



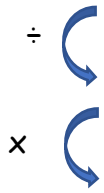
H_2	N_2	NH_3
3	1	2
1	0.33	0.67
19.30	6.37	12.93

So 6.37 moles of nitrogen would be needed and would produce 12.93 moles of ammonia.

Guided practice:

Methane (CH_4) reacts with oxygen to make carbon dioxide and water.

a. Write a balanced symbol equation for this reaction:
   $CH_4 + \_\_O_2 \rightarrow CO_2 + \_\_H_2O$
b. Fill in the top row of the table below with the numbers from your balanced equation



CH_4	O_2	CO_2	H_2O

c. If you started with two moles of CH_4, how much O_2 would you need? (the answer is 4, but you must use a calculation to prove this)
d. If you started with 3.5 moles of CH_4, how much O_2 would you need?
e. If you started with 3.5 moles of CH_4, how much CO_2 would you expect?

Ethane (C_2H_6) also reacts with oxygen to produce carbon dioxide and water:

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

a. If 4 moles of ethane are used, how many moles of CO_2 are produced?
b. If 5 moles of ethane are used, how many moles of H_2O are produced
c. If 4 moles of ethane are used with 10 moles of O_2, how many moles of CO_2 are made?
d. If 19 moles of oxygen are used, how much water is produced?
e. How many moles of oxygen and ethane would you have to use to generate 42 moles of water?

<u>Bonding, structures and properties</u>

Elements combining	Type of bonding	Type of structure	Description of bonding	Key features of structure
Metals	**metallic**	**Giant metallic**	Electrostatic attraction between delocalised electrons and positive ions	Delocalised electrons Positive metal ions in rows
Non-metal and metal	**ionic**	**Giant ionic**	Electrostatic attraction between oppositely charged ions	Alternating positive and negative ions
Non-metals	**covalent**	**Giant covalent**	A shared pair of electrons	Many strong covalent bonds, repeating structure
		Simple covalent		Covalently bonded molecules with weak intermolecular forces of attraction between molecules

If a question asks about melting point or electrical conductivity you will have to refer to bonding and structure in your answer. Always start by checking the types of elements combining using the periodic table to see if they are metals or non-metals

Substance	Melting point	Conducts electricity when solid	Conducts electricity when liquid
A	high	no	no
B	high	no	Yes
C	High	Yes	Yes
D	low	no	no

1) Which of the substances in the table could be…
    a) Sodium chloride (NaCl)
    b) Diamond ($C_{(diamond)}$)
    c) Chlorine
    d) Iron
2) Why does potassium have a lower melting point than sodium?
3) Why would we expect MgO to have a higher melting point than NaCl?
4) Why does $CaCl_2$ have a higher melting point than HCl?

<u>Quantitative testing</u>

There are many circumstances where we need to be able to quickly and definitely identify chemicals in the lab. We may want to know which chemical is which when we have forgotten to label them. We may need to confirm the product of a reaction to check that the reaction we intended has actually happened.

Identify the substances causing the changes described by giving the chemical name or formula (for some there may be more than one correct answer)

1. A gas that turns limewater ($Ca(OH)_2$) cloudy
2. A gas that relights a glowing splint
3. A substance that turns universal indicator red
4. Forms a white precipitate with (nitric acid) and silver nitrate
5. Turns bromine water from yellow to colourless
6. A gas that extinguishes a lit splint
7. Forms a white precipitate with (hydrochloric acid) and barium chloride
8. Turns anhydrous copper sulfate from white to blue
9. A gas that makes a squeaky pop with a lit splint
10. A negative ion that fizzes when acid is added

<u>Periodic trends</u>

It would be very hard to know every single property of every element, but it is not so hard to remember and use trends in properties from the arrangement of elements in the periodic table. Eg, down group 1 the elements increase in reactivity as the size of atoms increases and it becomes easier to lose the outermost electron as it is less attracted to the nucleus.

For each of the following pairs, pick the larger species

1. Argon atom or potassium ion?
2. Chloride ion or potassium atom?
3. Magnesium atom or sodium atom?
4. Sulfide ion or chloride ion?

5. Magnesium ion or sodium ion?
6. Oxide ion or chloride ion?
7. Aluminium ion or aluminium atom
8. Water molecule of hydrogen chloride molecule?
9. Gold atom or water molecule?
10. Fluorine molecule or chlorine molecule?

States of matter, separation of mixtures and purification techniques

Making a chemical is rarely as simple as just combining 2 ingredients and collecting the product. Usually what is made is a mixture of chemicals (unreacted reactants, solvents, possibly some unexpected oxides from oxygen in the air reacting) so it is important to know how to get the desired product from the reaction mixture.

The solubility rules in the table are useful to know

Soluble in water	Insoluble in water
All common sodium, potassium and ammonium (Na^+, K^+ and NH_4^+) salts	
All nitrates (NO_3^-)	
Most sulphates (SO_4^{2-})	Lead sulphate ($PbSO_4$), barium sulphate ($BaSO_4$), calcium sulphate ($CaSO_4$)
Most chlorides (Cl^-)	Lead chloride ($PbCl_2$) silver chloride ($AgCl$)
Sodium, potassium and ammonium carbonates (Na_2CO_3 K_2CO_3 $(NH_4)_2CO_3$)	Most carbonates (CO_3^{2-})
Sodium, potassium and ammonium hydroxides (NaOH KOH NH_4OH)	Most hydroxides (OH^-)

Filter, distil, dry, rinse with distilled water, leave to evaporate, drying agents eg, $CaSO_4$ react exact quantities are all techniques we can employ to obtain a better quality of product.

How would you separate and/or purify the following (to give the underlined substance)?

1. A yellow precipitate of lead iodide from a solution of ions
2. Sodium chloride from its solution
3. Iron from a mixture of iron and sulfur
4. Ethanol from a mixture of ethanol and water
5. Water from sea water

Acids, bases and salts

A key area of chemistry that is useful in many aspects of our courses.

1. Name and define a strong acid
2. Name and define a strong base
3. Name and define a weak acid
4. Name and define a weak base
5. Name and define a salt
6. Give the most common equation for a neutralisation reaction
7. Explain what phenolphthalein is
8. How many NaOH would react exactly with $1H_2SO_4$?
9. Which has higher pH, NH_3 or CH_3COOH?

10. Which has higher pH (at the same volume, same concentration), HCl or H_2SO_4?

Rates of reaction

Another key area of chemistry that appears in multiple contexts throughout the course

The following experiment was carried out: an excess of $CaCO_3$ chips were added to H_2SO_4 in a conical flask on top of a zeroed balance. The rate of reaction was monitored by recording the mass every 20 seconds until the reaction finished.

1. How would the student know the reaction had finished?
2. What happens in this reaction to cause mass to decrease?
3. Why would this reaction proceed most quickly at the start?
4. Give the units for the rate of this reaction
5. Sketch the shape of the graph (mass (y axis) against time (x axis) for this reaction on labelled axes
6. Give another way to monitor the rate of this reaction
7. What would the difference be if the concentration of acid were doubled?
8. What would the difference be if the $CaCO_3$ were switched for calcium oxide?
9. The experiment was repeated at a higher temperature, explain why the rate increased?
10. Aside from increasing temperature, give 2 ways in which the rate of reaction could be increased

THE END