UNDERSTANDING BENZENE STRUCTURE

LESSON 1

Benzene is a molecule that is made from two elements.

Both elements have 3 main ***isotopes***. However, in both cases, one of the elements' isotopes has such a small abundance that it makes only a very small contribution to the A_r.

1. Define the term *isotope*

   ……

   For the lighter element the abundance data is: For the heavier element the abundance data is:

Relative Mass	Abundance (%)
1.000	99.9885
2.000	0.0115

Relative Mass	Abundance (%)
12.000	98.931
13.000	1.069

2. Define the term *relative atomic mass.*

   ……

3. Calculate the relative atomic masses of the two elements and identify them. Express your answer to an appropriate number of **significant figures.**

   Element A_r ……. Identity……. Element A_r ……. Identity…….

DETERMINATION OF THE EMPIRICAL FORMULA OF BENZENE.

The relative formula mass M_r of benzene was determined by mass spectrometry. The M_r is 78.0

To determine the empirical formula of benzene 1.00g of benzene was fully combusted in excess oxygen. The gaseous products were fed through powered **anhydrous copper(II)sulfate** and the remaining gas was passed through powdered **calcium oxide** (lime).

The **anhydrous copper(II)sulfate** increased in mass by **0.692g** and turned from a white solid to a mixture of some white solid and some blue solid.

The **calcium oxide** increased in mass by **3.38g**

4. Define the term *empirical formula*

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5. Explain why the anhydrous copper(II)sulfate gained mass.

   ……

6. The blue product was copper(II)sulfate pentahydrate. Write a chemical equation the represents the reaction that caused the anhydrous copper(II)sulfate to gain in mass.

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7. Explain why the calcium oxide gained mass. (clue: think about the combustion products when complete combustion takes place with a hydrocarbon. Also recall the properties of group 2 oxides).

   ……

8. Write an equation for the reaction that took place when the calcium oxide gained mass.

   ……

9. Using this data, you can now work out both the *empirical formula* and then the *molecular formula* of the benzene.
   If you are unsure what to do, look at the steps on the next page.

empirical formula of benzene. ……

molecular formula of benzene. ……

Step-by-step calculations:

a) Calculate the **moles** of water gained by the anhydrous copper(II)sulfate.

……..

b) Calculate the total **moles** of the hydrogen present in the water. This hydrogen must have come from the benzene.

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c) Calculate the **moles** of carbon dioxide gained by the calcium oxide.

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d) Calculate the total **moles** of the carbon present. This carbon must have come from the benzene.

……

e) Calculate the **moles** of benzene that were combusted.

……

f) Now, determine the **empirical formula** and **molecular formula** of benzene.

empirical formula of benzene. ……

molecular formula of benzene. ……

10. If the combustion gases were collected at 122 ^{O}C, calculate the total volume of gases that was produced before it was passed through the copper(II)sulfate and calcium oxide. The pressure on the day that the experiment was performed was 99.7 kPa
Express your answer in cubic decimetres.

…… dm^3

11. Define the term ***enthalpy of combustion,*** $\Delta_c H$

……

12. Write an equation for the complete combustion of **benzene**

……

13. Write an equation for the complete combustion of **carbon**

……

14. Write an equation for the complete combustion of **hydrogen**

……

The **enthalpies of combustion** data are presented below.

Chemical	Enthalpy of combustion / kJ mol^{-1}
hydrogen	**-285.8**
carbon	**-393.5**
benzene	**-3267**

15. Define ***Hess's Law***

……

……

16. Define ***enthalpy of formation,*** $\Delta_f H$

……

……

17. Draw a Hess Cycle that would allow you to calculate the ***enthalpy of formation,*** $\Delta_f H$ of benzene using the information from the table shown above.
    Use the Hess Cycle to calculate the ***enthalpy of formation,*** $\Delta_f H$ of benzene.

$\Delta_f H$ **(benzene)=……..**

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In conclusion, you have arrived at the **molecular formula of benzene**. You may like to ponder over the possible structures of benzene that could have this molecular formula. This is what we will do in detail over the coming weeks.