QUESTION ONE (8 marks)

There are three isomers of C_5H_{12}.

(a)   Draw the structure of each isomer.

(b)   One of the alkane isomers from part (a) reacts with Cl_2 in the presence of light to give a single monohalogenated organic product. Draw the structure of that product.
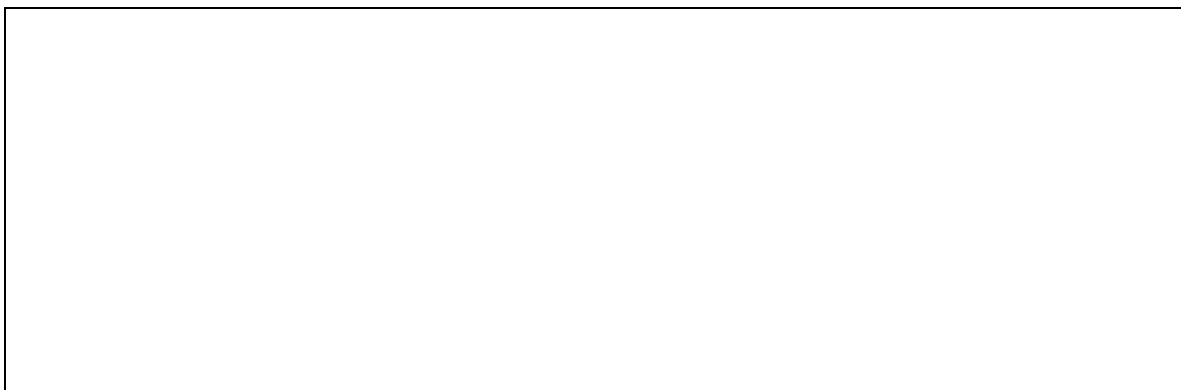
(c)   Another one of the isomers from part (a) reacts with Cl_2 in the presence of light to give four different monochloro alkanes. One of these is a secondary chloroalkane.
        (i)   Draw the structure of this chloroalkane.

(ii)   Draw the structures of alkenes produced when the secondary chloroalkane from
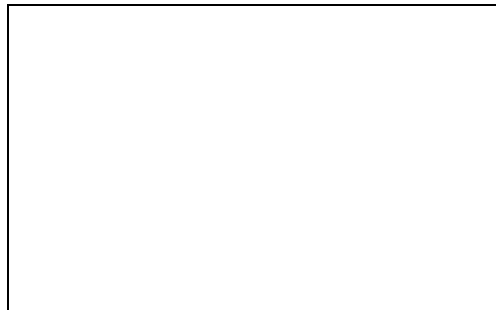   part (i) reacts with KOH in ethanol.

(iii)   Circle the alkene from part (ii) above that is formed in the greatest amount.
        Justify your answer.

QUESTION TWO (4 marks)

There are five C_5H_{10} constitutional (structural) isomers that are alkenes.

(a)   One of the five alkenes exists as *cis-trans* stereoisomers. Draw the structure of the cis isomer of this alkene.

(b)   Explain why the alkene in part (a) exists as *cis-trans* isomers whereas the isomeric alkene that has the same carbon skeleton does not.

(c)   Two C_5H_{10} alkenes have the same carbon skeleton, but neither exists as *cis-trans* isomers. One of these reacts with HCl to form a tertiary chloroalkane as the major product.

    (i)   Draw the structure of this alkene;
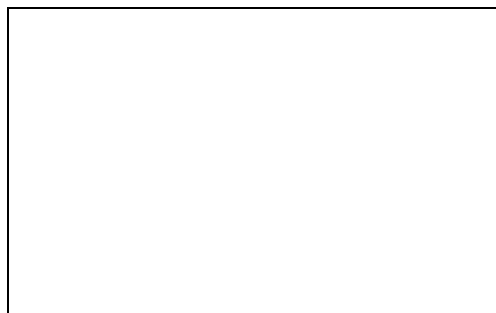
   (ii)   Draw the structure of the chloroalkane described above.
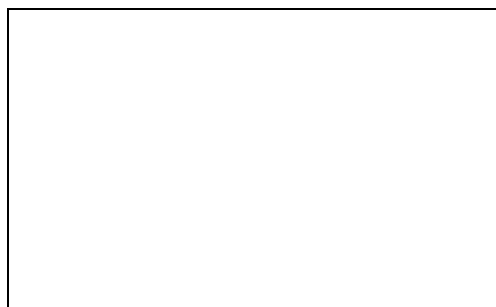
QUESTION THREE (12 marks)

This question is concerned with four alcohols and

QUESTION FOUR (5 marks)

$[B_7H_7]^{2-}$ is a **pentagonal bipyramid** (shown below without the H atoms) with ten triangular faces. It has two types of B atoms; two axial (ax) and five equatorial (eq). A *nido*-**pentagonal bipyramid** is missing one of these vertices/atoms.
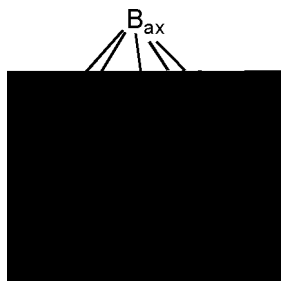
The cluster $[B_5NH_6]^{2-}$, in which one of the B atoms has been replaced by an N atom, is predicted to be a *nido*-pentagonal bipyramid. Sketch the possible isomers for this ion by writing B or N over the appropriate vertices in the polyhedra given below. You may not need to use all of the polyhedra to show all of the isomers.
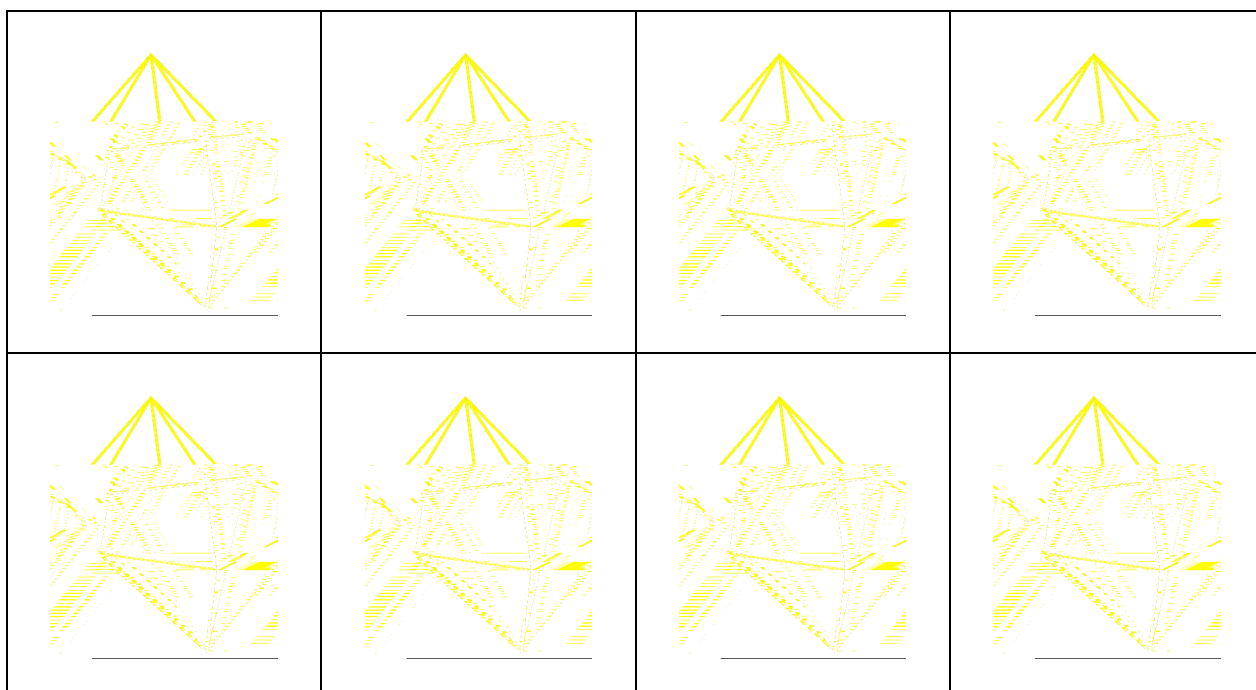
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(c) (i) Draw TWO Lewis structures for nitrogen dioxide (NO_2) and the 3-dimensional molecular shape for one of these.

(ii) The "formal charge" is the number of valence electrons in the atom, minus the number of lone pair electrons at that atom in the Lewis structure, minus the number of bonds to the atom in the Lewis structure. Formal charge can be used to help explain where electrons are likely to be found on atoms in a molecule. Identify your structure in part (i) that formal charge suggests is most likely.

(iii) The O-N-O bond angle is actually 134.3°. Does this value support your proposed Lewis structure? Justify your answer.

QUESTION SIX (10 marks)

Silver nitrate is used in volumetric analysis to determine the concentration of chloride ions in an aqueous solution. Because of the high cost of $AgNO_3$, a student uses an available supply of 0.0500 mol L^{-1} $AgNO_3$ solution and some solid $AgNO_3$ to prepare 100.0 mL of 0.0750 mol L^{-1} $AgNO_3$. She prepares the solution by:

     (i)   pipetting exactly 50.00 mL of the 0.0500 mol L^{-1} $AgNO_3$ solution into a 100.0 mL volumetric flask;

     (ii)   adding an appropriate mass of $AgNO_3$;

     (iii)   diluting the solution to exactly 100.0 mL.

(a)   What mass of $AgNO_3$ should be added in step (ii)?   [$M(AgNO_3) = 169.9$ g mol^{-1}]

(b)   Solid $MgCl_2$ (0.100 g) was then added to the solution. Assuming no change in the total volume, what is the concentration of each of the following species?
     [$M(MgCl_2) = 95.2$ g mol^{-1}]

     (i) $Mg^{2+}_{(aq)}$

     (ii) $Ag^{+}_{(aq)}$

     (iii) $NO_3^{-}{}_{(aq)}$

QUESTION SEVEN (7 marks)

The Kjeldahl method can be used to determine the percentage of nitrogen in meat and other organic products. A 0.0986 g sample was heated with concentrated sulfuric acid for two hours to oxidise organic matter and convert all nitrogen to ammonium ions. The solution was then made strongly basic by adding excess sodium hydroxide solution producing ammonia. The ammonia was then distilled into 50.00 mL of 0.1010 mol L^{-1} HNO_3. Exactly 23.45 mL of 0.1500 mol L^{-1} NaOH was required to neutralise the excess acid.

Calculate the amount (moles) of NH_3 that was distilled into the HNO_3 and hence determine the percentage of N in the original sample.

QUESTION EIGHT (6 marks)

For each of the following compounds, state with brief explanation whether its solubility in water will increase, decrease or be unaffected by a decrease in pH:

(a) $PbSO_4$

(b) $AgCl$

(c) CuS

QUESTION NINE (5 marks)

A compound consists of 14.29% carbon, 57.14% oxygen, 1.19% hydrogen and an element X having the same number of moles as there are moles of carbon.

(a)   Identify X.

(b)   Determine the empirical formula of the compound.

(c)   Suggest the likely identity of the compound.

QUESTION TEN (12 marks)

Write net equations for each of the following reactions, using appropriate ionic and molecular formulae for the reactants and products. Omit all ions of molecules that do not take part in the reaction. The equations must be balanced. All reactions occur in aqueous solution unless otherwise indicated.

(a)   Solid calcium carbonate is heated to a very high temperature.

(b)   Lithium nitride is added to water to produce a solution that turns pink litmus blue.

(c)   Concentrated hydrochloric acid is added to a solution of sodium hypochlorite.

(d)   Solutions of barium hydroxide and sulfuric acid are mixed

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QUESTION ELEVEN (13

QUESTION TWELVE (6 marks)

The average chemical formula for common diesel fuel is $C_{12}H_{26}$. Dodecane ($C_{12}H_{26}$) has an enthalpy of combustion of ó8072 kJ mol^{61} and a density of 0.745 g mL^{61}. The enthalpy of combustion for a given substance is defined as the enthalpy change for the reaction of one mole of the substance with oxygen to form $CO_2(g)$ and $H_2O(l)$. $M(C_{12}H_{26}) = 170$ g mol^{61}.

(a)   (2 marks) Write down a balanced equation for the combustion of dodecane.

(b)   (2 marks) Calculate the energy density, expressed as kJ of heat given off in combustion per litre of fuel (kJ/L) for dodecane.

(c)   (2 marks) What mass of CO_2 is produced in order to generate 15,000 kJ of energy?